Introduction and user manual

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

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2. INTRODUCTION

Energy is a prerequisite for industrial development and activity; without an effective energy supply neither are possible. While there is at present little real constriction on the overall supply of energy to industry, there are a number of serious issues when considering industrial energy use and the sustainable growth of industries particularly in developing countries. Such issues range from the additional cost of energy processes due to inefficient utilization, vulnerability to price shocks of imported fuels and the externalities associated with wide-scale inefficient and unclean utilization of energy, both at the local/national level and the regional/global level.

Meanwhile, at the household level, over 1.6 billion people lack access to modern forms of energy services. The vast majority of these people live in the rural areas of the poorest regions of the world. Many are either too poor, or too isolated to attract commercial energy-related investments since they do not constitute a viable market that can generate an adequate return on those investments.

This situation is of concern as energy is an essential building block for fighting poverty and promoting sustainable development. Therefore there is a definite need to establish close linkages between reliable energy services and income generation activities in rural areas. While the Millennium Development Goals do not specifically contain an energy component, the provision of safe and affordable energy is an important, if not vital, condition for their achievement.

While the adoption of renewable energy and energy efficiency technologies is at an advanced stage in some developed countries, developing countries are still far behind due to various barriers that include limited awareness amongst policy-makers, lack of capacity in terms of trained personnel, poor regulatory and policy frameworks and of course, the lack of finance.

Within many developing countries, there exists a lack of capacity and knowledge on how to foster a regulatory and policy environment that will better aid the adoption of more economically (in the long term) and environmentally sustainable methods of energy utilization, both in the industrial sector and the rural energy environment. Well-designed and effective policies as well as regulatory frameworks can have a significant positive impact on the uptake of new more energy-efficient industrial processes and the development of the rural/renewable energy technology sector.

The Renewable Energy and Energy Efficiency Programme (REEEP) and the United Nations Industrial Development Organization (UNIDO) are organizations developing capacity-building programmes that aim at addressing the barriers to developing renewable energy and energy efficiency within developing countries.

The "Sustainable Energy Regulation and Policymaking for Africa" training package has been developed by the United Nations Industrial Development Organization (UNIDO) and is co-funded by the Renewable Energy and Energy Efficiency Programme (REEEP).

2.1. About UNIDO

The United Nations Industrial Development Organization (UNIDO) was set up in 1966 and became a specialized agency of the United Nations in 1985. UNIDO has responsibility for promoting sustainable industrialization throughout the developing world, in cooperation with its 171 Member States. Its headquarters are in Vienna, and it is represented in 35 developing countries through its field offices. UNIDO helps developing countries and countries with economies in transition in their fight against marginalization in today's globalizing world.

UNIDO focuses its technical cooperation activities on three main thematic priorities, which directly respond to international development priorities in line with the Millennium Development Goals (MDGs):

Poverty reduction through productive activities

Distinctively different from other agencies and institutions, UNIDO addresses poverty reduction (MDG1) by focusing on enabling the poor to earn a living, rather than providing help to deal with the symptoms of poverty. As such, UNIDO focuses on micro, small and medium-scale enterprise development; rural and agro-industrial development (as well as "rural energy for productive use"); and women in development.

Trade capacity-building

Open borders and markets are essential; still, additional measures are required to increase the participation of developing countries. UNIDO thus combines building up the technical infrastructure required to participate in international trade (i.e. standards, quality, metrology, accreditation and certification) while strengthening key export sectors that require support services in strengthening/upgrading productive and export capacities.

Energy and environment

While energy is a prerequisite for poverty reduction (MDG1), environmental sustainability, as stipulated in MDG7 (Ensuring Environmental Sustainability) is one of today's greatest challenges. UNIDO therefore assists countries in the implementation of activities related to the multilateral environmental agreements;

the promotion of energy efficiency; and the promotion of sustainable energy production and consumption practices.

Industry and energy has been a central theme of UNIDO's work for over 25 years. The Organization's technical cooperation programmes address both the supply and demand side in developing countries through provision of energy for industry and by improving industrial energy end-use efficiency. UNIDO also promotes the adoption of renewable energy technologies within the rural regions of developing countries as well as promoting renewable energy technologies for industrial applications. Between 1987 and today, UNIDO has implemented a wide range of projects in developing countries, at the policy, institutional and enterprise levels.

Further information on UNIDO can be accessed at www.unido.org

2.2. About REEEP

The Renewable Energy and Energy Efficiency Partnership (REEEP) is a global public-private partnership and was launched by the United Kingdom along with other partners at the Johannesburg World Summit on Sustainable Development in August 2002. It was developed via an intensive consultation process in 2003 covering a wide range of stakeholders at the national and regional levels. In June 2004, the REEEP was formally established as a legal entity in Austria with the status of an international NGO.

REEEP actively structures policy initiatives for clean energy markets and facilitates financing mechanisms for sustainable energy projects. By providing opportunities for concerted collaboration among its partners, REEEP aims to accelerate the marketplace for renewable energy and energy efficiency. REEEP's goals are: to reduce greenhouse gas emissions, deliver social improvements to developing countries and countries in transition; by improving the access to reliable clean energy services, by making renewable energy technologies more affordable; and to bring economic benefits to nations that use energy in a more efficient way and increase the share of indigenous renewable resources within their energy mix.

The partnership is funded by a number of governments including: Australia, Austria, Canada, Ireland, Italy, Spain, the Netherlands, the United Kingdom, the United States and the European Commission. REEEP's regional secretariats provide access to best practice in policy and finance to promote renewable energy and energy efficiency. REEEP's International Secretariat engages political, financial and business support to reduce the risk inherent in implementing new policy and financing initiatives.

Further information on REEEP can be accessed at www.reeep.org

3. DEVELOPMENT OF THE TRAINING PACKAGE

In 2004, REEEP commissioned the development of an initial training package entitled “Regulation and Sustainable Energy”. This was produced by the Centre for Management under Regulation (CMUR) at Warwick University, United Kingdom, and provides an introduction to key issues in energy market and monopoly regulation as they affect sustainable energy, mainly electricity supply and consumption. This training package focused on the situation in developed countries, with case studies from Europe, the United States and Australia and was completed in April 2005. An outline of this training package is available from the REEEP website at www.reeep.org/groups/sern

REEEP then requested UNIDO to adapt and expand the training package to a developing country context, in the light of present experiences in, as well as constraints of, energy policy and regulation in developing countries.

In November 2005, UNIDO commissioned IT Power, AFREPREN, ESD and a host of national African experts to assist UNIDO to adapt and expand the existing training package, develop new material and publish a new training package on Sustainable Energy Regulation and Policymaking for Africa. The new training package focuses on regulation, policy and sustainable energy for African countries and includes case studies, and examples from a number of countries across sub-Saharan Africa.

3.1. Training package aims

This training package aims at reversing the existing lack of capacity and knowledge on how to foster regulatory and policy environments that will better aid the adoption of more economically (in the long term) and environmentally sustainable methods of energy supply and utilization, both in the industrial, commercial and urban domestic sectors and the rural energy environment in the developing countries.

The training package has three main focuses:

- Energy regulation and power sector reform.
- Increased renewable energy technology penetration for rural electrification.
- Sustainable use of energy through energy efficiency in industrial, commercial and domestic sectors (including energy efficiency within buildings).

The aim of the training package is to achieve a positive input in these three areas by increasing the awareness and knowledge of energy regulatory and policymaking bodies and their personnel, and thereby strengthen energy sector regulating and policymaking capacity within African governments.

The training package will:

- Provide a better understanding and awareness of the benefits of renewable energy and energy efficient technologies and an improved knowledge of proven policy and regulating models, mechanisms and practices available to support the development and deployment of sustainable energy technologies, through case studies from Europe, Africa and worldwide.
- Show how the pursuing of the key objective of sustainable energy development through renewable energy and energy efficient technologies can be promoted and supported by national energy regulations, policies and standards.

The training package has been designed to be used as a modular training resource in order to allow the user to select individual module topics without being forced to read all the proceeding modules. Therefore, a certain amount of repetition exists in the material presented between some of the different modules.

The information presented in each of the modules varies in terms of technical detail with some aspects being significantly technical in nature. Although the training manual is primarily directed towards energy sector policymaking and regulatory institutions, it is a prerequisite for these institutions to have an appreciation of the technical implications, mechanisms, tools and measures that will form the basis of appropriate and sustainable policies and regulations.

Further to this, policymakers and regulators should have an understanding of how the industrial, commercial and residential sectors will operate within, and conform to, any new or additional policies that aim to promote sustainable energy options. For this to be possible, these institutions need to have an intimate understanding of the different aspects of the energy sector and how they function. The training package, through its use of differing industrial, policy and regulatory perspectives as well as technical information, aims to provide this necessary level and diversity of information.

3.2 Suggested target audience

This training package is relevant to the needs of developing country governments, policymaking bodies and regulating institutions responsible for the development and functioning of the national energy sector and their staff. The training package should be particularly useful for staff in regulatory agencies and government departments who are new to regulation or to the ways that regulation can affect sustainable energy.

The main beneficiaries of the training package will be the policymakers and regulators of the energy sector in African countries, however many of the modules contain generic information on sustainable energy which can be useful to energy policymakers and regulators in all developing countries.

Although policymakers and regulators are the principal target audience for the training package, it will also be useful to others who need to understand sustainable energy regulation, particularly energy companies. It therefore has the potential to benefit a wide variety of governmental and non-governmental organizations in the energy sector, including private companies, utilities, universities, research institutes, developmental agencies, NGOs and others, which are involved in policymaking, policy analysis, regulation and standard development.

As interested parties take up this “Sustainable Energy Regulation and Policymaking for Africa” training package, it can be developed further or used for a variety of training purposes at regional and national level in Africa and other developing countries.

4. STRUCTURE OF THE TRAINING PACKAGE

The training package provides an introduction to the key issues relating to the energy market and energy regulation, as they affect sustainable energy (energy efficiency, cogeneration and renewable energy). The training package focuses mainly on the policies and regulation relating to the generation, transmission, distribution and consumption of electricity and the opportunities and barriers in developing renewable energy and energy efficiency in these sectors. It is stressed that the training package is intended as an introduction to the subject and each module contains references to sources of more in-depth information.

There is no “perfect” generic way of designing or implementing regulation or policies for sustainable energy development. Each energy national sector differs—for example, in patterns of ownership, the degree of integration of energy companies, the level of competition and the maturity of a particular energy system. This training package does not set out to prescribe or recommend models of regulation or policies, which should necessarily be copied, but instead aims to provide examples of where regulation and/or policies have proved effective (or harmful) for the development of sustainable energy technologies.

The modules of the training package are therefore designed to:

- Provide an introduction to energy regulation, focusing on the electricity market, and how it relates to power sector reform;
- Provide an introduction to renewable energy and energy efficiency technologies and programmes;
- Outline issues affecting the implementation of sustainable energy technologies;
- Highlight useful examples of “good practice” and explain why they are effective;
- Provide an indication of more detailed studies elsewhere;
- Provoke discussion amongst participants.

The training package consists of this user manual and four separate “sub-packages”. These sub-packages cover:

- Introduction to renewable energy and energy efficiency and the energy sector in Africa;

- Energy regulation (mainly covering electricity);
- Renewable energy;
- Energy efficiency.

In addition to the above sub-packages, an additional final module (module 20) examines the issues, barriers, challenges and opportunities surrounding the financing of renewable energy and energy efficiency projects and programmes. The first sub-package provides an overview on renewable energy and energy efficiency and the energy sector in Africa. The second sub-package on energy regulation is an opening section introducing the basic concepts of energy regulation; the third and fourth sub-packages on renewable energy and energy efficiency respectively cover the fundamentals of today's commercial renewable energy and energy efficiency options. The four sub-packages together give good theoretical grounding in sustainable energy policy and regulation as well as a critical analysis of practical and proven examples of sustainable energy policy and regulations in developing countries through a number of case studies focusing on Africa.

The training package is designed to be used as a set of presentations and written material for a course that can be run over a few days or as a longer, more in-depth course over weeks or months (see the following section on "How to use the training package"). Each module contains a "core" text that covers the main topic of the module. Each module also has attached to it case studies (where appropriate); a PowerPoint presentation; examples of thematic discussions; references to further written materials and websites and a glossary. Case studies are drawn from all over the world and from both developed and developing countries.

4.1. Course contents

The training package breaks down into the following sub-packages and modules, the contents of which are shown below:

Introduction and user manual

- A few words on UNIDO and REEEP
- Development of the training package
- Structure of the training package
- How to use the training package

I. Introduction sub-package

Module 1: Overview of renewable energy and energy efficiency

- Status of renewable energy and energy efficiency in Africa
- Why should Africa promote renewables?
- Why should Africa promote energy efficiency?

Module 2: The energy sector in Africa

- Power sector
- Renewable energy
- Energy efficiency

II. Energy regulation sub-package

Module 3: Introduction to energy regulation

- Why regulate?
- What can be regulated: electricity system structures
- Who regulates?
- Types of regulation
- Regulation issues for sustainable generation

Module 4: The reform of the power sector in Africa

- Reforms in the African energy sector
- Possible reform options—experiences in Africa
  - Corporatization
  - Management contract
  - Unbundling (vertical and horizontal)
  - Independent power producers
  - Electricity law amendment

Module 5: Structure, composition and role of an energy regulator

- Principles of regulation
- Different bodies involved in regulation
- Role of a regulator
- Setting up a regulator
- Building a credible regulatory arrangement

Module 6: Formulating regulatory scenarios and national self-assessment

- Power sector reform
- Regulatory framework
- Integrating renewable energy in the regulatory framework
- Integrating energy efficiency in the regulatory framework
    - Self-assessment tools

III. Renewable energy sub-package

Module 7: Renewable energy technologies

- Overview of renewable energy technologies
- Overview of costs of different technologies
- Overview of common barriers and issues limiting widespread use/ dissemination of renewable energy

Module 8: Impact of different power sector reform options on renewables

- Impact of electricity law amendment and unbundling on renewable energy
- Impact of independent power producers on renewable energy
- Impact of corporatization on renewable energy
- Impact of management contracting on renewable energy

Module 9: Regulatory and policy options to encourage development of renewable energy

- Design issues for regulatory/support mechanisms
- Types of regulatory and policy support mechanisms
- Examples of regulatory and policy support mechanisms in Africa and other developing countries
    - Methodology and examples on how to calculate the level of feed-in tariffs

Module 10: Increasing access to energy services in rural areas

- Approaching energy services for rural areas of developing countries
- The Millennium Development Goals
- Linkage of energy to the MDGs
- Policy options for increasing access to energy services in rural areas
- Different models for increasing energy services in rural areas
- Experiences with increasing energy services in rural areas

Module 11: Distributed generation: options and approaches

- Electricity supply scenarios
- Options for mini-grid systems
- Planning the approach
- Institutional issues
- Frameworks

IV. Energy efficiency sub-package

Module 12: Energy efficiency technologies and benefits

- The benefits of increased energy efficiency
- Where does energy efficiency fit in to the overall energy mix?
- Target sectors
- Overview of energy efficiency actions
- Common barriers to implementation of energy efficiency measures
- Combining renewables and energy efficiency together to improve sustainability of energy development

Module 13: Supply-side management

- Supply-side management options and opportunities
  - Resources and resource preparation
  - Power generation and energy conversion
  - Transmission
  - Distribution
  - Transport of fossil fuels
- Constraints and challenges of supply-side management

Module 14: Demand-side management

- Why promote demand-side management?
- What drives demand-side management?
- Types of demand-side management measures
  - Industrial and commercial DSM practices
  - Energy auditing
- Information dissemination of DSM
- Challenges of implementing DSM programmes

Module 15: Impact of different power sector reform options on energy efficiency in Africa

- Impact of unbundling on energy efficiency
- Impact of electricity law amendment on energy efficiency

- Impact of corporatization on energy efficiency
- Impact of independent power producers on energy efficiency
- Impact of management contract on energy efficiency

Module 16: Regulatory and policy options to encourage energy efficiency

- Institutional considerations
- Policy options for increasing energy efficiency in targeted sectors
- Regulatory options: demand-side management
- Regulatory options: supply-side management

Module 17: Industrial energy efficiency and systems optimization

- Why industrial energy efficiency?
- What motivates industry to become energy efficient?
- Promoting industrial energy efficiency
  - Energy management
  - System optimization
- Getting started
  - Building a market for industrial energy efficiency services
  - Programme design
  - Developing enabling partnerships
  - Financing considerations
- Pulling it together
  - Industrial standards frameworks

Module 18: Energy efficiency in buildings

- Energy efficiency in buildings methodology
- Energy efficiency measures for buildings
- Financing energy efficiency for buildings
- Developing and implementing policy on energy efficiency in buildings
- Policy tools to promote building efficiency

V. Financing

Module 19: Financing options for renewable energy and energy efficiency

- The financiers' perspective
- Basic types of financing
- Types of financing models
  - Government-led models
  - Market-based models
- Existing policies and regulations
  - Fiscal measures
  - Subsidies
  - Market-based instruments
  - Energy audits and feasibility studies
  - Institutional finance
- Design aspects for measures to attract private investment
- List of potential donors and funds
- Examples

4.2 Case studies

Each of the above modules has included in it a number of relevant case studies. The list of case studies is given here in full by package, module and by country. It is hoped that new case studies will be added to each module in the future, as more experience is gained.

Module #	Case study #	Country	Case study title
2	1	Mauritius	Cogeneration in Mauritius

Energy Regulation

Module #	Case study #	Country	Case study title
3	1	Zambia	Zambia energy regulation board
4	1	Zimbabwe	Power sector reform in Zimbabwe
	2	United Rep. of Tanzania	Electricity regulation in the United Republic of Tanzania: moving from government regulation to an independent regulatory body
	3	Ghana	Power sector reform and regulatory institutions of Ghana

Renewable Energy

Module #	Case study #	Country	Case study title
7	1	Denmark	Wind power in local government: Denmark's renewable energy island
	2	UK	Solar water heating in local government in the UK
8	1	Kenya	Geothermal development in Kenya
9	3	Denmark	Denmark: support mechanisms for wind energy
	1	Germany	German feed-in mechanisms
	2	Spain	Spain: support mechanisms for wind energy
	4	Ghana	Renewable energy in Ghana
	5	Zambia	Zambia: institutional framework and status of renewable energy
	6	UK	UK renewables obligation
10	1	Ghana	Ghana: East Maprusi solar project (RESPRO)
	2	Ghana	Ghana wind energy project
	3	Zambia	Zambia PV energy services companies
	4	Brazil	Brazil's rural electrification programmes
11	1	Eastern Caribbean	Policies for sustainable energy solutions—geothermal power development in the Eastern Caribbean
	2	Mexico	Mexico encourages renewables
	3	China	Huarci, Barkol, Xinjiang, China: a wind power village system project developed by harnessing a poverty alleviation loan

Energy efficiency

Module #	Case study #	Country	Case study title
13	1	China	EU-China partnership on climate change—clean coal technologies
14	1	United Rep. of Tanzania	Lighting retrofitting in Tanzania
	2	United Rep. of Tanzania	Tanzania: power factor correction
	3	Zambia	Zambia: automatic load control and alternative energy supply at Lusaka sater and sewerage company
	4	Zambia	Zambia: university energy assessment
	5	Ghana	Why DSM initially failed in Ghana
15	1	Ethiopia	Solar water heaters in Ethiopia
	2	Tunisia	Institutional framework and power sector reform working for Tunisia energy efficiency
16	1	Japan	Japan: overview of energy efficiency measures
	2	South Korea	Rational energy utilization act of South Korea
	3	China	China’s energy conservation policy
	4	Denmark	Denmark: electricity distribution companies as key actors in energy efficiency policy
	5	Belgium	Flanders’ energy savings obligations on electricity grid operators
17	1	U.S.A	Companies forge individual paths to energy management
18	1	Australia	Sustainable energy authority in Australia
	2	South Africa	Improving energy efficiency in Ekurhuleni Metropolitan Municipal (EMM) Buildings, South Africa
	3	Latvia	Efficient lighting in Latvian Academy of Sport Education (LASE), Latvia
	4	Ireland	Passive solar design in local government offices in Ireland

5. HOW TO USE THE TRAINING PACKAGE

5.1. Training tools

Each module provides an introduction with key aims for the module and what you should expect to know when the module has been completed. Each module also includes a number of training tools that can be used to enhance understanding of the module's contents and to deepen your knowledge of the subject. These are:

- Review questions

Distributed in the core text of each module, there are a number of questions for the reader to answer in their own time. Brief answers to each question are available at the end of each module but the questions are also intended to stimulate ideas for independent research on the internet or textbooks.

- Exercises

Contained within most modules there are suggested exercises. These can be used by students to test their understanding or by teachers to set as exercises during the course and work through answers during lessons with the students

- Presentations/suggested discussion topics

Each module includes a PowerPoint presentation, which presents suggested discussion topics. Teachers and students can use this during a course to lead discussions. The discussion topics are also a basis for research for students.

- Relevant case studies

Each module makes reference to a number of examples. At the end of most modules, there are also additional case studies available, which provide detailed accounts of examples relating to the topic(s) covered in the module.

- References and Internet resources

At the end of each module there are references and a list of Internet resources. These can be used by both students and teachers to maximize benefit from the course and deepen their knowledge of the subjects they are most interested in.

- Glossary of terms

A glossary of terms and key concepts is provided at the end of each module.

5.2. Suggested course schedules

There are a number of ways to use this training package. It can be used as part of an intensive training course, delivered over a few days, or as a longer duration course based at an institution over weeks or months. It is also possible to use it as self-study course.

The course is split into five main sections:

- Introduction;
- Energy regulation;
- Renewable energy;
- Energy efficiency;
- Financing.

It is recommended that all five sections be taught together in one course. A second recommended option is to group the study into a "renewable energy package" consisting of energy regulation and renewable energy, or an "energy efficiency package" consisting of "energy regulation" and "energy efficiency". Of course, each section could also be studied separately.

Below are suggested course schedules. It is stressed that these are only suggested programmes of study and you are free to use other methods or time scales.

Intensive course

An intensive course would be over the period of two weeks. The aim would be to cover all the basic material in each module during the course, while providing all the additional material—case studies, references and Internet search suggestions to the students for follow-up study and research once the course is finished.

Below is a suggested schedule for a two-week course using the complete package.

Day 1: Introduction and energy regulation

- Module 1: Overview of renewable energy and energy efficiency
- Module 2: The energy sector in Africa
- Module 3: Introduction to energy regulation

Day 2: Energy regulation

- Module 4: The reform of the power sector in Africa
- Module 5: Structure, composition, role of an energy regulator
- Module 6: Formulating regulatory scenarios and national self-assessment

Day 3: Renewable energy

- Module 7: Renewable energy technologies
- Module 8: Impact of different power sector reform options on renewables
- Module 9: Regulatory and policy options to encourage development of renewable energy

Day 4: Renewable energy

- Module 10: Increasing access to energy services in rural areas
- Module 11: Distributed generation: options and approaches

Day 5: Energy efficiency

- Module 12: Energy efficiency technologies and benefits
- Module 13: Supply-side management (SSM)

Day 6: Energy efficiency

- Module 14: Demand-side management (DSM)
- Module 15: Impact of different power sector reform options on energy efficiency

Day 7: Energy efficiency

- Module 16: Regulatory and policy options to encourage energy efficiency
- Module 17: Industrial energy efficiency and systems optimization

Day 8: Energy efficiency

- Module 18: Energy efficiency in buildings

Day 9: Finance

- Module 19: Financing options for renewable energy and energy efficiency

Day 10: Review

Long duration course

The structure and materials provided in the modules lend them to use in an educational institution, where a course could be given over the period of a few weeks or months, either as part of an established course or as an evening class.

An example of a long duration course is given below, using the length of a typical university semester, four months and estimating a minimum of half a day teaching time per week.

Month 1

Week 1	Introduction and energy regulation	Module 1: Overview or renewable energy and energy efficiency
		Module 2: The energy sector in Africa
Week 2		Module 3: Introduction to energy regulation
Week 3		Module 4: The reform of the power sector in Africa
Week 4		Module 5: Structure, composition, role of an energy regulator

Month 2

Week 5	Energy regulation	Module 6: Formulating regulatory scenarios and national self-assessment
Week 6		*Review of what has been learnt in Modules 1 to 6*
Week 7	Renewable energy	Module 7: Renewable energy technologies
Week 8		Module 8: Impact of different power sector reform options on renewables Module 9: Regulatory and policy options to encourage development of renewables

Month 3

Week 9	Renewable energy	Module 10: Increasing access to energy services in rural areas
Week 10		Module 11: Distributed generation: options and approaches
Week 11		*Review of what has been learnt in Modules 7 to 11*
Week 12	Energy efficiency	Module 12: Energy efficiency technologies and benefits
Week 13	Energy efficiency	Module 13: Supply-side management
Week 14	Energy efficiency	Module 14: Demand-side management

Month 3

Week 13	Energy efficiency	Module 15: Impact of different power sector reform options on energy efficiency Module 16: Regulatory and policy options to encourage energy efficiency
Week 14	Energy efficiency	Module 17: Industrial energy efficiency and systems optimization
Week 15	Energy efficiency Finance	Module 18: Energy efficiency in buildings Module 19: Financing options for renewable energy and energy efficiency
Week 16		*Review of what has been learnt in Modules 12 to 19*

5.3. Self-taught

The materials and learning tools provided in the training package make it easy for individuals to use it to teach themselves more about regulation and sustainable energy. Apart from the main text, there are questions and exercises, as well as references, therefore a teacher, although a source of support, is not indispensable. The following paragraphs provide some advice on individual learning using the materials provided.

1. Remember that people learn in different ways (and at different speeds). The units of the module follow a logical progression in setting out and elaborating the principles of the subject, but you can move about between units and topics if this suits you.

2. There is no single rule about how best to learn the kind of material presented in this training package. A way to start is to familiarize yourself with the different materials provided, the text, the presentations, the case studies and take a look at the references. Have a look through the text, and begin to familiarize yourself with the subject matter and coverage of each module.

3. You will find a summary of the subject matter in the module introduction, which covers the key aims and concepts of each module and what you should know by the end. Look out for the topics that are most interesting and relevant to you, and as you study note what seems more difficult and what seems easier.

4. Learning is an iterative process and it is often useful to go back to something studied earlier. You may also find it useful to move about between different units according to what interests you, or according to the connections that you make between different issues.

5. The training package has many questions and activities to help you acquire the necessary analytical skills, and you should take notes and actually note down your answers to questions as you go along. Answers to questions are sometimes provided but try to answer them on your own first before consulting the ones supplied.

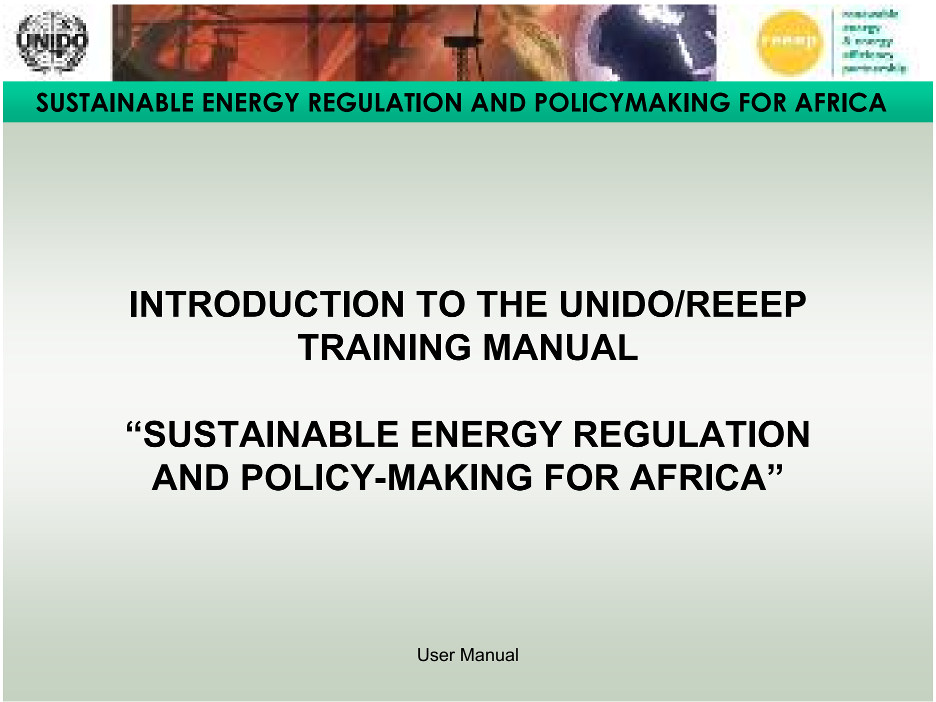
6. You are encouraged to take notes or create a personal study journal, as this activity helps you to keep a record of your learning. You can reflect on what you think is most important, interesting and relevant, and put it into your own words. This is a powerful means of acquiring and developing a sound knowledge of the subject. Notes should be well organized and well structured (i.e. making use of headings, indentations etc.), and clearly convey the meaning of what they refer to.

7. As you read you should simultaneously be:
   - Thinking about the content;
   - Making notes where appropriate;
   - Relating ideas and concepts;
   - Comparing information with your existing knowledge;
   - Considering the application of what you are studying.

8. Glossaries, key terms, concepts, abbreviations and acronyms: studying a new subject typically involves learning its specialized vocabulary and often a whole new range of acronyms. Specialized terms are an indispensable form of shorthand for key concepts, and how they are applied to the issues and questions with which the discipline is concerned. Lists of key terms and concepts, and acronyms and abbreviations are provided, where relevant, in the text of each module. It is also a good idea for you to build up your own glossary as you work through the units in order to develop and reinforce your understanding.

9. Questions: throughout the modules you are asked questions, which we call “Review Questions”. Some of these have answers included at the end of the module. Along with the discussions, it is not compulsory that you answer them all. However, depending upon your preference you may like to attempt them on your own, discuss and work them through with fellow professionals within your work or country location.

10. Using the Internet: the modules also make reference to websites, which offer a very rich source of further information. If you have access to the Internet this can be a powerful learning tool, to accompany you on this course. The links and references to websites provided are just a sample of some of the better websites found at the time of writing the module. You do not have to visit these websites, and indeed it cannot be guaranteed that the links will still work or that the third party resources referred to will be found on the Internet for any specific time period. If you want to download materials from the Internet, and build up your own electronic library based on the references in this course, you are strongly advised to do this as soon as possible, as this will give you a better chance of accessing materials before they are moved or disappear.

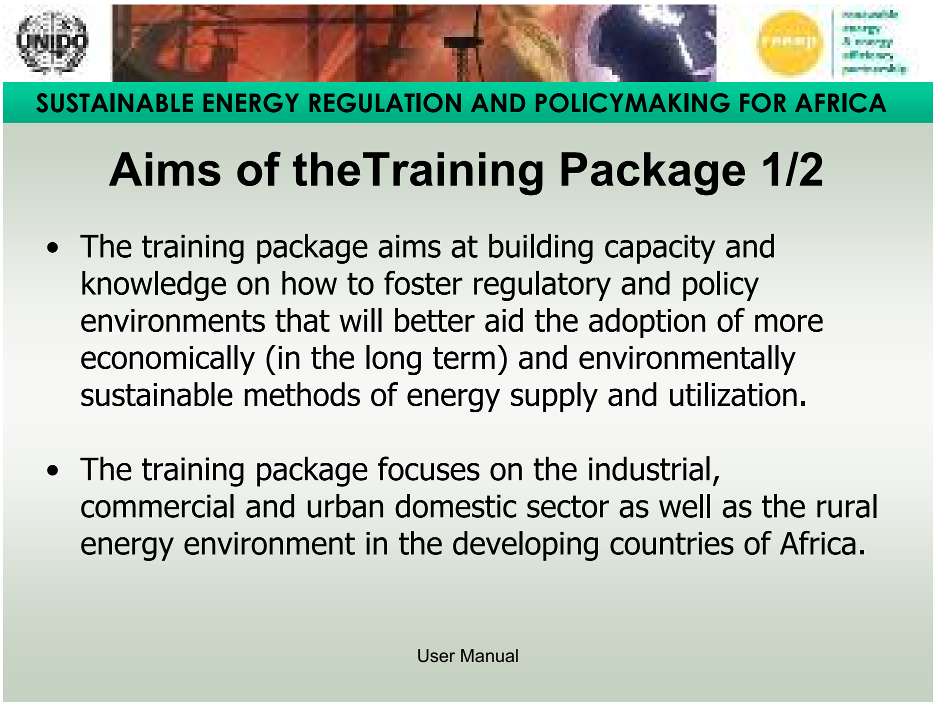


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

INTRODUCTION TO THE UNIDO/REEEP TRAINING MANUAL

“SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA”

User Manual



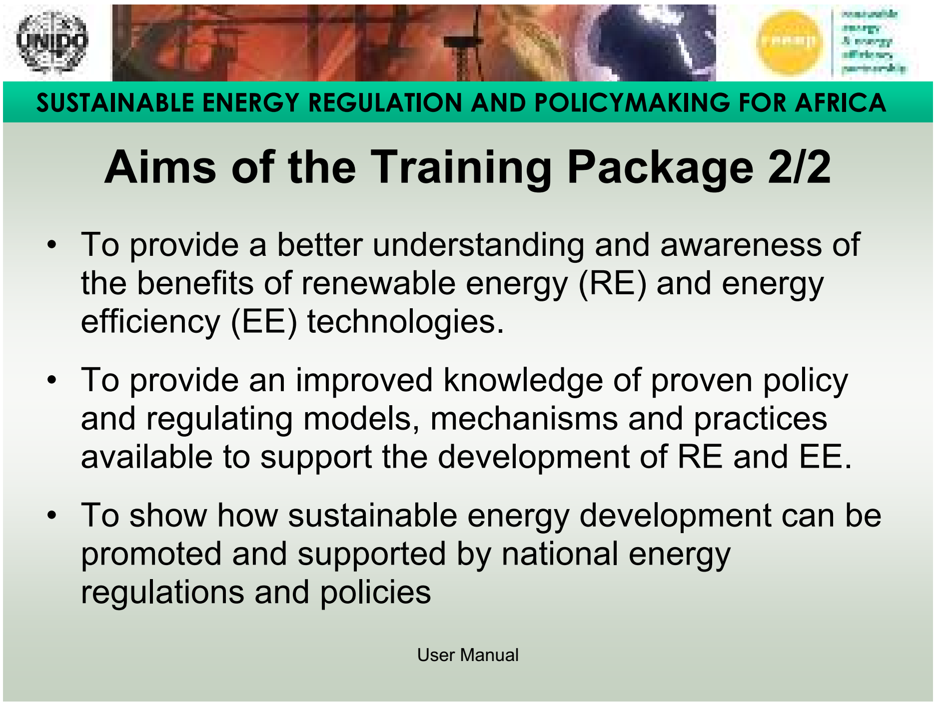
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Aims of theTraining Package 1/2

- The training package aims at building capacity and knowledge on how to foster regulatory and policy environments that will better aid the adoption of more economically (in the long term) and environmentally sustainable methods of energy supply and utilization.

- The training package focuses on the industrial, commercial and urban domestic sector as well as the rural energy environment in the developing countries of Africa.

User Manual



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Aims of the Training Package 2/2

- To provide a better understanding and awareness of the benefits of renewable energy (RE) and energy efficiency (EE) technologies.
- To provide an improved knowledge of proven policy and regulating models, mechanisms and practices available to support the development of RE and EE.
- To show how sustainable energy development can be promoted and supported by national energy regulations and policies

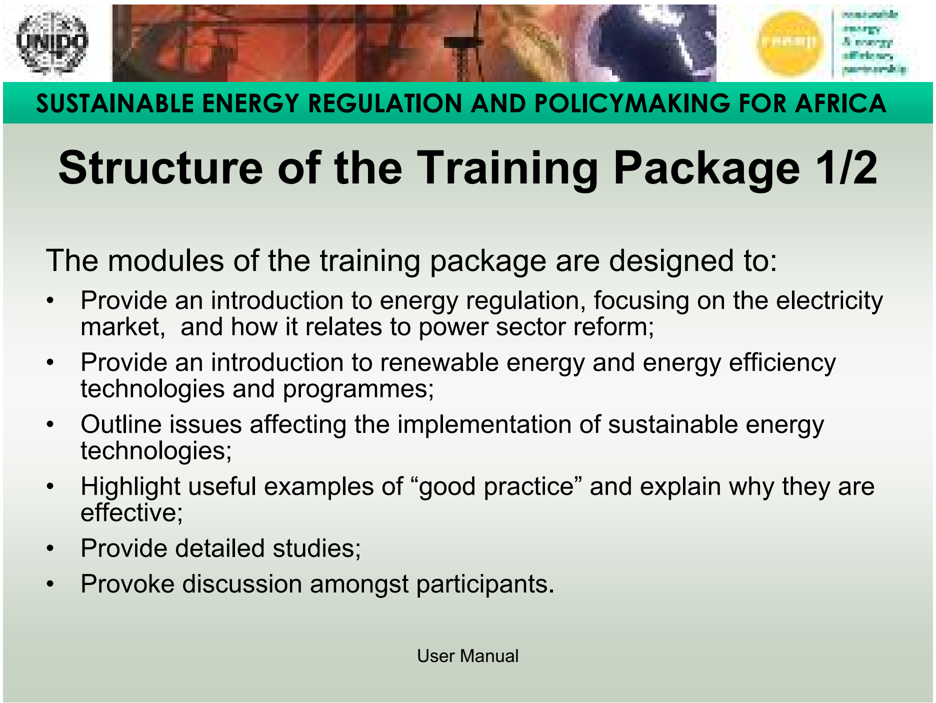
User Manual

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Training Package Target Audience

- This training package is relevant to the needs of developing country governments, in particular to the policymaking bodies and regulating institutions responsible for the development and functioning of the national energy sector.
- In addition, the training package is also relevant to a wide variety of governmental and non governmental organizations in the energy sector, including private companies, utilities, universities, research institutes, developmental agencies, NGOs and others, which are involved in policymaking, policy analysis, regulation and standard development.

User Manual



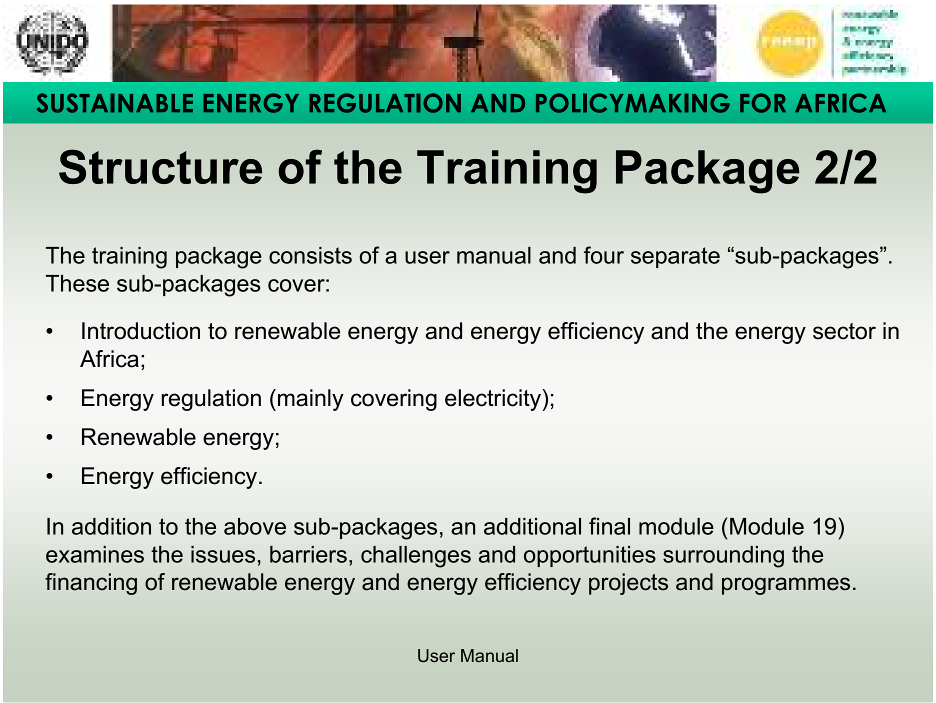
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Structure of the Training Package 1/2

The modules of the training package are designed to:

- Provide an introduction to energy regulation, focusing on the electricity market, and how it relates to power sector reform;
- Provide an introduction to renewable energy and energy efficiency technologies and programmes;
- Outline issues affecting the implementation of sustainable energy technologies;
- Highlight useful examples of “good practice” and explain why they are effective;
- Provide detailed studies;
- Provoke discussion amongst participants.

User Manual



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

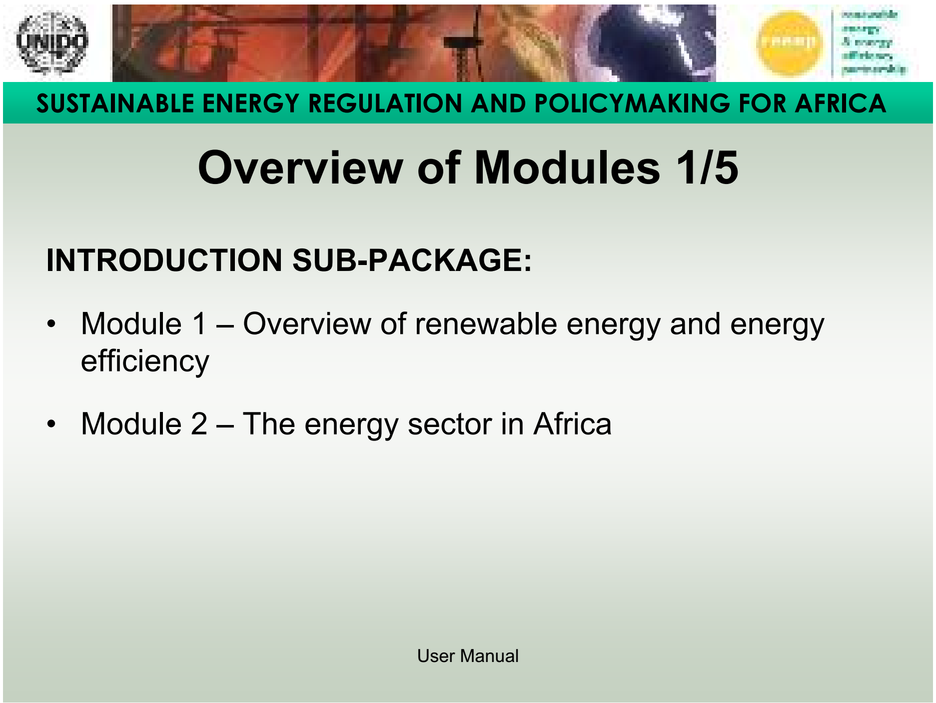
Structure of the Training Package 2/2

The training package consists of a user manual and four separate “sub-packages”. These sub-packages cover:

- Introduction to renewable energy and energy efficiency and the energy sector in Africa;
- Energy regulation (mainly covering electricity);
- Renewable energy;
- Energy efficiency.

In addition to the above sub-packages, an additional final module (Module 19) examines the issues, barriers, challenges and opportunities surrounding the financing of renewable energy and energy efficiency projects and programmes.

User Manual



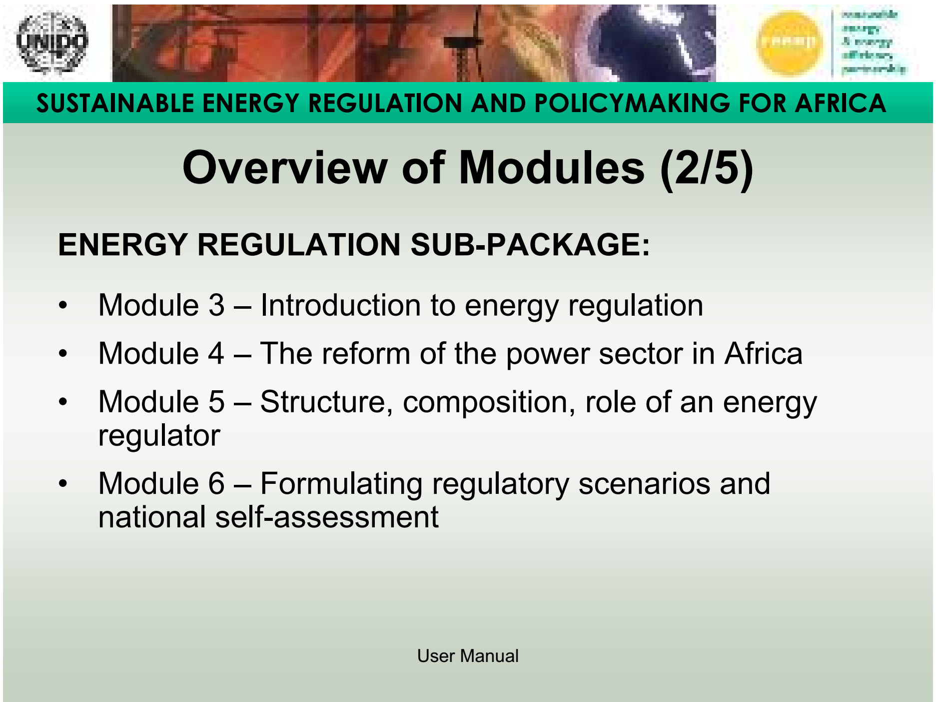
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Overview of Modules 1/5

INTRODUCTION SUB-PACKAGE:

- Module 1 – Overview of renewable energy and energy efficiency
- Module 2 – The energy sector in Africa

User Manual



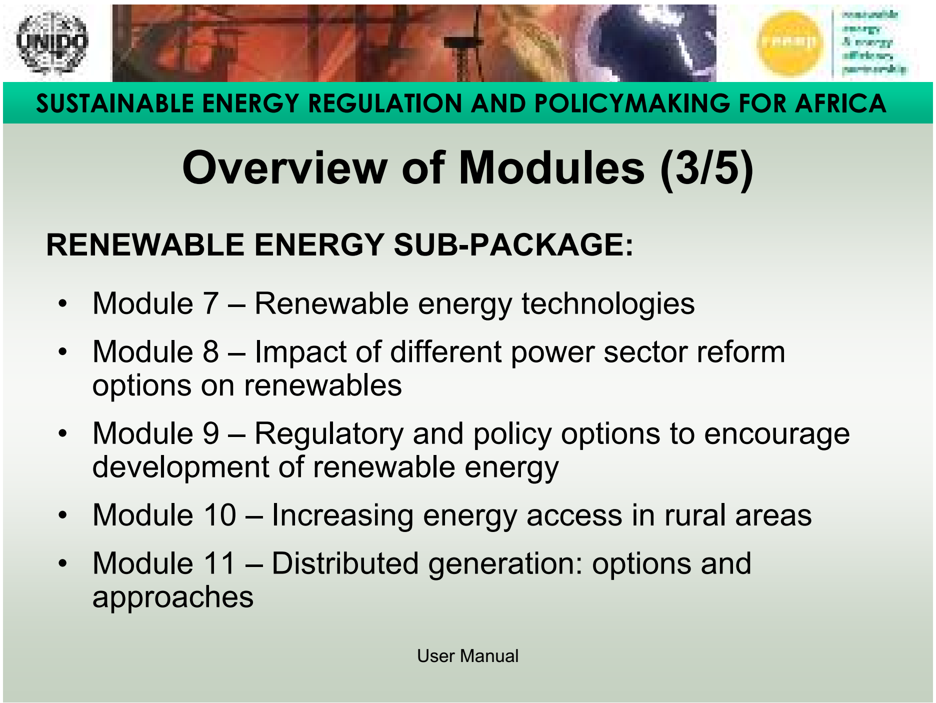
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Overview of Modules (2/5)

ENERGY REGULATION SUB-PACKAGE:

- Module 3 – Introduction to energy regulation
- Module 4 – The reform of the power sector in Africa
- Module 5 – Structure, composition, role of an energy regulator
- Module 6 – Formulating regulatory scenarios and national self-assessment

User Manual



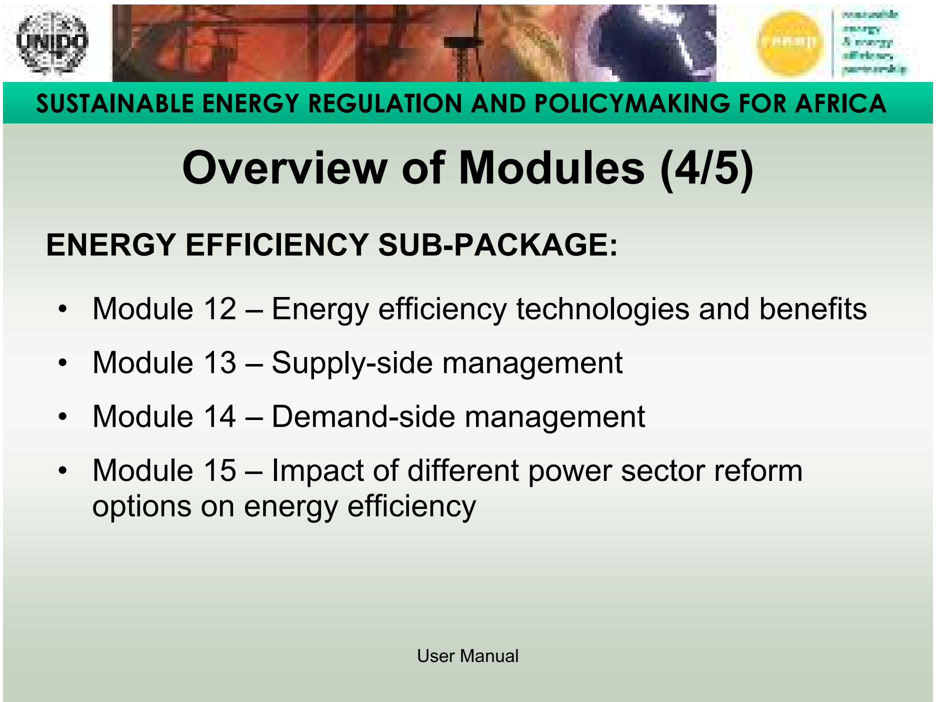
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Overview of Modules (3/5)

RENEWABLE ENERGY SUB-PACKAGE:

- Module 7 – Renewable energy technologies
- Module 8 – Impact of different power sector reform options on renewables
- Module 9 – Regulatory and policy options to encourage development of renewable energy
- Module 10 – Increasing energy access in rural areas
- Module 11 – Distributed generation: options and approaches

User Manual



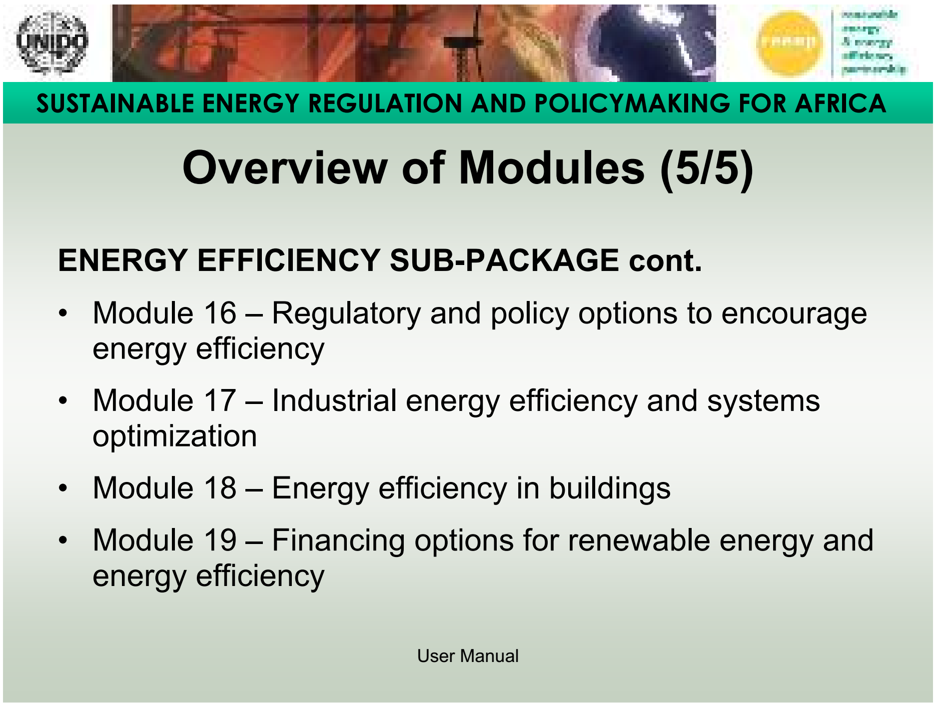
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Overview of Modules (4/5)

ENERGY EFFICIENCY SUB-PACKAGE:

- Module 12 – Energy efficiency technologies and benefits
- Module 13 – Supply-side management
- Module 14 – Demand-side management
- Module 15 – Impact of different power sector reform options on energy efficiency

User Manual



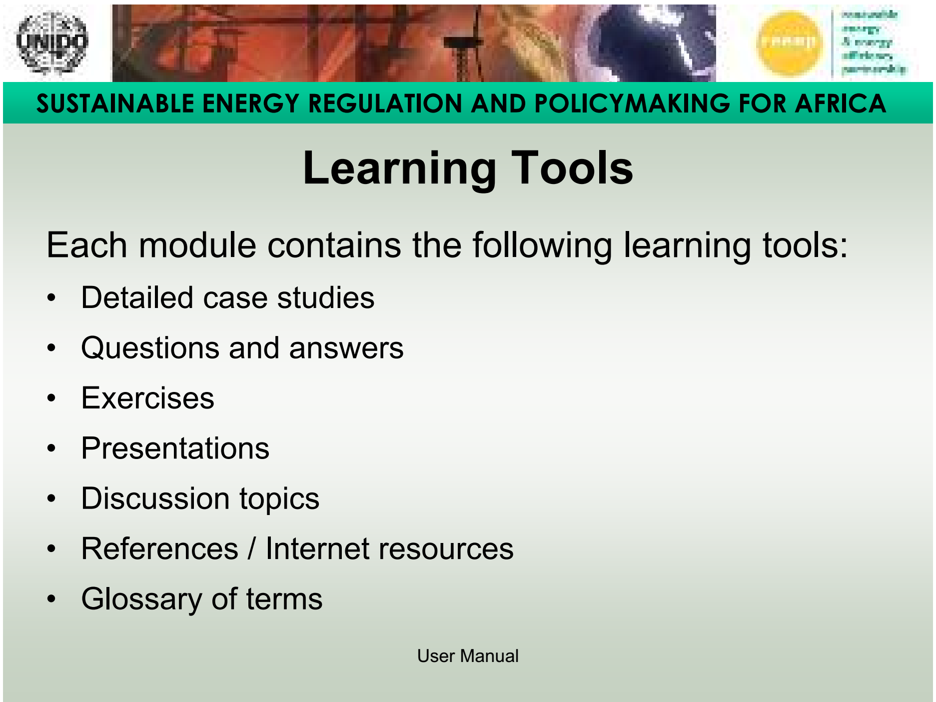
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Overview of Modules (5/5)

ENERGY EFFICIENCY SUB-PACKAGE cont.

- Module 16 – Regulatory and policy options to encourage energy efficiency
- Module 17 – Industrial energy efficiency and systems optimization
- Module 18 – Energy efficiency in buildings
- Module 19 – Financing options for renewable energy and energy efficiency

User Manual



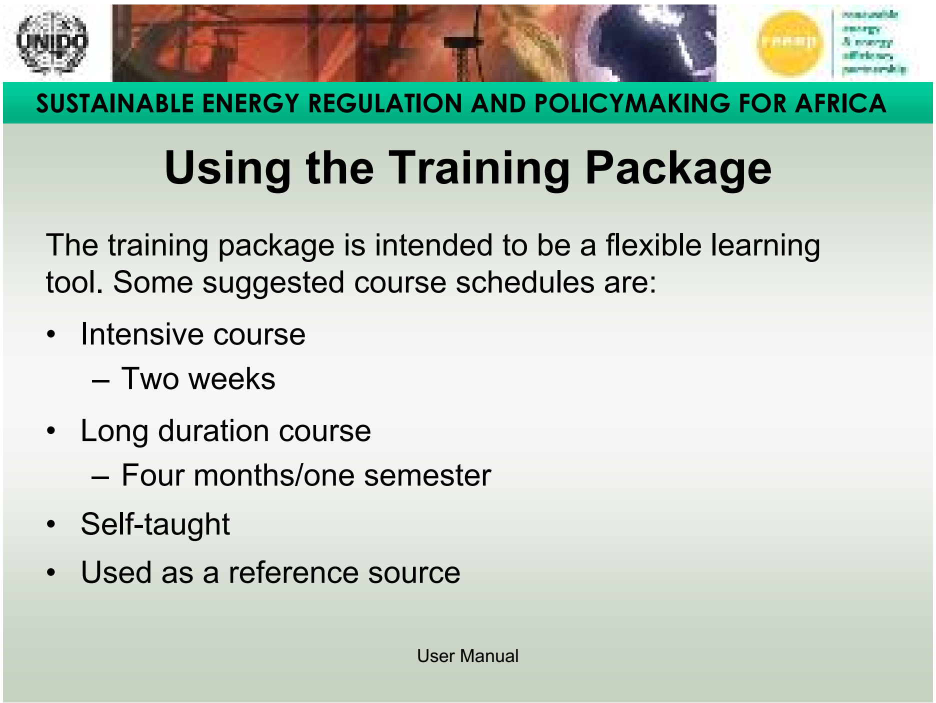
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Learning Tools

Each module contains the following learning tools:

- Detailed case studies
- Questions and answers
- Exercises
- Presentations
- Discussion topics
- References / Internet resources
- Glossary of terms

User Manual



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Using the Training Package

The training package is intended to be a flexible learning tool. Some suggested course schedules are:

- Intensive course
  - Two weeks
- Long duration course
  - Four months/one semester
- Self-taught
- Used as a reference source

User Manual

Module 1

Overview of renewable energy and energy efficiency

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This is an introductory module for the training package and provides a brief overview of energy sectors in Africa and a summary of the status of renewable energy and energy efficiency in Africa (a more detailed review appears in module 2). It then explains why African countries should promote renewable energy and energy efficiency.

The module explains how renewable energy technologies and energy efficiency measures can assist Africa to address the energy challenges facing many countries in the region. Key challenges include energy supply insecurity arising from high oil prices; recurrent drought-related hydropower crises; inability to provide adequate access to modern services for the region's poor; and, adverse local, regional and global environmental impacts of excessive reliance on conventional energy systems.

The final section of the module presents key terminologies, references as well as websites used.

1.2. Module aims

The aims of the present module are listed below.

- Provide an overview of the energy sector in Africa;
- Highlight the potential benefits/contribution of renewable energy to the African energy sector and explain why Africa should promote renewable energy;
- Highlight the potential benefits/contribution of energy efficiency to the African energy sector and explain why Africa should promote energy efficiency.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- Enhanced understanding/awareness of the potential benefits/contribution of renewables to the African energy sector;
- Enhanced understanding/awareness of the potential benefits/contribution of energy efficiency to the African energy sector.

2. INTRODUCTION

Renewable energy and energy efficiency options have been identified as important for the development of the sub-Saharan African energy sector. However, these options have not yet attracted a significant level of investment or policy commitment. As a result, they are not widely disseminated in the region.

This module presents key reasons why energy sector decision-makers in Africa should promote renewables and energy efficiency options.

Before delving into the rationale for sustainable energy promotion in Africa, the next section of this module will first provide an overview of the energy sector in Africa.

3. STATUS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY IN AFRICA

3.1. Brief overview of the African energy sector

Africa produces less than 10 per cent of the total world's primary energy supply (IEA, 2005). Energy production in Africa is not evenly spread across the continent. For example, in 2003 Africa produced 11 per cent of the world's crude oil, 85 per cent of which originated from only four countries: Algeria, Egypt Libyan Arab Jamahiriya and Nigeria. Similarly, about 5 per cent of the world's coal production is from Africa. South Africa, on its own, accounts for 97 per cent of Africa's total coal production (IEA, 2005). Table 1 shows energy production in Africa by source.

Table 1. Production of energy (by source) in Africa (2003)

Type	Amount (Mtoe)	Percentage
Solar/wind	0.058	0.01
Geothermal	0.680	0.06
Nuclear	3.300	0.30
Hydro	7.300	0.66
Petroleum products	128.560	11.69
Gas	129.890	11.81
Coal	139.010	12.64
Biomass*	272.100	24.74
Crude oil	418.780	38.08
Total	**1,099.678**	**100.00**

Source: IEA, 2005.

*Biomass refers to combustible renewables mainly fuelwood, charcoal and agro-residues.

With the exception of South Africa, on a per capita basis, sub-Saharan Africa is the lowest consumer of modern forms of energy (e.g. petroleum, electricity, coal and new renewables) in the world (IEA, 2005). This is demonstrated by the following figure, which compares electricity consumption per capita of sub-Saharan Africa to the rest of the world:

Figure I. **Electricity consumption per capita (kWh/capita) by regions of the world in 2000**

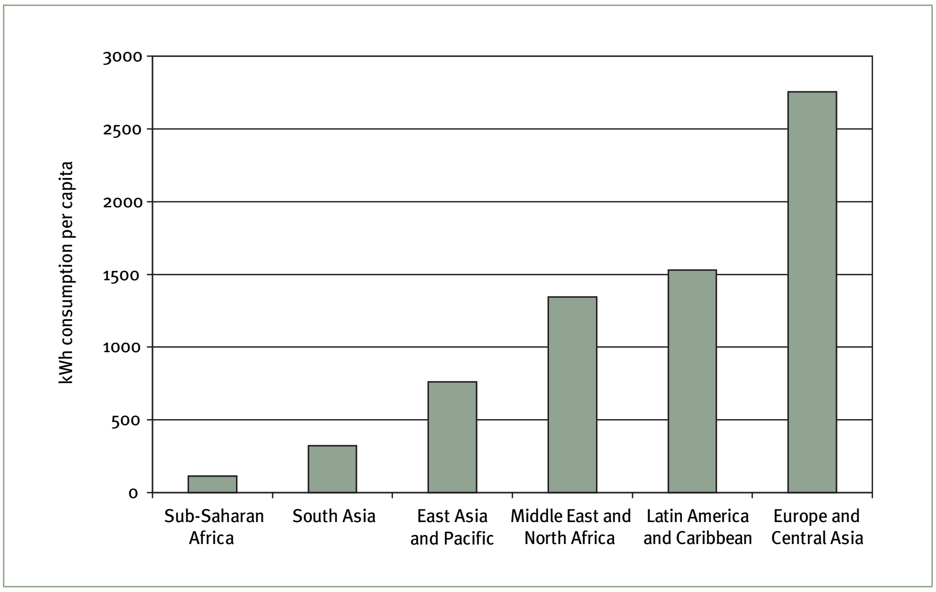
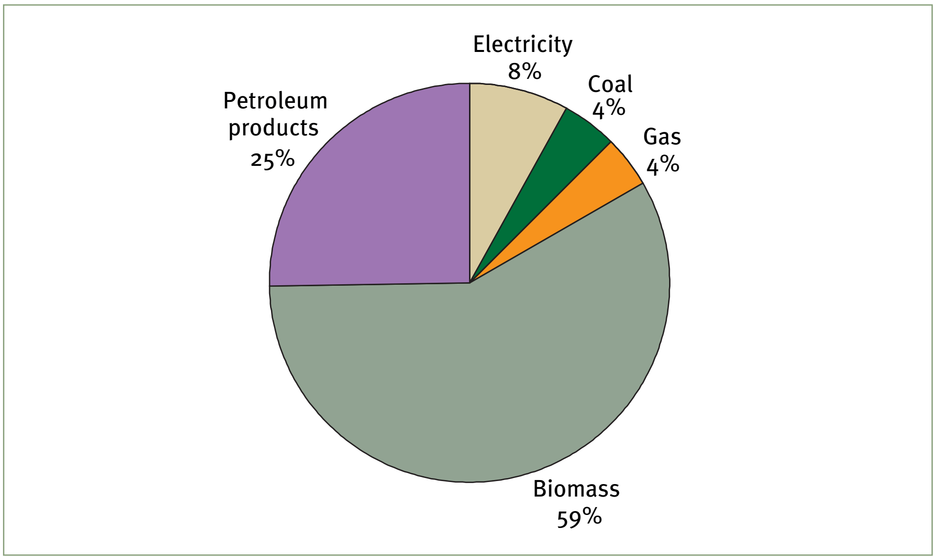


Figure II. **Energy consumption in Africa by source (2002)**



Source: IEA, 2005.

The region's low consumption of modern energy is largely due to continued heavy reliance on traditional biomass fuels coupled with underdeveloped modern energy subsectors especially petroleum and electricity. For example, until the late 1980s, only seven countries had an installed capacity exceeding 1 GW, the size of a single large power plant in USA. By 2001, the number of countries with over

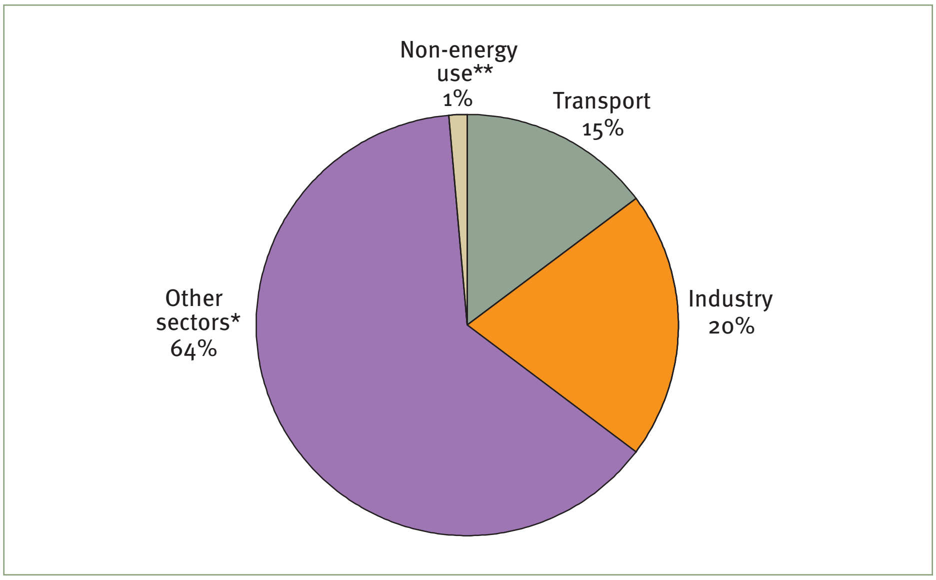
1 GW of installed capacity increased to only 12 (World Bank, 2003a) out of over 50 African countries.

Reliance on traditional biomass energy is particularly high in sub-Saharan Africa, accounting in some countries for up to 95 per cent of the total national energy consumption. Even in Nigeria, a major oil producer, an estimated 91 per cent of the household energy needs are met using biomass (Karekezi et al., 2002). Figure II shows energy consumption in Africa by source.

With the exception of a few oil-producing countries such as Angola, Cameroon, Egypt, Libyan Arab Jamahiriya, Nigeria and Tunisia, most African countries import petroleum either in the form of crude oil or its refined products. In these countries, petroleum imports can account for as much as 50 per cent of the country's export earnings, making it difficult to implement sound economic and environmental policies (IEA, 2003).

In overall terms, the industrial sector constitutes 20 per cent of total energy consumption; transport 15 per cent; while other sectors (i.e. agriculture, commercial, public services and household) account for more than 60 per cent of total energy consumption. Non-energy use accounts for about 1 per cent of the total energy consumption (see figure III).

Figure III. **Sectoral energy consumption in Africa (2002)**



*Other sectors include agriculture, commercial and public services and residential.

**Non-energy use covers the use of other petroleum products to produce white spirit, paraffin, waxes, lubricants and bitumen. The term also includes the non-energy use of coal. It assumes that the use of each of these products is exclusively non-energy.

Source: IEA, 2005.

3.2. Brief overview of renewable energy and energy efficiency in Africa

Africa has a vast range of renewable energy sources with significant potential. Although the number of renewable energy sources in the region is unevenly distributed, some of the resources are widely available.

Probably the most widespread renewable energy source in Africa is solar energy. A large number of African countries have daily solar radiation ranging between 4 and 6 kWh/m^2—offering a significant energy resource. As pointed out earlier biomass is another widespread renewable energy source, as it accounts for the bulk of most African countries' total national energy supply.

Wind energy is gradually gaining popularity. However, many sub-Saharan African countries are characterized by low wind speeds, particularly those which are near the equator and landlocked. This largely limits the potential for using wind energy for electricity generation to countries with a coastline (there are some exceptions such as Chad which, although landlocked, has good wind potential in some parts of the country). Nevertheless, even under low wind regimes, there exist opportunities for wind energy applications such as water pumping for potable water and irrigation.

Africa is well endowed with geothermal energy as a result of the formation of the Great Rift Valley. Using the prevailing technology, the region has the potential to generate 9,000 MW of electrical power (BCSE, 2003 and Simiyu, 2006) from hot water/steam based electricity generation. However, to date, only 127 MW has been exploited in Kenya, and less than 2 MW in Ethiopia (KENGEN, 2003; Wolde-Ghiorgis, 2003). The limited exploitation of the resource is partially due to the significant upfront cost and specialized expertise required. The potential of geothermal energy is even greater than the aforementioned estimate when direct thermal use of geothermal energy is taken into account (Simiyu, 2006).

Africa has substantial hydropower resources, with the technically exploitable energy potential estimated to be more than 3,140 TWh. Eastern, Southern, Central and parts of Western Africa have many permanent rivers and streams providing excellent opportunities for hydropower development. While large-scale hydropower development is becoming a challenge due to environmental and socio-economic concerns, small hydropower development continues to be an attractive resource, especially in remote areas of Africa.

While there are a few successful efforts to promote renewables in Africa, energy efficiency programmes have registered less than encouraging results. Efficiency programmes are largely absent in most countries although the potential gains from energy efficiency are enormous. In Kenya for example, it is estimated that between 10-30 per cent of the primary energy input is wasted (IEEN, 2002). Plans are, however, underway to initiate energy efficiency programmes in some countries in the region (e.g. Kenya). Most of these initiatives are donor-funded mainly by GEF, UNDP, REEEP, UNIDO, AfDB and the World Bank.

The industrial subsector is one of the three major energy-consuming subsectors in the sub-Saharan African region (the other two are the transport and residential sectors). It accounts for a quarter of the total commercial energy demand—the bulk of it in the form of electricity and imported oil. The region's industrial base is expected to expand and transform in the not-too-distant future, an evolution for which adequate energy services are a critical requirement.

Although sub-Saharan Africa has enough energy resources to meet the requirements of any plausible future industrial development scenario, the present pattern of energy consumption is far from efficient. In most countries in the region, the present pattern of energy utilization is sub-optimal and industrial energy use, in particular, is very inefficient. These inefficiencies constitute a large drain on many of the economies in the region and have adverse impacts on:

- The cost of energy supply;
- The prices of goods and services;
- The environment.

Given the significant renewable energy potential in the region, opportunities exist for exploiting renewable energy technologies that also have energy efficiency attributes such as bagasse-based cogeneration, solar water heaters and geothermal combined heat/power plants. For example, it is estimated that one of the largest consumers of domestic electricity is water heating. This typically accounts for about 30-40 per cent of electricity bills of certain categories of household consumers (Energy Management News, 1999). Solar water heaters provide an excellent opportunity for reducing the amount of electricity used for water heating, and simultaneously reduce the two peaks in electricity demand (morning and evening). Solar water heater projects have been launched in Morocco with an aim of initially installing 80,000 m^2 of solar water collectors (REPP, 2002). An Egyptian electricity utility is also providing incentives for domestic consumers who install solar water heaters. Tunisia has recently launched a utility-based solar water heater programme that is expected to lead to the wider use of solar heaters.

At the industrial level, solar water heaters can be useful in pre-heating water for use in boilers, therefore reducing the amount of electricity or fossil fuels needed to heat the water to produce process steam. This could yield significant savings in energy intensive industries.

Bagasse-based cogeneration also provides an opportunity for energy efficiency. A significant part of cogeneration initiatives is aimed at increasing the efficiency of factory energy use to free up more electricity for export to the grid. It is estimated that modest capital investments combined with judicious equipment selection, increased efficiency in the sugar manufacturing process (to reduce energy use) and proper planning could yield a 13-fold increase in the amount of electricity produced by sugar factories and sold to the national grid (Baguant, 1992).

Combined heat and power geothermal energy plants can also be considered as efficiency technologies. The heat part of a geothermal plant (which has not been widely exploited in the region) could be used for several uses, namely:

- Heating greenhouses—tried in Kenya for flower farming;
- Heating fish ponds—currently practised in parts of Asia;
- Water and space heating—done in parts of the developed world.

To conclude, the trend depicted in the foregoing discussion indicating under-exploited renewable energy and underdeveloped energy efficiency in the region can be traced back to national energy policies. While most sub-Saharan African countries now have dedicated energy policy documents articulating the objectives for the energy sector, they tend to mainly concentrate on conventional energy systems at the expense of renewable energy and energy efficiency. Although the overall objective of the national energy policies is to increase the provision of modern energy services to the bulk of the population, renewables and energy efficiency are usually not among the priority options.

There appears to be lack of policy implementation plans for renewables and energy efficiency such as those developed for conventional energy systems. As a result, renewables and energy efficiency development appears ad hoc and not explicitly linked to national energy plans.

The rationale for promoting renewable energy and energy efficiency in national energy policies is not well argued. This might partially explain why limited attention is accorded to renewable energy and energy efficiency. Consequently, the large-scale conventional energy sector (i.e. electricity and petroleum), which serves a smaller proportion of the population receives the bulk of energy investments in most countries in the region. In contrast, small-scale renewable energy options, which serve the bulk of the population, receive limited budgetary support. For example, the budgetary allocation for the energy sector in Zambia in 2002, indicates a heavy emphasis on electrification (mainly conventionally powered grid extension). Only 0.2 per cent of planned investments in the public investment plan was allocated to renewable energy and energy efficiency systems (Ministry of Finance and National Planning, 2002).

At the international level, promotion of renewable energy and energy efficiency is often driven by climate change and environmental drivers that do not resonate in Africa. Stressing the environmental benefits of renewable energy has not been effective in engendering support for renewable energy and energy efficiency in the region. Since Africa is not yet a net emitter of greenhouse gases, the promotion of renewable energy and energy efficiency systems is likely to be more successful if advanced on the basis of their socio-economic benefits and cost advantages.

On the whole, support for renewable energy and energy efficiency appears lukewarm. For example, a number of Governments in the region do not have a comprehensive vision, policy and plan on renewable energy and energy efficiency. Consequently, RE and EE systems development is often undertaken within an energy planning and policy vacuum often leading to discouraging results.

4. WHY SHOULD AFRICA PROMOTE RENEWABLES?

Given the large renewable energy potential that exists in Africa, it is only logical that these indigenous resources are used and promoted.

Furthermore renewable energy offers diversification in energy supply, thus strengthening energy security by broadening national energy generation portfolios. Countries with diversified energy generation are better-off than those which heavily depend on centralized large-scale hydro or conventional thermal-based generation, as the former is dependent on rainfall and the latter on imported petroleum fuels both of which can have a degree of uncertainty in supply. Reliance on a narrow range of energy supply options can lead to an energy crisis. Renewable energy can contribute to lowering the risk profile of a country's energy sector.

The energy sector in numerous African countries is characterized by high oil import bills, accounting for a significant proportion of export earnings (Karekezi and Kimani, 2001; AFREPREN, 2001). In addition, high oil imports increase the vulnerability of African countries to external oil price shocks which have an adverse impact on balance of payments. The use of renewable energy sources can reduce dependence on imported petroleum fuels (Mbuthi, 2004; Yuko, 2004). Table 2 estimates the potential for replacing electricity generation from fossil fuels by biomass-based cogeneration in three Eastern and Horn of Africa countries.

Table 2. Potential of cogeneration to replace electricity generation from fossil fuels

Country	Electricity generation from oil and petroleum (GWh)	Biomass-based cogeneration potential (GWh)
United Rep. of Tanzania	143	315
Kenya	1,509	2,606
Ethiopia	19	1,750

Sources: Adapted from IEA, 2003.

This is best illustrated by power sectors in the three East African countries. In the United Republic of Tanzania and Uganda, the power sectors are predominantly large-scale hydro. Due to prolonged drought during the period of 2005/2006, the water level in the hydropower dams was very low leading to severe electricity generation shortfalls. Consequently, the two countries have been experiencing load shedding lasting about eight hours a day. By contrast, Kenya's power sector has a much lower risk profile as it has several electricity generation options including hydropower, geothermal, thermal and a limited amount of wind energy. While the drought of 2005/2006 affected its hydropower dams, the availability of other renewable energy options contributed to a steady supply of electricity.

Another important reason for Africa to promote renewables is to enhance the competitiveness of its agricultural commodities. For agro-processing industries such as coffee, tea, sugar, sisal and cotton located in remote areas (sometimes away from the grid), embedded renewable-based generation can lower energy costs, thereby making the products competitive in the world market. Embedded generation can also contribute to the stability of the national or local grid where agro-processing industries are connected.

The failure of conventional energy systems to reach the majority of the population should be a strong incentive for African governments to promote renewables. For example, after more than 40 years of independence, the majority of the population, especially the poor, still have no access to modern energy services such as electricity. On the other hand, there is growing evidence that investment in small and medium-scale renewable energy technology projects, e.g. small-hydro, could be an important option for providing modern energy services to the poor, particularly those residing in remote and scattered rural settlements (Mapako and Mbewe (eds.), 2004; Karekezi and Kithyoma, 2002; UNDP, 2004; World Bank, 2004). Renewable energy can play an important and cost-effective role in rural electrification, particularly in areas far from the grid.

Review question

List the potential benefits of promoting renewable energy in Africa.

5. WHY SHOULD AFRICA PROMOTE ENERGY EFFICIENCY?

There are several reasons for Africa to promote energy efficiency. First and foremost, the rate at which energy demand increases in many sub-Saharan African countries appears to be outpacing the rate at which energy supply is being increased. Therefore, an obvious option is the implementation of energy efficiency measures that would free up supply capacity to meet the rising demand.

Secondly, the worsening energy crisis in the region has served as a "wake-up call" to the region's policymakers on the importance of energy efficiency. In the electricity subsector, drought-induced generation capacity short falls are becoming prevalent. In the petroleum subsector, the steep increase in world oil prices is having a devastating effect on sub-Saharan African economies. Energy efficiency programmes would help to mitigate the adverse impacts of these crises.

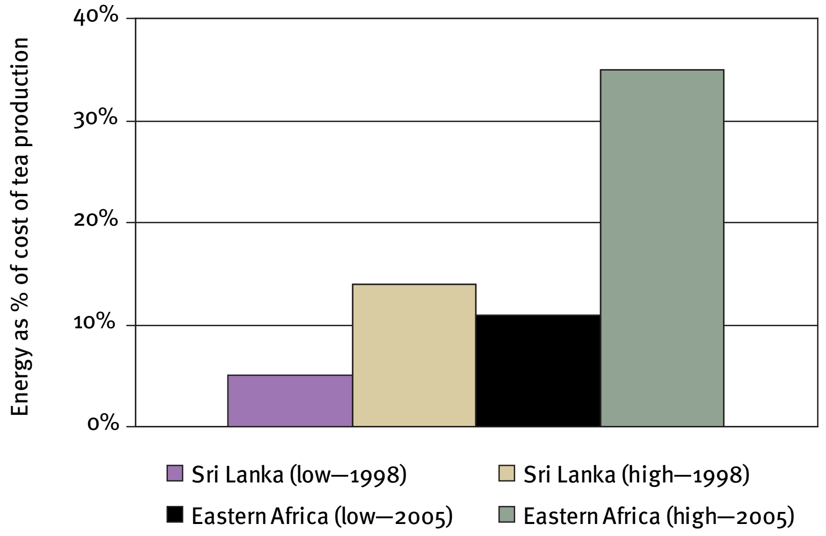
Thirdly, with the gradual withdrawal of donor participation in the financing of large-scale energy investments, alternative financial resources are limited and expensive. Therefore, implementation of energy efficiency programmes could delay the need for new investment in additional/enhanced energy supply infrastructures. This is especially important for African countries, which are often capital constrained.

Fourthly, energy efficiency measures can "shave off" peak loads in a power system thereby minimizing the need for huge investments to meet peak demand which lasts for only a few hours in a day. For example, the peak load experienced in the mornings is often associated with water heating. Therefore, using energy efficient water heating technologies such as solar water heaters can "shave off" a significant amount of the peak load.

Fifthly, energy efficiency measures can significantly reduce the cost of energy supply. For example, in Tunisia where a major programme of the national utility is promoting solar water heaters, it is estimated that by converting water heating systems to use solar only, it can reduce the utility's cost of electricity supply by about 20 per cent (Awerbuch, 2005).

Sixthly, the high cost of energy in the industrial sector in sub-Saharan African countries is eroding the competitiveness of their products in the local, regional and international markets (GEF-KAM, 2005). Therefore, industrial energy efficiency measures reduce the cost of production thereby enhancing competitiveness, especially where commodity prices are not set by the producer. For example, the world price of tea is not set by the respective producing countries. Therefore, to ensure the profitability of tea production, tea factories have to keep their cost of production (especially energy costs) as low as possible. A comparison between two competing regions, i.e. Eastern Africa and Sri Lanka, reveals that the cost of energy for tea production in Eastern Africa accounts for a larger proportion of the cost of production than in Sri Lanka. The significant difference is essentially due to lack of energy efficiency measures and the limited use of abundant renewable small hydro resources that are often found in tea-growing regions—see figure IV.

Figure IV. **Energy as percentage of cost of production**



Another reason why Africa should promote energy efficiency is that it can generate jobs. For example, the production of energy efficient charcoal and fuel-wood stoves has provided a significant amount of employment opportunities in urban and rural areas. An ideal illustration is the introduction of the Kenya ceramic *jiko*—an energy efficient charcoal stove—which is currently produced by over 200 businesses, the bulk of which are informal sector manufacturers (Solutions Site, 2006).

Lastly, the promotion of energy efficiency in Africa can help in arresting environmental degradation such as deforestation and associated soil erosion caused by charcoal production; indoor air pollution caused by the use of traditional biomass; and local air pollution associated with thermal electricity generation. In addition, the climate change benefits accrued from energy efficiency can attract CDM-related financing and grant financing from agencies such as the Global Environment Facility (GEF).

6. CONCLUSION

By way of conclusion, the following points can be made:

- The rationale for promoting renewables and energy efficiency is not well argued in governmental energy policy documents. Consequently, financing for renewable energy and energy efficiency development is miniscule compared to that of conventional energy systems.
- At international level, the promotion of renewable energy and energy efficiency is often driven by climate change and environmental concerns which are not always prior issues in the African context.
- A solid rationale for renewable energy and energy efficiency promotion in Africa can be built around the following:

  Enhanced energy security arising from reduced exposure to high oil import;

  Costs and frequent drought-related hydropower crises;

  Availability of plentiful and cost-competitive renewable energy sources such as hydropower, solar and geothermal resources;

  Ability to provide cost-competitive energy services to remote rural settlements that are far from the grid;

  Significant job and enterprise creation potential of renewables and energy-efficiency initiatives.

LEARNING OUTCOMES

Key points covered

These are the most important points covered in this module:

- Africa has a vast range of new and renewable energy sources with significant potential. However, in spite of the enormous potential, renewable energy only contributes about 1 per cent of the region's modern energy supply.
- The rationale for promoting renewables and energy efficiency in national energy policies is not well argued. Consequently, the large-scale conventional energy sector (i.e. electricity and petroleum), which serves a smaller proportion of the population receives the bulk of energy investments in most countries in the region.
- Renewable energy offers diversification in energy supply, thus strengthening energy security by broadening the energy generation portfolio used within a country.
- The energy sector in numerous African countries is characterized by high oil import bills, accounting for a significant proportion of export earnings.
- Energy efficiency measures can "shave off" peak loads in a power system thereby minimizing the need for large supply investments to meet peak demands which last for only a few hours in a day.
- Energy efficiency measures can significantly reduce the cost of energy supply.
- The high cost of energy in the industrial sector in sub-Saharan African countries is eroding the competitiveness of their products in the local, regional and international markets. Energy efficiency measures can therefore enhance the region's competitiveness.
- Although the environmental rationale for promoting renewables and energy efficiency in Africa is weak, there are strong energy security and socio-economic reasons for promoting sustainable energy in Africa.

Answers to review questions

Question: List the potential benefits of promoting renewable energy in Africa.

Answer:

- Renewable energy technologies offer a potential for diversification in energy supply, thus strengthening energy security by broadening the energy generation portfolio used within a country.
- The use of renewables can reduce dependence on imported petroleum fuels.
- The use of renewable energy enhances the competitiveness of agricultural commodities.
- Renewable energy technologies can play an important and cost-effective role in rural electrification particularly in areas far from the grid.
- Renewable energy technologies can help in poverty alleviation. Particularly, the medium and large-scale renewable energy technologies provide significant job creation opportunities.
- Most renewable energy technologies are relatively new and small-scale technologies that do not require large amounts of capital. They are also relatively less sophisticated meaning that a significant industry could be developed in Africa even where technical expertise is limited.
- Alternative renewable energy-based electricity generation options can be used, such as wind, small hydropower, bagasse-based cogeneration and geothermal, to reduce adverse local, regional and global environmental impacts of increased reliance on conventional energy options.
- The climate change benefits of renewables in Africa can be an attractive carbon trading option that can increase the flow of concessionary finance into the region.

Question: List the potential benefits of promoting energy efficiency in Africa.

Answer:

- Implementation of energy efficiency measures can free up energy supplies to meet growing demand.
- Energy efficiency measures could particularly mitigate the worsening energy crises in the region.
- Implementation of energy efficiency programmes could delay the need for new investment in energy supply infrastructure.
- Energy efficiency measures can “shave off” peak loads in a power system thereby minimizing the need for huge investments to meet peak demand.
- Energy efficiency measures can significantly reduce the cost of energy supply.
- Industrial energy efficiency reduces the cost of energy used in production thereby enhancing competitiveness.
- Energy efficiency can be an important source of job creation.

- Promotion of energy efficiency in Africa can help in arresting environmental degradation such as deforestation and associated soil erosion caused by charcoal production; indoor air pollution caused by use of traditional biomass; and local air pollution associated with thermal electricity generation.
- In addition, the climate change benefits accrued from energy efficiency investments can attract CDM-related financing.

Presentation/suggested discussion topics

Presentation:

INTRODUCTION – Module 1: Overview of renewable energy and energy efficiency

Suggested discussion topics:

1. What are the main renewable energy sources present in your country? How could these resources be utilized and what are the barriers to this occurring?
2. In your opinion what is the level of energy efficiency in your country? What kind of programmes/policies/regulations could promote greater efficiency in your country?

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ENDA: www.enda.sn/energie

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GEF: www.gefweb.org/wprogram

IEA: www.eia.doe.gov

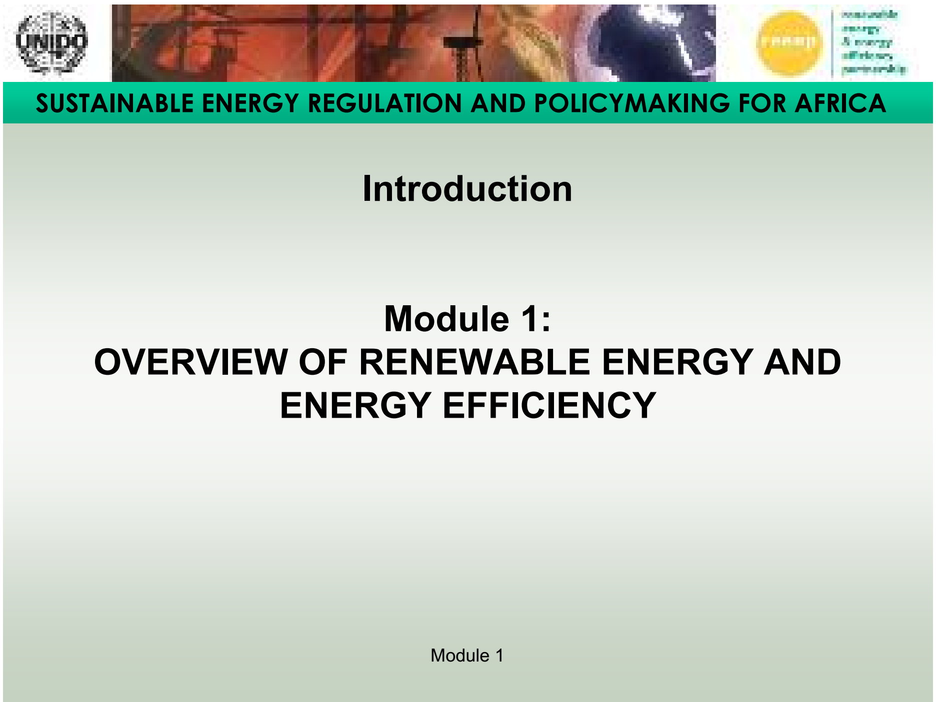
GLOSSARY/DEFINITION OF KEY CONCEPTS

Climate change	All forms of climatic variations, especially significant changes from one prevailing climatic condition to another.
Carbon intensity	The amount of carbon by weight emitted per unit of energy consumed.
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Emissions	Flows of gas, liquid droplets or solid particles released into the atmosphere.
Energy demand (millions toe)	The amount of modern energy required by various sectors of a country.
Energy efficiency	Using less energy to accomplish the same task
Energy efficiency measures	The whole of investments done and systems and technologies adopted to increase energy efficiency
Energy imports (US$ million)	The total cost of energy brought from foreign countries into the domestic territory of a given country.
Energy production (million toe)	The amount of modern energy produced within the country.

Energy reserves	Estimated quantities of energy sources that have been demonstrated to exist with reasonable certainty on the basis of geologic and engineering data (proven reserves) or that can reasonably be expected to exist on the basis of geologic evidence that supports projections from proven reserves (probable or indicated reserves).
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Energy supply	Amount of energy available for use by the various sectors in a country.
Energy use per capita (Kgoe)	The average amount of energy consumed per inhabitant in a given country.
Fossil fuel	An energy source formed in the earth's crust from decayed organic material, e.g. petroleum, coal, and natural gas.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal Plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.
Global warming	An increase in the near surface temperature of the earth due to increased anthropogenic emissions of greenhouse gases.
Greenhouse effect	The effect produced due to certain atmospheric gases that allow incoming solar radiation to pass through to the earth's surface, but prevent the radiations which are reradiated from the earth, from escaping into outer space.
Greenhouse gas	Any gas that absorbs infrared radiation in the atmosphere.
Gross domestic product ($US million)	The total output of goods and services produced within the territory of a given country.
Gross domestic product growth rate (per cent)	The annual rate of increase/decrease in the gross domestic product.
Gross national product ($US million)	The total output of goods and services produced within the territory of a given country (GDP), plus the net receipts of primary income from investments outside the country.
Gross national product	The average income per inhabitant of a country, derived by

per capita ($US)	dividing the GNP by the population.
Household energy expenditures	The total amount of funds spent on energy consumed in, or delivered to, a housing unit during a given period of time.
Household stoves	Household heating and cooking devices.
Household	A group of people who share a common means of livelihood, such as meals regardless of source of income and family ties. Members who are temporarily absent are included and temporary visitors are excluded.
Hydro turbine	A device used to generate electricity using kinetic energy from moving water.
Improved household stoves	Household heating and cooking devices that have been altered in design to improve their efficiency.
Institutional stoves	A heating and cooking device commonly used in medium and large institutions.
Kenya ceramic jiko	An improved household stove that uses charcoal and has a ceramic lining to improve efficiency. Widely disseminated in Kenya, and adopted in many African countries.
Less developed countries	Countries that are below a given level or threshold of per capita GNP as defined by the World Bank.
Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100kW but below 1MW).
Modern energy	Refers to high quality energy sources e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biofuels.
National budget ($US million)	Estimated government expenditure on goods and services, including expenditure on national defence and security.
National debt ($US million)	The direct liabilities of the government owed to debtors.
Petroleum consumption	The sum of all refined petroleum products supplied.
Photovoltaic cells	Devices used to transform solar energy into electrical energy.
Pico hydro	Small-scale power generating systems that harness the power of falling water (less than 100 kW).
Population (millions)	The total number of people living within the borders of a country, whether citizens or not.
Primary energy	Energy sources in their crude or raw state before processing into a form suitable for use by consumers.

Renewable energy	Non-fossil and non-nuclear energy sources, i.e. wind, solar geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.
Renewable energy technologies (RETs)	Technologies using renewable energy.
Small and micro enterprises	An enterprise that generates income up to a certain pre-defined limit.
Small hydro	Small-scale power generating systems that harness the power of falling water (1-15 MW).
Solar collector	A device which is capable of absorbing solar radiation and converting it into some other form of energy.
Solar thermal technologies	Devices that use the sun as the primary source of energy for heat appliances, e.g. solar water heaters, solar dryers.
Solar water heaters	Devices that use solar energy to heat water for domestic, institutional, commercial and industrial use.
Sub-Saharan Africa	All African countries north of the Republic of South Africa and south of the North African countries (Algeria Egypt, Libyan Arab Jamahiriya, Morocco, Tunisia).
Sustainable energy	General term encompassing both renewable energy and energy efficiency.
Traditional energy	Low quality and inefficient sources of energy, predominantly biomass in nature and not often traded (e.g. wood fuel, crop residues and dung cakes).
Traditional stoves	Inefficient heating and cooking devices that use firewood, charcoal and other biomass based fuels.
Wind pumps/mills	Devices that use wind energy to lift water from underground sources.
Wind turbines	Devices used to generate electricity using kinetic energy from wind.
Wood stoves	Heating and cooking devices that use firewood as the main fuel.

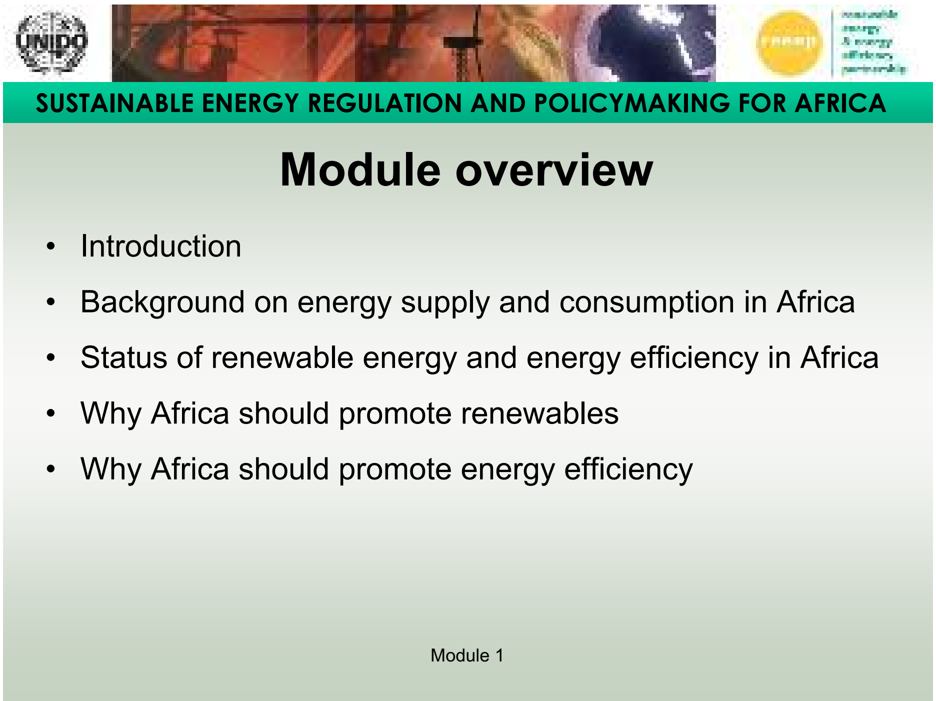


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

Module 1:
OVERVIEW OF RENEWABLE ENERGY AND ENERGY EFFICIENCY

Module 1

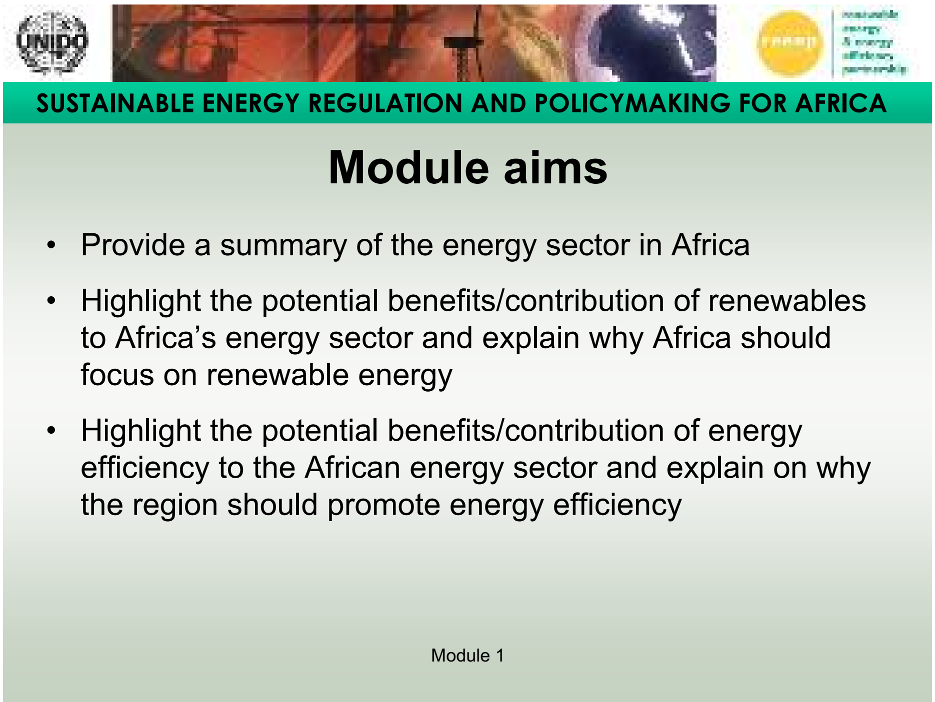


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Introduction
- Background on energy supply and consumption in Africa
- Status of renewable energy and energy efficiency in Africa
- Why Africa should promote renewables
- Why Africa should promote energy efficiency

Module 1

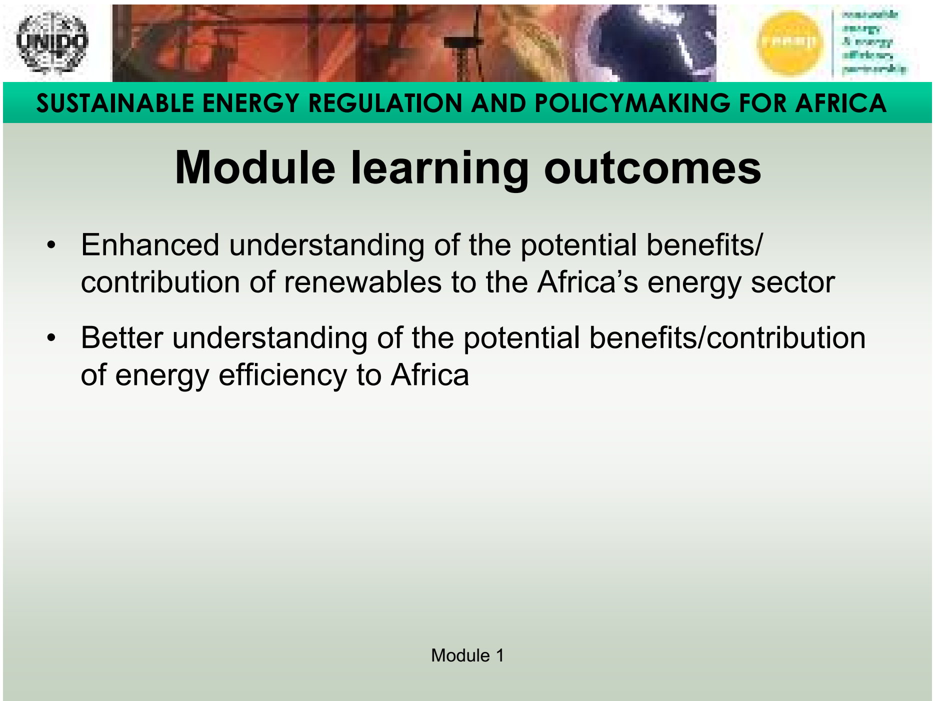


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Provide a summary of the energy sector in Africa
- Highlight the potential benefits/contribution of renewables to Africa's energy sector and explain why Africa should focus on renewable energy
- Highlight the potential benefits/contribution of energy efficiency to the African energy sector and explain on why the region should promote energy efficiency

Module 1

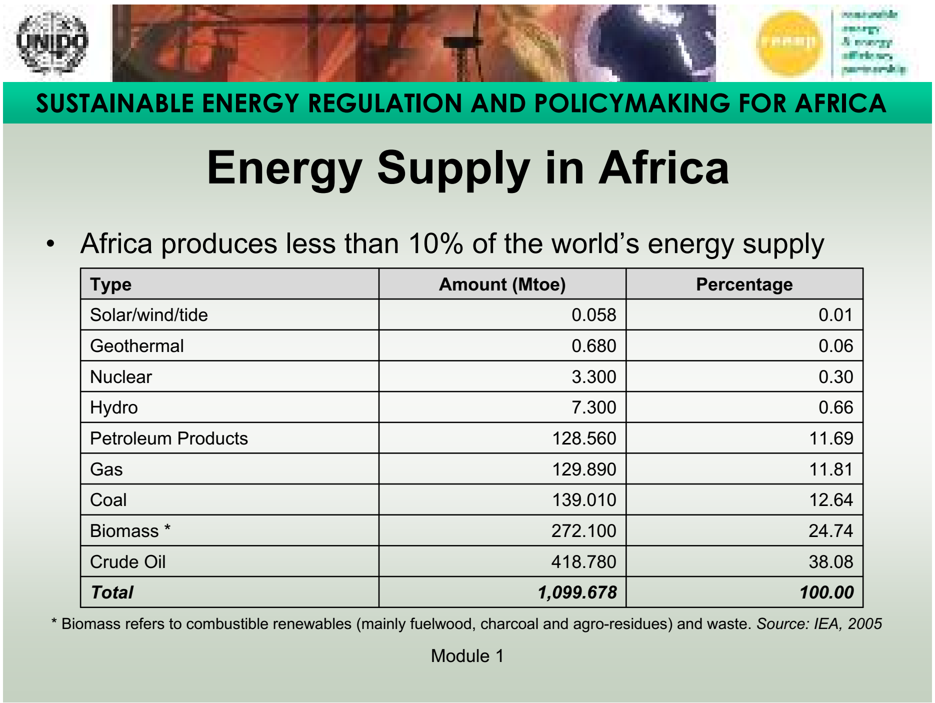


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Enhanced understanding of the potential benefits/ contribution of renewables to the Africa's energy sector
- Better understanding of the potential benefits/contribution of energy efficiency to Africa

Module 1



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

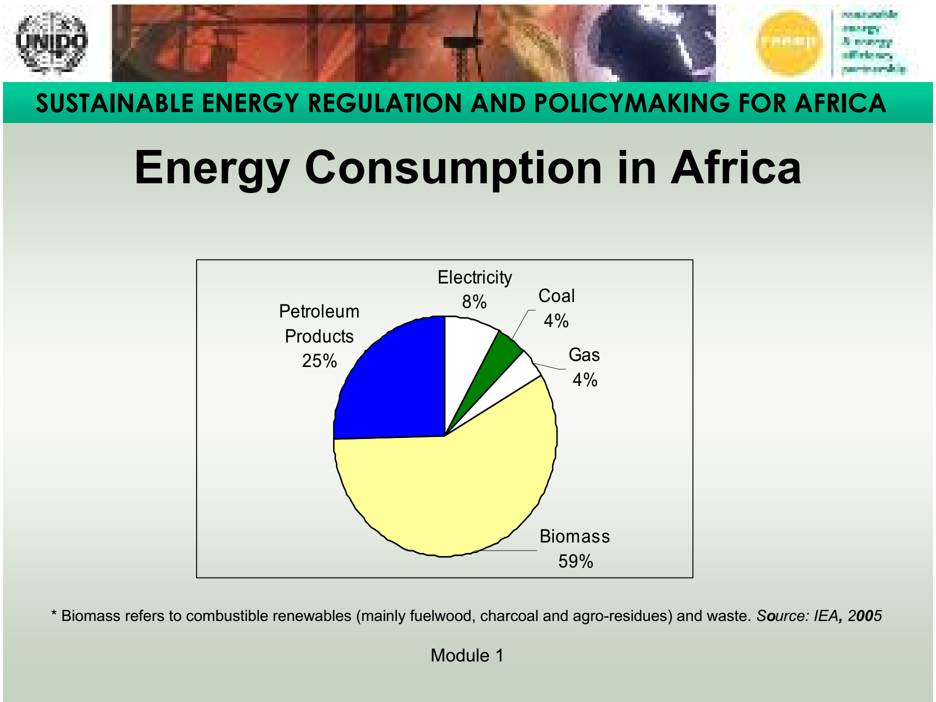
Energy Supply in Africa

- Africa produces less than 10% of the world's energy supply

Type	Amount (Mtoe)	Percentage
Solar/wind/tide	0.058	0.01
Geothermal	0.680	0.06
Nuclear	3.300	0.30
Hydro	7.300	0.66
Petroleum Products	128.560	11.69
Gas	129.890	11.81
Coal	139.010	12.64
Biomass *	272.100	24.74
Crude Oil	418.780	38.08
Total	***1,099.678***	***100.00***

* Biomass refers to combustible renewables (mainly fuelwood, charcoal and agro-residues) and waste. *Source: IEA, 2005*

Module 1

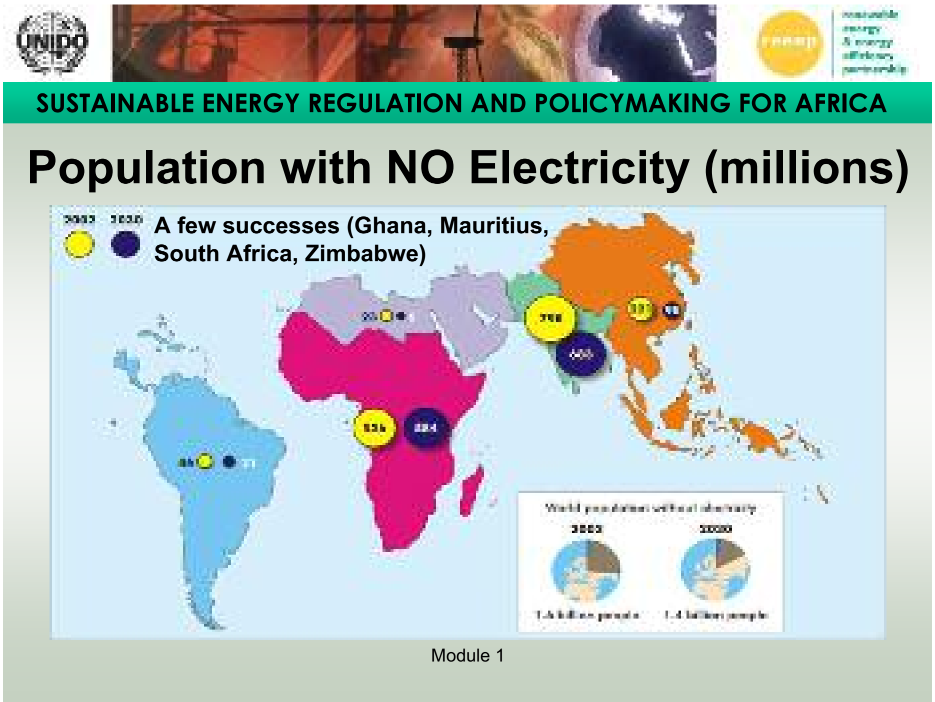


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Consumption in Africa

* Biomass refers to combustible renewables (mainly fuelwood, charcoal and agro-residues) and waste. *Source: IEA, **2005***

Module 1

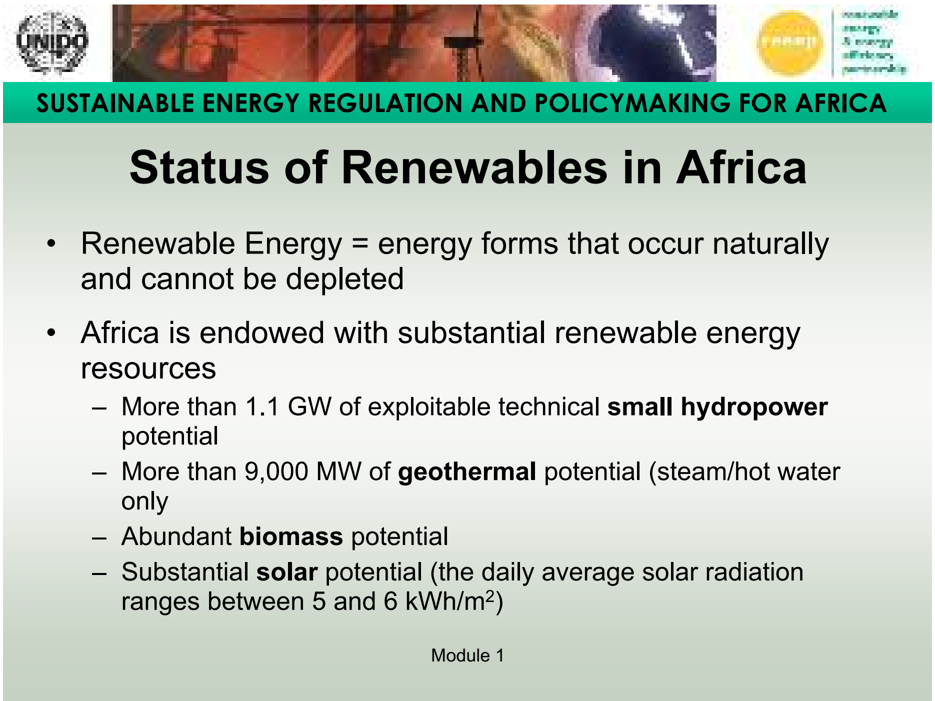


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Population with NO Electricity (millions)

A few successes (Ghana, Mauritius, South Africa, Zimbabwe)

Module 1

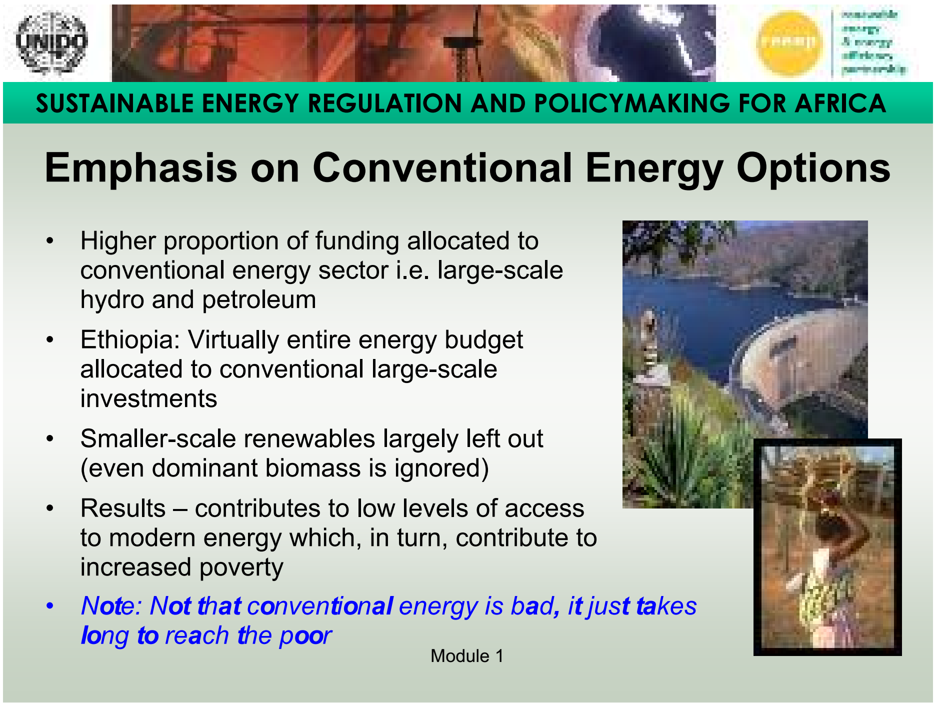


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Status of Renewables in Africa

- Renewable Energy = energy forms that occur naturally and cannot be depleted
- Africa is endowed with substantial renewable energy resources
  - More than 1.1 GW of exploitable technical **small hydropower** potential
  - More than 9,000 MW of **geothermal** potential (steam/hot water only
  - Abundant **biomass** potential
  - Substantial **solar** potential (the daily average solar radiation ranges between 5 and 6 kWh/m^2)

Module 1

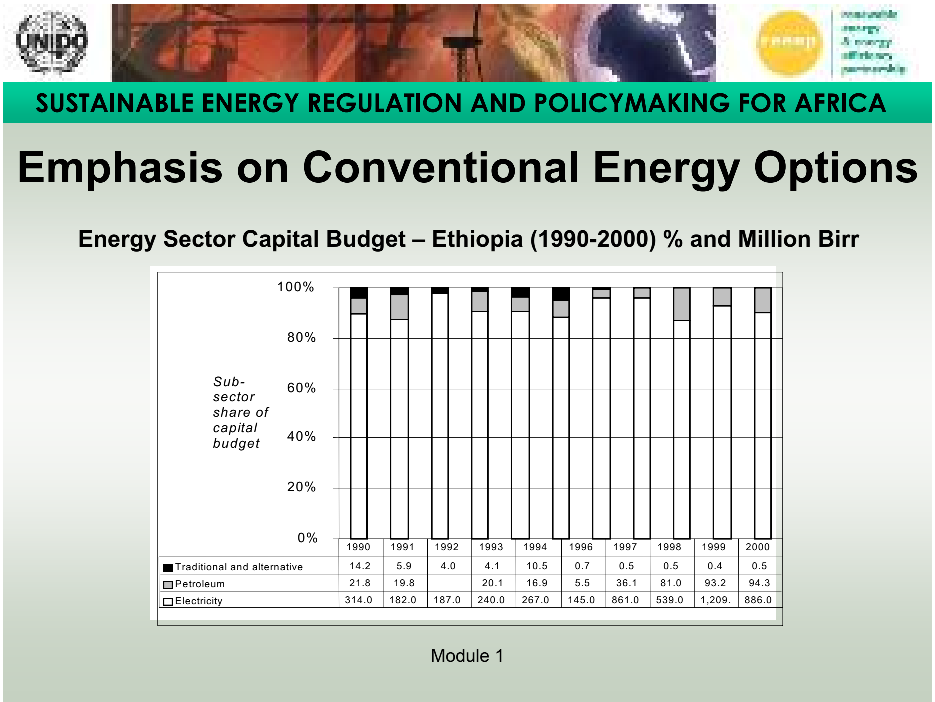


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Emphasis on Conventional Energy Options

- Higher proportion of funding allocated to conventional energy sector i.e. large-scale hydro and petroleum
- Ethiopia: Virtually entire energy budget allocated to conventional large-scale investments
- Smaller-scale renewables largely left out (even dominant biomass is ignored)
- Results – contributes to low levels of access to modern energy which, in turn, contribute to increased poverty
- *Note: Not that conventional energy is bad, it just takes long to reach the poor*

Module 1



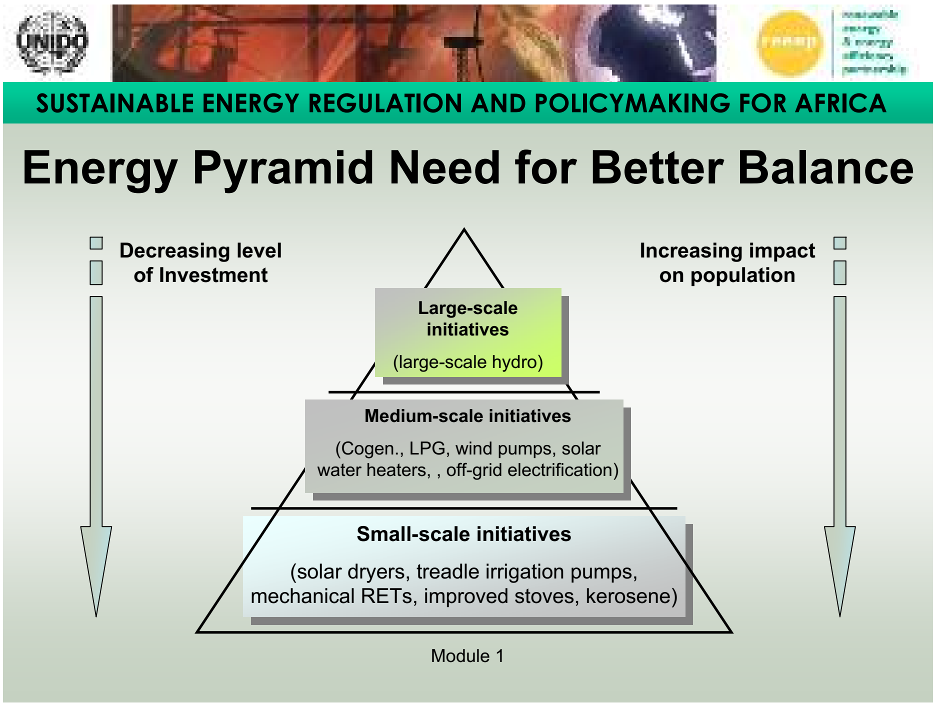
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Emphasis on Conventional Energy Options

Energy Sector Capital Budget – Ethiopia (1990-2000) % and Million Birr

	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
■ Traditional and alternative	14.2	5.9	4.0	4.1	10.5	0.7	0.5	0.5	0.4	0.5
▨ Petroleum	21.8	19.8		20.1	16.9	5.5	36.1	81.0	93.2	94.3
□ Electricity	314.0	182.0	187.0	240.0	267.0	145.0	861.0	539.0	1,209.	886.0

Module 1



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Pyramid Need for Better Balance

Decreasing level of Investment

Increasing impact on population

Large-scale initiatives

(large-scale hydro)

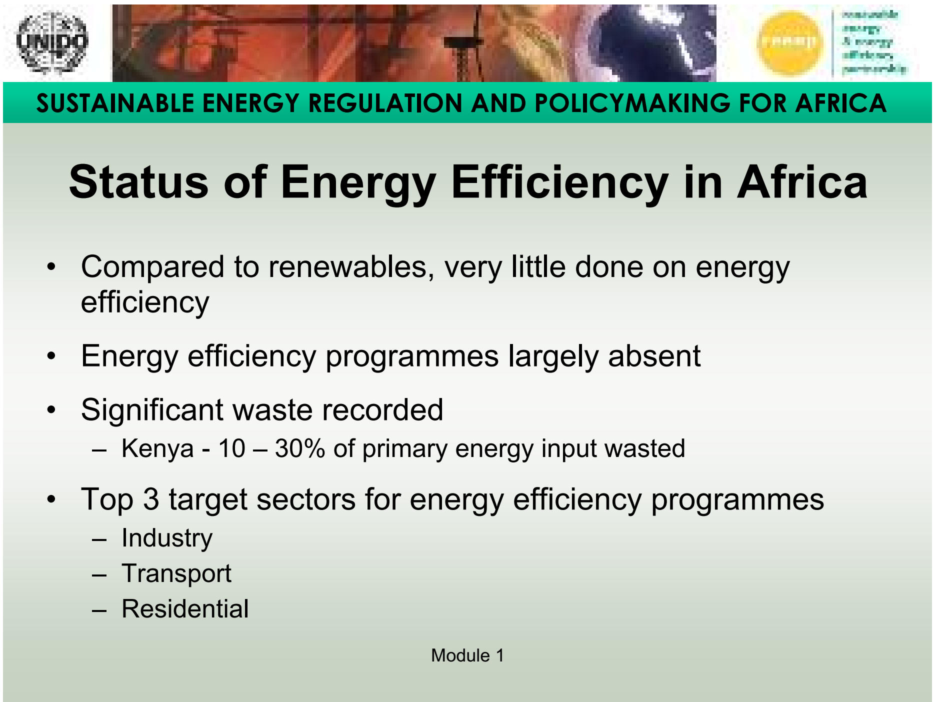
Medium-scale initiatives

(Cogen., LPG, wind pumps, solar water heaters, , off-grid electrification)

Small-scale initiatives

(solar dryers, treadle irrigation pumps, mechanical RETs, improved stoves, kerosene)

Module 1

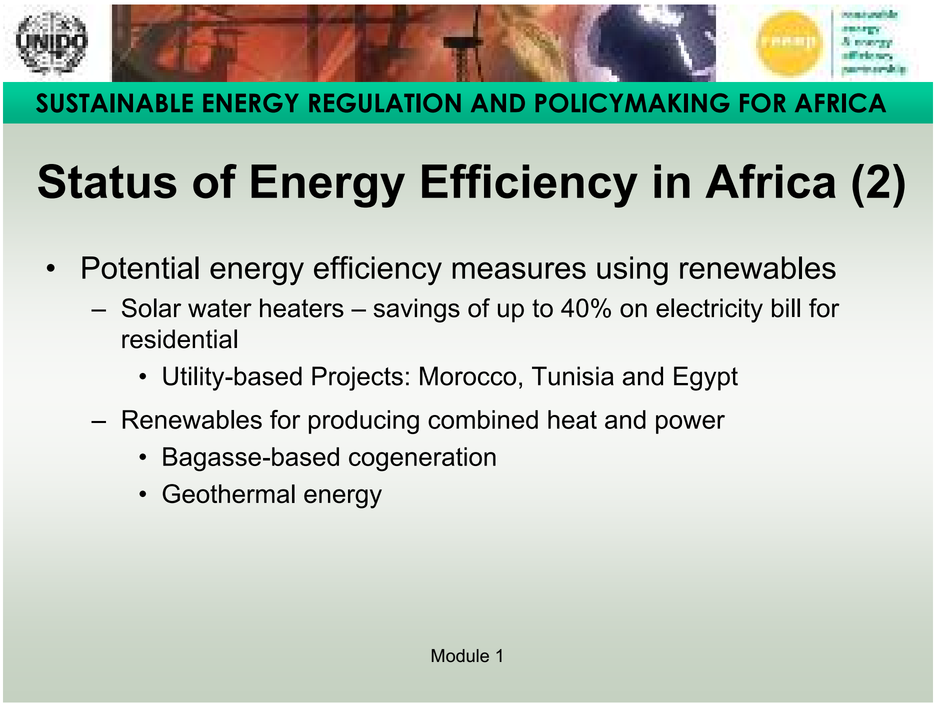


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Status of Energy Efficiency in Africa

- Compared to renewables, very little done on energy efficiency
- Energy efficiency programmes largely absent
- Significant waste recorded
  - Kenya - 10 – 30% of primary energy input wasted
- Top 3 target sectors for energy efficiency programmes
  - Industry
  - Transport
  - Residential

Module 1

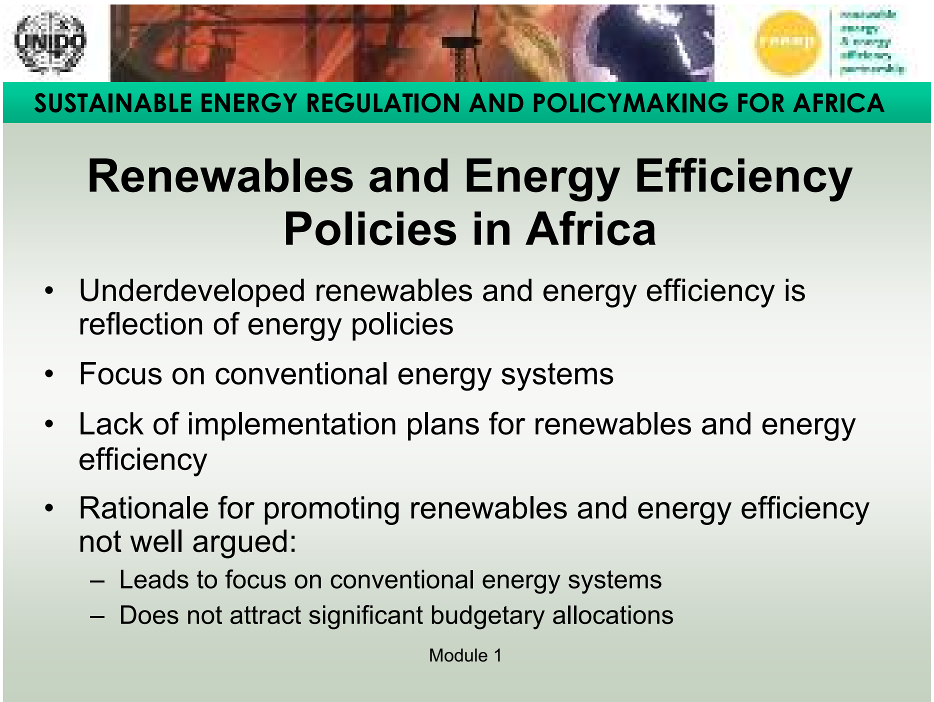


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Status of Energy Efficiency in Africa (2)

- Potential energy efficiency measures using renewables
  - Solar water heaters – savings of up to 40% on electricity bill for residential
    - Utility-based Projects: Morocco, Tunisia and Egypt
  - Renewables for producing combined heat and power
    - Bagasse-based cogeneration
    - Geothermal energy

Module 1

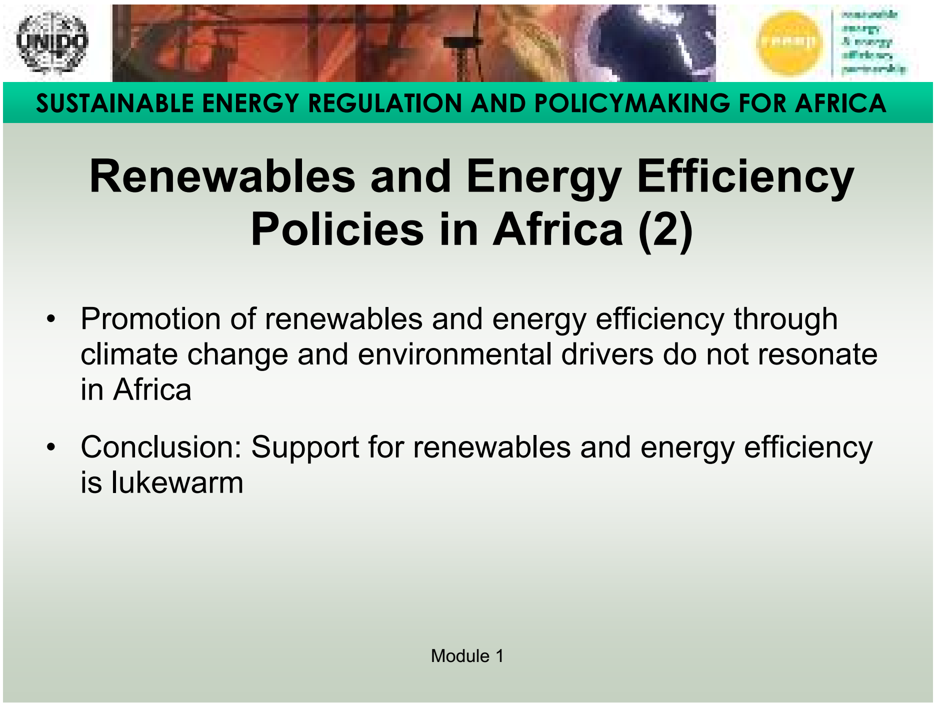


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewables and Energy Efficiency Policies in Africa

- Underdeveloped renewables and energy efficiency is reflection of energy policies
- Focus on conventional energy systems
- Lack of implementation plans for renewables and energy efficiency
- Rationale for promoting renewables and energy efficiency not well argued:
  - Leads to focus on conventional energy systems
  - Does not attract significant budgetary allocations

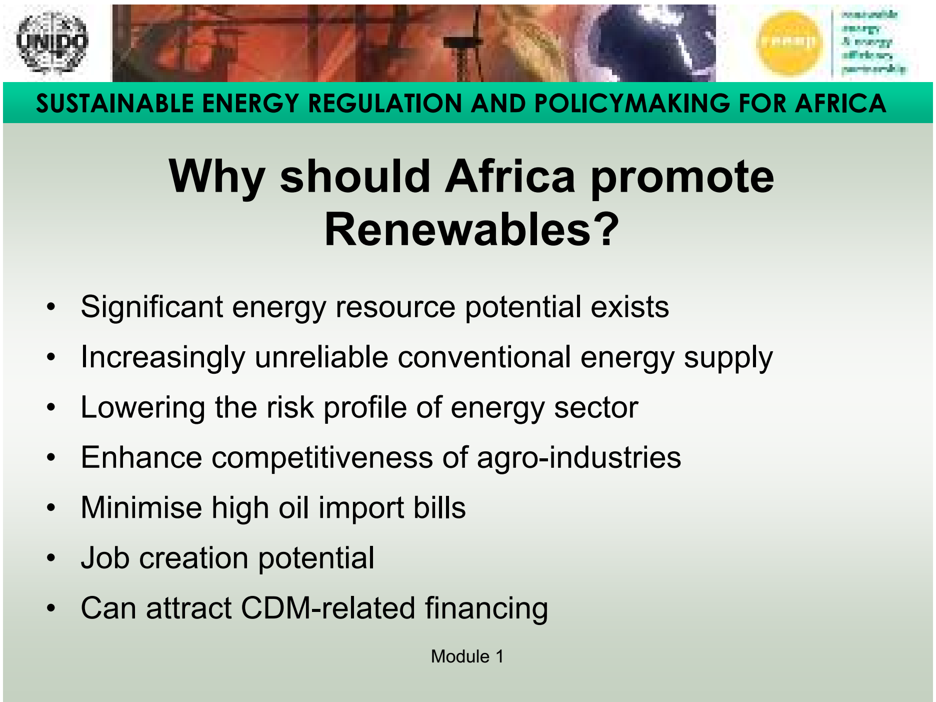
Module 1



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewables and Energy Efficiency Policies in Africa (2)

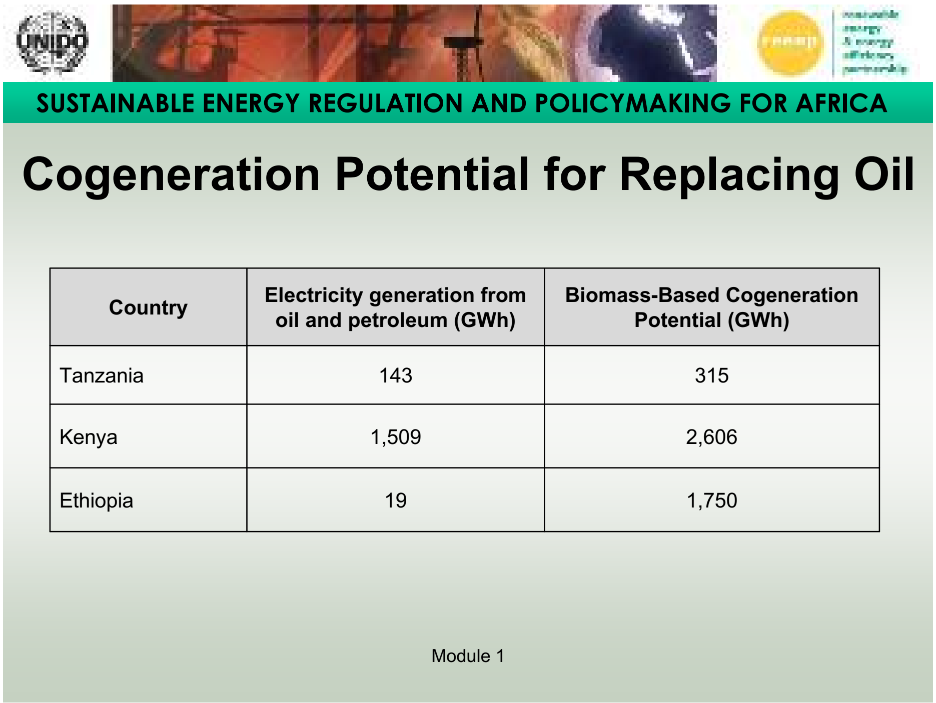
- Promotion of renewables and energy efficiency through climate change and environmental drivers do not resonate in Africa
- Conclusion: Support for renewables and energy efficiency is lukewarm



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why should Africa promote Renewables?

- Significant energy resource potential exists
- Increasingly unreliable conventional energy supply
- Lowering the risk profile of energy sector
- Enhance competitiveness of agro-industries
- Minimise high oil import bills
- Job creation potential
- Can attract CDM-related financing

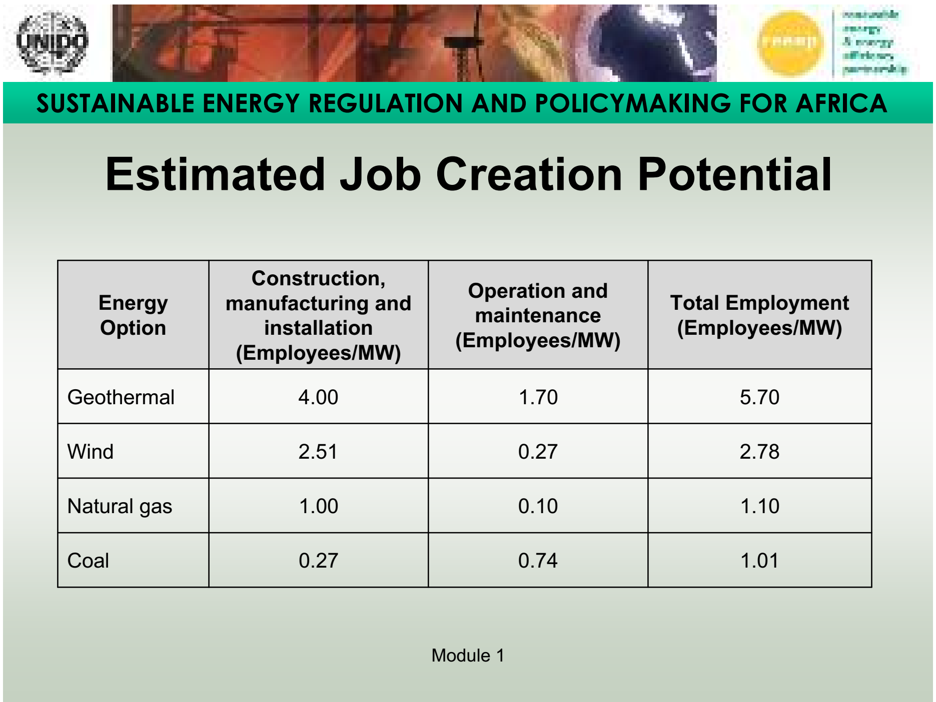


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Cogeneration Potential for Replacing Oil

Country	Electricity generation from oil and petroleum (GWh)	Biomass-Based Cogeneration Potential (GWh)
Tanzania	143	315
Kenya	1,509	2,606
Ethiopia	19	1,750

Module 1

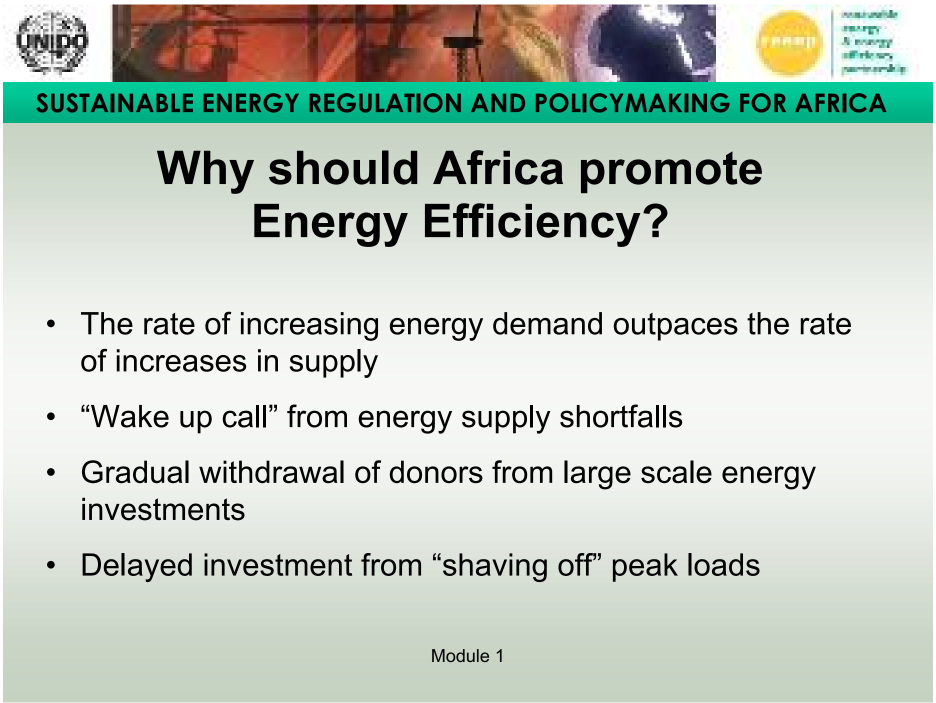


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Estimated Job Creation Potential

Energy Option	Construction, manufacturing and installation (Employees/MW)	Operation and maintenance (Employees/MW)	Total Employment (Employees/MW)
Geothermal	4.00	1.70	5.70
Wind	2.51	0.27	2.78
Natural gas	1.00	0.10	1.10
Coal	0.27	0.74	1.01

Module 1

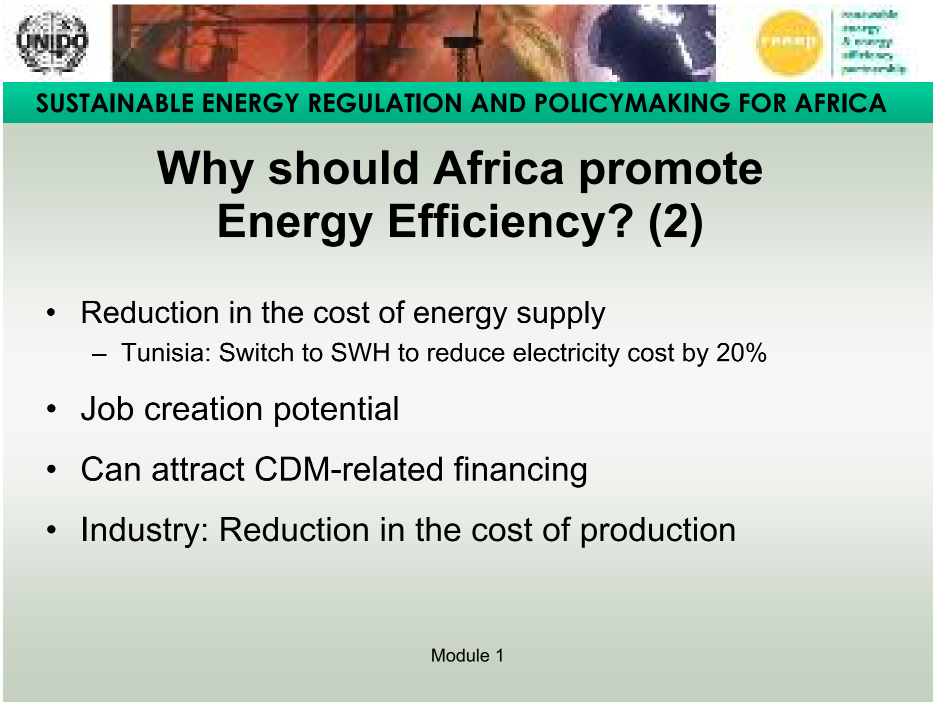


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why should Africa promote Energy Efficiency?

- The rate of increasing energy demand outpaces the rate of increases in supply
- “Wake up call” from energy supply shortfalls
- Gradual withdrawal of donors from large scale energy investments
- Delayed investment from “shaving off” peak loads

Module 1

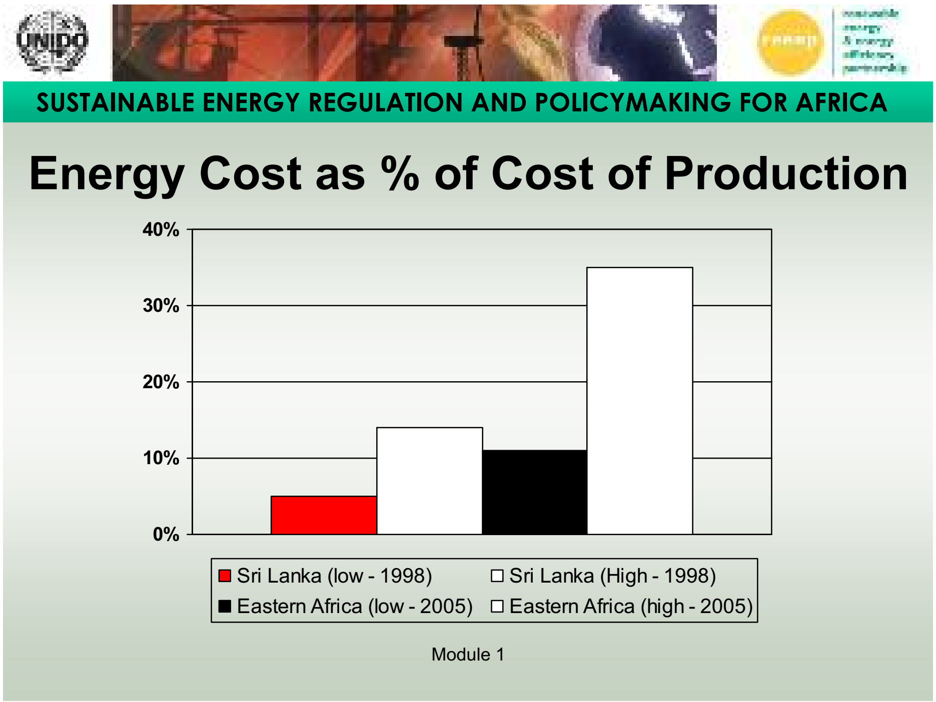


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why should Africa promote Energy Efficiency? (2)

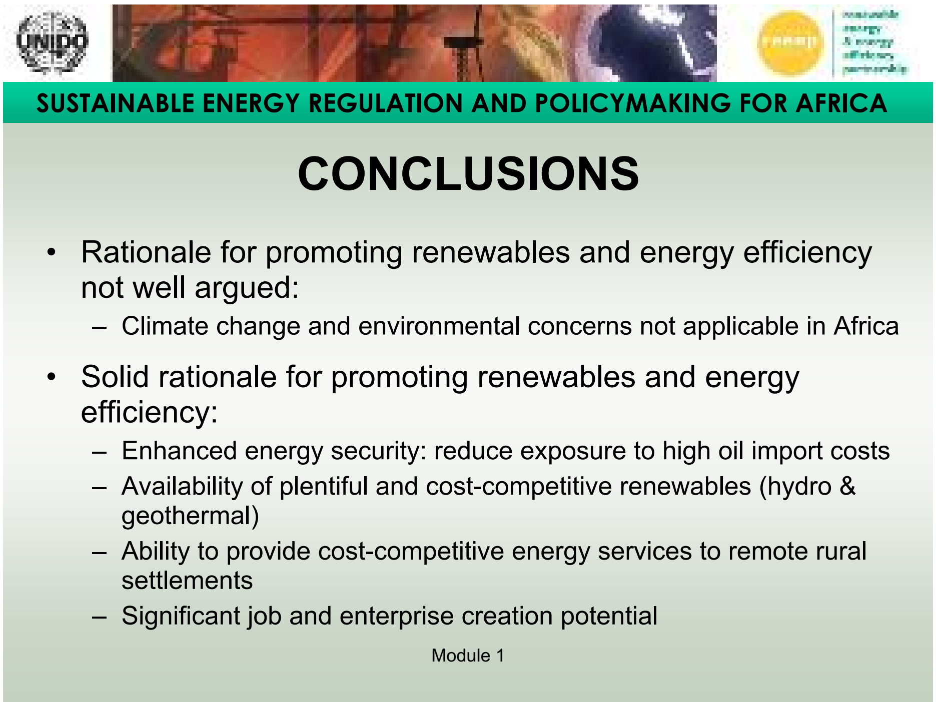
- Reduction in the cost of energy supply
  - Tunisia: Switch to SWH to reduce electricity cost by 20%
- Job creation potential
- Can attract CDM-related financing
- Industry: Reduction in the cost of production

Module 1



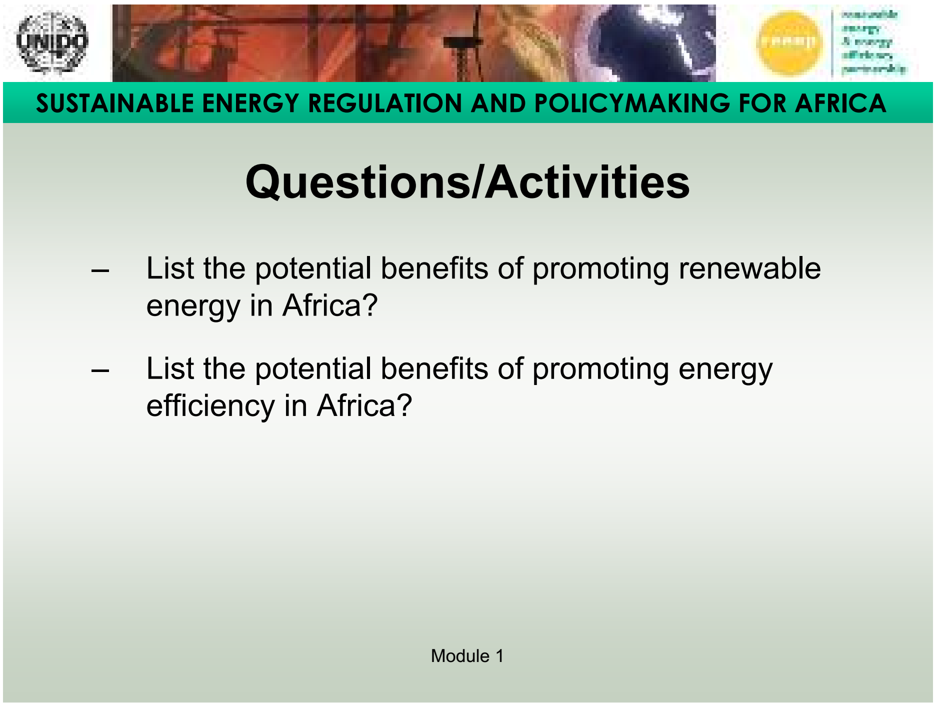
Energy Cost as % of Cost of Production

🟥 Sri Lanka (low - 1998) ☐ Sri Lanka (High - 1998)
■ Eastern Africa (low - 2005) ☐ Eastern Africa (high - 2005)



CONCLUSIONS

- Rationale for promoting renewables and energy efficiency not well argued:
  - Climate change and environmental concerns not applicable in Africa
- Solid rationale for promoting renewables and energy efficiency:
  - Enhanced energy security: reduce exposure to high oil import costs
  - Availability of plentiful and cost-competitive renewables (hydro & geothermal)
  - Ability to provide cost-competitive energy services to remote rural settlements
  - Significant job and enterprise creation potential



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

- List the potential benefits of promoting renewable energy in Africa?
- List the potential benefits of promoting energy efficiency in Africa?

Module 1

Module 2

The energy sector in Africa

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Africa's energy sector is broad and a few sectors were selected in this module to illustrate the status and recent developments in the power, renewable energy and energy efficiency issues in the region. The module specifically provides a broad overview of the energy sector in Africa and in its later sections delves into specific overviews of the power sector, renewable energy and energy efficiency.

The module is organized into three sections. Section 1 provides an overview and the status of the power sector in Africa. Section 2 provides a broad overview of renewable energy technologies and their status in Africa. The section continues to discuss the potential benefits of renewable energy technologies in Africa. Section 3 describes the status of energy efficiency in Africa and the barriers faced in enhancing renewable energy and energy efficiency in the region. The section concludes by describing the efforts required in overcoming the barriers to energy efficiency.

In each of the sections, a set of questions is provided for discussion. The questions would enable learners to discuss specific sections of the module and provide experiences in their own countries. The concluding section presents the main points discussed in the module. Other sections provided in the module include references, Internet resources, answers sections, and a glossary/ definitions of key concepts.

1.2. Module aims

The aims of the present module are listed below:

- Provide an overview of the energy sector in Africa;
- Present the status of the performance of the power sector in Africa;
- Highlight key characteristics of the power sector in Africa;
- Review the status and the benefits of renewable energy in Africa;
- Provide an overview of energy efficiency in Africa;
- Review the benefits of energy efficiency with special emphasis on the industrial sector.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- Broad appreciation of key elements of the energy sector in Africa;
- Enhanced understanding of the current status of the power sector, renewable energy and energy efficiency in Africa;
- Better grasp of the benefits of renewable energy and energy efficiency in Africa.

2. INTRODUCTION

While this module uses Africa-wide data, emphasis is placed on sub-Saharan Africa—the region where the need to improve modern energy services for the poor is particularly acute. In addition, although the title of this module includes the wider term “energy”, the bulk of the module focuses on the power sector, renewable energy and energy efficiency. It therefore does not explore other sources of energy such as oil and natural gas.

It is widely recognized that the availability of modern, reliable and efficient energy services is an important and indeed essential driver for economic development. Most countries in Africa, however, face major challenges in trying to achieve their development and social obligations because of inadequate access to modern energy services—a situation which needs to change if the continent and its sub-regions are to be economically competitive with other developing regions of the world and realize their sustainable development goals.

Many countries in Africa are still meeting a large proportion of their national energy demands from traditional biomass, which often has adverse environmental and health impacts. Renewable energy and energy efficient technologies have not attracted the level of investment or policy commitment they require and have not been widely disseminated in the region. Resources allocated to developing renewable energy technologies and energy efficient systems are negligible in comparison to resources allocated to the conventional energy sector.

3. POWER SECTOR

3.1. Definition and key players in the power sector

The power sector can be defined as an energy sector that consists of both electricity generation plants (and combined heat and power (CHP) plants) and transmission and distribution infrastructure, and whose primary business is to generate, transport and sell electricity (or electricity and heat in the case of CHP) to the public. Key players in the sector in Africa include utilities, independent power producers (IPPs), transmission system operators and distributors, rural electrification agencies and funds, as well as ministries and regulators (for policy design and policy implementation—through regulation—respectively).

Other players include manufacturers and consulting engineers who supply equipment and services for the generation, transmission and distribution of electric power by utilities and other power producers. The sector includes issues related to management and regulation of the players in the sector, production, transmission, and distribution of power as well as services related to the production, installation, overhaul and maintenance of power equipment and related consulting engineering.

3.2. Status of the power sector in Africa

Electricity is needed both to industrialize and provide basic energy for the majority of the people living off the grid in rural areas. Most sub-Saharan African (SSA) countries face a major challenge in trying to achieve their development and social obligations because of inadequate modern energy services. Low levels of electricity access in SSA demonstrate this deficiency as an estimated 17 per cent of the region's population, and less than 5 per cent of rural areas are electrified (Davidson and Sokona, 2002). This situation needs to change if sub-Saharan Africa is to be economically competitive with other developing regions of the world and realize its sustainable development goals.

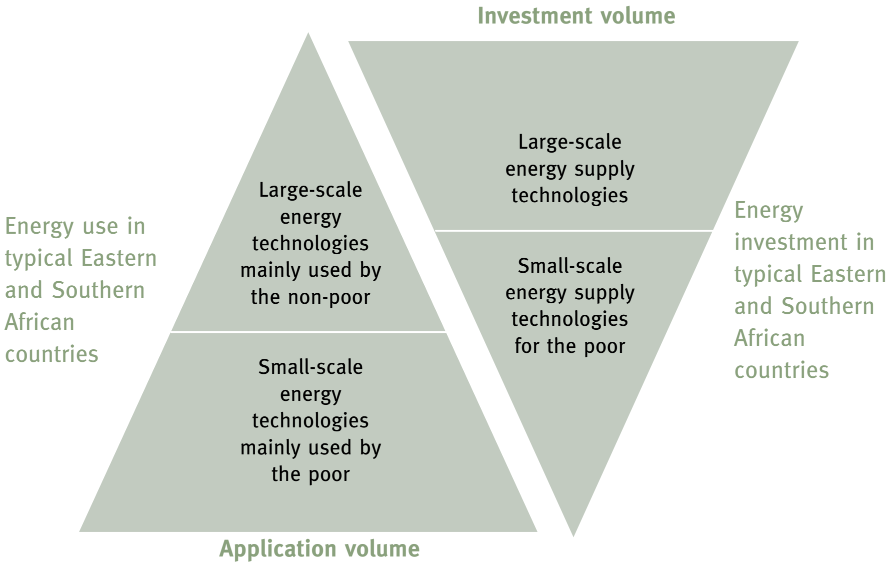
Characteristics of the African power sector

Sources of power supply in Africa broadly reflect each sub-region's energy resource endowment. For example, oil and gas reserves are concentrated in North and West Africa—consequently, the power sector of these two sub-regions is dominated by fossil fuel fired electricity generation systems. On the other hand, the electricity industries of Eastern and Central Africa are dominated by hydroelectric power plants with some limited use of geothermal based and biomass based power stations. Coal (and to a lesser extent hydropower) is the dominant fuel for much of the Southern African power industry.[1]

Figure I. **Map of Africa showing North, South and sub-Saharan African countries**

The African power sector is characterized by small systems, with over three-quarters of the continent's installed capacity coming from South Africa and North Africa (World Bank, 2003 a; IEA, 2002). This is in spite of the fact that the large-scale conventional energy sector (electricity and petroleum) receives the bulk of energy investment in most African countries (Wolde-Ghiorgis, 2002) and serves only a small proportion of the population, with provision of electricity being largely confined to urban middle and upper income groups and to the formal commercial and industrial sectors. Figure II illustrates this somewhat paradoxical situation.

Figure II. **Energy use vs. energy expenditure in typical Eastern and Southern African countries**



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[1] Africa is a diverse group of countries in many respects, especially in terms of economic system and level of economic development. Nonetheless, it has become common for countries of Africa to be grouped according to the system used by the African Development Bank (AfDB). The system contains North Africa (Algeria, Egypt, Libyan Arab Jamahiriya, Morocco, Tunisia); West Africa (Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo); East Africa (Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda, United Republic of Tanzania); and Southern Africa.

In spite of substantial investment, the power sector in sub-Saharan Africa is characterized by unreliability of supply, low capacity utilization and availability factor, deficient maintenance, poor procurement of spare parts and high transmission and distribution losses. The financial performance of many power utilities throughout Africa is largely unsatisfactory (Karekezi and Kimani, 2002, AFREPREN/FWD, 2001b; Teferra, 2000; Mapako, 2000; Kayo, 2001; Dube, 2001; NER, 2001).

In addition, power utilities in Africa have, by and large, failed to provide adequate electricity services to the majority of the region's population, especially to rural communities and to the urban poor (Karekezi and Kimani, 2002; Karekezi et al, 2004). In spite of abundant resources of both fossil and non-fossil energy resources, the majority of the population in African countries is without access to electricity for lighting and relies on low quality energy resources, such as firewood and charcoal to satisfy cooking needs.

Table 1. Access to electricity and modern cooking fuels in 2002. (*World Bank, 2000 and IEA, 2004*)

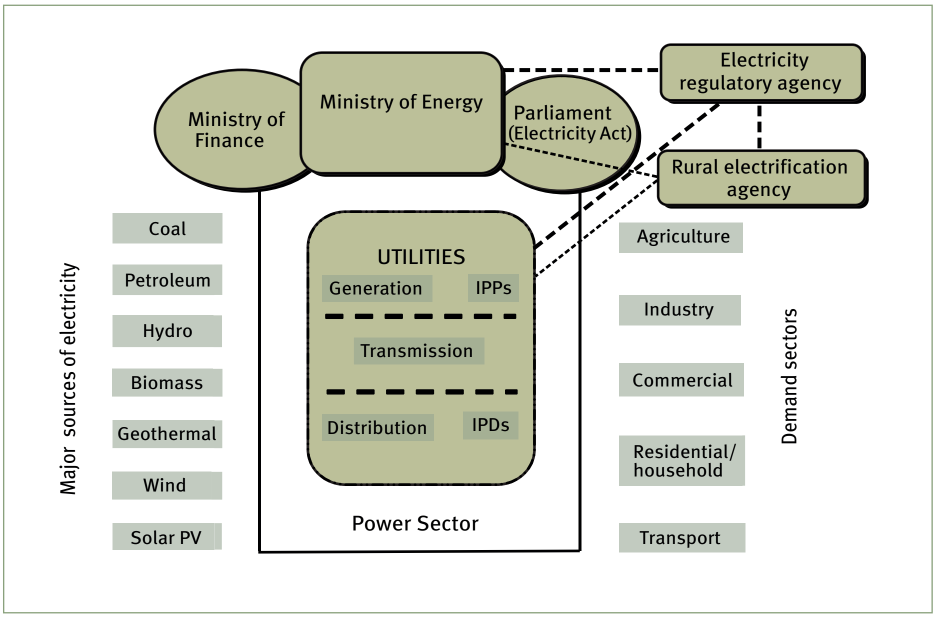
Country or region	Population using biomass for cooking (million)	Population without electricity (million)	Urban population with electricity (%)	Rural population with electricity (%)
North Africa	n.a.	**9**	**99**	**88**
Sub-Saharan Africa (SSA)	**575**	**526**	**52**	**8**
Africa	n.a.	**535**	**62**	**19**
South Asia	713	798	69	33
Latin America	96	46	98	61
China and East Asia	998	216	96	83
Middle East	8	14	99	78
Developing economies	**2,390**	**1,615**	**85**	**52**

It is estimated that 64 per cent of Africa’s population—equivalent to about more than 500 million people have no access to electricity. These figures mask huge differences between the various African countries. Most North African countries have high levels of access to electricity. Except for Ghana, Mauritius, Seychelles and South Africa, none of the SSA countries have electricity rates that exceed 50 per cent, and in about half of the African countries, the electrification rate is under 25 per cent. In more than 10 countries, less than 10 per cent have access to electricity. While 52 per cent of the population in SSA in urban areas have access, the rate is as low as 8 per cent in rural areas.

Institutional structure of the African power sector

Figure III illustrates the typical institutional structure of the power sector prevailing in many African countries covered in the study.

Figure III. **Typical institutional structure of the power sector in Africa**



Source: Compiled by authors.

Key:

IPPs = Independent power producers.
IPDs = Independent power distributors.

Prior to power sector reforms, very few African countries had an Electricity Regulatory Agency and IPPs. With the on-going reforms, IPPs now constitute important new players alongside the state-owned utility at the generation and distribution levels. Independent power distributors (IPDs) are few and far between.

Another important development is the growing number of relatively independent rural electrification agencies whose principal responsibility is to enhance access to electricity among the rural population through investments in electricity transmission and distribution infrastructure and in some cases subsidizing capital investment in rural electricity generation.

Power sector reforms have transformed the parliament into a crucial institution in the sector due to its important mandate of formulating and amending the Electricity Act that governs the power sector. In a few cases, parliamentary committees in charge of energy have begun to flex their oversight roles over their respective country's energy sector. The Ministry of Energy[2] continues to be the dominant player even in the new "reformed" power sector through the Ministry's control over policy formulation, implementation and, more importantly, control over key senior appointments in state-owned power sector entities. The Ministry of Finance is also an important institution because of its critical role in key power sector financing and investment decisions.

Installed capacity, electricity generation and consumption in Africa

As shown in figure III, there are seven major sources of electricity supplying electricity to the main demand sectors. However, the core sources of electricity in most sub-Saharan African countries are hydropower, oil products and coal. In Southern Africa, the dominant sources of electricity are coal (e.g. in South Africa and Zimbabwe) and hydropower (e.g. Lesotho, Malawi and Zambia). Kenya is the only country to commercially exploit geothermal energy for electricity generation (Ethiopia has attempted to exploit its geothermal resources but with less success). This is in contrast to North African countries, which depend on petroleum-based electricity generation. In most of sub-Saharan African countries, biomass in the form of bagasse is used for cogeneration in sugar industries. Wind power use is growing in North Africa. Solar PV systems are mainly used in rural areas to meet light electrical loads such as lighting, radio and television.

The major electricity demand sectors are industry, commerce and households. Use of electricity for transport is largely limited to electric trains in parts of Southern and Northern Africa. In agriculture, some electricity is used in large farms as well as in agro-industries.

The total electricity production for Africa in 2000 was 441 TWh (IEA, 2002). The bulk of the electricity produced in Africa is from thermal stations, because of the large coal plants in South Africa and oil fired generation units of Nigeria and North Africa. In spite of the massive exploitable hydropower capacity in Africa, its contribution to total power generation is relatively low. Hydropower contributes about 18 per cent of the total power generation in Africa (figure IV).

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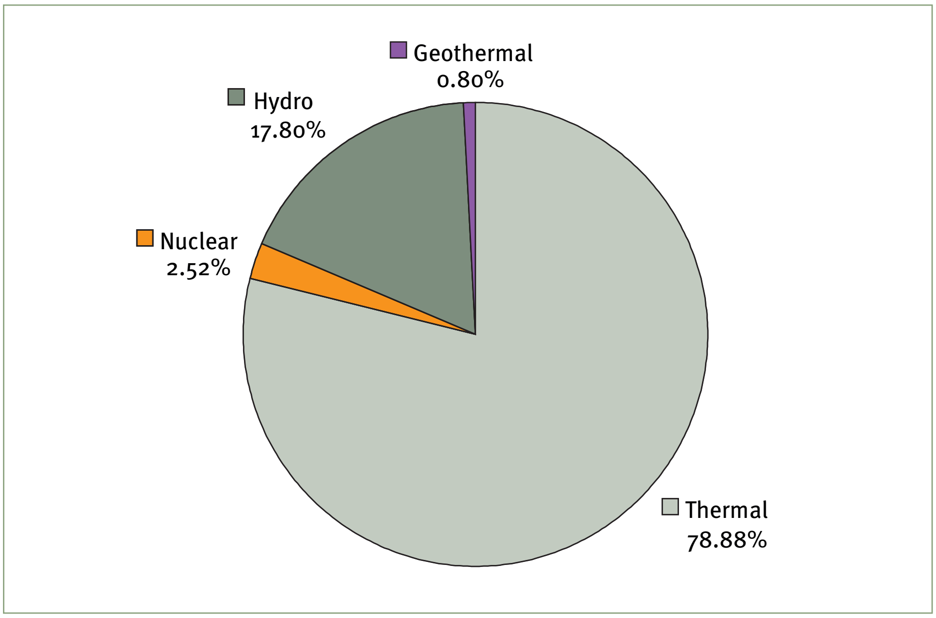
[2] For some countries in Africa, the Ministry in charge of the energy sector may not always be the Ministry of Energy. Others could be: Ministry of Natural resources or Ministry of Mines and Energy.

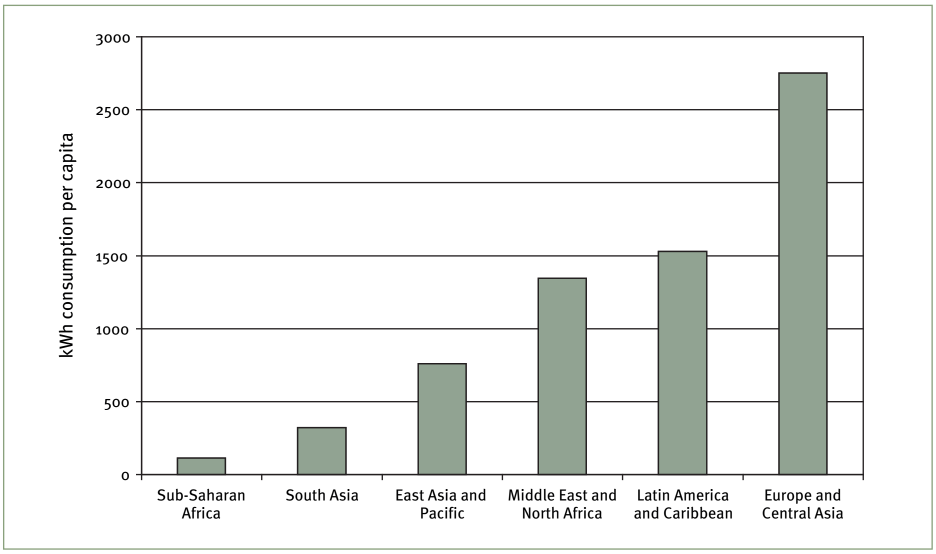
Figure IV. **Electricity production in Africa (2004)[a]**



[a] Does not include cogeneration, back-up power plants and other off-grid power generators, which could total to a significant contribution to the region's power supply. Many cogeneration plants especially in agro-processing industries are used for own consumption (used by plant/factory generating the electricity) and may not be registered in national electricity statistics. For example, in Mauritius, cogeneration accounts for 40 per cent of the country's power supply (Veragoo, 2003).

Source: IEA, 2005.

Figure V. **Electricity consumption per capita by regions of the world (2000)**



Source: World Bank, 2003a.

Electricity demand in the region, on a per capita consumption basis, is very low. The average electricity consumption per capita in sub-Saharan Africa (excluding South Africa) is estimated to be about 112.8 kWh (World Bank, 2003). A more detailed assessment of the annual per capita consumption of electricity at national level reveals extremely low levels of electricity use for some sub-Saharan African countries, as shown in table 2.

Table 2. Electricity consumption per capita for selected sub-Saharan African countries (2000)

Country	kWh per capita
Ethiopia	22.1
D.R.Congo	40.2
Eritrea	40.7
Mozambique	52.6
United Republic of Tanzania	55.6
Uganda	57.9
Benin	63.6
Sudan	66.2
Malawi	73.3
Nigeria	80.9
Congo	86.1
Angola	88.2
Kenya	117.0
Zimbabwe	874.0

Sources: IEA, 2002; AFREPREN/FWD, 2003, World Bank 2003a

3.3. Performance of the power sector in Africa

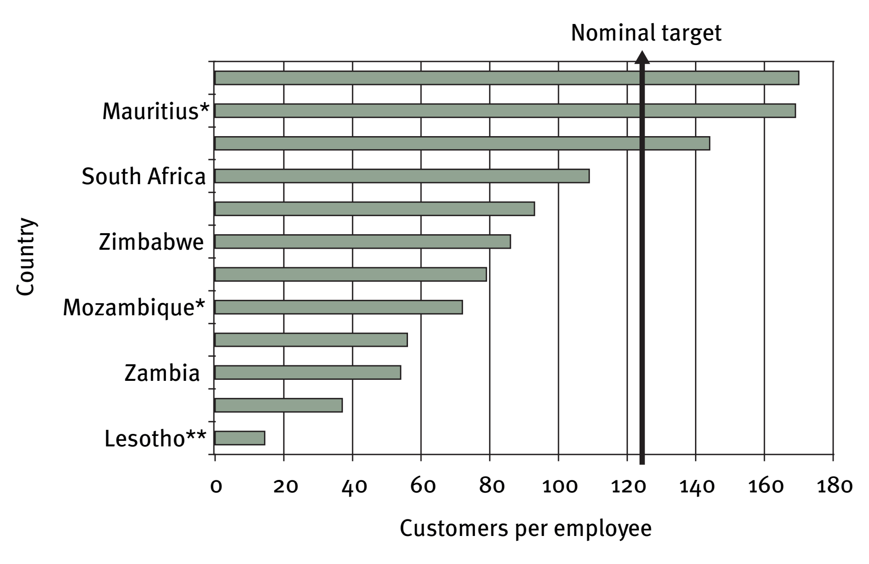
The performance of the power sector in the African region varies widely depending on the level of economic development of a particular country, political conditions as well as the approach used to reform the electricity industry. This section provides a detailed assessment of the performance of the power sector in the region based on the findings of country studies. The performance of the power sector can broadly be categorized into two: *(a)* technical performance—taking into account indicators of utilities' technical and management operations; and, *(b)* financial performance.

Technical performance

Traditionally, power utilities in Africa have enjoyed a monopolistic hold over their national electricity industry. There is growing consensus that this monopoly has contributed to the undeniable under-performance in the delivery of electricity services (Karekezi and Mutiso, 1999). As mentioned earlier, power sector institutions are mainly characterized by unreliability of power supply; low capacity utilization and availability factors; deficient maintenance; poor procurement of spare parts; and high transmission and distribution losses among other problems.

With the exception of Côte d'Ivoire, Egypt, Eritrea, Mauritius and Uganda, customers per employee ratios of most sub-Saharan African utilities are below the international norm, as shown in figure VI. This measure of performance should, however, be treated with some caution because of its inability to differentiate between utilities that are essentially generation-only entities from those which encompass both generation and distribution.[3]

Figure VI. **Customers per employee in selected African countries (2001)**



Sources: AFREPREN/FWD, 2003; Okumu, 2003; Kinuthia, 2003.
*1999 data.
**1996 data.

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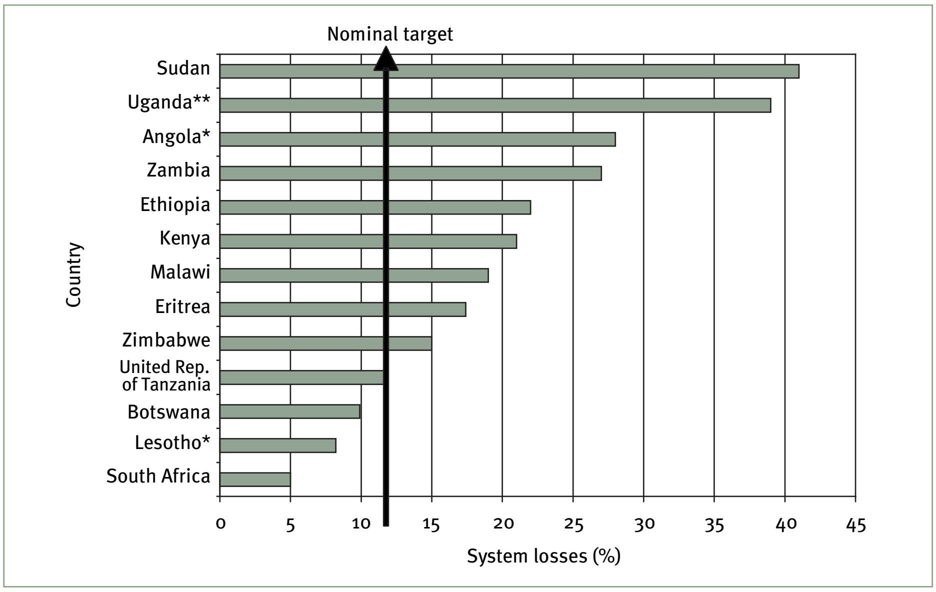
[3] In many French-speaking African countries, national power utilities are often in charge of water distribution as well. This distorts the customer per employee indicator.

Figure VII. **System losses in selected African countries (2001)**



Sources: AFREPREN/FWD, 2003; Okumu, 2003; Kinuthia, 2003.
*1996 data.
**2002 data.

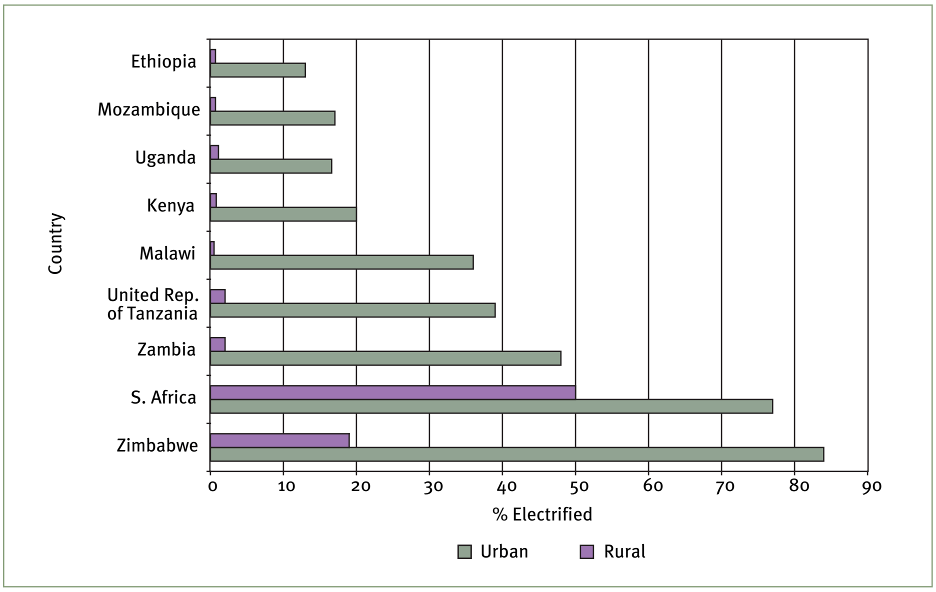
The electricity supply industry in Africa is characterized by high system losses when compared with the international target of about 10-12 per cent (figure VII). Some of the power systems in Africa record figures as high as 41 per cent.

As mentioned earlier, most power utilities in Africa have failed to provide adequate levels of electricity services to the majority of the region's population, especially to rural communities and the urban poor. Provision of electricity is largely confined to the privileged urban middle and upper income groups as well as the formal commercial and industrial subsector.

Household electrification is low especially in the rural areas of sub-Saharan Africa—where the majority of the poor in Africa reside. With the exception of Zimbabwe and South Africa, statistics also show that even in urban areas, the percentage of households served with electricity is still relatively small (figure VIII).

At national level, with the exception of North African countries, Côte d'Ivoire, Ghana, Mauritius, Nigeria, South Africa and Zimbabwe, and the rest of sub-Saharan Africa generally register electrification levels well below 30 per cent. This is a very low figure, compared to other developing countries in Asia and Latin America, which are able to supply more than 70 per cent of their population with electricity.

Figure VIII. **Urban and rural electrification in selected African countries (2001)**



Sources: AFREPREN/FWD, 2003; Okumu, 2003; Kinuthia, 2003.

Financial performance

The financial performance of utilities in most African countries is equally unsatisfactory. The debt owed by customers in most utilities is usually a sizeable amount. In most cases, governments and their parastatals account for a large share of the utility debt. For instance, by 1997, the Government of the United Republic of Tanzania owed its national utility 30 billion Tanzania shillings ($US 47.62 million). This, according to Tanzania's Prime Minister, has exacerbated the country's power problems (Kibanga, 1997).

The inability of utilities to mobilize sufficient investment capital for the development and expansion of the electricity sector is an important reason for embarking on comprehensive reforms. The development of power supply has absorbed a relatively large share of the public investment in many African countries. Governments have traditionally guaranteed the financing of power sector investment. In addition, most governments have adhered to the belief that low-priced electricity is critical to achieving economic and social development. Consequently, electricity tariffs in some African countries still demonstrate the legacy of non-sustainable pricing policies. Low tariffs are often an indication of substantial subsidies from the Government. On the other hand, countries in West Africa, particularly French-speaking countries, seem to record very high tariffs which may be attractive to investors but could have a detrimental impact on low-income electricity consumers. Reform of the electricity sector in Eastern and Southern Africa has also led to steep increases in electricity prices.

In most countries, the cost of poor financial management in the utility has, in the past, been transferred to the whole population in the form of increased national debt or inclusion of electricity debt in debt relief programmes (which takes resources away from other sectors such as health and education). This is an inequitable arrangement given that the entire population is responsible for repayment of a debt incurred by a power utility that serves on average, less than 30 per cent of the population (AFREPREN/FWD, 2001a).

To conclude, most African power utilities routinely record unsatisfactory technical and financial performance which compares poorly with their counterparts in other developing countries in Latin America and South-East Asia. In the past, it has been observed that, even when a new effective management team took over an African utility, the improved performance that ensued petered out over time. The utility usually reverted to its historically poor performance. This was largely attributed to the continued influence of Government.

Consequently, many utility analysts became convinced that only more drastic structural changes to the power sector could lead to sustained improvements in technical and financial performance. It is this reasoning that, in part, led to power sector reform.

Review questions

1. Define the power sector.
2. List some of the main players in the power sector.
3. What are some of the key characteristics of the power sector in Africa?

Discussion questions/exercises

1. List some of the key players in the power sector in your country and discuss their role.
2. Discuss with colleagues the performance of the power sector in your country.

4. RENEWABLE ENERGY

4.1. What is renewable energy?

Renewable energy refers to energy forms that cannot be easily depleted. Renewable energy sources occur naturally, and encompass energy forms, such as wind, solar, hydro, biomass, geothermal, tide and wave energy. A wide range of renewable energy technologies has been disseminated in Africa, with varying levels of success. Africa is endowed with substantial renewable energy resources. The region has 1,100 MW of hydropower capacity, 9,000 MW of geothermal potential (hot water and steam based), abundant biomass, and significant solar and wind potential (Karekezi and Ranja, 1997; BCSE, 2003). The following sections highlight the status of renewable energy in Africa and their benefits to the region.

4.2. Status of renewable energy technologies in Africa

The following subsections review the status of renewables in Africa. To begin with, small and medium renewable energy technologies are reviewed, after which the focus turns to two medium to large-scale renewable energy technologies namely, biomass cogeneration and geothermal.

Small hydropower

Small hydropower is often categorized into mini and micro hydro, referring to the harnessing of power from water at a small scale (capacity of less than 10 MW). Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply. It is also a very reliable technology with a solid track record, well suited to rural areas outside the central power grid (Hydronet 3, 1994; Pandey, 2002).

Figure IX. **Small hydro powerhouse**

Figure X. **De-silting tank**

Much of the unexploited potential for small hydro is in remote areas of Africa (Hydronet 3, 1994). Eastern and Southern Africa have many permanent rivers and streams providing excellent hydropower development potential. However, as shown in table 3, small hydro utilization in the region is still very low.

Table 3. Small hydropower developed and potential in selected African countries

Country	Small hydro potential (MW)	Harnessed (MW)
Uganda	46	8.00
Mauritius	—	6.70
Kenya	600	14.00
Burundi	42	18.00
Zambia	4	1.05
United Rep. of Tanzania	70	9.00
Lesotho	—	8.74
Malawi	—	5.10
Botswana	—	1.00
Rwanda	20	3.00
South Africa	—	0.40
Swaziland	—	0.30
Mozambique	—	0.10

Source: Karekezi and Ranja, 1997; www.small-hydro.com; *Innovation Energies Developpement (IED)*, 2006; Presentation, Unilever Kenya, 2006.

Solar energy

Direct solar energy can be broadly categorized into solar photovoltaic (PV) technologies (converting the sun's energy into electrical energy) and solar thermal technologies (using the sun's energy directly for heating, cooking and drying, etc.) Solar energy is the best-known renewable energy technology in Africa. It has been in use for a long time for drying animal skins and clothes, preserving meat, drying crops and evaporating seawater to extract salt (Karekezi and Ranja, 1997).

Substantial research has been undertaken over the years into exploiting Africa's huge solar energy resource. Today, solar energy is utilized at various levels. On a small-scale, it is used at the household level for lighting, cooking, water heaters and solar architecture houses. Medium-scale appliances include water heating in hotels and irrigation. At the community level, it is used for vaccine refrigeration, water pumping, purification and rural electrification. On the industrial scale, it is used for pre-heating boiler water for industrial use and power generation, detoxification, municipal water heating, telecommunications, and, more recently, transportation (solar cars) (Karekezi and Ranja, 1997; Ecosystems, 2002).

Solar PV has been promoted widely in the region, with almost every sub-Saharan African country having had a major PV project. There is growing evidence, however, that solar PV projects in the region have mainly benefited high-income segments of the population, due to the high cost of solar PV. Solar PV is unaffordable to the majority of the population in Africa (Karekezi and Kithyoma, 2002; Mulugetta, et al 2000, Mapako, 2001; Cloin, 1998).

Table 4. Estimated number of solar PV systems disseminated

Country	Number of systems	Estimated installed capacity (kWp)
Angola	—	10
Botswana	5,700	1,500
Burundi	1,800	—
Djibouti	941	—
Eritrea	2,000	400
Ethiopia	5,000	1,200
Kenya	150,000	3,600
Mozambique	—	100
Malawi	900	40
South Africa	150,000	8
Swaziland	1,000	50
United Rep. of Tanzania	2,000	300
Uganda	3,000	152
Zambia	5,000	400
Zimbabwe	84,500	1,689

Source: AFREPREN, 2004; AFREPREN, 2003; Mapako and Mbewe, 2004; MPWE, 1994; Kgathi et al., 1997; www.uneprisoe.org; Karekezi and Ranja, 1997; Karekezi et al., 2004.

Solar thermal technologies that have been disseminated in Africa include solar water heaters, solar cookers (Kammen 1991; 1992), solar stills and solar dryers. With increased efficiency and reduced cost of solar water heaters, small-scale solar water heaters have a payback period of 3-5 years (Karekezi and Karottki, 1989; Karekezi and Ranja, 1997). However, the diffusion of these systems has been slower than anticipated. In some developing countries, LPG subsidies make it difficult for solar water heaters to be competitive (Vanderhulst et al., 1990).

In sub-Saharan Africa, not much aggregate data on the dissemination of these systems has been gathered (Ward et al., 1984; Karekezi and Ranja, 1997). The data available are from just a few country studies. For example, in Botswana, about 15,000 domestic solar water heaters have been installed (Fagbenle, 2001). In Zimbabwe, about 4,000 solar water heaters are in use (AFREPREN, 2001). Additional estimates on solar water heater installed capacity are provided in table 5. The bulk of the solar water heaters in use are bought by high-income households, institutions and large commercial establishments such as hotels and game lodges.

Table 5. Domestic solar water heater installed capacity

Country	Installed capacity (1000 m²)
Botswana	50
Malawi	4.8
Mauritius	40
Namibia	24
Seychelles	2.4
South Africa	500
Zimbabwe	10

Source: DBSA, 1999; Mogotsi, 2000; Mandhlazi, 2000; Mapako, 2000; AFREPREN, 2002.

Wind energy

Low wind speeds prevail in many sub-Saharan African countries, particularly in land-locked countries. South Africa, North Africa and the Red Sea coast have some of the highest wind potential in the region. Average wind speeds of 7.2–9.7 m/s have been recorded around Cape Point and Cape Alguhas in South Africa (Diab, 1986; Afriwea, 2005). The North African coast is another attractive wind speed region.

Large-scale wind power generation projects to exploit this abundant energy source are now under way in Morocco, Egypt and South Africa. Kenya has a few wind generators that are connected to the grid (Afriwea, 2005; KPLC, 2003; KENGEN, 2003).

In comparison with other parts of the world, Africa has seen little development of modern wind turbines and most of its wind machines (found in Eastern and Southern Africa) are used for water pumping, rather than for electricity generation. Wind pumping supplies water for household use, irrigation and for livestock (Harries, 2002). South Africa and Namibia possess large numbers of wind pumps. An estimated 300,000 wind pumps are in operation in South Africa. The dissemination of wind pumps in selected African countries is shown in table 6.

Table 6. Average wind speed potentials and number of wind pumps for selected countries

Country	(Average) wind speed potential (m/s)	Number of wind pumps
Botswana	2-3	200
Burundi	>6	1
Djibouti	4	7
Ethiopia	30.5-5.5	—
Eritrea	3-8	<10
Guinea	2.0.40	—
Kenya	3	272
Mauritius	8.0	—
Morocco	>10	—
Mozambique	0.7-2.6	50
Namibia	—	30,000
Rwanda	—	—
Seychelles	3.62-6.34	—
South Africa	7.29-9.7	300,000
Sudan	3	12
United Rep. of Tanzania	3	58
Uganda	4	7
Zambia	2.5	100
Zimbabwe	3-4	650

Sources: Diab, 1988; Stassen, 1986; Linden, 1993; Fraenkel et al., 1993; Kenya Engineering, 1994; IT Power, 198; Mosimanyane et al., 1995; Sampa, 1994; Sawe, 1990; Mwandosya and Luhanga, 1983; Turyahikayo, 1992; Razanajatovo et al., 1994; Karekezi and Ranja, 1997; Karekezi and Kithyoma, 2002.

Small-scale biomass energy

In the past 20 years, substantial efforts have been made towards modernizing small-scale biomass energy systems. Two of the most sustained efforts have been the development of an energy efficient charcoal kiln and an environmentally sound improved cooking stove for rural and urban households in sub-Saharan Africa. Both of these initiatives have delivered significant benefits to the urban and rural poor. The informal sector, which provides employment to the urban poor, is the principal source of improved stoves (Karekezi, 2002).

In terms of energy used per system, small-scale traditional bio-energy systems appear marginal. However, their importance lies in the very large number of users of such systems—bio-fuelled cookstoves meet the bulk of cooking, heating and lighting needs of most rural households in Africa (Karekezi, 2002; Karekezi and Kithyoma, 2002).

Charcoal is an important household fuel and to a lesser extent, industrial fuel. It is mainly used in the urban areas where its ease of storage, high-energy content and lower levels of smoke emissions make it more attractive than wood fuel. It is the primary fuel for the urban poor in Africa (Kalumiana, 2002).

Traditional charcoal production, a major source of employment for the rural poor, relies on the rudimentary earth kiln considered to be a contributor to land degradation in many peri-urban regions of sub-Saharan Africa. Efforts to improve and modernize small-scale biomass energy constitute an important component of national energy strategies in many sub-Saharan African countries and could potentially yield major benefits to both the urban and rural poor (Karekezi, 2002).

Another small-scale biomass energy technology that has attracted considerable attention over the last three decades is biogas. Conceptually, biogas technology appears simple and straightforward. The raw material is animal dung, plentiful in many rural areas of sub-Saharan Africa; the technology appears not to be overly complicated; and it requires a relatively limited level of investment. The technical viability of biogas technology has been repeatedly proven in many field tests and pilot projects. However, numerous problems have arisen when mass dissemination is attempted (Karekezi, 2002).

Table 7. Small and medium-scale biogas units in selected sub-Saharan African countries

Country	Number distributed
United Republic of Tanzania	>1,000
Kenya	500
Botswana	215
Burundi	279
Zimbabwe	200
Lesotho	40
Burkina Faso	20

Source: Karekezi and Ranja, 1997; Karekezi, 2002.

First, dung collection has proved more problematic than anticipated, particularly for farmers who do not keep their livestock penned in one location. Second, small-scale farmers with small herds were not able to get sufficient feedstock to feed the bio-digester unit and ensure steady generation for lighting and cooking. The investment cost of even the smallest biogas unit is also prohibitive for most poor African rural households (Karekezi and Ranja, 1997; Karekezi, 2002).

Though evidence from many African countries is still limited, the general consensus is that the larger combined septic tank/biogas units that are run by institutions such as schools and hospitals are more viable than small-scale biogas digesters (Karekezi, 2002).

Large-scale biomass energy (cogeneration)

Large-scale biomass utilization encompasses direct combustion for process heat; ethanol production; gasification; heat cogeneration; biogas production; and briquetting. The best-known large-scale biomass energy systems with sound economic track records are cogeneration using biomass as fuel stock and the production of ethanol as a substitute for petroleum fuel (Karekezi and Ranja, 1997). This section focuses on biomass cogeneration.

Cogeneration is the simultaneous production of electricity and process heat from a single dynamic plant. A cogeneration plant heats up steam that drives a turbine to produce electricity. Various forms of biomass can be used to fuel the plant including bagasse (sugarcane waste) from sugar industries and wastes from paper and pulp, palm wood and rice industries. For instance, in cane milling industries, cane stalks are shredded and crushed to extract cane juice while a by-product, bagasse, is sent to the boiler to provide steam and electricity for the factory (Deepchand, 2001).

Cogeneration offers substantial opportunities for generating electricity and/or heat energy with limited capital investments, while avoiding the negative environmental effects of increased fossil fuel combustion. Industries can be located in remote areas not linked to the electricity grid. Extra electricity can be made available to other users through mini-grids. For industries close to the grid, sale of surplus to the national utility would increase their income (Deepchand, 2001).

The sugar industry is a major user of cogeneration technology. By the beginning of the year 2000, worldwide sugar mill cogeneration had reached almost 1,100 MW installed and operating, with another 450 MW under construction. Most developments are being registered in India and Mauritius (Deepchand, 2002).

Mauritius provides an example of a very successful use of cogeneration, meeting over 40 per cent of its electricity generation, with over half of this coming from bagasse from the sugar industry (Herbrard, 2003; Veragoo, 2003)—see box 1.

Sugar is produced in a number of Eastern and Southern African countries. It is a major agricultural export for Ethiopia, Madagascar, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe. The potential for electricity generation from bagasse is high, since cogeneration equipment is almost always an integral component of sugar factory design. Estimates show that up to 16 sub-Saharan African countries could meet significant proportions of their current electricity consumption from bagasse-based cogeneration in the sugar industry (Deepchand, 2001).

Box 1. **Cogeneration in Mauritius**

The Mauritian experience in cogeneration is one of the success stories in the energy sector in Africa. As a result of extensive use of cogeneration in Mauritius, the country's sugar industry is self-sufficient in electricity and sells excess power to the national grid. In 1998, close to 25 per cent of the country's electricity was generated from the sugar industry, largely using bagasse, a by-product of the sugar industry. By 2002, electricity generation from sugar estates stood at 40 per cent (over half of it from bagasse) of the total electricity demand in country.

Government support and involvement has been instrumental in the development of a cogeneration programme in Mauritius. First, in 1985, the Sugar Sector Package Deal Act (1985), was enacted to encourage the production of bagasse for the generation of electricity. The Sugar Industry Efficiency Act (1988) provided tax incentives for investments in the generation of electricity and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritian Government abolished the sugar export duty, an additional incentive to the industry. A year later, foreign exchange controls were removed and the centralization of the sugar industry was accelerated. These measures have resulted in the steady growth in the export of bagasse-based electricity to the country’s grid.

Bagasse-based cogeneration development in Mauritius has delivered a number of benefits including reduced dependence on imported oil, diversification in electricity generation and improved efficiency in the power sector in general. Using a wide variety of innovative revenue sharing measures, the cogeneration industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the poor smallholder sugar farmer. The equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned modern biomass energy projects in other African countries.

Sources: Veragoo, 2003; Deepchand, 2001.

Table 8. Cogeneration (bagasse) potential for Eastern and Southern Africa, 2003

Country	Installed capacity in 2003 (MW)	Total generation in 2003 (GWh)	Cogeneration potential	
			Quantity (GWh)	% of total generation
Ethiopia	493*	1,812*	150.3	8.3
Kenya	1,143	4,563	530.3	11.6
Malawi	306	1,177	250.8	21.3
Mauritius	725	1,564*	600.0	38.4
Sudan	1,380	3,165	643.5	20.3
United Rep. of Tanzania	863*	2,770*	100.8	3.6
Uganda	303	1,756	173.4	9.9
Zimbabwe	1,961	7,906	686.4	8.7
Swaziland	180	395	—	—
Total	7,354	25,108	3,135.5	122.1

Source: Deepchand, 2002, 2006; Karekezi and Kimani, 2002; AFREPREN/FWD, 2004.
*2001 data.

Geothermal energy

Geothermal energy is the natural heat from the earth’s interior stored in rocks and water within the earth’s crust. This energy can be extracted by drilling wells to tap concentrations of steam at high pressures and at depths shallow enough to be economically justifiable. The steam is then piped to turbines to generate electricity. Worldwide, around 8,100 MW of geothermal power is generated, out of an estimated global potential of 60,000 MW (BCSE, 2003). This estimated potential does not include non-steam and non-hot water based geothermal potential. The potential of geothermal energy that exploits the difference in temperatures between the earth’s surface and its underground is huge but it requires very high upfront investments.

Table 9. Land use requirements for different energy technologies

Technology	Land occupied (m^2 per MWh-year for 30 years)
Coal (including pit coal mining)	3,700
Solar thermal	3,600
Photovoltaic	3,200
Wind (land with turbine and roads)	1,300
Geothermal	400

Source: Bronicki, 2001

Geothermal power exploitation has numerous advantages over other energy sources (Bronicki, 2001). Among the benefits of geothermal power are near-zero emissions (true for modern closed cycle systems that re-inject water back to the earth's crust), and very little space requirement per unit of power generated (in contrast to other energy sources such as coal or hydro-dam based electric power (table 9).

Using today's technology, Africa has the potential to generate 2,500 MW of energy from geothermal power (BCSE, 2003). Of this geothermal power potential, only 127 MW has been tapped in Kenya, and less than 2 MW in Ethiopia (KENGEN, 2003; Wolde-Ghiorgis, 2003). These estimates of existing geothermal power generating capacity do not include direct thermal use of geothermal energy, which is widely practised in Africa. The geothermal potential for selected African countries is provided in table 10.

Table 10. Geothermal potential for selected African countries

Country	Potential generation in MW
Kenya	2,000
Ethiopia	>1,000
Algeria	700
Djibouti	230-860
Uganda	450
United Republic of Tanzania	150

Source: BCSE, 2003; Khennas, 2004.

Varying levels of geothermal exploration and research have been undertaken in Djibouti, Eritrea, Madagascar, Malawi, Uganda, the United Republic of Tanzania and Zambia, but the potential for grid connected geothermal exploitation is highest in Ethiopia, Kenya, Uganda and the United Republic of Tanzania, which are all covered by the Great Rift Valley. Government representatives from Eritrea, Ethiopia, Uganda and the United Republic of Tanzania are considering the use of small-scale geothermal plants for rural electrification mini-grid systems, although this has not yet been attempted (BCSE, 2003).

Kenya was the first country in sub-Saharan Africa to exploit geothermal energy. As mentioned earlier, Kenya has 127 MW of installed geothermal electricity capacity (KENGEN, 2003; Mbuthi, 2004). The government has plans to increase geothermal power capacity to 576 MW by 2019 (KPLC, 2000).

In Kenya, both the private and public sector are involved in the development of geothermal energy (BCSE, 2003). A feasibility study carried out to evaluate Olkaria's potential for generating electricity found that the geothermal field covered 80 km^2 with sufficient steam for 25,000 MW-years (with re-injection, this potential could be indefinite). The present area, covering 11 km², has steam for 400 MW-years. Out of the total 127 MW installed capacity, Kenya Electricity Generating Company, KenGen, Kenya's public utility company, has an installed capacity of 115 MW and OrPower 4, an independent power producer, has an installed capacity of 12 MW. Together, these plants meet 11 per cent of the national electricity supply (Mbuthi, 2004), once again demonstrating the viability of the 10 per cent renewable energy target proposed at the 2002 World Summit for Sustainable Development (WSSD) conference.

4.3. Potential benefits of renewables to the African energy sector

There is growing evidence that investment in small and medium-scale renewable energy technologies can have significant and sustainable impact in improving energy services for the majority of sub-Saharan Africa's population, especially the poor (Mapako and Mbewe (eds.), 2004; Karekezi and Kithyoma, 2002; UNDP, 2004; World Bank, 2004; The Economist Newspaper Ltd., 2004). The modular nature of most renewables (i.e. the fact that they can be applied incrementally) and the consequent low and progressive nature of investment requirements make them particularly suitable for capital-constrained African countries. Some of the key benefits of RETs are discussed in the following subsections.

Balance of payments

The energy sector in numerous African countries is characterized by high levels of imports of petroleum products, accounting for a significant proportion of export earnings (Karekezi and Kimani, 2001; AFREPREN, 2001). Such high imports increase the vulnerability of African countries to external oil price shocks and have an adverse impact on balance of payments.

Renewable energy could play a vital role in minimizing fuel imports by providing an alternative to thermal-based electricity in the form of, for example, small hydro power units, cogeneration (using biomass as fuel) and geothermal energy (Mbuthi, 2004; Yuko, 2004). They offer diversification in energy generation, thus strengthening energy security.

For example, with the exception of Sudan, all of the oil/petroleum products consumed in Eastern and Horn of Africa countries are imported as these countries do not have commercial deposits that can be used economically (the United Republic of Tanzania, however, has significant gas deposits that it has began to exploit). Fossil fuels are still a major source of commercial energy in these countries, accounting for over 70 per cent of commercial energy used (IEA, 2003).

In countries where oil and petroleum is used for electricity generation, the use of renewable energy technologies such as biomass-based cogeneration could replace the use of oil products, and lead to considerable savings in foreign exchange. Table 11 estimates the potential for replacing electricity generation from fossil fuels by biomass-based cogeneration in three Eastern and Horn of Africa countries.

Table 11. Potential of cogeneration that could replace electricity generation from fossil fuels

Country	Electricity generation from oil and petroleum (GWh)	Biomass-based cogeneration potential (GWh)
United Republic of Tanzania	143	315
Kenya	1,509	2,606
Ethiopia	19	1,750

Sources: Adapted from IEA, 2003; EIU, 2003.

Poverty alleviation, job and enterprise creation

Small and medium-scale RETs can play an important role in poverty alleviation. This is particularly true of small-scale RETs that are made locally and operate on the basis of solar, thermal or animate power. Such systems can not only provide energy that is affordable to the poor but can also be a source of employment and enterprise creation for both the rural and urban poor in the East and Horn of Africa. Examples include (Mapako and Mbewe (eds.), 2004; Karekezi and Kithyoma, 2002) UNDP, 2004; World Bank, 2004; The Economist Newspaper, 2004):

- Low cost and more efficient biomass-based combustion technologies (e.g. improved cooking stoves, efficient charcoal kilns, brick making kilns, fish smokers, tea dryers and wood dryers).
- Pico and micro hydro for shaft power that can be used to process agricultural produce and increase its value, as well as for water pumping.
- Low cost efficient hand tools and animal drawn implements, which would increase the agricultural productivity of rural areas of Eastern and Horn of Africa;
- Treadle and ram pumps for irrigation, which increase agricultural outputs thus generating income for the rural farmer.
- Solar dryers that can lower post-harvest losses and enable the rural farmer to market his/her produce when prices are higher.
- Solar water pasteurizers that provide clean potable water and reduce water borne diseases, which translates to increased availability of labour and thus increases agricultural output and income.

Geothermal resource development and exploitation can create significant job and enterprise opportunities both directly and indirectly. In 2002, the 45 MW plant at Olkaria I (Kenya) employed 493 people: 15 scientists, 21 engineers, 82 technicians, 175 artisans/craftsmen and 200 support staff (Mariita, 2002), which translates to over 5,000 people who directly or indirectly depend on the 45 MW plant.

The following table provides estimates of the job creation potential of various electricity generation options. As the table shows, RE options (geothermal and wind) have much higher job creation potential than conventional energy systems (coal and natural gas):

Table 12. Estimated job creation potential of energy technologies

Energy option	Construction, manufacturing and installation (employees/MW)	Operation and maintainance (employees/MW)	Total employment (employees/MW)
Geothermical	4.00	1.70	5.70
Wind	2.51	0.27	2.78
Natural gas	1.00	0.10	1.10
Coal	0.27	0.74	1.01

Source: Adapted from Kammen, et al., 2004; EERE, 2006.

It is also possible to ensure that benefits from medium to large-scale RE projects flow to the low-income groups. Using a wide variety of innovative revenue sharing measures, the cogeneration industry in Mauritius has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the low-income smallholder sugar farmers (Deepchand, 2003, see box 2). In many respects, the equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned large and medium-scale energy development programmes of sub-Saharan African countries.

Box 2. **Sharing of revenue from bagasse energy in Mauritius**

Cogeneration of bagasse energy in Mauritius on a commercial basis is a win-win situation for all the stakeholders in the sugar industry. A ministerial statement issued in 1985 mandated all stakeholders to get a share of revenue from electricity sales to the grid. Consequently, a Bagasse Transfer Price Fund (BTPF), in which proceeds from the sale of excess bagasse used to generate electricity sold to the grid are placed, was set up. Cogenerators receive all their payments from the Central Electricity Board (CEB) in addition to a share of 50 per cent of the BTPF on a pro-rata basis, with respect to their electricity export.

Moreover, millers are provided with fiscal incentives for energy savings, and if operating next to a power plant, they are no longer required to operate, repair and maintain a boiler and turbo-alternator. In addition, the agreement between the co-generator and the miller specifies a given amount of exhaust steam (around 450 kg per tonne cane). Any improvement in exhaust steam consumption lower than 450kg/tonne cane brings additional revenue to the miller.

The planters who do not own mills (non-miller planters) share 38 per cent of the BTPF on the basis of individual sugar production. In addition, they earn dividends from their shares in the Sugar Investment Trust (SIT) set up in 1994. The miller-planters, on the other hand, are entitled to 12 per cent of the BTPF, shared on a pro-rata basis with respect to their individual sugar production. The agricultural and non-agricultural workers of the sugar estates and factories as well as their respective staff, and the employees of the parastatal organizations dealing with the sugar industry are all beneficiaries due to being shareholders of SIT.

Source: Deepchand, 2003.

Independent technology development

In addition, and in contrast to conventional energy technologies (e.g. oil, coal, natural, gas and large hydropower), RETs due to their modularity and small-scale generally do not require large amounts of capital.

In addition, a significant industry could be developed in Africa even where currently technical expertise is limited. The chances of an African country (with the exception of South Africa) becoming a significant player in the world’s conventional energy market are slim but, with increased financial support, it may be possible for an African country to become a significant player in the small and medium-scale RET market. For example, Kenya is now a global leader in geothermal energy development, with experts from Kenya offering their expertise in developing geothermal power plants in other countries in the region, and even in developed countries (Mariita, 2002).

Environment

In addition to their global contribution to reducing greenhouse gases, RETs reduce local and regional energy-related environmental impacts. For example, cleaner and more efficient bio-stoves fitted with chimneys can reduce indoor air pollution, which is a major contributor to respiratory illness (Kammen and Ezatti, 2002; Smith 1991; Smith, 1994). Cleaner fuels can reduce transport-related pollution and wind, solar, hydro or geothermal energy can reduce the need for coal or other fossil fuel plants that cause significant local and regional pollution (Johansson et al., 2005).

Increasing use of bagasse-based cogeneration in sugar factories has a positive global environmental impact and would reduce greenhouse gas emissions that are linked to the greenhouse effect. For example in Mauritius, the impact of bagasse energy projects on the environment has been quantified. In the short term, bagasse projects avoid the use of 215,000 tons of coal, the emission of 650,000 tons of CO_2 and generation of 35,000 tons of coal ash. The long-term figures are 375,000 tons of coal, 1,130,000 tons of CO_2 and 60,000 tons of coal ash when the target of producing 110 kWh of electricity for each ton of sugarcane is achieved. Eastern and Horn of Africa countries could derive significant environmental benefits from the increased development of cogeneration (Deepchand, 2001). While Africa's contribution to greenhouse gases is negligible, the climate benefits of renewables can be used to access existing climate-related financing.

As pointed out before geothermal power offers the combined environmental advantages of very low emissions and a very low land requirement when compared to conventional energy sources (Bronicki, 2001).

These environmental benefits could be used to attract Clean Development Mechanism (CDM) financial support to the country. Similarly, Eastern and Horn of Africa countries could derive significant environmental benefits from the increased development of cogeneration (Deepchand, 2001).

Power deficits

The general unreliability of large-scale conventional energy supply in Africa has already been mentioned. In particular, large-scale energy sources such as hydropower can prove unreliable. Hydropower is dependent on rainfall, and is therefore vulnerable to drought. Many sub-Saharan African countries have experienced serious droughts in the past, which have affected hydro power generation (table 13). Droughts are likely to become more frequent in the future (UNDP, 2004).

Table 13. Drought and its effect on hydropower generation

Country	Drought period	Consequences
Uganda	2004/2005	Reduction in water levels at Lake Victoria resulting in reduction in hydro-power generation by 50 MW
Kenya	1992	Failure of rains led to power rationing in April-May 1992
Kenya	1998-2001	Massive drought decreased hydro generation (25 per cent in 2000), which had to be replaced by more expensive fuel-based generation. Power rationing in 1999-2001.
Lesotho	1992	Hydro operation limited to 6 months, leading to 20 per cent reduction compared to 1991.
Malawi	1997-1998	Engineering operations affected by drought. Amount of hydro energy generated was 6 per cent less than in years of normal rainfall.
Mauritius	1999	Massive drought led to 70 per cent drop in normal annual production of electricity.
United Rep. Tanzania	1997	The Mtera dam reached its lowest ever level resulting in a of 17 per cent drop in hydro generation, use of thermal generation to meet the shortfall, and power rationing.
Zambia	1992	Poor rainfall resulted in a 35 per cent reduction in hydro generation in relation to the previous year.
Zimbabwe	1993	Drought led to a drop of over 9 per cent in energy production compared to 1992.

Source: AFREPREN, 2004.

Renewables that are not reliant on rainfall (e.g. geothermal, solar, wind) can reduce the weather-related risks associated with heavy reliance on hydroelectric schemes. For instance, bagasse-based and geothermal-based power plants were used to meet the power deficits caused by drought in Mauritius (in 1999) and in Kenya (in 1998-2000). During the drought period, Kenya's two geothermal plants offered almost 100 per cent availability to cover base load needs regardless of prevailing weather conditions (Mbuthi, 2004).

Review questions

1. What is renewable energy?
2. What is the most popular renewable energy technology in Africa and why?
3. What are some of the advantages of renewable energy in Africa?

Discussion questions/exercises

1. Discuss the renewable energy sources and their applicability in your country.

5. ENERGY EFFICIENCY

5.1. What is energy efficiency?

Energy efficiency means using less energy to accomplish the same task. More efficient use of energy throughout a country will result in less money spent on energy by homeowners, schools, government agencies, businesses and industries. The money that would have been spent on energy can instead be spent on other things like consumer goods, education, services and products.

5.2. Status of energy efficiency in Africa

Energy efficiency in Africa is generally low, both at the industrial, transport and domestic level. Conversely, higher energy efficiency is often associated with higher productivity, as energy and production technologies are often linked, and energy efficiency implies lower costs. Consequently, this observation triggered most efficiency-oriented energy projects in Africa. Numerous programmes for development aid or technical assistance have been focusing on improving access to sustainable energy in recent years. Apart from a few success stories, however, experience shows that positive appraisals of many projects evaporate after completion and withdrawal of the implementing expert team. Altogether, the diffusion of sustainable technologies with higher energy efficiency and renewable energies for cooking, heating, lighting, electrical appliances and building insulation in developing countries has been slow.

In most cases, the reasons for non-sustainable efficiency programmes are related to high transaction costs, lack of capacity, and the fact that implementation of innovative institutional structures in the form of energy agencies is lacking (Praetorius, B. and Bleyl, W., 2006). In overall terms, efficiency programmes are largely absent in most countries. In Kenya for example, it is estimated that between 10 and 30 per cent of primary energy input is wasted (IEEN, 2002). Plans are, however, underway to initiate energy efficiency programmes in some countries in the region while countries such as the United Republic of Tanzania have already existing initiatives in place (see the full case study at the end of the module). Most of these initiatives are donor funded mainly by GEF, UNDP, REEEP, UNIDO, ADB and the World Bank.

Box 3. **GEF-UNDP initiative in Kenya**

A GEF-UNDP funded project on industrial energy focusing mainly on energy efficiency in industries is currently being implemented in Kenya, and is likely to result in significant energy savings. The Kenya Power and Lighting Company has also benefited from a World Bank-funded project on demand side management. However, demand side management has largely been limited to public awareness and sensitizing consumers, as opposed to the installation or application of energy efficient technologies by the utility.

UNDP-Kenya with the aim of increasing energy efficiency and conservation in small and medium enterprises in Kenya through the industrial energy efficiency project (IEEP) sponsored a training course on “energy efficiency financing” in 2002. The aim of the course was to train managers and engineers in Kenyan small and medium-scale industries how to use manufacturing techniques that are more efficient, less costly and more profitable.

The training was a success and this is visible through the many local companies. A small local company was able to save $US 429 per month on fuel costs by installing an economizer on its boiler.

In the year 2004, the industrial sector in Kenya consumed an estimated total of 514 million tonnes of oil equivalent. This constitutes about 18.2 per cent of the total commercial energy consumed in the country in that year. It has been estimated that in the industrial sector, savings in excess of $US 36 million are possible. The rate of economic growth in the country has, meanwhile, peaked in the period between 2003 and 2006 and is expected to continue at that level or to grow at an even faster rate in the years ahead, with attendant increase in the demand for petroleum and petroleum products. All these should set the stage for higher savings in energy consumption in the industrial sector if the necessary measures are put in place. The expected increase in the price of energy too will further enhance the prospect for energy efficiency in the industrial sector. Increasing local as well as international competition is causing Kenyan enterprises to look at their energy use critically. Potential energy savings exist in highly efficient, well-managed industrial plants.

Source: UNDP website: http://www.ke.undp.org/Energy%20and%20Industry.htm
Exchange rate used: $US 1/69.95 Ksh.

At the regional level, there are enough resources available to meet the future energy demand. However, they are unevenly distributed and many of the countries in the sub-Saharan African region will, for the foreseeable future, depend on imported oil—a major contributor to the balance of payments problem experienced by most sub-Saharan African countries. In most countries in the region, the present pattern of energy utilization is sub-optimal and industrial energy use, in particular, is very inefficient. These inefficiencies constitute a large drain on many of the economies in the region.

Although sub-Saharan Africa has enough energy resources to meet the requirements of any plausible future industrial development scenarios, the present largely inefficient pattern of energy consumption has an adverse impact on:

- The cost of energy supply;
- The prices of goods produced;
- The environment.

A number of renewable energy technologies such as bagasse-based cogeneration, solar water heaters and geothermal combined heat and power plants can also be considered energy efficiency technologies.

It is estimated that one of the largest consumers of domestic electricity is water heating. This typically accounts for about 30 to 40 per cent of electricity bills (Energy Management News, 1999). In many cases the domestic hot water systems are only about 60 per cent efficient. Over 25 per cent of the energy leaks out of water heaters due to standing losses, and another 15 per cent may be lost in the hot water pipes. Solar water heaters provide an excellent opportunity for reducing the amount of electricity used for water heating, thus shaving the two peaks in electricity demand (morning and evening). Solar water heater projects have been launched in Morocco with an aim of initially installing 80,000 m^2 of solar water collectors (REPP, 2002). A utility in Egypt is providing incentives for domestic consumers who install solar water heaters.

At the industrial level, solar water heaters can be useful in pre-heating water for use in boilers, therefore reducing the amount of electricity or fossil fuels needed to heat the water to produce steam. This could yield significant savings to energy intensive industries.

Cogeneration also provides an opportunity for energy efficiency. A significant part of any cogeneration initiative is aimed at increasing the efficiency of local energy use to free up more electricity for export to the grid. It is estimated that modest capital investments combined with judicious equipment selection, increased efficiency in the sugar manufacturing process (reducing energy use) and proper planning could yield a 13-fold increase in the amount of electricity produced by sugar factories and sold to the national grid in Mauritius (Baguant, 1992). The promotion of cogeneration for sale of electricity to the grid is therefore an important energy efficiency tool for sugar industries in the region.

Combined heat and power geothermal energy plants can also be considered as energy efficiency technologies. The heat part of a geothermal plant (which has not been exploited in the region) could be used for heating water for several uses, namely:

- Greenhouse flower farming—tried in Kenya;
- Fish farming as currently practised in parts of Asia;
- Heating water for domestic supply and district heating as practised in parts of the developed world.

Review questions

1. List some of the common barriers to energy efficiency in Africa.
2. Define energy efficiency.

Discussion questions/exercises

1. Are there any energy efficiency programmes in your country?
2. What are some of the barriers to investment in energy efficiency in your country’s industrial sector?

6. BARRIERS TO RENEWABLE ENERGY AND ENERGY EFFICIENCY IN AFRICA

While it is recognized that renewable energy and energy efficiency cannot solve all of Africa's energy problems, they are perceived as having significant potential to meet growing energy requirements in the region. If properly harnessed, these systems could meet a significant proportion of energy demand for the bulk of African countries (Karekezi and Kithyoma, 2005). However, renewable energy and energy efficiency have not attracted the level of investment or policy commitment they require and have not been widely disseminated in the region. Resources allocated to developing these systems are negligible in comparison to resources allocated to the conventional energy sector. The success of renewable energy and energy efficiency in the region has been limited by a combination of factors that include:

- Poor institutional framework and infrastructure;
- Inadequate planning;
- Lack of coordination and linkage in RET programmes;
- Pricing distortions that place them at a disadvantage;
- High initial capital costs;
- Weak dissemination strategies;
- Lack of skilled manpower;
- Poor baseline information; and
- Low maintenance capacity (Karekezi and Kithyoma, 2005; Karekezi et al., 2003).

Other deficiencies that limit the use of energy efficiency measures in particular, especially in the industrial sector, include:

- Lack of commitment by management;
- Lack of proper instrumentation and controls;
- Inadequate data collection and analysis capability;
- Substandard plant house-keeping measures;
- Poor equipment maintenance;
- Inadequate insulation of hot water and steam piping.

Investments in energy efficiency measures are often more than cost-recovering over their lifetime cycle, and therefore, the standard model of economic theory would suggest that any cost-effective measure should be automatically implemented. Empirical research, however, shows that this is often not the case—and many energy saving measures with high rates of return on capital are not being realized, a phenomenon commonly labelled as the "efficiency gap".

The Efficiency Gap is the potential energy efficiency that is precluded by the possibility of market failures.

This section discusses the following common barriers the development of renewable energy and energy efficiency in Africa is faced with:

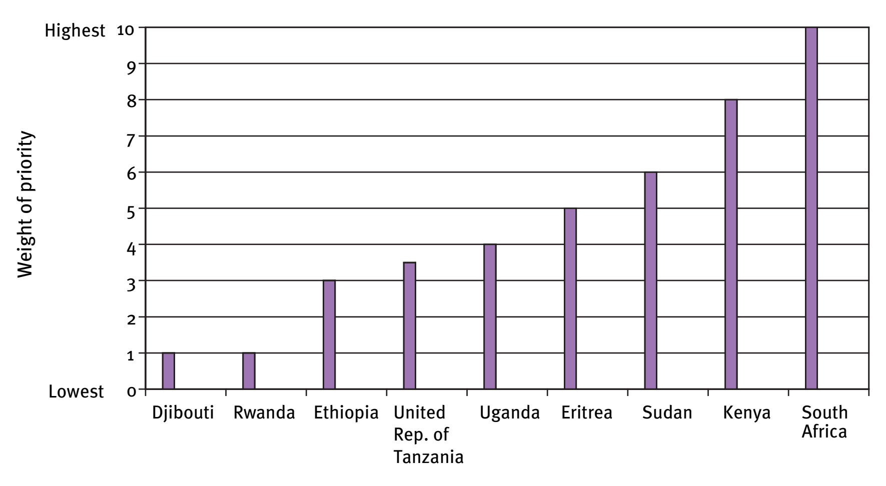
- Policy/regulatory barriers;
- Financial/investment barriers;
- Research/technology barriers.

Policy/regulatory barriers

Experience in the region shows that the introduction and success in the use of any renewable energy technology and energy efficiency measure highly depends on the existing policy framework. Government policies are a crucial factor in terms of their ability to create an enabling environment for energy efficient systems, to mobilize resources and to disseminate results, as well as encouraging private sector investment (Sampa and Sichone, 1995). Most of the early policy initiatives on renewable energy and energy efficiency in the region were driven by the oil crises of the 1970s. In response, governments established either an autonomous Ministry of Energy or a department dedicated to the promotion of sound energy policies, including support for renewable energy and energy efficiency. For example, in its Third National Development Plan (1979-1983), Zambia proposed to develop alternative forms of energy as partial substitutes for conventional energy resources. Unfortunately, once the energy crisis subsided, government support for renewable energy and energy efficiency systems diminished. This was common across the region. Most of the remaining support is now at a rhetorical level (Karekezi and Kithyoma, 2005)

Often governments in the region do not have a comprehensive vision, policy and plan on the development and dissemination of renewable energy and energy efficiency measures. Consequently, the promotion of renewable energy and energy efficiency is often undertaken within an energy planning and policy vacuum. As a result, the development of these systems often follows an ad hoc path with no reference to a coherent vision and plan. For example, in Malawi, the policy vacuum has meant that the majority of renewable energy and energy efficiency dissemination efforts have not only been ad hoc in nature, but operated largely as an informal activity outside the formal Government planning and budgeting cycle, thus failing to attract significant support from the national treasury and donor agencies (Kafumba, 1994)

Figure XI. **Policy support for renewable energy and energy efficiency**



Source: Karekezi and Kithyoma, 2005

Key:

0-3: Low priority, no specific mention of renewable energy and energy efficiency in policy
4-6: Lukewarm support for renewable energy and energy efficiency, mentioned in policy but in general statements with no specific targets
7-10: High priority with specific targets and significant budgetary allocation for renewable energy and energy efficiency

Limited policy support for renewable energy and energy efficiency is further demonstrated by the low budgetary allocations in most countries. For example, the budgetary allocation for the energy sector in Zambia in 2002 indicates a heavy emphasis on electrification (mainly grid extension). Only 0.2 per cent of planned investments in the public investment plan are allocated to renewable energy and energy efficiency mainly regarding wood fuel efficiency (Ministry of Finance and National Planning, 2002). In addition, a survey carried out in Botswana revealed that about 57 per cent of the respondents had no knowledge of government policies designed to promote the use of renewable energy an energy efficient systems (Karekezi and Kithyoma, 2005). In Malawi, the policy vacuum has meant that the majority of energy efficiency dissemination efforts are largely informal sector activities. They lack the fiscal support of the central government and its major donors (Kafumba, 1994; Karekezi and Kithyoma, 2005).

As mentioned earlier, emphasis is placed on the petroleum and power subsectors, which supply a small portion of the population, at the expense of renewables. For example, investment trends in Ethiopia's energy sector reveal heavy investments in the electricity and petroleum subsectors. Investments in petroleum quadrupled from 1990-2000, while investments in electricity almost tripled in the same period. In contrast, expenditure on traditional and alternative energy (including renewables and energy efficient systems) has steadily decreased from about 1 per cent of total expenditure in 1990, to 0.1 per cent of total expenditure in the year 2000 (Karekezi and Kithyoma, 2005).

In the newly deregulated electricity industry, renewable energy and energy efficiency measures face new challenges and barriers. With the exception of South Africa, few other regulators have made the preparation of integrated resource plans (IRPs) which include renewable energy and energy efficiency as an important prerequisite for licensing. In most countries of the region, there are, at the moment, no explicit and effective incentives in place for the promotion of energy efficiency or demand side management (DSM).

Renewable energy and energy efficiency programmes in Africa, therefore, are unlikely to register significant development and dissemination without supportive government policies and plans, which are backed by the requisite budgetary allocations.

Investment and financing barriers

Studies have shown that one of the main obstacles to implementing renewable energy and energy efficiency programmes is often not the technical feasibility of these initiatives but the absence of low-cost, long-term financing (News at Seven, 1994).

Banking institutions lay down stringent conditions for the financing of these systems. Conditions required included a feasibility study conducted at the applicant's expense, due to the limited knowledge of renewable energy and energy efficiency systems by bank officials. In addition, the banks required land titles as collateral, portfolios of project sponsors and managers, data on past and current operations, approximate value of existing investments, valuation reports, raw material procurement plans, and marketing strategies for the finished product (Turyareeba, 1993b). In certain countries (e.g. United Republic of Tanzania), banks are unwilling to accept land titles as collateral because of the uncertain land ownership infrastructure. This means that in the case of the bagasse-based cogeneration industry, sugar factories cannot use the title deeds of their sugar cane fields as collateral to obtain credit for investment in cogeneration plants.

However, it is important to note that stringent conditions set by banks also apply to conventional energy investments. As renewable energy and energy efficiency projects are a relatively new type of investment, it is simply much more difficult to collate the required information and track history.

Another barrier to the promotion of renewables and energy efficiency is the lack of awareness of existing innovative local and international financing options. For instance, there is limited knowledge and expertise on how utility financing could be used to underwrite renewable energy and energy efficiency investments. Some utility officials may be worried that investment in energy efficiency can lead to lower revenues, but it is a matter of demonstrating that the initial investment in energy efficiency can yield significant benefits for the utility by reducing high-cost peak loads and improve the profile of the power demand curve that the utility has to meet or supply.

There appears to be limited ability to access to internationally available "sustainable energy financing", e.g. from the Global Environment Facility (GEF) and various other financing schemes such as Activities Implemented Jointly (AIJ), the Clean Development Mechanism (CDM), the Prototype Carbon Fund and Community Development Carbon Fund.

Research, technological and skills barriers

In most sub-Saharan African countries, there is inadequate information on the potential of energy efficient systems and the possible savings from energy efficiency initiatives. In addition, there is limited availability of comprehensive and well-documented data sets on the dissemination of energy efficient systems in the region and their potential benefits in the economic development of the region, such as job creation and poverty alleviation.

The region's poor baseline information on energy efficient systems is exacerbated by inadequate documentation and library services. Information on past experiences that would help avoid duplication and the recurrence of past errors has been dumped instead of being transferred to libraries and the public domain. For instance, the Mauritian experience with cogeneration as a sustainable source of electricity is not widely known in the region nor is Seychelles and North-Africa's relatively successful experience with solar water heater programmes (considered both a renewable energy and energy efficiency intervention). The few industrial energy efficiency programmes that have been implemented in the region are also not well documented.

At a macro-economic level, the potential positive impact of energy efficient systems on the national balance of payments through the reduction in the import of fossil fuels is poorly documented. Consequently, energy efficient systems have not been given due attention in national economic policy, planning and budgetary allocations. In addition, power master plans in most African countries largely focus on conventional energy sources with limited reference to energy efficiency.

The importance of technical know-how in the increased utilization of renewables and energy efficiency measures has been recognized in the region, but there remains a continuing shortage of qualified personnel. Technical knowledge is needed to build a critical mass of policy analysts, economic managers and engineers who will be able to manage all aspects of efficient systems development. Trained manpower capable of developing and manufacturing energy efficient systems is a prerequisite for their successful dissemination (Karekezi and Kithyoma, 2005).

Governments and ministries in Africa suffer from a shortage of qualified renewable energy personnel. In Kenya, for example, there was a lack of expertise in wind energy when a Dutch aid organization was hoping to finance wind projects in the country. In Zambia, at one time, only one engineer was responsible for coordinating all renewable energy activities of the government. This deficit is largely responsible for the generally underdeveloped research and technological capability and the poor management of renewable energy programmes. A British-financed project to map out the wind regime in Seychelles was unsuccessful due to the absence of trained personnel (Karekezi and Kithyoma, 2005)

Although Government, donors and NGOs have, in the past, invested in building renewable energy skills and expertise, the trained personnel often move into other sectors. This is primarily due to the embryonic nature of the renewable energy and energy efficiency industry and the limited business development training provided to trainees (Karekezi and Kithyoma, 2005).

7. OVERCOMING THE BARRIERS TO RENEWABLE ENERGY AND ENERGY EFFICIENCY IN AFRICA

The following are proposed measures that could help in overcoming the barriers faced in developing both renweable energy and energy efficiency systems in the region.

Energy efficiency and renewable energy policy programmes

Pro-active and long-term policy-oriented energy efficiency and renewable energy programmes aimed at senior decision-makers in both Government and the private sector should be initiated. Such policy programmes should be designed to demonstrate the economic and environmental benefits of energy efficient systems and renewable energy technologies for Africa, specifically for the region's poor population, and propose short- and medium-term policy initiatives that would engender large-scale dissemination of renewable energy and energy efficiency systems (Karekezi and Kithyoma, 2005; Karekezi et al., 2003).

Priority should be given to the real and tangible economic benefits (such as job creation and income generation) that renewable energy and energy efficiency programmes can deliver at both the micro and macro levels. For example, renewable energy technologies and energy efficiency measures are generally more labour-intensive than conventional energy projects and can help to address problems of employment of the poor. Unfortunately, empirical data on the actual livelihood potential of renewable energy technologies and energy efficient systems measures are not widely available. Such data would assist in encouraging higher budgetary allocations to the development of these systems (Karekezi and Kithyoma, 2005).

Of particular interest to policy-makers in sub-Saharan Africa would be revenue neutral policies and institutional measures. For example, it is possible to make the case that the loss of revenue associated with the removal of duties and taxes on renewable energy technologies and energy efficient systems can be recouped from the long-term savings in imports of petroleum fuels that require foreign currencies as well as from the tax remittances from a functional and vibrant domestic renewable energy and energy efficiency (REEE) industry (Karekezi and Kithyoma, 2005).

With a clear and well-defined vision, policy and plans on renewable energy and energy efficiency in place, a regulatory structure would be required to ensure the implementation of the policies. Regulation would be undertaken at both regional and national level, and could be undertaken using a wide range of instruments. For example, measures that encourage national utilities to purchase/ generate/promote renewable energy and energy efficiency as a mechanism for diversifying generation may also yield positive results. Regulators could ease licence requirements for cogenerators to encourage entry, and regulators could ensure attractive prices for cogenerators. In addition, regulators can play the important role of educating consumers on renewable energy and energy efficiency. The South African National Electricity Regulator (NER) provides a useful model (Karekezi et al., 2003).

Appropriate technology, technology transfer and building local capacity

The choice of energy efficient systems and renewable energy technologies for dissemination and development in sub-Saharan Africa should take into account the existing technical knowledge and local industries. Energy efficient systems and renewable energy technologies that improve existing methods and build on already established industries are likely to be successfully disseminated. In addition, these technologies can become self-sustainable in the long-term (Karekezi and Kithyoma, 2005).

Experience has shown that most energy efficient systems and renewable energy technologies (especially those that can be locally manufactured) require subsidies in the initial stages, but can become financially sustainable in the short to medium term after a certain level of technology dissemination has been attained. After attaining a dissemination of a critical number of units and assemblers/ manufacturers, each industry can become self-sustaining and subsidies can be gradually withdrawn without any adverse effects on continued dissemination (Karekezi and Kithyoma, 2005).

One of the key factors that led to the high penetration rates of improved stoves in Kenya was the low cost of the stoves (about $US 2). In addition, the stove dissemination programme did not attempt to install a new production and marketing system, but instead used the same network that produced and marketed the traditional stove. The stove programme utilized both mechanized and semi-mechanized stove producers thus creating job opportunities and keeping the price of the improved stove affordable (Karekezi and Ranja, 1997).

It is necessary to consider the training of individuals, the business systems by which they will work and the systems by which they will continue to be paid.

Where training or capacity is inadequate, manufacture, assembly and dissemination of the technology will not be successful. For example, unlike the Kenyan stove dissemination scene where the informal sector forms the backbone of the stove's manufacture, assembly and dissemination, the informal sector in Khartoum forms the weakest link in stove production. Production of liners is limited to a few formal producers with an installed capacity of 7,500 liners per month, but the capacity to produce the metal component is much lower (Karekezi et al., 2006).

Sub-Saharan African countries need to develop rural energy technologies strategies that rely on a diverse set of technologies that are not confined to PV electrification and that reflect their national natural endowment profiles as well as the incomes of the poor. If a proportion of the funds for rural electrification were allocated to the promotion of non-electrified technologies, this would result in their low cost and in the significant dissemination of these technologies. In the near term, the ideal situation would be to transform current rural electrification programmes and agencies into rural energy agencies that are given the mandate to disseminate rural energy technologies (Mapako and Mbewe, 2004).

Long-term renewable energy and energy efficiency training programmes designed to develop a critical mass of locally trained personnel with technical, economic and social-cultural skills are urgently needed. Many of the engineering and technical courses that are currently taught at universities and colleges in Africa provide little exposure to appropriate energy efficient technologies and to essential business development skills. Modest changes in the curricula of existing colleges and universities could significantly increase the supply of skilled renewable energy and energy efficiency engineers, policy analysts and technicians with the requisite business development expertise (Karekezi and Kithyoma, 2005).

In addition, efforts are needed to integrate analytical expertise within the energy sector with that of other key actors in the development process: the banking or micro-finance industry; social/rural development and public health communities. This is the key to understanding not only the resources and technologies available, but also the institutional setting through which they may be adopted and accepted by the target communities (Karekezi and Kithyoma, 2005).

Information exchange and sharing at the regional level on renewable energy and energy efficiency should be encouraged. Countries with more successful experiences of renewable energy and energy efficiency development can provide model examples for other countries that are still at the early stage of project/programme development. For example, Mauritius and Kenya could provide useful lessons for other countries in the region that are embarking on cogeneration and geothermal power, respectively (Karekezi et al., 2003).

Innovative financing mechanisms

Priority should be given to the establishment of innovative and sustainable financing programmes for energy efficiency systems and renewable energy technologies. These may range from the creation of a specific National Fund financed by a modest tax on fossil fuels to credit schemes aimed at developing renewable energy and energy efficiency industries and developing endowments for renewable energy and energy efficiency agencies. In Ghana, a national energy fund has been successfully utilized to finance RE and EE activities on a sustainable basis. An important challenge is the bundling of discrete renewable energy and energy efficiency projects into large programmes, which can be financed by major bilateral and multilateral donor and financing agencies.

African countries could tap into the various international and regional initiatives, (including GEF, NEPAD, and the FINESSE programme of the African Development Bank) which can initiate, support and be linked into the national policy strategy.

The UNFCCC-related Clean Development Mechanism (CDM) presents a new financing opportunity for Africa. It allows industrialized countries to meet part of their commitment to reduce emissions of GHGs by investing in projects in African countries that reduce those countries' emissions. The rationale is that the negative impacts of emissions are independent of their source and that emissions reductions may be less costly in developing countries. The CDM also provides a way to engage African countries in the emissions reduction process and should provide them with additional funding, allowing them to follow a less emissions-intensive path than they would otherwise follow.

The CDM could help mitigate the high up-front financing barrier that faces renewable energy and energy efficiency projects in Africa in several ways. Firstly, one of the basic requirements of the CDM is that the projects that industrialized countries invest in should meet the host country's development priorities. This provides room for the host country to select the projects for investment. Hopefully this will ensure that the host country has more leverage on the implementation of the project than has been the case with development projects in the past. The range of technologies being considered under the CDM project is wide, but includes many renewable energy technologies and energy efficiency systems. CDM projects, however, have very high transaction costs and require specialized skills that limit the participation of African countries with limited expertise. The projects also require setting up new institutional entities, for example designated national authorities (DNAs).

Review questions

1. List the common barriers to energy efficiency in Africa.

Discussion questions/exercises

1. What are the main barriers to investment in renweable energy and energy efficiency in your country's industrial sector?

8. CONCLUSION

The following conclusions can be drawn:

- The poor state of managerial and financial performance justified the reform of the power utilities in Africa. These reforms, in part, led to better financial performance in some countries, e.g. Uganda and Zimbabwe and an improvement (albeit for a limited period) in the general technical performance of national utilities in others, e.g. Kenya.
- Though endowed with substantial renewable energy sources, Africa's potential has not been fully exploited, mainly due to the limited policy interest and investment levels. Renewable energy offers substantial opportunities for generating electricity and/or heat energy with limited capital investments, while avoiding the negative environmental effects of increased fossil fuel combustion.
- Although sub-Saharan Africa has enough energy resources to meet the requirements of any plausible future industrial development scenarios, the present pattern of energy consumption is far from efficient.
- In spite of the region's limited consumption of modern energy, energy efficiency is a key option for supplying energy to more consumers without increasing adverse environmental effects. However, this option has not been adequately exploited.

LEARNING RESOURCES

Key points covered

These are the key points covered:

- The module recognizes that the availability of modern, reliable and efficient energy services is an important and indeed essential driver for economic development.
- Most countries in Africa are faced with major challenges in trying to achieve their development and social obligations because of inadequate access to modern energy services. The majority of the population still depend on traditional biomass, which often has adverse environmental and health impacts.
- Sources of power supply in Africa broadly reflect each sub-region's energy resource endowment with North and West Africa concentrated with oil and gas reserves; Eastern Africa with hydroelectric power (with some limited use of geothermal-based and biomass-based power stations), while Southern Africa is reliant on coal (and to lesser extent hydropower).
- The core sources of electricity in most sub-Saharan African countries are hydropower and oil products.
- The African power sector is characterized by small systems, with over three-quarters of the continent's installed capacity in North Africa and the Republic of South Africa. The large-scale conventional energy sector though receiving the bulk of energy investment only serves a small proportion of the population. Consequently, there are low levels of electricity access in sub-Saharan Africa with an estimated 17 per cent of the region's population, and less than 5 per cent of rural areas having electricity. Electricity is largely confined to urban middle and upper income groups and to the formal commercial and industrial sectors.
- The modular nature of most renewable energy technologies (i.e. the fact that they can be developed incrementally) and the consequent low and progressive nature of investment requirements make them particularly suitable for capital-constrained African countries.
- Energy efficiency means using less energy to accomplish the same task. Using less energy would mean a cost saving which could then be used on consumer goods, education, services and products. Energy efficiency in Africa is, however, generally low, both at the industrial, transport and domestic level.
- Despite their recognition as important contributors to the region's energy sector, energy efficiency systems have not been widely disseminated in the region.

Answers to review questions

Question: Define the power sector.

Answer: The power sector can be defined as an energy sector that consists of both electricity generation plants (and combined heat and power (CHP) plants) and the transmission and distribution infrastructure, and whose primary business is to generate, transport and sell electricity (electricity and heat in the case of CHP) to the public.

Question: Who are some of the main players in the power sector?

Answer: The main players in the sector in Africa include government ministries, utilities, independent power producers (IPPs), transmission and distribution operators, regulators and rural electrification agencies. Other players include manufacturers and consulting engineers who supply equipment and services for the generation, transmission and distribution of electric power by utilities and other power producers.

Question: What are some of the key characteristics of the power sector in Africa?

Answer: Use of small systems, with over three quarters of the continent installed capacity in North Africa and the Republic of South Africa.

Sources of power supply in Africa broadly reflect each subregion's energy resource endowment. For example, fossil-fuel fired electricity generation systems in North and West Africa, hydroelectric power plants with some limited use of geothermal-based and biomass-based power stations in Eastern and Central Africa, and coal (and to lesser extent hydropower) in the Southern African power industry.

The large-scale conventional energy sector (electricity and petroleum) receives the bulk of energy investment in most African countries whilst serving only a small proportion of the population.

Provision of electricity in Africa is largely confined to urban middle and upper income groups and to the formal commercial and industrial sectors.

Low levels of electricity access only an estimated 17 per cent of sub-Saharan Africa's population is electrified.

Question: What is renewable energy?

Answer: Renewable energy refers to energy forms that cannot easily be depleted and include energy forms such as wind, solar, hydro, biomass, geothermal, tide and wave energy.

Question: Which is the most popular renewable energy technology in Africa? State the reason.

Answer: Solar technology is the most widely disseminated technology in Africa both in urban and rural areas and mostly used in schools and dispensaries. Solar energy as a resource has been in use for a long time for drying clothes and animal skins, for preserving meat, drying crops and evaporating seawater to extract salt.

Question: What are some of the advantages of renewable energy in Africa?

Answer: They have greater impact on improving energy services for the majority of Africa's population, especially the poor.

Renewables could play a vital role in minimizing fuel imports by providing an alternative to thermal-based electricity in the form of, for example, small hydro power units, cogeneration (using biomass as fuel) and geothermal energy

They offer diversification in energy generation, thus strengthening energy security.

Small and medium-scale renewable energy technologies (RETs) can play an important role in poverty alleviation.

They are relatively new technologies that due to their modularity do not require large amounts of capital. They are also relatively less sophisticated meaning that a significant industry could be developed in Africa even where technical expertise is limited. They are often cost competitive over their life cycle compared to conventional energy.

In addition to their global contribution to reducing greenhouse gases, RETs reduce local and regional energy-related environmental impacts and lastly,

Renewables that are not reliant on rainfall (e.g. geothermal, solar, wind) can reduce the weather related risks associated with heavy reliance on hydroelectric schemes.

Question: List some of the common barriers to energy efficiency in Africa.

Answer:

- Policy/regulatory barriers
- Financial/investment barriers
- Research/technology barriers

Question: Define energy efficiency.

Answer: Energy efficiency means using less energy to accomplish the same task. More efficient use of energy in a country means less money spent on energy by homeowners, schools, government agencies, businesses and industries, making this money available for other goods and services.

Exercises

1. Discuss the characteristics of the energy sector in Africa.
2. Using relevant documents, write a 2-3 page essay on renewable energy applications in your country.
3. What are some common barriers to energy efficiency in Africa? Discuss.

Presentation/suggested discussion topic

Presentation:

ENERGY REGULATION – Module 2: The Energy Sector in Africa

Suggested discussion topic:

1. Discuss the potential benefits of renewable energy applications in your country?

Relevant case studies

1. Cogeneration in Mauritius

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REEEP: www.reeep.org

IT-Power: www.itpower.co.uk

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GLOSSARY/DEFINITION OF KEY CONCEPTS

Bagasse	The fibrous residue of sugar cane left after the extraction of juice and often used as a fuel in cogeneration installations.
Biogas digesters	Structure used for producing biogas from animal and crop residues under anaerobic conditions.
Bio-gas	A mixture of methane, carbon dioxide and water vapour.
Biofuels	Liquid fuels and blending components produced from biomass (plant) feedstocks, used primarily for transportation.
Boiler	A device for generating steam for power, for heating purposes; or for generating hot water for heating purposes or hot water supply.
Clean development mechanism (CDM)	One of the flexible mechanisms under the Kyoto Protocol which allows industrialized countries to meet part of their commitment to reduce emissions of greenhouse gas emissions by investing (money and/or technology) in emission reducing projects in developing countries. The rationale is that the negative impacts of emissions are independent of their source and that emissions reductions may be less costly in developing countries. The CDM provides a way to engage African countries in the emissions reduction process and should provide such countries with additional funding, allowing them to follow a less emissions-intensive path than they would otherwise follow.
Climate change	All forms of climatic variations, especially significant changes from one prevailing climatic condition to another.
Charcoal	Charred wood in the absence of oxygen.
Cogeneration	Simultaneous production of electricity and heat energy.
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Distribution losses (%)	The proportion of electricity lost in the process of distribution of electricity to consumers including losses due to pilferage. It is expressed as a percentage of generated electricity.
Electrification levels (%)	The percentage of the population or households that are connected to electricity from the grid.
Efficiency (in licensing)	The ability of the licensing agency to process applications within the shortest possible time and in the least number of stages the application needs to go through.

Electricity/power sector reforms	Deliberate changes in the structure and ownership of the electricity sector aimed at improving performance, efficiency and investment.
Electricity regulator	The agency in charge of monitoring the electricity sector.
Electrification	This is the process of connecting additional households, institutions and enterprises to the national grid.
Energy demand (millions toe)	The amount of modern energy required by various sectors of a country.
Energy efficiency (EE)	Using less energy to accomplish the same task.
Energy efficiency measures	The whole of investments done and systems and technologies adopted to increase energy efficiency.
Energy production (million toe)	The amount of modern energy produced within the country.
Energy reserves	Estimated quantities of energy sources that have been demonstrated to exist with reasonable certainty on the basis of geological and engineering data (proven reserves) or that can reasonably be expected to exist on the basis of geological evidence that supports projections from proven reserves (probable or indicated reserves).
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Energy supply	Amount of energy available for use by the various sectors in a country.
Fossil fuel	An energy source formed in the earth's crust from decayed organic material e.g. petroleum, coal and natural gas.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal plant:	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.
Greenhouse effect	The effect produced due to certain atmospheric gases that allow incoming solar radiation to pass through to the earth's surface, but prevent the radiation which is reradiated from the earth, from escaping into outer space.
Greenhouse gas	Any gas that absorbs infrared radiation in the atmosphere.

Household	A group of people who share a common means of livelihood, such as meals regardless of source of income and family ties. Members who are temporarily absent are included and temporary visitors are excluded.
Independent power producers (IPPs)	Privately owned power companies that produce electricity and sell it for a profit to the national grid or to a distribution utility.
Legal and regulatory framework (LRF)	Combination of the laws, institutions, rules and regulations governing the operations of the electricity industry.
Licensing	The act of issuing licenses allowing investors to operate legitimately within the electricity sector, usually as IPPs or independent power distributors (IPDs)
Liberalization	The removal of restrictions on entry and exit of the electricity industry making it open to any prospective and interested players. Often implies reduced state intervention.
Modern energy	Refers to high quality energy sources, e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biofuels.
Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100 kW but below 1 MW).
Population (millions)	The total number of people living within the borders of a country, whether citizens or not.
Primary energy	Energy sources in their crude or raw state before processing into a form suitable for use by consumers.
Renewable energy (RE)	Non-fossil and non-nuclear energy sources, i.e. wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.
Renewable energy technologies (RETs)	Technologies using renewable energy sources.
Small and micro enterprises	An enterprise that generates income up to a certain predefined limit.
Small hydro	Small-scale power generating systems that harness the power of falling water (1-15 MW).
Solar dryer	A special structure that uses the sun's energy to dry agricultural produce (fruits, vegetables, meat).
Solar photovoltaic (PV) technologies	Devices that convert the sun's energy into electricity for use in lighting, refrigeration, telecommunications, etc.
Solar thermal technologies	Devices that use the sun as the primary source of energy for heat appliances, e.g. solar water heaters, solar dryers.

Solar water heaters	Devices that use solar energy to heat water for domestic, institutional, commercial and industrial use.
Traditional energy	Low quality and inefficient sources of energy, predominantly biomass in nature and not often traded (e.g. wood fuel, crop residues and dung cakes).
Wind pumps/mills	Devices that use wind energy to lift water from underground sources.
Wind turbines	Devices used to generate electricity using kinetic energy from wind.
Utility	An entity partially or wholly involved in electricity generation, transmission, and/or distribution.
System losses (%)	The power that is lost during generation, transmission and distribution of electricity.
Total electricity consumption (GWh)	Total amount of electricity consumed within a country.
Transmission losses (%)	The proportion of electricity lost in the process of transmission of electricity.

Case study 1.

COGENERATION IN MAURITIUS

CONTENTS

1. COGENERATION IN MAURITIUS

1.1. Background

Mauritius, as a Small Island Developing State forming part of the African continent, is devoid of any fossil fuel and depends heavily on imported energy for use in the various sectors of the economy. Hydropower and sugar cane bagasse are the two renewable resources that can potentially be used for electricity generation. Hydropower is limited to availability of rainwater, seasonal in nature, and this resource is fully exploited in Mauritius. Interest in the use of bagasse for electricity generation and export to the grid intermittently in Mauritius started in 1957 from one sugar factory and since then more and more of these factories have joined in. But the most significant developments occurred in 1980 when a 10 MW continuous power plant (where the term “continuous” indicates bagasse fueling only) was commissioned to export electricity to the grid during the crop season only and in 1984 when another factory invested in a firm power plant (21.7 MW) (where the term “firm” indicates that the plant operates using both bagasse and coal when no bagasse is available) to export electricity to the grid all year round.

With the success achieved in those plants and pressed by events in the Gulf area in 1991, the Government in collaboration with the private sector worked out a Bagasse Energy Development Programme. The objectives of the programme were to displace investments to be effected by the utility, to reduce the reliance of the country on petroleum products and diversify its energy base, to allow for the modernization and rehabilitation of the sugar industry and improve its viability, to save on foreign exchange through reduction in imports of fossil fuel and finally to contribute in the mitigation of the enhanced greenhouse effect by displacing fossil fuel.

A number of factors contributed to the eventual success of bagasse energy development. A clear policy on bagasse use for electricity was defined by the Government and agreed to by all stakeholders. A number of plans, policies, actions and legislations to facilitate bagasse energy development were put in place. Constraints identified all along the implementation of these plans were attended to in consultation with all stakeholders including Government agencies and the utility, with the Mauritius Sugar Authority acting as the focal point/facilitator.

While providing incentives to entrepreneurs to invest in power plants as independent power producers, the interests of the small cane growers and the workers had not been ignored. Through legislation and the creation of a Sugar Investment Trust, the Government ensured that this vulnerable group in the sugar industry shares in the profits.

1.2. Status of cogeneration in Mauritius

The sugar industry's future is at stake. In the local context, the cost of production is increasing and on the international scene, sugar prices are decreasing. These factors will impact negatively on the industry if measures are not taken to mitigate these effects. Factory modernization, centralization and exploitation of the by-products for more value added products are measures that will ensure the long-term viability of the industry. Energy from bagasse was one option that was given top priority in this context.

With the centralization of cane milling activities, investments were made in seven continuous power plants and three firm power plants. Some characteristics of these power plants are given in table 1.

Table 1. Bagasse-based power plants in Mauritius up to year 2000

Factory	Tonnes cane per hour	Power	Start date	Units from bagasse (GWh)	Units from coal (GWh)	Total units from bagasse and coal (GWh)
FUEL	270	F	Oct. 1998	60	115	175
Deep River Beau Champ	270	F	April 1998	70	85	155
Belle Vue	210	F	April 2000	105	220	325
Médine	190	C	1980	20	—	20
Mon Trésor Mon Désert	105	C	July 1998	14	—	14
Union St Aubin	150	C	July 1997	16	—	16
Riche en Eau	130	C	July 1998	17	—	17
Savannah	135	C	July 1998	20	—	20
Mon Loisir	165	C	July 1998	20	—	20
Mon Désert Alma	170	C	Nov. 1997	18	—	18
Total		3 F		360 GWh	420 GWh	780 GWh
		7 C		235 GWh F		
				125 GWh C		

F = Bagasse during crop and coal during intercrop
C = Bagasse during crop season only

1.3. Impact of cogeneration development in Mauritius

Impacts of cogeneration in the power sector

Over the 10-year period (1993-2002), the installed capacity of the sugar industry located power plants increased from 43 MW to 242 MW, with the concurrent increase in electricity export to the grid (table 2). In 1996, 119 GWh of electricity were exported from bagasse-based generation. This was achieved through investment mostly by private sugar mills implementing cogeneration technology with their own private funds. By the year 2002, cogenerated energy increased significantly with investment in more efficient bagasse-to-electricity processes and in a greater number of units, so much so that the electricity exported to the grid from bagasse increased to 300 GWh from the 160 MW installed (or 33 per cent) firm duel-fuel installed capacity, with 10 of the 11 sugar factories operating bagasse units and contributing to the total. With coal being burnt in three firm power plants the total electricity export from the sugar industry reached 746 GWh in 2002. This represented 43.5 per cent of the total electricity exported to the grid for the island.

Table 2. Evolution of cogeneration (1991-2002)

	Cogeneration			Island total		Bagasse (%)		Bagasse + coal (%)
	Bagasse		Coal					
Year	IC	GWh	GWh	IC	GWh	IC	GWh	GWh
1993	43	71	40	308	870	14.0	8,2	12,8
1994	43	77	46	308	945	14.0	8,1	13,0
1995	43	84	41	332	1047	13.0	8,0	11,9
1996	43	119	—	332	1151	13.0	10,3	10,3
1997	53	125	23	370	1252	14.3	10,0	11,8
1998	90	225	62	397	1365	22.7	14,2	18,7
1999	90	184	155	425	1424	21.2	12,9	23,8
2000	160	274	327	478	1527	33.5	17,0	39,4
2001	246	300	411	660	1657	37.3	18,1	42,9
2002	242	299	447	656	1715	36.9	17,4	43,5

Source: CEB reports, Commercial scale cogeneration of bagasse energy in Mauritius, Deepchand, 2002; Veragoo, 2003.

The kWh/tonne cane processed in 1991 was 12 and even after implementation of the projects in the year 2002, the value had only reached 61 kWh per tonne of cane (table 3). This is well below the 110 kWh/tonne cane obtained in Réunion where only two factories are in operation, each processing around 900,000 tonnes of cane annually. Each factory is equipped with 2 x 30-35 MW power plants operating at a pressure of around 82 bars. In Mauritius only the Compagnie Thermique de Bellevue (CTBV) operates with this efficiency in Mauritius and has reached a conversion efficiency of 130 kWh/tonne cane.

Table 3. Evolution of electricity production from the sugar industry (GWh) and kWh/tonne cane

Power	Fuel source	Year											
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Firm	Bagasse	39	50	39	44	46	70	66	81	111	167	186	171
	Coal	54	43	40	46	41	10	23	62	155	327	411	447
Continuous	Bagasse	21	28	27	28	30	33	53	109	78	107	114	128
Intermittent	Bagasse	10	6	4	4	5	7	6	4	1	0.5	0	0
Total GWh (bagasse)		70	84	70	76	81	110	125	194	190	274.5	300	299
Total GWh (bagasse & coal)		124	127	110	122	122	120	148	256	345	601.5	711	746
Total tonne cane x 10^6		5.62	5.78	5.40	4.81	5.16	5.26	5.79	5.78	3.88	5.1	5.78	4.87
kWh/tc		12	15	13	16	16	21	22	34	49	54	52	61

Impact of cogeneration on the sugar sector

Bagasse energy projects are linked with sugar factory modernization in that boilers, turbo alternators and other energy efficient equipment represent a major proportion (up to 50 per cent) of the cost of a sugar factory. Investing in an energy project ensures that this part of the investment (useful life of 25 years), crucial to sugar processing, is financed independently of sugar activities. In addition, the sale of electricity adds to the revenue of sugar companies. Furthermore, linking energy projects to centralization brings about a reduction in the cost of production. In 1985, 21 sugar factories were in operation and the number decreased to 11 in 2005. Ten of these factories export energy to the grid and only three of them are firm duel fuel power plants. It has been projected that by 2010, only four sugar factories will be in operation through the process of centralization and it is envisaged that each one of them will be equipped with a firm power plant which is generally more efficient in energy cogeneration and export to the grid.

Environmental impact/benefit of cogeneration

From an environmental life cycle perspective, sugar cane bagasse energy is associated with a net positive global benefit in that sugar cane is an annually renewable crop and contributes to a reduction in greenhouse gas emissions from energy which would have otherwise been generated from fossil fuels. The carbon dioxide released from the combustion of bagasse is re-absorbed in the ensuing crop and hence is carbon neutral. With the use of cane field residues for energy, more electricity can be generated, otherwise the residues decay and release methane, another greenhouse gas.

With the export of around 300 GWh of cogenerated electricity to the grid, around 200,000 tonnes of coal are avoided, thus alleviating the burden on foreign exchange for such imports. In addition the projects also generate carbon emission credits that are potentially tradable under the Kyoto Protocol Clean Development Mechanism. The value of such credits could be as much as $US 20 per tonne of carbon dioxide. The revenue derived therefore further enhances the financial viability of this renewable energy project.

The environmental control technology adopted in the power plants results in improved thermal efficiency (that is, less heat is rejected compared to older systems and fewer particulate matter emissions (< 100 mg/Nm^3) are produced. Sulphur dioxide (SO_2) emission is insignificant (bagasse contains no sulphur) and nitrogen oxide (NO_2) emissions are also reduced due to the use of spreader stoker technology.

Impact of cogeneration on the Mauritian economy

Bagasse-based cogeneration development in Mauritius has delivered a number of benefits including reduced dependence on imported oil, diversification in electricity generation and improved efficiency in the power sector in general. Using a wide variety of innovative revenue sharing measures, the cogeneration industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders in the sugar economy, including the poor smallholder farmer. The equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned modern biomass energy projects in Africa.

2. TECHNIQUES ADOPTED IN SUCCESSFUL DEVELOPMENT OF COGENERATION

The following factors have contributed to the success of cogeneration:

- Clearly spelled out policy on sugar cane bagasse for cogenerated electricity and provision for appropriate incentives to induce investment in sugar factory modernization and investment in power plants.
- Adoption of energy efficiency and conservation measures in cane juice heating, evaporation, sugar boiling and crystallization to bring down process steam consumption.
- Electrification of drive processes of all prime movers in cane milling.

- Targeting a cane crushing capacity of around 200 tonnes of cane per hour to match with one module of 35-40 MW installed capacity power plant operating at a steam pressure of around 82 bars. This is a commercially proven technology.
- Use of coal as a complementary duel fuel in case of shortage of cane to enable year round power export to grid.
- Undertaking centralization of cane milling to ensure bagasse availability on site rather than saving bagasse in clusters and transporting it to a central power plant.
- Working out and establishing the kWh price independently of the utility and the IPP or alternatively inviting requests for proposals with set guidelines in a competitive bidding process.
- Make provision for participation of small planters and workers in the equity portion of investment.
- Negotiating and presenting a power purchase agreement describing in detail the obligations of the IPP towards the utility and vice versa, including in particular payment obligations by the utility. This PPA is used inter alia in negotiating a loan from the bank.

3. POTENTIAL FOR REPLICATION IN THE AFRICAN CONTINENT

The success achieved with bagasse energy cogeneration in Mauritius can be replicated in almost all the cane sugar producing countries on the African continent. Sharing of experiences and opportunities for training can be offered given the variety of power plants in terms of capacities, operating pressures and degrees of sophistication linked with plant efficiency.

Table 4 gives the production statistics of sugar and cane in countries on the African continent. The potential amount of electricity that can be exported to the grid using two commercially proven technologies (steam pressures of 44 and 82 bars respectively) have also been worked out on the basis of results obtained in Mauritius. It must be highlighted that such plants require a minimum cane crushing capacity of 200 to 300 tonnes cane per hour and many of the African countries at present have cane production well below these capacities. However, it has been observed that the cane sugar industry in a number of these countries is being rehabilitated and modernized and there is merit in coupling these plants with a cogeneration facility. All the cane sugar factories in Mauritius and Réunion have successfully integrated sugar and electricity production. The total potential in the countries in Africa is around 9,600 GWh on the basis of present cane production. Only Mauritius and Réunion are exploiting sugar cane bagasse in a significant manner for energy production.

Table 4. Production of sugar and sugar cane and potential for cogeneration in Africa (2002)

African countries	Sugar (x 10^3t)	Sugar cane[a] (x 10^3t)	Cogeneration potential (GWh) @ 31 bars[b]	@ 44 bars[c]	@ 82 bars[d]
Angola	31	282	104	20	31
Benin	5	45	2	3	5
Burkina Faso	40	364	18	25	40
Burundi	21	191	10	13	21
Cameroon	113	1,027	50	72	113
Chad	33	300	15	21	33
Congo	55	500	25	35	55
Côte d'Ivoire	158	1,436	71	101	158
Egypt	1,397	12,700	635	889	1,397
Ethiopia	294	2,672	131	187	294
Gabon	18	164	8	11	18
Guinea	26	236	12	17	26
Kenya	423	3,845	192	269	423
Madagascar	32	291	15	20	32
Malawi	257	2,336	117	164	257
Mali	34	309	15	22	34
Mauritius	552	5,018	250	351	552
Morocco	156	1,418	71	99	156
Mozambique	242	2,200	110	154	242
Nigeria	20	182	9	13	20
Réunion	210	1,909	95	134	210
Senegal	93	845	42	59	93
Sierra Leone	6	55	3	4	6
Somalia	21	191	10	13	21
South Africa	2,755	25,045	1252	1,753	2,755
Sudan	792	7,200	360	504	792
Swaziland	520	4,727	236	331	520
United Rep. of Tanzania	190	1,727	86	121	190
Togo	3	27	1	2	3
Uganda	244	2,218	111	155	244
Zaire	75	682	34	48	75
Zambia	231	2,100	105	147	231
Zimbabwe	565	5,136	257	360	565
Total	9,612	87,378	4,362	6,117	9,612

[a] Estimated at sugar recovered % cane of 11%

[b] Based on 50 kWh/tonne cane

[c] Based on 70 kWh/tonne cane

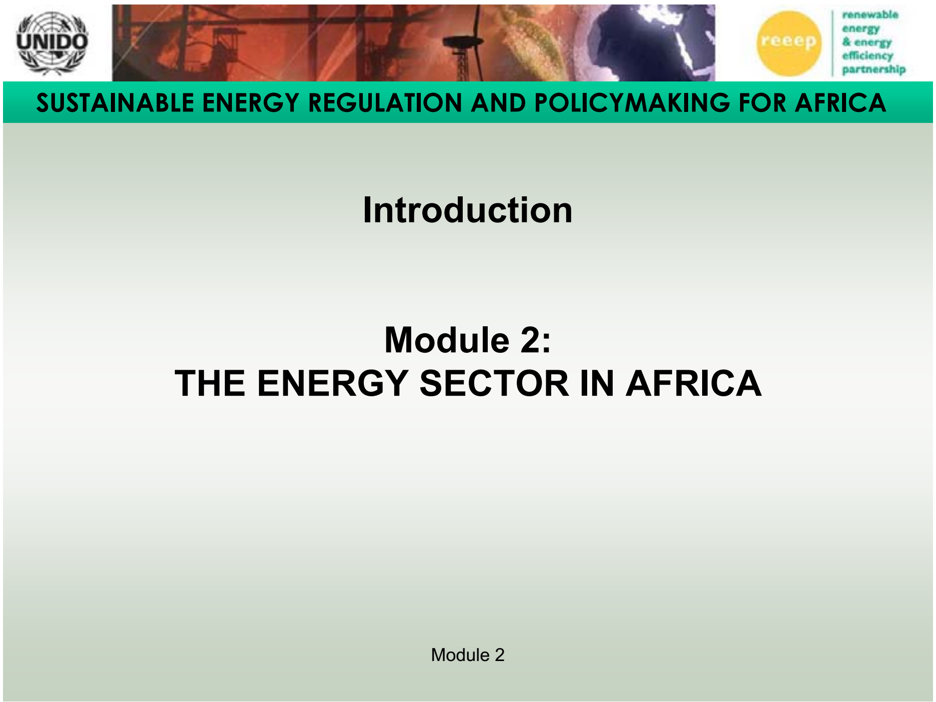
[d] Based on 110 kWh/tonne cane

CONCLUDING REMARKS

The sugar cane crop is an agriculturally grown crop, which is known to have a high bioconversion efficiency of the capture of sunlight; this results in a high amount of atmospheric carbon being fixed into biomass. Until recently, the main interest in sugar cane was only to recover sugar from this biomass, but in the light of recent successful experiences in cogeneration, it can now be considered as a major renewable energy resource in cane sugar-producing countries. The majority of the countries on the African continent are endowed with agro-climatic conditions which are conducive to sugar cane production and, with proper investment and management of resources, high yields are potentially obtainable.

Amongst other energy carriers, electricity from the fibrous fraction of cane known as bagasse has been shown to be commercially viable in island states such as Mauritius and Réunion which are devoid of fossil fuel reserves. On the African continent, around 10,000 GWh of electricity is potentially exportable to the grid based on the current amount of cane production when using state-of-the-art technology for conversion of bagasse into electricity. Power sector reforms in the African countries should take on board this option of cogeneration through the inclusion of independent power producers to undertake power generation.

Opportunities for the replication of this success in other countries in the region should be examined, especially as this technology is environment friendly and can attract funds from international agencies such as the GEF, the Prototype Carbon Fund and activities implemented jointly under the Clean Development Mechanism of the Kyoto Protocol.

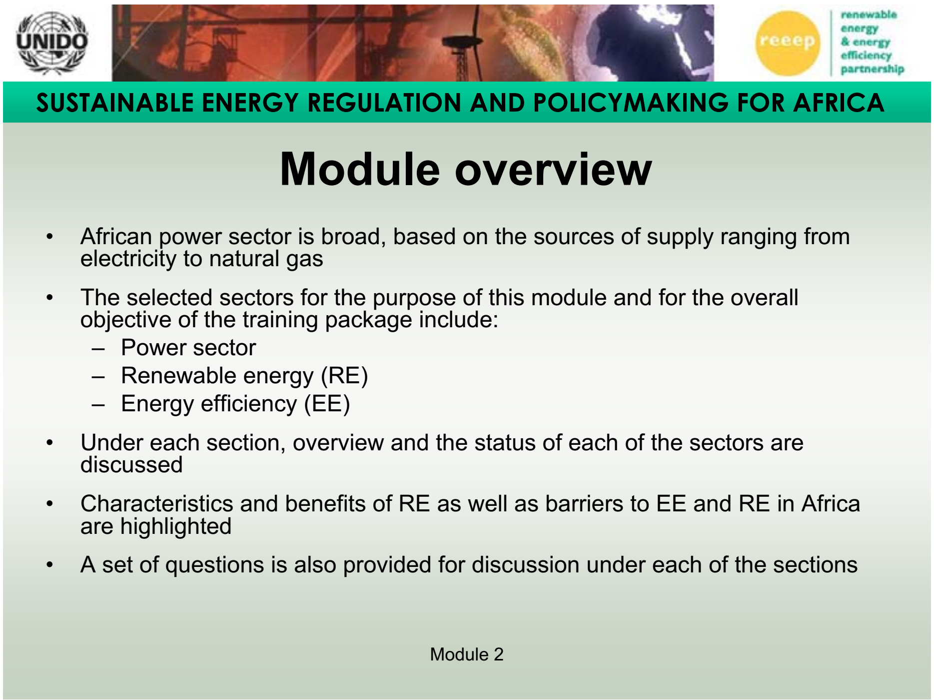


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

Module 2:
THE ENERGY SECTOR IN AFRICA

Module 2

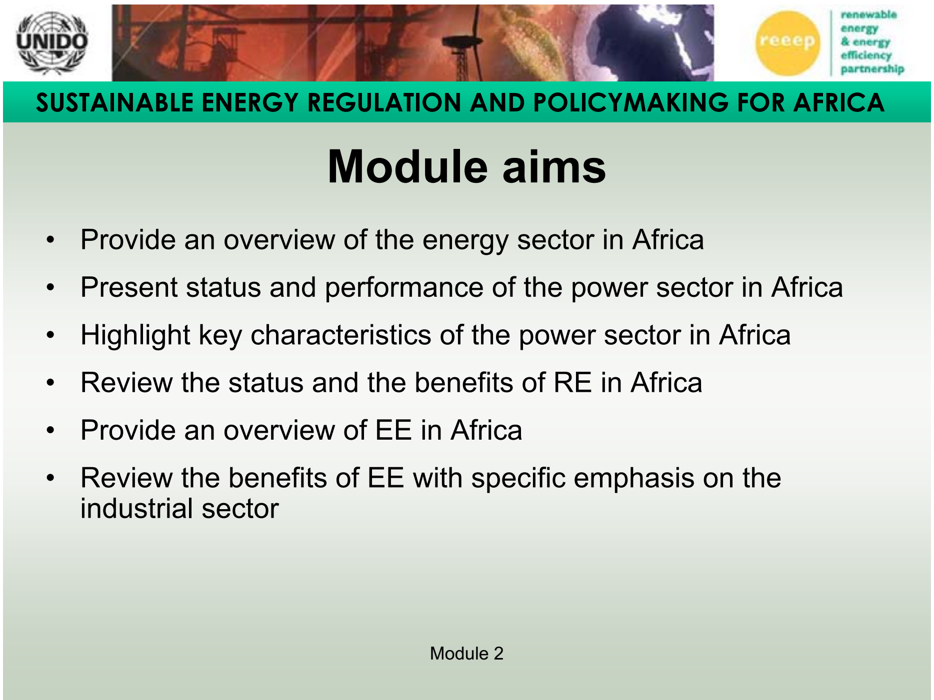


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- African power sector is broad, based on the sources of supply ranging from electricity to natural gas
- The selected sectors for the purpose of this module and for the overall objective of the training package include:
  - Power sector
  - Renewable energy (RE)
  - Energy efficiency (EE)
- Under each section, overview and the status of each of the sectors are discussed
- Characteristics and benefits of RE as well as barriers to EE and RE in Africa are highlighted
- A set of questions is also provided for discussion under each of the sections

Module 2

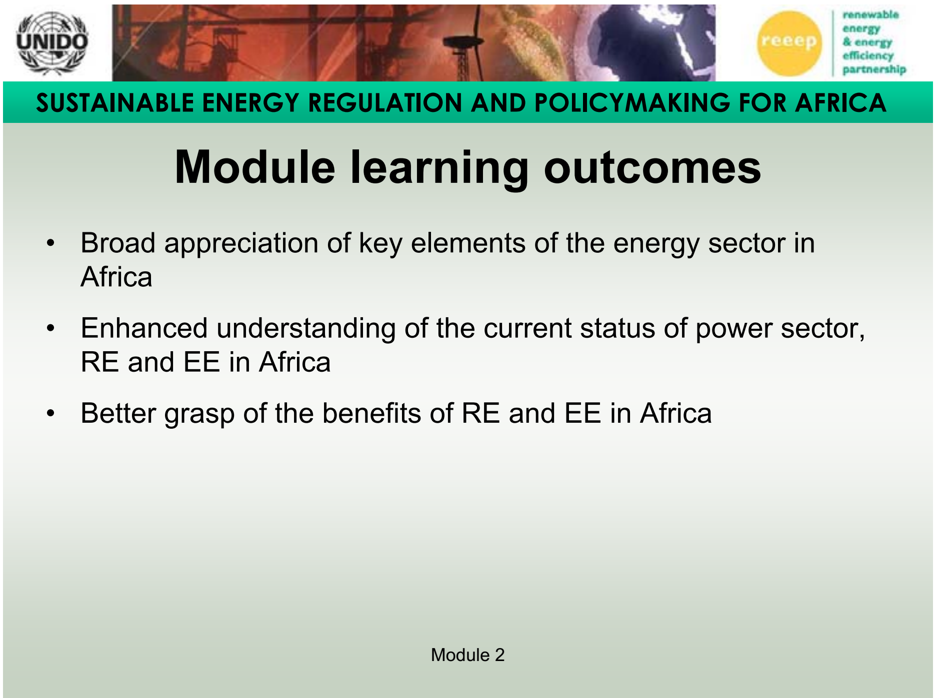


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Provide an overview of the energy sector in Africa
- Present status and performance of the power sector in Africa
- Highlight key characteristics of the power sector in Africa
- Review the status and the benefits of RE in Africa
- Provide an overview of EE in Africa
- Review the benefits of EE with specific emphasis on the industrial sector

Module 2

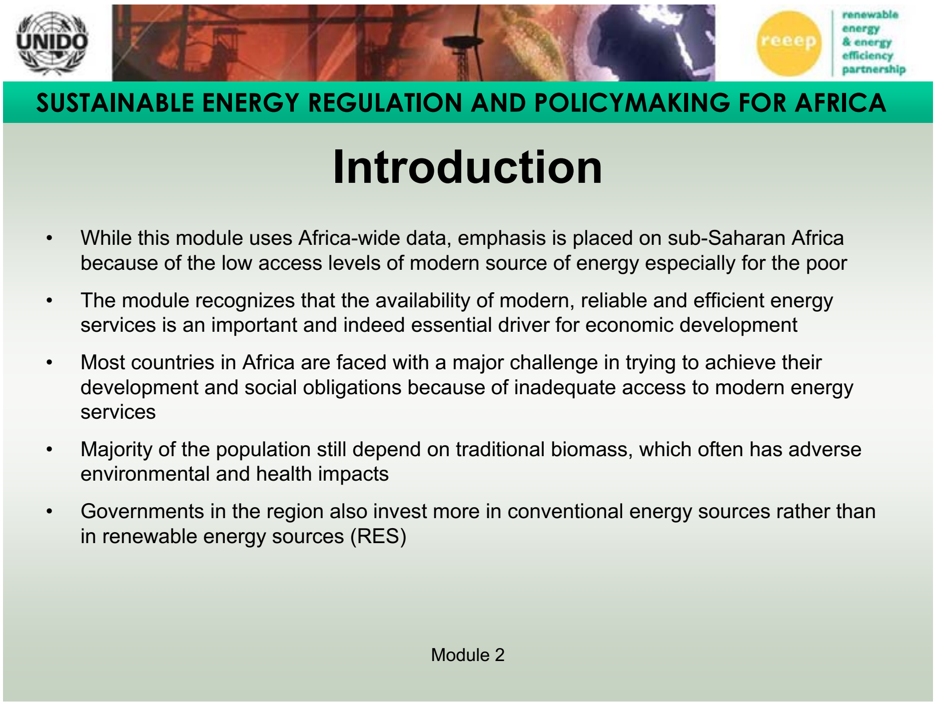


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Broad appreciation of key elements of the energy sector in Africa
- Enhanced understanding of the current status of power sector, RE and EE in Africa
- Better grasp of the benefits of RE and EE in Africa

Module 2

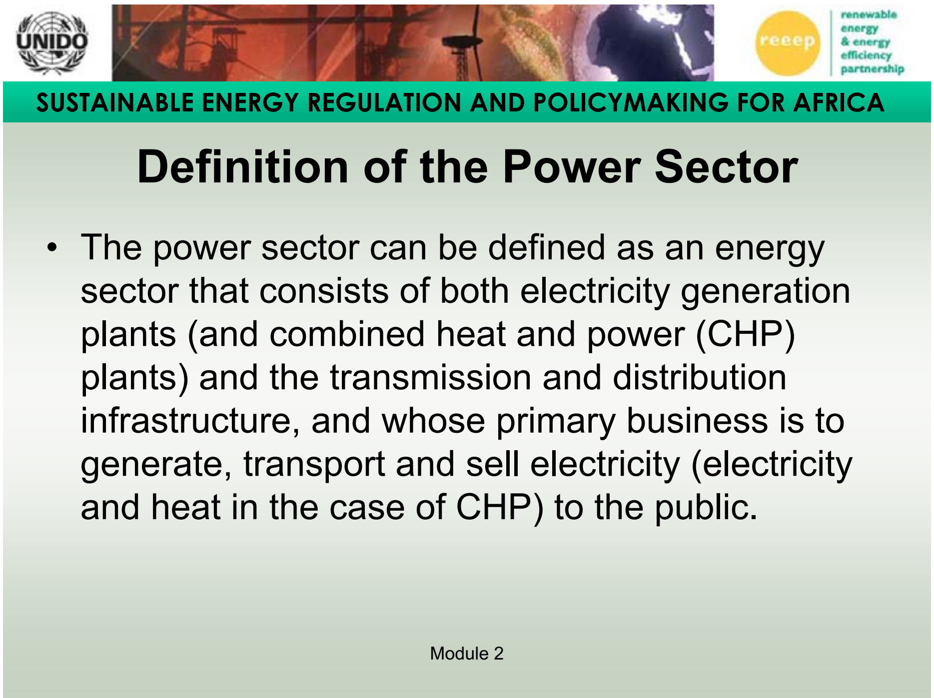


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

- While this module uses Africa-wide data, emphasis is placed on sub-Saharan Africa because of the low access levels of modern source of energy especially for the poor
- The module recognizes that the availability of modern, reliable and efficient energy services is an important and indeed essential driver for economic development
- Most countries in Africa are faced with a major challenge in trying to achieve their development and social obligations because of inadequate access to modern energy services
- Majority of the population still depend on traditional biomass, which often has adverse environmental and health impacts
- Governments in the region also invest more in conventional energy sources rather than in renewable energy sources (RES)

Module 2

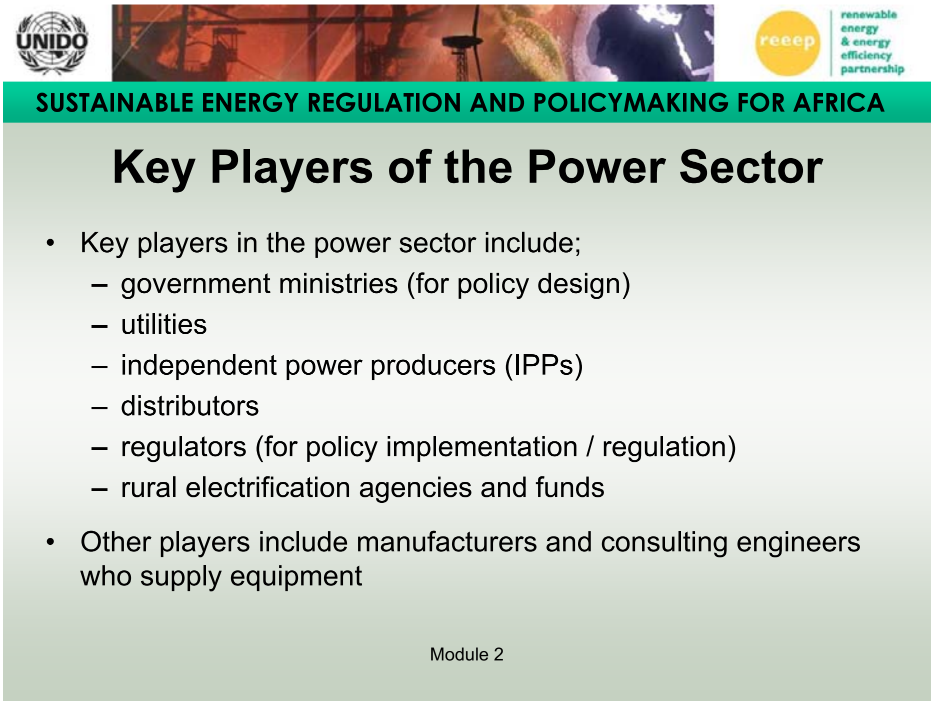


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Definition of the Power Sector

- The power sector can be defined as an energy sector that consists of both electricity generation plants (and combined heat and power (CHP) plants) and the transmission and distribution infrastructure, and whose primary business is to generate, transport and sell electricity (electricity and heat in the case of CHP) to the public.

Module 2



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Key Players of the Power Sector

- Key players in the power sector include;
  - government ministries (for policy design)
  - utilities
  - independent power producers (IPPs)
  - distributors
  - regulators (for policy implementation / regulation)
  - rural electrification agencies and funds
- Other players include manufacturers and consulting engineers who supply equipment

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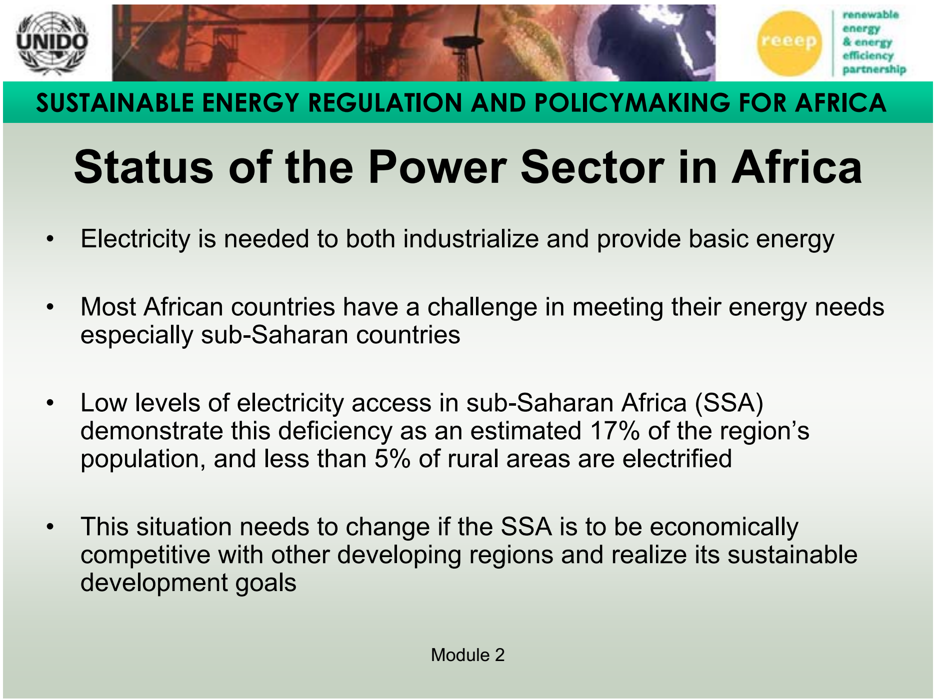

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Status of the Power Sector in Africa

- Electricity is needed to both industrialize and provide basic energy
- Most African countries have a challenge in meeting their energy needs especially sub-Saharan countries
- Low levels of electricity access in sub-Saharan Africa (SSA) demonstrate this deficiency as an estimated 17% of the region’s population, and less than 5% of rural areas are electrified
- This situation needs to change if the SSA is to be economically competitive with other developing regions and realize its sustainable development goals

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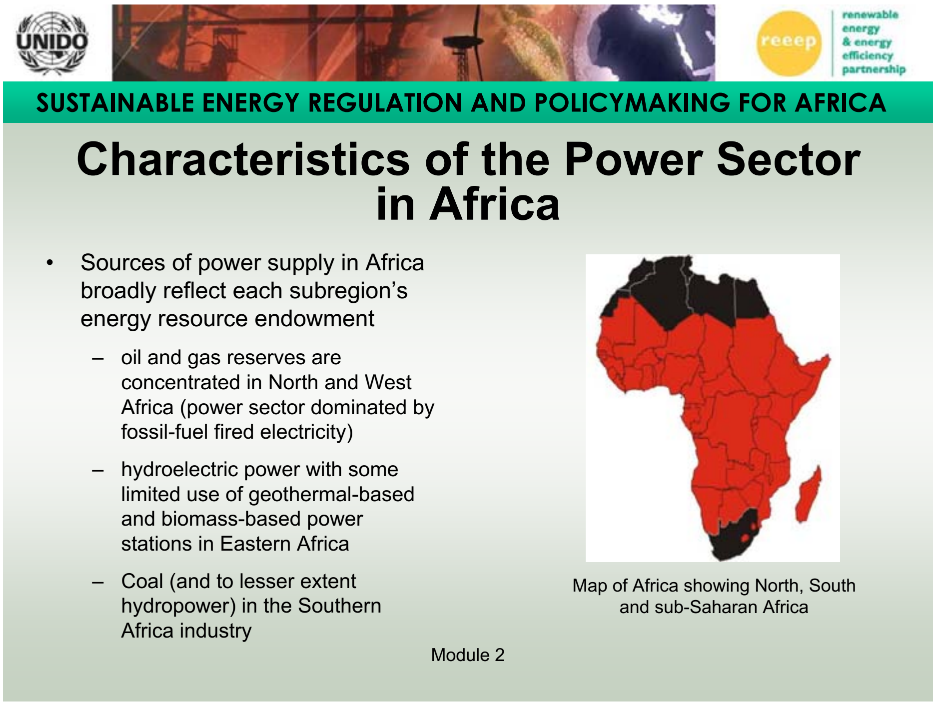


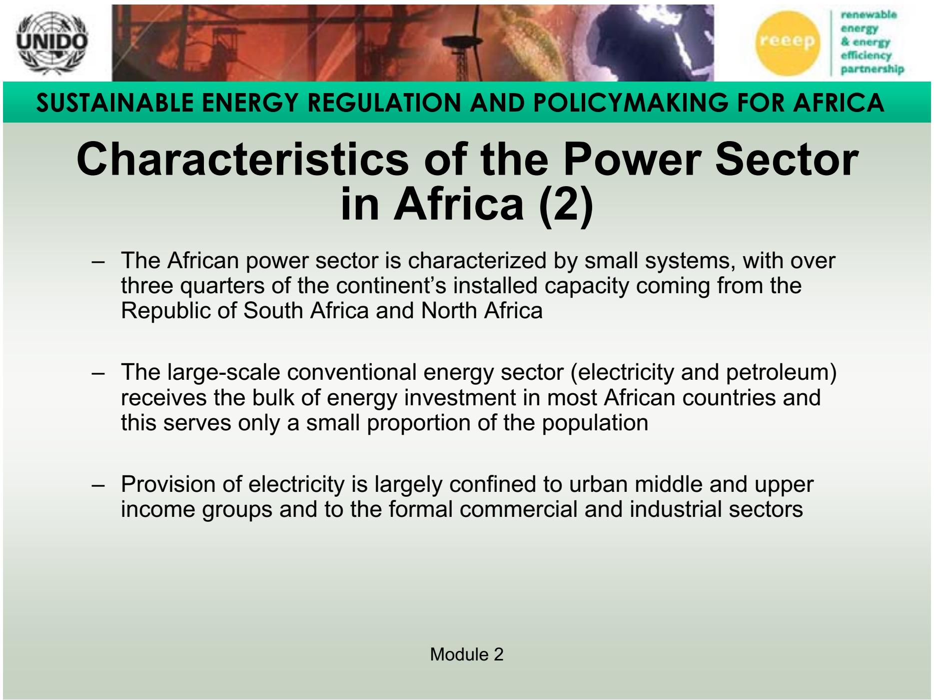
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Characteristics of the Power Sector in Africa

- Sources of power supply in Africa broadly reflect each subregion's energy resource endowment
  - – oil and gas reserves are concentrated in North and West Africa (power sector dominated by fossil-fuel fired electricity)
  - – hydroelectric power with some limited use of geothermal-based and biomass-based power stations in Eastern Africa
  - – Coal (and to lesser extent hydropower) in the Southern Africa industry

Map of Africa showing North, South and sub-Saharan Africa

Module 2

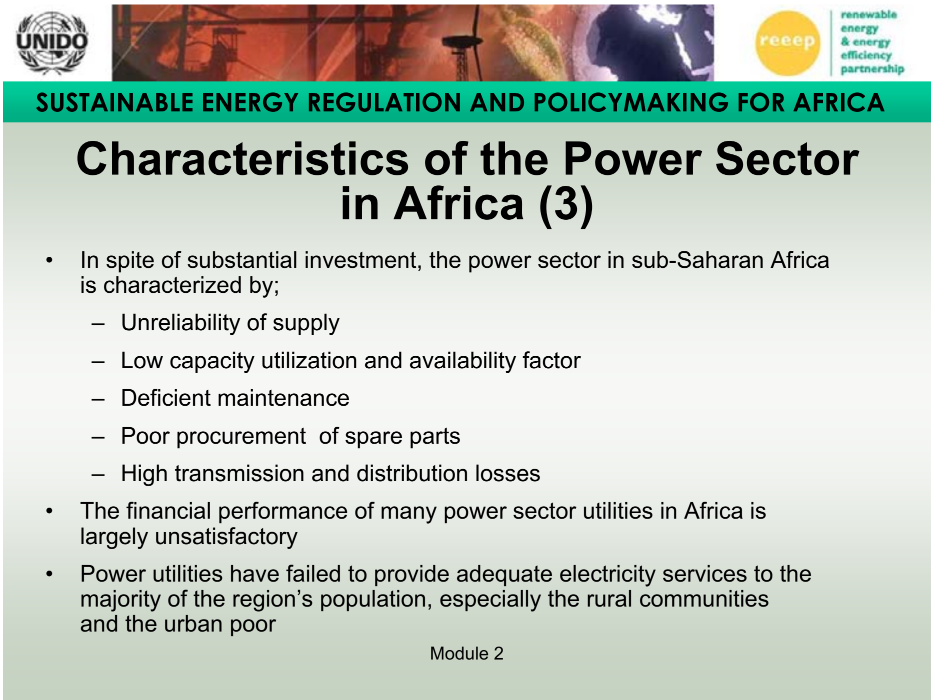


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Characteristics of the Power Sector in Africa (2)

- – The African power sector is characterized by small systems, with over three quarters of the continent's installed capacity coming from the Republic of South Africa and North Africa
- – The large-scale conventional energy sector (electricity and petroleum) receives the bulk of energy investment in most African countries and this serves only a small proportion of the population
- – Provision of electricity is largely confined to urban middle and upper income groups and to the formal commercial and industrial sectors

Module 2

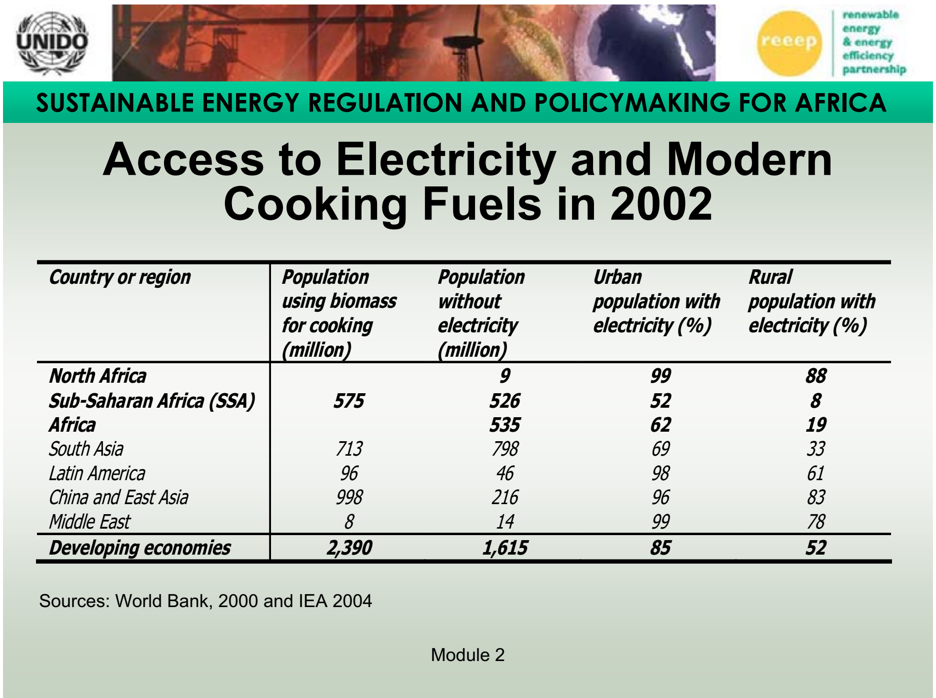


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Characteristics of the Power Sector in Africa (3)

- In spite of substantial investment, the power sector in sub-Saharan Africa is characterized by;
  - Unreliability of supply
  - Low capacity utilization and availability factor
  - Deficient maintenance
  - Poor procurement of spare parts
  - High transmission and distribution losses
- The financial performance of many power sector utilities in Africa is largely unsatisfactory
- Power utilities have failed to provide adequate electricity services to the majority of the region’s population, especially the rural communities and the urban poor

Module 2



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Access to Electricity and Modern Cooking Fuels in 2002

Country or region	*Population using biomass for cooking (million)*	*Population without electricity (million)*	*Urban population with electricity (%)*	*Rural population with electricity (%)*
North Africa		***9***	***99***	***88***
Sub-Saharan Africa (SSA)	***575***	***526***	***52***	***8***
Africa		***535***	***62***	***19***
South Asia	*713*	*798*	*69*	*33*
Latin America	*96*	*46*	*98*	*61*
China and East Asia	*998*	*216*	*96*	*83*
Middle East	*8*	*14*	*99*	*78*
Developing economies	***2,390***	***1,615***	***85***	***52***

Sources: World Bank, 2000 and IEA 2004

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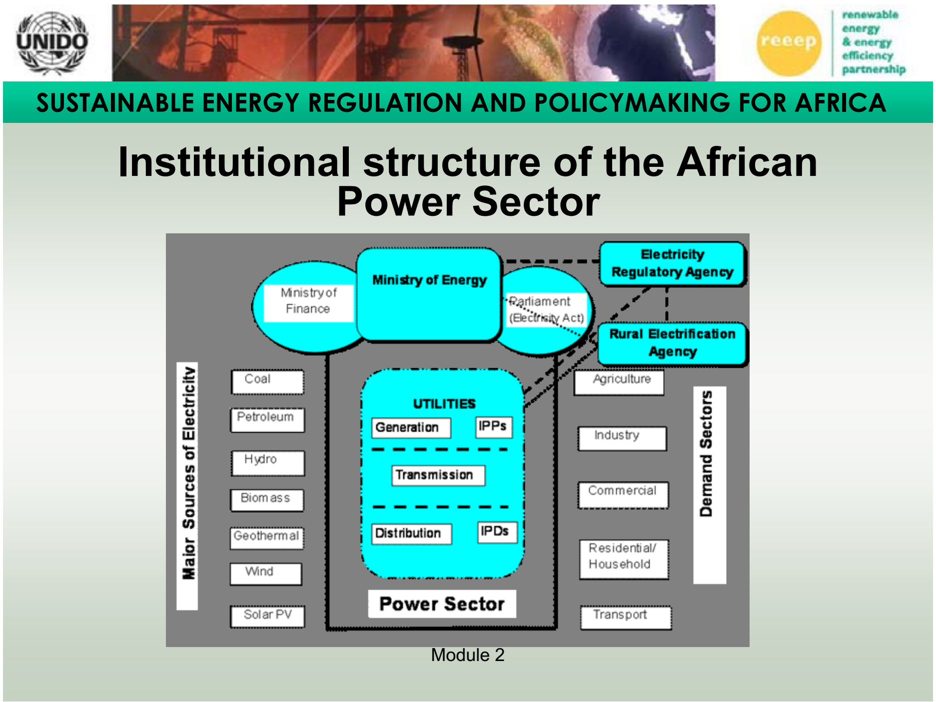


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Institutional structure of the African Power Sector

Ministry of Finance

Ministry of Energy

Parliament (Electricity Act)

Electricity Regulatory Agency

Rural Electrification Agency

Major Sources of Electricity

Coal

Petroleum

Hydro

Biomass

Geothermal

Wind

Solar PV

UTILITIES

Generation

IPPs

Transmission

Distribution

IPDs

Power Sector

Agriculture

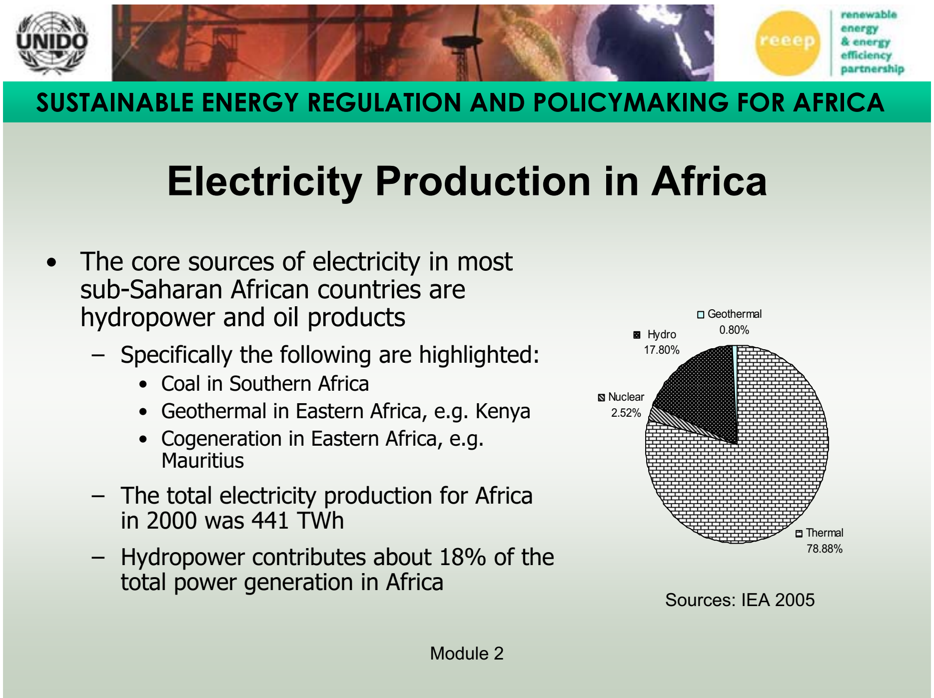
Industry

Commercial

Residential/ Household

Transport

Demand Sectors

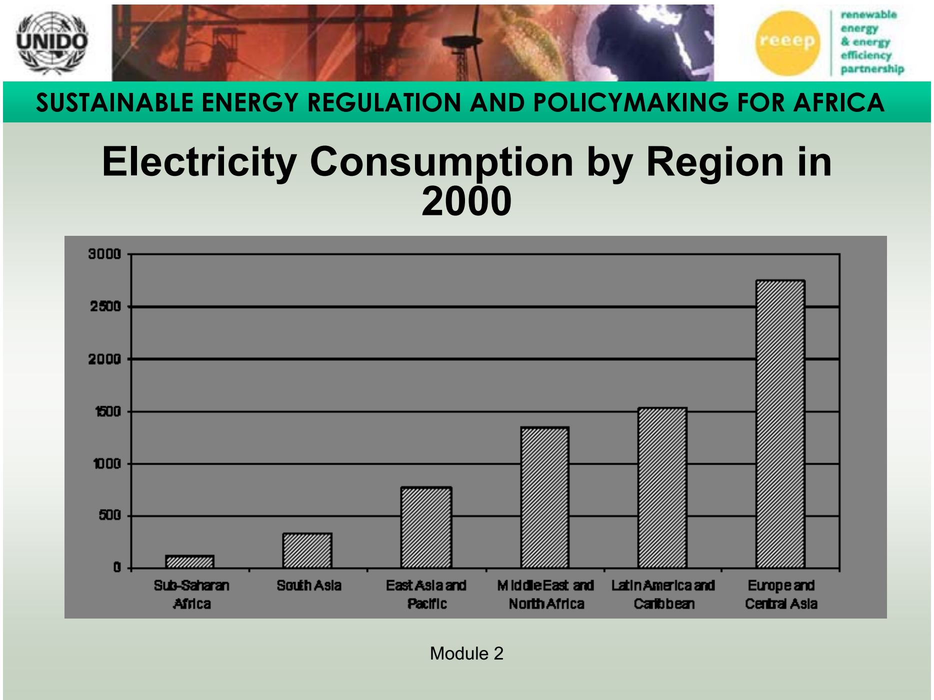


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Electricity Production in Africa

- The core sources of electricity in most sub-Saharan African countries are hydropower and oil products
  - Specifically the following are highlighted:
    - Coal in Southern Africa
    - Geothermal in Eastern Africa, e.g. Kenya
    - Cogeneration in Eastern Africa, e.g. Mauritius
  - The total electricity production for Africa in 2000 was 441 TWh
  - Hydropower contributes about 18% of the total power generation in Africa

Sources: IEA 2005



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Electricity Consumption by Region in 2000

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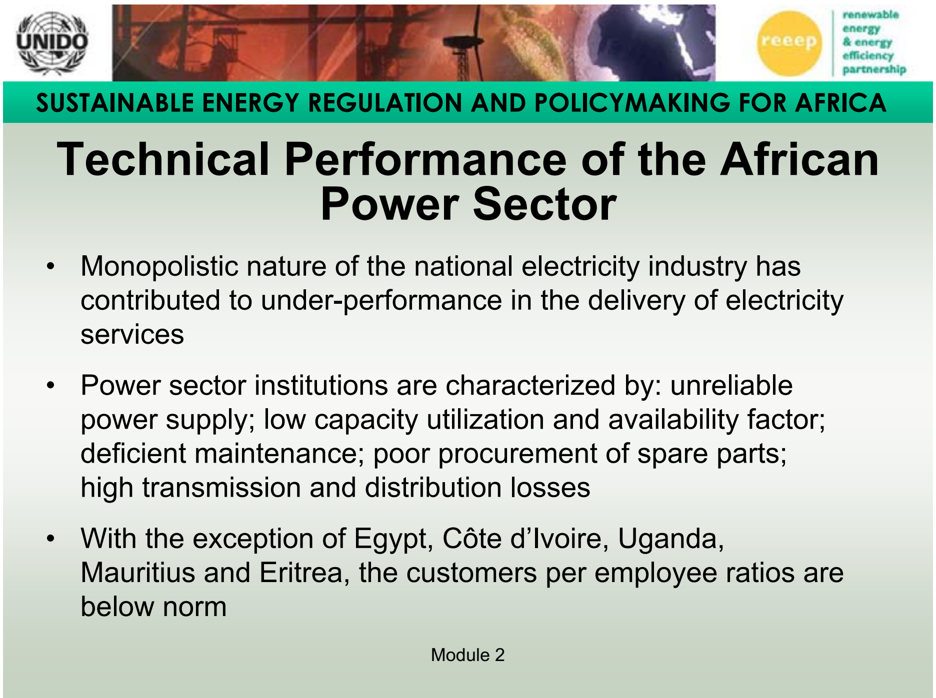

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Technical Performance of the African Power Sector

- Monopolistic nature of the national electricity industry has contributed to under-performance in the delivery of electricity services
- Power sector institutions are characterized by: unreliable power supply; low capacity utilization and availability factor; deficient maintenance; poor procurement of spare parts; high transmission and distribution losses
- With the exception of Egypt, Côte d’Ivoire, Uganda, Mauritius and Eritrea, the customers per employee ratios are below norm

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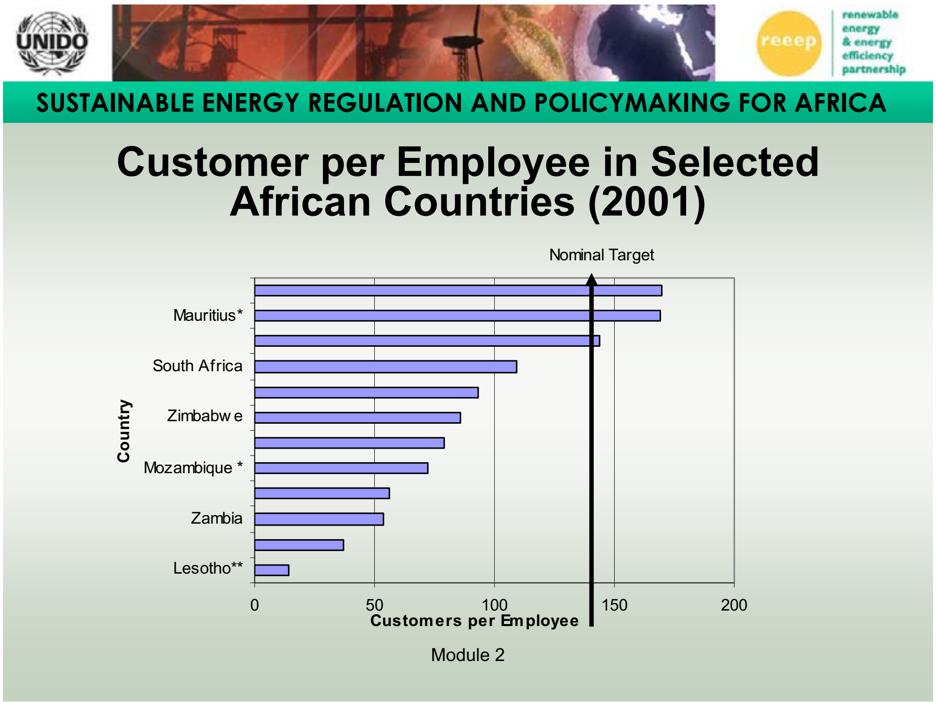

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Customer per Employee in Selected African Countries (2001)

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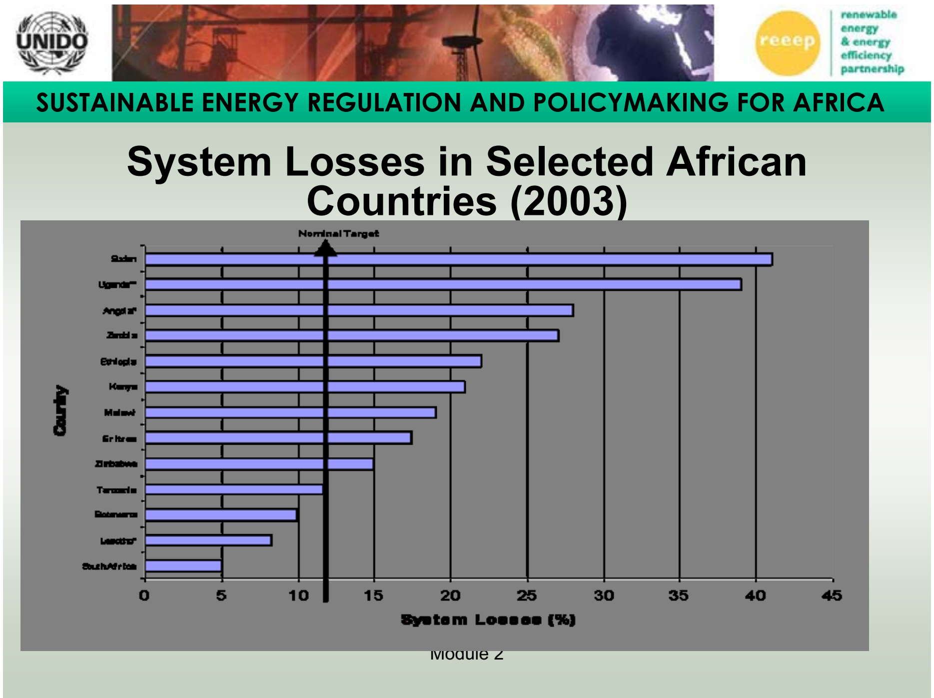

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

System Losses in Selected African Countries (2003)

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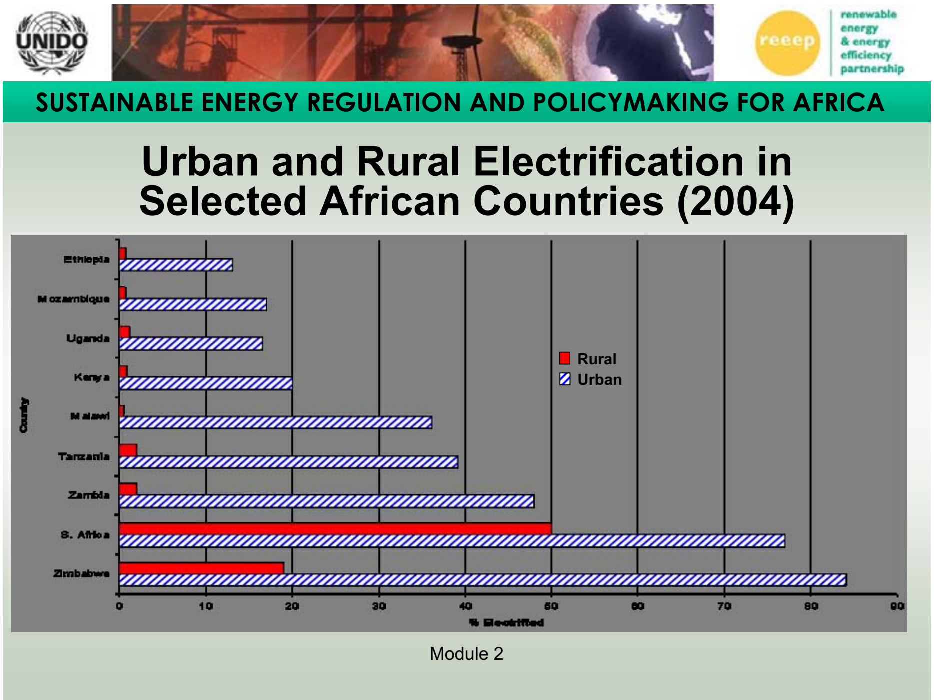

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Urban and Rural Electrification in Selected African Countries (2004)

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financial Performance of the African Power Sector

- The financial performance of most African utilities is unsatisfactory as:
  - Debt owed by customers is usually sizable. In most cases, the government and its parastatals account for a large share of this debt
  - Inability of utilities to mobilize sufficient investment capital
  - Non-sustainable pricing policies
  - Poor financial management of the utility

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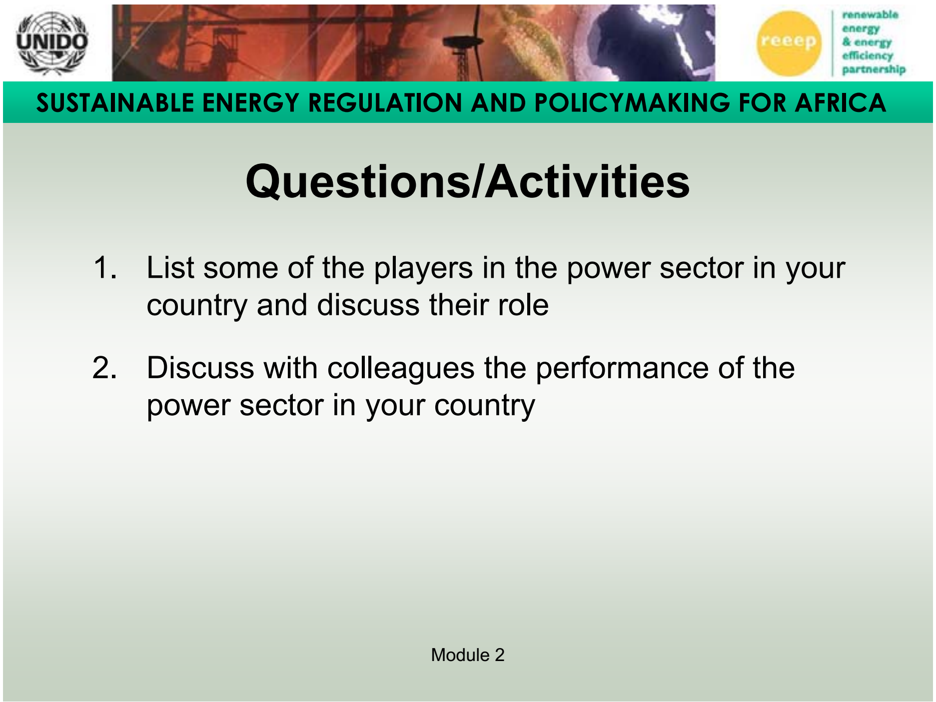

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

1. List some of the players in the power sector in your country and discuss their role
2. Discuss with colleagues the performance of the power sector in your country

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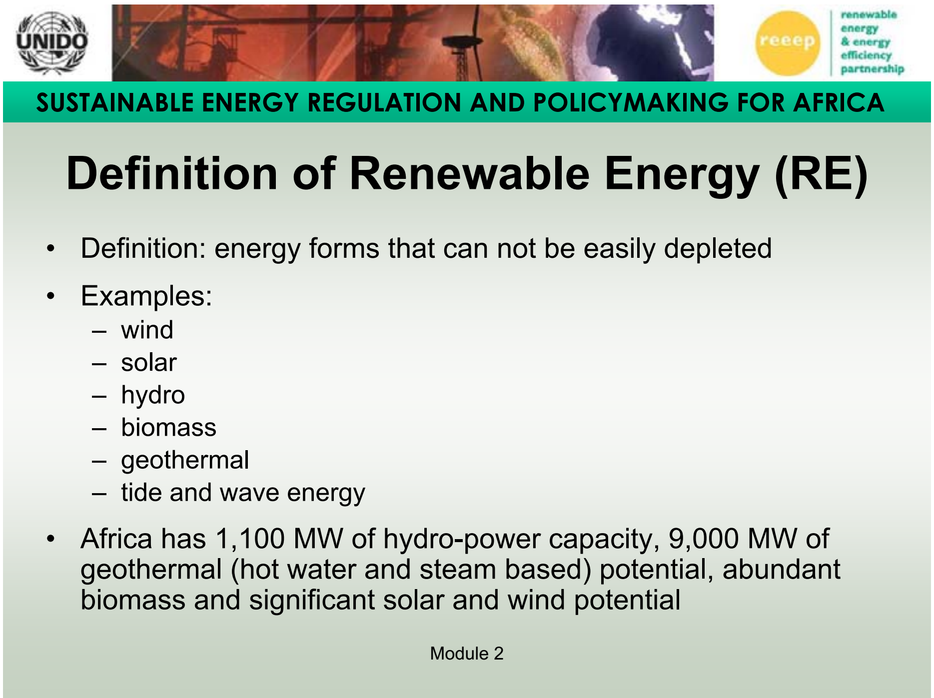

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Definition of Renewable Energy (RE)

- Definition: energy forms that can not be easily depleted
- Examples:
  - wind
  - solar
  - hydro
  - biomass
  - geothermal
  - tide and wave energy
- Africa has 1,100 MW of hydro-power capacity, 9,000 MW of geothermal (hot water and steam based) potential, abundant biomass and significant solar and wind potential

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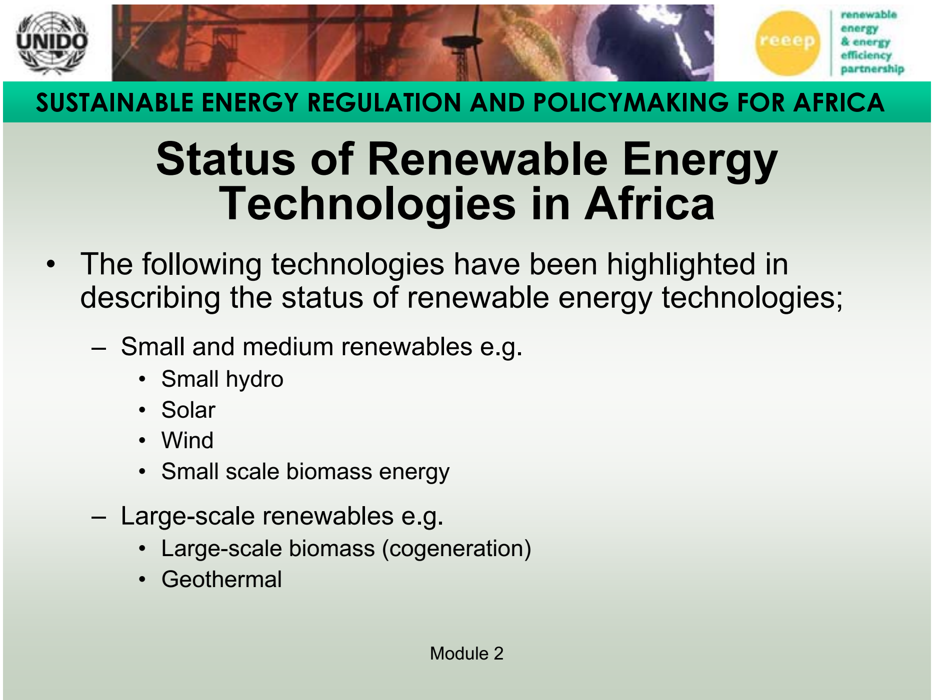

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Status of Renewable Energy Technologies in Africa

- The following technologies have been highlighted in describing the status of renewable energy technologies;
  - Small and medium renewables e.g.
    - Small hydro
    - Solar
    - Wind
    - Small scale biomass energy
  - Large-scale renewables e.g.
    - Large-scale biomass (cogeneration)
    - Geothermal

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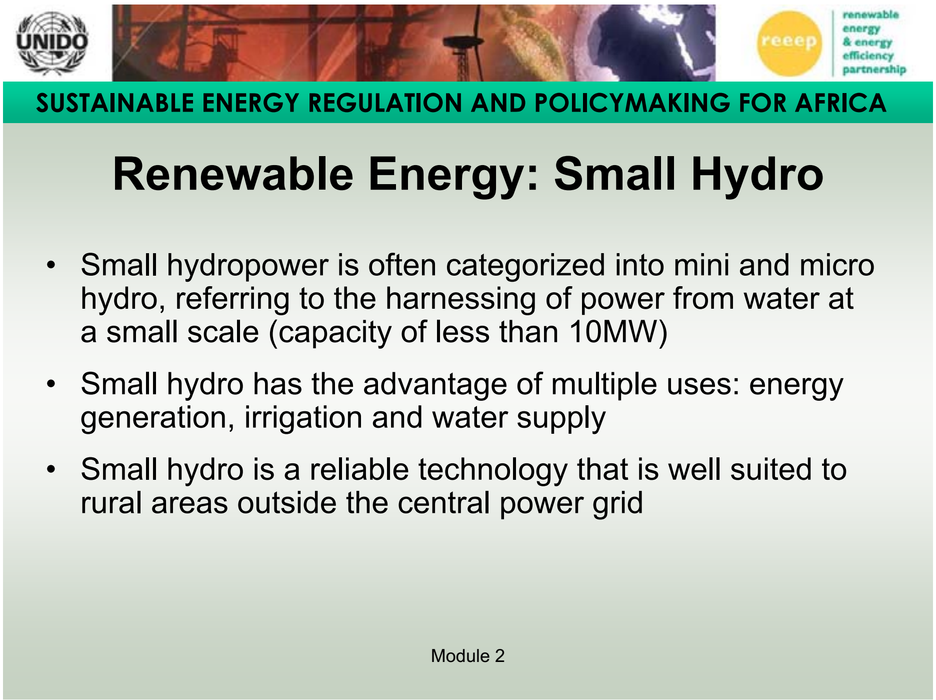

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Small Hydro

- Small hydropower is often categorized into mini and micro hydro, referring to the harnessing of power from water at a small scale (capacity of less than 10MW)
- Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply
- Small hydro is a reliable technology that is well suited to rural areas outside the central power grid

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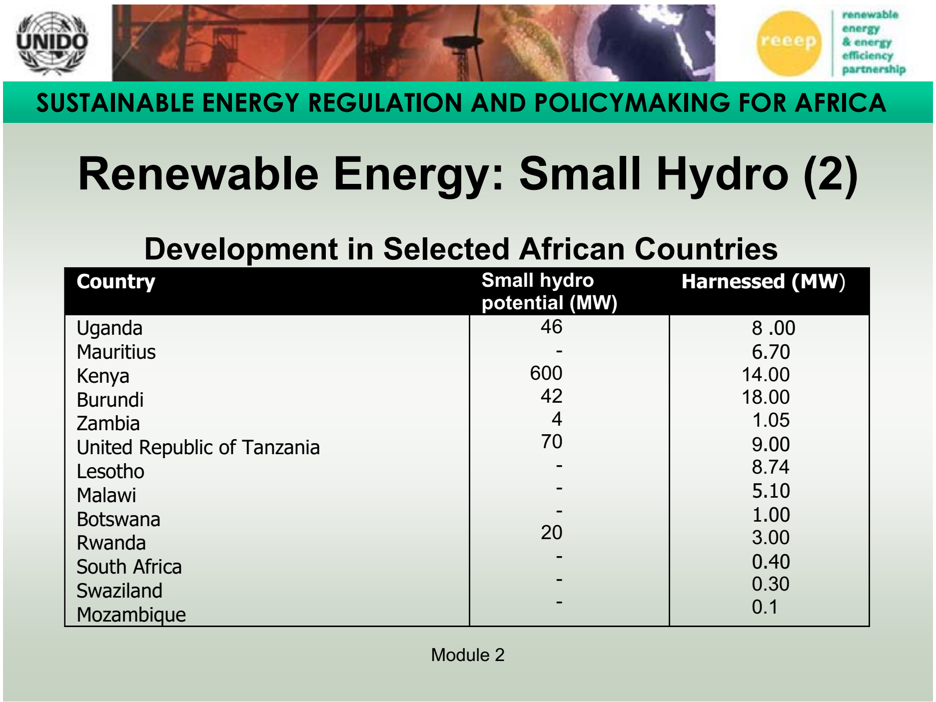

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Small Hydro (2)

Development in Selected African Countries

Country	Small hydro potential (MW)	Harnessed (MW)
Uganda	46	8 .00
Mauritius	-	6.70
Kenya	600	14.00
Burundi	42	18.00
Zambia	4	1.05
United Republic of Tanzania	70	9.00
Lesotho	-	8.74
Malawi	-	5.10
Botswana	-	1.00
Rwanda	20	3.00
South Africa	-	0.40
Swaziland	-	0.30
Mozambique	-	0.1

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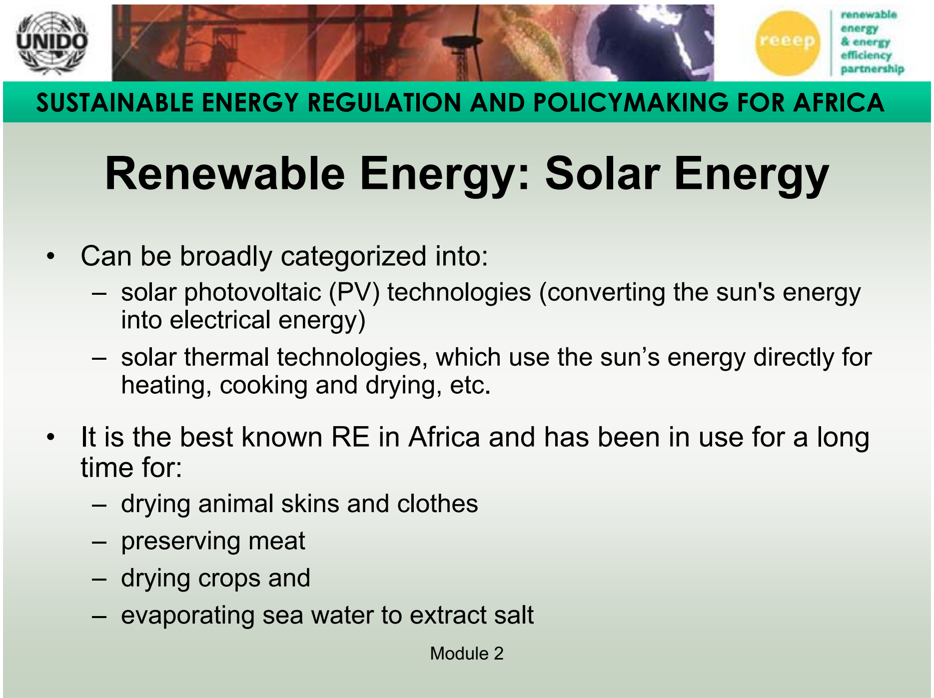


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Solar Energy

- Can be broadly categorized into:
  - solar photovoltaic (PV) technologies (converting the sun's energy into electrical energy)
  - solar thermal technologies, which use the sun's energy directly for heating, cooking and drying, etc.
- It is the best known RE in Africa and has been in use for a long time for:
  - drying animal skins and clothes
  - preserving meat
  - drying crops and
  - evaporating sea water to extract salt

Module 2

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Solar Energy (2)

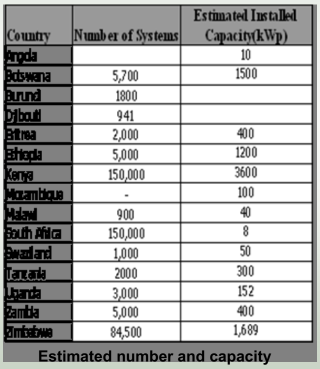
- Solar energy is now utilized at various levels e.g.
  - Small-scale: household level for lighting, cooking, water heaters and solar architecture houses
  - Medium-scale appliances: water heating in hotels and irrigation
  - Industrial scale: used for pre-heating boiler water for industrial use and power generation, detoxification, municipal water heating, telecommunications, and, more recently, transportation (solar cars)

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Solar Energy (3)

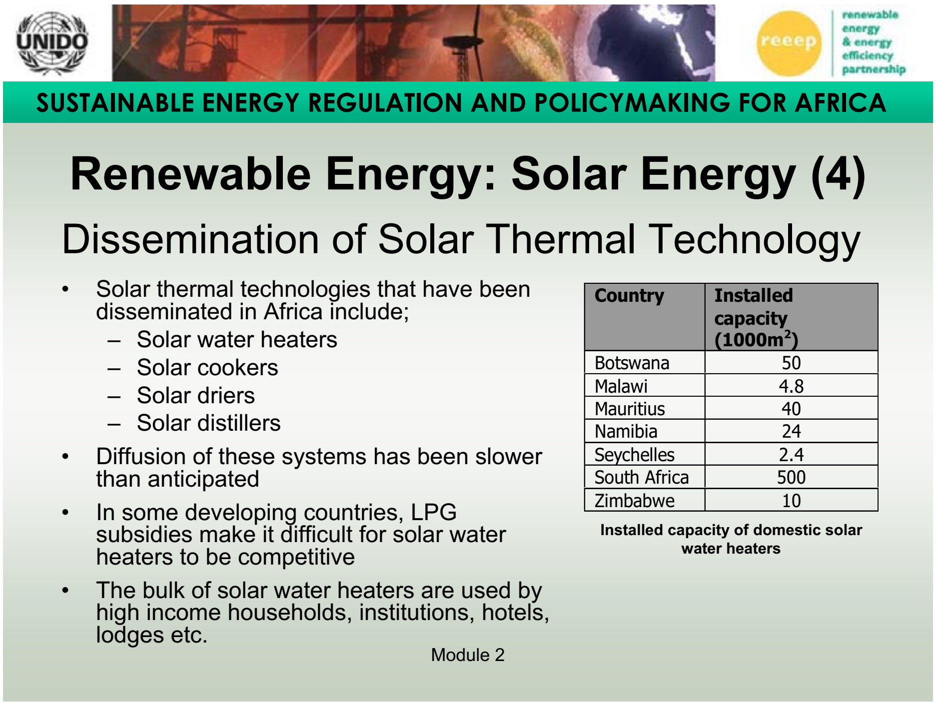
Dissemination of Solar PV Technology

- PVs have been promoted widely in the region and almost every sub-Saharan African country has had a major PV project
- The solar PV projects in the region have mainly benefited the high-income population segments
- Due to its cost, Solar PV is unaffordable to majority of the population in Africa



Country	Number of Systems	Estimated Installed Capacity(kWp)
Angola		10
Botswana	5,700	1500
Burundi	1800	
Djibouti	941	
Eritrea	2,000	400
Ethiopia	5,000	1200
Kenya	150,000	3600
Mozambique	-	100
Malawi	900	40
South Africa	150,000	8
Swaziland	1,000	50
Tanzania	2000	300
Uganda	3,000	152
Zambia	5,000	400
Zimbabwe	84,500	1,689

Estimated number and capacity disseminated solar PV Systems



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

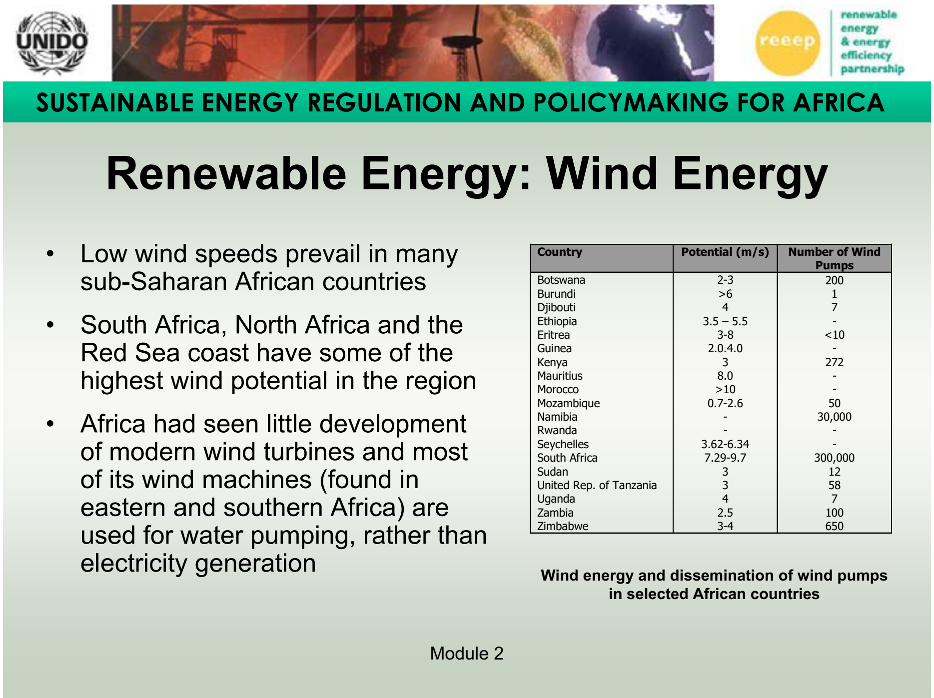
Renewable Energy: Solar Energy (4)

Dissemination of Solar Thermal Technology

- Solar thermal technologies that have been disseminated in Africa include;
  - Solar water heaters
  - Solar cookers
  - Solar driers
  - Solar distillers
- Diffusion of these systems has been slower than anticipated
- In some developing countries, LPG subsidies make it difficult for solar water heaters to be competitive
- The bulk of solar water heaters are used by high income households, institutions, hotels, lodges etc.

Country	**Installed capacity (1000m^2)**
Botswana	50
Malawi	4.8
Mauritius	40
Namibia	24
Seychelles	2.4
South Africa	500
Zimbabwe	10

Installed capacity of domestic solar water heaters



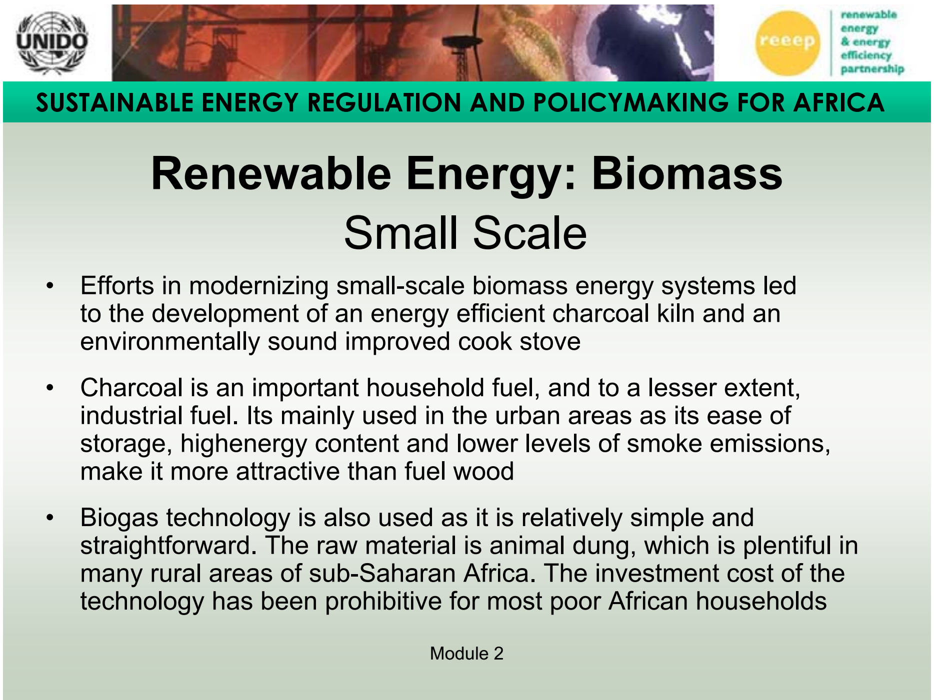
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Wind Energy

- Low wind speeds prevail in many sub-Saharan African countries
- South Africa, North Africa and the Red Sea coast have some of the highest wind potential in the region
- Africa had seen little development of modern wind turbines and most of its wind machines (found in eastern and southern Africa) are used for water pumping, rather than electricity generation

Country	**Potential (m/s)**	**Number of Wind Pumps**
Botswana	2-3	200
Burundi	>6	1
Djibouti	4	7
Ethiopia	3.5 – 5.5	-
Eritrea	3-8	<10
Guinea	2.0.4.0	-
Kenya	3	272
Mauritius	8.0	-
Morocco	>10	-
Mozambique	0.7-2.6	50
Namibia	-	30,000
Rwanda	-	-
Seychelles	3.62-6.34	-
South Africa	7.29-9.7	300,000
Sudan	3	12
United Rep. of Tanzania	3	58
Uganda	4	7
Zambia	2.5	100
Zimbabwe	3-4	650

Wind energy and dissemination of wind pumps in selected African countries

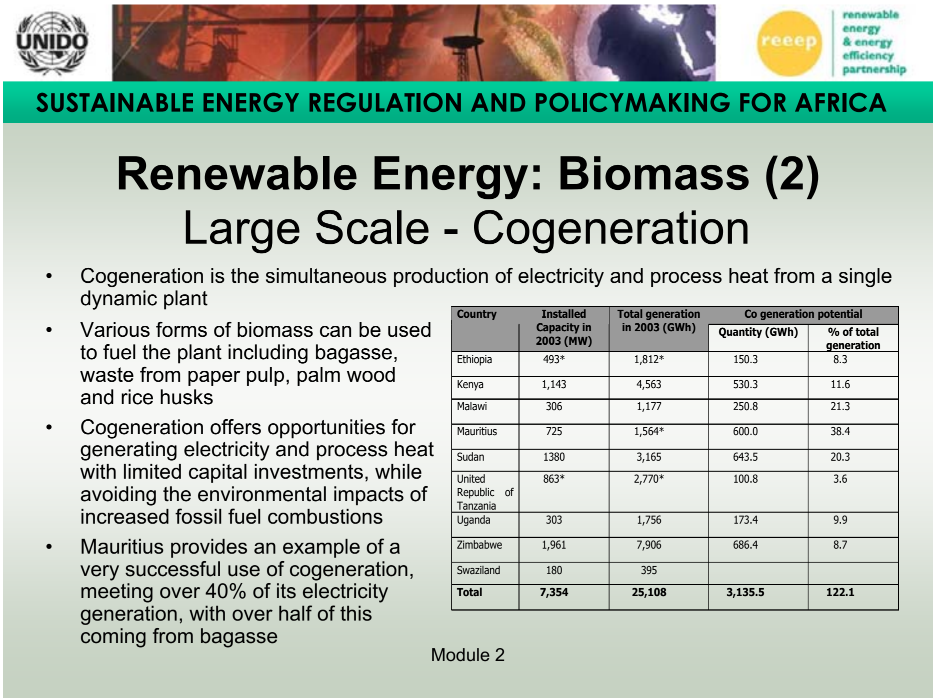


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Biomass
Small Scale

- Efforts in modernizing small-scale biomass energy systems led to the development of an energy efficient charcoal kiln and an environmentally sound improved cook stove
- Charcoal is an important household fuel, and to a lesser extent, industrial fuel. Its mainly used in the urban areas as its ease of storage, highenergy content and lower levels of smoke emissions, make it more attractive than fuel wood
- Biogas technology is also used as it is relatively simple and straightforward. The raw material is animal dung, which is plentiful in many rural areas of sub-Saharan Africa. The investment cost of the technology has been prohibitive for most poor African households

Module 2



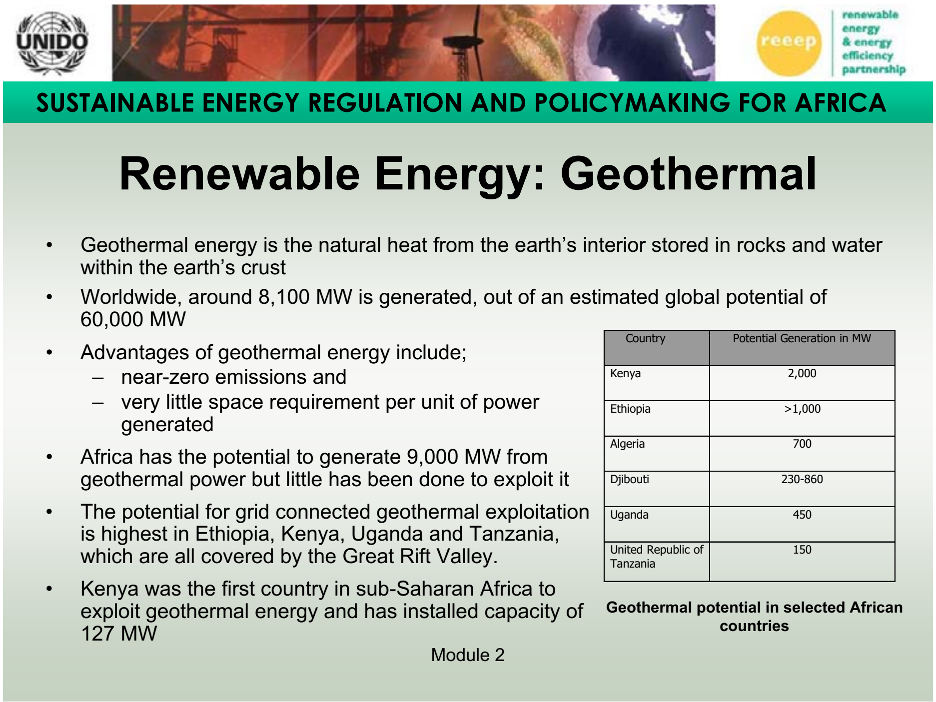
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy: Biomass (2)
Large Scale - Cogeneration

- Cogeneration is the simultaneous production of electricity and process heat from a single dynamic plant
- Various forms of biomass can be used to fuel the plant including bagasse, waste from paper pulp, palm wood and rice husks
- Cogeneration offers opportunities for generating electricity and process heat with limited capital investments, while avoiding the environmental impacts of increased fossil fuel combustions
- Mauritius provides an example of a very successful use of cogeneration, meeting over 40% of its electricity generation, with over half of this coming from bagasse

Country	Installed Capacity in 2003 (MW)	Total generation in 2003 (GWh)	Co generation potential	
			Quantity (GWh)	% of total generation
Ethiopia	493*	1,812*	150.3	8.3
Kenya	1,143	4,563	530.3	11.6
Malawi	306	1,177	250.8	21.3
Mauritius	725	1,564*	600.0	38.4
Sudan	1380	3,165	643.5	20.3
United Republic of Tanzania	863*	2,770*	100.8	3.6
Uganda	303	1,756	173.4	9.9
Zimbabwe	1,961	7,906	686.4	8.7
Swaziland	180	395		
Total	**7,354**	**25,108**	**3,135.5**	**122.1**

Module 2



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

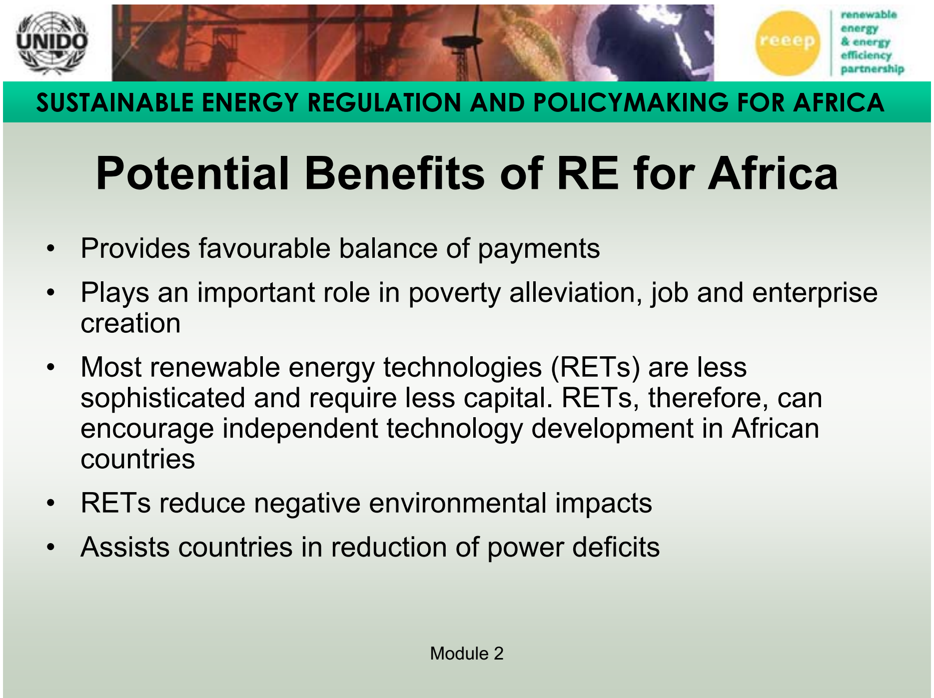
Renewable Energy: Geothermal

- Geothermal energy is the natural heat from the earth's interior stored in rocks and water within the earth's crust
- Worldwide, around 8,100 MW is generated, out of an estimated global potential of 60,000 MW
- Advantages of geothermal energy include;
  - near-zero emissions and
  - very little space requirement per unit of power generated
- Africa has the potential to generate 9,000 MW from geothermal power but little has been done to exploit it
- The potential for grid connected geothermal exploitation is highest in Ethiopia, Kenya, Uganda and Tanzania, which are all covered by the Great Rift Valley.
- Kenya was the first country in sub-Saharan Africa to exploit geothermal energy and has installed capacity of 127 MW

Country	Potential Generation in MW
Kenya	2,000
Ethiopia	>1,000
Algeria	700
Djibouti	230-860
Uganda	450
United Republic of Tanzania	150

Geothermal potential in selected African countries

Module 2

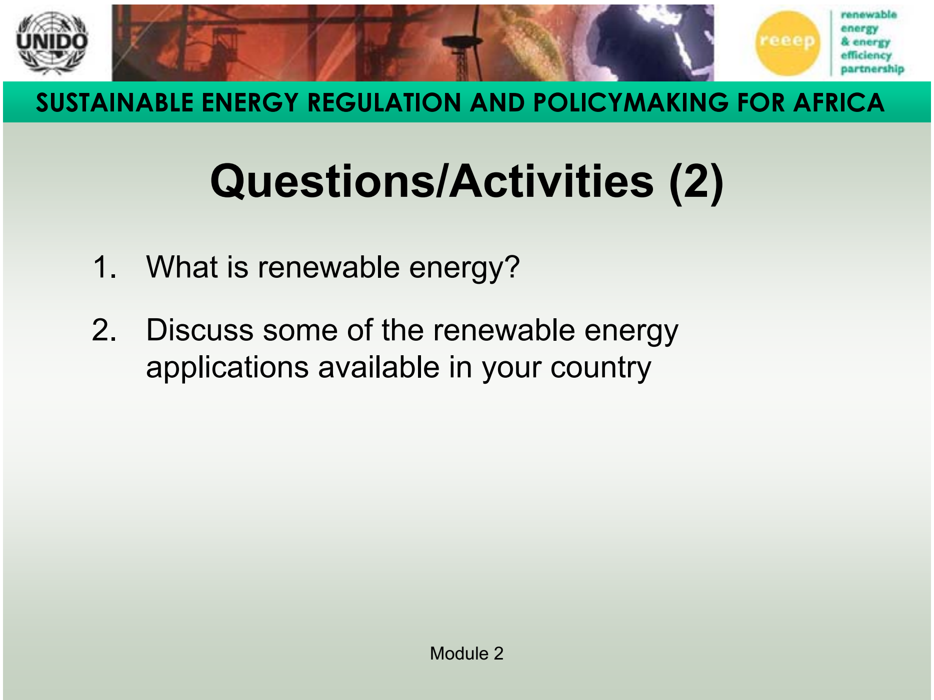


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Potential Benefits of RE for Africa

- Provides favourable balance of payments
- Plays an important role in poverty alleviation, job and enterprise creation
- Most renewable energy technologies (RETs) are less sophisticated and require less capital. RETs, therefore, can encourage independent technology development in African countries
- RETs reduce negative environmental impacts
- Assists countries in reduction of power deficits

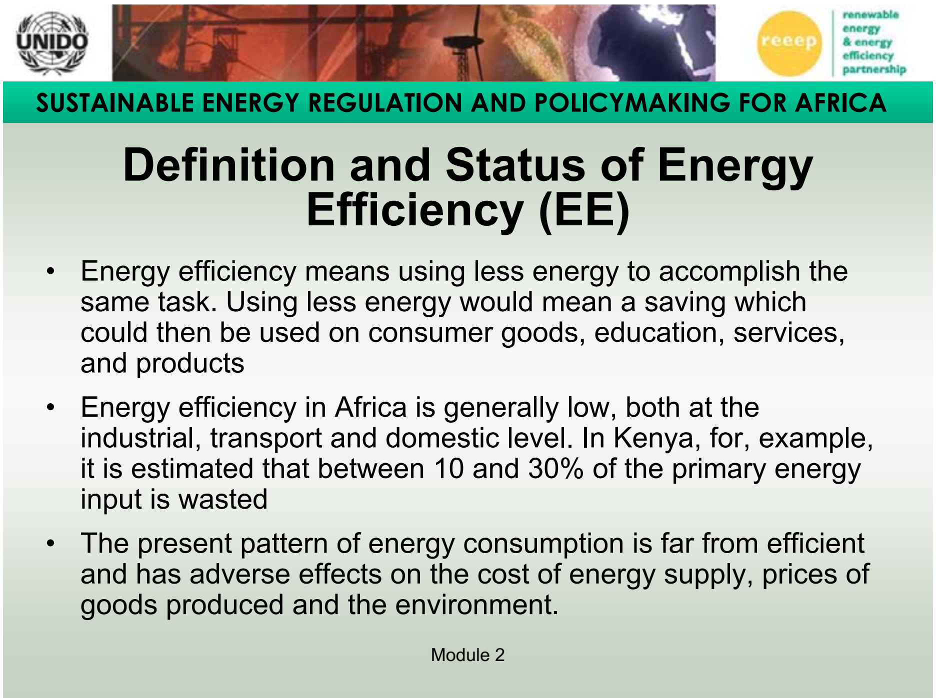
Module 2



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (2)

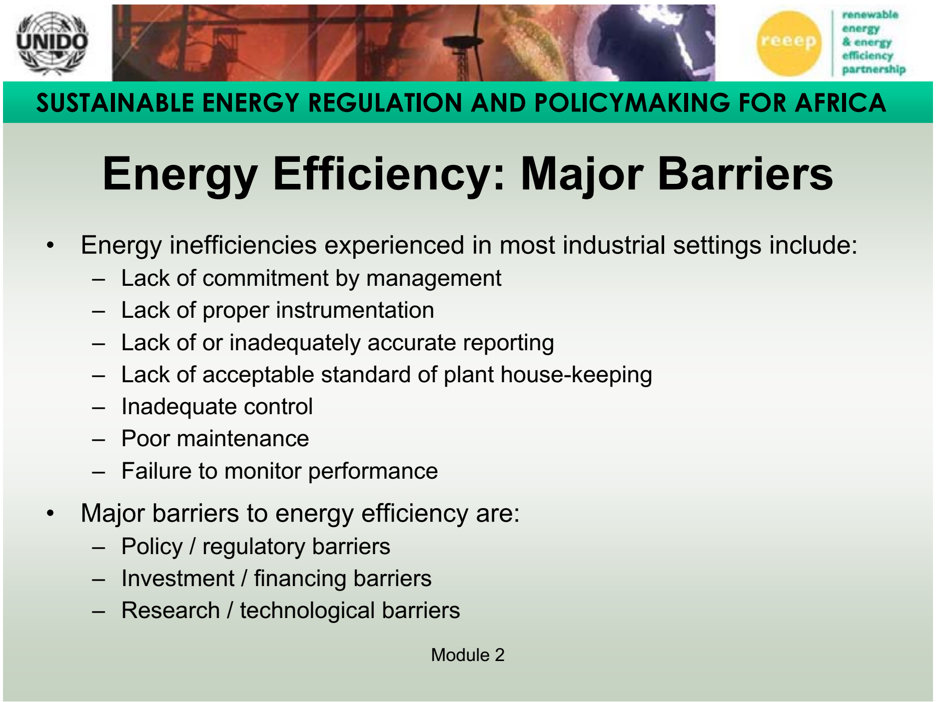
1. What is renewable energy?
2. Discuss some of the renewable energy applications available in your country



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Definition and Status of Energy Efficiency (EE)

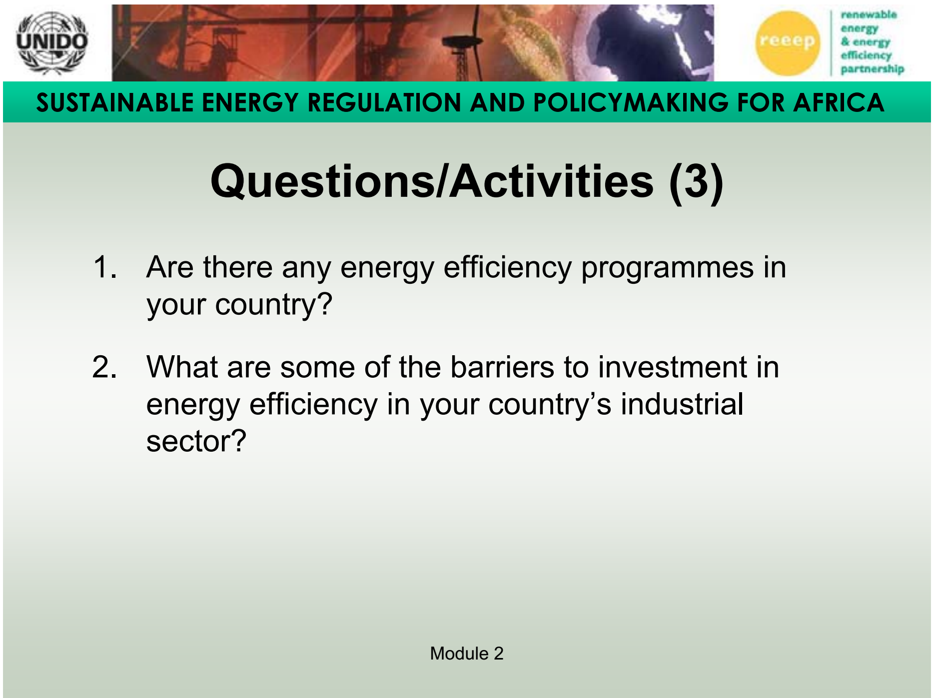
- Energy efficiency means using less energy to accomplish the same task. Using less energy would mean a saving which could then be used on consumer goods, education, services, and products
- Energy efficiency in Africa is generally low, both at the industrial, transport and domestic level. In Kenya, for, example, it is estimated that between 10 and 30% of the primary energy input is wasted
- The present pattern of energy consumption is far from efficient and has adverse effects on the cost of energy supply, prices of goods produced and the environment.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency: Major Barriers

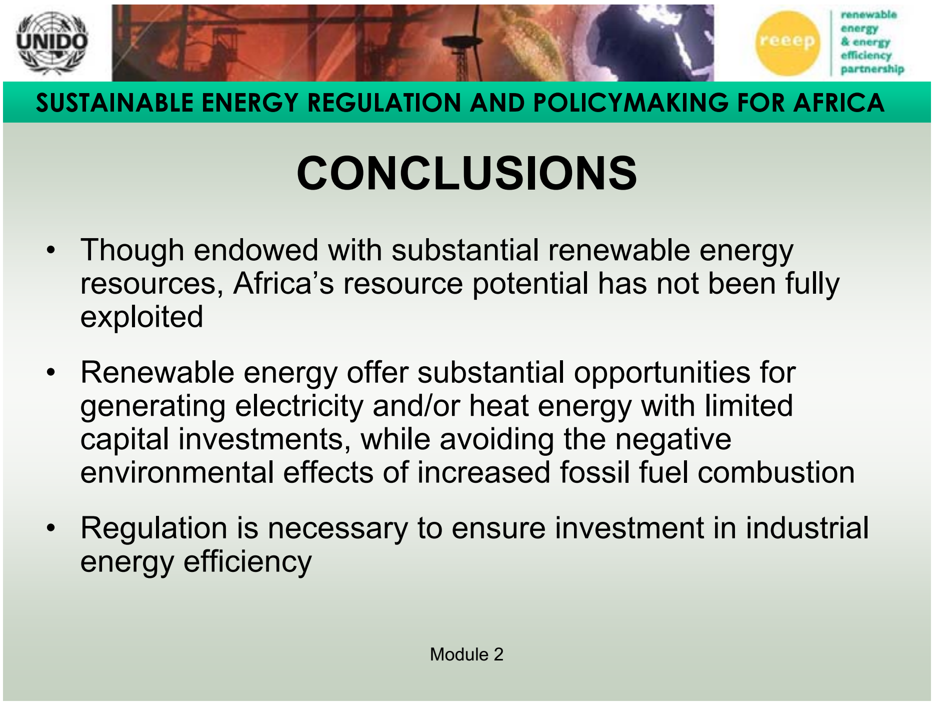
- Energy inefficiencies experienced in most industrial settings include:
  - Lack of commitment by management
  - Lack of proper instrumentation
  - Lack of or inadequately accurate reporting
  - Lack of acceptable standard of plant house-keeping
  - Inadequate control
  - Poor maintenance
  - Failure to monitor performance
- Major barriers to energy efficiency are:
  - Policy / regulatory barriers
  - Investment / financing barriers
  - Research / technological barriers



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (3)

1. Are there any energy efficiency programmes in your country?
2. What are some of the barriers to investment in energy efficiency in your country’s industrial sector?



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Though endowed with substantial renewable energy resources, Africa’s resource potential has not been fully exploited
- Renewable energy offer substantial opportunities for generating electricity and/or heat energy with limited capital investments, while avoiding the negative environmental effects of increased fossil fuel combustion
- Regulation is necessary to ensure investment in industrial energy efficiency

Module 3

Introduction to energy regulation

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This module examines the following themes:

- Regulation is primarily designed to address the failure of markets to deliver desired goods, whether these are economic, social or environmental.
- One model of regulation will not fit all energy systems. Whether a system is state-owned or privatized, monopoly or competitive, integrated or unbundled, established or developing will affect the role of the regulator and the degree to which the regulator can intervene in the system. However, various regulatory models can be adopted or adapted to encourage the development of sustainable energy technologies.
- The need to develop sustainable energy policies raises new issues for policy-makers and regulators, including how to integrate possibly conflicting policy goals.
- Regulation is carried out in a number of different ways by different institutions. Each has strengths and weaknesses.
- Similarly, there are different models of regulatory strategy employing a range of incentives and penalties. Practitioners need to be aware of the advantages and disadvantages of these in seeking to encourage the deployment of sustainable energy technologies.

1.2. Module aims

The aims of the present module are listed below:

- To introduce the concept of regulation and provide some different definitions of regulation.
- To show that there is no “ideal” way to regulate.
- To outline the major bodies involved in the regulation of energy.
- To outline the basic methods of regulation.
- To outline the new issues raised by the need to develop sustainable energy.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To be able to define regulation.
- To understand the role of regulation in a market system.

- To understand that there are different ways to regulate and different bodies that can be involved in regulation.
- To describe some different regulation systems.
- To appreciate some of the basic issues that sustainable energy can raise in relation to regulation.

2. INTRODUCTION

This module addresses the underlying basis for regulation with regard to the energy industries, although it will focus mainly on the electricity industry rather than other energy industries such as gas. It outlines the aims, design and degree of regulation to provide a basic introduction to the main issues and to establish a foundation for the following modules.

It is worth highlighting that the module concentrates on the rationale and the role of the economic regulator, which in turn assumes a degree of liberalization in a system. In a non-liberalized or state-owned system, many of the regulator's functions will be performed by the government.

In most African countries utilities are still state owned, and although many countries have committed themselves to a programme of liberalization and privatization of the electricity sector, only Cameroon, Côte d'Ivoire, Egypt and South Africa, have made significant advances in the liberalization of their electricity sectors.

Similarly, although this paper deals with economic regulation, some of the mechanisms outlined can be employed by environmental regulators to control or limit environmental pollution. While some points may therefore not seem directly relevant, they may have a more general value for different regulators or types of systems.

3. DEFINITION OF REGULATION

What is regulation? The Oxford Dictionary gives a definition for the action of regulating that illustrates well the wide-ranging activities that come under the heading of "regulation". Regulation is to carry out these actions "in accordance with rules or conventions" or "by-law".

> To regulate: to control, especially by rules, administer, conduct, direct, govern, manage, monitor, order, organize, oversee, restrict, and supervise.
>
> Regulation: rule, in accordance with rules or conventions, by law, commandment, decree, dictate, directive, edict, law order, requirement, restriction, rule, and statute.
>
> — Oxford Dictionary

Review questions

How would you define regulation?
What kind of actions does a regulator undertake?
Make a list of regulatory actions, based on an example in your country.

4. WHY REGULATE?

In very broad terms, regulation seeks to address "market failure" and is deemed necessary to protect consumers, society and/or the environment.

The primary driver for regulation of infrastructure sectors (public service sectors) such as energy is generally to ensure proper competition and to prevent the growth of a dominant group or single utility servicing either function, essentially this is an attempt to keep prices down.

In non-liberalized markets, the degree of regulation is a direct political decision, and is explicitly connected to policy aims. In theory, the introduction of competition has often been seen as a way of reducing regulation. In a pure economic sense, regulation in competitive markets need only be applied where the benefits of doing so act to reduce the cost to the consumer to a greater degree than if the regulation did not exist—for example to limit market abuse. It is often suggested that "competition is the best regulator", i.e. that effective competition will lead to the most efficient operation of the market as companies are given incentives to serve the needs of consumers.

However, this does not necessarily mean that where competition exists, regulation is no longer necessary. Regulation may be required to ensure effective competition is maintained—for example to prevent anti-competitive behaviour by companies with market power that can harm consumers and competitors. Regulation may also be required to ensure that certain services or goods are provided where competition alone would not secure this.

In general then, markets are regulated to ensure economic efficiency and to mitigate market failures to ensure that socially desirable goods and services are provided or protected. Briefly, the motives for regulation in competitive markets can be listed as:

- Economic efficiency (e.g. the prevention of market abuse);
- Consumer protection (e.g. to keep prices down);
- Environmental protection (e.g. to reduce harmful emissions such as CO_2, SO_2, NO_x, etc);
- Social justice (e.g. to ensure universal supply);
- Security of supply (to keep the lights on).

Most of these motives could also apply to regulation in non-competitive markets.

Some of these motives could be seen as contradictory—for example, keeping prices down may not be compatible with promoting renewable energy technologies, which can be more expensive than conventional technologies. Policymakers and regulators will have to resolve these issues by taking into account other factors, such as the time scales for which the regulation is designed. In the short term, for example, increased renewable energy generation or energy efficiency activities may increase energy prices, but in the longer term—with both new technologies becoming cheaper (through learning effects) and oil prices rising—they may well lead to reduced prices. Similarly, the social desirability of ensuring universal supply can increase prices, but this has to be balanced against improved quality of life for citizens, e.g. by poverty reduction through employment generation, by health improvement and environmental benefits.

Balancing these issues will undoubtedly be a challenge, and may more appropriately be addressed by politicians and policymakers rather than regulators. However, putting the policies into practice is the job of the regulator, and in practice many choices on measures and rules will refine the balance of the policy aims. So while regulation could be seen as institutionally separate from the political decision of how to balance policy aims, in the real world, it may well fall to regulators to decide on specific issues on a case-by-case basis.

Regulators are also involved in advising policymakers on policy choices, because of their expertise in economics and in the practicalities of devising and monitoring rules to implement policies. They are therefore participants in the debate about policy choice, often with a considerable degree of influence and hence they are not just implementing policy that is made elsewhere.

5. WHAT CAN BE REGULATED: ELECTRICITY SYSTEM STRUCTURES

Electricity industry structures vary widely from country to country. The main variations are in terms of:

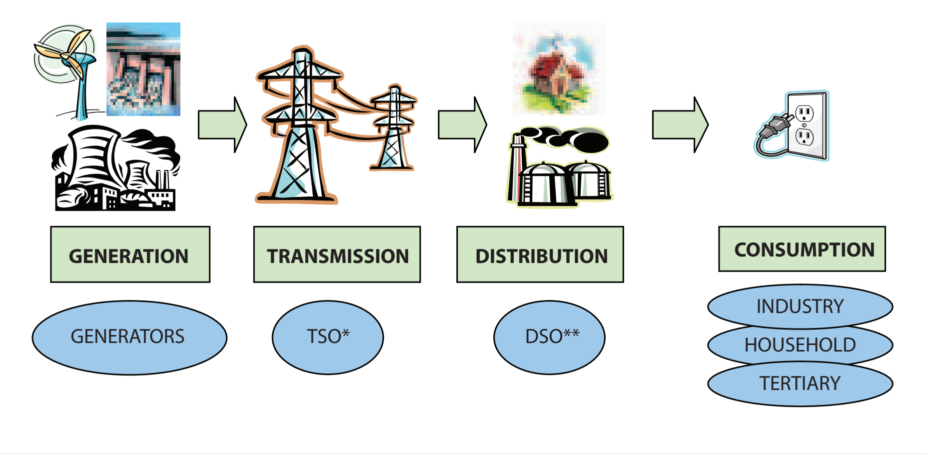
- Level of competition;
- The degree of integration (vertical and/or horizontal);
- Ownership (public or private);
- The degree to which the system is established or developing.

Whatever the electricity industry structure and its state of development, there are essentially four functions that the electricity supply industry is performing:

- Generation;
- Transmission;
- Distribution;
- Supply (often called retail).

Any or all of these functions may be privately or publicly owned. Two or more of them may be contained within the same company (as is often the case in African countries). Generation and supply may be undertaken on a monopoly basis or subject to competition. Transmission and distribution will always be provided on a monopoly basis.

Figure I. Electricity: from generation to consumption



*Transmission System Operator
**Distribution System Operator

5.1. Competition

In electricity industries, the primary functions where regulated competition applies are in generation and supply, though this can be broken down to create separate markets for smaller functions such as metering.

There are a number of reasons to regulate competition within these two functions, and the priority given to these functions will vary between regulatory regions. The primary driver for regulation of these functions is to ensure proper competition.

Ensuring fair competition with regard to electricity generation requires the creation of a marketplace which is open to both existing generators and which does not induce barriers to deter newcomers. Regulation should prevent the capture of sufficient market power by a single generator or by groups of generators such that prices can be controlled by the entity.

Fair competition is also necessary in the electricity supply function, i.e. the firms who buy from generators and sell to consumers. Significant regulatory issues include consolidation of companies within the function such that one or more companies can come to dominate the function, though this must be balanced with the economy-of-scale advantages that consolidation can bring and the cost reductions that can thus be passed on to the consumer.

5.2. Integration

Companies may be horizontally integrated such that one company controls a significant fraction of the market for one function, for example, all of the supply of electricity to consumers. In a privatized industry such control tends to imply significant market power and this can be undesirable with regard to consumer benefit. Generally, horizontal integration is implicit in state-owned industry.

Companies may also be vertically integrated, that is, with two or more functions under the ownership of one company or agency. Such integration may be valuable to the company but not necessarily to society. Most notably, vertical integration may lead to the company achieving sufficient market power such that other competitors can be disadvantaged, with a corresponding impact on consumer welfare.

Where market power is established, or as part of a privatization process, the separation of selected functions is often required by government or regulators in order to prevent abuse of market power. This “unbundling” of functions into separate and discrete services can take different forms.

In some cases, governments or regulators may be satisfied with a degree of internal separation—for example into separate companies with safeguards to prevent collusion. In other cases, this will not be considered adequate and companies will be required to divest one or more function.

The degree of unbundling within an industry will have significant implications for the potential of companies to exert market power across electricity industry functions. For example, vertical integration of a generation and distribution company can mean preferential treatment by one part of the company for another, to the disadvantage of competitors and to the overall welfare of consumers. For this reason, regulation often prohibits cross-ownership of some functions, or can apply strict controls over ownership to try to prevent firms with interests in multiple functions from gaining competitive advantages. Unbundling of functions can prevent this, provided that strict monitoring occurs to ensure the controls are effective and are not simply for appearance’s sake.

5.3. Ownership

In some countries, there is a mix between public and private ownership, whereas in others the whole industry will be in private hands—for example, some generators may be state owned while others are privately controlled. In such a situation, both may be subject to the competitive market, or one or both entities may not.

The shift of an industry from the public to the private sector may take place in a number of phases. Corporatization involves state-owned industries being turned into businesses (or corporate) units with rather more autonomy and may also be a precursor to privatization. If desired, privatization then occurs, usually accompanied by some change in regulation to govern the new structure. This change in regulation is often referred to as deregulation though it is often perhaps more accurate to say that it is re-regulation.

Privatization may also be accompanied by liberalization—opening up certain markets to competition, although liberalization may also be introduced in some cases even where privatization has not taken place.

5.4. System development

The age and extent of electricity systems has a direct impact on the costs and technical implications of operating and maintaining it. In many African countries, there is still a need for significant investment in order to expand and improve the electricity system. This has a huge cost implication and leads to questions over who will pay for this expansion: the state, the private sector or a combination of the two. Historically, the state has been responsible for the expansion of infrastructure, such as the electricity network but this has lead to very low rates of development of the electricity system in many countries and now alternative solutions to injecting the required investment are being sought.

In a “mature” system, networks are already established and are generally geared towards shifting power from large-scale, centralized generating plants to the end user via transmission and distribution lines. In a mature system, with established rules and regulations, creating a favourable environment for sustainable energy can mean the need for many changes which can take time and a lot of industry coordination.

In contrast, less mature systems can develop to accommodate sustainable energy technologies as they retain flexibility by virtue of the fact that they are still growing. In order for an expanding system to integrate the increased use of renewable energy sources, the right incentives and regulations need to be provided, as well as again industry coordination.

Box 1. Some of the challenges for utility regulation in Africa

- Poor financial performance of many state-owned utilities
- Inappropriate pricing (usually as a result of political pressures)
- Managerial and technical deficiencies (regulation is a relatively new concept for many countries)
- Unsustainable subsidies
- Limited public sector finance for new infrastructure
- Limited private sector participation
- Low levels of access to services

Source: Extract from the presentation made at the 2nd AFUR annual conference by Mufor Atanga, AFUR secretary general, March 2005.

6. WHO REGULATES?

The independent or semi-independent specialist utility or energy regulator is becoming a common model for regulation of the energy industries, particularly where these industries have been transferred to the private sector. However, this is not the only model, in some countries—even where the industry has been privatized—a central government department will retain either the whole regulatory function or parts of it.

Three different models for regulation are commonly found in Africa: regulation through a government department, a ministerial agency or a fully independent regulator. Typically, water regulation is vested in a government department (such as the Department of Water Development, under the Ministry of Water, Land and Environment in Uganda), electricity is regulated by a ministerial agency, usually under the Ministry of Energy (such as the NER in South Africa) and only in the telecommunications sector can completely independent regulators commonly be found.

Whether it is a government department or a regulator who has the primary role, there will often be other bodies with a role in regulating the energy industry.

The following bodies can all be involved in regulating the energy industry:

- Central government departments;
- Specialist utility or energy regulatory agencies (including rural electrification and energy efficiency agencies);
- Generalist competition regulators;
- Environmental regulators;
- Local authorities;
- Courts and tribunals.

6.1. Central government departments

Where central government departments are directly involved, they make regulation answerable to elected politicians and hence can increase democratic control and legitimacy. Whether or not this is considered desirable will depend upon different views on the purpose of regulation and role of government. For example, there may be concerns that governments may be willing to compromise economic efficiency to meet other goals—for example, there may be pressures to protect companies from competition to preserve jobs.

6.2. Specialist utility or energy regulators

One of the main arguments made in the favour of specialist utility or energy regulators is that, where the agency enjoys reasonable independence from government, they provide a bulwark against “political interference” which might damage economic efficiency. The main argument against is lack of accountability to the government and parliament. Establishing an independent regulator places considerable power in the hands of an appointed individual, (or a group of individuals where a commission-type structure exists) who may pursue policies that are at odds with government policy or publicly mandated policy goals. These regulators are generally subject to a set of duties provided by legislation, although the legislation may provide for a considerable degree of discretion on the part of the regulator in applying and balancing these duties. Achieving the benefits of independence without sacrificing accountability is thus one of the key challenges.

6.3. Generalist competition regulators

The role of generalist competition regulators is to take action against activities that may hamper competition in any sector of the economy. Typically they will have a role in assessing whether certain mergers should be allowed to proceed and in taking action where companies with market power are found to be acting anti-competitively. In some countries, the specialist utility regulators may have some concurrent powers with the generalist competition regulators.

6.4. Local authorities

Local authorities may have two types of role. Firstly in planning control—e.g. in the siting of energy facilities such as power stations, wind turbines, etc. Secondly, in some countries, local authorities provide municipal electricity and/or heat (district heating) supply—these companies may be regulated by a sector regulator where one exists or they may be largely self-regulatory.

6.5. Courts and tribunals

The position of courts and tribunals can vary somewhat, depending on the particular structure. In some systems they are empowered to act as the point of last appeal on disputes between other regulatory bodies and companies. In other systems, courts and tribunals can be the first point of call concerning company behaviour.

7. TYPES OF REGULATION

Power sector reform in developing countries began over 10 years ago. Usually, the reforms have involved some combination of restructuring, privatization and unbundling. Regulatory reform has also been a key element of the overall process, with countries generally moving away from regulation through a government ministry, most often towards the creation of an “independent regulatory agency”.

The aim of regulatory reform was, and is, to depoliticize regulatory functions such as tariff setting, and improve the transparency of decision-making in the power sector. There are many different types of regulation, and all have their advantages and disadvantages. There is no single solution to suit all countries, so each situation has to be analysed to determine its characteristics and an appropriate regulation system designed and put in place.

This section examines different types of regulation commonly in use, including command and control, self-regulation and incentive-based regulation methods. Roughly speaking command-and-control regulation is imposed by government, self-regulation means the private sector manages its own regulatory scheme, and incentive-based regulation can be considered as regulation in between those two, i.e. carrot-and-stick regulation; “carrot” for the private sector to act, “stick” for the government when policy objectives are not sufficiently met. All of these are described in more detail below. For each type of regulation the advantages and disadvantages are presented.

Finally some other market controls available for regulation purposes are presented, such as trading permits, regulation by contract and competition laws.

7.1. Command and control

Command and control (C&C) regulation is typically the imposition of standards backed up by legal sanctions if the standards are not met. The law is therefore used to define and prohibit certain types of activity or force certain types of action. Standards can be set either through legislation, or by regulators empowered by regulation to define rules.

Advantages

There are a number of strengths in such a direct approach to acceptable behaviour: it can often be implemented quickly, sets out clearly defined limits and shows the government or regulator to be acting decisively.

Disadvantages

However, it can also be a somewhat heavy-handed and complex approach to regulating activities. The problems that can be created by this approach fall into a number of categories:

- Regulatory capture: C&C requires the regulator and the regulatee to cooperate, in particular to ensure that information is provided to allow the regulator to carry out its duties. This close relationship can lead to a situation where the regulator can be “captured” by the regulatee, and can begin to operate in their interests, rather than the interests of the public at large.
- Legalism: C&C has often been portrayed as complex, inflexible and over-intrusive. It can be difficult to devise precise rules, especially if an industry is undergoing change, and in addition, the direct involvement of politicians can mean that rules are drawn up in response to specific situations or areas of concern, often in a short time scale. This can mean that C&C regulation is not always an effective or forward-looking method of regulating industry.
- Setting standards: Sometimes it is difficult to set an appropriate standard—for example, to permit a specified level of pollution or realistic efficiency targets for transmission and distribution systems.
- Enforcement: The complexity of the rules and the possibility that their design may not encompass all possible activities, makes enforcement difficult for regulators. In addition, complexity can lead to a situation where attempted enforcement can be challenged in the courts.
- Innovation: C&C regulations are often blamed for not being cost effective as being imposed and thus applied by industry without any economical analysis, thus not encouraging innovation

Table 1. Strengths and weaknesses of command and control regulation

Strengths	Weaknesses
Fixed performance standards backed up in law	Close relationship between regulator and business could lead to “regulatory capture”
Clear definition of unacceptable behaviour	Can be complex and legalistic
Seen as politically decisive	Defining acceptable standards can be difficult

7.2. Self-regulation

Self-regulation could be portrayed as DIY (do-it-yourself) command and control. It often takes the form of a business or a trade association developing its own rules of performance, which it also monitors and enforces. There can be some government oversight of the regulation, but as a rule self-regulation is often seen as a way of business taking pre-emptive to avoid government intervention.

Advantages

The advantages of this approach include a high level of commitment from the businesses involved (given that it is in their interests to make the system work as the alternative is government intervention), and the well-informed and comprehensive nature of the rules that are set. It can also be more flexible than governmental C&C as it does not require legislation.

Disadvantages

On the other hand, it can also be seen as undemocratic, closed to outside scrutiny and open to abuse by the very interests who devise the rules. At the very least, self-regulation will always be open to challenge by outside interests who feel that the standards and rules are not primarily geared towards reducing the impacts of undesirable activities.

Table 2. Strengths and weaknesses of self-regulation

Strengths	Weaknesses
Can be well-informed, with a high-level of commitment from firms	Could be self-serving/undemocratic
Cheap for government	Legalism not necessarily avoided
Easy to change to fit circumstances	Weak enforcement
“Realistic” standards created	Independent oversight difficult

7.3. Incentive-based regulation

The aim of incentive-based regimes is to induce a regulated entity to limit or stop an undesirable activity by imposing taxes or granting subsidies—in other words a “carrot and stick” approach to ensure a socially or environmentally desirable end. The scheme of punishment and reward operates in a mechanical way, so reducing the scope for regulatory discretion, which in turn reduces the possibility of regulatory capture. It also allows the company a degree of flexibility in deciding whether to conform to the rule, or to accept the punishment.

An incentive is any policy, rule, pricing mechanism or procedure that seeks to modify the behaviour of persons or companies by changing the marginal costs or marginal benefits associated with particular decisions and activities. It could be said that all regulation is based on incentives in one way or another, as regulation functions through the basic concept of penalties for “bad” behaviour and rewards for “good” behaviour.

Incentive-based regulation tries to reward the utility with increased profits for reducing costs and improving services in a more pronounced fashion than other forms of regulations. The aim is to induce a regulatee to limit or stop an undesirable activity by imposing taxes or granting subsidies—in other words a “carrot and stick” approach to ensure a socially desirable end. To apply incentive-based regulation the general steps are to choose the units of measurement, set the baseline level, choose targets for improvement and/or maintenance and then apply incentives and penalties.

One type of incentive-based regulation is performance-based regulation (PBR), where incentives are tied to improvements in utility performance, price reduction and service quality improvement. There is less reliance on costs and less relationship to earning, with more emphasis on prices. PBR is also more reliant on external performance standards and less sensitive to company specific actions.

The advantages of PBR are that it may help improve plant utilization, reduce operation and maintenance (O&M) costs and improve system reliability. It also sets specific goals for utility management to focus on, can promote demand-side management (DSM) and simulates competition where real competition may not be practical. In general, PBR is also regarded as giving greater flexibility to utilities to make their own choices on how to respond to regulation. The disadvantages of PBR are that by placing emphasis on reducing costs, it may lead to inadequate O&M in an effort to save money. Incentives on certain items and not on others may divert attention to those areas where an incentive is offered to the detriment of other areas which may be equally important. It is also very important to set the rules correctly from the outset. If benchmarks and targets are wrong they could benefit the utility or the customer to the disadvantage of the other party.

However, overall, PBR aims to promote sharing of benefit between the utility and the customers. The utility benefits through incentives and lower costs, leading to higher profits and better return on investments for its shareholders. The customers benefit from lower prices and improved service.

Advantages

The scheme of punishment and reward operates in a mechanical way, so reducing the scope for regulatory discretion, which in turn reduces the possibility of regulatory capture. It also allows the company a degree of flexibility in deciding whether to conform to the rule, or to accept the punishment.

Disadvantages

The incentive-based approach can create rules that are too complicated and inflexible and do not take into account market realities, especially if they are not updated regularly to follow developments in the market. Incentive-based regulation assumes economic rationality, which may not always be the case. In addition, sometimes it is difficult to predict the impact of this type of regulation, for example, "bad" behaviour, e.g. polluting, could be rewarded if the rules are not set correctly.

Table 3. Strengths and weaknesses of incentive-based regulation

Strengths	Weaknesses
Low regulatory discretion	Rules may be complex and inflexible
Allows choice for regulatees	Assumes economic rationality—not always the case
Low enforcement costs	Difficult to predict impact
Encourages technological innovation	May reward polluters

The appropriateness of applying one of these three types of regulation depends on the available competences at regulatory and private sector level, and on the historical relationship between the government and the given sector.

Command and control is usually least appreciated by the private sector because it does not allow for flexibility in its behaviour; governments have applied C&C when the need for change was urgent and time was lacking for sectoral negotiations, or when voluntary commitments from the industry had failed to deliver the desired result. Self-regulation is usually applied when the industry has gathered significant experience and is convinced of the need for regulation. Incentive-based regulation can be regarded as a form of regulation in between C&C and self-regulation, i.e. the private sector is stimulated to change its investments and strategic behaviour allowing for some degree of flexibility ("carrot"), while governments remain in control through possible penalties when targets are not sufficiently met ("stick").

Different market-based mechanisms have been developed aiming to allow for more flexibility and choice by the private sector in how to deal with targets and policies imposed by governments and regulators. Some types of market-based mechanisms are described below.

7.4. Market controls

There is a range of market-based mechanisms that can be used to regulate activities. Market-based regulations (e.g. regulation by contract) can prove cost-effective, and minimize regulatory interference in the day-to-day operation of companies. Some of the more common market-based mechanisms are outlined below.

Competition laws

These are laws used to control the behaviour of companies to ensure that the market delivers services by limiting undesirable activities such as predatory pricing or cross-subsidization. Competition law can be preferred to command and control regulation because it is less intrusive for companies, and cheaper for the public purse, given that disputes are resolved in court rather than by publicly funded agencies.

However, the laws themselves only establish broad principles, rather than being defined for specific commercial or technical problems. Relying on courts to sort out the details of implementation risks a less than expert judgement than might be the case with decisions taken by a regulatory agency.

Regulation by contract

The government can use its own buying power to specify conditions in contracts with outside businesses. The contractual conditions can be used to drive socially desirable ends, such as a specified proportion of renewable power used in the production of goods. Regulation-by-contract is sometimes regarded as a short-term solution, worth considering when trying to increase regulatory robustness rapidly in the short term, but preferably it should be reinforced and eventually replaced by more permanent regulatory measures.

Regulation-by-contract would be aimed at managing regulatory discretion resulting particularly from weak institutional environments and would be initiated in order to support regulatory independence.

Increasing regulation-by-contract should not be seen as an intention to replace existing regulatory agencies with an alternative mechanism, but rather as a method of complementing their work by enhancing the effectiveness and credibility of the regulator.

Under a regulation-by-contract regime a regulator will potentially have to engage in contract re-negotiations, and hence the regulator's role will increasingly be that of honest broker or even impartial player focused on creating solutions and building consensus between service providers/investors and governments. When designing regulation-by-contract arrangements, increased emphasis should be placed on the issue of pass-through costs, as well as the possible inclusion of re-opener clauses in contracts, although these are generally not favoured.

Tradable permits

This is an increasingly important approach for limiting carbon dioxide emissions following the development of the European Emissions Trading Scheme. A specified level of acceptable emissions is set by the government, and market participants are granted an allocation of allowances up to that limit. The participants can then chose to reduce their emissions below the allocated limit and trade their excess allowances, or to buy allowances to allow them to exceed the limit. In addition, participants may also choose to exceed the limit and pay a penalty rather than buy additional allowances.

Politically, this is an attractive mechanism as it leaves companies free to decide how to behave, so, in theory, achieving the most economically efficient route to reducing emissions. However, the success of the scheme depends on the limits set by governments: with undemanding limits, the price of traded allowances will be low, and there will be little financial incentive for companies to change their practices. In addition, the success of any scheme will depend on enforcement and verification by a regulatory body.

Disclosure regulation

This requires producers to state the source or content of their power product, and has been applied in some countries and states to ensure that information is provided on the generation mix used to produce electricity. The mechanism allows consumers to choose a preferred source of generation (e.g. renewable generation rather than fossil fuel), but it depends on the reliability of the information presented. It also assumes that consumers will make the "right" choice to achieve the desired end.

In Europe the support schemes for renewable energy thus far have mainly been "supply-driven", i.e. the support stimulated the production of more green energy ("pushing the market"). Disclosure regulation aims to stimulate consumption of more green energy by both industrial and domestic consumers ("pulling the market").

Consumer demand is rising in different European countries, with the Netherlands having the longest history in demand driven markets, but some evolution has been taking place over the last couple of years in other countries including Germany, France and United Kingdom.

Table 4. Strengths and weaknesses of market-based mechanisms

Strengths	Weaknesses
Firms respond to market not bureaucrats	Uncertainties and transaction costs
Applicable across sectors	Lack of response in crisis
Flexibility	Needs healthy permit market
Low enforcement costs	Can create barriers to entry (disputes resolved by participants)
	Depends a lot on reliability of information

Other regulation mechanisms

Other regulation methods that can be used include direct action by government, regulation through rights and liabilities laws and regulation through public compensation. The advantages and disadvantages of each of these are laid out in the table below.

Table 5. Strengths and weaknesses of other regulation methods

Strengths	Weaknesses	
Direct action	States can plan long-term, "acceptable" infrastructure	Costly, can involve contentious subsidies
Rights/liabilities law	Low intervention	Costs to individuals, evidential and legal difficulties
Public compensation	Firms aware of costs	Monitoring performance difficult

Review questions

1. What are the advantages and disadvantages of:
   - *(a)* Command and control regulation?
   - *(b)* Self-regulation?
   - *(c)* Incentive-based regulation?
2. Name some market-based regulation mechanisms.

Discussion questions/exercises

If the trend is towards more regulation by contract, what are the implications for the existing regulatory agencies? And what are the prospects for creating new regulatory agencies in countries and sections where they do not exist?

8. REGULATION ISSUES FOR SUSTAINABLE GENERATION

Energy systems are made up of interacting components (e.g. a generating plant and the transmission system). Separating the main components in this section is therefore a little artificial, and it needs to be remembered that there may be issues which cross over a number of different areas. So, for example, distributed generation obviously raises issues for regulation of transmission and distribution networks, as well as for generation. Some of these issues will be dealt with in later modules—the outline given here is intended as a basic introduction.

8.1. Regulation and generation

In state-owned systems the government still plays an important role in deciding which technologies are used to generate power. In liberalized systems, governments have effectively stepped away from dictating which technologies are chosen. This choice is instead left to the market. However, economic regulation, and the way that the market is designed can still influence this choice.

Review questions

Think about the following questions. To what degree are they true for the current system in your country?

- Do market participation rules discriminate against smaller-scale generation or independent generators because of high transaction costs, or overly punitive penalties for intermittent generation?
- Does the design of the market encourage or hinder new entry?
- Is the market so competitive that it discourages innovation and the development of new generating technologies?
- Does the design of the market encourage demand-side bidding (i.e. is there a value attached to a consumer reducing demand at certain times)?

8.2. Regulation of electricity transmission and distribution

Transmission networks

Transmission networks are the system of connections carrying high voltage electricity from the large generators to the distribution networks and to the largest of electrical consumers. Their upkeep and operation is the business of transmission system operators (TSOs). TSOs are also responsible for the balancing of consumption and generation on the system.

Distribution networks

The conduit between the transmission grid and the majority of electrical consumers is carried out by distribution network operators (DNOs). DNOs are required to ensure, through their networks, that consumers have access to a secure and reliable supply of electricity provided at a minimum feasible cost. Although it is widely acknowledged that minimization of costs can be achieved through the maximization of operational efficiency of the network, regulatory intervention, through efficiency targets and efficiency rewarding mechanisms, is often required to engage DNOs in meaningful efficiency improvement exercises. Currently, energy efficiency targets in the tariff-setting mechanism for transmission and distribution systems are used in only a few countries in sub-Saharan Africa (e.g. Ghana).

Transmission and distribution of electricity are both natural monopolies; it would be far too costly and not very efficient to have more than one transmission and distribution system. Provided there is spare power transfer capacity in the systems, the average cost of both transmitting and distributing electricity reduces as the amount of electricity distributed increases. Thus, the cost of any additional unit of electricity distributed will be both lower than the cost of previous units and lower the average cost per unit.

Natural monopolies may also result from “economies of scope”. These exist where two or more services can be provided more cheaply by one single company than if each service was provided by two separate companies. “Economies of density” play a significant part in making both transmission and distribution network operation natural monopolies. It is much cheaper on a per household basis to have one single network (and network operator) serving a neighbourhood than to have two networks, each serving half of the same neighbourhood, as this avoids duplication of large parts of a network, and thus the costs associated with this.

Both transmission and distribution networks thus need to be regulated to move towards greater efficiency so that overall prices are reduced and that these reductions are passed on to the consumer.

In this context, efficiency can refer to the costs of providing a range of services as well as tasks such as minimizing losses and acting to provide a guarantee of quality of supply to consumers. Increased efficiency can occur in a number of ways, for example:

- Through providing energy services (supplying light and heat rather than just energy);
- As the result of improved management, technical performance and utility practices;
- As the application of improved technology such as new information and communication technology (ICT).

The central incentive for improved network efficiency is the network operator's desire to improve its profits. Properly designed policy frameworks and regulatory mechanisms (i.e. efficiency rewarding tariff setting mechanisms) should be put in place to ensure that the more efficiently the network operates, from an economic and use-of-resources point of view, the greater the company's profit margins are.

To protect the consumer, the regulator can limit the amount of profit the network operator makes from improved efficiency by putting in place a mechanism that acts to pass on some of the value of improvements to the consumer. This process can be improved by the use of benchmarking (also known as comparative regulation), that is, by comparing the performances of separate companies in re-assessing the prices that the DNO is allowed to charge. Regular re-assessments of the prices that the DNOs are allowed to charge are usually used to facilitate this—typically every 4-5 years.

As the efficient operation of the network also has implications for the quality of supply, the regulator may choose to introduce incentives to the TSO or DNO to maintain certain levels of quality of supply and punish the DNO should they fail to achieve these standards.

Whilst many of the basic issues relating to regulation of transmission and distribution are similar, there are important differences relating to sustainable energy that are specific to either kind of network. One issue is the connection of renewable energy generators to networks—typically, though not exclusively, to distribution networks. This requires consideration of the appropriateness of particular regulation relating to connection on either kind of grid and to the issue of equality for all competitors. Consideration must be given to regulation that gives incentives for the reduction of energy consumption, such as demand-side management, increased energy efficiency and loss reduction.

8.3. Regulation for sustainable energy

The age and extent of electricity systems can have a direct impact on the costs and technical implications of implementing sustainable energy policies. In a "mature" system, networks are already established and are generally geared towards shifting power from large-scale, centralized generating plants to the end user via transmission and distribution lines. In contrast, less mature systems can develop to accommodate sustainable energy technologies as they retain flexibility by virtue of the fact that they are still growing. New technologies can be designed in to the expanding system, and new consumers can be offered services rather than just energy supply.

Regulation can have a direct impact on changes and developments in the system through the provision and regulation of incentives such as support mechanisms (e.g. investment subsidies, tax credits) for renewable power technologies or the operation of demand-side management programmes.

Regulation can also play a less overt role in the technological choices within energy systems by addressing rules and practices which favour the dominant technologies in the system. For example, companies have developed to sell kWh rather than to provide energy services; regulators can take action to encourage the emergence of energy service supply companies, which will in turn improve the energy efficiency of consumers. Similarly, the rules governing connection and performance have developed to support the large-scale, centralized nature of many electricity systems and have therefore tended to exclude the possibility of connecting smaller-scale generation to distribution networks. Regulators can address these imbalances and so provide greater incentives to implement smaller scale, often renewable, generation.

9. EXAMPLES OF REGULATION IN AFRICA

9.1. Energy regulation in Zambia

The regulatory structure for the electricity sector in Zambia is the independent Energy Regulation Board (ERB), which was created under the Energy Regulation Act of April 1995. Some of the provisions in the legislation that contributed to the successful establishment and development of the ERB were the following:

- Establishment of ERB as an independent statutory body and the sole licensing authority for operators in the energy sector.
- ERB Board members (regulators) are appointed on a professional basis, do not represent any stakeholder interests, serve a specified fixed term(s) and the basis for their removal from office is clearly stated in the legislation. Once appointed, the Board operates independently in its decision-making based on the governing legislation.
- There is a provision for earmarked funding for the ERB in the form of a percentage of energy cost passed on to the consumers.

The successful establishment and development of the ERB was a direct consequence of the Zambian Government's deliberate policy and political will to establish an independent regulator. With the policy and legislation in place, the Board was appointed in February 1997 and the ERB became operational immediately. Supported by strong political will and legislation, the ERB embarked on an extensive capacity-building programme and as a result of this extensive capacity-building, ERB quickly developed into a strong regulatory authority with strong expertise, competency, independence and accountability.

The ERB has a mandate to regulate all undertakings in the energy sector, which comprises electricity, petroleum, coal, wood fuel and renewable sources of energy. The ERB regulates through the issue of licences, which stipulate the conditions under which the licence undertakings should operate.

In order to promote the development of renewable energy, the ERB zero-rated licence fees for this subsector. This measure is still ongoing.

For solar energy, there is no regulation for the retailers who sell mostly substandard imported PV modules in small shops: the licence is currently applied only to 17 individual companies that install solar equipment.

The ERB regulation for installers specifies 3-4 sets of equipment that can be installed (photovoltaic modules, batteries, fitting), in order to avoid the installation of substandard equipment. Inspections are conducted, but for the moment without penalties. A code of practice for "photovoltaic systems designs and installation" is currently being produced by the Zambia Bureau of Standards. The question of the qualification of installers is also on the agenda and the introduction of competence certificates is under consideration by the ERB.[1] A code of practice can be regarded as a self-regulation for industry to comply with in terms of quality of materials and installation, but usually without the threat of a severe penalty as in command and control regulation. Respect of codes of practice can be used by companies as a marketing tool towards customers, and are supported as such by industrial associations and even governments or regulators.

The ERB also recommended the Government to remove import duty on imported renewable energy products. This measure is also still ongoing but does not apply to solar panel batteries and some other components which are not renewable energy specific.

The National Energy Policy[2] outlines a list of possible measures with regard to renewable energy, e.g. financial incentives, a dedicated renewable energy agency, training courses and a research and development strategy. At this point the National Energy Policy is not yet translated into legislation, policies and regulations.

For a more detailed account of the establishment of the Zambian ERB, the reader should refer to case study 1, which is attached to this module.

9.2. Water sector reform in uganda

The water sector in Uganda does not yet have an independent regulator. The primary responsibility for regulation is vested in the Ministry of Water, Land and Environment.[3] The present approach is regulation-by-contract, with the Ministry responsible for monitoring performances according to the contracts. However, regulation is complex, with a number of different agencies and bodies involved.

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[1] The National Energy Policy, Ministry of Energy and Water Development, Zambia, February 2007.

[2] Photovoltaic Energy Services for Zambia, X. Lamaire, Centre for Management under Regulation, Warwick Business School, April 2006.

[3] Mr. E. Kisembo, Reform manager, Ministry of Water, Land and Environment, Uganda, 2nd AFUR Annual Conference, March 2005, Kampala, Uganda.

Recognizing the need for promoting the attainment of the Millennium Development Goals (MDGs), the Uganda water sector found it necessary to separate the treatment of urban, commercial town operations from those of rural villages, which had a different framework in place in order to facilitate cross-subsidies, financial support and enhanced access to services.

The following lessons have been learnt from the water sector reform process so far in Uganda:

- Different models have to be used for small rural water operations and larger town water operations.
- Rural water operations make use of private contractors within a management contract framework, while the National Water and Sewerage Corporation (NWSC) takes responsibility in the towns, in terms of a performance contract with the Ministry.
- The present regulatory approach (by contract) does not sufficiently address such issues as tariff setting, contract disputes and capital investment planning.
- A certain amount of self-regulation is taking place in terms of the larger town operations, central government having transferred power to local authorities even though these commonly lack capacity to exercise such powers.
- Key regulatory challenges for the Uganda water sector include the formalizing of an appropriate regulatory framework promoting best practices and fostering confidence among private operators.

Discussion questions/exercises

1. What is the regulatory framework for the power sector in your country?
2. What regulatory mechanisms are being used?
3. Write a short summary of the situation (1-2 pages).

10. CONCLUSION

Regulation is primarily designed to address the failure of markets to deliver desired goods—whether economic, social or environmental. Regulation is the primary tool to address those market distortions and is, when carefully designed, capable of serving a range of policy goals related to energy supply, including improved market functioning, poverty reduction and sustainable development. There is no standard method that works in every situation, therefore the circumstances for different countries and the industries within those countries have to be analysed and the most appropriate regulation method selected accordingly.

LEARNING RESOURCES

Key points covered

Here are the most important points covered in this module:

- The concept of regulation and its main aim: to address the failure of markets to deliver desired goods and services, whether economic, social or environmental.
- There is no "ideal" way to regulate and every country has different circumstances which require their own individual solutions. The type of regulation of the energy industry will depend on the level of maturity of the system, the degree of competition, the degree of integration of the market actors, etc.
- There are a number of bodies involved in the regulation of the energy sector. The most common actors are government departments, Agencies linked to the Ministry of Energy of a country (usually semi-independent) and fully independent regulators.
- An introduction to some of the basic methods of regulation: command and control, incentive-based regulation, self-regulation and market controls.
- An outline of the issues raised by the need to develop sustainable energy and the role of the regulator to change and adapt the electricity system across its four main functions: generation, transmission, distribution and supply.

Answers to review questions

Question: What kind of actions does a regulator undertake?

Answer: Actions a regulator may undertake: set and revise electricity prices, grant generation, transmission, supply and distribution licences, manage energy efficiency programmes, monitor performance of utilities, ensure that the laws regarding energy are being abided by, set rules to maintain quality of supply, set grid codes, set safety standards, promote effective competition.

Question: What are the advantages and disadvantages of:

(a) Command and control regulation?
(b) Self-regulation?
(c) Incentive-based regulation?

Answer: *Command and control regulation.*

Advantages: it can often be implemented quickly, sets out clearly defined limits and shows the government or regulator to be acting decisively. Disadvantages: it can be a somewhat heavy-handed and complex approach to regulating activities.

Self-regulation.

Advantages: there is often a high level of commitment from the businesses involved, and the rules that are set are well-informed and of a comprehensive nature. It can also be more flexible than governmental C&C as it does not require legislation. Disadvantages: it can be seen as undemocratic, closed to outside scrutiny and open to abuse by the very interests who devise the rules.

Incentive-based regulation.

Advantages: the scheme of punishment and reward operates in a mechanical way, so reducing the scope for regulatory discretion, which in turn reduces the possibility of regulatory capture. It also allows the company a degree of flexibility in deciding whether to conform to the rule, or to accept the punishment. Disadvantages: the incentive-based approach can create rules that are too complicated and inflexible and do not take into account market realities. It also assumes economic rationality, which may not always be the case.

Question: Name some market-based regulation mechanisms.

Answer: Market-based regulation mechanisms: competition laws, regulation by contract, tradable permits, disclosure regulation.

Presentation/suggested discussion topics

Presentation:
ENERGY REGULATION – Module 3: Introduction to energy regulation

Suggested discussion topics:

1. Compare and contrast different types of regulation, give examples of each from the countries of the students.
2. Which type of regulation is most appropriate for developing countries which have developing power sector systems (electricity in particular)? Discuss.

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B. Tenenbaum, F. Woolf, Energy and Mining Sector Board Discussion Paper Series, Paper no. 7, May 2003, World Bank.

Legal and regulatory framework of the electricity supply industry (ESI) in Southern and East Africa, Status report as at February 2005, SAD-ELEC Ltd., Norwegian Water Resources and Energy Directorate, February 2005.

INTERNET RESOURCES

SERN: www.reeep.org/groups/sern

Regulatory Assistance Project (RAP): www.raponline.org

About regulated industry: www.utilityregulation.com

National Association of Regulatory Utility Commissioners—NARUC: www.naruc.org

Public Utility Research Center: www.purc.org

Department of Water Development, Uganda: www.dwd.co.ug

African Forum of Utility Regulators: www.afurnet.org

Centre of Regulation and Competition: www.competition-regulation.org.uk

The Global Regulatory Network (GRN) strengthens regional associations and promotes the understanding of complex regulatory practices: www.globalregulatorynetwork.org

GLOSSARY/DEFINITION OF KEY CONCEPTS

Demand-side management	The planning, implementation and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand.
Deregulation	The process of removing or reducing regulation. It is often employed in connection with the liberalization process for privatized industries.
Distribution	The transport of low voltage electricity. This connects the transmission network with the majority of electricity consumers. Management of distribution is a natural monopoly due to the economies of scale inherent to it.
Distributed generation	Essentially any generator which connects directly to the distribution (low voltage) electricity grid rather than the transmission (high voltage) grid.
Distribution network operator	The owner of the physical network providing electricity at low voltages. Generally connects the transmission grid to the majority of consumers, though some larger consumers may connect directly to the transmission grid.
Economies of scope	Economies of scope are conceptually similar to economies of scale, primarily referring to efficiencies associated with demand-side changes, such as increasing or decreasing the scope of distribution of different types of products. In the context of this module they refer to the potential for distribution and transmission system operators to provide two or more services more cheaply than if either was provided by a single company.
Economies of density	Economies of density in the context of this module imply that one single transmission and distribution system as a natural monopoly is the cheapest option for the community that the system covers
Energy services	The provision of energy supply and measures concerned with end-use in a single package.
Generation	Generation of electricity (power) from energy sources. These can be oil, gas, coal, fission, wind, waste, biomass, etc.

Horizontal integration	One company controls a significant fraction of the market for one function, for example, all of the supply of electricity to consumers.
Liberalization	Technically, the removal of restrictions on the movement of capital. It has come to refer to a policy of promoting liberal economics by limiting the role of government in the operation of the market economy. Liberalization can include privatization and deregulation/re-regulation. Typically, it refers to the establishment of an industry structure to allow competition. The process includes the shifting of publicly owned companies into the private sector, such that provision of services is subject to greater competition or, in the case of natural monopolies to greater oversight with regard to economic efficiency.
Monopoly	The situation wherein one company has the market power to control the price or availability of a good or service. If this is unregulated, the company is likely to produce fewer goods or to sell goods more expensively than would be the case in a competitive environment. In practice, a monopoly may refer to an industry where one company has power to control the sector regardless of other companies or it may refer to a sector where only one company exists. It should be noted that outside natural monopolies, few monopolies are absolute and that even dominant companies may be subject to pressures on their price setting or limiting of supply. The effects of monopoly, including natural monopoly, on welfare can be limited by appropriate regulation.
Performance-based regulation	Regulatory approaches rely on the application of financial incentives and disincentives related to specific outputs to induce desired behaviours on the part of regulated companies. PBR links company outputs to revenue and can be applied to achieve benefits such as increased innovation, increased standards for quality of supply, reduced losses and a range of other things which are perhaps otherwise not addressed by regulatory approaches such as rate-of-return.
Price capping	The application of a limit on the prices that a utility may charge in a given regulatory period. A regulator sets the amount with the aim of taking into account the increases in productivity expected of the sector in comparison with the ongoing inflation in the economy as a whole. Price capping will often be used in conjunction with benchmarking in order to allow the regulator to assess more easily the levels of productivity that a company should be achieving.

Price regulation	Regulation wherein utilities are incentivized to maximize their efficiency in order to maximize their profits. Prices are regulated but profits are not. The usual form is to allow prices to rise by an amount related to inflation minus an efficiency factor—if this factor is large enough prices would actually have to fall. The main criticism is that it can allow companies to make unreasonably high profits if the efficiency factor is set too low. It originated in the United Kingdom as RPI-X (retail price index less the expected future productivity gains (the X)). It is usually differentiated from the rate of return regulation.
Privatization	The process of moving a body or institution from ownership in the public sector to ownership in the private sector. This can be carried out using different processes, for example, the sale of shares to the general public or the sale of the whole company to a specific bidder.
Quota mechanism	More generally known as a Renewable Portfolio Standard or as an obligation mechanism.
Regulation	Controlling or directing in accordance to rules, conventions or law.
Supply	The selling of electricity to consumers (also called retail).
Sustainable energy	The term sustainable energy usually encompasses two parts: Renewable energy and energy efficiency.
Tariff mechanism	A mechanism to encourage the growth of renewable energy generating capacity. Notable examples are Denmark and Germany. A tariff mechanism generally provides a particular rate per kWh of electricity generated and guarantees that payments will continue for a fixed or minimum period. The tariff can be fixed beforehand, or can be fixed to reduce in specific gradations over time or can be linked to the average electricity tariff. Also known as a price mechanism.
Transmission	The system of connections carrying high voltage electricity, i.e., transport of high voltage electricity.
Vertical integration	Two or more functions are under the ownership of one company or agency, for example, generation and transmission.

Case study 1.

ZAMBIA ENERGY REGULATION BOARD

CONTENTS

1. BACKGROUND

Prior to the change of Government in 1991, state-owned companies (usually monopolies) operating under extensive Government control characterized the Zambian economy.

When the current Government assumed power in 1991, new economic liberalization policies were adopted leading to the promulgation of new legislation. In the energy sector, a new ministry responsible for energy was created (the Ministry of Energy and Water Development). The National Energy Policy was formulated and adopted in 1994, followed by enactment of the Electricity Act and the Energy Regulation Act in 1995.

The Energy Regulation Board (ERB) started operating in February 1997 following issuance, by the Minister of Energy, of the statutory instrument No. 6 of 1997, the Energy Regulation Act (Commencement) Order of 27 January 1997. By the year 2000 the ERB had undertaken several capacity-building activities, developed into a strong regulatory authority and was well recognized both by the Zambian stakeholders and the international community.

This case study outlines some of the factors which contributed to the successful establishment and development of the Zambian Energy Regulation Board.

2. POLICY AND REGULATORY FRAMEWORK

The Zambian National Energy Policy of 1994 (NEP 1994) clearly states the Government's intention to liberalize the energy sector. In order to achieve this, the policy identified the need to establish an independent energy regulatory authority.

The Energy Regulation Board was created under the Energy Regulation Act, Chapter 436 of the Laws of Zambia. Some of the provisions in this legislation which contributed to the successful establishment and development of the ERB are as follows:

- Establishment of ERB as an independent statutory body and the sole licensing authority for operators in the energy sector (i.e. electricity, petroleum, renewable energy and other forms of energy).

- ERB Board members (regulators), appointed on a professional basis, do not represent any stakeholder interests, serve a specified fixed term(s) and the basis for their removal from office is clearly stated in the legislation. Once appointed, the Board operates independently in its decision-making based on the governing legislation.
- Provision for earmarked funding in form of a percentage of energy cost passed on to the consumers.

3. INSTITUTIONAL CAPACITY-BUILDING

The successful establishment and development of the ERB was a direct consequence of the Zambian Government’s deliberate policy and political will to establish an independent regulator.

With the policy and legislation in place, the Board was appointed in February 1997 and the ERB became operational immediately. At that time, the only other known energy regulator in sub-Saharan Africa was the National Electricity Regulator (NER) of South Africa. NER was equally new and only regulated the electricity sector.

Supported by strong political will and legislation, the ERB embarked on an aggressive capacity-building programme. Some of the notable capacity-building activities carried out were as follows:

- With World Bank funding, some Board members (including the Chairman) attended the 2nd International Training Program on Utility Regulation and Strategy offered by the University of Florida (USA) in June 1997. This course equipped the Board members with useful knowledge on how regulatory institutions function and also provided strategic guidance on how to develop the ERB.
- The ERB engaged short-term international consultants to help with the drafting of temporary licences in order to conform with the requirements of the Energy Regulation Act which required that all operators in the energy sector be licensed by the ERB. The World Bank funded this activity. By December 1997, ERB had licensed the first private electricity company in Zambia, Copperbelt Energy Corporation (CEC). ERB had also issued temporary licences to the state-owned electricity utility company, ZESCO Ltd and all major operators in the Petroleum subsector. This activity enabled ERB to start collecting licence fees from the licensed undertakings.
- By the beginning of 1998, ERB had established a steady cash flow stream from licence fees. This enabled the Board to engage consultants to help with the development of a human resource manual, the organizational structure and the

staff recruitment process. This activity was completed by June 1998 with a staff compliment of about 25. The ERB Board decided to offer a competitive salary structure based on the Zambian private sector average. This way ERB was able to attract qualified professionals from both the private and public sector.

- It is worth noting that none of the recruited members of staff had previous regulatory experience since the profession was new to this part of the world. With funding from the World Bank, international consultants were engaged to train all ERB staff. In addition, all ERB staff were sent on educational tours to various regulatory institutions around the world. Countries visited included Australia, Canada, Jamaica, Philippines, South Africa, United Kingdom and the United States. This activity was executed between June 1998 and December 1998.
- In 1999, the Swedish International Development Agency (Sida) provided funding for further capacity-building activities and logistical support to the ERB. With this funding, more training programmes were conducted and study tours organized to Finland, Norway, South Africa, Sweden and the United Kingdom for all ERB staff. Further, international consultants were attached to the ERB to help with drafting of permanent licences under the same Sida support. By the end of 1999, all staff members had received adequate training, visited other regulatory agencies around the world and could now confidently perform their regulatory functions.
- At the beginning of 2000, USAID funded the twinning arrangement between two United States regulatory agencies and the ERB for an initial period of two years. The assistance also included other capacity-building activities.

As a result of the above-stated capacity-building activities, ERB quickly developed into a strong regulatory authority with strong expertise, competency, independence and accountability. Within the first three years of being established, ERB handled several regulatory functions such as tariff adjustment cases, drafting of technical standards, public hearings, technical support to the Government and licensed all operators in the energy sector.

In order to promote the development of renewable energy, the ERB initiated zero-rated licence fees for this subsector. This measure is still on going. The ERB also recommended to Government to remove import duty on imported renewable energy products. This measure is also still ongoing but does not apply to solar panel batteries and some components which are not renewable energy specific.

As a first mini grid using small hydro in Zengamina is urging ERB to decide on tariff options and principles, ERB is currently considering different tariff setting options for renewable energy applications. At least three more mini grids (using biomass, small hydro and PV) are expected to be operational by 2009. In November 2007 a workshop was organized in Lusaka in order to provide ERB with expert knowledge on tariff setting options and methodologies, as well as to facilitate discussion with stakeholders which included communities, civil society, private and public sector (including Ministries of Energy & Water Development, and Finance), ZESCO, the Rural Electrification Authority, ERB, Development Bank of Zambia, UNIDO, UNDP and international cooperating partners.

On the international level, ERB and NER (South Africa) initiated the SADC Regional Electricity Regulatory Authority (RERA). Initial conferences were co-chaired by ERB and NER in 1998 and 2000. The ERB also participated in the launch of the African Forum for Utility Regulators (AFUR) in 2000.

4. FOLLOW-UP ACTIVITIES

The ERB has continued with capacity-building programmes. In 2003, the Government amended the Energy Regulation Act in order to further strengthen the ERB. Some of the key amendments were:

- Stiffer penalties for contravention of the provisions of the act. This has made ERB stronger and more effective.
- Provision for appeal to the High Court of Zambia should a person be refused a licence by ERB. This has made ERB more accountable.
- Additional reporting requirements by licensed undertakings. This has given ERB more authority to enforce compliance.
- Restructuring the composition of the Board and provision for appointment of the Executive Director as chief executive of the Board.

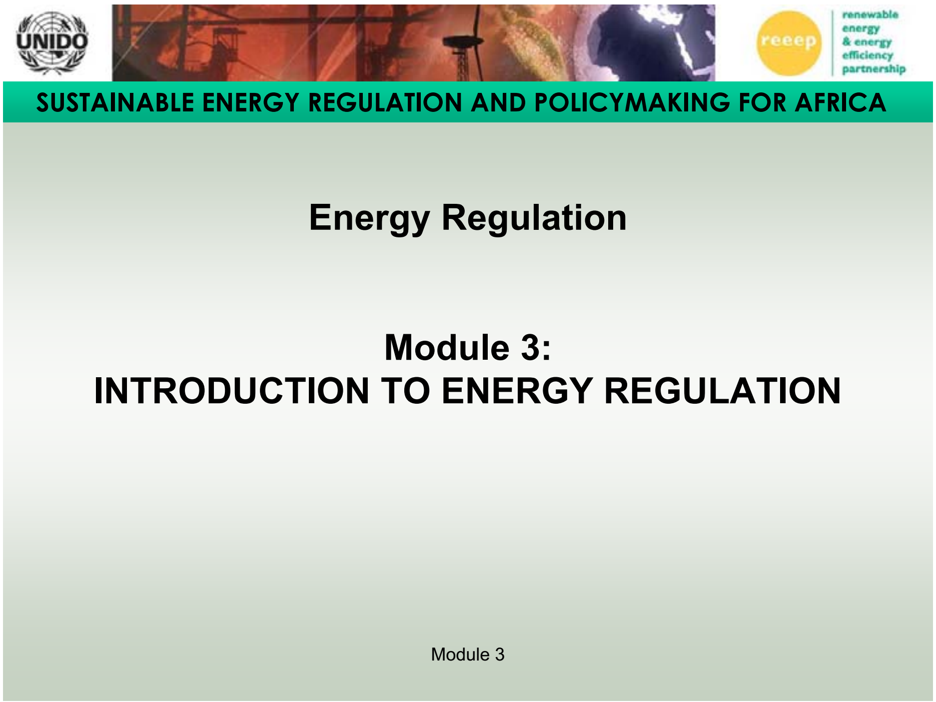
It is the desire of the Government of the Republic of Zambia to strengthen the role and independence of the energy sector regulator. In 2005, the Government engaged a consultant to review and define the relationship between the Government and the ERB. This review is also intended to ensure that the ERB is not only independent but also accountable. The consultant has submitted a draft final report, which Government is currently studying (March 2006). Key elements of the report include:

- Definition of the role of the regulator based on international best practice;
- Definition and separation of policy and regulatory functions;
- Review of the performance of the ERB.

It is the intention of the Government to review the regulatory framework in the future, taking into account the recommendations of this report.

5. CONCLUSIONS/LESSONS LEARNED

The most important lesson from this Zambian ERB case study is that to build a successful independent regulatory authority, a country should ensure that there is strong political will, a clear policy, supporting legislation and appropriate institutional arrangements such as independence, earmarked funding, accountability, credibility, no regulatory capture, competency, regulators appointed on a professional basis and no arbitrary removal of regulators.

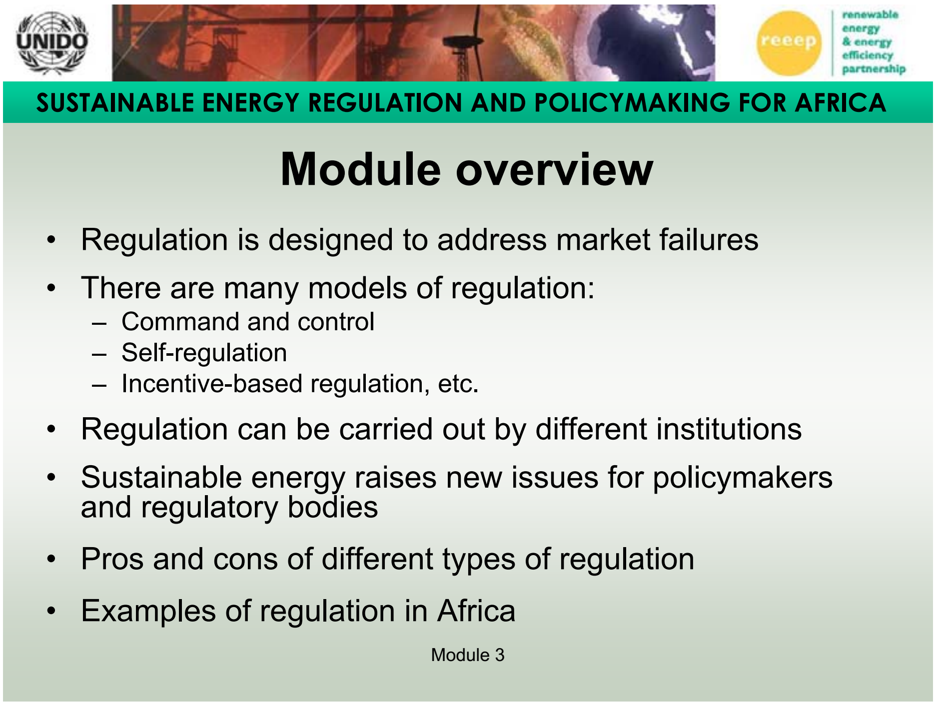


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Regulation

Module 3:
INTRODUCTION TO ENERGY REGULATION

Module 3

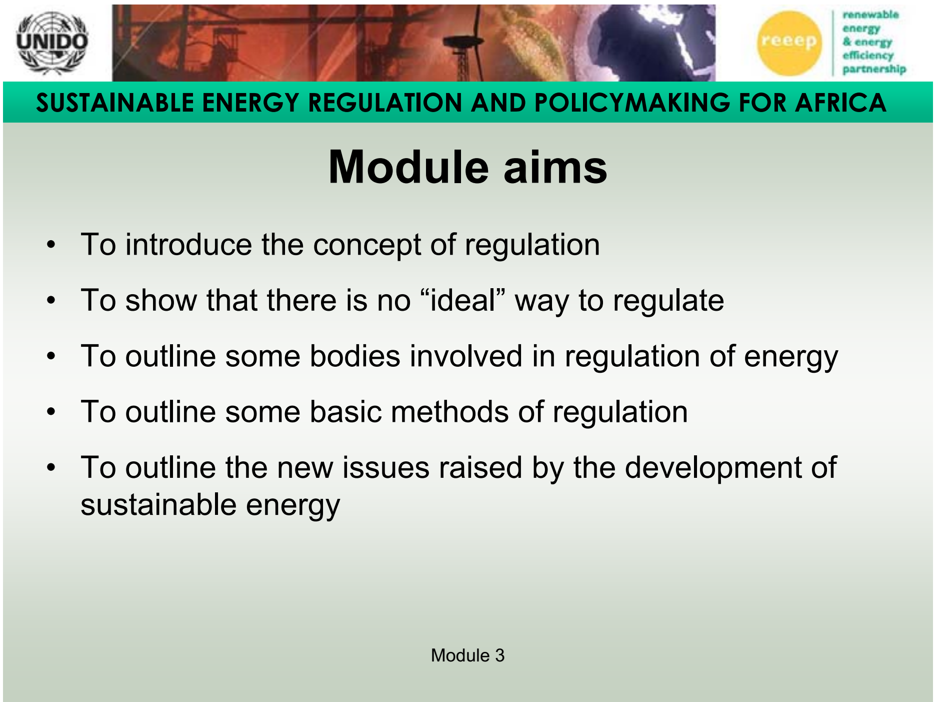


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Regulation is designed to address market failures
- There are many models of regulation:
  - Command and control
  - Self-regulation
  - Incentive-based regulation, etc.
- Regulation can be carried out by different institutions
- Sustainable energy raises new issues for policymakers and regulatory bodies
- Pros and cons of different types of regulation
- Examples of regulation in Africa

Module 3

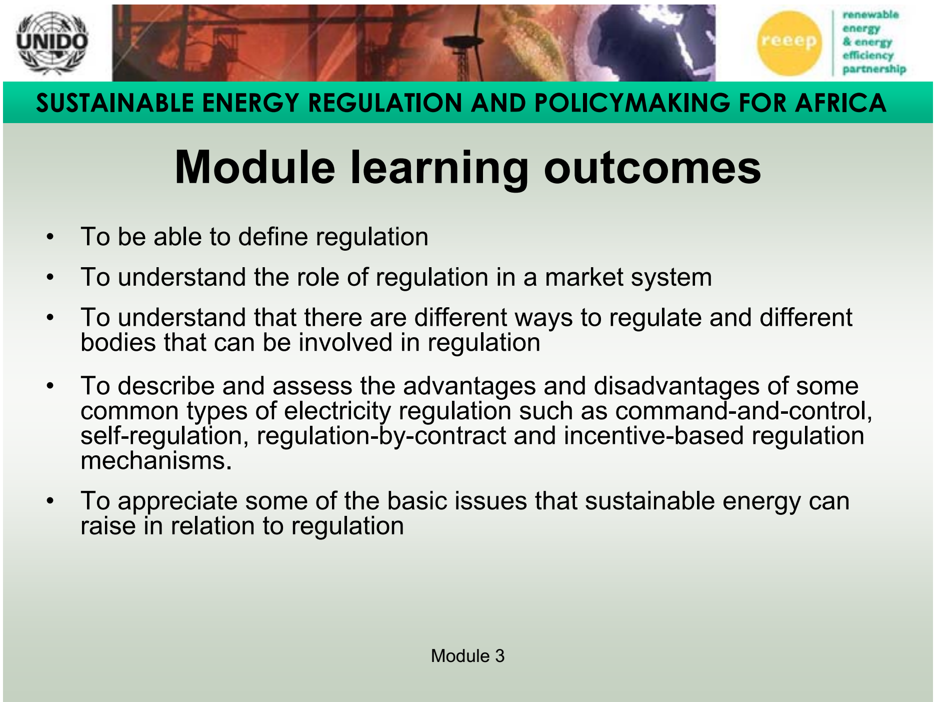


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To introduce the concept of regulation
- To show that there is no “ideal” way to regulate
- To outline some bodies involved in regulation of energy
- To outline some basic methods of regulation
- To outline the new issues raised by the development of sustainable energy

Module 3

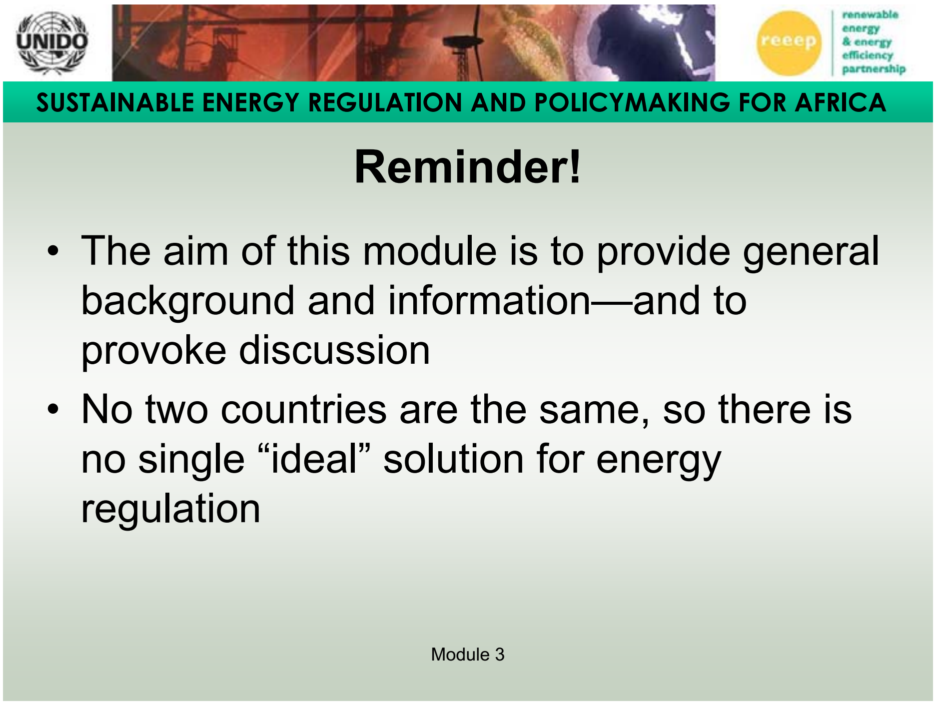


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define regulation
- To understand the role of regulation in a market system
- To understand that there are different ways to regulate and different bodies that can be involved in regulation
- To describe and assess the advantages and disadvantages of some common types of electricity regulation such as command-and-control, self-regulation, regulation-by-contract and incentive-based regulation mechanisms.
- To appreciate some of the basic issues that sustainable energy can raise in relation to regulation

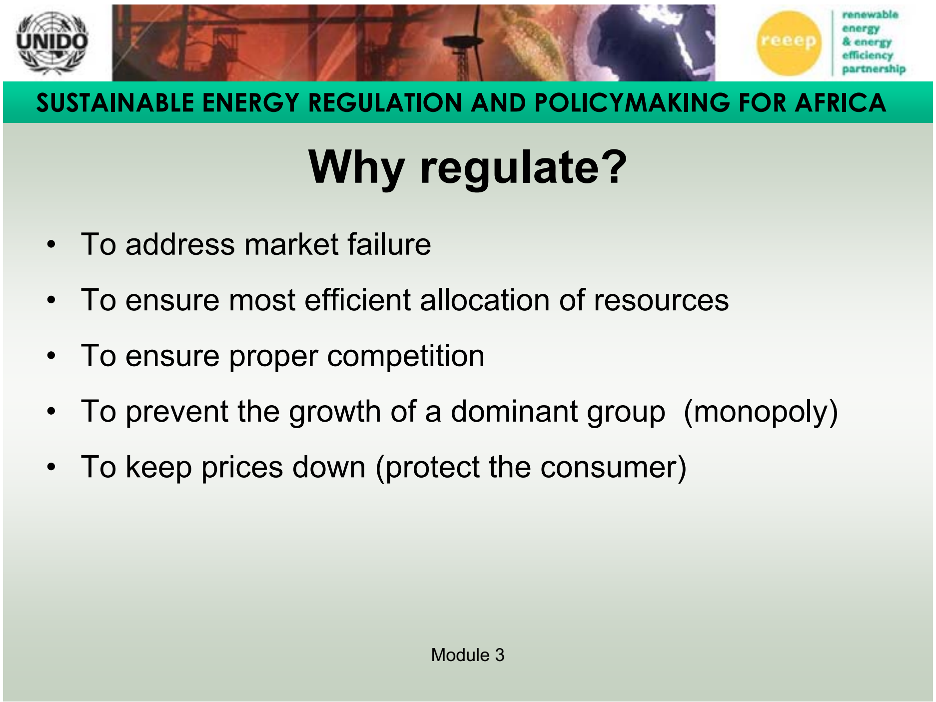
Module 3



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reminder!

- The aim of this module is to provide general background and information—and to provoke discussion
- No two countries are the same, so there is no single “ideal” solution for energy regulation



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why regulate?

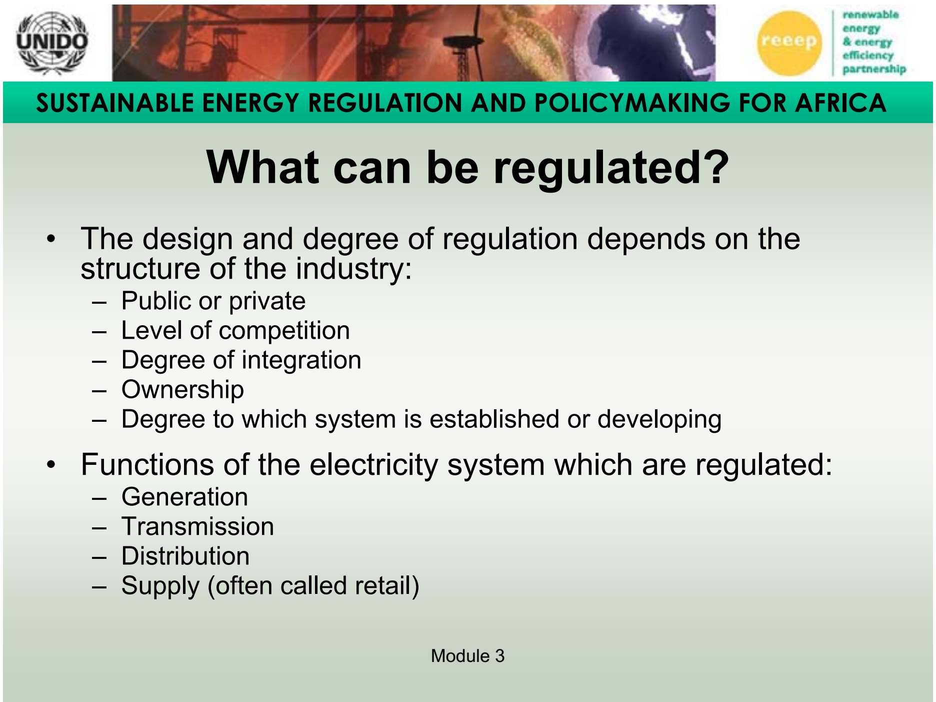
- To address market failure
- To ensure most efficient allocation of resources
- To ensure proper competition
- To prevent the growth of a dominant group (monopoly)
- To keep prices down (protect the consumer)

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why regulate? (2)

- Motives for regulation in competitive markets:
  - Economic efficiency
  - Consumer protection
  - Environmental protection
  - Social justice
  - Security of supply
- Most of these could also apply to non-competitive markets

Module 3

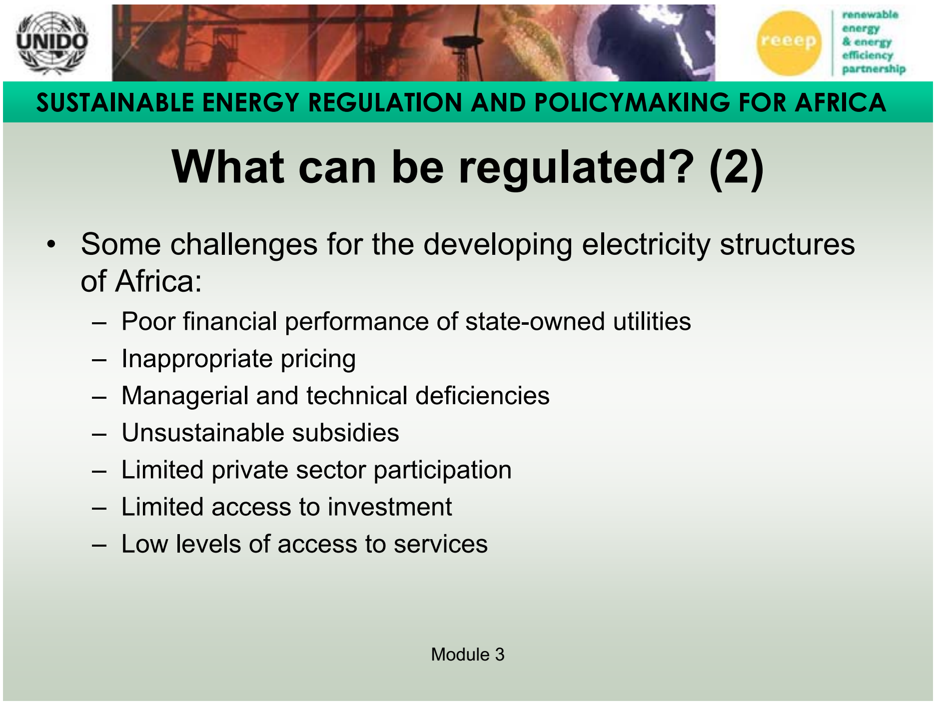


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What can be regulated?

- The design and degree of regulation depends on the structure of the industry:
  - Public or private
  - Level of competition
  - Degree of integration
  - Ownership
  - Degree to which system is established or developing
- Functions of the electricity system which are regulated:
  - Generation
  - Transmission
  - Distribution
  - Supply (often called retail)

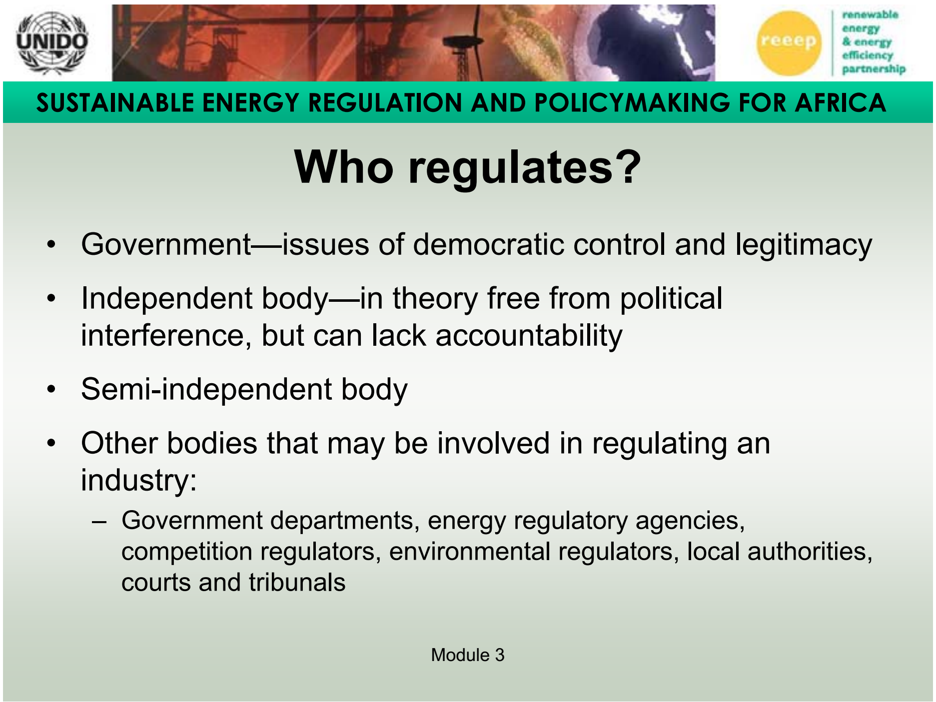
Module 3



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What can be regulated? (2)

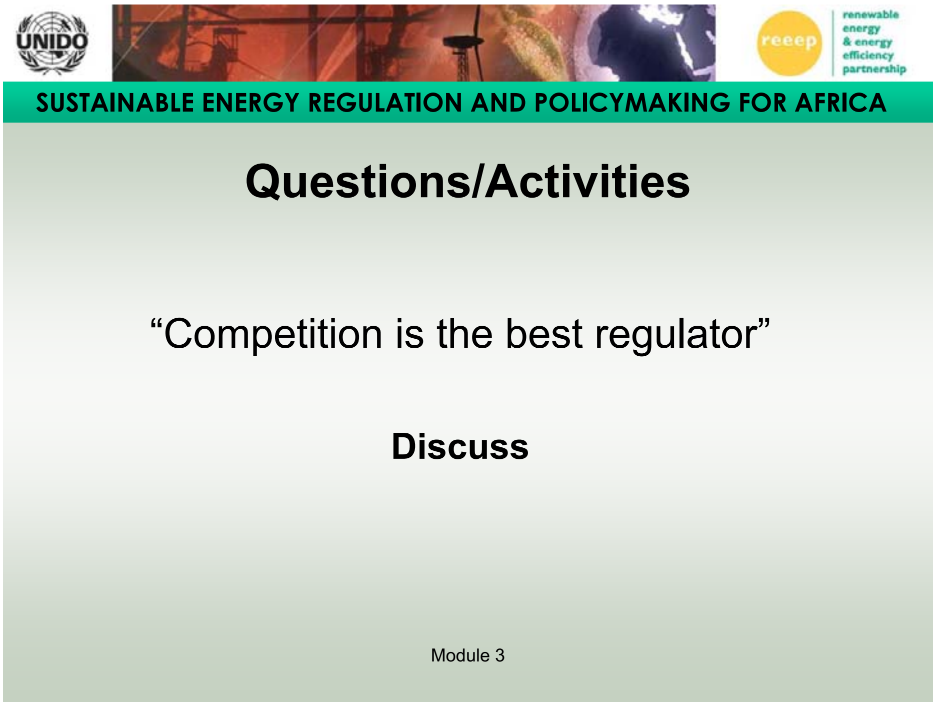
- Some challenges for the developing electricity structures of Africa:
  - Poor financial performance of state-owned utilities
  - Inappropriate pricing
  - Managerial and technical deficiencies
  - Unsustainable subsidies
  - Limited private sector participation
  - Limited access to investment
  - Low levels of access to services



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Who regulates?

- Government—issues of democratic control and legitimacy
- Independent body—in theory free from political interference, but can lack accountability
- Semi-independent body
- Other bodies that may be involved in regulating an industry:
  - Government departments, energy regulatory agencies, competition regulators, environmental regulators, local authorities, courts and tribunals



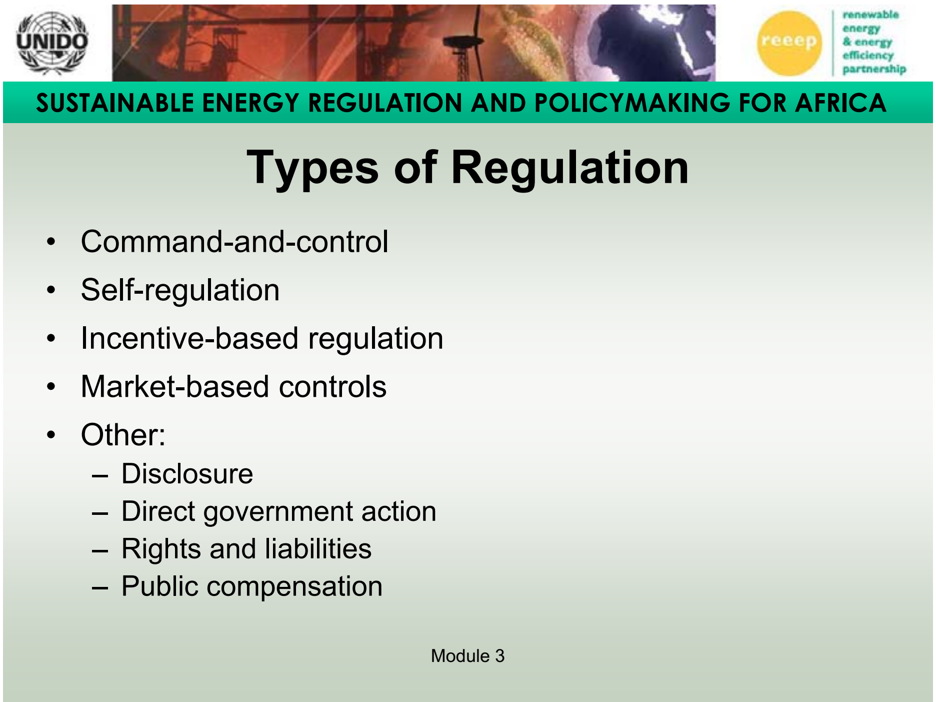
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

"Competition is the best regulator"

Discuss

Module 3

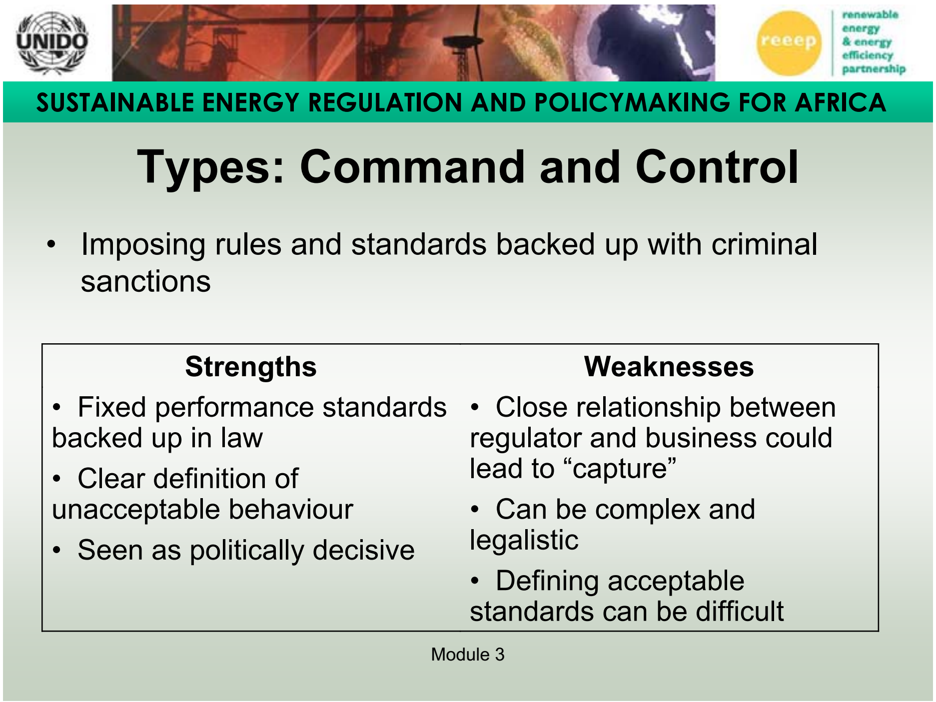


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types of Regulation

- Command-and-control
- Self-regulation
- Incentive-based regulation
- Market-based controls
- Other:
  - Disclosure
  - Direct government action
  - Rights and liabilities
  - Public compensation

Module 3

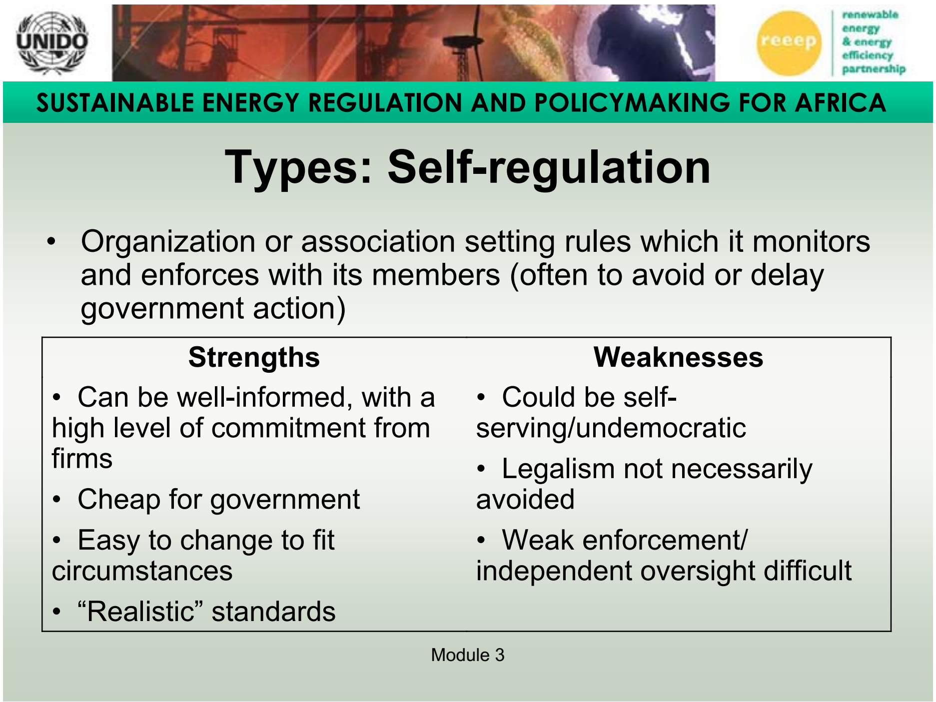


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types: Command and Control

- Imposing rules and standards backed up with criminal sanctions

Strengths	Weaknesses
• Fixed performance standards backed up in law • Clear definition of unacceptable behaviour • Seen as politically decisive	• Close relationship between regulator and business could lead to “capture” • Can be complex and legalistic • Defining acceptable standards can be difficult

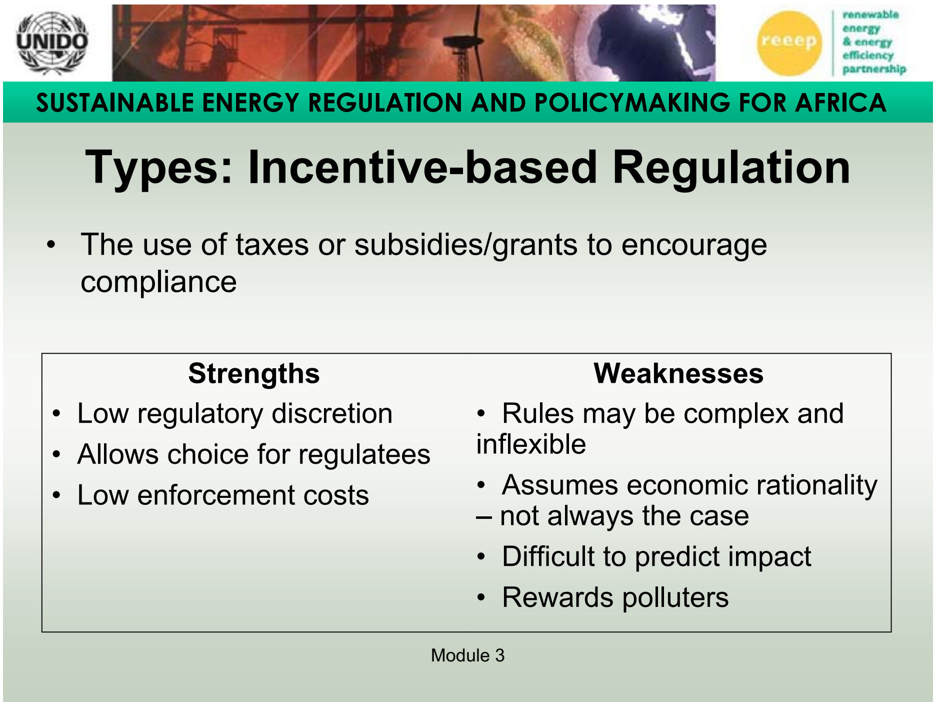


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types: Self-regulation

- Organization or association setting rules which it monitors and enforces with its members (often to avoid or delay government action)

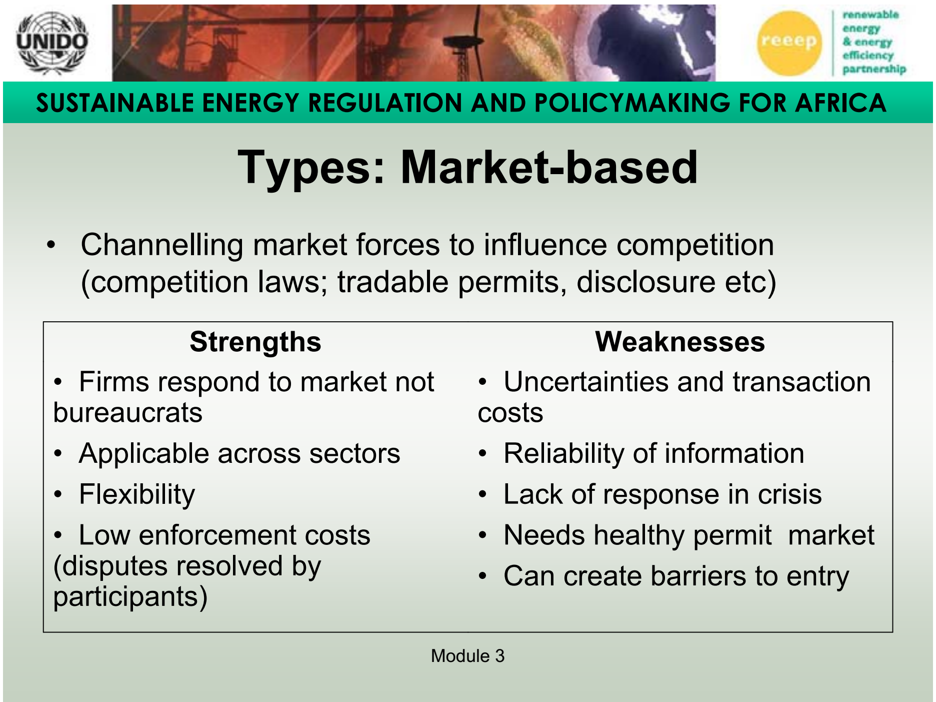
Strengths	Weaknesses
• Can be well-informed, with a high level of commitment from firms • Cheap for government • Easy to change to fit circumstances • “Realistic” standards	• Could be self-serving/undemocratic • Legalism not necessarily avoided • Weak enforcement/ independent oversight difficult



Types: Incentive-based Regulation

- The use of taxes or subsidies/grants to encourage compliance

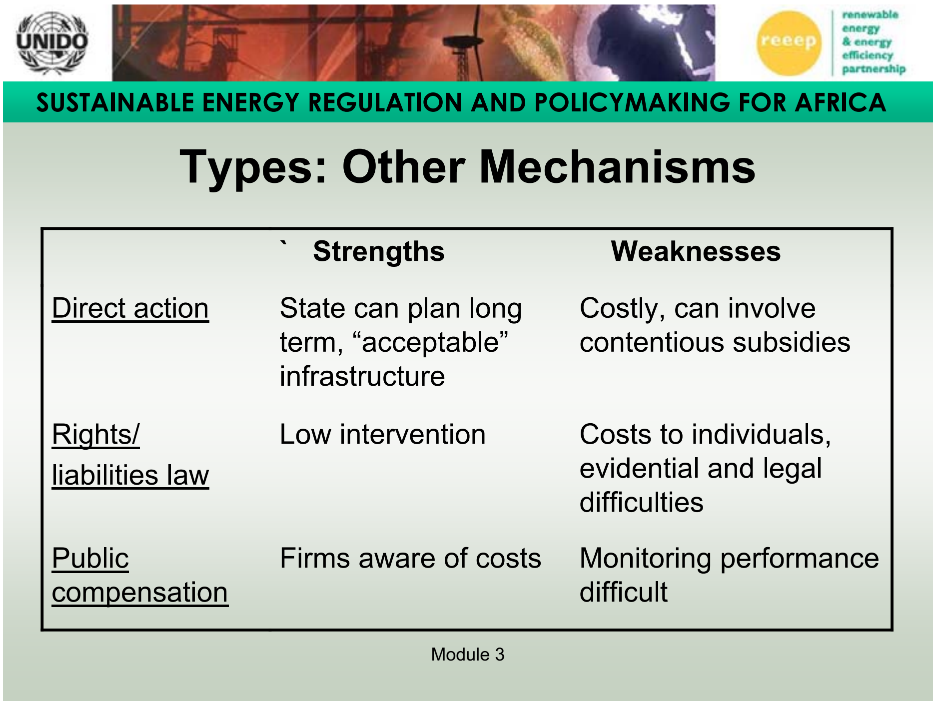
Strengths	Weaknesses
• Low regulatory discretion • Allows choice for regulatees • Low enforcement costs	• Rules may be complex and inflexible • Assumes economic rationality – not always the case • Difficult to predict impact • Rewards polluters



Types: Market-based

- Channelling market forces to influence competition (competition laws; tradable permits, disclosure etc)

Strengths	Weaknesses
• Firms respond to market not bureaucrats • Applicable across sectors • Flexibility • Low enforcement costs (disputes resolved by participants)	• Uncertainties and transaction costs • Reliability of information • Lack of response in crisis • Needs healthy permit market • Can create barriers to entry



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types: Other Mechanisms

	` **Strengths**	**Weaknesses**
Direct action	State can plan long term, “acceptable” infrastructure	Costly, can involve contentious subsidies
Rights/ liabilities law	Low intervention	Costs to individuals, evidential and legal difficulties
Public compensation	Firms aware of costs	Monitoring performance difficult

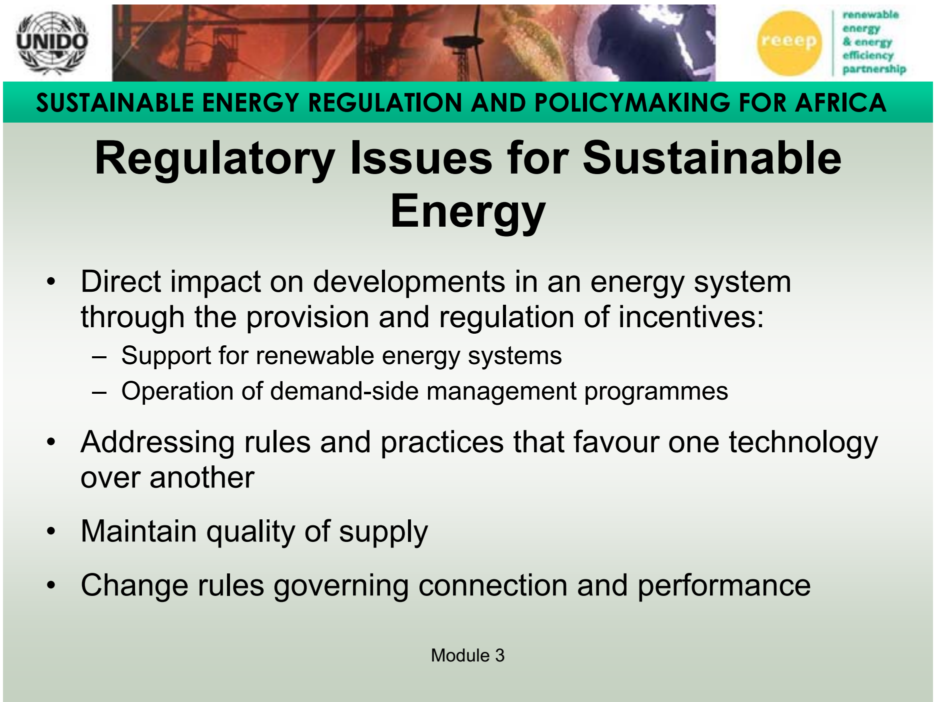
Module 3

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Examples for Africa

- Energy regulation in Zambia
  - An independent regulatory body
- Water regulation in Uganda
  - Regulation through a Government Ministry

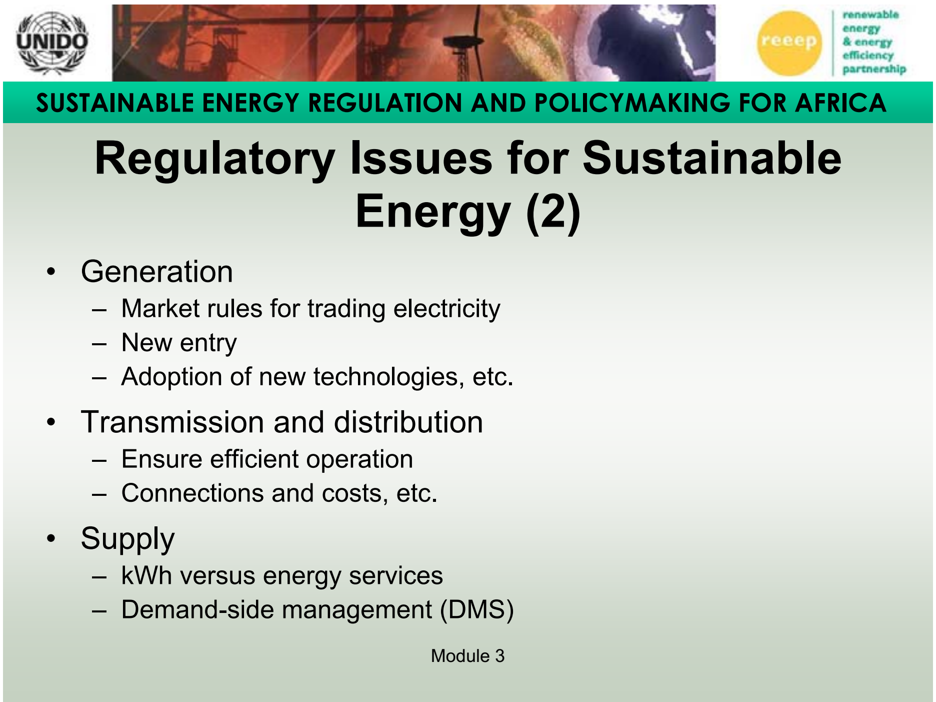
Module 3



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulatory Issues for Sustainable Energy

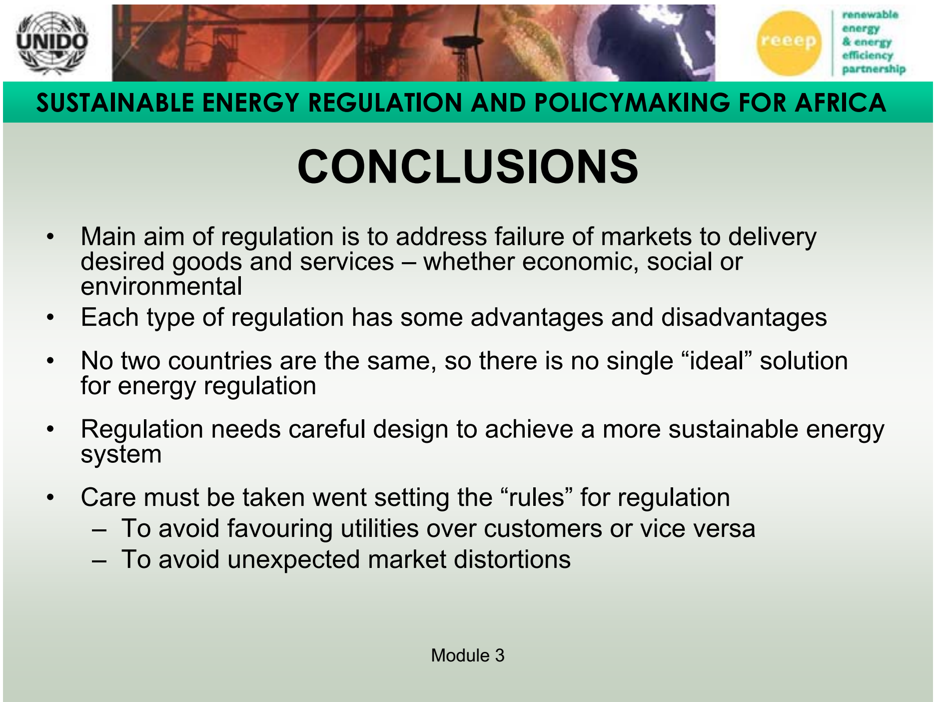
- Direct impact on developments in an energy system through the provision and regulation of incentives:
  - Support for renewable energy systems
  - Operation of demand-side management programmes
- Addressing rules and practices that favour one technology over another
- Maintain quality of supply
- Change rules governing connection and performance



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulatory Issues for Sustainable Energy (2)

- Generation
  - Market rules for trading electricity
  - New entry
  - Adoption of new technologies, etc.
- Transmission and distribution
  - Ensure efficient operation
  - Connections and costs, etc.
- Supply
  - kWh versus energy services
  - Demand-side management (DMS)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Main aim of regulation is to address failure of markets to delivery desired goods and services – whether economic, social or environmental
- Each type of regulation has some advantages and disadvantages
- No two countries are the same, so there is no single “ideal” solution for energy regulation
- Regulation needs careful design to achieve a more sustainable energy system
- Care must be taken went setting the “rules” for regulation
  - To avoid favouring utilities over customers or vice versa
  - To avoid unexpected market distortions

Module 3

Module 4

The reform of the power sector in Africa

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

The overall objective of this module is to provide a broad overview of power sector reform and highlight the drivers of reforms in Africa. In addition, the module discusses the implementation process of power sector reforms in Africa. Though there is a wide spectrum of reform options implemented in the region this module and other relevant modules in the training package focus on five of the most common reform options which include: unbundling (also referred to as restructuring); management contracts; corporatization/commercialization; independent power producers; and electricity law amendment.

The module provides an overview of power sector reform by describing its genesis, key characteristics and the pace of implementation in Africa. It highlights that power sector reforms were primarily designed to bridge short-term generation shortfalls and improve the financial health of state-owned power utilities. Although descriptions of the power sector are provided, the module does not include an analysis of the impact of power sector reform on sustainable energy —an issue that is addressed in two separate modules (modules 9 and 16) available in this training package.

The module is organized into three sections with the first providing the rationale and the status of power sector reform in Africa and the second describing the five main reform options implemented in Africa. The final section of the module presents key overall conclusions about the principal characteristics and trends of power sector reforms in Africa.

1.2. Module aims

The aims of the present module are listed below:

- Provide an overview of power sector reform in Africa;
- Highlight the drivers of power sector reform in Africa;
- Review power sector reform options implemented in sub-Saharan Africa. Specifically, this module focuses on the following reform options:
    - Corporatization
    - Management contract
    - Unbundling (vertical and horizontal)
    - Independent power producers
    - Electricity law amendment

- Provide examples, where relevant, of countries that have implemented the aforementioned reform options.

1.3. Module learning outcomes

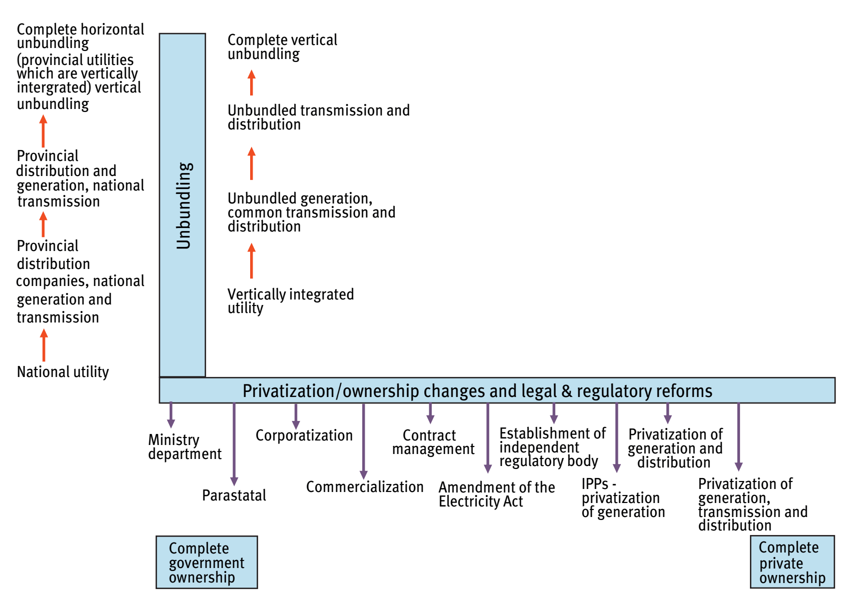
The present module attempts to achieve the following learning outcomes:

- Understanding power sector reforms in Africa;
- Being informed of the current status of power sector reform in Africa;
- Gaining appreciation of the key drivers of power sector reform in Africa.

2. INTRODUCTION

Although power sector reform has a wider meaning, the bulk of the existing literature, particularly from multilateral development banks, often equate reform with deregulation or, more specifically, the drastic reduction of government participation in the electricity subsector. To provide a clear understanding of power sector reform in Africa, this module offers a broad overview of power sector reforms and discusses the different reform options implemented in the region.

Figure I. Power sector reform options



There is a wide spectrum of power sector reform options as is shown in figure I. For the purpose of this module however, five major reform options implemented in Africa have been selected. They include:

- Unbundling, also referred to as restructuring
- Management contracts
- Corporatization/commercialization
- Independent power producers (IPPs)
- Electricity law amendment

The rationale for the selection of the aforementioned reform options for this module and for the training package in general is such:

- They are common reform options that have been widely implemented in Africa.
- They appear to have the most significant impact on renewable energy and energy efficiency in the region.

Comparing the reform process in Africa to the rest of the world, it appears that sub-Saharan Africa has been the slowest to implement power sector reforms. This is according to the latest and most comprehensive global survey of the status of power sector reforms in developing countries conducted in 1998 by ESMAP (Bacon and Besant-Jones, 2002). The survey included 48 sub-Saharan African countries and revealed that, in contrast to other regions in the developing world, in overall terms, sub-Saharan Africa's power sector was the least reformed (see table 1 and 2 below).

Table 1. Status of power sector reforms in the developing world (1998)[a]

	Region (number of countries)					
Key Step	**SSA (48)**	**MNA (8)**	**EAP (9)**	**ECA(27)**	**SAR (5)**	**LCC (18)**
Corporatization/ commercialization	15 (31%)	2 (25%)	4 (44%)	17 (63%)	2 (40%)	11 (61%)
Independent power producers	9 (19%)	1 (13%)	7 (78%)	9 (33%)	5 (100%)	15 (83%)
New electricity act	7 (15%)	1 (13%)	3 (33%)	11 (41%)	2 (40%)	14 (78%)
Establishment of regulator	4 (8%)	0 (0%)	1 (11%)	11 (41%)	2 (40%)	15 (83%)
Unbundling	4 (8%)	3 (38%)	4 (44%)	14 (52%)	2 (40%)	13 (72%)
Privatization of distribution	1 (2%)	1 (13%)	1 (11%)	8 (30%)	1 (20%)	8 (44%)
Privatization of generation	0 (0%)	1 (13%)	2 (22%)	10 (37%)	2 (40%)	7 (39%)
Reform indicator	0.83 (12%)	1.13 (19%)	2.44 (41%)	2.96 (49%)	3.20 (53%)	4.61 (77%)

[a] It is, however, important to note that the current status of reforms might have changed significantly from the 1998 situation

Note 1: SSA = Sub-Saharan Africa; EAP = East Asia and Pacific; ECA = Europe and Central Asia; LCC = Latin America and Caribbean; MNA = Middle East and North Africa; SAR = South Asia.

Note 2: Reform indicator = average number of reform options implemented per country (see key reform steps in table 3).

Note 3: Data on SSA slightly differs from the ESMAP data provided in Bacon 2001, due to the difference in the implied meaning of privatization of generation and distribution.

Source: Adopted from Bacon and Besant-Jones, 2002.

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More recently, information indicates that the trends in SSA reforms depicted in the above table have not significantly changed, with the exception of the development of IPPs becoming the predominant reform option as well as corporatization. Table 3 presents a summary of the prevailing status of reforms in sub-Saharan Africa.

Table 2. Summary of status of power sector reforms in sub-Saharan Africa (2002)

Key step	Number of countries (%)
Corporatization/commercialization	17 (35%)
Independent power producers	17 (35%)
New electricity act	12 (25%)
Establishment of regulator	9 (19%)
Unbundling	6 (13%)
Privatization of distribution	3 (6%)
Privatization of generation	1 (2%)

Sources: AFREPREN, 2003; Marks, 2000:b; Bacon, 2001; Engorait, 2003a; Daniel, 1998e:9; Daniel, 1998d:14; Daniel 1997:33; Daniel, 1998a:40,42; Daniel, 2001a: 17; Daniel, 2001b: 16; Daniel, 200c1: 17, 18; Daniel, 1999: 44-55; Daniel, 2000a; Daniel, 2000b:14-15; Government of Kenya, 1997:31; Marks, 2001b; Marks, 2002b; Marks, 2002c; Marks, 2002d; Marks, 2002h; Marks, 2002l; Marks, 2003; Marks; 2001l; Nyoike, 2003; Republic of Kenya, 1997; Teferra, 2002; WENRECO, 2003; World Bank, 1996:96, 96.

The majority of the countries reforming their power sector have mainly corporatized their utilities and invited IPPs to offset the generation shortfall experienced by the state-owned utilities. There appears to be much slower progress with respect to reforms aimed at minimizing or withdrawing government control of the power sector, such as, establishment of independent regulatory agencies, amendment of the electricity law, unbundling and privatization of the generation and distribution subsectors.

The following section provides a broad overview of power sector reforms in Africa and a detailed discussion of the selected reform options.

3. REFORMS IN THE AFRICAN ENERGY SECTOR

3.1. Rationale for power sector reform in Africa

As mentioned earlier, the bulk of the existing literature on reform in the electricity sector often equates the drastic reduction of government participation. This view has been bolstered by numerous studies that appear to equate poor performance in the subsector with high levels of state intervention.

The need for embarking on comprehensive power sector reform arose from two primary concerns: firstly, the dissatisfaction over the poor technical, financial, and managerial performance of the state-owned electricity utilities. Secondly, the inability of utilities and the government to mobilize sufficient investment capital for the electricity subsector's development and expansion.

Other reasons for power sector reforms include the following:

- Introducing competition: increasing the number of players in the market to ensure increased quality of service as well as lower tariffs.
- Tariff reform: adjusting tariffs in order to remove subsidies thus ensuring they become cost-reflective.
- Minimizing government's regulatory role: shifting the regulatory mandate from the Ministry/Department of Energy to an "independent" regulatory agency to ensure a level playing field.
- Amending electricity acts: reviewing electricity acts to establish a sound legal basis for power sector reforms.

It is also worth mentioning that other macroeconomic factors external to the power sector played a major role in the reform process. These factors include power sector investment constraints, national government fiscal constraints, limited options for raising capital, international investment climate, multilateral structural adjustment/commitment lending policies particularly by World Bank and IMF, and national economic reform—economy-wide liberalization and reform programmes initiated as a result of fiscal crises and structural adjustment policies.

It is, however, imperative to note that none of the reform efforts in the sector were specifically aimed at the increased use of renewable energy and energy efficiency options nor did they explicitly mention improving access to electricity—especially among the poor, which is a major concern.

3.2. Typical restructuring and privatization paths followed by most African countries

The major reforms that have been taking place in Africa are structural changes and privatization of power utilities. Structural changes refer to the process of unpackaging vertically integrated utilities into separate generation, transmission and distribution companies (vertical unbundling) and conversely unpackaging national utilities into smaller district or provincial utilities (horizontal unbundling). Horizontal unbundling appears to be feasible in very large economies such as in the United States of America. In Africa, only Nigeria appears to be considering this option.

The privatization process is essentially an issue of changing ownership of assets. It commences with bringing the assets of the state-owned utilities under a parastatal. The parastatal is thereafter commercialized (also referred to as corporatized) and it ultimately goes through several other steps to become a fully privately owned entity. The most common privatization path undertaken by the majority of African countries has been the corporatization, commercialization, issuing of management contracts and stop at allowing the entry of independent power producers (IPPs).

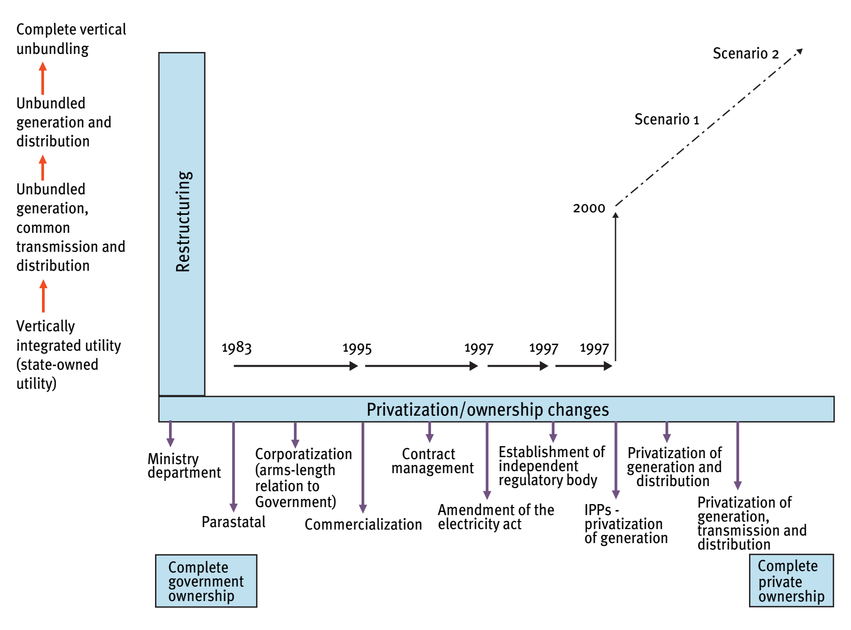
The following figure (figure II) for Kenya’s electricity industry illustrates the typical restructuring and privatization paths followed by the majority of the African countries including Ghana, Namibia, South Africa, Uganda, Zambia and Zimbabwe. However, not all countries strictly follow the path nor do they adopt all reform options.

Figure II, which is representative of trends in sub-Saharan African countries, appears to indicate that a lot more privatization has been undertaken than unbundling. In addition, in most countries unbundling is implemented well after the advent of privatization.

Furthermore, figure II illustrates the long time lag between implementation of the different reform options. For example, there is often a bigger lag between commercialization and the amendment of the Electricity Act. However, as soon as the Act is amended several other developments take place almost at the same time. For example, it is not uncommon to have the electricity regulatory agency and IPPs established in the same year as the Act. As mentioned earlier, unbundling takes place much later, this being mainly due to the legal changes to the utility that are required, such as including asset transfers procedures. The long time lag is also partly due to lengthy appointment procedures for the newly established institutions.

In terms of unbundling, some countries such as Kenya have opted to only unbundle the generation segment. Others such as Uganda and Zimbabwe have taken the option of completely unbundling the entire formerly integrated utility into separate generation, transmission and distribution entities.

Figure II. Reform options in Kenya



Scenario 1 and 2 = Possible future reform and possibly extreme options complete privatization and unbundling.

In the case of West Africa, the reforms of the electricity sector were implemented at different time intervals in different countries: Côte d'Ivoire was the first to implement reforms in the early 1990s, followed by Senegal (1998), Mali, Gambia, and finally in 2003, Benin. In all of these cases, the key reform objectives were to enhance technical efficiency (renovation and extension of the grid, improvement of the quality of electricity) as well as improved financial and managerial performance.

3.3. Status of power sector reform in Africa

The following table (table 3) summarizes the implementation status of the various power sector reform options for selected African countries. It includes the status of legal, regulatory and institutional reforms in the countries covered in the study.

Table 3. Status of reform implementation

					Private sector participation			
Country	Reform policy	Commercialization/ corporatization	Regulation agency	New/amended electricity act	Independent power producers (IPPs)	Independent power distributors (IPDs)	Unbundling	Management contract
Kenya	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented	Implemented	Pending
Namibia	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented
United Rep. of Tanzania	Implemented	Implemented	Pending	Pending	Implemented	Implemented	Pending	Implemented
Uganda	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Zambia	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented	Implemented	Implemented
Zimbabwe	Implemented	Implemented	Implemented	Implemented	Pending	Pending	Implemented	Implemented
Côte d’Ivoire	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented	Not implemented
Niger	Implemented	Implemented	Implemented	Implemented	Pending	Not implemented	Not implemented	Pending
Mali	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented	Not implemented	Implemented
Ghana	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Not implemented
Eritrea	Implemented	Implemented	Implemented	Implemented	Pending	Pending	Not implemented	Pending
Cameroon	Implemented	Implemented	Implemented	Implemented	Pending	Pending	Not implemented	Implemented
Ethiopia	Implemented	Implemented	Implemented	Implemented	Not implemented	Not implemented	Not implemented	Not implemented
Malawi	Implemented	Implemented	Implemented	Implemented	Pending	Not implemented	Implemented	Implemented
Mauritius	Implemented	Implemented	Not implemented	Implemented	Implemented	Not implemented	Not implemented	Not implemented
Mozambique	Implemented	Implemented	Pending	Implemented	Implemented	Not implemented	Not implemented	Not implemented
South Africa	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Sudan	Implemented	Implemented	Not implemented	Implemented	Implemented	Implemented	Not implemented	Not implemented
Swaziland	Implemented	Implemented	Pending	Pending	Not implemented	Not implemented	Not implemented	Not implemented
Burundi	Implemented	Implemented	Pending	Implemented	Not implemented	Not implemented	Not implemented	Not implemented
Rwanda	Implemented	Implemented	Implemented	Pending	Implemented	Pending	Implemented	Implemented
Burkina Faso	Implemented	Implemented	Implemented	Implemented	Pending	Not implemented	Not implemented	Implemented
Senegal	Implemented	Implemented	Implemented	Implemented	Pending	Pending	Not implemented	Implemented

One important aspect of power sector reform in Africa is that full privatization of generation and distribution has not taken place, implying that all generation and distribution entities in the country are not wholly owned by public or private sector. Instead, privatization of generation and distribution has mainly taken the form of partial private ownership of utility assets through equity, the awarding of concessions and management contracts.

Figure III. Summary of the status of reforms in various countries

Electricity industry structure

Competitive generation and distribution				
Fully unbundled utility		Zimbabwe	Uganda	
Multiple generation with single buyer (monopsony)		Kenya Niger Senegal Mali Zambia	Cameroon Côte d'Ivoire United Rep. of Tanzania Namibia Ghana	
Monopoly (vertically integrated utility)		Eritrea Burkina Faso		
	Sector wholly owned and managed by Government	**Public corporations without management contract with private sector**	**Public corporations with management contract with private sector**	**Sector wholly owned and managed by private sector**

Ownership changes/management

Source: Karekezi et al., 2005.

While a significant number of countries are planning the sell off government shares in power utilities in the future, some countries such as Senegal and Mali[1] 1ave reverted back to state ownership from fully privatized electricity utilities. There are important lessons that can be drawn from these developments. First and foremost, it appears that privatization of distribution appears to be more difficult to implement than privatization at generation. Secondly, by examining well

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[1] Mali's EDM, is essentially a public-private partnership between the Government of Mali and IPS of the Aga Khan Group with share holding of 66 per cent and 34 per cent, respectively.

performing utilities in the region such as those in Mauritius, South Africa and Zimbabwe, it can be concluded that privatization appears not to be the ultimate solution to sustained good performance of the utility. The utilities in the aforementioned countries appear to have performed relatively well without privatization.

Review questions

Discussion questions

1. List the key drivers of power sector reform in your country.
2. List some of the power sector reform options implemented in your country.

Revision question

1. Explain the common drivers of power sector reforms in Africa.

4. POSSIBLE REFORM OPTIONS—EXPERIENCES IN AFRICA

The following sections discuss the status of selected key reform options, and the status of their implementation in selected African countries.

4.1. Corporatization

Corporatization (sometimes simply referred to as commercialization[2]), is the act of transforming a state-owned utility into a limited liability corporate body often with the government as the main shareholder. Most African countries have implemented corporatization as a reform option (as depicted in table 4). This is because it is normally the first step in the reform of state-owned utilities. The key objective of this option in the reform process is to ensure that the utility runs its operations based on the business principle of profit maximization.

Table 4. Commercialization/corporatization in Africa—case examples

Country	Status
Egypt	Egyptian Electricity Authority (EEA)—corporatized in 1997
Ethiopia	Ethiopian Electric Light and Power Authority (EELPA) was corporatized in 1997 and renamed Ethiopian Electric Power Corporation (EEPCO).
Kenya	Kenya Power and Lighting Company (KPLC)—commercialized in 1995
Nigeria	National Electric Power Authority (NEPA)—corporatized in 1997 to become NEP Plc
Malawi	The Electricity Supply Commission of Malawi (ESCOM), was corporatized in July 1998, following repeal of the 1965 Electricity Act. The utility was renamed Electricity Supply Corporation of Malawi Ltd.
Zimbabwe	Zimbabwe Electricity Supply Authority (ZESA)—corporatized in July 2002

Sources: Financial Times, July 1997:33; Republic of Kenya, 1995:27-28 & GOK, 1996:31 and Teferra, 1998:8; Marks, 2002h.

Note: The information in the table above is from currently available sources and may have changed with time.

Power sector reforms, involving corporatization/commercialization of power utilities, have significantly improved the financial performance of the state-owned utilities. This is attributed to the regulation aspect where an incorporated entity

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[2] This is the transformation of a state-owned utility from one that depends on state funding for its operation to one that operates on commercial principles, thereby ensuring that its revenue fully covers its costs. This process is, in most cases, taken further to transform the state-owned utility into a corporate entity—a process referred to as corporatization.

is required to be profit making. Some of the principal sub-objectives of corporatization include:

- Separating utility from the ministry;
- Creating clear accounting framework;
- Cost recovery in pricing;
- Reducing or eliminating subsidies;
- Enforcing revenue collection.

Corporatization appears to go hand-in-hand with tariff reforms. Prior to the advent of electricity regulatory agencies and power sector reforms in general, electricity tariffs were approved and, in some cases, determined by government. This was during the period when provision of electricity was perceived as a social welfare service rather than a commercial service. Governments, therefore, strived to ensure that electricity was affordable to all by keeping the tariffs low and, to a large extent, subsidized.

Corporatization has, therefore, led to, among other developments, increases in the tariff levels in line with the following objectives:

- To recover the cost of electricity generation, transmission and distribution;
- To fairly and equitably spread the above costs to consumers based on the true cost of service delivery, consumption levels and patterns, and affordability to pay;
- To promote the efficient use of electricity.

Table 5 shows recent tariff increases in selected countries in the region.

Table 5. Recent tariff increases

Country	Average tariff increase	Year of tariff review	Reason for tariff review
Ghana	326 %	1998	General tariff review
Zimbabwe	70 %	2000	Annual tariff review
Uganda	56 %	2001	General tariff review
Malawi	35 %	2000	Effect of foreign exchange adjustment
Kenya	25 %	1999	General tariff review
Ethiopia	26 %	1998	General tariff review
Eritrea	18 %	2003	Annual tariff review
Namibia	10 %	2001	Annual tariff review
Cameroon	7.5 %	2004	Annual tariff review
Niger	6.0 %	2002	Annual tariff review
S. Africa	5.5 %	2001	Annual tariff review

Sources: Pineau, 2005; Dube, 2005; Kayo, 2005; Habtetsion, 2005; Mamadou, 2005; Gboney, 2001; AFREPREN/FWD, 2001a; 2000c; Nyoike and Okech, 2001; Teferra, 2001; UEDCL, 2001; NER, 2000; NER, 2001.

4.2. Management contract

A management contract describes a situation where the management of the utility is contracted out to a private entity. The utility, however, remains the owner of the assets. A management contract, to a large extent, is usually part of the wider commercialization process.

Management contracts are increasingly becoming a common feature in state-owned power utilities, particularly in West African countries. A number of countries have attempted to introduce management contracts to improve efficiency and profitability of their utilities. Countries in the study that have incorporated this option include Uganda, the United Republic of Tanzania and Ghana. Other countries include Guinea Bissau, Malawi, Morocco and Togo. Most of these contracts involve an agreement through which operational management of the utility or part of it is delegated to a firm of management consultants, but major assets and investment decisions remain under the government.

Box 1. **Management contract experiences in Africa**

The foreign firms involved in management contracts in Africa have mainly been dominated by French entities. More recently, South African firms (Net Group Solutions and Eskom Enterprises—a subsidiary of the South African utility, Eskom) have begun showing interest in the African power utility management contract market. South African-led management contract initiatives are now under way in Malawi, Uganda and the United Republic of Tanzania.

Management contracts in Africa have not been without controversies. For example, a review of the management contracts instituted in Mali, Senegal, Cameroon, and, to a lesser extent, in Côte d'Ivoire, indicates a significant degree of dissatisfaction in their performance. In Mali and Senegal, for example, management contracts have been prematurely terminated.

The table below provides case examples of management contracts implemented in selected African countries.

Table 6. Management contracts in Africa—case examples

Country	Status
Côte d' Ivoire	A management contract was first signed in 1990 between Énergie Électricité de la Côte d'Ivoire (EECI) and Compagnie Ivoirienne d'Électricité (CIE). The major shareholders of CIE are French utilities, SAUR and Électricité de France (EDF). The management contract was reviewed in 2005 for another 15 years.
Guinea Bissau	In 1997, Société Guinéenne d'Électricité (SOGEL) a private concession-holder was given a ten-year renewable contract to run all technical, administrative, financial and commercial power supply services. It bills customers according to tariffs set by the supervisory authority.
Morocco	A consortium including the Portuguese companies Electricidade de Portugal and Pleidade was awarded a 30-year contract in May 1998 to manage water, electricity and sewerage works in the greater Raban region.
United Rep. of Tanzania	The Tanzanian Government contracted out the running of the gas turbines at Ubongo to a Swedish/Swiss company, Asea Brown Bovery (ABB). The Tanzanian Government contracted a South African firm, Net Group Solutions, to manage Tanzania Electric Service Company (TANESCO) for two years from July 2002.
Ghana	In 1997, Electricity Corporation of Ghana (ECG) signed a management contract with EdF/SAUR consortium to handle the firm's customer services.
Togo	In 2000, a consortium comprising France's Elyo and Canada's Hydro Québec International won a five-year renewable management contract to run the integrated utility Compagnie d'Énergie Électrique du Togo (CEET).
Nigeria	South Africa's Eskom is to jointly manage with Nigeria's Electric Power Authority (NEPA) areas of Nigeria's power supply. This shall be under a rehabilitate-operate-transfer (ROT) scheme.
Uganda	In 1999, the board of directors of the Uganda Electricity Board "contracted" Mr. Paul Mare as the utility's new managing director. There are indications that the new managing director remained on the payroll of his previous employer, Eskom, and UEB simply tops up his salary to provide a sufficiently attractive remuneration package. This is a unique form of management contract where an individual, rather than an organization, is contracted.
Malawi	In mid-2001, ESCOM signed a management contract with South Africa's Technology Services International, a division of Eskom Enterprises.
Rwanda	Electrogaz is to be placed under management contract. A prequalification tender for the management contract was issued in 2001.

Sources: Bacon and Gutierrez, 1996:105; Coopers and Lybrand, 1996:157; Marandu 1998:9; ESMAP & World Bank, 1996:31; Financial times, Apr 1997:16; African review, Mar 1997:27; ECA, 1995:5 and Financial times, June 1998:4; African Energy, Issue 30, September 2000: 9; African Energy, Issue 28, July 2000; Marks, 2003; Marks, 2002l; Marks, 2002j. The Guardian, 2003.

Note: The information in the table above is from currently available sources and may have changed with time.

4.3. Unbundling

Unbundling plays three important roles within a power reform context. Firstly, unbundling allows management to gain a clearer understanding of the technical and financial performance of the previously integrated components of a vertically integrated utility. Secondly, it also increases opportunities for competition. For example, an unbundled generation entity is expected to compete with private sector-led IPPs. Thirdly, it is expected that by ensuring that the unbundled entities are managed independently, unbundling would lead to improved technical and financial performance.

Unbundling of power utilities can be undertaken in two forms namely; horizontal unbundling and vertical unbundling. The latter unbundling option appears to be the preferred choice and has been implemented in many African countries. The various forms of unbundling options are described in the following sections.

Vertical unbundling

Vertical unbundling refers to the process of separating vertically integrated utilities into independent generation, transmission and distribution companies. This process often follows the following procedure:

Vertically integrated utility: the power utility undertakes electricity generation, transmission and distribution.

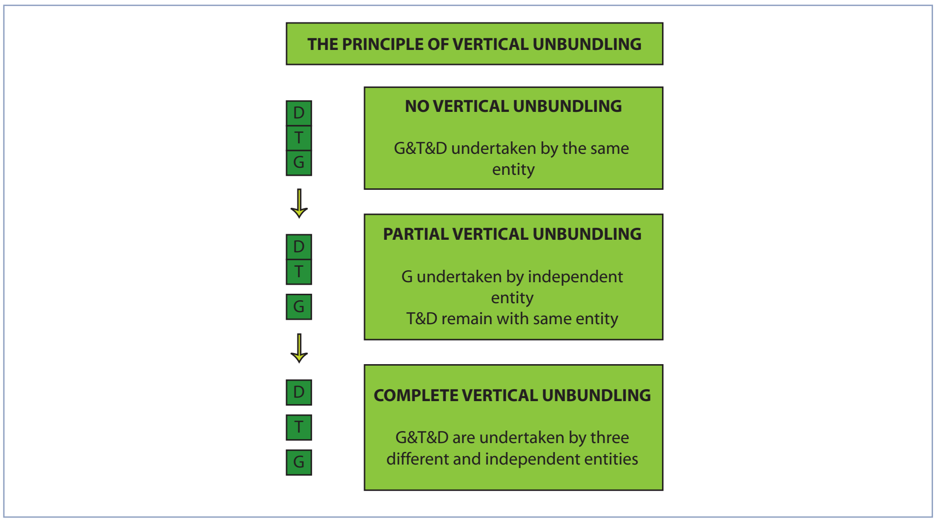
Unbundled generation, common transmission and distribution: the generation component of the utility becomes an independent entity while transmission and distribution remains a single entity.

Unbundled transmission and distribution: in addition to the unbundled generation, the distribution entity is separated from transmission.

Complete vertical unbundling: this is a state where three entities, i.e. generation, transmission and distribution are independent.

This principle is schematically presented in figure IV.

Figure IV. The principle of vertical unbundling



G: Generation; T: Transmission: D: Distribution
Sources: IT Power

The following table discusses case examples of the unbundling of national utilities implemented in selected African countries

Table 7. Vertical unbundling of national utilities—case examples

Country	Details	Status
Kenya	In 1998, the national utility was unbundled into Kenya Electricity Generating Company (Generation) and Kenya Power & Lighting Company (Transmission & Distribution).	Implemented
Uganda	In March 2001, UEB was unbundled and three companies created and registered.	Implemented
Malawi	In 2002 the Electricity Supply Commission of Malawi was split into generation, transmission and distribution.	Implemented
South Africa	Regional Electricity Distributors responsible for electricity and electrification programmes have been established in Johannesburg.	Implemented
Zimbabwe	In 2002, Zimbabwe Electricity Supply Authority (ZESA) was into generation, transmission and distribution companies.	Implemented
United Rep. of Tanzania	State utility to be split into generation, transmission and distribution companies.	Forthcoming

Sources: Marks, 2002h; Marks, 2001b; Marks, 2003; Enguirat, 2003. Nyoike, 2003.

Note: The information in the table above is from currently available sources and may have changed with time.

Horizontal unbundling

Horizontal unbundling refers to the process whereby generation, transmission and distribution are undertaken by a national monopoly utility are separated in order to have each province with its own generation, transmission and distribution entity/entities. This is undertaken as follows:

National utility: the power utility undertakes electricity generation, transmission and distribution nation-wide.

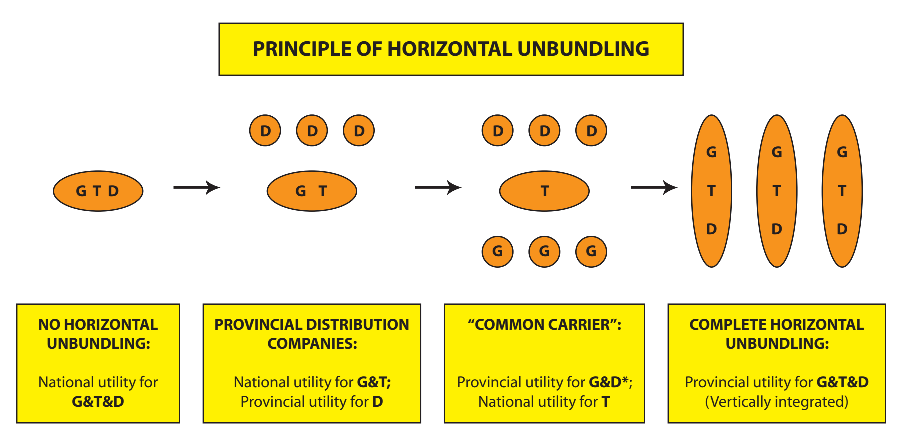
Provincial distribution companies, national generation and transmission: the national distribution component of the utility is reduced to entities at provincial level. Generation and transmission components remain at national level.

Provincial distribution and generation and national transmission (common carrier): in addition to provincial distribution entities, generation entities are also established at the provincial level. Transmission, however, remains at a national level.

Complete horizontal unbundling (vertically integrated provincial utilities): this is a state whereby each province has a utility undertaking electricity generation, transmission and distribution.

This principle is presented in figure V below.

Figure V. The principle of vertical unbundling



G: Generation; T: Transmission: D: Distribution
** G&D can be vertically integrated per provincial utility*
Sources: IT Power

4.4. Independent power producers

Independent power producers (IPPs) constitute an important form of private sector participation in Africa's power sector. With demand outstripping supply in many African countries, independent power projects are becoming a major source of new power generation capacity in these countries. By the end of 2002, about 35 per cent of the planned IPPs were operational. The balances were either in progress or their dates of implementation were not yet due. The status of more recent IPPs in selected sub-Saharan African countries is provided in table 8.

Overall, the growth of independent power projects in Africa in the late 1990s (figure IV) was very rapid. Only a few projects in Côte d'Ivoire and Egypt were implemented by 1991. However, there was a major increase in the number of IPPs in Africa during 1996 and 1997, a period when the majority of legislative and structural changes took place in the region. As figure IV demonstrates, it appears that the rapid growth of IPPs experienced in 1996-1998 is beginning to slow, a trend that has accelerated in 2000 and 2001. The available data however, are not conclusive.

Table 8. Summary of the status of recent IPPs in selected African countries[a]

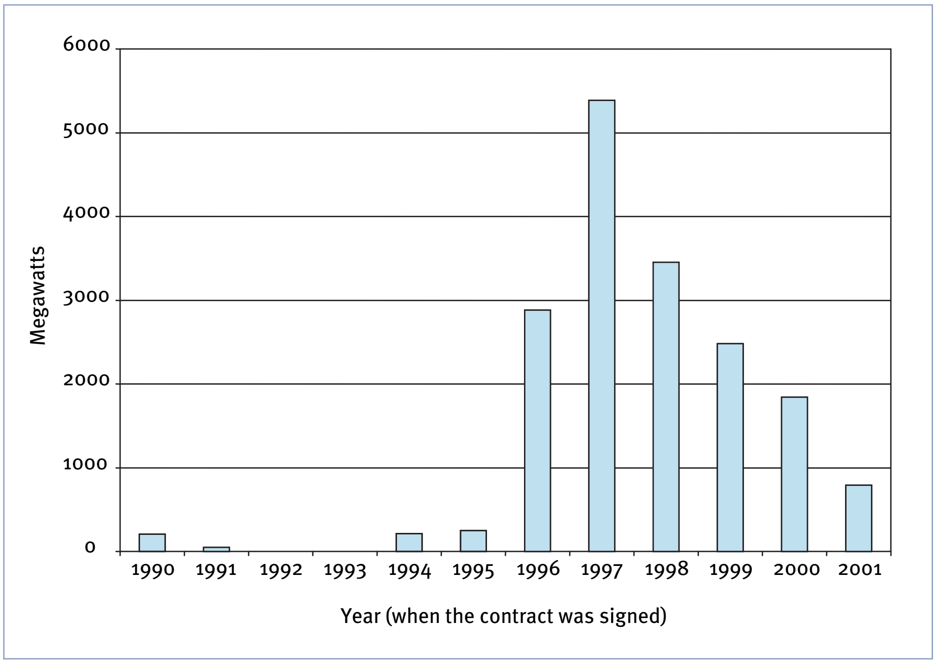
Country	Name	Size	Investment	Fuel	Companies	Status*
Ghana	Takoradi II	330 MW	$414 m (90% share holding by private sector)	Oil	CMS and VRA	Complete
	Tema	220 MW	$200 m	Oil/gas	KMR, Marubeni	Planned
Kenya	Tsavo, Kipevu II	74 MW	$ 86 m (100% shareholding by private)	Oil	Tsavo Power Company (Cinergy of the US, IPS of Kenya, Wartsila of Finland, the CDC of the UK, and the IFC)	Complete
	Nairobi South Plant	56 MW	$ 50 m (100% shareholding by private)	Oil	Iberafrica (Spain)	Complete
	Olkaria III (Phase I)	12 MW	$ 17.5 m (100% shareholding by private)	Geothermal	Ormat Turbines Ltd.	Complete
	Mombasa Barge-Mounted Power Project	43 MW	$ 20 m (100% shareholding by private)	Oil	Westmont Ltd.	Complete
	Sondu Miriu	60 MW	$ 52 m	Hydro	JBIC, Kengen	Ongoing
	Olkaria III	64 MW	$ 172 m	Geothermal	Ormat	Complete
	Lanet and Eldoret	2 x 55 MW	$ 135 m	Oil	BSWC	Planned
Côte d'Ivoire	Azito	450 MW	$ 225 m (100% shareholding by private)	Gas	Cinergy (IPS, ABB, EdF)	Complete
	Vridi	210 MW	$ 97.5 m (98% shareholding by private)	Gas	CIPREL (EDF and SAUR)	Complete
Tanzania (United Republic of)	IPTL power project	100 MW	$ 100 m (100% shareholding by private)	Oil	Independent Power, Tanwart: venture between Tanzanians and a Malaysian company	Complete
	Ubungo, Songo Songo	110 MW	$ 340 m	Gas	CDC, AES	Complete
Senegal	GTI-Dakar	50 MW	$ 62 m (100% shareholding by private)	Oil	General Electric's structured finance group subsidiary, IFC and the Italian utility Sondel	Complete
Zambia	Lusemfwa Hydro Power Company	36 MW	- 51% shareholding by private	Hydro	Eskom Enterprises	Complete
	Itezhi-tezhi	120 MW	$ 122 m	Hydro	OPPPI	RFP complete
	Kafue Gorge Lower	600 MW	$ 435.7m	Hydro	OPPPI	RFP completed
Uganda	Bujagali	250 MW	$ 550 m	Hydro	AES	Postponed
	Kakira Sugar Works	12 MW	$ 11.3 m	Bagasse	Kakira Sugar Works	Ongoing
Sudan	Khartoum North	200 MW	$ 267 m	Hydro	Chinese power company, Harpen Wang Chen	Planned

[a] At the time of writing this module there are no IPPs in Botswana, Burkina Faso, Eritrea, Ethiopia, Lesotho, Malawi, Namibia or Niger. IPPs are, however, envisaged in the future in these countries.

* Status as of May, 2004.

Source: Ferreira, 2004; AFREPREN, 2004; Nakhooda, 2005.

Figure VI. Growth of independent power projects in Africa



Sources: Karekezi and Mutiso, 1999; Daniel, 2000a; Daniel, 2000b; Daniel, 2001a; Daniel, 2001b; Daniel, 2001c; Marks, 2001a, Marks, 2001b; Marks, 2001c.

Except for a few countries such as Mauritius, reforms appear to favour large and centralized power projects thereby precluding small and medium-scale renewable energy technologies. In spite of significant potential, IPP developments have not considered small to medium-scale renewable energy technologies such as mini-grids, cogeneration, small hydro, geothermal and wind.

In many African countries, power sector reform appears to have involved limited local private participation in IPP development. Current trends seem to indicate that, in the medium term, the exit of the state from electricity generation (and eventually from the entire electricity industry), would effectively hand over the industry to non-national operators. In political terms, this may be an unsustainable arrangement. Without significant local involvement, it is possible that reforms may be reversed in the future mainly because there would be no significant local stakeholder group.

Local private participation in IPP development and use of renewables and energy efficiency options has mainly been hampered by the emphasis on large-scale investment. In most African countries, the size of IPPs (both implemented and proposed) is greater than the prevailing installed capacity (largely from the state-owned utilities), which is an indication of a heavy emphasis on large-scale investments. Large-scale IPP developments may have several drawbacks with regard to local private participation in the region.

Firstly, large-scale IPP development is generally a high-tech, capital-intensive endeavour that requires heavy capital investment which dissuades local investors. Small-scale IPP development, for example, small hydro and cogeneration plants, involve technology that can easily be locally managed. In addition, the capital requirements of these small and medium-scale renewables are modest and can be sourced locally.

Box 2. **Local participation and cogeneration development in Mauritius**

Mauritius provides a model case example of the potential of local private participation and renewables development in the power sector. Due to private investment in the sector, the Mauritian sugar industry, which had been churning out bagasse as residues from its sugar processing activity, is now using these residues as fuel in highly efficient cogeneration systems. Currently, about 40 per cent of annual electricity generation comes from local privately-owned and operated bagasse-based cogeneration plants within the sugar industry (Veragoo, 2003). Over time, the local bagasse-based cogeneration industry has made steady progress in technology development, starting with modest investments of about $US 4 million in bagasse-based cogeneration power plants comprising of conventional low-pressure boilers with installed capacity in the range of about 10-15 MW. After steady growth, local private investors in partnership with foreign investors have recently made an investment of about $US 100 million in a hi-tech high-pressure bagasse-based cogeneration power plant with an installed capacity of 70 MW (Quevauvilliers, 2001, Deepchand, 2006).

The success of the cogeneration industry in Mauritius stems from the investments in, and use of, high pressure boiler systems (up to 82 bar pressure) and highly efficient condensing/extraction-condensing turbo-generators which allow the project owners to implement much higher capacities than what the mills need, thereby giving them the opportunity to sell excess power to the grid. The sale to the grid has been facilitated and encouraged by the favourable buyback tariffs and terms reflected in a transparent and long-term Standard Power Purchase Agreement (PPA).

In some years, the revenues coming from the use of bagasse in power generation represent more than half of the total revenues of the sugar mills. In Mauritius, revenues earned by the sugar mills from the sale of electricity to the grid are shared with the farmers using an agreed sharing mechanism. This effectively increases the earnings of the farmers from the same amount of sugar cane produced because bagasse, which had been traditionally considered as waste, is now being purchased as a biofuel. The impact of this development on the economic situation of the farmers is not negligible.

Because of these experiences, Mauritius has recently started to provide expertise in developing and implementing cogeneration systems in other African countries through consultancy work and management contracts within the sugar industry.

Secondly, large-scale, capital-intensive IPP developments invariably attract the politically connected rent-seeking class. The controversial IPP projects in

Zimbabwe involving YTL (a Malaysian company), in the United Republic of Tanzania involving IPTL (another Malaysian company) and Kenya are classic examples of the disarray that the rent-seeking class can cause. There could therefore be a case to examine smaller IPPs which may be less capital intensive and would not attract the interests of the local rent-seeking class. One of these case examples, which demonstrates both the use of renewable energy and local participation in the power sector, is cogeneration in Mauritius as described above in box 2.

The Mauritian example demonstrates the potential financial and technical capability and viability of local private investors in IPP development. Appropriate policy and financial incentives could encourage the development of locally owned IPPs. The ideal entry point, as in the case of Mauritius and applicable to most African countries, is likely to be renewable energy options such as bagasse-based cogeneration and small hydro that can be developed by IPPs and local agro-based agencies in a decentralized manner.

4.5. Electricity law amendment

The amendment of the electricity law usually involves the National Assembly or Parliament of a country passing an amendment to the existing Act to establish new legislation governing the electricity subsector and/or other energy subsectors. This can, for instance, remove the monopoly of the national utility—a major barrier to private sector participation. It also often provides for the establishment of an independent regulatory body for the electricity subsector and defines its role. In some instances, the Act provides some independence to the Regulator. The Electricity Act could also create a provision for a rural electrification programme and/or fund.

In most African countries, the Electricity Act is the principal instrument that defines the legal and regulatory framework. In the past, the legal and regulatory framework was originally designed for state-owned or government-regulated power utilities, with little or no provision for private sector participation. Recently, with the exception of Tanzania, all other countries covered in this study have amended their Electricity Acts, leading to a number of important regulatory changes presented in the following table (table 9).

Table 9. Changes in the legal and regulatory framework

Provision in the electricity act	Previous legal and regulatory framework	New legal and regulatory framework
Regulatory agency	Regulation by the ministry in conjunction with the public utility	Regulation by an independent regulatory body
Rural electrification agency	Rural electrification programme administered by ministry and/or utility	Rural electrification administered by an independent body
Licensing of IPPs: - For own use	Application to ministry through the public utility.	In most countries by the electricity regulatory board (ERB). Others (e.g. Kenya) by minister on advice from ERB.
- For sale to public utility	Non-existent. Generation sole responsibility of utility.	Power purchase agreement approved by ERB.
Licensing of IPDs	Non-existent. Distribution sole responsibility of utility.	By the regulatory body.
Gazette of licence application and licence granted	Not mandatory since private power generation was licensed for applicant's own use.	A requirement for the regulatory body (and in some countries the applicant) for applications and in some countries for licence granted.
Tariff setting	Proposed by public utility and approved by ministry.	Proposed by utility and approved by the regulatory body. In some countries (e.g. Kenya) the regulatory body can also review tariff without request by utility.
Appeals and dispute resolution	On a point of law, the law courts.	The regulatory body, minister, arbitration tribunals and law courts.

Sources: Pineau 2005b; Habtetsion, 2005b; Dube, 2005b; Kalumiana, 2005b; Nyang, 2005b; Diarra, 2005a; Bassirou, 2005b; Sarr & Sokona, 2003, Kayo 2005b; Kahyoza 2005a; Tse, 2005b; NARUC, 2003; Government of Ghana, 1997; Government of Kenya, 1997; Government of Uganda, 1999; Government of Zambia, 1995; Federal Government of Ethiopia, 1997; Federal Government of Ethiopia, 1999.

IPPs – Independent power producers
IPDs – Independent power distributors

Note: In countries where there is no regulatory body established, the Minister concerned continues to be the main regulator.

Review questions

Discussion question

1. Compare and contrast reforms implemented in your country and those of your neighbouring countries.

Review questions

1. Name and define the two forms of utility unbundling.
2. What is the role of unbundling?

5. CONCLUSION

Most African countries are still at the initial stages of power sector privatization and restructuring. Countries such as Egypt, Mauritius and South Africa have had state-owned and vertically integrated power sectors for a long time and have recorded impressive performances. These countries are now contemplating the introduction of private participation in the power sector.

Corporatization/commercialization of the power utilities in Africa have, to a certain extent, improved the financial performance of the state-owned utilities. This is attributed to the regulatory condition that an incorporated entity is required to be profit making. This often involves the introduction of commercial objectives into the management and operation of a state-owned (public) utility.

In most cases, management contracts involve contracting a private management firm to take charge of day-to-day operations of the utility. The utility, however, remains the owner of the assets. Management contracting is, to a large extent, usually part of a wider commercialization process and appears to be gradually gaining ground in sub-Saharan Africa.

With regard to unbundling, a vertically integrated utility is separated into legally and functionally distinct companies providing generation, transmission and distribution. Unbundling is important as it allows management to gain a clearer understanding of the technical and financial performance of the previously integrated components of a vertically integrated utility and also increases opportunities for competition. Vertical unbundling is becoming increasingly common in much of sub-Saharan Africa.

Independent power producers (IPPs) constitute an important form of private sector participation in Africa’s power sector. With demand outstripping supply in many African countries, independent power projects constitute a major source of new power generation capacity in Africa. However, to date, not many IPPs are renewables-based.

Amendments to the national electricity laws have contributed to the removal of the monopoly of the national utility—a major barrier to private sector participation—and at times provide for the establishment of an independent regulatory body for the electricity subsector.

LEARNING RESOURCES

Key points covered

The key points covered in the module are as follows:

- Although power sector reform has a wider meaning, the bulk of the existing literature, particularly from multilateral development banks, often equate reform with deregulation or, more specifically, the drastic reduction of government participation in the electricity subsector.
- In Africa, it is generally agreed that the need for embarking on power sector reforms arose from poor technical and financial performance of the state-owned electricity utilities and the inability of utilities and the government to mobilize sufficient investment capital for the electricity subsector's development and expansion.
- Reforms were not explicitly designed to promote renewables and energy efficiency but were rather primarily designed to bridge short-term generation shortfalls and improve the financial health of state-owned power utilities.
- Major reform options implemented in Africa include:
  Unbundling, also referred to as restructuring;
  Management contracts;
  Corporatization/commercialization;
  Independent power producers (IPPs);
  Electricity law amendment.
- Compared to the rest of the world, it appears that sub-Saharan Africa has been the slowest to implement power sector reforms.
- The majority of the countries reforming their power sector have mainly corporatized their utilities and invited IPPs to address the generation shortfall experienced by many state-owned utilities.
- Corporatization (sometimes simply referred to as commercialization) appears to be the first reform option executed in most African countries. Corporatization appears to go hand-in-hand with tariff reforms.
- The most common power sector privatization path undertaken by the majority of African countries has been the corporatization, commercialization, issuing of management contracts and allowing the entry of independent power projects (IPPs).
- In Africa, full privatization of generation and distribution, implying that all generation and distribution entities in the country are wholly private owned, has not taken place in most countries. Instead, privatization of generation and

distribution has mainly taken the form of partial private ownership of utility assets through equity, the awarding of concessions and management contracts.

- With demand outstripping supply in many African countries, independent power projects are becoming a major source of new power generation capacity in these countries. By the end of 2002, about 35 per cent of the planned IPPs were operational.
- In most African countries, the Electricity Act is the principal instrument that defines the legal and regulatory framework.

Answers to review questions

Question: Discuss the common drivers of power sector reforms in Africa?

Answer:

The main drivers for reforms in the power sector are:

Poor technical, financial, and managerial performance: Dissatisfaction over the poor technical, financial, and managerial performance of the state-owned electricity utilities.

Insufficient investment capital: Inability of utilities and the government to mobilize sufficient investment capital for the electricity subsector's development and expansion.

Introducing competition: Increasing the number of players in the market to ensure increased quality of service as well as lower tariffs.

Tariff reform: Adjusting tariffs in order to remove subsidies thus ensuring they become cost-reflective.

Question: What are the two forms of utility unbundling?

Answer:

Vertical unbundling: refers to the process of separating vertically integrated utilities into independent generation, transmission and distribution companies.

Horizontal unbundling: refers to the process whereby generation or distribution undertaken by a national monopoly utility, are separated in order to have each province with its own generation, transmission and distribution entity/entities.

Question: What is the key role of unbundling?

Answer:

Unbundling plays two important roles within a power reform context. Firstly, unbundling allows management to gain a clearer understanding of the technical and financial performance of the previously integrated components of a vertically integrated utility. Secondly, it also increases opportunities for competition.

Exercises

1. Should power sector reforms be a priority for Africa? Using relevant data and information to support your arguments, write 2-3 page essay.
2. Discuss the status of past and on-going power sector reforms in your country? Write a 2-3 page essay.

Presentation/suggested discussion topics

Presentation:
ENERGY REGULATION—Module 4: The Reform of the Power Sector in Africa

Suggested discussion topic:
What are the key power sector reform drivers in your country?

Relevant case study

1. Power sector reforms in Zimbabwe

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INTERNET RESOURCES

AFREPREN/FWD: www.afrepren.org

UNIDO: www.unido.org

REEEP: www.reeep.org

IT-Power: www.itpower.co.uk

UNDP: www.ke.undp.org/Energy%20and%20Industry.htm

KAM: kenyamanufacturers.org

ADB: www.undp.org/seed/eap/projects/FINESSE

UNFCCC on Climate Change: www.climatenetwork.org/eco or http://unfccc.int

World Bank: www.weea.org/Newsletter/02/02.htm

Energy management training (India): www.energymanagertraining.com/new_index.php

GTZ: www.gtz.de/wind

Small hydro: www.small-hydro.com

"Cogen for Africa" Project: cogen.unep.org

Greening the Tea Industry in East Africa Project: greeningtea.unep.org

www.reeep.org

African Forum for Utility Regulation: www.afurnet.org

Regional Electricity Regulators Association of Southern Africa: www.rerasadc.com

International Energy Initiative: www.ieiglobal.org

World Resources Institute: www.wri.org

www.consumerenergycenter.org/renewables/solarthermal/hotwater.html

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GLOSSARY/DEFINITION OF KEY CONCEPTS

Bagasse	The fibrous residue of sugar cane left after the extraction of juice and often used as a fuel in cogeneration installation.
Blackout (also referred to as outage)	An interruption of electricity service or power loss that affects electricity consumers in an area.
Billing	The process of issuing statements indicating electricity consumption of and charges to consumers.
Biofuels	Liquid fuels and blending components produced from biomass (plant) feedstocks, used primarily for transportation.
Clarity (in licensing)	This refers to how easily understood the licensing process and requirements are.
Cogeneration	Simultaneous production of electricity and heat energy.
Complete government ownership	When the government owns all the generation, transmission and distribution assets within a national utility.
Complete horizontal unbundling (provincial utilities which are vertically integrated)	When each province owns a utility that undertakes electricity generation, transmission and distribution in vertically integrated operations.
Complete private ownership	When all generation, transmission and distribution entities in the country are wholly owned by the private sector.
Complete vertically unbundling	When the generation, transmission and distribution entities are independent companies.
Corporatization	This is the act of transforming a state-owned utility into a limited liability corporate body often with the Government as the main shareholder.

Demand-side management	Planning, implementation, and evaluation of utility-sponsored programmes to influence the amount or timing of customers' energy use.
Deregulation	Drastic reduction of government's participation in the electricity subsector by opening up the sector to the private investors
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Distribution	Delivery of electricity to the customer's home or business through low voltage distribution lines.
Direct access	The ability of a customer to purchase electricity or other energy sources directly from a supplier other than their traditional supplier.
Efficiency (in licensing)	The ability of the licensing agency to process applications within the shortest possible time and in the least number of stages the application needs to go through.
Electricity/power sector reforms	Deliberate changes in the structure and ownership of the electricity sector aimed at improving performance, efficiency and investment.
Electricity regulator	The agency in charge of monitoring the electricity sector.
Electrification	This is the process of connecting additional households, institutions and enterprises to the national grid.
Energy ministry/ department	The government body that provides policy directives with regard to the energy sector.
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Energy supply	Amount of energy available for use by the various sectors in a country.
Energy demand (millions toe)	The amount of modern energy required by various sectors of a country.
Energy production (million toe)	The amount of modern energy produced within the country.
Financial capability	Ability to raise financial resources required to establish an electricity generation/distribution enterprise.
Forced outage	The shutdown of a generating unit, transmission line, or other facility for emergency reasons or a condition in which the generating equipment is unavailable for load due to unanticipated breakdown.
Fossil fuel	An energy source formed in the earth's crust from decayed organic material e.g. petroleum, coal, and natural gas.

Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth. The fluids are extracted by drilling and/or pumping.
Greenfield power development	Development of new power projects.
Household	A group of people who share a common means of livelihood, such as meals regardless of source of income and family ties. Members who are temporarily absent are included and temporary visitors are excluded.
Independent power distributors (IPDs)	Privately-owned power companies that purchase electricity from the national grid or from other independent sources and distribute it to consumers for a profit.
Independent power producers (IPPs)	Privately-owned power companies that produce electricity and sell it for a profit to the national grid or to a distribution utility.
Interconnected system	An integrated electricity generation, transmission and distribution network.
Isolated/self-contained system	A stand-alone electricity generation, transmission and distribution network serving a confined part of a country or region.
Legal and regulatory framework (LRF)	Combination of the laws, institutions, rules and regulations governing the operations of the electricity industry.
Liberalization	The removal of restrictions on entry and exit of the electricity industry making it open to any prospective and interested players. Often implies reduced state intervention.
Licensing	The act of issuing licences allowing investors to operate legitimately within the electricity sector, usually as IPPs or IPDs.
Load limiter	A gadget that limits the maximum power demand and is designed to cut off power when the rated demand is exceeded.
Load shedding/power rationing	Scheduled electricity supply and interruptions when power demand exceeds supply.
Local participation	The involvement of local inhabitants of a country in the investment in private electricity generation/distribution enterprises.
Management capability	Having adequate skills to efficiently and profitably run an electricity generation/distribution enterprise.
Modern energy	Refers to high quality energy sources e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biofuels.

Management contract	The outsourcing of managerial functions of the utility to a private entity, with the government after remaining the owner of the assets.
Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100 kW but below 1 MW).
Multi-sector regulator	A regulatory agency which monitors the electricity sector and other sector(s), such as petroleum, water, telecommunications, etc.
National grid	The network of electricity transmission and distribution cables used in the conveyance of electricity within a country.
National utility	An entity which undertakes electricity generation, transmission and distribution nation-wide. It is usually wholly or partially state-owned.
Outage	See black out.
Open access	A regulatory mandate to allow others to use a utility's transmission and distribution facilities to move bulk power from one point to another on a non-discriminatory basis for a cost-based fee.
Parastatal	A Government body with its own management and powers to decide and implement investments in line with the parent ministry/department policy directives.
Performance-based appraisal	An evaluation approach that allows the regulator to reward the utility for meeting or surpassing the predetermined performance standards or penalizes it when the standards are not met.
Pilfers/Illegal connections	Consumers of electricity who use illegal means of connections and have no formal contract with the utility.
Population (millions)	The total number of people living within the borders of a country, whether citizens or not.
Primary energy	Energy sources in their crude or raw state before processing into a form suitable for use by consumers.
Privatization/asset sales	Involvement of private sector investment in a predominantly state-owned company, through the sale of part or all of the shares owned by the government.
Regulatory capture	Term used to describe a situation whereby the utility or private power companies control the regulatory agency either through heavy representation in the regulator's board or by being the sole financier.
Ring fencing	Defining the function of an entity in the electricity industry through legal and regulatory instruments.

Small and micro enterprises	An enterprise that generates income up to a certain predefined limit.
Small hydro	Small-scale power generating systems that harness the power of falling water (1-15 MW).
Small power producer (SPP)	This is a power producer according to the Public Utility Regulatory Policies Act (PURPA), who generates electricity using renewable energy (wood, waste, conventional hydroelectric, wind, solar and geothermal) as a primary energy source. Fossil fuels can be used, but renewable resources must provide at least 75 per cent of the total energy input.
Single sector regulator	A regulatory agency that monitors only the electricity sector.
Solar photovoltaic (PV) technologies	Devices that convert the sun's energy into electricity for use in lighting, refrigeration, telecommunications, etc.
Solar thermal technologies	Devices that use the sun as the primary source of energy for heat appliances, e.g. solar water heaters, solar dryers.
Southern African power pool (SAPP)	An integrated network of electricity transmission lines linking several eastern and southern African countries.
Steam turbine	A device that converts high-pressure steam, produced in a boiler, into mechanical energy that can then be used to produce electricity by forcing blades in a cylinder to rotate and turn a generator shaft.
Structural change	This is the process of unbundling vertically integrated utilities into separate generation, transmission and distribution companies. It also involves increasing the number of utilities in the country.
Tariff bands	The classification of electricity consumption into progressive clusters, e.g. 0-50 kWh; 51-100 kWh; 101-150 kWh, etc.
Tariff setting mechanism	A predetermined methodology adopted to arrive at electricity tariffs.
Tariff structure	The composition of the different elements that determine the tariff.
Technical capability	Having adequate skills to operate and maintain equipment used in a power utility.
Transparency (in licensing)	The extent to which the licensing authority appears to be open and fair in its review, approval and rejection of licence applications.
Tidal power	Energy obtained by using the motion of the tides to run water turbines that drive electric generators.
Unbundling	The process of breaking-up a vertically integrated public utility into either different entities of generation, transmission and distribution, or into regional companies within the country.

Utility	An entity partially or wholly involved in electricity generation, transmission, and/or distribution.
Vertically integrated utility	An entity that undertakes electricity generation, transmission and distribution.
Weir	A dam in a waterway over which water flows and that serves to raise the water level or to direct or regulate flow.

Case study 1.

POWER SECTOR REFORM IN ZIMBABWE

CONTENTS

1. INTRODUCTION

The power sector in Zimbabwe has been under reform since 1980 when the country became independent. At independence the country inherited a power sector comprising of six utilities—Central African Power Corporation (CAPC), a statutory corporation jointly owned by the Governments of Zimbabwe and Zambia and responsible for generation and transmission, Electricity Supply Commission (ESC), a statutory corporation owned by the Government of Zimbabwe responsible for transmission and distribution of electricity in the country except for the four largest cities of Harare, Bulawayo, Gweru and Mutare that had their own electricity departments responsible for transmission and distribution of power within the cities.

This institutional arrangement created a complex management structure for the power sector. The Ministry responsible for energy only had direct control over the ESC. It had to share control over CAPC with the Government of Zambia. The Minister responsible for local government was also involved in the management of the municipal electricity departments, in particular in the setting of electricity prices within the licensed areas for the cities. Further, although the ESC, Harare and Bulawayo owned coal-fired power stations, their operations were managed and paid for by the CAPC that then recovered its costs by selling the power to the three utilities.

In order to streamline the management of the power sector an Electricity Act (Chapter 13:05) was passed in 1985 that provided for the amalgamation of the six utilities into the Zimbabwe Electricity Supply Authority (ZESA). Although the creation of ZESA simplified the Government's administration of the power sector and facilitated the introduction of a uniform national tariff structure, reducing the number of tariff categories from over sixty to less than ten, the expected economies of scale and rapid expansion of supply did not immediately materialize. Instead the amalgamation process resulted in an exodus of managerial and technical skills leading to operational inefficiencies and financial losses, a slow down in the generation and transmission expansion programme and the virtual suspension of the rural electrification programme.

To address the post-amalgamation challenges, the Government adopted a new power sector reform strategy in 1991 as part of a World Bank-driven Economic Structural Adjustment Programme (ESAP). A two-pronged reform strategy was introduced—a performance improvement programme (PIP) and a review of the legal and regulatory framework (LRF). As reflected in the statistical highlights in the next section, the PIP was a major success in terms of turning around the operational and financial performance of the utility between 1991 and 2000. The LRF review progressed at a relatively slow pace with the new Electricity Act

(Chapter 13:19) and Rural Electrification Fund Act (Chapter 13:20) only being enacted in January 2002. Under the new acts, Zesa is at an advanced stage of being unbundled into a Rural Electrification Agency and separate companies for Generation (Zimbabwe Power Company, ZPC), Transmission (Zimbabwe Electricity Transmission Company, ZETCO), Distribution (Zimbabwe Electricity Distribution Company, ZEDC), Telecommunications (POWERTEL), and support services (Zesa Enterprises, ZE). A new regulatory body, the Zimbabwe Electricity Regulatory Commission, ZERC, was only established in June 2005 and is still to make a significant impact in the power sector.

2. BACKGROUND AND THE MAIN DESCRIPTION OF THE POWER SECTOR REFORM PROCESS

The legislation that governs the electricity supply industry in Zimbabwe is the Electricity Act (*Chapter 13:19*) and Rural Electrification Fund Act (*Chapter 13:20*) of 2002. The Electricity Act created the Zimbabwe Electricity Regulatory Commission (ZERC) and provided the legal framework for the on-going unbundling of the state-owned utility, the Zimbabwe Electricity Supply Authority (ZESA), into five companies responsible for generation, transmission, distribution, telecommunications and support services.

The Rural Electrification Fund Act created a Rural Electrification Agency that has the mandate for the total electrification of all rural areas. The main functions of the Agency are the planning of projects, raising and accounting of rural electrification funds and monitoring of project implementation.

2.1. Pre-masterplan electrification for the urban and rural poor since independence

At independence in 1980 the distribution and supply of electricity in Zimbabwe was the responsibility of the municipalities based in the four major cities of Harare, Bulawayo, Gweru and Mutare, with the Electricity Supply Commission (ESC) supplying and distributing in the rest of the country. At that time there was almost 100 per cent electrification of the areas where the white and black urban elite lived while the bulk of the poor black population had little or no access to electricity. This deficiency influenced the national energy policy of the Government to give priority to the electrification of the urban and rural poor.

It was relatively easier to connect the urban poor as most of their residential areas were close to the existing grid. Not many rural poor were in that fortunate position except those peasant-farming areas that were adjacent to electrified white commercial farms. Rural electrification also presented another major challenge because rural Zimbabweans do not live in compact villages but in scattered homesteads, where each family lives next to their farming plot. The cost of building a distribution network to serve such isolated homesteads was beyond the financial capability of the utility and the Government. Even if such capacity was there the income levels of the rural poor were too low for them to afford the electricity.

In an effort to accelerate rural electrification a new Electricity Act (*Chapter 13:05*) was enacted in 1985. This created the national utility, ZESA, from an amalgamation of the ESC and the municipal electricity departments. One of the principal objectives of creating ZESA was to increase financial resources for the electrification of the rural areas by enhancing the financial viability of the industry through the removal of duplication of functions among the utilities and improving efficiencies through economies of scale.

The problem of scattered homesteads was avoided by a Government decision to focus rural electrification on rural business or government administration centres that were designated as growth points. Tax and other incentives were given to promote investment at these points. The idea was to create nuclei of rural towns that would generate employment and reduce the drift to established urban areas. The growth points were also planned with provision for residential stands to cater for those who could afford to pay for household electricity.

2.2. Rural electrification masterplan

In 1993 ZESA adopted a performance improvement programme as part of the Government's macroeconomic structural adjustment programme. The programme was based on explicit performance contracts that the Government established for the utility and its board and executive management.

One of the major areas of performance improvement was the adoption of explicit economic and financial viability criteria in project selection. This approach had a profound impact on rural electrification that was suspended pending review of its financial and economic impact. The review concluded that priority needed to be given to the electrification of those rural centres that had potential for increased agricultural production and had a good road network for easy market access. Such centres would be able to quickly benefit by using electricity to increase agricultural productivity and for agro-processing industries. The resultant increase in income levels would then encourage the electrification of households. Using these criteria a rural electrification masterplan study was launched in 1994.

The study identified 415 rural service centres, business centres and growth points to be given priority attention for electrification. To finance the programme, the study recommended the introduction of a levy of 1 per cent of every customer's bill. The purpose of the levy was to provide capital subsidies only. As explained in more detail in the next section, consumption subsidies were to be provided by the utility through cross-subsidies.

Collection of the rural electrification (RE) levy started in 1996 and the rural electrification programme was relaunched in 1997. To get additional funds for the programme, a scheme was introduced for mobilizing community contributions. The masterplan was publicized so that communities would be able to plan ahead to raise funding for projects that would productively use electricity soon after the connection of a centre to the grid. To promote household electrification at centres already electrified, the RE levy was used to provide a 50 per cent to 60 per cent subsidy to villagers who could raise the balance of the capital costs for electrifying their households.

To ensure the financial sustainability of projects, the level of subsidies was established through financial and economic feasibility studies. The studies assumed that completed projects financed by the RE levy would be handed over to the distribution utility. The utility would then assume responsibility for operation and maintenance and establish tariff levels that ensured breakeven financial performance at a minimum.

The implementation of the masterplan study recommendations involved an extensive stakeholder consultation programme that included the potential beneficiaries as well as government and political leaders. These consultations confirmed the soundness of the strategy of focusing on grid extension for productive activities and to improve service delivery by rural health and educational institutions. Consultations also established that off-grid options such as PV were not popular especially with women because these installations did not lessen the domestic burden of fetching water and firewood.

The programme was a great success. In contrast to the pre-masterplan phase that failed to meet its target, the masterplan phase exceeded expectations. The response from the rural communities was so overwhelming that, within three years, the number of community initiated projects exceeded the number of masterplan projects. A total of 768 centres had been electrified by the beginning of 2001 compared to 415 centres that had been planned. In contrast the pre-masterplan phase completed the electrification of only 28 out of 48 growth points that had been planned.

Because of the overwhelming demand the utility's construction crews could not cope. It was therefore decided to hire private contractors. Many of the contractors were former utility employees who had taken early retirement as a consequence of the manpower rationalization undertaken as part of the performance improvement programme. Not only did this improve the project implementation rate but the competitive tendering also reduced construction costs by as much as 50 per cent. This was achieved by the bulk purchasing of materials by the utility and the contractors providing the labour, transport and construction equipment.

The success of the masterplan programme attracted a lot of political interest. Every Member of Parliament wanted an electrification project in their constituency before the next parliamentary elections scheduled for 2005. This interest had both positive and negative consequences. While the pace of rural electrification has increased significantly, this has been done at the expense of the financial viability of the utility.

3. IMPACT OF THE REFORM PROCESS

3.1. Impact on electrification access

The positive result of the increased political interest was the approval to increase the rural electrification levy from 1 per cent to 6 per cent, the enactment of the Rural Electrification Fund Act and establishment of a dedicated Rural Electrification Agency (REA) in 2002.

Electrification targets were raised. An expanded electrification programme was launched in which a total of 9,906 rural institutions, irrigation and village schemes were identified for electrification by the end of 2005. A unique feature of the expanded programme was the financing of both electricity and end-use infrastructure, mainly irrigation equipment, by the REA. Although the ambitious 2005 target was not achieved, the rate of connection of rural institutions has increased dramatically. As shown in table 2 below, by the end of June 2005 a total of 3,992 had been electrified.

Table 1. Electrified rural institutions as at 30 June 2005

Institution	Average installed capacity kVA	Total number completed	%
Business and government administration centres	100-200	901	22
Rural health centres	50	331	8
Primary schools	25	944	24
Secondary schools	50	589	15
Small farms/irrigation schemes	25-300	593	15
Villages/other schemes	10-300	634	16
TOTAL		3992	100

Source: Mangwengwende, 2005.

The positive impact on electrification access rates is evident in the statistics in table 2 below. The electrification access statistics are based on the proportion of the population who are connected to the grid. Surveys have established that the average number of people who benefit from each domestic connection is at least 10 to 12. This gives the number of people who have the benefit of an electricity connection. This figure is then expressed as a percentage of the population estimated from official census figures.

Table 2. Electrification access statistics

	Year													
	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Urban %	66	66	67	69	70	72	74	78	80	81	82	84	84	85
Rural %	10	11	11	12	12	12	14	16	17	18	20	22	23	25
National %	20	22	22	24	25	27	29	31	34	36	37	39	41	41

Source: Mangwengwende, 2005.

If account is taken of people who are not connected but have a direct and indirect benefit by living within 10 to 20 kilometres of an electrified centre, it is reasonable to assume that three quarters of the population are enjoying the benefits of grid electrification. For example, where electric motors have replaced diesel engines for grinding mills, the costs of milling maize that forms the staple diet have been reduced by 50 per cent. Rural health and educational institutions are now able to improve the quality and range of their services because they are able to attract and retain qualified staff.

3.2. Impact on financial performance

An indication of the financial performance of ZESA during the different electrification phases is given in table 3 and figure I below:

Table 3. Revenue, profit, debt collection and system losses

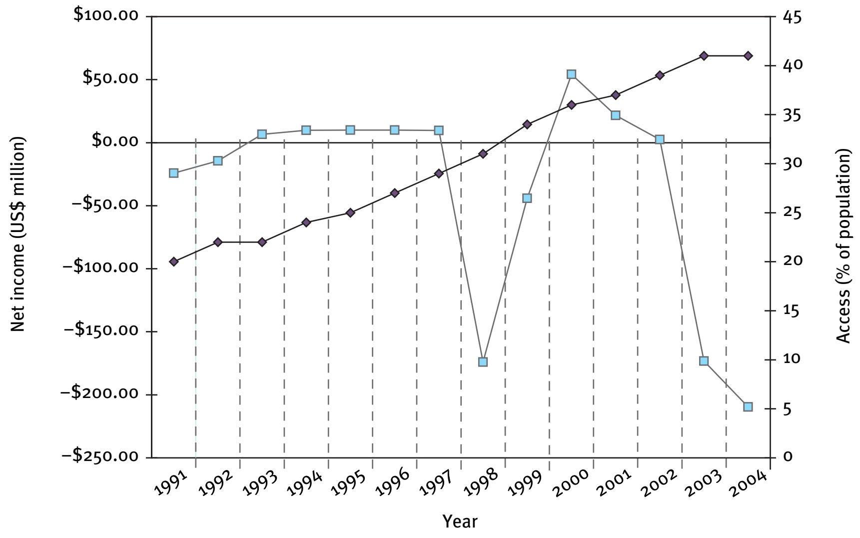
Year	Revenue ($US million)	Operating profit ($US million)	Net profit ($US million)	Debtors (days)	Losses %
1990	223.6	64.1	(0.8)	70	8.7
1991	184.9	62.6	(24.1)	74	10.7
1992	279.2	67.8	(14.5)	85	9.9
1993	305.7	101.8	6.7	99	11.0
1994	234.1	101.3	9.9	61	11.9
1995	265.2	104.3	10.0	50	10.7
1996	303.5	105.7	10.0	56	10.8
1997	331.7	100.3	9.6	32	10.8
1998	260.3	(2.0)	(174.1)	25	11.3
1999	230.9	40.4	(44.1)	32	12.8
2000	428.3	124.6	54.2	33	13.3
2001	521.1	120.8	33.0	39	14.6
2002	349.8	76.2	3.1	52	15.2
2003	178.4	(24)	(173)	52	N/A
2004	176.3	(25)	(210)	56	N/A

Source: Mangwengwende, 2005.

Note: $US equivalent based on official exchange rates. From 2002 to 2004 parallel rates have been used to give more realistic equivalent figures.

Figure 1 gives a clearer picture of the financial viability in terms of the net profit (purple line) and electrification access (blue line) as a percentage of the population living in houses connected to the grid. The graph shows a steady growth in access from 20 per cent in 1991 to 41 per cent in 2004. During the same period the financial performance has been mixed depending on the electrification phase. With the exception of one year the utility had positive operating profits until 2002. The operating profit represents the financial viability without taking account of how the utility is financed. Taking account of the utility's heavy debt financing, the net profit was negative in the early 1990s, in 1998 and 1999 and since 2003.

Figure I. Net profit *(light blue)* and electricity access *(purple)*



Source: Mangwengwende, 2005.

The pre-masterplan programme had limited success because the utility's profits were insufficient to meet the requirements. In addition, the projects targeted were selected on the basis of political decisions that did not take account of economic and financial viability. While some of the growth points grew rapidly following electrification, some failed to take off and were a heavy drain on the utility's finances.

The masterplan electrification phase was not only effective in increasing access but was also accompanied by the best financial performance of the utility. The net losses recorded in 1998 and 1999 were unrelated to the electrification programme but were due to the revaluation of the foreign currency denominated liabilities following the massive devaluation of the Zimbabwe dollar between November 1997 and early 2000. The adverse effects of the devaluation were reversed within 16 months through a series of quarterly tariff adjustments.

The positive trend in financial performance was reversed in 2002 when political pressure forced ZESA to incur heavy short-term debt to finance the expanded rural electrification programme. Many of the projects were also selected for political expediency rather than on economic and financial viability criteria as recommended in the masterplan. The cost of the expanded programme was estimated at Z$ 25 billion which was equivalent to $US 450 million at the official exchange rates at the time. Although there was a six-fold increase in the RE levy, the REA was still only able to raise about $US 18 to 30 million per year. The REA did not have the borrowing capacity to bridge the financing gap.

To go around this constraint the REA continued to operate as a subsidiary of the utility, which was then directed by Government to borrow on behalf of the REA. This was a contravention of the RE Fund Act which states that *"The Board (of the Fund) shall ensure that in any financial year expenditures and commitments from the Fund shall not exceed the annual income of the Fund"* (section 36). This provision was made to maintain the financial viability of the REA.

By the end of 2004 ZESA had borrowed more than Z$55 billion on the domestic market and $US110 million on the international market to finance the expanded rural electrification programme. These were all high interest short-term facilities with maturities ranging from 90 days to five years. Debt service on the loans exceeded the utility's capacity forcing Government to assume the responsibility of direct financial subsidies to keep the utility from bankruptcy.

4. ANALYSIS OF KEY SUCCESS/FAILURES

The rural electrification experience in Zimbabwe shows that electrification access is ultimately a pricing and financing problem. In summary, the success in balancing access and financial viability during the masterplan phase was achieved due to the following factors:

- Successful marketing of the project selection based on economic and financial criteria;
- Efficient revenue collection ensured that funds were available for rural electrification;
- Increased use of private contractors helped in reducing the cost of grid extension;
- Explicit capital subsidies for rural electrification supplemented by the mobilization of community contributions removed the burden of financing from the utility;
- Cross subsidies to support lifeline tariffs for the poor helped to encourage use of electricity as an energy source for the poor households.

The masterplan was an effective tool for depoliticizing the rural electrification programme. Publicizing the masterplan was an important strategy to prevent politically motivated changes in project priorities. A transparent queue-jumping mechanism through community contributions provided a way to harness political involvement in a constructive way.

The issue of affordability is so important that it requires further elaboration. The grid can be extended and connections made but the poor would still not have access if they were unable to afford to pay for a meaningful amount to make a difference to their lives. It is for this reason that cross subsidies have been used as an integral part of increasing access to the poor.

The creation of a national utility made it possible to adopt a uniform national electricity tariff. Consequently the urban customers subsidized the rural customers. Within the domestic tariff category an inverted block tariff was adopted to ensure that poor customers were subsidized by the richer customers, consumption bands being used to differentiate the rich from the poor.

The domestic tariff structure that has been used successfully for many years is illustrated in table 4.

Based on observed consumption patterns of the different groups this block structure is to be revised into three blocks of 0 to 250 kWh, 251 to 500 kWh and above 500 kWh. The lifeline amount of 50kWh is too small to justify the expense of a grid connection and 250 kWh is adequate to meet basic subsistence requirements for an average low-income household. The middle and upper classes have also been receiving an unnecessary subsidy and have not had sufficient incentives for energy conservation.

In order to encourage the poor to use electricity for cooking, low consumption domestic customers are subsidized by the industrial and commercial customers as well as the higher consumption domestic customers. The rationale for placing the subsidy burden on the industrial and commercial customers is the benefit that these customers derive from increased consumption of electricity by the poor. Their benefit from the increased sale of electrical appliances and demand for other electricity-related services far outweigh the cost of the consumption subsidy.

Table 4. Domestic tariff structure

Block of monthly consumption	Relative tariff level	Comment
First 50 kWh	1.000	Lifeline block for lighting and small power applications
51-300 kWh	1.125	Lighting, small power and basic heating (one to two plate stove). The bulk of the poor
301-1000 kWh	2.500	Single middle class home or several poor families sharing single connection
Above 1000 kWh	3.000	Single upper class home or several poor families sharing single connection

Source: Mangwengwende, 2005.

Note: All charges are in Zimbabwean dollar.

However the affordability levels of the customer groups carrying the subsidies place an upper limit on the level of sustainable subsidies. Each customer category has to bear a significant proportion of the cost of providing supply to the group. To sustain electrification access while avoiding the problem of electricity thefts and other non-technical losses, there is no alternative but to enhance the payment capability of the poor. In other words, electrification access has to be planned jointly with a poverty reduction programme.

Affordability can be defined in terms of the percentage of net income used to pay for a product or service. If 10 per cent of net income is taken as an upper limit for a household to afford electricity, it becomes easy to determine the income threshold for viable electrification access.

Using this affordability test in Zimbabwe there is no electrification of urban informal settlements. Rural households are only connected on the basis of affordability. By promoting the use of grid electricity on productive activities, income levels near electrified centres have been increasing to the point where the villagers are able to raise sufficient money to qualify for the 50 per cent to 60 per cent capital subsidy from the RE Fund.

5. LESSONS LEARNED

The key lessons that can be drawn from the electrification experience in Zimbabwe are:

- Electrification access levels for the poor can be increased without adversely affecting the financial performance of the electricity supply industry provided the necessary capital and consumption subsidies are financed in a sustainable manner.
- There is an income threshold level below which electrification for the poor does not make business sense. It is therefore necessary to use electrification access as a tool for poverty reduction in order to enhance affordability through an increase in income levels of the poor.
- Grid extension is the most cost-effective option for the simultaneous achievement of the multiple challenges of increasing electrification access, lessening the domestic burdens of women, reducing poverty through increased economic productivity and sustaining the financial viability of the electricity supply industry.
- Rural electrification is of immense political interest. This interest can have both positive and negative impacts on access and financial viability. Political support is essential in order to have the necessary policy, legal and institutional support for electrification. The major negative impact of politics is on financial viability. Explicit performance contracts based on a transparent strategic plan and performance improvement programme can be an effective tool to minimize adverse political interference.

6. RECOMMENDATIONS/THE WAY FORWARD

The following conclusions and recommendations can be drawn from the Zimbabwe power sector reform process:

- Given the critical role and importance of an independent regulatory body it was an error to establish the ZERC at the end instead of at the start of the reform process. The absence of the regulatory body has been the major reason for the major shortfalls in achieving reform objectives.
- Although it was possible to achieve significant performance improvements without privatization and independent regulation, such improvements were not sustainable as long as there was no protective legal and regulatory framework as well as a body to enforce the laws and regulations.
- Although the protection of the environment is now a legal requirement under the new Electricity Act, the absence of an independent regulatory body to enforce the law has kept this important issue in the background during the reform process.
- Provided there is efficient revenue collection, a small levy for rural electrification is a very effective financing mechanism for significantly increasing electricity access for the rural areas.

Case study 2.

ELECTRICITY REGULATION IN THE UNITED REPUBLIC OF TANZANIA: MOVING FROM GOVERNMENT REGULATION TO AN INDEPENDENT REGULATORY BODY

CONTENTS

1. ELECTRICITY TRANSMISSION AND DISTRIBUTION NETWORK

Electricity supply in the United Republic of Tanzania consists of both a national interconnected grid and isolated distribution systems. The electricity subsector is still dominated by the state-owned utility, Tanzania Electric Supply Company Ltd. (TANESCO).

TANESCO distribution network serves about 400,000 customers most of whom are supplied by the national grid.[1] As such, the electrification level is still marginal, leading to low per capita electricity consumption of about 84 kWh per year (2002). Extension of the distribution network is hampered by the historically poor financial performance of TANESCO partly in terms of unpaid bills, debt and interests accrued from long-term loans. Other reasons for the poor performance are reported to include weak management and operational performance. The insufficient delivery service of TANESCO is also characterized by high system losses, which are estimated to be in the order of 28 per cent.[2]

2. INSTITUTIONAL STRUCTURE OF THE ENERGY SECTOR

The Government of the United Republic of Tanzania through the Ministry of Energy and Minerals is the policymaker and regulator of electricity generation and distribution in the country. The Government utility, TANESCO, is responsible for about 70 per cent of electricity generation and owns about 98 per cent of Tanzania's distribution network.

TANESCO has a monopoly on the interconnected electricity transmission grid and therefore, all independent power producers (IPPs) have to sell their power under special power purchase agreements (PPAs) to TANESCO. Since there are no standard PPAs set out by the government, each agreement is usually concluded after prolonged negotiations.

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[1] Mwihava, 2005

[2] Ngeleja, 2003.

3. LEGAL AND REGULATORY FRAMEWORK

The Government's long-term plan (Vision 2025) and sectoral policies such as the National Environmental Policy (1997), the National Science and Technology Policy for Tanzania (1996), and the National Energy Policy (2003) widely support energy conservation and efficiency, and the use of locally available energy streams to meet the challenging development process. The Government now needs to go further by providing regulatory and appropriate standardization for achieving policy objectives.

For instance, the Energy Policy needs be put into operation by the provision of a regulatory framework. The government must also ensure mandatory compliance to energy conservation and efficiency, and ensure minimum renewable energy streams into commercial energy. This should be done by regulating the energy sector and by providing appropriate incentives.

The Government being the regulator and policymaker needs to implement these kinds of actions by creating an enabling environment and by empowering appropriate institutions. The ongoing reforms in the power sector of Tanzania are steps in the right direction.

4. POWER SECTOR REFORMS

Tanzania's power sector reforms are important in accelerating its capacity to meet the challenge of electrification. Rural electrification currently stands at 2 per cent, while urban electrification is at 37 per cent. The reforms are expected to bring about:

- Regulation and control;
- Modernization;
- Meeting energy conservation and efficiency policies, including the emerging environmental legislations;
- Addressing barriers to electrification and investments in the electricity sector.

In order to prepare TANESCO for privatization, in 2002 the Government approved an arrangement to contract M/S Net Group Solutions Limited to manage TANESCO. This South African company was contracted to undertake the top management of the power utility. The decision to have a management contract was prompted by the poor performance of TANESCO.

In the forthcoming reforms, the government will remain the owner and policymaker where as regulatory issues will be transferred to the Energy and Water Utilities Regulatory Authority (EWURA). EWURA was established by an Act of Parliament in 2003 and arrangements are under way to make it operational. Amongst others, the functions of EWURA will include the establishment of standards for goods and energy services and ensuring the efficiency of production and distribution of energy services.

TANESCO will be unbundled into separate segments responsible for power generation, transmission and distribution (Mwihava and Mbise, 2003). Generation and distribution activities will further be divided into a number of companies to allow private sector participation in a competitive manner. Besides competitiveness in the energy sector, the reforms in the corporate structure of TANESCO are expected to promote energy conservation and energy efficiency and to attract the utilization of alternative energy streams.

5. THE WAY FORWARD

The following are therefore some recommendations for improving the country's energy demand and supply, which take on board sustainable energy issues:

- Remove monopoly in the electricity sector by privatizing the national utility, TANESCO;
- Energy policy and power systems master plans should promote IPPs by creating appropriate incentives (such as low interest loans) for achieving specific mandates for renewable energy streams to the commercial energy sector;
- Institute more regulation to the power sector by enabling the functions and activities of relevant authorities such as EWURA;
- Increase capacity-building programmes to decision-makers and technical personnel in the power sector;
- Demonstrate further the advantages of energy conservation and efficiency by utilizing proven techniques and technologies. This should also include publicity and awareness programmes;
- Institute energy efficiency standards including energy star programmes and building code standards.

Case study 3.

POWER SECTOR REFORM AND REGULATORY INSTITUTIONS OF GHANA

CONTENTS

1. INTRODUCTION

The power sector reforms in Ghana were driven by a shortage of financing for much-needed capacity expansion in 1995. Sector reform was a condition of the World Bank lending for new electricity generation capacity. Since then, the reform has been extended to other subsectors in energy including petroleum.

2. ELECTRICITY REFORM PROGRAMME

The main objectives of Ghana's electricity reform programme are as follows:

- Ensuring proper policies and incentives to expand electricity access to spur growth, improve productivity, service delivery and the quality of life, and institute programmes to enhance energy efficiency;
- Regulating the sector to make each part of the sector operate with economic efficiency;
- Delivering electricity and electricity-related services to customers in an efficient and cost effective manner, while ensuring the sector's financial viability;
- Harnessing Ghana's as well as the region's rich energy resources for development and making the necessary policy and institutional changes to pass on the economic benefits equitably to the people of Ghana;
- Increasing efficiency of asset utilization and thereby determining a realistic level of investments needed to meet energy demand created by growth.

3. STATUS OF IMPLEMENTATION OF REFORM

Under the first round of sector reforms initiated in 1995, initiatives implemented include: Enactment of the Public Utilities Regulatory Commission (PURC) Act of 1997 (Act 538) and Energy Commission (EC) Act of 1997 (Act 541).

The PURC vets and approves tariff proposals from the utilities and develops consumer protection guidelines. The PURC has effected several tariff adjustments resulting in cost-reflective tariffs. In addition, an automatic price adjustment mechanism to effect quarterly adjustments for changes in foreign exchange fluctuations was introduced in 2003.

The EC's mandate is to put in place several pieces of subsidiary legislation ("Legislative Instruments") that are the key to more transparent regulation of the electricity supply industry. These include the “Technical and Operational Rules for Delivery of Electricity Services” and the “Electricity Supply (Standards of Performance) Rules” for the distribution segment. After extensive consultation with stakeholders, the EC expects to shortly complete drafting the “Technical and Operational Rules for the National Interconnected System” on “Wholesale Power Supply Market Rules”.

In 1998, the Electricity Corporation of Ghana was converted into a limited liability company, Electricity Company of Ghana Limited (ECG) under the Statutory Corporations (Conversions to Companies) Act 461 of 1993. Subsequently now, it is proposed to unbundle the Northern Electrification Department (NED), the distribution business unit of the Volta River Authority (VRA) and merge it with ECG to create one distribution company.

In 1998, the Government issued policy directives requiring VRA to functionally unbundle and transfer national transmission and load dispatch assets to an Electricity Transmission Utility (ETU). As an initial step towards compliance, VRA registered (in 1999) a wholly owned subsidiary company—the National Grid Company Ltd. (GRIDCO) and commissioned a number of studies to facilitate the functional unbundling of the ETU from its other generation and distribution business units, including: *(a)* a Transmission System Pricing Study; *(b)* a Transmission System Expansion Plan; and *(c)* a Transmission Assets Valuation Study. The above notwithstanding, the Government has recently decided to completely separate the ETU from VRA.

In September 2005, parliament passed the VRA Act Amendment Bill which effectively amended the VRA Act (Act 46), paving the way for the formal separation of the generation and transmission functions of VRA.

The “Status of Implementation of Ghana Power Sector Reform Programme,” a paper dated June 9, 2004, issued by the Ministry of Energy, states that the following actions were ongoing or were intended to be completed shortly:

- Establishment and operation of a Power Sector Reform Implementation Secretariat.
- Preparation of legislative instruments to underpin the corporate unbundling of VRA to create an autonomous state-owned electricity transmission utility and a joint venture thermal power generation company while retaining (through a new VRA Act) the reservoir management and hydropower generation functions in the streamlined VRA Hydro.
- Establishment of an autonomous state-owned entity to which the EC can grant the ETU licence, following notification by the Minister of the legislative instrument that empowers the ETU to take over from VRA all system operation and dispatch functions. Until such time that the Energy Commission completes the preparation, approval and notification of the “Technical and Operational Rules of Practice for the National Interconnected System”, the Government has

decided that VRA would continue to be responsible for the safe, reliable, economic dispatch of grid operations.

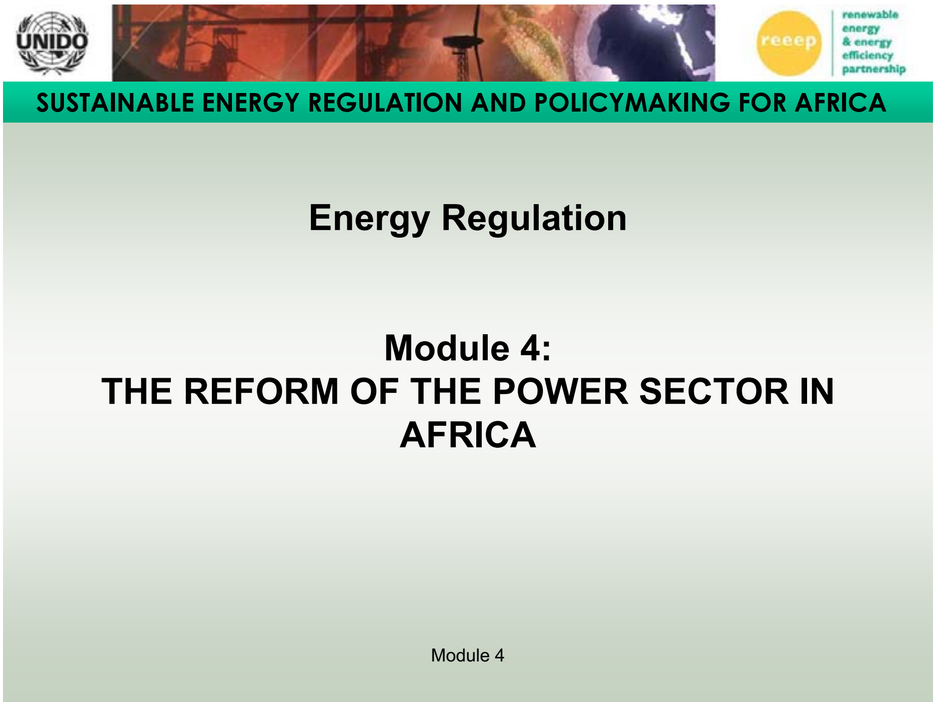
- Implementation of a proposed Aboadze Thermal Power Joint Venture: to complete development of the Takoradi Thermal Power Complex (consisting of T1 and T2). The Government plans to assign CMS Energy as the T1 plant operator under a performance based contract. VRA, however, believes that the selection of a plant operator for T1 should be made based on an international competitive bidding process and has indicated this to the Government.
- Merger of NED into ECG to form a single distribution company (the consolidated ECG"), and implementation of a performance-based "management support services agreement" as a means to improve financial management, commercial and technical operations at ECG.
- Parliamentary ratification of the full complement of EC legislation instruments to underpin EC technical regulation functions, especially technical and operational rules for the national interconnected system, and standards of performance for delivery of electricity supply services.

As can be deduced from the above and as per the government paper cited in the previous paragraph, several actions under the reform programme have been completed. These include the establishment of the Reform Secretariat and activation of various committees to lead the respective initiatives on restructuring, determination of joint venture arrangements; the amendment of Act 46, engagement of a consultant to carry out asset revaluation as a prelude to the separation of the books of accounts for the newly restructured companies; and the implementation of a performance-based contract to put in place the proposed management services provider for the consolidated ECG.

In addition, the Government has initiated actions on preparing a comprehensive public education and awareness strategy and the Energy Commission is working towards notification of a series of legislative instruments to prescribe technical and operational rules for the national interconnected system ("Wholesale Power Supply Market Rules").

The Energy Commission has already developed the Licensing Manual for the Electricity Sector. The electricity supply and distribution ("Electricity Distribution Rules"), which has been laid down in parliament, will attain the mandatory 21 parliament sitting days becoming law when parliament resumes sitting in mid January 2006.

Action has also been taken towards restructuring and cleaning up the VRA and ECG balance sheets, including debt restructuring to settle all payables/receivables among government entities and reduce some of the debt burden of these companies. Debt relief to the extent of $US 144.9 million equivalent of debt/government receivables for VRA and $US 95.06 million equivalent for ECG has been provided.

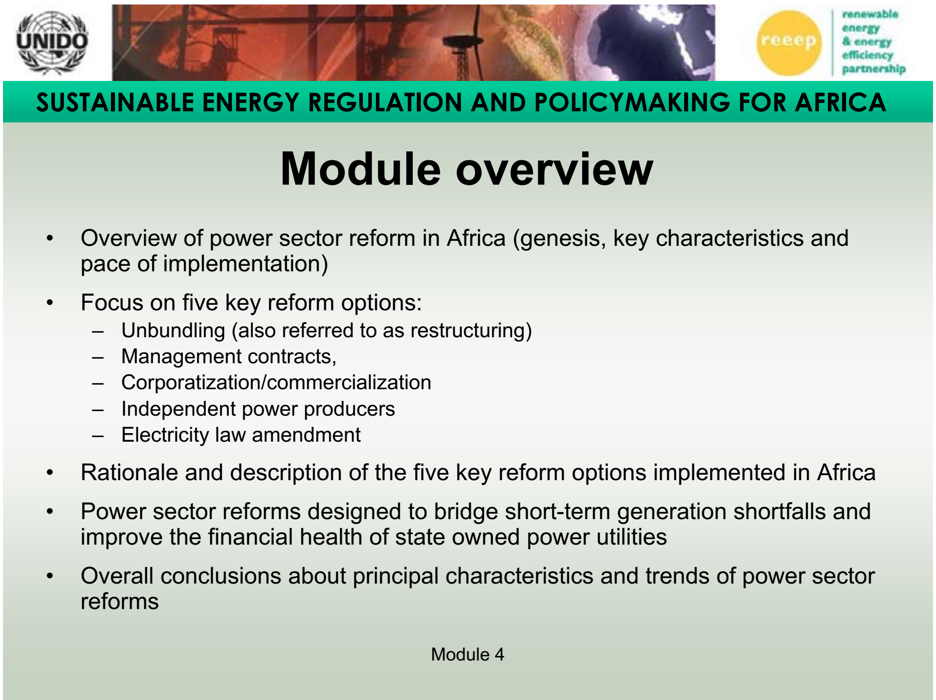


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Regulation

Module 4:
THE REFORM OF THE POWER SECTOR IN AFRICA

Module 4

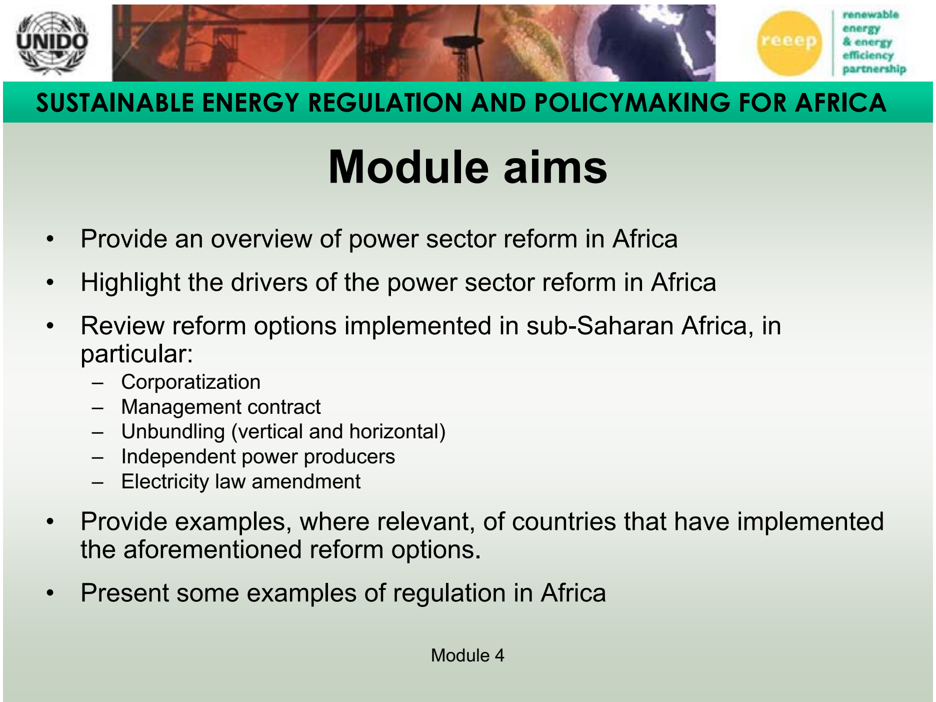


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Overview of power sector reform in Africa (genesis, key characteristics and pace of implementation)
- Focus on five key reform options:
  - Unbundling (also referred to as restructuring)
  - Management contracts,
  - Corporatization/commercialization
  - Independent power producers
  - Electricity law amendment
- Rationale and description of the five key reform options implemented in Africa
- Power sector reforms designed to bridge short-term generation shortfalls and improve the financial health of state owned power utilities
- Overall conclusions about principal characteristics and trends of power sector reforms

Module 4

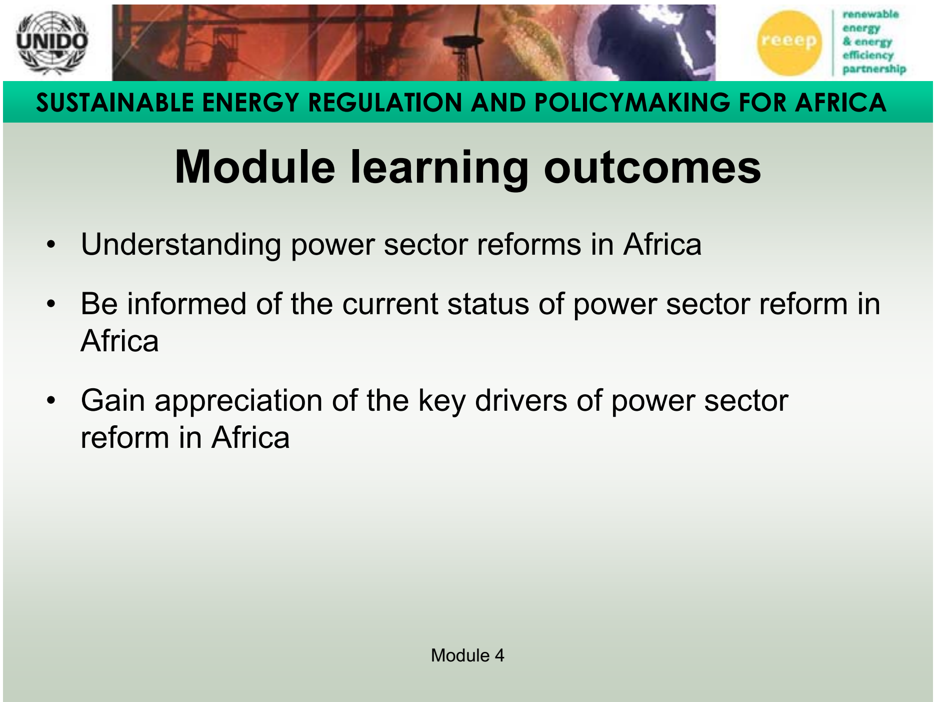


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Provide an overview of power sector reform in Africa
- Highlight the drivers of the power sector reform in Africa
- Review reform options implemented in sub-Saharan Africa, in particular:
  - Corporatization
  - Management contract
  - Unbundling (vertical and horizontal)
  - Independent power producers
  - Electricity law amendment
- Provide examples, where relevant, of countries that have implemented the aforementioned reform options.
- Present some examples of regulation in Africa

Module 4

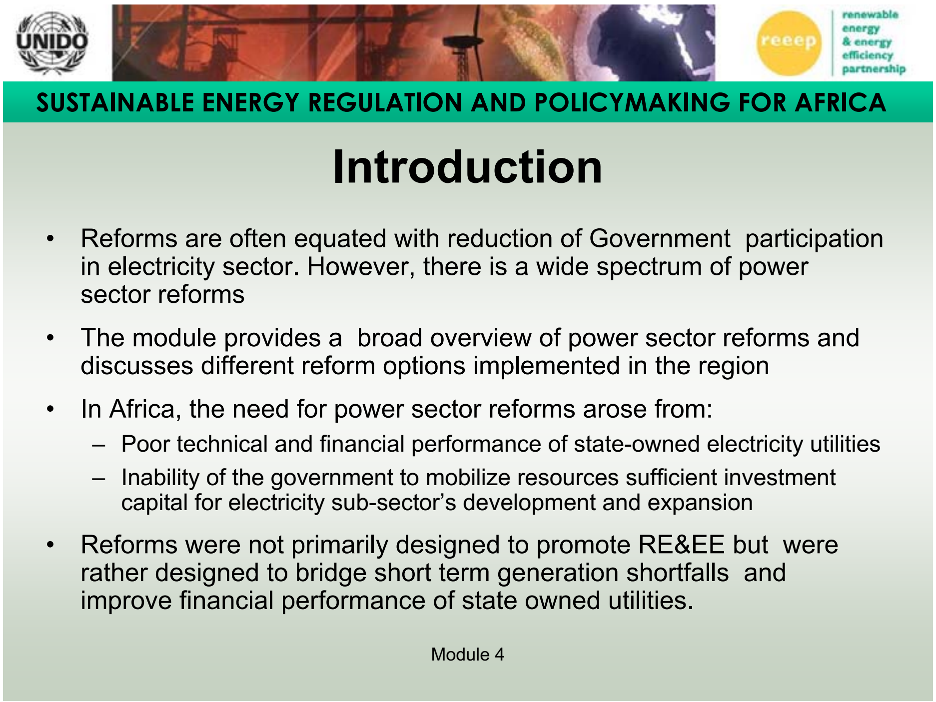


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Understanding power sector reforms in Africa
- Be informed of the current status of power sector reform in Africa
- Gain appreciation of the key drivers of power sector reform in Africa

Module 4



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

- Reforms are often equated with reduction of Government participation in electricity sector. However, there is a wide spectrum of power sector reforms
- The module provides a broad overview of power sector reforms and discusses different reform options implemented in the region
- In Africa, the need for power sector reforms arose from:
  - Poor technical and financial performance of state-owned electricity utilities
  - Inability of the government to mobilize resources sufficient investment capital for electricity sub-sector's development and expansion
- Reforms were not primarily designed to promote RE&EE but were rather designed to bridge short term generation shortfalls and improve financial performance of state owned utilities.

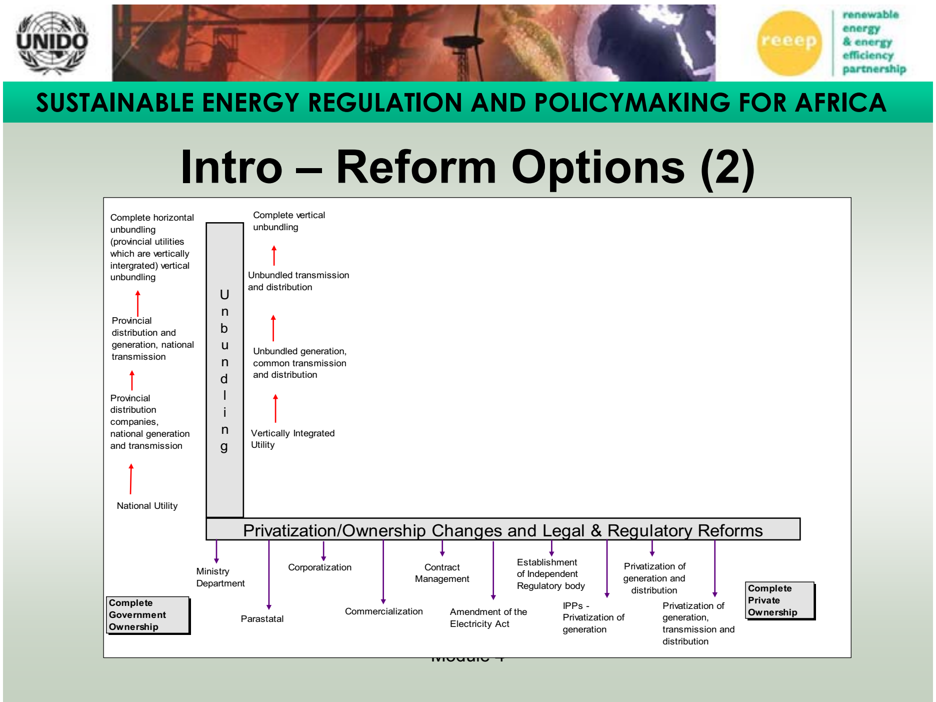
Module 4

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Intro – Reform Options

- Five major reform options implemented in Africa have been selected. They include:
  - Unbundling, also referred to as restructuring
  - Management contracts
  - Corporatization/commercialization
  - Independent power producers (IPPs)
  - Electricity law amendment.
- The rationale for the selection of the aforementioned reform options is:
  - They are common and have been widely implemented in Africa
  - They appear to have the most significant impact on RE&EE in the region.

Module 4



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Intro – Reform Options (2)

Complete horizontal unbundling (provincial utilities which are vertically intergrated) vertical unbundling

Provincial distribution and generation, national transmission

Provincial distribution companies, national generation and transmission

National Utility

Unbundling

Complete vertical unbundling

Unbundled transmission and distribution

Unbundled generation, common transmission and distribution

Vertically Integrated Utility

Privatization/Ownership Changes and Legal & Regulatory Reforms

Complete Government Ownership

Ministry Department

Parastatal

Corporatization

Commercialization

Contract Management

Amendment of the Electricity Act

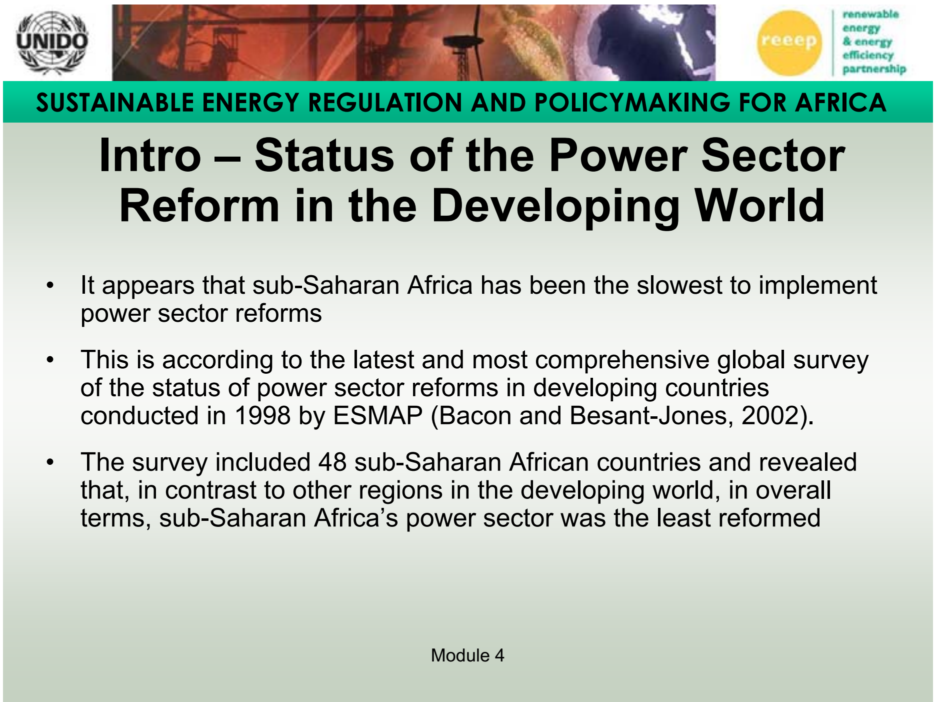
Establishment of Independent Regulatory body

IPPs - Privatization of generation

Privatization of generation and distribution

Privatization of generation, transmission and distribution

Complete Private Ownership

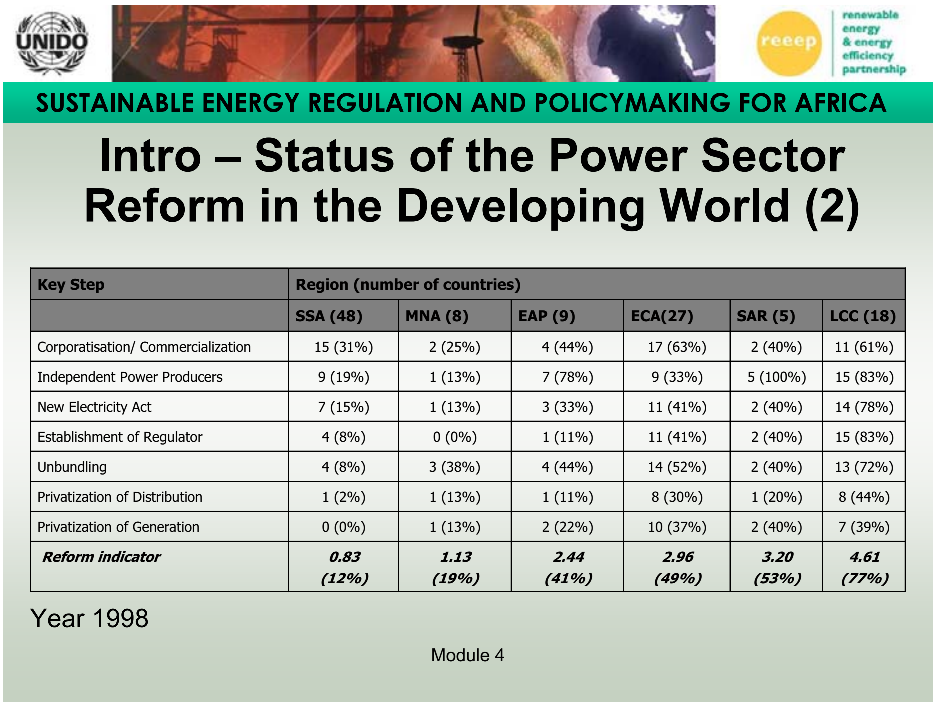


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Intro – Status of the Power Sector Reform in the Developing World

- It appears that sub-Saharan Africa has been the slowest to implement power sector reforms
- This is according to the latest and most comprehensive global survey of the status of power sector reforms in developing countries conducted in 1998 by ESMAP (Bacon and Besant-Jones, 2002).
- The survey included 48 sub-Saharan African countries and revealed that, in contrast to other regions in the developing world, in overall terms, sub-Saharan Africa's power sector was the least reformed

Module 4



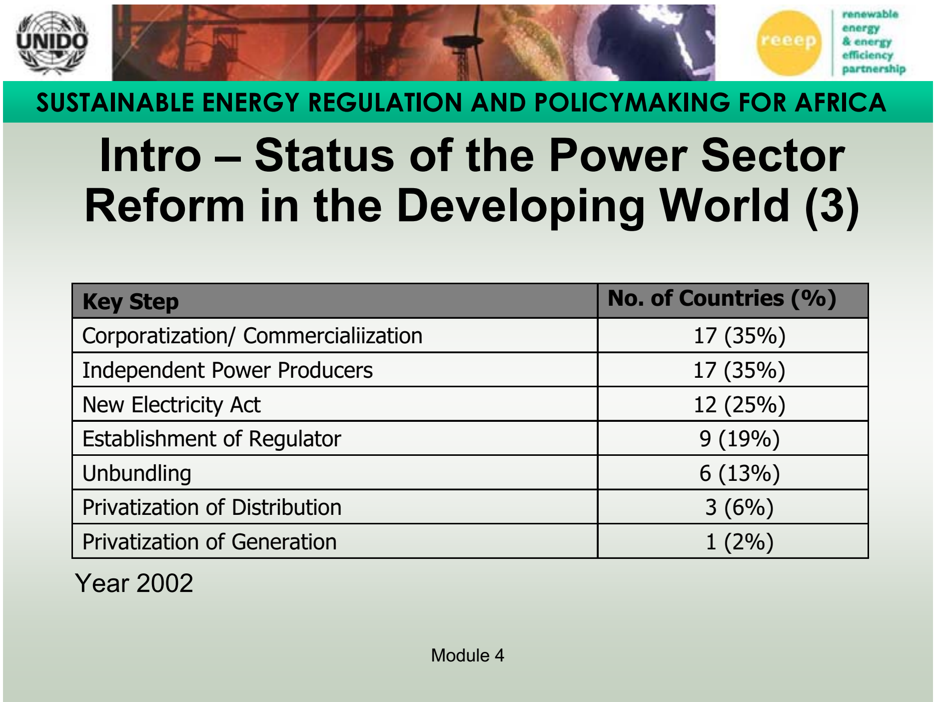
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Intro – Status of the Power Sector Reform in the Developing World (2)

Key Step	Region (number of countries)					
	SSA (48)	**MNA (8)**	**EAP (9)**	**ECA(27)**	**SAR (5)**	**LCC (18)**
Corporatisation/ Commercialization	15 (31%)	2 (25%)	4 (44%)	17 (63%)	2 (40%)	11 (61%)
Independent Power Producers	9 (19%)	1 (13%)	7 (78%)	9 (33%)	5 (100%)	15 (83%)
New Electricity Act	7 (15%)	1 (13%)	3 (33%)	11 (41%)	2 (40%)	14 (78%)
Establishment of Regulator	4 (8%)	0 (0%)	1 (11%)	11 (41%)	2 (40%)	15 (83%)
Unbundling	4 (8%)	3 (38%)	4 (44%)	14 (52%)	2 (40%)	13 (72%)
Privatization of Distribution	1 (2%)	1 (13%)	1 (11%)	8 (30%)	1 (20%)	8 (44%)
Privatization of Generation	0 (0%)	1 (13%)	2 (22%)	10 (37%)	2 (40%)	7 (39%)
Reform indicator	***0.83 (12%)***	***1.13 (19%)***	***2.44 (41%)***	***2.96 (49%)***	***3.20 (53%)***	***4.61 (77%)***

Year 1998

Module 4



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Intro – Status of the Power Sector Reform in the Developing World (3)

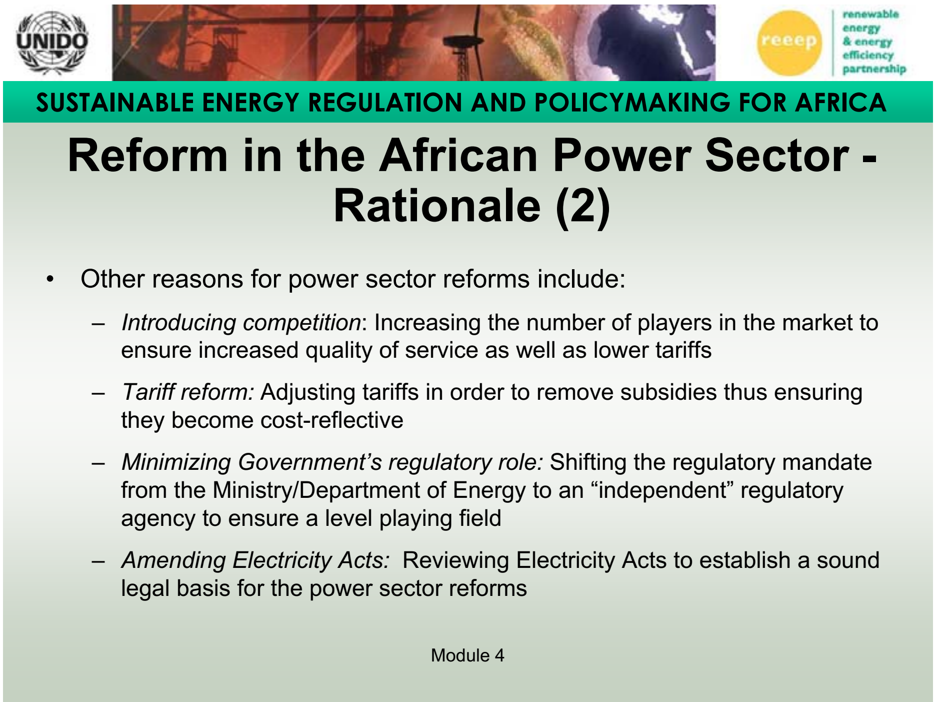
Key Step	No. of Countries (%)
Corporatization/ Commercialiization	17 (35%)
Independent Power Producers	17 (35%)
New Electricity Act	12 (25%)
Establishment of Regulator	9 (19%)
Unbundling	6 (13%)
Privatization of Distribution	3 (6%)
Privatization of Generation	1 (2%)

Year 2002

Module 4

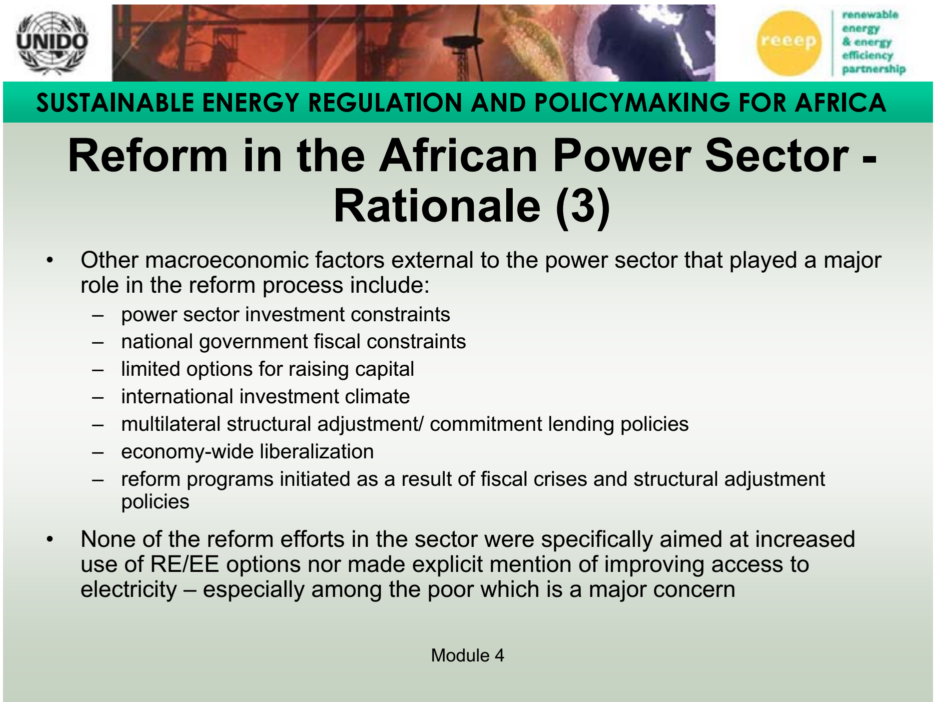
Reform in the African Power Sector - Rationale

- Comprehensive power sector reform arose from two primary concerns:
  - the dissatisfaction over the poor technical, financial, and managerial performance of the state-owned electricity utilities
  - the inability of utilities and the Government to mobilize sufficient investment capital for the electricity subsector's development and expansion



Reform in the African Power Sector - Rationale (2)

- Other reasons for power sector reforms include:
  - *Introducing competition*: Increasing the number of players in the market to ensure increased quality of service as well as lower tariffs
  - *Tariff reform:* Adjusting tariffs in order to remove subsidies thus ensuring they become cost-reflective
  - *Minimizing Government's regulatory role:* Shifting the regulatory mandate from the Ministry/Department of Energy to an "independent" regulatory agency to ensure a level playing field
  - *Amending Electricity Acts:* Reviewing Electricity Acts to establish a sound legal basis for the power sector reforms



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector - Rationale (3)

- Other macroeconomic factors external to the power sector that played a major role in the reform process include:
  - power sector investment constraints
  - national government fiscal constraints
  - limited options for raising capital
  - international investment climate
  - multilateral structural adjustment/ commitment lending policies
  - economy-wide liberalization
  - reform programs initiated as a result of fiscal crises and structural adjustment policies
- None of the reform efforts in the sector were specifically aimed at increased use of RE/EE options nor made explicit mention of improving access to electricity – especially among the poor which is a major concern

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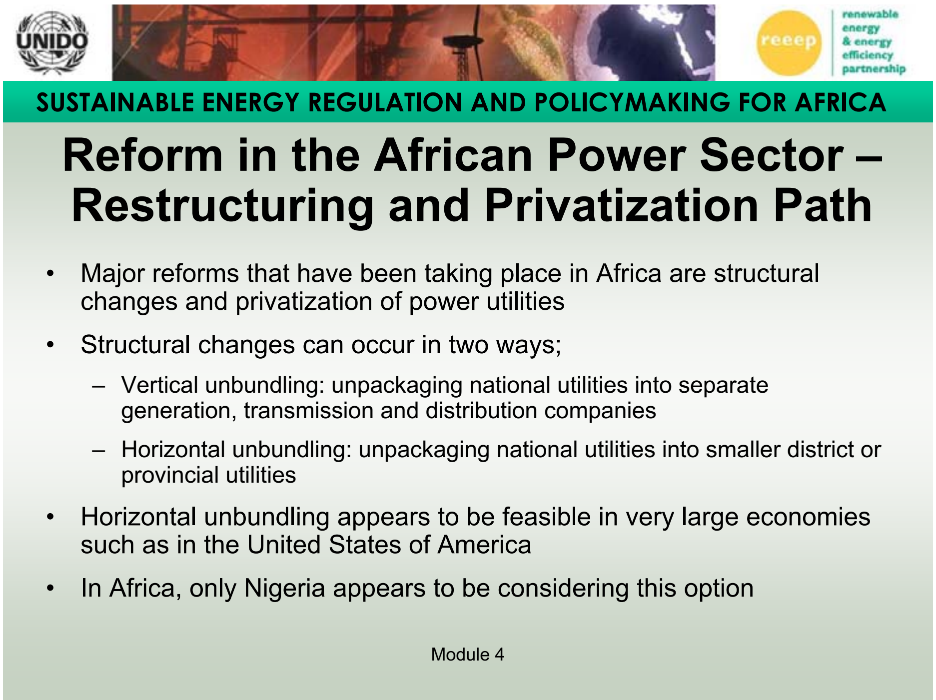

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Restructuring and Privatization Path

- Major reforms that have been taking place in Africa are structural changes and privatization of power utilities
- Structural changes can occur in two ways;
  - Vertical unbundling: unpackaging national utilities into separate generation, transmission and distribution companies
  - Horizontal unbundling: unpackaging national utilities into smaller district or provincial utilities
- Horizontal unbundling appears to be feasible in very large economies such as in the United States of America
- In Africa, only Nigeria appears to be considering this option

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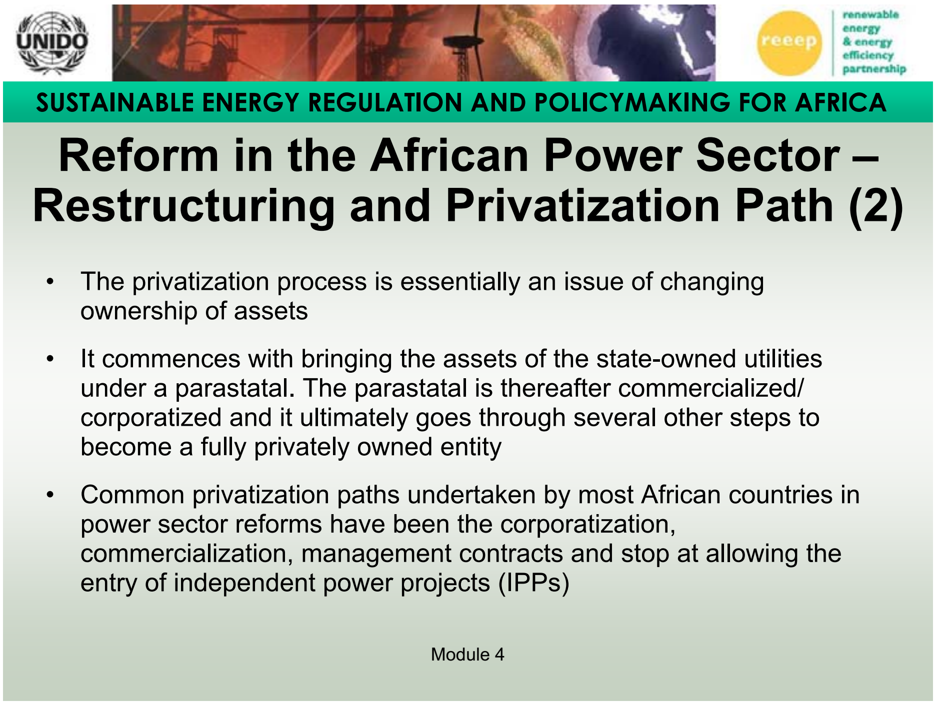

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Restructuring and Privatization Path (2)

- The privatization process is essentially an issue of changing ownership of assets
- It commences with bringing the assets of the state-owned utilities under a parastatal. The parastatal is thereafter commercialized/ corporatized and it ultimately goes through several other steps to become a fully privately owned entity
- Common privatization paths undertaken by most African countries in power sector reforms have been the corporatization, commercialization, management contracts and stop at allowing the entry of independent power projects (IPPs)

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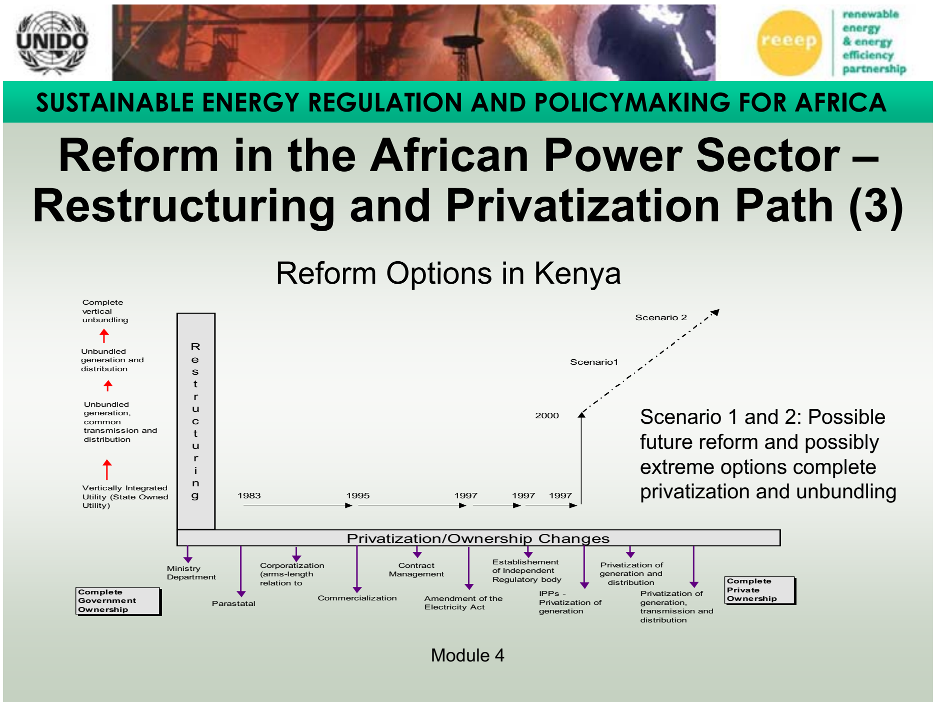

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Restructuring and Privatization Path (3)

Reform Options in Kenya

Scenario 1 and 2: Possible future reform and possibly extreme options complete privatization and unbundling

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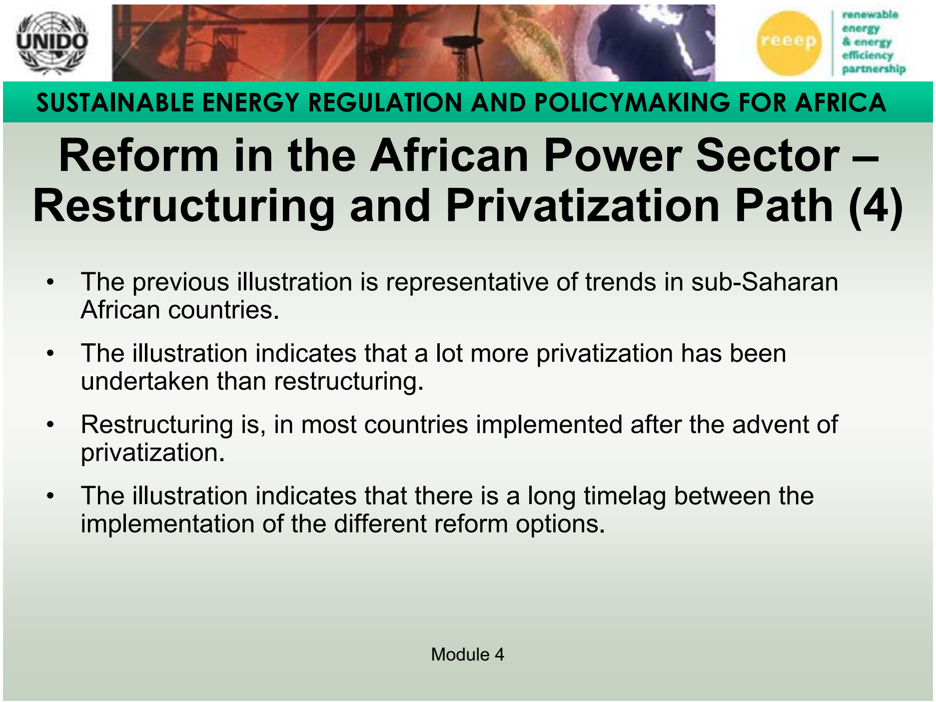

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Restructuring and Privatization Path (4)

- The previous illustration is representative of trends in sub-Saharan African countries.
- The illustration indicates that a lot more privatization has been undertaken than restructuring.
- Restructuring is, in most countries implemented after the advent of privatization.
- The illustration indicates that there is a long timelag between the implementation of the different reform options.

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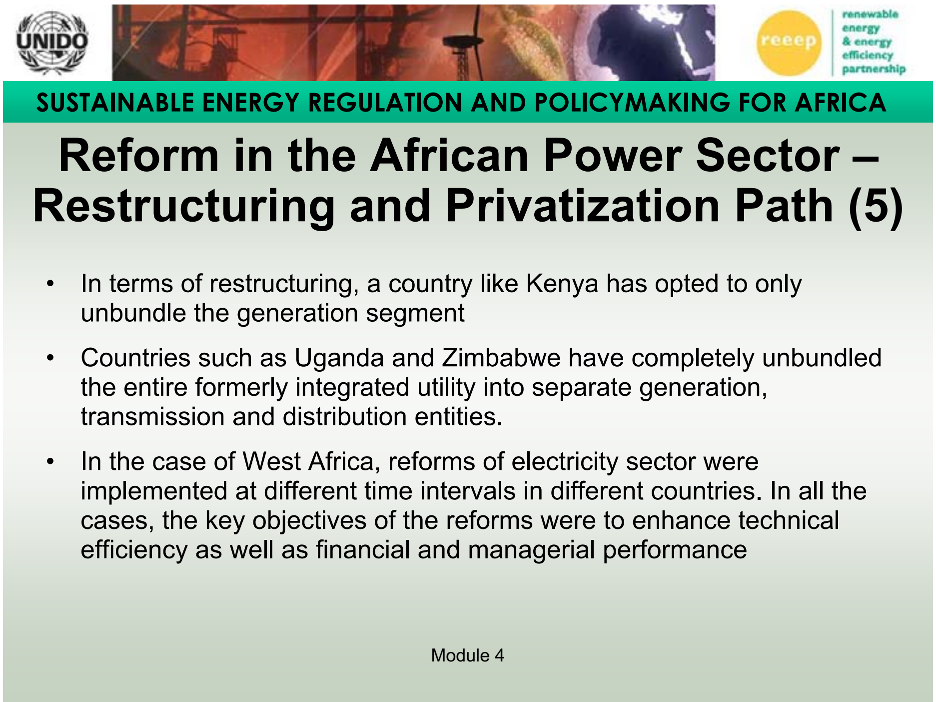

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Restructuring and Privatization Path (5)

- In terms of restructuring, a country like Kenya has opted to only unbundle the generation segment
- Countries such as Uganda and Zimbabwe have completely unbundled the entire formerly integrated utility into separate generation, transmission and distribution entities.
- In the case of West Africa, reforms of electricity sector were implemented at different time intervals in different countries. In all the cases, the key objectives of the reforms were to enhance technical efficiency as well as financial and managerial performance

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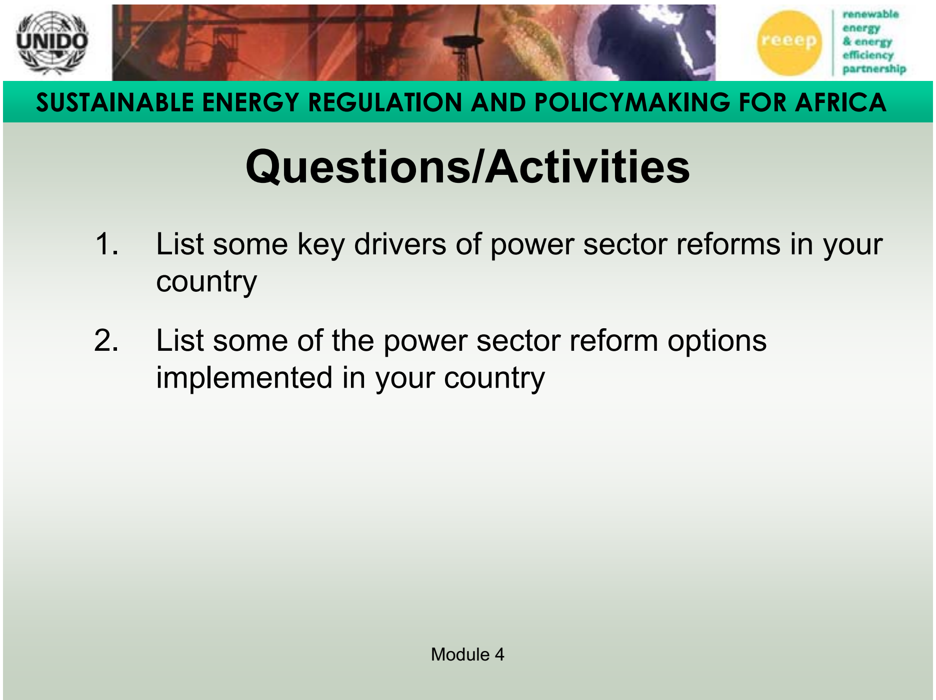
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reform in the African Power Sector – Status

- Senegal and Mali utilities have reverted back to state ownership from privatization. Important lessons that can be drawn from these developments are:
  - Privatization of the distribution appears to be more difficult to implement than privatization at generation
  - For well performing utilities such as those in Zimbabwe, Mauritius and South Africa, it can be concluded that privatization appears not to be the ultimate solution for sustained good performance of the utility



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

1. List some key drivers of power sector reforms in your country
2. List some of the power sector reform options implemented in your country

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options - Corporatization

- Corporatization (commercialization) appears to be the first reform option executed in most African countries as the utilities in most countries have implemented the option
- The key objective of this option is to ensure that the utility runs its operations based on the business principle of profit-maximization
- Power sector reforms, involving corporatization/commercialization of the power utilities, have significantly improved the financial performance of the state-owned utilities
- Some of the principal sub-objectives of corporatization include:
  - Separating utility from the ministry
  - Creating clear accounting framework
  - Cost recovery in pricing
  - Reducing or eliminating subsidies
  - Enforcing revenue collection

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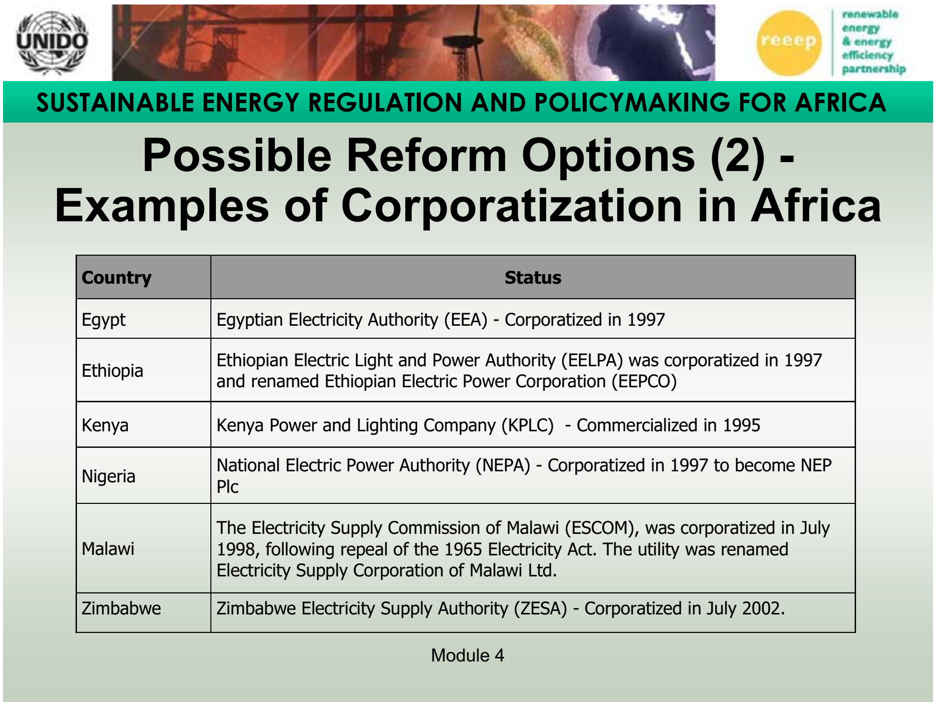

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (2) - Examples of Corporatization in Africa

Country	Status
Egypt	Egyptian Electricity Authority (EEA) - Corporatized in 1997
Ethiopia	Ethiopian Electric Light and Power Authority (EELPA) was corporatized in 1997 and renamed Ethiopian Electric Power Corporation (EEPCO)
Kenya	Kenya Power and Lighting Company (KPLC) - Commercialized in 1995
Nigeria	National Electric Power Authority (NEPA) - Corporatized in 1997 to become NEP Plc
Malawi	The Electricity Supply Commission of Malawi (ESCOM), was corporatized in July 1998, following repeal of the 1965 Electricity Act. The utility was renamed Electricity Supply Corporation of Malawi Ltd.
Zimbabwe	Zimbabwe Electricity Supply Authority (ZESA) - Corporatized in July 2002.

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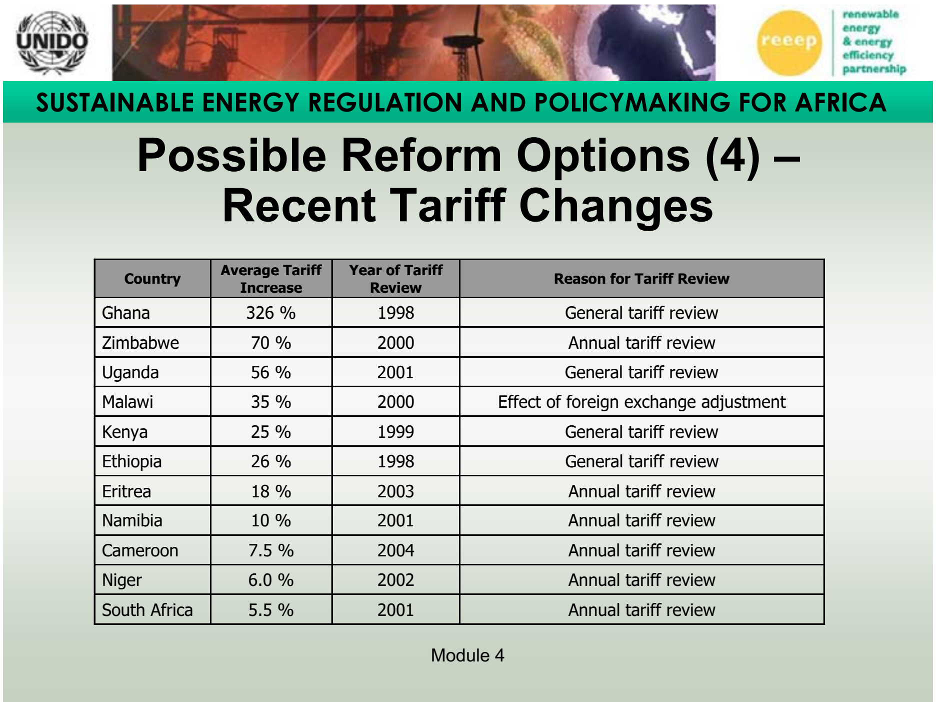
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (3) - Corporatization and Tariff Reform

- Corporatization appears to go hand-in-hand with tariff reforms
- Prior to the advent of power sector reforms, electricity tariffs were approved and, in some cases, determined by Government
- Provision of electricity was perceived as a social welfare service rather than a commercial service
- Governments strived to ensure that electricity was affordable to all by keeping the tariffs low and, to a large extent, subsidized
- Corporatization has led to, among other developments, increases in the tariff levels in line with the following objectives:
  - To recover the cost of electricity generation, transmission and distribution
  - To fairly and equitably spread the above costs to consumers based on the true cost of service delivery, consumption levels and patterns, and affordability to pay
  - To promote the efficient use of electricity



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (4) – Recent Tariff Changes

Country	Average Tariff Increase	Year of Tariff Review	Reason for Tariff Review
Ghana	326 %	1998	General tariff review
Zimbabwe	70 %	2000	Annual tariff review
Uganda	56 %	2001	General tariff review
Malawi	35 %	2000	Effect of foreign exchange adjustment
Kenya	25 %	1999	General tariff review
Ethiopia	26 %	1998	General tariff review
Eritrea	18 %	2003	Annual tariff review
Namibia	10 %	2001	Annual tariff review
Cameroon	7.5 %	2004	Annual tariff review
Niger	6.0 %	2002	Annual tariff review
South Africa	5.5 %	2001	Annual tariff review

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (5) – Management Contract

- This describes a situation where the operational management of the utility, or part of it, is contracted out to a management consulting firm while investment decision-making and assets ownership remain under the utility or the government
- A management contract, to a large extent, is usually part of the wider commercialization process
- Management contracts are increasingly becoming a common feature in state-owned power utilities, particularly in West African countries
- A number of countries have attempted to introduce management contracts to improve efficiency and profitability of their utilities
- Countries in the study that have incorporated this option include Uganda, United Rep. of Tanzania, Ghana, Malawi, Guinea Bissau, Morocco and Togo

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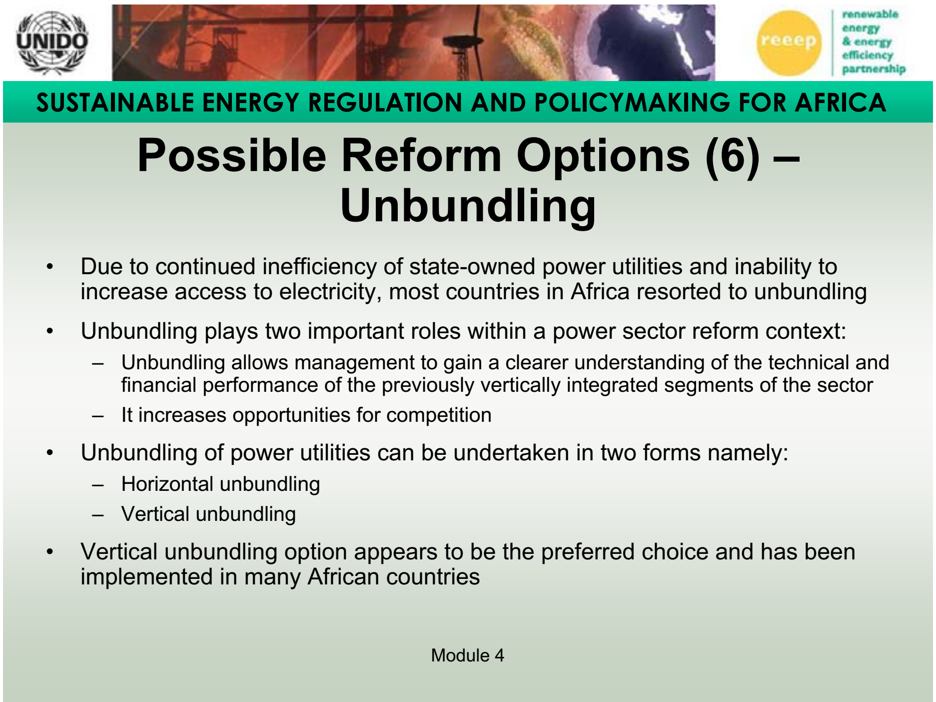

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (6) – Unbundling

- Due to continued inefficiency of state-owned power utilities and inability to increase access to electricity, most countries in Africa resorted to unbundling
- Unbundling plays two important roles within a power sector reform context:
  - Unbundling allows management to gain a clearer understanding of the technical and financial performance of the previously vertically integrated segments of the sector
  - It increases opportunities for competition
- Unbundling of power utilities can be undertaken in two forms namely:
  - Horizontal unbundling
  - Vertical unbundling
- Vertical unbundling option appears to be the preferred choice and has been implemented in many African countries

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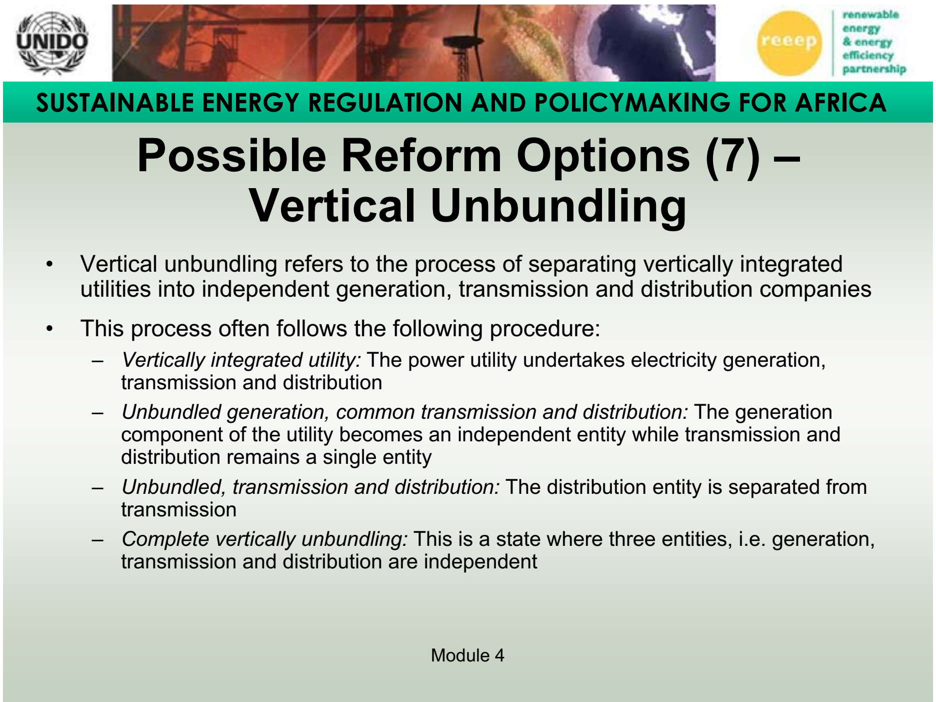
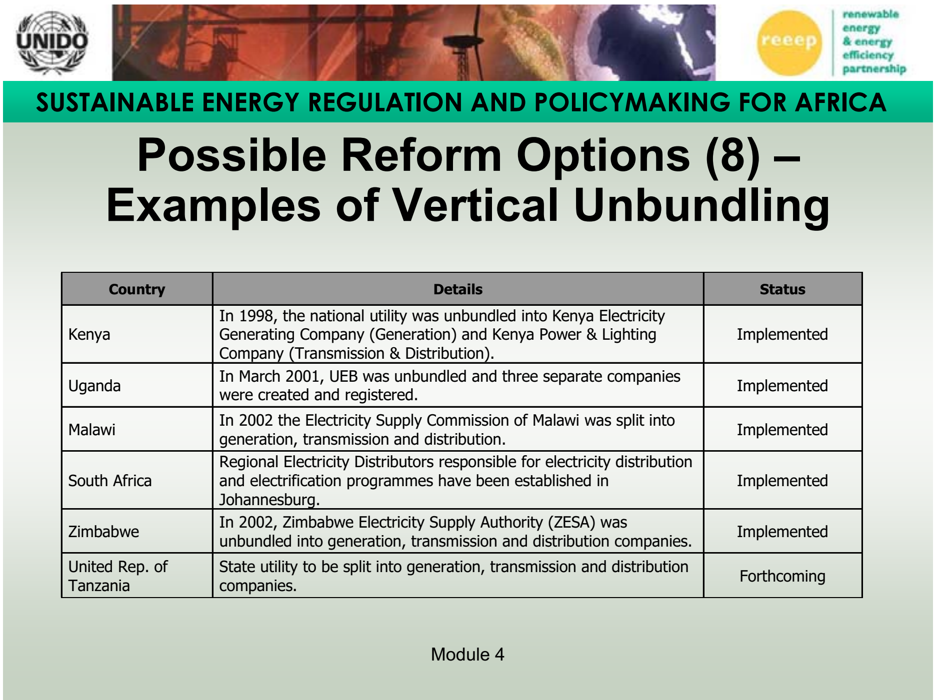


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (7) – Vertical Unbundling

- Vertical unbundling refers to the process of separating vertically integrated utilities into independent generation, transmission and distribution companies
- This process often follows the following procedure:
  - *Vertically integrated utility:* The power utility undertakes electricity generation, transmission and distribution
  - *Unbundled generation, common transmission and distribution:* The generation component of the utility becomes an independent entity while transmission and distribution remains a single entity
  - *Unbundled, transmission and distribution:* The distribution entity is separated from transmission
  - *Complete vertically unbundling:* This is a state where three entities, i.e. generation, transmission and distribution are independent



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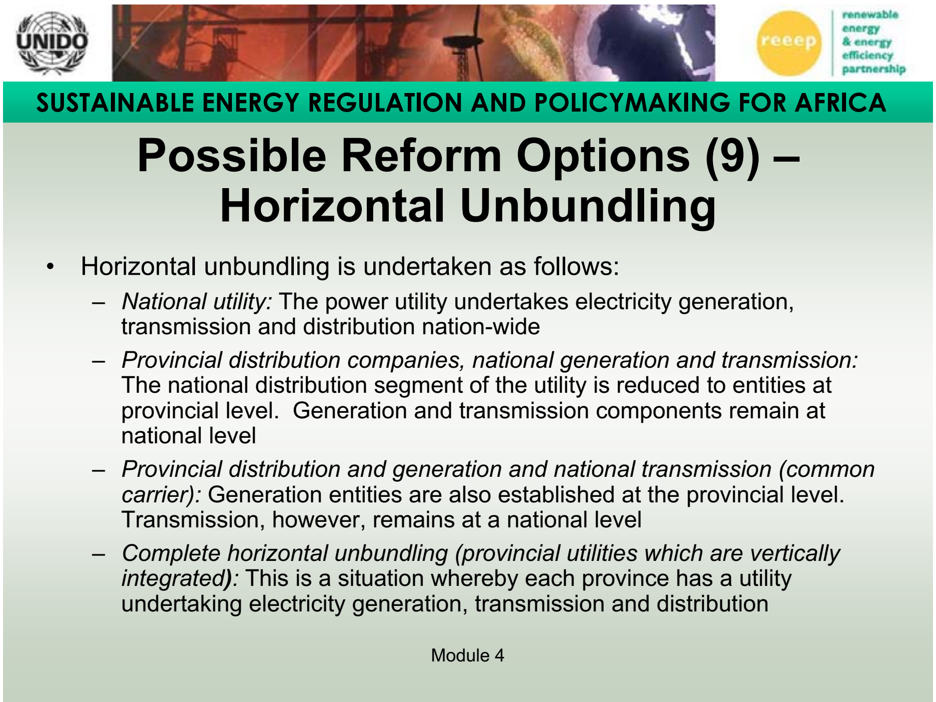
Possible Reform Options (8) – Examples of Vertical Unbundling

Country	Details	Status
Kenya	In 1998, the national utility was unbundled into Kenya Electricity Generating Company (Generation) and Kenya Power & Lighting Company (Transmission & Distribution).	Implemented
Uganda	In March 2001, UEB was unbundled and three separate companies were created and registered.	Implemented
Malawi	In 2002 the Electricity Supply Commission of Malawi was split into generation, transmission and distribution.	Implemented
South Africa	Regional Electricity Distributors responsible for electricity distribution and electrification programmes have been established in Johannesburg.	Implemented
Zimbabwe	In 2002, Zimbabwe Electricity Supply Authority (ZESA) was unbundled into generation, transmission and distribution companies.	Implemented
United Rep. of Tanzania	State utility to be split into generation, transmission and distribution companies.	Forthcoming



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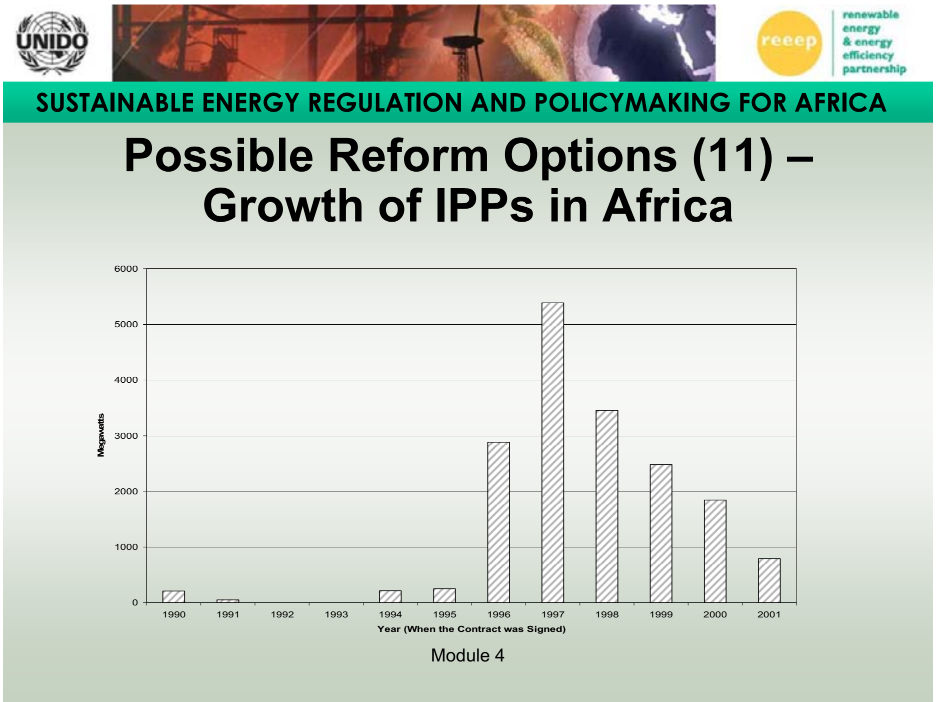
Possible Reform Options (9) – Horizontal Unbundling

- Horizontal unbundling is undertaken as follows:
  - *National utility:* The power utility undertakes electricity generation, transmission and distribution nation-wide
  - *Provincial distribution companies, national generation and transmission:* The national distribution segment of the utility is reduced to entities at provincial level. Generation and transmission components remain at national level
  - *Provincial distribution and generation and national transmission (common carrier):* Generation entities are also established at the provincial level. Transmission, however, remains at a national level
  - *Complete horizontal unbundling (provincial utilities which are vertically integrated):* This is a situation whereby each province has a utility undertaking electricity generation, transmission and distribution

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (10) – Independent Power Producer

- Independent power producers (IPPs) are becoming a major source of new power generation capacity in the Africa
- There was a major increase in the number of IPPs in Africa during 1996 and 1997, a period when the majority of legislative and structural changes took place in the region
- The rapid growth of IPPs experienced in 1996-1998 is beginning to slow, a trend that has accelerated in 2000 and 2001
- Except for a few countries such as Mauritius, reforms appear to favour large and centralized power projects thereby precluding small and medium-scale renewables
- In spite of significant potential, IPP developments have not considered small to medium scale renewables such as mini-grids, cogeneration, small hydro, geothermal and wind



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (11) – Growth of IPPs in Africa

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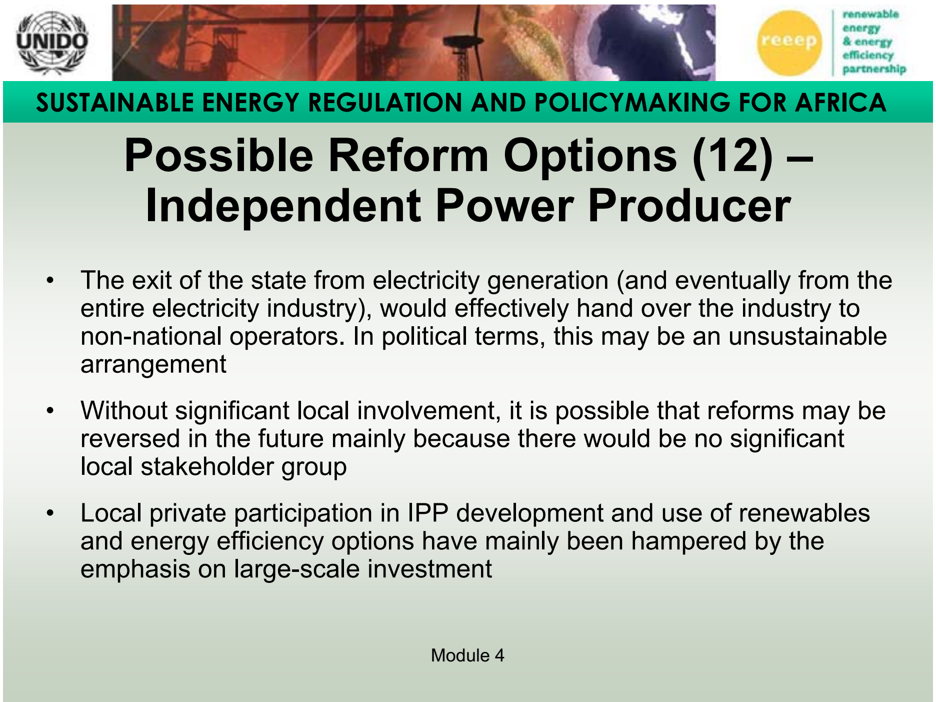

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (12) – Independent Power Producer

- The exit of the state from electricity generation (and eventually from the entire electricity industry), would effectively hand over the industry to non-national operators. In political terms, this may be an unsustainable arrangement
- Without significant local involvement, it is possible that reforms may be reversed in the future mainly because there would be no significant local stakeholder group
- Local private participation in IPP development and use of renewables and energy efficiency options have mainly been hampered by the emphasis on large-scale investment

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

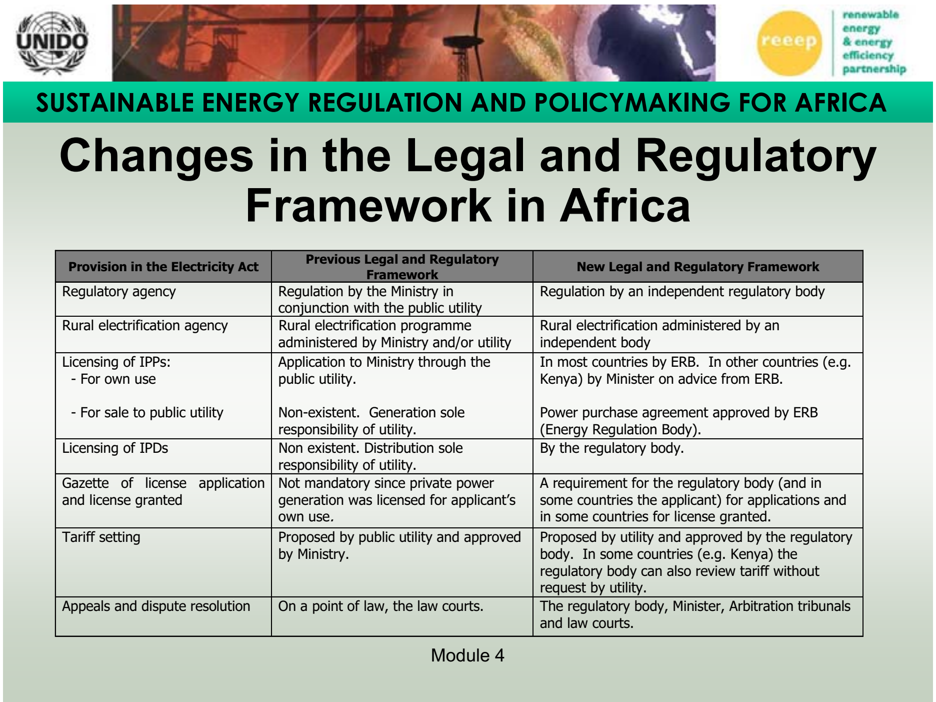
Possible Reform Options (13) – Independent Power Producer

- Large-scale IPP developments may have several drawbacks with regard to local private participation in the region. These include:
  - Large-scale IPP development is generally a high-tech capital-intensive
  - Large-scale capital-intensive IPP developments invariably attract the politically connected rent-seeking class
- Mauritius demonstrates the potential financial and technical capability and viability of local private investors in IPP development
- Appropriate policy and financial incentives could encourage the development of locally owned IPPs

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Possible Reform Options (14) – Electricity Law Amendment

- This involves the National Assembly or Parliament of a country passing an amendment to the existing Act to establish new legislation governing the electricity subsector and/or other energy subsectors
- This may remove the monopoly of the national utility – a major barrier to private sector participation
- It often provides for the establishment of an independent regulatory body for the electricity subsector and defines its role
- In some instances the Act provides some independence to the Regulator
- The Electricity Act could also create a provision for a rural electrification programme and/or fund
- In most African countries, the Electricity Act is the principal instrument that defines the legal and regulatory framework



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Changes in the Legal and Regulatory Framework in Africa

Provision in the Electricity Act	Previous Legal and Regulatory Framework	New Legal and Regulatory Framework
Regulatory agency	Regulation by the Ministry in conjunction with the public utility	Regulation by an independent regulatory body
Rural electrification agency	Rural electrification programme administered by Ministry and/or utility	Rural electrification administered by an independent body
Licensing of IPPs: - For own use - For sale to public utility	Application to Ministry through the public utility. Non-existent. Generation sole responsibility of utility.	In most countries by ERB. In other countries (e.g. Kenya) by Minister on advice from ERB. Power purchase agreement approved by ERB (Energy Regulation Body).
Licensing of IPDs	Non existent. Distribution sole responsibility of utility.	By the regulatory body.
Gazette of license application and license granted	Not mandatory since private power generation was licensed for applicant's own use.	A requirement for the regulatory body (and in some countries the applicant) for applications and in some countries for license granted.
Tariff setting	Proposed by public utility and approved by Ministry.	Proposed by utility and approved by the regulatory body. In some countries (e.g. Kenya) the regulatory body can also review tariff without request by utility.
Appeals and dispute resolution	On a point of law, the law courts.	The regulatory body, Minister, Arbitration tribunals and law courts.

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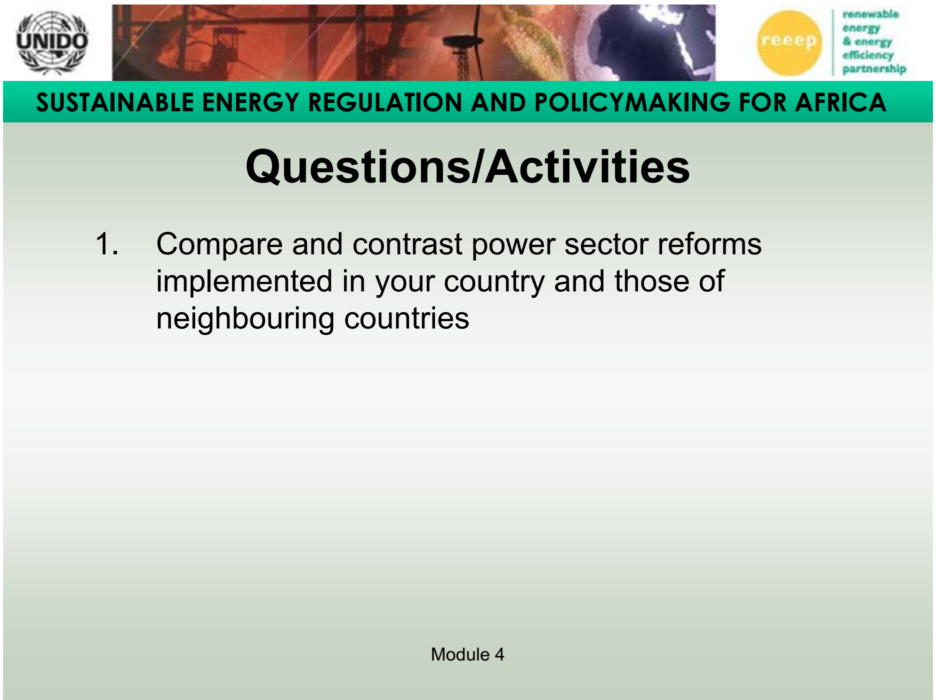

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

1. Compare and contrast power sector reforms implemented in your country and those of neighbouring countries

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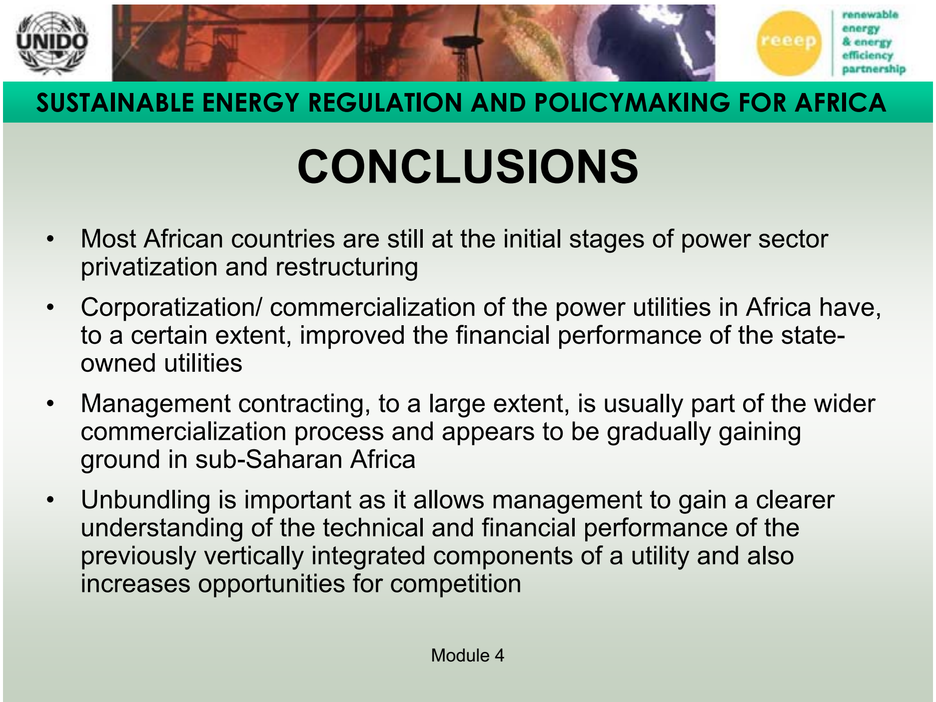

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Most African countries are still at the initial stages of power sector privatization and restructuring
- Corporatization/ commercialization of the power utilities in Africa have, to a certain extent, improved the financial performance of the state-owned utilities
- Management contracting, to a large extent, is usually part of the wider commercialization process and appears to be gradually gaining ground in sub-Saharan Africa
- Unbundling is important as it allows management to gain a clearer understanding of the technical and financial performance of the previously vertically integrated components of a utility and also increases opportunities for competition

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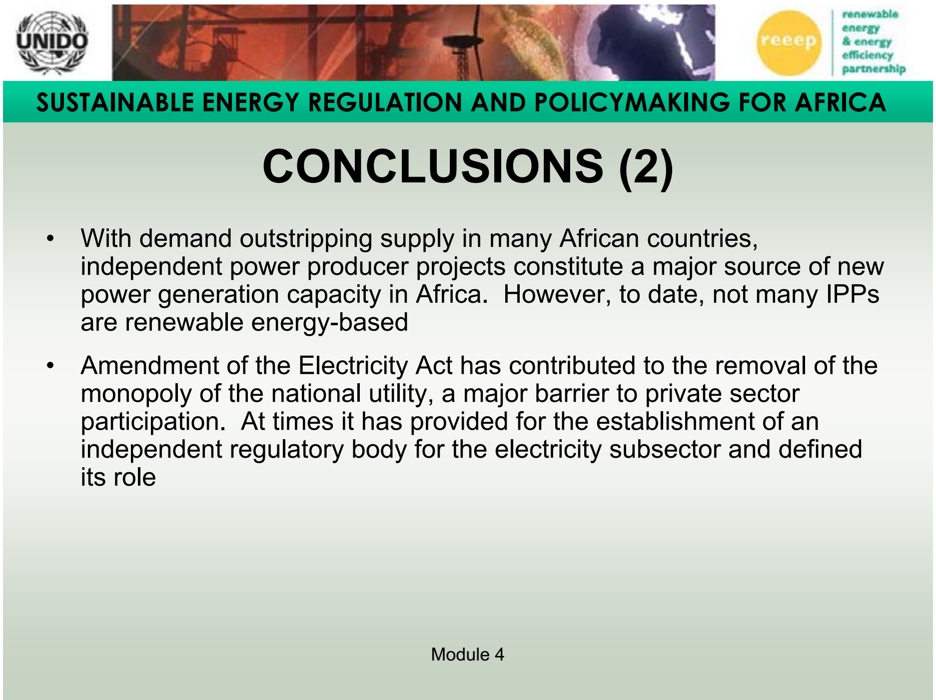

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS (2)

- With demand outstripping supply in many African countries, independent power producer projects constitute a major source of new power generation capacity in Africa. However, to date, not many IPPs are renewable energy-based
- Amendment of the Electricity Act has contributed to the removal of the monopoly of the national utility, a major barrier to private sector participation. At times it has provided for the establishment of an independent regulatory body for the electricity subsector and defined its role

Module 4

Module 5

Structure, composition and role of an energy regulator

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

There is no “perfect” regulatory system. Continuous improvements and adjustments are necessary as it adapts to internal and external changes. A good regulatory system may take a long time to develop. However, appropriate clarity of the relationship between government and regulator is crucial to good reduction of investor risks and protection of consumer’s interests.

There are three basic principles on which a regulatory system must be built: independence, transparency and investor/consumer protection. This module will examine these principles and the composition and tools necessary for a regulatory body to carry out its work effectively.

1.2. Module aims

The aims of the present module are listed below:

- To introduce the basics principles along which an effective regulatory system is built;
- To provide an overview of the issues of independence, transparency and consumer/investor protection;
- To show that there is no “ideal” model or structure for a regulatory body;
- To outline the basic functions and role of a regulator;
- To outline some basic compositions of regulators and the resources they will need at their disposal;
- To introduce some basic recommendations towards building a credible regulatory environment.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To understand the role of the regulator;
- To describe the basic principles of independence, transparency and consumer and investor protection and why they are important;
- To describe the main functions of a regulator;

- To appreciate the main issues involved in setting up a regulatory body;
- To understand the importance of a credible regulatory environment;
- To be able to list some measures that increase regulatory transparency.

2. INTRODUCTION

Effective protection of the property rights of investors and a framework of known legal rules are conducive to stronger economic development. However, simply transplanting Western legal and regulatory models to developing countries is often inadequate to respond to the different circumstances in these countries. One of the commonly neglected reasons for this is fewer resources being available in developing countries. A legal or regulatory system may need to be designed differently to take this and other factors into account.

Generally, respect for basic property and contract rights and an independent judiciary with some ability to command compliance from government an politicians is key to an effective legal and regulatory system. However, there is no "perfect" regulatory system. Continuous improvements and adjustments are necessary as it adapts to internal and external changes. A good regulatory system may take a long time to develop.

In the energy sector of many developing countries, the process of reform is still underway, therefore a regulatory agency's structure must permit it to adapt effectively to changing technological evolutions and market conditions.

In addition, appropriate clarity of the relationship between government and regulator, including definitions in the governing legal framework, is crucial to good regulation and reduction of investor risks. And, at the end of the day, there must exist the political will allowing regulators to "do their jobs".

Overall, there are three basic principles on which a regulatory system must be built: independence, transparency and investor/consumer protection.

The importance of achieving a degree of regulatory independence, although controversial at times, cannot be underestimated. Independence is crucial to the regulator's task.

Transparency is the key to attracting and retaining efficient investment as it creates confidence in the commitment of the government/regulator to set of fair policies both now and in the future. Absence of regulatory transparency can severely undermine investor confidence.

It is also the regulator's role to strike the balance between encouragement of investors and consumer protection. A regulatory agency must support investment by protecting investors from arbitrary government actions but also in turn protect consumers from abuse by firms with substantial market power.

Finally, a regulator must be provided with the tools and resources essential for delivering on its mandate, whether this is in terms of laws, financial resources or high quality staff.

3. PRINCIPLES OF REGULATION

3.1. Independence

Regulatory autonomy or independence usually means having a regulatory body free from influence from external sources in its decision making. This often means independence or autonomy from the government. Ensuring that political oversight is not seen to impede the functioning of the regulator can be crucial in establishing the credibility of a newly created regulator.

However, it is commonly accepted that balancing regulatory autonomy/independence with sustainable financing of regulatory agencies is a difficult task and there is seldom a perfect answer. Indeed, the principal source of financing for many regulators is the government, leaving them at least partly vulnerable to political influence.

One way suggested to partly mitigate the issue of dependence on government funding is to have ring-fenced funding for the regulator. However, reduced independence of a newly established regulatory agency may be necessary during a two or three year transition period while permanent funding is established and other stakeholders learn about the processes used by the regulator.

Further, the only way a regulator can be truly independent is if it has been provided with the tools and resources essential for delivering on its mandate. A weak regulator, for example, in terms of financial or human resources, will find it very difficult to remain autonomous.

3.2. Transparency

Transparency means transparent regulatory decision-making and robustness, expediency, quality and predictability of regulatory decision-making. The following might be regarded as a wide and dynamic definition of the concept of regulatory transparency:[1]

> Transparency is defined as “tools and measures that foster confidence in and understanding of the regulatory processes and decisions by all stakeholders”.

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[1] Dr. R. Hern, NERA Economic Consulting at the 2nd Annual AFUR Conference in Kampala, March 2005.

Regulatory transparency is more important in weak institutional environments with less investor confidence. The idea is that the openness of the regulatory process to stakeholders promotes legitimacy. However, it is recognized that there should be a balance between transparency and respect for the requirements of investor confidentiality. In brief, transparency:

- Is crucial to the legitimacy of the regulatory process;
- Is the key to attracting and retaining efficient investment;
- Creates confidence in the credible commitment from the government/ regulator to a set of fair policies both now and in the future;
- The financial impact of the absence of regulatory transparency is potentially vast and could severely undermine investor confidence.

One method for the regulator to promote transparency is to prepare and distribute to stakeholders and the general public an annual report on regulatory activities and sector performance.

3.3. Investor and consumer protection

The basic role of the regulator is to balance the interests of three stakeholder groups: the government, electricity (or energy) service suppliers and customers. Each of these groups has potentially conflicting interests.

The government is subject to short-term political pressures from various constituencies. For investors to commit to long-term investments, the regulator must be free from undue influence. For example suppliers want high returns, and an unchecked monopolist will charge too high a price. Customers, conversely, want reliable electricity at low prices.

Therefore, a key element of the regulator’s role is striking the balance between encouraging investors and protecting consumers, while fulfilling government objectives. The regulator should ensure that both suppliers and consumers uphold their obligations relating to commercial operations. The utility has the obligation (via licensing) to provide a service under the approved tariffs and quality standards. Consumers have an obligation to pay for that service to ensure the financial viability of the sector.

For example, the review of tariffs and costs, one of the core functions of a regulator, is central to protecting consumers and facilitating investment. The regulator must also be wary of the emergence of monopolies that could have enough influence to set higher than market prices.

The purpose of regulation is to ensure that price reflects the least cost of service, given mandated quality and reliability standards. The role of the regulator is to promote the long-term objectives established by the government, while balancing the interests of all three stakeholder groups (government, suppliers, consumers). The long-term sustainability of the sector depends on looking beyond the immediate interests of each of the groups.

Review question

Describe in your own words the principles of independence, transparency and investor and consumer protection.

4. DIFFERENT BODIES INVOLVED IN REGULATION

As presented in the introductory module of this course, various governmental and non-governmental bodies can be involved in the activity of regulation.

The independent or semi-independent specialist utility or energy regulator is becoming a common model for regulation of the energy industries, particularly where these industries have been transferred to the private sector. This is common in many African countries whose energy sector has recently gone through a reform process, often creating an independent energy regulatory body as part of that process.

However, this is not the only model, in some countries—even where the industry has been privatized—a central government department will retain either the whole regulatory function or parts of it. In this case, electricity is typically regulated by a ministerial agency, usually under the Ministry of Energy. (But not always. For example, in the United Republic of Tanzania, the Energy and Water Utility Regulatory Authority (EWURA) is placed under the Ministry of Water.)

Whether it is a government department or an independent regulator who has the primary role, there will often also be other bodies with a role in regulating the energy industry. These were outlined in module 3, and this outline is repeated here for convenience. The following bodies can all be involved in regulating the energy industry:

- Central government departments;
- Specialist utility or energy regulatory agencies;
- Generalist competition regulators;
- Environmental regulators;
- Local authorities;
- Courts and tribunals.

4.1. Central government departments

Where central government departments are directly involved they make regulation answerable to elected politicians and hence can increase democratic control and legitimacy. Whether or not this is considered desirable will depend upon different views of the purpose of regulation and role of government. For example, there may be concerns that governments may be willing to compromise economic efficiency to meet other goals—for example, there may be pressures to protect companies from competition to preserve jobs.

4.2. Specialist utility or energy regulators

One of the main arguments made in the favour of specialist utility or energy regulators is that, where the agency enjoys reasonable independence from government, they provide a bulwark against "political interference" which might damage economic efficiency. The main argument against is a lack of accountability to the government and parliament. Establishing an independent regulator places considerable power in the hands of an appointed individual, (or a group of individuals where a commission-type structure exists) who may pursue policies that are at odds with government policy or publicly mandated policy goals. These regulators are generally subject to a set of duties provided by legislation, although the legislation may provide for a considerable degree of discretion on the part of the regulator in applying and balancing these duties. Achieving the benefits of independence without sacrificing accountability is thus one of the key challenges.

4.3. Generalist competition regulators

The generalist competition regulator's role is to take action against activities that may hamper competition in any sector of the economy. Typically they will have a role in assessing whether certain mergers should be allowed to proceed and in taking action where companies with market power are found to be acting anti-competitively. In some countries, the specialist utility regulators may have some concurrent powers with the generalist competition regulators.

4.4. Local authorities

Local authorities may have two types of role. Firstly in planning control—e.g. in the siting of energy facilities such as power stations, wind turbines, etc. Secondly, in some countries, local authorities provide municipal electricity and/or heat (district heating) supply—these companies may be regulated by a sector regulator where one exists or they may be largely self-regulatory.

4.5. Courts and tribunals

The position of courts and tribunals can vary somewhat, depending on the particular structure. In some systems they are empowered to act as the point of last appeal on disputes between other regulatory bodies and companies. In other systems, courts and tribunals can be the first point of call concerning company behaviour.

Box 1. **Establishment of the Energy Regulation Board of Zambia**

Prior to the change of Government in 1991, state-owned companies (usually monopolies), operating under extensive Government control, characterized the Zambian economy.

When the current Government assumed power in 1991, new economic liberalization policies were adopted leading to the promulgation of new legislation. In the energy sector a new ministry responsible for energy was created (the Ministry of Energy and Water Development). The National Energy Policy was formulated and adopted in 1994 followed by enactment of the Electricity Act and the Energy Regulation Act in 1995.

The Energy Regulation Board (ERB) started operating in February 1997 following issuance, by the Minister of Energy, of the statutory instrument No.6 of 1997, the Energy Regulation Act (Commencement) Order of 27 January 1997. By 2000, the ERB had undertaken several capacity-building activities, developed into a strong regulatory authority and was well recognized both by the Zambian stakeholders and the international community.

To build a successful independent regulatory authority, a country should ensure that there is a strong political will, clear policy, supporting legislation and appropriate institutional arrangements such as independence, earmarked funding, accountability, credibility, no regulatory capture, competency, regulators appointed on professional basis and no arbitrary removal of regulators.

5. ROLE OF A REGULATOR

5.1. Why regulate in the electricity sector?

Below is a brief reminder of why regulation is important in the electricity sector[2] (although the same principles can apply to other sectors also):

- To constrain the exercise of monopoly power by incumbent suppliers;
- To provide incentives for operating efficiency and quality of service;
- To optimize the structure of the sector;
- To promote least-cost system expansion (with private capital invested in independent power producers—IPPs);
- To stimulate energy conservation and R&D.

5.2. Purpose of a regulator

The purpose of a regulator is often seen as "balancing" of interests but unless benefits are also created under the regulatory regime (i.e. improved sector performance), the system is unlikely to be sustainable.

The role of the regulator is:

- To protect consumers from abuse by firms with substantial market power;
- To support investment by protecting investors from arbitrary government action;
- To promote economic efficiency.

Under a regulation-by-contract regime and potentially having to engage in contract re-negotiations, the regulator's role will increasingly be that of honest broker or even impartial player focused on creating solutions and building consensus between service providers/investors and governments.

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[2] Designing an Independent Regulatory Commission, S. V. Berg, A. N. Memon, R. Skelton, Public Research Utility Center, University of Florida.

Review question

List the main reasons why regulation is important in the electricity sector.

6. SETTING UP A REGULATOR

6.1. Introduction: designing a regulator

A well functioning regulatory agency needs adequate resources, an appropriate legal mandate and clear agency values and operating procedures. This is by no means an easy or straightforward task and a number of questions can be raised when thinking of how to set up a regulator. Some of these are listed below:

Legal mandate

- Should the regulator have jurisdiction over one industry? One sector? Or many sectors?
- What are the functions of the regulator and what are those of the ministries?
- After establishment, at what point and how should revisions be made to the law?

Values

- If independence is important, how can it be achieved?
- What processes will promote transparency?
- What kind of information does the regulator require in order to be able to make informed decisions?

Resources

- Consideration of resources affects start-up strategy;
- What kind of leadership is required (individual or committee)?
- How does funding, recruitment of professionals, and staff development affect the performance of a regulator?

What is suggested to be defined first are the key objectives, against which the regulator's success will later be judged. Then the values and principles to be applied in the regulatory process as well as the functions that need to be assigned and implemented need to be defined here. Then a process that will ensure that decision-making is transparent need to be designed.

6.2. Resources

One of the often-neglected reasons why transplanting western regulation models to developing countries do not generally work is because of a lack of available resources. A regulatory system may well need to be designed differently where the resources available for investment in it are more limited, as is the case in most developing countries.

It must not be forgotten that while creating laws and rules is relatively straight forward, creating new institutions with roles in regulation requires relatively heavy investment in terms of labour costs. Therefore, in developing countries, a policy of selecting rules and regulations that reduce institutional costs would seem logical.

When discussing availability of resources, it should be born in mind that the term "resources" could mean many things. The term should not be understood in a narrow sense, as it could encompass any of the following and more:

- Manpower to monitor, conduct, process and enforce rules and sanction systems;
- Investment in information technology to facilitate communication and therefore also the effectiveness of decision-making;
- Human capital, where average lower educational achievement affects both the quality of decision-making by officials and the ability of ordinary citizens to initiate or contribute to the enforcement process.

These resources are necessary for an effective regulator to exist, therefore when they become constrained or limited, this should not be ignored but action should be taken to create solutions or adapt the existing system, so it may continue to be effective. The following are suggestions for adapting a regulatory regime to ease the pressure on limited resources:[3]

- Regulatory goals may be more effectively pursued if they coincide, or are compatible, with community norms.
- If the regulatory regime can in some way be identified with, or internalized by, the community, whether within or outside traditional law, this will facilitate monitoring and enforcement, both of which are heavily resource intensive.
- Sanctions often fail to be effectively applied due to corruption or simply insufficient assets by those failing to comply with the initial fining. In the later case, there is an understandable reluctance to impose imprisonment as the principal alternative to paying of fines, especially for minor offences. Therefore, in some cases it may be more cost effective for regulatory systems to focus their enforcement efforts less on those who actually contravene the rules but have insufficient wealth to pay penalties (e.g. an individual who fails to pay an electricity bill) and more on third parties who can control the contravener's conduct and do have sufficient assets for financial penalties to be effective as a deterrent. So, for example, a firm or employer can be held

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[3] Towards appropriate institutional arrangements for regulation in less developed countries, A. Ogus, Working Paper Series, Paper No. 119, Centre for Regulation and Competition, University of Manchester, June 2005.

responsible for the contravention, in the expectation that it can apply effective informal sanctions on their employees. In some developing country contexts, the same idea might be extended to render the extended family or community responsible to equivalent effect.

- Using discretion instead of rules in decision-making is also a way to reduce bureaucracy and complex rule-making by leaving decisions in the hands of informed individuals. However, this has two disadvantages: first, the exercise of discretion requires greater knowledge and expertise than simple application of rules and, secondly, discretion can be exploited more easily than rules for the purposes of corruption.

6.3. Legal mandate

The functions of a regulator are usually defined in primary legislation. Changes to regulatory functions are also usually implemented through primary legislation. Clarity in the legislation setting up the regulator must be ensured. There must be a clear mandate and the tools and means to implement that mandate should be made available to the regulator.

A regulator's work will include, amongst other functions, issuing licences, setting performance standards, monitoring the performance of regulated firms, establishing the level and structure of tariffs, arbitrating disputes among stakeholders and reporting sector and regulator activities to the appropriate government authority. For each of these functions, the regulator needs sufficient legal authority to carry out its responsibilities.

6.4. Values and principles

The values and principles a regulator decides to use to apply the regulatory process are important, as these will determine whether credibility with the investment community, legitimacy for consumers and strong incentives for economic efficiency are established. Box 2 below gives a review of international best practice. These principles should be incorporated in the regulatory process for effective implementation of government policies. For example, the accountability component includes a procedure for appeal to a regulatory decision.

Box 2. **Best practice principles for regulatory commissions: international experience**

The following characteristics have been identified with best practice around the world:

Communication: information should be made available to all stakeholders on a timely and accessible basis.

Consultation: participation of stakeholders in meetings promotes the exchange of information and the education of those affected by regulatory decisions.

Consistency: the logic, data sources, and legal basis for decisions should be consistent across market participants and over time.

Predictability: a reputation for predictable decisions facilitates planning by suppliers and customers, and reduces risk as perceived by the investment community.

Flexibility: the agency should use appropriate instruments in response to changing conditions, balancing this regulatory discretion against the costs associated with uncertainty.

Independence: autonomy implies freedom from undue stakeholder influence, which promotes public confidence in the regulatory system.

Effectiveness and efficiency: cost effectiveness should be emphasized in data collection and in the policies implemented by the regulator.

Accountability: regulators should provide clearly defined processes and rationales for decisions. In addition, appeals procedures need to be specified to provide appropriate checks and balances.

Transparency: the openness of the process to stakeholders promotes legitimacy.

Source: Australian Regulatory Forum (1999), www.accc.gov.au

6.5. Functions

A review of experience around the world indicates that the following are the key regulatory functions in the electric power sector:[4]

- Issuing licences related to regulatory functions;
- Setting performance standards;
- Monitoring the performance of regulated firms;

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[4] Designing an Independent Regulatory Commission, S. V. Berg, A. N. Memon, R. Skelton, Public Research Utility Center, University of Florida.

- Establishing the level and structure of tariffs;
- Establishing a uniform accounting system;
- Arbitrating disputes among stakeholders;
- Performing (usually via an independent consultancy) management audits on regulated firms;
- Developing human resources for the Independent Regulatory Commission (IRC);
- Reporting sector and IRC activities to the appropriate government authority.

All of these functions have implications for the central objectives of regulation: ensuring that costs and prices are as low as possible, conditional on continuing to attract needed capital investment for the sector. Interrelationships among the functions affect costs and tariffs. Often rate re-balancing (to reduce cross-subsidies from particular customer groups) or rate increases (to bring prices up to costs) are objectives of reform, and the creation of a regulator clearly involves a review of costs and tariffs.

Issuing licences is often one of the first actions undertaken by a new regulator. A licensing regime tests the suitability of applicants as potential suppliers of goods or services. Licensing systems are relatively expensive to administer, however they have proved a popular instrument amongst regulation agencies in developing countries, while in Europe there is movement away from licensing with more emphasis on industry monitoring systems.

The popularity of licensing systems in developing countries can be explained for the following reasons, amongst others:

- Weak monitoring systems (due to lack of human and financial resources);
- Easy method for revenue raising through registration and licensing fees (easier and more acceptable than taxation);
- Less prone to corruption.

However, some problems remain with the cost of this approach, especially since companies still have to be monitored post-licensing to ensure they do not subsequently default on their licence conditions.

6.6. Operational structure

Agreed regulatory functions largely determine the design of a regulatory body's organizational structure. Figures I and II display two models of organizational structure for multi-member commissions.[5] Under model A, the chairman and members concentrate on decision-making, while the professional preparatory work and due-diligence effort is done under the supervision of an appointed executive director. Under model B, individual members have hands-on managerial roles, and head the individual functional departments. It is possible to combine these models through the use of task forces lead by individual commissioners.

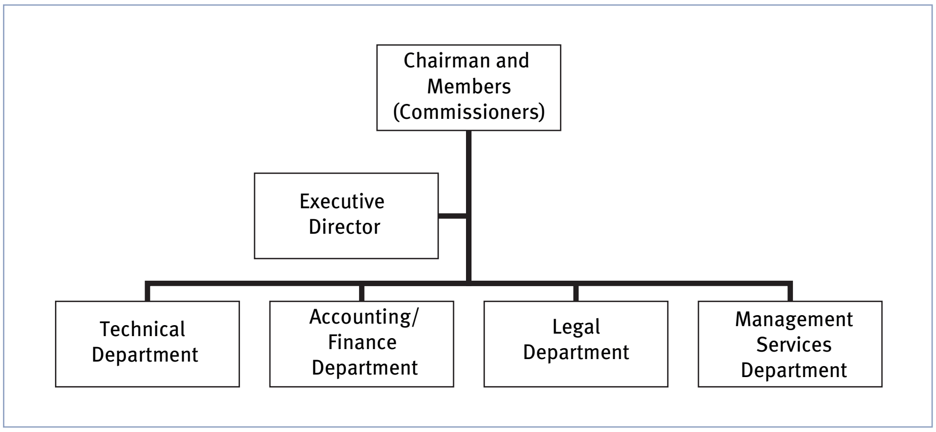
An additional option is to have an external consultation committee, which could provide the viewpoints of ministries affected by regulator decisions and inform the ministries of sector developments.

Whether commission members are full or part-time, their actual professional background, and their status in terms of seniority, age, etc. are factors that might affect which model is chosen. For example, if members work full-time, model B might be appropriate. Members who lack professional expertise or who are very senior may not want to head the relevant departments as required under model B.

While an odd number of commissioners, including the chairman, is useful to ensure decision-making, the size of commissions, including chairman, can vary from one member (United Kingdom) to three (Orissa in India), five (FERC in the United States, Argentina, Mexico, New York, Pakistan) or seven members (Federal agency in Canada). On the basis of international experience, the regulator should not have more than seven members.

Terms of appointment can vary from five years (Argentina, Bolivia, United Kingdom, United States) to six (California State Commission, New York) to seven (Canada). Most appointments are renewable for at least one additional term. To ensure continuity of decision-making, staggered terms of four to five years are often appropriate.

Figure I. Organizational chart model A: multi-member commission



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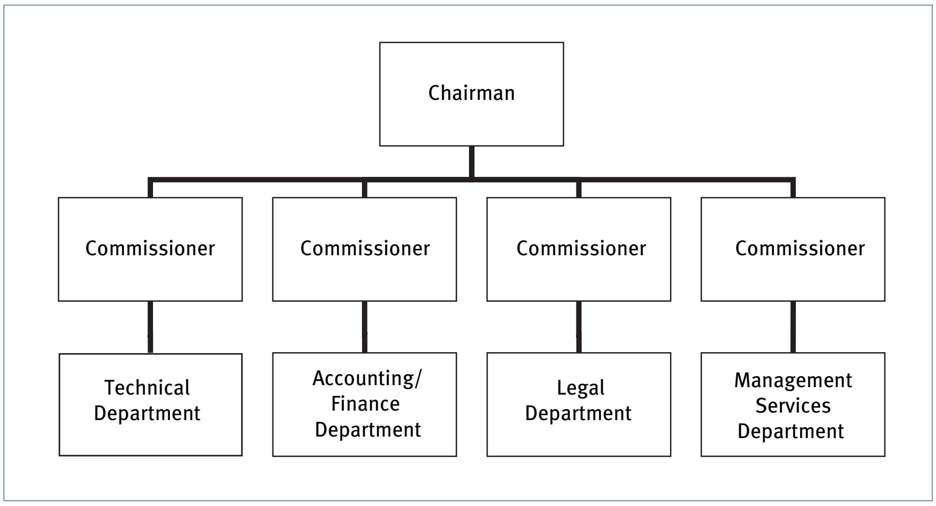
[5] From the appendix of “Designing an Independent Regulatory Commission”, S. V. Berg, A. N. Memon, R. Skelton, Public Research Utility Center, University of Florida.

Figure II. Organizational model B: specialized responsibilities



6.7. Staff skills and competencies

As discussed above, a regulatory body of high quality cannot be set up without the right resources, and this includes human resources in terms of high quality and correctly trained staff. Commissioners and staff with the right qualifications and experience must be hired. Where all positions cannot be satisfactorily filled, training should be arranged for staff.

Commissioners' personal attributes should include the ability to consider multiple perspectives and resistance to improper influences and preoccupations. Training and experience in economics, finance, law, public administration or engineering are also useful.

In selecting staff, emphasis must be placed on skills as well as on personal integrity. Market-based salaries are desirable, and this may call for exceptional measures or incentives to recruit and retain the qualified professionals needed.

Staffing head count is important. Understaffing prevents proper attention to required functions; overstaffing can dilute focus. Rather than attempt to recruit and maintain all expertise on a permanent basis, a commission can rely on expert consultants and fixed-term contracts, keeping the permanent commission staff as small as possible.

Depending on the size of the country and the resources available, the regulator could contract out or outsource activities such as detailed analytical work and compliance audits of regulated firms.

Box 3. **Skills shortages in African regulators and what actions can be taken**

A recent "skills audit" commissioned by the African Forum for Utility Regulators (AFUR) came to the conclusion that a shortage of skills is seriously impacting on the ability of regulators to conduct their activities.

The same study identified the requirement for a structured cost effective training programme that can be undertaken over a period of time. Training may be best delivered as a set of short courses/seminars, which cover a range of regulatory knowledge areas. The focus should be on providing the knowledge which regulators need rather than emphasizing a requirement for formal accreditation.

What is currently limiting training opportunities for many staff is the cost of travel to training venues, which are often in Europe or the USA. Many staff would benefit from courses being available to them closer to home, or access to information to encourage on-the-job learning.

Some of the areas where training is most likely to be required in the next two years, as identified by the AFUR skills audit were:

- Funding a regulatory body
- Understanding the nature of the utility market—natural monopolies and competition
- Ensuring that any restructuring or consolidation of companies providing a utility service was compatible with effective competition
- Financial analysis
- Regulating overall price levels
- Controlling pricing when users have no choice of supplier
- Tariff setting
- Information issues
- Making good regulatory decisions
- Reviews of and appeals against regulatory rules and decisions
- Knowing how to communicate to the public
- Negotiating techniques and strategies
- Critically reviewing company plans to provide utility services

When selecting and evaluating staff for regulatory agencies, there is often a focus on specialist skills and knowledge, relating to the sector being regulated. In the case of energy, specialist skills that might be targeted are, for example:

- Energy economics;
- Energy contract negotiations;
- Electricity systems (generation, transmission, distribution, supply).

Training and experience in economics, finance, law, public administration or engineering are also useful. There is also a need to assemble staff that have overarching organizational management knowledge. These include knowledge/competency in areas such as personnel management, financial control and operational management. Without good general management abilities no regulatory body will operate effectively regardless as to the degree of specialized knowledge its staff possess.

Equally, "soft skills" can impact on the effectiveness of any organization at all levels of seniority. Soft skills relate to the "unseen" abilities of staff and managers—their personal motivation, ability to communicate well, ability to work in teams, staff levels of basic education and IT literacy. These "soft" skills can have an enormous impact on the effectiveness of organizations to undertake the tasks expected of them and it is important that these are taken into consideration when recruiting staff.

Review questions

1. List five of the best practice principles for regulation commissions according to international experience. Write a sentence describing each one.
2. What are the key functions of a regulator?

7. BUILDING A CREDIBLE REGULATORY ARRANGEMENT

While regulatory concerns make up only a small part of the investor's overall risk assessment, regulatory capacity, competence, independence and transparency remain important to infrastructure development and operation. Without a credible regulatory structure, investors will generally try to "bypass" the regulator by negotiating directly with the host government.

7.1. Transparency

Why is regulatory transparency important? Transparency is important for independent operation while assuring legitimacy of the regulatory process. However, whether the emphasis is placed on transparency or not depends on the general institutional framework in a country. Information dissemination mechanisms must be appropriate and capable of reaching all the stakeholders. Finally, the commercial confidentiality of the regulated bodies needs to be taken into account.

Transparency is also important because it is an important part of attracting and retaining investment. It does this by reducing regulatory risks faced by investors. Many investors view transparency as a threshold to investment decisions prior to consideration of other factors. Lower regulatory risks through greater transparency mean lower cost of capital and thus lower required rates of return. Transparency creates confidence in the commitment from the government to a defined set of policies now and in the long-term. Transparency facilitates better regulatory decisions taking account all stakeholder interests and prevents corruption and regulatory capture.

Many regulatory documents are placed in the public domain, including decision statements. Regulatory documents are fairly comprehensive, and usually set out tariff review procedures, intended methodologies and consultation process requirements. This can be considered to be the "bare minimum" of factors that should be set out in publicly available regulatory documents.

How can regulatory transparency be measured? The NERA Survey[6] of global regulatory practices focused on six key dimensions to define and measure the degree of regulatory transparency. These include clarity of roles and objectives; predictability; transparency of decisions; accountability; participation; and access to information.

Many of these dimensions overlap with what is considered good regulatory governance. However, regulatory transparency has potentially high costs and these

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[6] Regulatory Transparency: International Assessment and Emerging Lessons, A Final Report for the World Bank, NERA Economic Consulting, 6 June 2005.

must be recognized. The importance of well-defined appeal mechanisms must also be properly understood. The implementation of a regulatory transparency framework should take place within three partly-overlapping dimensions of the institutional framework, the regulatory regime and a number of trade-offs that will need to be made. A number of ways to increase regulatory transparency are given below, although this is not an exhaustive list.

- Increasing regulatory transparency can be enhanced if the regulator circulates draft decisions to stakeholders for comment before finalizing a regulatory decision or decision process;
- Where in-keeping with the limits of confidentiality, the publishing of regulatory contracts is a practical way to promote transparency;
- Encouragement of customer involvement, as in the case of the Water Watch Groups use in Zambia,[7] can be very useful as an action to enhance transparency;
- Readily accessible language and terminology are also important to enhance regulatory transparency;
- Clearly articulated procedures for licensing, including interaction with stakeholders and public consultation as part of this process;
- Active use of websites for disseminating information on regulatory decisions and regular press briefings.

A set of “Guidelines for Transparency” were proposed by AFUR at its 2nd Annual Conference (March 2005, Kampala, Uganda) and are shown in box 4.

Box 4. **Guidelines for transparancy**

Concept	Tools
1. Clarity of roles	• Formally codify regulated entities’ functions in a licence/contract. • and objectives • Define regulator’s functions and duties in primary legislation or regulatory documents.
2. Predictability	• Set out in regulatory documents the tariff review procedures and methods
3. Transparency of decisions	• Place major regulatory documents in the public domain. • Make consultation responses available to the general public in full or in a summary.

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[7] Involving the community in regulating water supply and sanitation services in low-income areas, Ngabo Nankonde-Muleba, Public Relations Officer, National Water Supply and Sanitation Council (NWASCO), Zambia.

	• The regulator's comments on points raised during the consultation process should be made directly available to the regulated entities and the public.
4. Participation	• There should be compulsory or voluntary consultations on regulatory decisions or processes with regulated firms, other industry firms and consumers by means of public hearings, dissemination of draft reports for comment by stakeholders and focus groups, or meetings with representative groups.
5. Accountability	• Set out in primary legislation the rights of contract or licence-regulated entities or other stakeholders to formally challenge a regulator's decision. • Set out in primary legislation the rights of contract or licence-regulated entities or other stakeholders' right to challenge the regulator's decisions by means of an appeal or a judicial review.
6. Open access to information	• Publish an annual report (regulator and regulated entity). • Publish a website (regulator) containing: - Primary and secondary legislation - Other regulatory documents - Consultation papers - Regulatory decisions - Information for consumers

Transparency can be particularly challenging for African regulators to promote when trying to reach small end-users and consumers, particularly because these often have very limited access to information and modern communication media.

In developed countries there has been an increased emphasis on regulates and third parties contributing to, and participating in, regulatory policy and rule-making. Potential benefits of this approach are:

- Improved information flows;
- Better transparency;
- Greater accountability.

But there are disadvantages to this approach, as, for example, direct access to regulatory officials does increase the opportunity for corrupt transactions. In the United States, in an effort to maximize consultations while limiting opportunities for private manipulation of the policy-making process resulted in the practice of officially recording meetings.

Box 5. Regulatory transparency: international assessment and emerging lessons

The World Bank initiated this study of the transparency of institutions in charge of utility regulation, in order to assess current levels of regulatory transparency and formulate recommendations for improvement.

Transparency is often seen as a critical component of "good regulation" because it increases the legitimacy of regulators in the eyes of regulated operators, Government officials and customers. Indeed, increasing transparency is sometimes presented as a key reason for setting up an independent regulatory agency, on the assumption that this allows more transparent regulation than regulation by contract or through a ministerial body. However, the degree of transparency in regulation as currently observed in many jurisdictions is not always optimal. Fostering transparency in regulation therefore remains a key challenge, particularly in countries with weaker institutional endowments.

Transparency in government is increasingly demanded by private corporations and civil society groups and is a rising theme in public debate and academic literature alike. Transparency can help to prevent political capture, reduce regulatory intervention risk and discourage corruption. In the utilities sector with its long-term, large-scale and sunk investment requirements, transparency is particularly important to attract private sector investors and reassure customers.

There is little consensus on the definition of regulatory transparency. In essence, transparency allows the institution carrying out regulatory functions to operate independently (with respect to the tasks and functions over which it has discretion) whilst fostering the legitimacy of the regulatory process.

However, measures to improve transparency of the regulatory process cannot simply be imported or transferred from one regulatory system to another. Transparency requirements should instead take account of three main factors: the broader institutional and legal framework, the type of regulatory regimes and the cost and "affordability" of transparency.

The study raised a number of questions that have been highlighted by the investigation of regulatory transparency concepts and practice contained in this study. Indeed, this study should very much be seen as an initial framework for reflecting on the importance of transparency for utility regulation rather than presenting solid comparative evidence on the relative levels of transparency in different regulatory frameworks.

It is clear from this study that the understanding of regulatory transparency and its measurement is very much in its infancy when compared to initiatives taken to evaluate transparency in government in general by various institutions such as NGOs, consultancies or a multilateral organization such as the IMF. The conclusions here focus on an evaluation of the initial findings and suggestions for taking this investigation further.

Key questions identified as an outcome of this study are:

- How can regulatory transparency be measured and evaluated?
- How can regulatory transparency be fostered even in a weak institutional environment?
- Can a basic package of regulatory transparency measures be defined?
- Should Governments legislate on regulatory transparency at a national or regional level?

Source: Regulatory Transparency: International Assessment and Emerging Lessons, A Final Report for the World Bank, NERA Economic Consulting, 6th June 2005.

7.2. Communication strategy

Part of building a credible regulatory environment is establishment of good communication channels with all stakeholder groups. This means that communication should be in both directions, non-discriminatory and not unduly influence the regulator but provide useful information on stakeholder views. The key stakeholders to communicate with are the consumers, the utilities, energy companies and the government.

In Africa especially, there is a lack of awareness of the role of an energy or electricity regulator. The information about the role and activities of the regulator is often not well disseminated and this sometimes leads to incorrect perceptions by end-users (customers) that the actions of a regulator are an attempt by government to restrict their energy use or deny them the right to energy, or manipulation on the part of utilities to make higher profits.

End-users have to be informed of the benefit to them with regard to actions taken by a regulator, in particular in the case of tariff increases or energy efficiency programmes. There are a number of ways to create good information flow to the public and raise awareness and different options will be better suited to different countries. Some examples are:

- Newspaper adverts and articles;
- Radio and TV programmes and interviews;
- Periodic e-mail alerts;
- Production and distribution of booklets;
- Creation of “Energy Advice Centres” to operate at a local level.

There should be a clear procedure laid out for end-users, energy companies and utilities wishing to communicate with the regulator. There should be a possibility to communicate by telephone, e-mail, via a website and not just by letter and there should be a fixed time limit for response to enquiries. Clear and transparent procedures should be laid out for a number of situations, so that all communications are dealt with in an equitable manner and under a fixed time frame. For example the following communications should have clear procedures:

- Announcements by the regulator to the stakeholders;
- Simple communications: e.g. requests for information, answers to factual questions;
- Stakeholder consultations;
- Requests for clarifications;
- Complaints.

The role of the regulator as a communicator of changes in the energy and electricity sector and in government policy is important and should not be neglected. The regulator should either have a member of staff dedicated to this role or clearly assign communication activities to members of staff who may also have other responsibilities (i.e. include communication aspects in the staff job description).

7.3. Evaluating a regulation system

To facilitate the building of credible regulatory arrangements, the development of a regulatory "scorecard" might be considered, focused primarily on the robustness, expediency, quality and predictability of regulatory decision-making. This was among the ideas discussed at the African Forum for Utility Regulators (AFUR) at its 2nd Annual Conference (March 2005, Kampala, Uganda).

A regulatory scorecard could include:

- Extent to which regulatory decisions are published;
- Speed at which the regulator makes decisions;
- Ability (and willingness) of the regulator to procure external independent advice when required;
- Quality of the Chief Executive of regulatory agency;
- Rate of staff turnover, particularly for the Chief Executive and key managers/specialists.

A scorecard has the advantage of enabling comparison between sectors and/or countries. It could also help measure improvements. However, which indicators are chosen and how they are measured must be considered carefully. For meaningful comparisons to be possible, consistent, good quality data must be collected.

8. CONCLUSION

Effective protection of the property rights of investors and government officials operating within a framework of known legal rules are conducive to stronger economic development. However, simply transplanting Western legal and regulatory models to developing countries is often inadequate to respond to the different circumstances in these countries.

In fact, there is no “quick and easy” model that can be applied, however, there are some best practice principles emerging from international experience that can provide guidelines to governments wishing to establish regulatory agencies. These guidelines place emphasis on independence of the regulator from external influence and hence to establish credibility and transparent regulatory decisions that will foster confidence and legitimacy in the eyes of investors and consumers alike.

In the energy sector of many developing countries, the process of reform is still underway, therefore a regulatory agency’s structure must permit it to adapt effectively to changing technological and market conditions. In addition, appropriate clarity of the relationship between government and regulator is crucial to good regulation and reduction of investor risks. And, at the end of the day, there must exist the political will to allow regulators to “do their jobs”.

In setting up a regulator, there are a number of steps to be taken, including establishing its legal mandate, designing the basic values and principles with which the regulator will apply the regulatory process, establishing the core functions of the regulator and distinguishing them from the functions of government ministries, deciding on the operational structure and hiring qualified and experienced staff. Overall, a well functioning regulatory agency needs adequate resources, an appropriate legal mandate and clear agency values and operating procedures.

LEARNING OUTCOMES

Key points covered

These are the main themes covered in this module:

- The basic principles of regulation, independence, transparency and investor and consumer protection were described;
- Different models for a regulatory body were described;
- The benefits of regulating the electricity sector were outlined and the role of the regulator was described;
- An overview of setting up a regulator body was given, including design principles and questions, necessary resources, legal mandate, functions, operational structure and desirable staff skills and experience;
- Some issues involved in building a credible regulatory environment were reviewed and suggestions were made on how to evaluate a regulatory system.

Answers to review questions

Question: Describe in your own words the principles of independence, transparency and investor and consumer protection.

Answer: Regulatory autonomy or independence usually means having a regulatory body free from influence from external sources in its decision making. This often means independence or autonomy from the government but also means avoiding undue influence from the private sector and consumers.

Transparency means transparent regulatory decision-making and robustness, expediency, quality and predictability of regulatory decision-making.

A key element of the regulator's role is striking the balance between encouraging investors and protecting consumers, while fulfilling government objectives. The regulator should ensure that both suppliers and consumers uphold their obligations relating to commercial operations. The utility has the obligation (via licensing) to provide services under the approved tariffs and quality standards. Consumers have an obligation to pay for services supplied to ensure the financial viability of the sector.

Question: List the main reasons why regulation is important in the electricity sector.

Answer:

- To constrain the exercise of monopoly power by incumbent suppliers;
- To provide incentives for operating efficiency and quality of service;
- To optimize the structure of the sector;
- To promote least-cost system expansion (with private capital invested in independent power producers—IPPs);
- To stimulate energy conservation and R&D.

Question: What are the main functions of a regulator?

Answer:

- Issuing licences related to regulatory functions;
- Setting performance standards;
- Monitoring the performance of regulated firms;
- Establishing the level and structure of tariffs;
- Establishing a uniform accounting system;
- Arbitrating disputes among stakeholders;
- Performing (usually via independent consultancy) management audits on regulated firms;
- Developing human resources for the IRC;
- Reporting sector and IRC activities to the appropriate government authority.

Exercises

1. What ways are there for a regulator to ensure regulatory transparency? (Half a page)
2. Describe the level of regulatory transparency in the energy sector in your country as you perceive it. What measures could the regulator take to increase transparency? (1-2 page essay).

Presentation/suggested discussion topics

Presentation:

ENERGY REGULATION – Module 6: Structure, composition and role of an energy regulator

Suggested discussion topics:

1. The three main principles of regulation are independence, transparency and investor and consumer protection. In your opinion which is the most important of these?
2. An independent regulator body is preferable to regulation by government. Discuss.

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Survival Guide for the independent Regulator, M. A. Jamison, Public Utility Research Center, University of Florida, November 2004

Enhancing Transparency and Credibility of the Regulatory Process, International Training Program on Utility Regulation and Strategy, Country Experience with Competition, Session 31, January 2002, presented by M. H. Au

Regulatory Transparency: International Assessment and Emerging Lessons, A Final Report for the World Bank, NERA Economic Consulting, 6th June 2005

Information disclosure and policy influence, S. V. Berg, PURC, University of Florida, International Training Program on Utility Regulation and Strategy, June 1999

INTERNET RESOURCES

Public Utility Research Center: www.purc.ufl.edu

National Water Supply and Sanitation Council (NWASCO), Zambia:
www.zambia-water.org.zm/nwasco/admin/consumer/user/details.php?id=1

Centre on Regulation and Competition: www.competition-regulation.org.uk/index.shtml

African Forum of Utility Regulators: www1.worldbank.org/afur/resources-e.html

Zambia Energy Regulation Board: www.erb.org.zm/home.htm

The New Zealand Electricity Commission: www.electricitycommission.govt.nz

World Energy Council: www.worldenergy.org/wec-geis/default.asp

Ghana Energy Commission: www.energycom.gov.gh

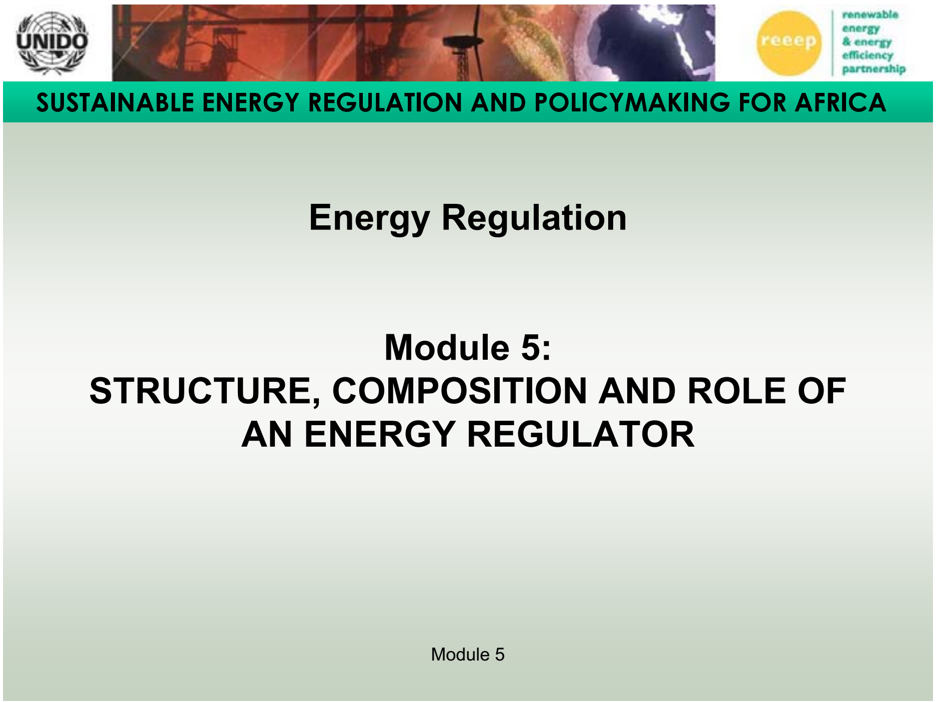
Australian Competition and Consumer Commission:
www.accc.gov.au/content/index.phtml/itemId/142

GLOSSARY/DEFINITION OF KEY CONCEPTS

Licensing	A licensing regime is a regulatory instrument which controls entry into the market of new suppliers.
Market power	The ability of a company or group of companies to exert control over a market such that the quantity of goods available in the market or the price of goods is impacted. Monopolies, oligopolies and monopsonies are all typified by companies who can exert market power.
Monopoly	The situation wherein one company has the market power to control the price or availability of a good or service. If this is unregulated, the company is likely to produce fewer goods or to sell goods more expensively than would be the case in a competitive environment. In practice, a monopoly may refer to an industry where one company has power to control the sector regardless of other companies or it may refer to a sector where only one company exists. It should be noted that outside natural monopolies, few monopolies are absolute and that even dominant companies may be subject to pressures on their price setting or limiting of supply. The effects of monopoly, including natural monopoly, on welfare can be limited by appropriate regulation.
Monopsony	A market where a single consumer of a service or good has sufficient market power to dictate the price of that good or service. One example of such a situation can occur in the electricity sector if the sector has only one main buyer of electricity.
Oligopoly	Oligopoly occurs when a number of firms dominate the market for a service or good and effectively act to maintain prices at a higher level than would be likely to occur through competition, effectively mimicking a monopoly. Oligopolies may form as a result of outright collusion, as with the formation of a cartel or may be more informal, as with the adoption of non-price competition, wherein companies in the oligopoly compete on factors other than price in order to avoid margin reducing price wars.
Regulatory independence	Regulatory independence or autonomy, usually means having a regulatory body free from influence from external sources in its decision making. Generally, this means keeping relationships with operators, consumers, private interests and political authorities appropriately formal and ensuring organisational autonomy with respect to the government.
Regulatory risk	A risk to businesses that changes in regulation will have a negative impact on their operation. Where governments and regulators raise regulatory risk, they are likely to come under pressure to allot some form of compensation to companies who suffer as a result of regulation in order to ensure that future investment is not discouraged.

Transparency

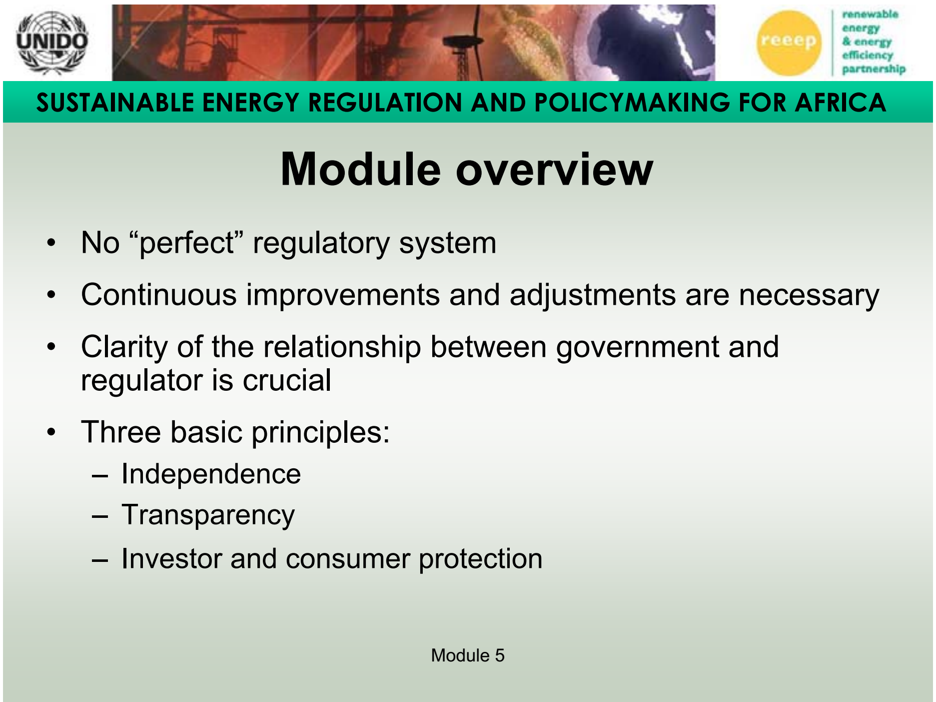
Transparency means robustness, expediency, quality and predictability of regulatory decision-making. Tools and measures that foster confidence in and understanding of the regulatory processes and decisions by all stakeholders should be put in place to aid transparency of decision-making by the regulator.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Regulation

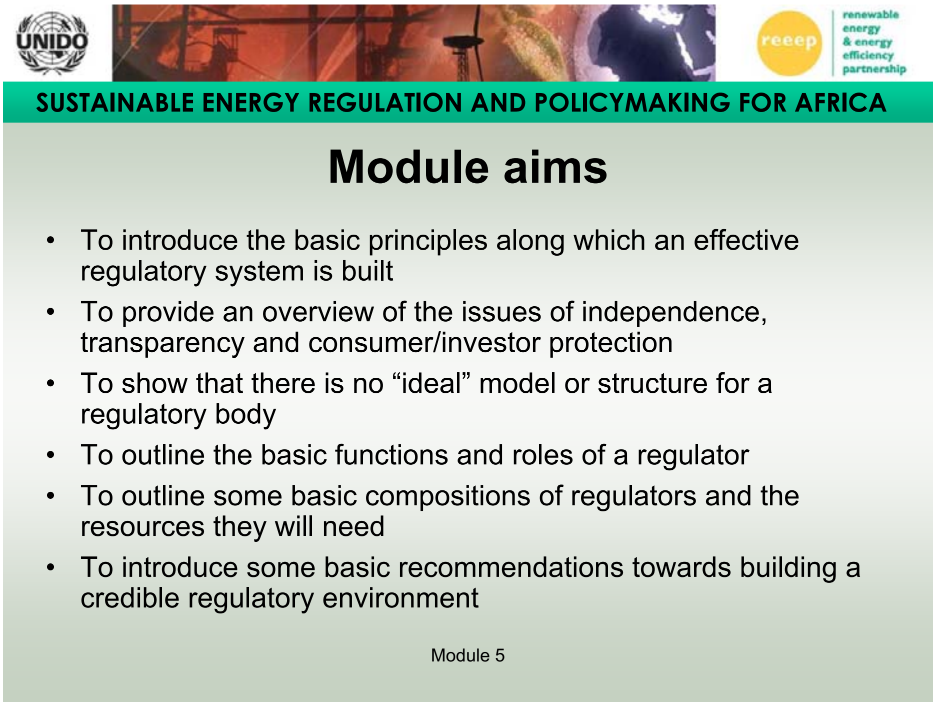
Module 5:
STRUCTURE, COMPOSITION AND ROLE OF AN ENERGY REGULATOR



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- No “perfect” regulatory system
- Continuous improvements and adjustments are necessary
- Clarity of the relationship between government and regulator is crucial
- Three basic principles:
  - Independence
  - Transparency
  - Investor and consumer protection

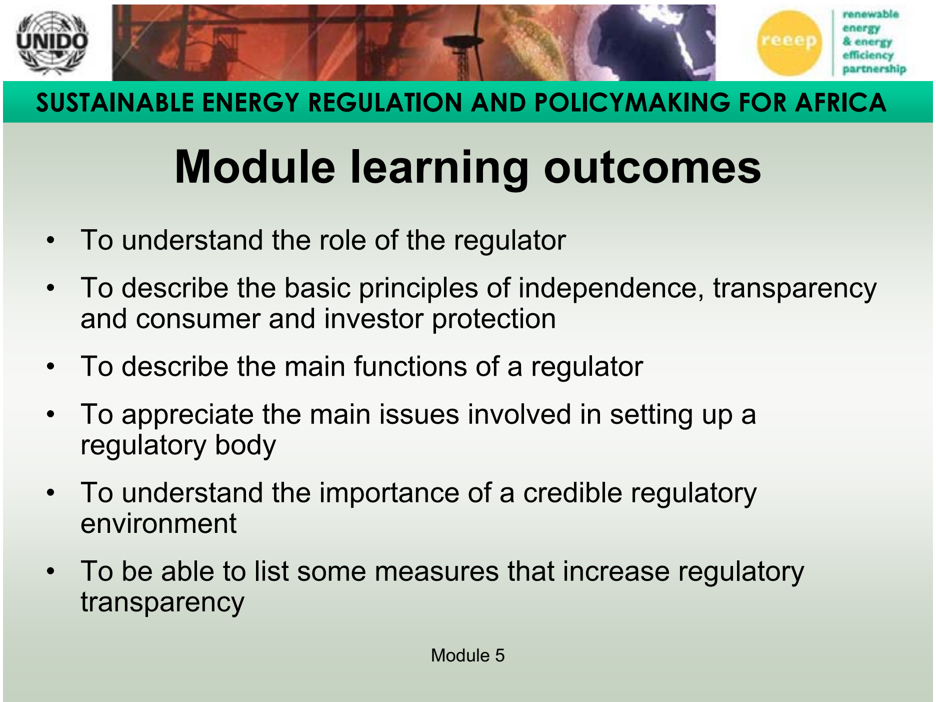


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To introduce the basic principles along which an effective regulatory system is built
- To provide an overview of the issues of independence, transparency and consumer/investor protection
- To show that there is no “ideal” model or structure for a regulatory body
- To outline the basic functions and roles of a regulator
- To outline some basic compositions of regulators and the resources they will need
- To introduce some basic recommendations towards building a credible regulatory environment

Module 5

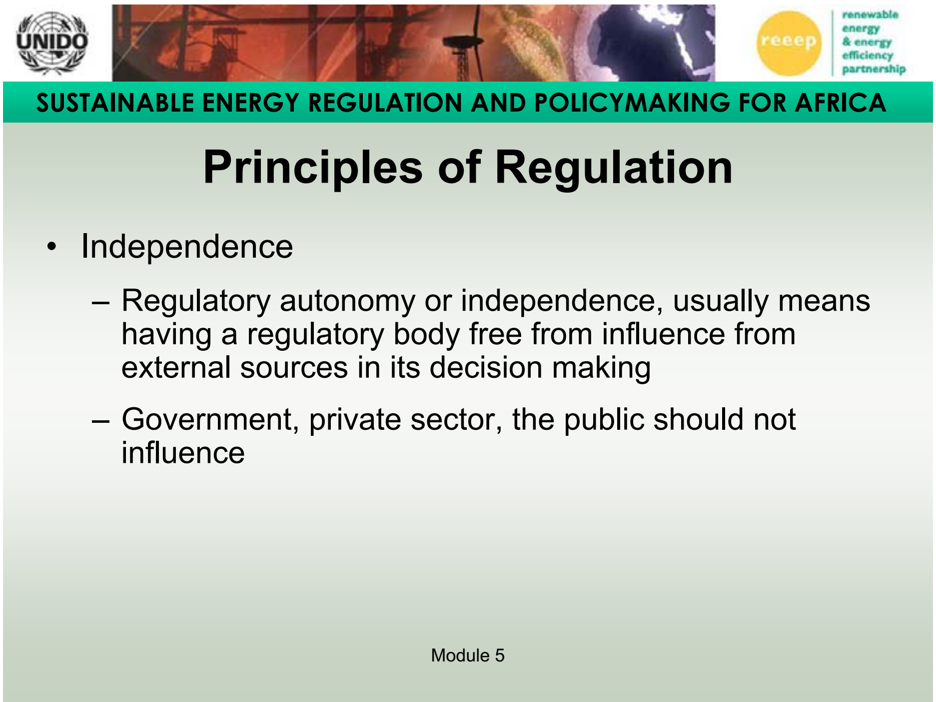


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To understand the role of the regulator
- To describe the basic principles of independence, transparency and consumer and investor protection
- To describe the main functions of a regulator
- To appreciate the main issues involved in setting up a regulatory body
- To understand the importance of a credible regulatory environment
- To be able to list some measures that increase regulatory transparency

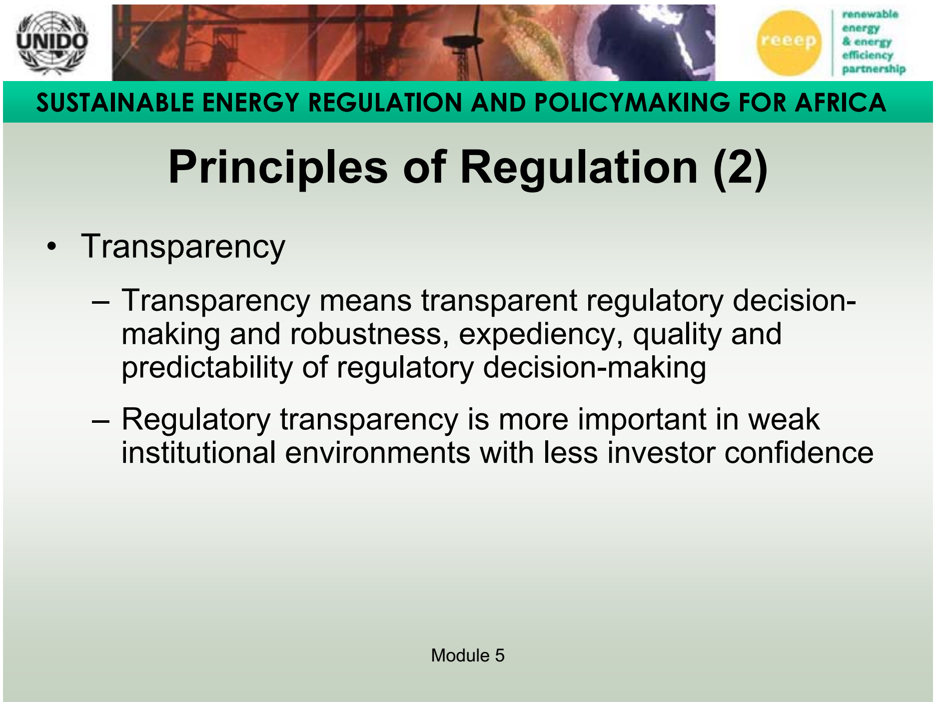
Module 5



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Principles of Regulation

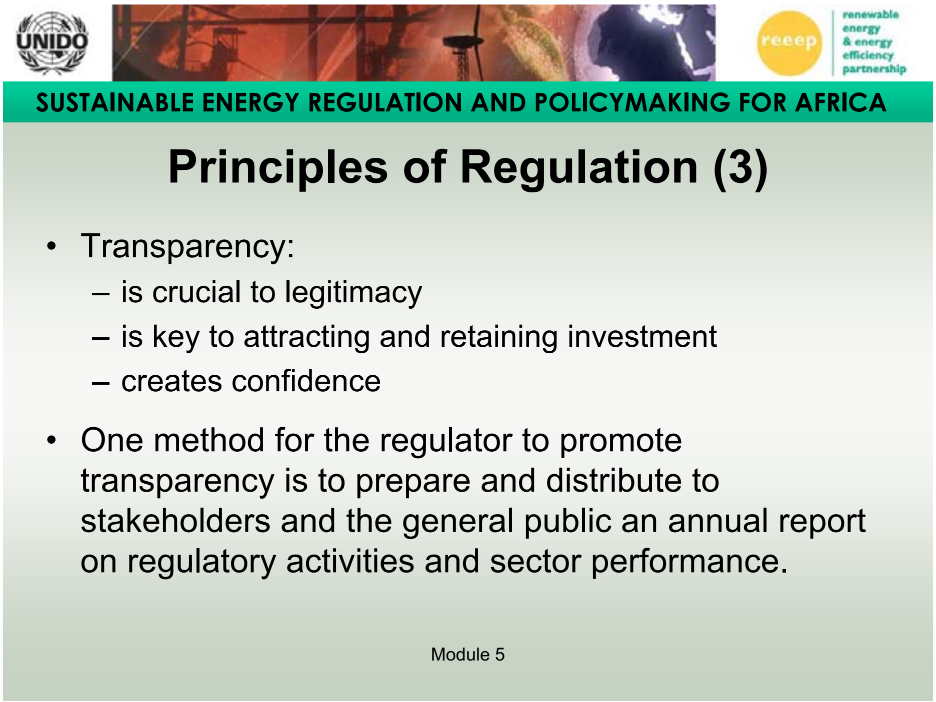
- Independence
  - Regulatory autonomy or independence, usually means having a regulatory body free from influence from external sources in its decision making
  - Government, private sector, the public should not influence



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Principles of Regulation (2)

- Transparency
  - Transparency means transparent regulatory decision-making and robustness, expediency, quality and predictability of regulatory decision-making
  - Regulatory transparency is more important in weak institutional environments with less investor confidence

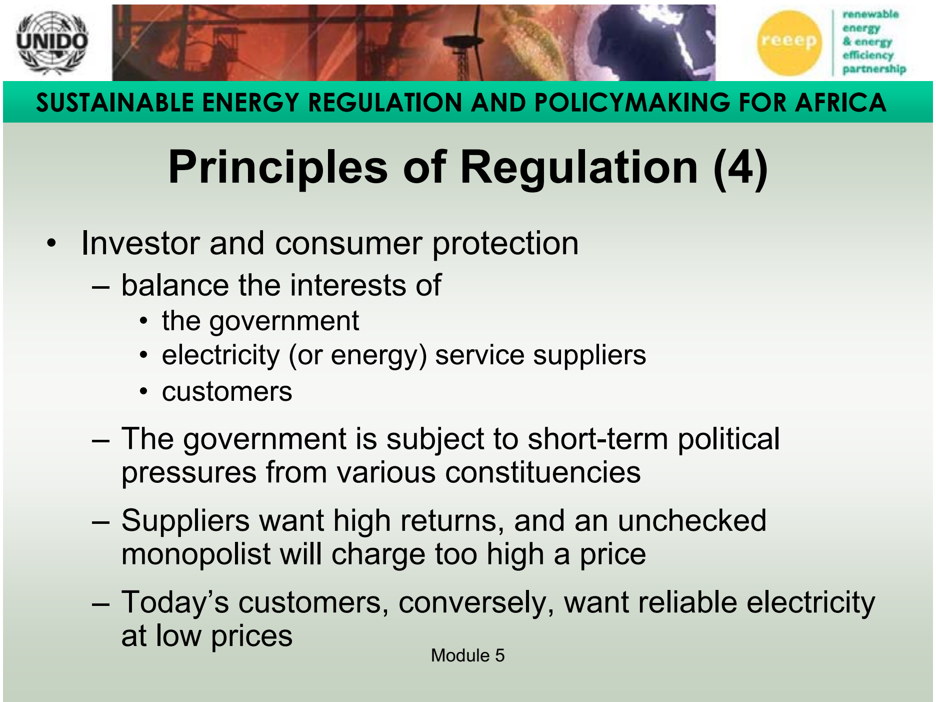


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Principles of Regulation (3)

- Transparency:
  - is crucial to legitimacy
  - is key to attracting and retaining investment
  - creates confidence
- One method for the regulator to promote transparency is to prepare and distribute to stakeholders and the general public an annual report on regulatory activities and sector performance.

Module 5

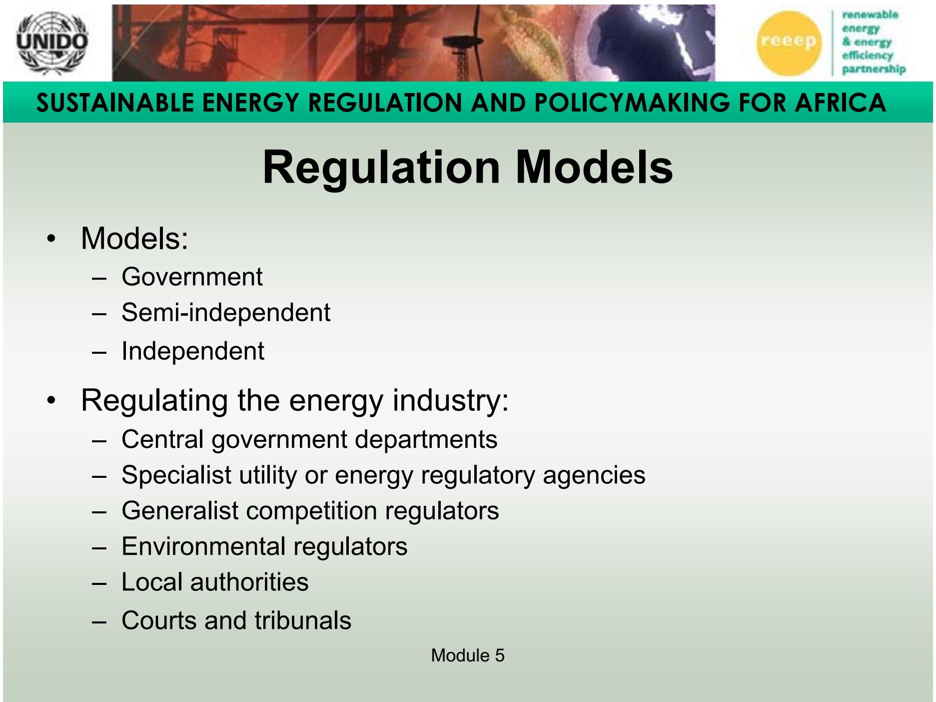


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Principles of Regulation (4)

- Investor and consumer protection
  - balance the interests of
    - the government
    - electricity (or energy) service suppliers
    - customers
  - The government is subject to short-term political pressures from various constituencies
  - Suppliers want high returns, and an unchecked monopolist will charge too high a price
  - Today’s customers, conversely, want reliable electricity at low prices

Module 5

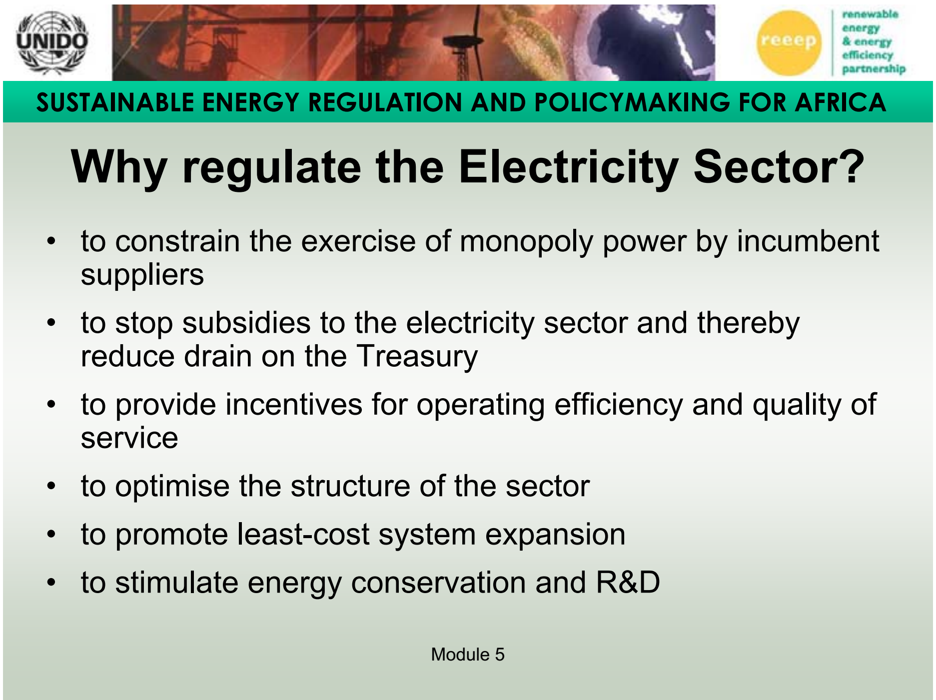


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulation Models

- Models:
  - Government
  - Semi-independent
  - Independent
- Regulating the energy industry:
  - Central government departments
  - Specialist utility or energy regulatory agencies
  - Generalist competition regulators
  - Environmental regulators
  - Local authorities
  - Courts and tribunals

Module 5

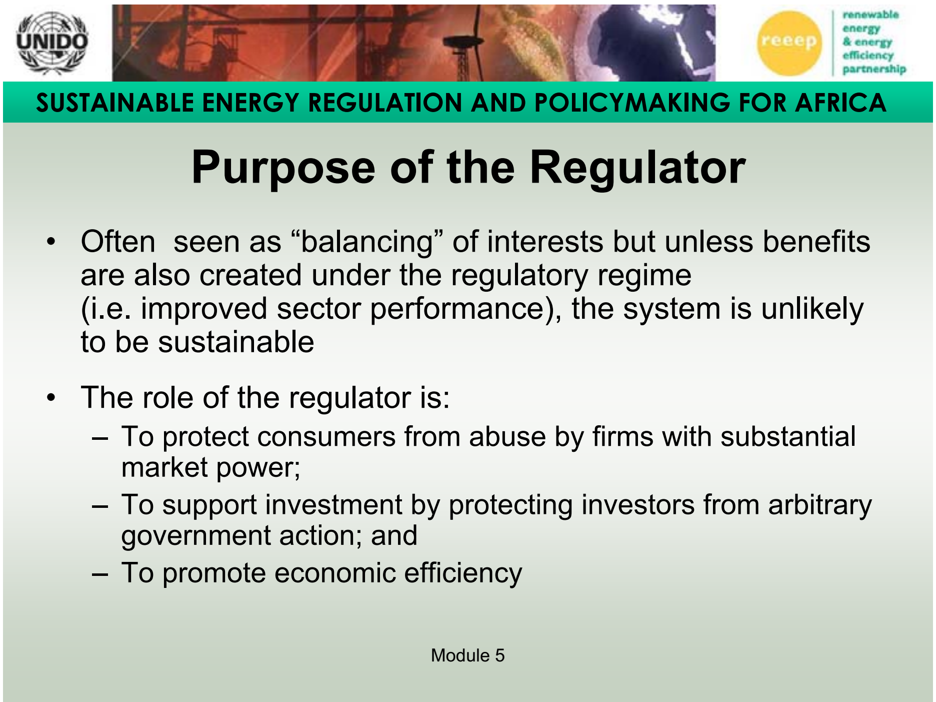


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why regulate the Electricity Sector?

- to constrain the exercise of monopoly power by incumbent suppliers
- to stop subsidies to the electricity sector and thereby reduce drain on the Treasury
- to provide incentives for operating efficiency and quality of service
- to optimise the structure of the sector
- to promote least-cost system expansion
- to stimulate energy conservation and R&D

Module 5



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Purpose of the Regulator

- Often seen as “balancing” of interests but unless benefits are also created under the regulatory regime (i.e. improved sector performance), the system is unlikely to be sustainable
- The role of the regulator is:
  - To protect consumers from abuse by firms with substantial market power;
  - To support investment by protecting investors from arbitrary government action; and
  - To promote economic efficiency

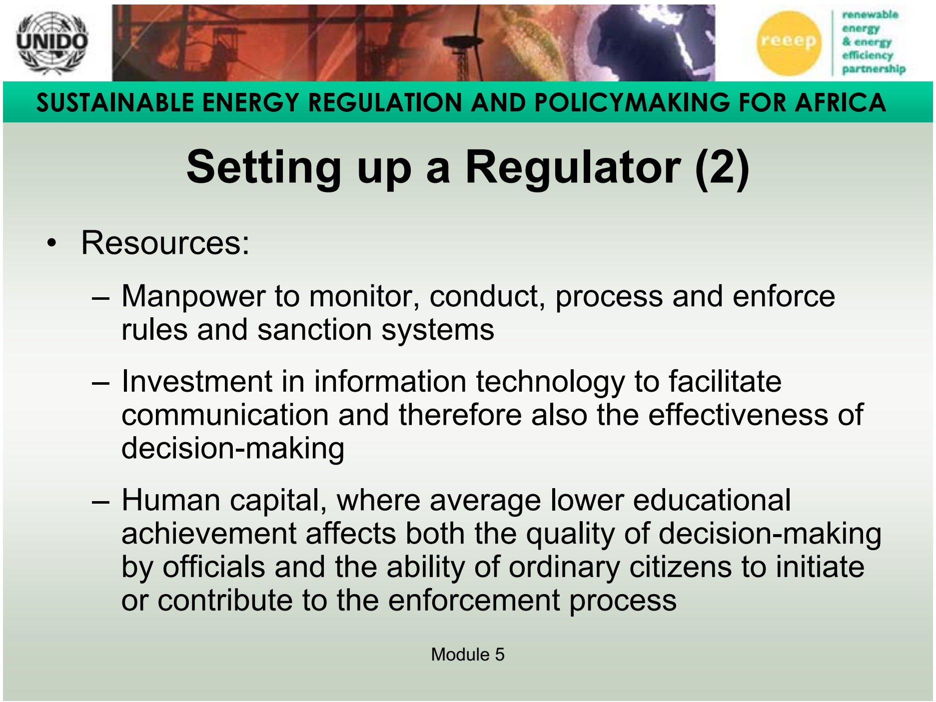
Module 5

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Setting up a Regulator

- A well functioning regulatory agency needs :
  - adequate resources
  - an appropriate legal mandate
  - clear agency values and operating procedures

Module 5

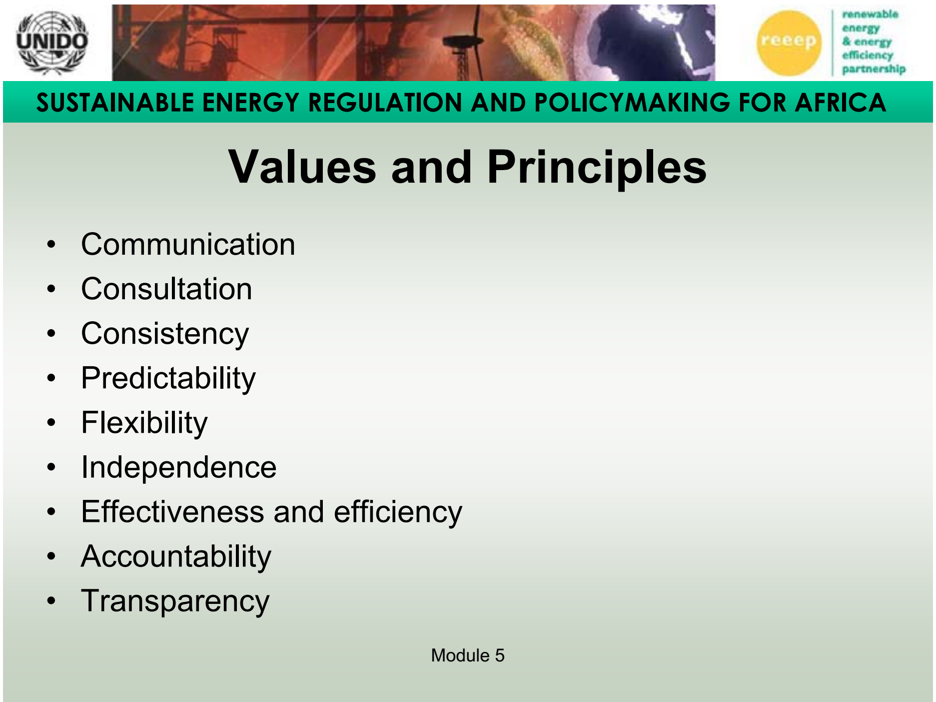


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Setting up a Regulator (2)

- Resources:
  - Manpower to monitor, conduct, process and enforce rules and sanction systems
  - Investment in information technology to facilitate communication and therefore also the effectiveness of decision-making
  - Human capital, where average lower educational achievement affects both the quality of decision-making by officials and the ability of ordinary citizens to initiate or contribute to the enforcement process

Module 5

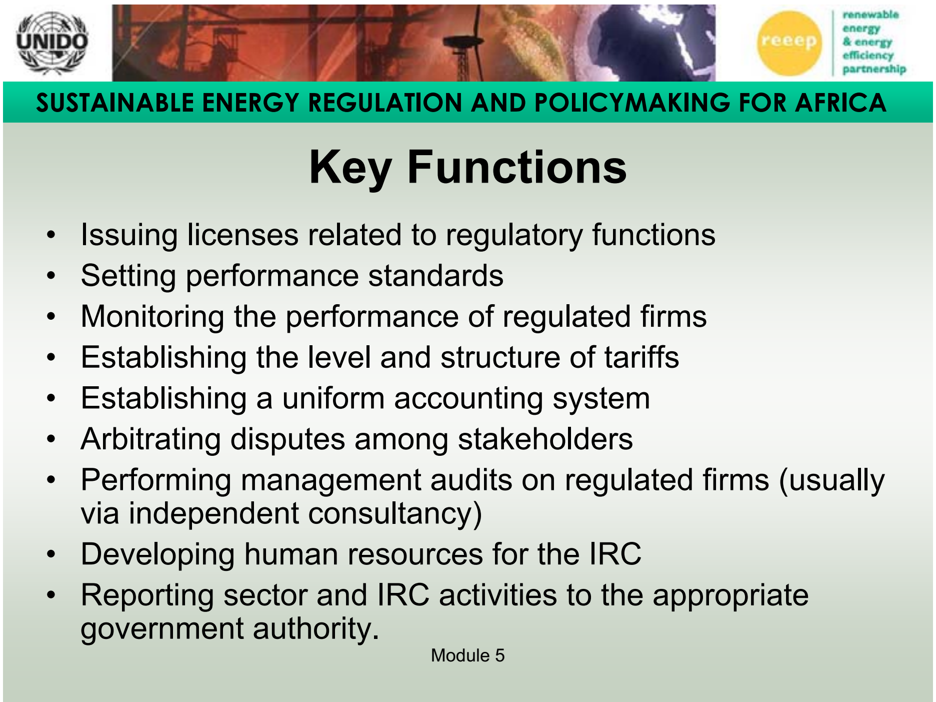


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Values and Principles

- Communication
- Consultation
- Consistency
- Predictability
- Flexibility
- Independence
- Effectiveness and efficiency
- Accountability
- Transparency

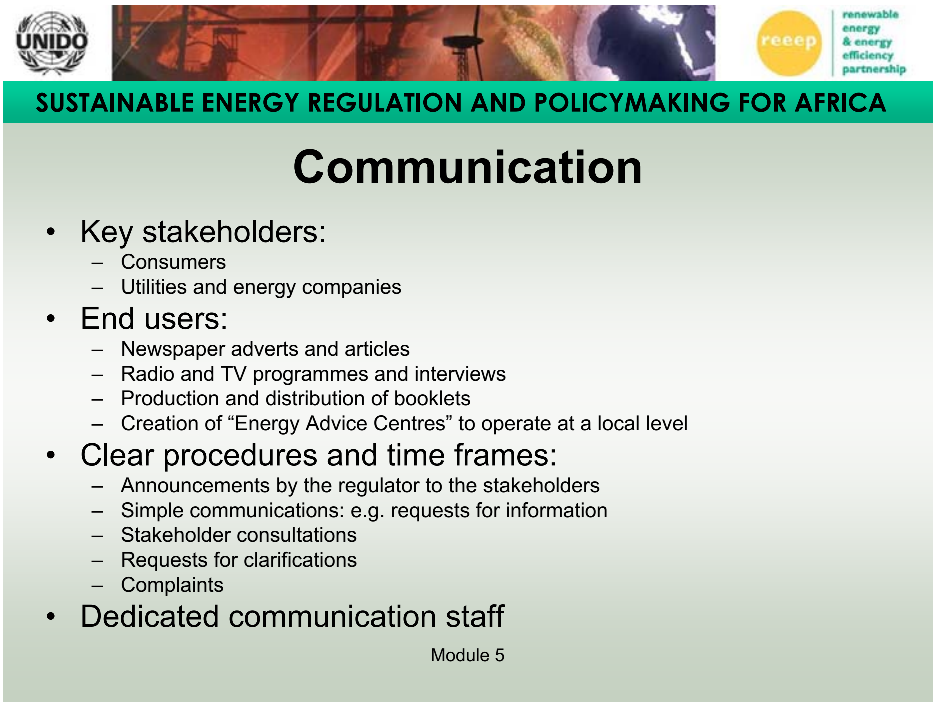
Module 5



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Key Functions

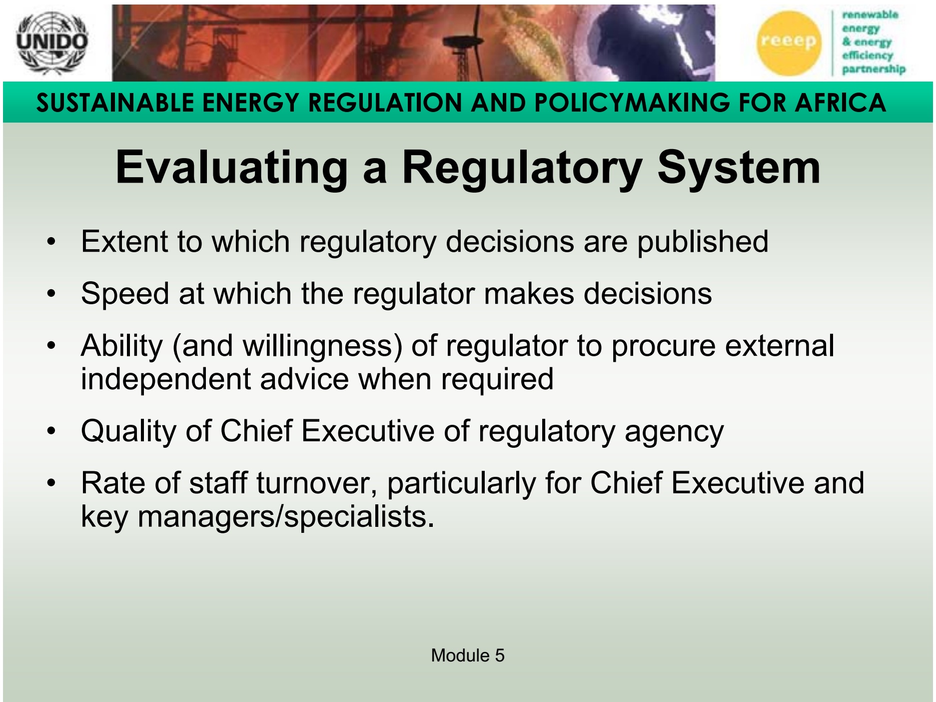
- Issuing licenses related to regulatory functions
- Setting performance standards
- Monitoring the performance of regulated firms
- Establishing the level and structure of tariffs
- Establishing a uniform accounting system
- Arbitrating disputes among stakeholders
- Performing management audits on regulated firms (usually via independent consultancy)
- Developing human resources for the IRC
- Reporting sector and IRC activities to the appropriate government authority.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Communication

- Key stakeholders:
  - Consumers
  - Utilities and energy companies
- End users:
  - Newspaper adverts and articles
  - Radio and TV programmes and interviews
  - Production and distribution of booklets
  - Creation of “Energy Advice Centres” to operate at a local level
- Clear procedures and time frames:
  - Announcements by the regulator to the stakeholders
  - Simple communications: e.g. requests for information
  - Stakeholder consultations
  - Requests for clarifications
  - Complaints
- Dedicated communication staff

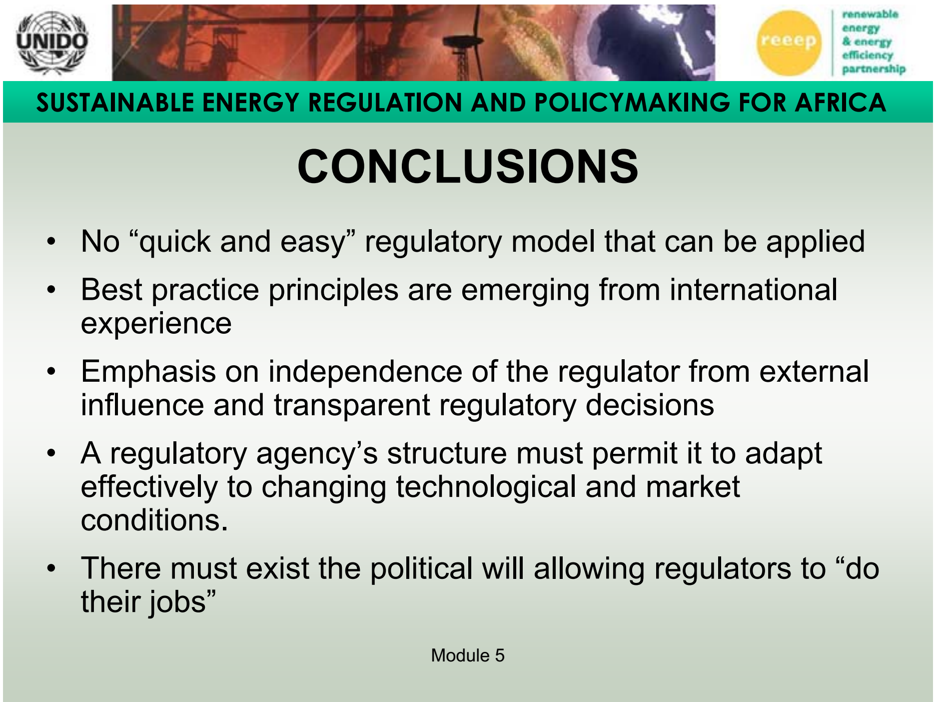


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Evaluating a Regulatory System

- Extent to which regulatory decisions are published
- Speed at which the regulator makes decisions
- Ability (and willingness) of regulator to procure external independent advice when required
- Quality of Chief Executive of regulatory agency
- Rate of staff turnover, particularly for Chief Executive and key managers/specialists.

Module 5



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- No “quick and easy” regulatory model that can be applied
- Best practice principles are emerging from international experience
- Emphasis on independence of the regulator from external influence and transparent regulatory decisions
- A regulatory agency’s structure must permit it to adapt effectively to changing technological and market conditions.
- There must exist the political will allowing regulators to “do their jobs”

Module 5

Module 6

Formulating regulatory scenarios and national self-assessment

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This module focuses on the design of the regulatory framework, with special emphasis paid to the implementation of institutions to foster sustainable energy in developing countries.[1] It provides tools to evaluate the situation in a country and how to identify gaps and barriers for rural electrification and energy efficiency. It aims to enable decision-makers to prioritize measures and implement institutions and policies that increase the generation of electricity in a sustainable way both financially, politically and environmentally.

1.2. Module aims

This module aims to:

- Provide an overview of the current situation and sustainable energy options for African states.
- Give insight on institutional content and processes with regard to sustainable energy.
- Enable an assessment to be made of levels of sector reform, and the policy and framework in a given country.
- Give design elements and suggest options for the integration of sustainable energy.

1.3. Module learning outcomes

Participants should take from this module:

- An understanding of the link between institutions, policies, regulations and sustainable energy.
- Explicit guidelines to foster sustainable energy.
- Tools to evaluate the situation in their country.
- Inspiration to develop a comprehensive sustainable strategy for a given country.

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[1] This module will focus mainly on electricity generation and savings.

2. INTRODUCTION

The different sections of the module briefly recall some of the most important points raised by the previous modules and provide a brief overview of the history of the reforms that have taken place in the electricity sector, emphasizing the role of institutions and specific policies to promote sustainable energy. Specifically the differences between developed countries and developing countries are explained, and some examples from the developing world are presented.

It has to be kept in mind that the process of (de)regulation cannot in itself guarantee that an existing energy system will be the most efficient and sustainable one. It is indeed very likely that it will not be, especially in the African context. Therefore, appropriate policies and frameworks need to be put in place.

The module contents primarily serve as guidance for the self-assessment tools which are referred to throughout the module. These tools will enable participants to evaluate the level of reforms in a country, taking into account its specific context. In this module, readers are asked to evaluate the situation in their home country using a checklist of possible measures. The checklist is meant as a first-step basic evaluation tool only as the institutions and policies for sustainable energy will obviously not be the same for all the countries. The checklist should provide a mechanism with which to evaluate the prevailing national sustainable energy regulation and policy situation in a given country and aid the process of further developing such regulations and policies.

The self-assessment tool consists of four questionnaires, the first of which assesses the current status of the power sector in a given country. The next questionnaire looks into the energy regulatory framework in general, and the final two go into more detail with regard to the renewable energy and energy efficiency measures respectively.

The completion of each questionnaire automatically generates a results page which allows for a quick interpretation of the national situation, and which includes more detailed exercises wherever relevant.

Overall these tools will help to identify the major gaps in the current policy and regulatory framework, providing ideas and suggestions on how to create a bias towards renewable energy and energy efficiency.

3. POWER SECTOR REFORM

Before going into the self-assessment exercise the following section provides introductory information on the experiences in the European context and the possible future for power sectors in Africa.

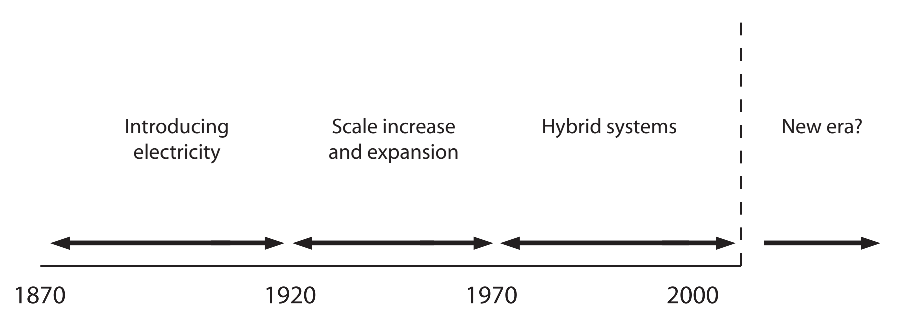
More background information can be found in module 4 “The reform of the power sector in Africa”.

3.1. The move from centralized to decentralized energy systems in Europe

There have been four eras in the development of the electricity supply system in Europe (see figure 1). These are:

- An era of decentralized generation (1870-1920)
- An era of centralized generation (1920-1960)
- An era of a hybrid system (1960-2000)
- A new era of decentralized generation (2000-...)

Figure I. The eras of electricity supply structure in Europe



Source: SUSTELNET, 2002

In terms of scale, European countries have been through a three-staged process from small-scale distributed generation to large-scale centralized generation and are now looking again at the merits of distributed generation.

For African countries with low rates of electrification and low economies of density, there is an opportunity to move directly, in some areas, from the first to the third stage of electrification. To do this they will be required to multiply the use of stand-alone systems for their scattered populations. This would allow for more flexibility than the extension of the grid, as potential systems can be upgraded according to the needs of the users.

Distributed generation in African countries is and will remain quite different from that in European countries. In the latter, connected local systems are complementary to the grid; in African countries stand-alone systems are and probably will remain for a long time to come the only sources of electricity for isolated populations.

The search for economies of scale no longer seems to be the only driving force for the electricity generation market. Economies of scale are not considered as important as they used to be, owing to technological progress.

Centralized electricity generation systems are the product of the socio-technical context of the decades in which electrification took place in Europe and other parts of the developed world in the last century. It does not seem necessary for new systems to be developed in the same manner since the context has changed.

Firstly, electricity generation from big power plants with traditional sources such as coal, oil or gas, require high initial levels of investment. These sources emit CO_2 into the atmosphere and contribute to global warming. Secondly, transmitting electricity over long distances might not be the best solution, since building transmission networks is costly and also transmission losses, which are seldom negligible, have to be taken into account.

In some developing countries, especially in Africa, the connection of households in rural areas to the grid remains largely hypothetical even in the very long-term and this is mainly attributable to demographic dispersion and the lack of financial resources. In fact, on the African continent less than 8 per cent of the population living in rural areas has access to electricity.

Planners are aware that the rate of electrification in Africa is not likely to increase significantly if the same development models are used. In fact, at the rate of electrification during the last decade, it would take more than 80 years to electrify sub-Saharan Africa (IEA, 2002). Renewable sources of electricity could provide affordable and “clean” sources of electricity in the future. More specifically they could make a substantial contribution to meeting the current needs of developing countries for off-grid or mini-grid generation in remote areas.

Rather than fixed investments for large-scale projects, investments for small-scale renewable systems are more flexible and easily adaptable to demand. These systems can be established close to where the demand is, which means that costly transmission networks are not needed.

Today the establishment of enough small-scale renewable electricity generating plants to contribute to a significant proportion of total installed capacity is feasible because of the considerable reduction in costs. Renewable energies like solar photovoltaic systems are fully operational and can often compete with conventional sources of energy in terms of cost in remote areas. The current trend towards establishing centralized electricity generating systems in developing countries is a legacy of the developed world. It has less relevance today owing to changes in the technological context, which allow for the follow-up or even the remote control of renewable energy systems.

Established financial and institutional practices, as well as political interests can nevertheless marginalize renewable sources of electricity. International and national institutions still provide large amounts of funding for conventional sources of electricity generation, as these are often easier to implement and thus can better meet budgeting timetables than small-scale newer renewable technologies. New mechanisms, policy approaches and/ or institutions will therefore often be required to support the large-scale utilization of newer technologies.

3.2. Self assessment of the power sector in your country

Exercises

1. Please read first the sections “3.2.1 Level of competition and unbundling” and “3.2.2 Electricity Law Amendment”, as these will provide guidance on how to interpret the results of the questionnaire as well as inspiration on the way forward.
2. Please complete the questionnaire on Power Sector Reform in annex II of this module (See excel-sheet “Complete Power Sector Reform”).
3. Based on the results (See excel-sheet “Check your results”) think of an appropriate way for the power sector in your country to develop and transform.
4. Write a 1,500 word essay outlining the way forward for your country.

Level of competition and unbundling

The matrix used for this self-evaluation represents potential paths for electricity reforms (Hunt and Shuttleworth, 1996 in Turkson J.K., 2000).

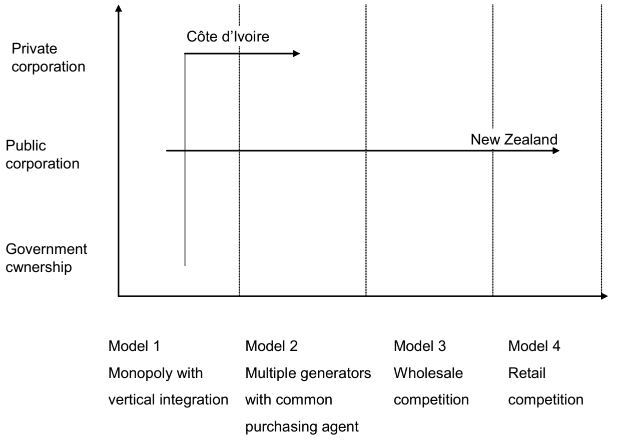
The horizontal axis represents the level of competition on the market:

- Model 1: No competition. Utilities are vertically integrated from generation-transmission-distribution to the end-users.
- Model 2: Competition between generators but with one purchasing agent who has the monopoly over transmission and distribution networks and over sales to the end-users.
- Model 3: Competition between generators. Open access to the transmission network. Several distribution companies are able to buy directly from a producer. Distribution companies keep a monopoly over end-users.
- Model 4: Competition between generators. Open access to the transmission network. Several distribution companies can buy directly from a producer. Distribution is separate from retail activity. End-users are able to choose their supplier.

The vertical axis represents the change of ownership:

- Government ownership (administration following public accountancy rules)
- Public corporation (corporation state owned but a commercial logic and financial autonomy)
- Private enterprises

Figure II. Various paths for electricity reforms



Source: Hunt and Shuttleworth, 1996, in Turkson J.K., 2000

Electricity law amendment

In most African countries the Electricity Law is the principal instrument outlining the legal and regulatory framework, and amendments generally have to pass the National Parliament or Assembly. Typical amendments include:

- Removing the monopoly of the national utility;
- The establishment of a (independent) regulatory body, including its role and responsibilities;
- Create a provision for a rural electrification or renewable energy programme or fund.

4. REGULATORY FRAMEWORK

Before going into the self assessment exercise the following section provides a quick summary of the roles of a regulator and principles for good regulation.

More background information and African examples can be found in module 3 “Introduction to Energy Regulation”.

4.1. Regulatory coverage

The principal roles for the regulator include:

- To ensure free and fair competition within the sector: The regulator must ensure that companies do not abuse their strong position, for example by making it difficult for new companies to enter the market. This role usually includes carrying out the liberalization policy and monitoring the power sector reforms process.
- Protect customers, industry and government interests: One of the key challenges of energy regulators lies in striking a balance between the interests of domestic and non-domestic customers, the industry and the government. Energy regulators must work to protect companies and individuals from the discretionary power of the state and act as referees in case of conflicts.
- Energy planning: what are the future power needs for a country and how can these best be addressed. The socio-economic comparison of the most efficient technology should take into account not only its immediate financial costs, but also its longer term socio-economic potential, and its social and environmental impact. To be able to make these comparisons, most regulators have economic, technical, social and environmental competences.
- Licensing;
- Develop standards/codes of good practice;
- Tariff setting;
- Consumer complaints;
- Manage support system for RE/EE;
- Provide social services, e.g. equal access to minimum energy services for everybody in society.

Splitting regulatory functions between different institutions and government departments tends to compartmentalize the decision-making processes, thereby preventing any long-term integrated planning. It therefore makes sense to make the regulatory body responsible for all main sources of energy. What these “main sources of energy" are varies at regional level and also sometimes at the country-level. For instance in Europe regulatory bodies usually cover the markets for electricity and gas (as being the main energy sources in use) and increasingly include renewable energy and/or energy efficiency.

The situation of African countries is quite different though, as traditional sources of energy (like wood fuel) are still used and will most probably be used for quite a long period.

The tendency of regulatory bodies in Africa is to focus only on "modern" sources of energy like electricity and gas, but there is a strong case to include other energy sources with an important share in the national fuel mix (e.g. wood fuel). Moreover, whereas the focus of energy systems in most European countries is clearly grid-connected, most African countries face challenges both in urban environments and even more in off grid in rural and remote areas. Accordingly both require differentiated regulatory approaches.

Common agencies and responsibilities to be incorporated in or supervised by the regulatory body include:

- Rural electrification agencies and or rural electrification service companies (RESCOs);
- Renewable energy agencies;
- Energy efficiency agencies and/or energy service companies (ESCOs);
- Entity in charge of grid-extension planning.

Zambia provides a particularly good example of a dedicated energy regulator—the Zambian Energy Regulation Board.[2]

4.2. Principles of good regulation

Key characteristics of a good regulatory framework include:

- Transparency and simplicity: mean that processes and procedures should provide clear information and enable the participation of stakeholders. Access to transcripts, record keeping and the publication of reports and public meetings help improve and maintain credibility of energy regulators. Their language should be simple and understandable;[3]

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[2] For a detailed account of the Zambian Energy Regulation Board, the reader should refer to module 5, case study 1.

[3] Extract from a draft guidelines for energy regulation and regulatory practice by the Programme Committee of the World Forum on Energy Regulation. October 2003.

- Stability is often used in the regulatory context to signify certainty or predictability regarding standards. Stability is strongly tied to effective management and that in turn means accountability and communication. Managing with accountability means knowing who is responsible for what, up and down the chain of command, and acting accordingly on that knowledge;[4]
- Coherence of regulatory reforms against the risk of fragmentation completes the principles of transparency, simplicity and stability;
- Sustainability: the aim of regulation is not just to introduce competition to improve financial efficiency, but also to improve the sustainability of energy policies. This means that the regulatory framework takes into account socio-economic and longer-term development goals. The tension between conventional and sustainable sources of energy has to be approached with an open mind: there is no technology that can be considered as absolutely ideal in the perspective of the promotion of sustainable development, and different situations will require different solutions. To avoid bias or prejudice towards given energy sources, the decision-making process should include staff with a broad range of technological knowledge, including on renewable energy technologies and energy efficiency systems.

4.3. Self-assessment of the regulatory framework in your country

Exercises

1. Complete the Questionnaire on the Regulatory Framework in annex III of this module (See annex III - excel-sheet “Complete Regulation”). The score which is calculated (See annex III - excel-sheet “Check result Regulation”) gives a rough indication of the performance of the regulatory body in your country in covering the key relevant areas in the energy sector. Note that this score is indicative only on the "coverage" (yes/no) of these key areas, but not on the "quality" of this coverage, as this would require further performance analysis
2. Carry out the two exercises mentioned in annex III - excel-sheet “Check result Regulation”.

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[4] Extract from the speech of the Chairman Nils J. Diaz, NRC Regulatory Information Conference, Washington, D.C, March 8, 2005.

5. INTEGRATING RENEWABLE ENERGY IN THE REGULATORY FRAMEWORK

The following sections will outline the key issues to address with regards to renewable energy and how to integrate these into the reform process and the regulatory framework.

Options and examples are provided as an introduction for the self assessment tool on renewable energy which is in annex III of this module and which aims to assess the legal and regulatory framework in a particular country from a renewable energy perspective. It is therefore recommended to read the following sections 5.1 to 5.5 first, before completing the questionnaire on renewable energy. Once completed additional guidance is provided in section 5.6 to help interpret the results.

This approach should allow readers to determine where a given country is in terms of regulations and policies designed to promote renewable energy and—in section 6—energy efficiency. It should also allow readers to judge how the situation in the country can develop based on an evaluation of the national situation.

The following paragraphs are meant to provide guidance and inspiration when completing the self-assessment exercise to evaluate the existing situation and fill any gaps identified.

5.1. The legacy of the old institutional systems

To understand the barriers that prevent the wider adoption of renewable sources of electricity generation, one has also to look at the institutional configurations that have resulted from the development of electricity systems elsewhere.

Public policymakers tend to favour large-scale investments, which provide electricity access to urban areas as a priority. Due to population density, it is simpler and cheaper to connect inhabitants of urban areas than rural areas. The lack of financial resources leads to priority being given to connecting urban areas using conventional sources of electricity generation. In fact, evidence shows that the financial system is reluctant to finance projects using technologies that are still perceived (often wrongly) to be unproven or more risky.

The lack of long-term strategies for the promotion of renewable energy and energy efficiency seems to be common in many African countries. The current strategies continue to favour conventional energy systems (often through state subsidies), even when they are more costly and polluting in the long term, making it virtually im possible for renewable energies to compete because all the costs have to be borne by the end-users while conventional energies are heavily subsidized by the state.

Reforms that aim to introduce more competition can foster the development of small-scale generation and open access for small-scale renewable generators (e.g. to distribution networks).

However, reforms can provide companies with incentives to maintain established technologies, instead of investing in new technologies that are perceived to be riskier. To implement decentralized electricity systems requires a new way of thinking, underpinned by specific technical knowledge.

5.2. How can renewable energy be integrated into sector reforms and regulatory frameworks?

Generally energy regulators do not have the authority to take corrective actions (like tax incentives or grants) for social and environmental costs which are not reflected in the market price and consequently, as the principal objective for energy regulators is still to reduce the price of energy for consumers, mainstream regulatory mechanisms do not encourage electricity generation from renewable sources or energy efficiency. Increased amounts of distributed generation may require different forms of price controls and investment incentives designed to create a level playing field between conventional sources of electricity and electricity from renewable sources.

Access to energy is not just a simple matter of kWh, but rather it is an essential service for the local communities. The importance of the social dimension of electricity system reforms cannot be underestimated. This social dimension is widely accepted and is a political goal in itself. Regulators can for instance make their contribution to alter the natural bias in favour of urban areas, which is even more pronounced in Africa than it is elsewhere, by facilitating the entrance of new competitors to off-grid areas.

A regulatory framework that promotes sustainable energy should aim to maximize access to cheap energy alternatives, which can accelerate rural electrification and offer a better quality of service, while minimising negative environmental impacts. To achieve economic efficiency as well as environmental and social justice, there is a need to implement a regulatory framework that promotes sustainable energy and not just competition between conventional energies.

5.3. Integrated energy planning

An appropriate regulatory framework for renewable energy should be first and foremost a framework that ensures that there is a level playing field for renewable energy in rural electrification; i.e. every time a remote village is to be given access to electricity, the comparison should be made between the different sources of off-grid energy and the extension of the network.

This means that when assessing the appropriateness of a given technology, the cost-effectiveness should, apart from economical considerations (including the subsidies for conventional energy sources), take into account social (e.g. market development and income generation) and environmental (e.g. health and climate change) considerations. These three dimensions of an investment analysis are explained in some more detail in annex III of this module.

Apart from the investment analysis the fact can not be neglected that the majority of utilities in Africa face serious financial difficulties; the extension of the grid to areas where the level of consumption per household is low and the households scattered will only increase their financial burden. The key consideration is the delivery of energy services rather than the production of electricity in itself. Since the level of demand for electricity is very low in rural areas, it seems that small-scale projects can make a big difference to the everyday lives of inhabitants. This would be preferable to waiting for a connection to the grid that is unlikely ever to be profitable. The question therefore is how to set up widespread rural electrification projects that are financially and technically viable in the long term.

Rural electrification needs to be boosted with the establishment of a dedicated entity or team to look into planning and implementation with regard to rural electrification. This entity can either be an independent agency, or a dedicated team integrated within the national energy planning authority, the ministry of energy or the energy regulator. In any case it is essential for this entity to cooperate with the institutions in charge of national energy planning (government departments, planning authorities, regulators) to be able to make integrated and realistic assumptions, forecasts and plans.

This entity needs a sufficient budget, which can be provided by a levy on electricity complemented with loans from international and regional banks. The management of the funding needs transparent and clear rules of allocation. This entity can work by giving direct subsidies and tendering long-term concessions. It can also give long-term refundable loans to local companies or provide grants to end-users. This entity can also bundle small-scale projects to mobilize funds from international organizations or via the Clean Development Mechanism.

It is vital for this entity to have good expertise with a stable staff and a clear definition of its goals and the scope of its activities in relation with the role of the regulatory body.[5] Like a utility, it can be placed under the periodic control of the regulator, which can monitor the progress made in rural electrification on behalf of rural households and communicate the results through annual auditing. More and more African countries are setting up an independent rural electrification agency (e.g. Congo, Nigeria, Senegal, Uganda and Zambia).

It has been demonstrated in several developing countries that decentralised energy provision can be financially feasible and sustainable if it is linked to improving economic activity, i.e. the aim should be to activate or increase a local economic potential through the provision of energy services. Such a link is essential for an energy system to survive in the long term and to decrease its dependence from external funding. The inclusion of micro-finance institutions (using funds from the international donor community to overcome the investment barrier) are often part of the success stories.

Grid-connected and off-grid RE systems

A proper connection of small RE plants (e.g. small hydro power plants or wind turbines) to the grid network has to take into account the following aspects:

- The administrative planning authorization process has to be simplified and be straightforward;
- Providing open access to the network means ensuring that there is free and fair competition by removing barriers of entry—whether legal, technical or financial;
- To avoid delays in connection to the transmission network, the substation can be established by the private investor (also see box 6);
- Sales to third parties and open access to the network should be made possible;
- Effective metering of the generation controlled by the utility is required.

When the connection to the network is not possible, this should be clearly notified to all local actors, so that the implementation of stand-alone systems can be considered. Often utilities tend to have totally unrealistic grid extension projects, which raise expectations from clients who, confronted by local politicians, think that they will be soon connected, which tends to freeze implementation of RE (i.e. solar systems) in large areas supposed to be connected to the network

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[5] The regulator does not have to operate or supervise this entity but must ensure that the rural electrification entity/agency follows clear rules in giving priority to areas to electrify and that it is not under permanent pressure from local politicians.

in the near future. It is the role of the rural electrification agency to ensure that the plans from utilities are realistic and that private investors who invest in new generation projects can have them easily connected to the grid.

Concession/delegated systems

A rural electrification agency can make sure that the most efficient solution is provided by monitoring a concession system where every time an area is opened to electrification, it is then done with the least costly technology—not in the short term, but in the long term—after comparison of the investments on the longest cycle of generation.[6] Concession also means that the owner has responsibility for the local grid and sometimes—when it applies—for building the substations to the transmission network.

This "stop and go" nature[7] to of the concession system and the fierce competition among competitors has proven to be problematic. This can be smoothened by very long-term concessions and an agreement for periodical revision of the financial conditions by an independent audit. In order to ensure greater development and avoid only the best projects being carried out, the concession approach could also bundle more attractive projects with projects with less attractive potential rates of return—thereby ensuring a greater of access by as many rural communities as possible.

Good planning of the opening of areas to concession contracts could enable the market to grow steadily. It is important to make sure that the final offer is viable in the long term by means of an estimate by the agency of an appropriate rate of return. This should not underestimate the difficulties and the delays in implementing technical systems that accompany the process of social engineering.

Examples are presented in box 1 and box 2.

Box 1. **Mini-grid concessions in Bolivia**

In Bolivia, prior to 2000, all operators of isolated village mini-grids above 300kW of installed generating capacity were required to acquire concessions. This created two problems.

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[6] Solar photovoltaic panels for instance are now guaranteed by manufacturers to produce 80% of their initial capacity for 20 years.

[7] "Stop and go" means the support system covers only a limited selection of projects, thus often failing to provide an incentive to utilities and project developers to go out and look for projects, nor does it provide confidence in the support scheme for the investment sector.

First, concessions could legally be granted only to entities that were shareholder companies. This conflicted with the fact that many mini-grids were operated by cooperatives. And second, the reporting requirements and technical standards for concessionaires were impossible (that is, too costly) to satisfy for many of the smaller rural systems.

A partial solution was introduced in 2000. The threshold of regulation was raised to 500 kW peak demand, and cooperatives were allowed to maintain their legal status for an initial period of seven years. Several proposed systems of graduated regulation for rural off-grid systems with different levels of minimal requirement are under discussion.

Source: The World Bank Group, Energy and Mining sector Board Discussion Paper, 2006.

Box 2. **Rural photovoltaic concessions in South Africa: the case of NuRa**

The rural concessions with solar home systems in South Africa represent one of the most ambitious projects of rural electrification using solar energy in Africa. The initial programme, which was launched in 1999 by the government as part of the National Electrification Programme and projected that more than 300,000 solar home systems would be implemented. A call for proposals was issued in February 1999 and seven consortia were identified. Five concessions have reached the implementation stage.

In each concession, the concessionaire gets a monthly fee from the clients, which covers the maintenance costs and the costs of replacement of the batteries. The concessionaire acts like a small local utility that provides a service—electricity—for remuneration. The case of the NuRa concession in Kwazulu-Natal shows that well-managed concession schemes appear to hold promise for the large-scale dissemination of photovoltaic systems in Africa.

The concession attributed to NuRa covers 10,000 km^2. Eight energy stores are disseminated in the concession. They stock parts and sell not only small photovoltaic components but also liquefied petroleum gas—LPG. The sale of LPG allows for an increase in the turnover of the energy stores and thereby facilitates the provision of energy services to rural households (energization approach). To ensure a better quality of service, small local shopkeepers (called "tuck shops") will also soon be able to sell photovoltaic components.

The concession system appears to be one of the ways to deliver a solar energy service and to solve the question of long-term maintenance of solar home systems, which has plagued solar projects for so many years in Africa.

Source: SERN case studies, 2006.

In summary, the following elements are essential with regard to rural electrification:

- A dedicated rural electrification entity (being either a division within the existing electricity institutions or an independent agency) to coordinate all the actors in rural areas and good planning in terms of grid network extension.
- Long-term concessions or delegated systems to attract lasting private investments and a sound financial and taxation environment.
- The existence of standards and codes of practise to ensure the quality of the service provided to end-users.

5.4. Common support mechanisms for renewable electricity

Different support mechanisms to promote electricity from renewable sources are now quite common after having been pioneered in Europe, USA and the developing world. In addition—and mainly thanks to these support mechanisms, costs have been reducing. For example, the prices paid through feed-in tariffs in Denmark for onshore wind fell from 10 euro cents per kWh in the 1980s to 5 euro ents per kWh in 2004.[8] They enable new competitors to enter the market and get access to the network.

But in African countries, in which many remote areas are not connected, the problem is different. Renewable energies are in some cases already competitive, even without the financial support of the state.

This section briefly examines to what extent each of these mechanisms can be adapted to the African context. The mechanisms are:

- The feed-in tariff system;[9]
- The quota obligation system backed by green certificates;
- The tender system;
- In parallel, (investment) subsidies and/or tax incentives are applied.

Feed-in tariff systems, investment subsidies and tax incentives are so called price-based mechanisms (i.e. the mechanism primarily aims to influence the cost/price for RE), whereas quota systems and tender schemes are quantity-based measures (the mechanism primarily aims to achieve a given amount of RE).

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[8] IEA 2006 Energy policies of IEA countries—Country report on Denmark.

[9] More information on feed-in tariff and quota systems can be found in module 9.

These systems are described in more detail in module 9 “Regulatory and Policy Options to encourage the development of Renewable Energy”.

Feed-in tariffs[10]

Feed-in tariffs have been adopted in more than 30 countries, including many developing countries such as Brazil, China, Costa Rica, some Indian states, Indonesia, Nicaragua, Sri Lanka, Thailand and Turkey. If the feed-in tariff is set at an appropriate level for a specific period of time, the guaranteed income stream will provide an incentive for investors to invest in renewable electricity generation projects.

Most African countries are facing serious financial constraints. The main disadvantage of feed-in tariffs is that they can be perceived as costly. Scheme design can mitigate this (e.g. by tapering down tariffs over a number of years) and another way of offsetting the cost can be to remove some of the subsidies currently used for conventional energy, which may be encouraging overconsumption, costly imports of energy and pollution.

The reorientation of previous subsidies for conventional energies toward the support of renewable energy can help to set up a local industry instead of financing imports. If a country like India can become a leader in a high technology such as wind power, African countries can realize less complex technologies, in manufacturing terms, such as solar water heaters, can be produced at local level. Even if the solar cells have to be imported, photovoltaic solar panels could be manufactured locally. Biomass is also a sector where potentialities are tremendous for local companies.

Box 3. **Feed-in tariff in Sri Lanka**

Feed-in tariffs offer either a minimum guaranteed price for output or a premium in addition to the market price for output

The Ceylon Electricity Board (CEB), Sri Lanka's state-owned electric utility, purchases electricity generated by renewable energy generators under a Standard Small Power Purchase Agreement (SPPA) between the renewable energy generator and CEB. The SPPA is valid for 15 years. CEB reviews its generation plans, absorptive capacity, the potential of the proposed plant, and other variables, and issues a Letter of Intent to the prospective power producer.

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[10] Please refer to annex 1 in module 9 “Regulatory and Policy Options to encourage development of Renewable Energy”, for the methodology and examples on how to calculate the level of feed-in tariffs.

The tariff is governed by a Standard Small Power Purchase Tariff and its computation is based on the avoided cost. The avoided cost is calculated every December by the CEB to be used the following year. The tariff is accompanied by a guarantee that the future tariff paid to each renewable energy generator will not fall below 90 per cent of the tariff paid on the first year.

Source: G. Creacen and D. Loy, 2006.

Quota systems

Fewer countries to date have implemented quota systems, compared to feed-in tariffs. Countries that have implemented quota systems include Australia, Belgium, India, Italy, Thailand, United Kingdom and some states in the United States. The results have been variable; the main disadvantage being that the lack of a guaranteed price can limit investor interest, particularly if there is uncertainty about how long the obligation will persist.

For a lot of African countries, it seems very difficult to create a viable liquid green certificates market with only few (if not just one) supply companies. But South Africa is considering setting up a compulsory market in green certificates. This could be the start of a compulsory green certificates market at a regional level.[11]

A quota obligation system can be implemented without certificates (see box 4). An obligation on suppliers to supply a certain percentage of renewable electricity in their electricity mix can be set at a low level and increased progressively, since suppliers will not have the flexibility of exchanging certificates to meet their obligation. Even at a low level, such an obligation could provide a serious incentive for established utilities to start to consider renewable electricity and to integrate it into their technology portfolio.

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[11] The voluntary market is quite important in the USA where it represents one third of the total market. It exists in some African countries such as South Africa, but on a small scale. The existence of a middle class sensitive to environmental issues seems to be a pre-condition for the development of such a market. See the annual survey Green Power Marketing in the United States: A Status Report (Ninth Edition), 2006 from the National Renewable Energy Laboratory, Colorado.

Box 4. **The quota system in India**

The quota system is an obligation on electricity suppliers to supply a certain amount of electricity generated from renewable sources. Customers may also be obliged to source a proportion of their power from renewable sources.

As per the Electricity Act of 2003, each state Electricity Regulatory Commission of India shall determine a minimum percentage of renewable energy that must be purchased by state utility.

This percentage varies considerably according to the priority of each regional state. Sometimes, the obligation has been set at a very low level and is already fulfilled. In other cases, the obligation has been at a high level, as some regional states benefit from a very favourable geographical position in terms of wind resources.

Quota systems can be quite complex to design when they include tradable certificates, but this gives some flexibility to suppliers who can exchange certificates to meet their obligation. Reflection on the way to implement such a tradable certificate system is currently going on in India.

Source: SERN case studies, 2007

Tenders

Bidding/tender systems have also been used in developed countries to promote renewable electricity. It has been more or less abandoned due to its “stop-go” nature, with delays between each call for tender. This system can be designed to get the best offer for a given technology or to get the cheapest technology.

In the African context, tenders can be used in a different way to introduce effective competition between renewable and conventional electricity. Rather than just having new generation capacity connected to the network (where renewable electricity will probably not be competitive) it could deliver local long term concessions to electrify new areas by the most appropriate technologies.

Given the small size of the market in developing countries, the “stop-go” nature of this bid could be a deterrent. Therefore a correct design with appropriate requirements included in the tender, plus continued regulatory oversight is required to make sure that those who win the tenders do actually invest in maintaining the local network on the basis of the systems they have sold, and agree to provide network access to other companies. Only if the services are delivered should companies be rewarded and allowed to make profits. It is also necessary that the concessions are long-term, with at least 20 years’ duration. It would then be possible to compare conventional off-grid energy with low investment costs and high operating costs, with alternative energy that has high investment costs and low operating costs.

This system can provide a way to introduce real competition between renewable electricity and conventional electricity, while also ensuring that it is connected to the network.

Subsidies and tax incentives

A stable regulated support system (i.e. the package of financial incentives, tax breaks, investment grants and other) is one important factor that can help to boost local private investments in rural electrification. Incentives—direct subsidies to tax exemptions—will also stimulate interest in the sector. To remove or lower duties and taxes appears to be a necessary first step.

In general, the design of the system has to be tuned to target potential investors, recognizing the different requirements of small, large, local and foreign investors.

Investment subsidies and tax incentives are usually in place to complement the major support instrument or to focus investment towards specific sectors or technologies.

Box 5. **Wind power in India: A real success story**

India has frequent power cuts, high voltage and frequency fluctuations and a significant demand-supply gap. Tax exemptions and accelerated depreciation of up to 80 per cent of project costs in the first year have proved successful in driving the wind power sector in India. There was more than 5,000 MW of installed wind capacity in 2005. India now has a powerful and influential national wind power industry.

This success has relied on investment by the private sector. Each investor owns specific turbines in a wind farm. Direct sales to third parties are permitted so as to attract investments from industries that need power generation. The latest form of investment is in wind farms run by manufacturers on behalf of investors, a kind of energy service. Open access is nevertheless currently restricted to each Indian regional state. A manufacturer can therefore only get electricity from wind farms implemented in the same state as his plant.

Wind technology manufacturers are in charge of developing and running wind farms, from the wind generator to the substation. They also invest in the construction of the substation so as to avoid delays in connection to the transmission network. They in turn, are reimbursed by the supplier. The meter located at the grid substation are sealed, maintained and calibrated by the state electricity utility, which purchases the generated electricity. Monthly metering is done in the presence of both parties. The level of wheeling charges is fixed by each regional state and can be as low as 2 per cent of the energy.

Source: SERN case studies, 2007

Conclusion on financial support instruments

Briefly summarizing the main features of the described support instruments:

- Feed-in tariffs tend to favour new entrants;
- The quota obligation system puts the obligation on existing companies;
- The tender/concessions system tends to open new areas to electrification.

As the idea in Africa is to generate more power by attracting investors, it could be that a targeted feed-in system is more adapted for the promotion of renewable energy than a general feed-in tariff system (which may appear too costly) or a quota system (more complex to implement with certificates). The concession system is ideal to open areas for rural electrification.

These mechanisms enable renewable energies to compete on a fair basis with conventional energy; the government (in the case of the feed-in tariff system) or the consumers (in case of the obligation system) agree to pay to have green energy. This proves not just to be sound for the environment, but also on a socio-economic perspective as it has generated substantial amounts of jobs and very powerful industries in some countries such as Germany and Spain.

Whatever the system chosen, it needs also to be implemented with a long-term development perspective and a clear evaluation of the potentialities of the targeted renewable sector to be promoted. The design of the mechanisms has to be simple and guarantee long-term activities.

Although obviously essential, the financial mechanism in itself is not sufficient to allow the market to grow. It is also therefore necessary to address non-financial barriers like quality assurance and lack of awareness through communication campaigns. These non-financial measures are described below.

5.5. Standards, labels and codes of practice

Apart from the financial support the regulation of non-financial aspects plays a key role in the success of the support instrument, e.g. by informing consumers through communication campaigns and guaranteeing quality products through official standards, labels and codes of practice. These are essential tools for raising the quality of products and services. Without these, consumers will generally only have access to sub-standard products and services at low prices. As a result, consumers will have no incentive to buy good quality products. After a while the growth of the market will be negatively affected.

Regulated codes of practise for suppliers and installers of goods and services are an essential tool to ensure high standards of service. In the past, poor performance on the part of local or international companies has been a major reason for the failure of numerous renewable energy projects.

The difficulty is to define standards, labels and codes of practise that can be effectively monitored but are not so strict that they damage small businesses, but are strict enough to ensure quality. The strictest standards and codes of practice should be reserved for large industry players, such as large wind power developments.

5.6. Self-assessment exercise on renewable energy

Exercises

1. Complete the questionnaire on renewable energy in annex III of this module (See annex III - excel-sheet “Complete Renewable Energy”), and carry out the exercises where mentioned (See annex III - excel-sheet “Check result Renewable Energy”).
2. Guidance and background information are provided below to help interpret the results.

Renewable energy coverage in the regulatory framework

The score which is calculated (See annex III - excel-sheet “Check result Renewable Energy”) gives a rough indication of the integration of renewably energy in the regulatory framework in your country. Note that this score gives an indication only on whether RE is covered (yes/no) in regulation, but not on the "quality" of this coverage. The quality of the support instruments will be checked in some more detail in the performance analysis in the following section, e.g. by looking into effectiveness and efficiency.

Effectiveness and efficiency

The most common support mechanisms for RE are described in section 5.4 "Common support mechanisms for renewable electricity". The appropriateness of adopting or changing into one or another system will depend on a wide-range of criteria including the historical context of the national power sector and the institutional environment.

Some objective criteria are available though to evaluate the performance of a support system, e.g. the effectiveness and efficiency of the system. A simplified calculation is presented in the Questionnaire (See annex III - excel-sheet “Check your results”) and more background is given below.

Effectiveness

Effectiveness in this context means the success of the support measure(s) in increasing the production of renewable electricity over a given period.

In order to assess the effectiveness of a given support mechanism the growth rate in renewable energy is used here as a (simplified) indication of the effectiveness of the (major) support mechanism. The renewable energy production before and after the start of the support mechanism are considered.

For comparison, the global PV market has been growing at an impressive 30 per cent per year over the last 10 years, but growth rates of around 10 per cent are already quite high and suggest the measure is quite effective.

The best figure to use is the amount of new energy produced (MWh) before and after the start of the support mechanism. If these data are not available, the capacity installed (MW) before and after can be used, although this is less secure as the actual energy produced can differ significantly.

A differentiated approach per renewable energy technology (RET) can be applied following the same principles.

Note that high growth rates can be misleading when a new technology is being used in a country. For instance when hardly any PV systems are in use and the next year 200 kW is being installed, the snapshot would show a seemingly extraordinary growth rate of 200 per cent. It is therefore advised to look at growth rates over several years, especially in upcoming markets.

Efficiency

Whereas effectiveness aims to assess the absolute effect of the support mechanism, the result does not necessarily mean the support instrument has also been cost-efficient. Cost-efficiency means how well the financial support reflects the additional cost (for a given RET compared to a reference technology) and aims to assess whether the support is not captured by market actors and intermediaries keeping the costs artificially high.

On the other hand, a so called “levelled playing field” should be agreed when comparing the cost-efficiency of the use of different renewable energy sources against each other and against other energy sources. A support mechanism in favour of RE is usually justified because of the competitive disadvantage that RE suffer due to incomplete internalization of external costs (i.e. environmental, health and socio-economic impacts) in regard to conventional energy sources. Whereas the environmental cost can to some extent be quantified (i.e. by using the price of CO_2), it remains at least partly subjective how to assess the socio-economic impact (i.e. employment, income and development generation, poverty reduction), the impact on health and the impact of other greenhouse gas emission than CO_2. The inclusion of social and environmental aspects in support policies is elaborated in some more detail in annex I “A multi criteria analysis for investments”.

A rough indication can be obtained by dividing the budget for the main support instrument (MUSD) by the growth in renewable energy production (MWh) over the same period of time.

This cost can be compared to other (national or international) RE support measures and be benchmarked against them, and/or be compared to the electricity price, and as such be used as an efficiency indicator. This figure also enables one to assess whether this cost can be justified, taking into account development, social and environmental policy goals.

The overall renewable electricity production is used here regardless of the RET. In order to properly evaluate efficiencies, these should be calculated per RET. It should be emphasised once again that the tool as presented is primarily intended to demonstrate the principles of effectiveness and efficiency as performance indicators of support instruments. A detailed analysis of the cost-efficiency of supporting policies in a given country in reality is often not such a straightforward process and requires the availability of good and sufficient data and an in-depth analysis either by the entity in charge of the support scheme(s), or by an external consultancy.

Important note: The principle of calculating the effectiveness and efficiency of a given measure as explained here can be applicable to a small-scale measure, e.g. at village or province level. It should be emphasised that this is merely a first indication of how effective the support instrument actually is. When trying to assess these parameters at a national or regional level the analysis tends to become quite complex, as in reality the effectiveness and efficiency of a support instrument are influenced by other criteria like the interaction with other instruments, the availability of financial resources and human skills, grid barriers, etc.

More detailed analysis of effectiveness use the absolute growth as ratio of the additional potential, but this requires the availability of data both on growth and on additional potential.[12]

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[12] OPTRES—Effectiveness and efficiency of present RES-E support policies in EU Member States, www.optres.fhg.de

6. INTEGRATING ENERGY EFFICIENCY IN THE REGULATORY FRAMEWORK

It is known that there is huge untapped potential for energy saving in African countries. By lowering the growth rate of the demand for electricity and reducing the pressure to add new generation capacity, energy efficiency could for instance enable energy companies to reallocate resources to the maintenance and improvement of the existing network.

The experience in developed countries, especially in the United States, is now quite extensive. Lessons can be learned and transferred to developing countries.

The following elements are essential:

- An agency or a private-public foundation to coordinate the efforts of all actors;
- An appropriate and stable investment climate to favour long-term investment.

The subject of energy efficiency regulation including supply-side and demand-side management is elaborated in more detail in modules 13 to 16.

6.1. The creation of an energy savings agency[13]

Most countries committed to energy efficiency have set up a specific agency dedicated to energy savings (sometimes as a department within the energy agency). Such an agency, with a dedicated staff, can ensure the continuity of a policy of energy efficiency and capitalize on past experience.

Commonly, these agencies launch awareness campaigns, conduct energy audits, conceive and promote quality standards and labels. They can also bundle projects to get funds or loans from international or regional banks.

Currently there are very few such dedicated institutions for energy savings in Africa (e.g. Tunisia and Ghana). The case of the Tunisian energy efficiency agency is briefly described in box 6.

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[13] Once again, the terminology can vary; the important point is that an autonomous body is created to fill the special function of coordination and funding energy efficiency measures.

Box 6. **National Agency for Energy Efficiency (ANME) in Tunisia**

Since 1985 Tunisia has been at the forefront of energy efficiency policies in the Mediterranean region. This policy was primarily inspired by the forecasted energy deficit, and was built around three pillars:

1. Putting in place an institutional framework, with a dedicated national energy savings agency (ANME) in charge of policy implementation;
2. The elaboration of a complete set of regulatory measures to promote energy efficient practices and techniques;
3. The adoption of financial incentives, including subsidies for energy audits and investments as well as fiscal measures.

An overall savings target of 640 kToe (kiloton oil equivalent) was set by 2010, and a decrease in energy intensity of 2 per cent per year. ANME plays a central role in administering the set of measures and has been able to make energy efficiency an integral part of energy practices throughout different sectors.

In addition a further reinforcement of this policy and a long-term perspective were presented in its energy efficiency policy strategy for 2030, focusing on:

- Energy efficiency in industry
- increased use of CHP
- Increased use of gas
- Certification of electrical appliances
- Increased use of solar thermal

Some more background can be found in module 15 “Impact of Power Sector Reforms on Energy Efficiency in Africa.”

Source: Energy Efficiency in Tunisia towards 2030, April 2006, Agence Nationale pour la Maîtrise de l’Énergie (ANME)

6.2. The role of energy service companies (ESCOs)

In some developed countries, Energy Service Companies (ESCOs) have seized the opportunity to design propositions for consumers in which they undertake to invest and install energy efficient systems, using the resulting energy savings to reduce consumers’ bills and allow them to take a margin.

ESCOs could operate in the same way in developing countries, so long as there is an appropriate regulatory framework to increase energy efficiency on the side of energy consumers.

6.3. Financial and tax incentives

Financial and tax incentives can accelerate investments in energy efficiency appliances. Utilities can also raise public awareness and conduct energy savings campaigns if they are financially able through an obligation to commit funds for energy savings—reaching a target of electricity saved in the year—and a financial penalty in case of non-compliance. Creation of specific funds for improving load power factor can also be implemented.

6.4. Tariff setting

Tariffs can be set to reduce the peak demand, thus improving the profile of demand to avoid investments in peak generation capacity, the use of extra generators, or the reinforcement of networks. Tariffs can also reduce the overall demand of some sectors by benchmarking the most efficient actors.

6.5. Standards, labels and energy audits

Labels developed for European countries can be adapted for use in African countries. Standards for appliances such as air-conditioning have proved to be very effective in some African countries like Ghana. Energy audits also need to be conducted systematically.

Box 7. **The Energy Foundation and standard regulation in Ghana**

The Energy Foundation was created in November 1997 as a Government-private sector partnership. It is a consumer-focused institution that aims to avoid the bureaucracy that leads to public mistrust. It is registered as a company and governed by an executive council. It has no power to enact or enforce regulations, but plays an advisory role in the formulation of regulations.

The Energy Foundation has since its inception worked on promoting sustainable energy, conducting advocacy and running public awareness campaigns. It also works to put demand-side management at the top of the political agenda. It is well-known for developing standards for energy efficiency and labels for energy appliances with the aid of foreign organizations, such as the Alliance to Save Energy, the Lawrence Berkeley National Laboratory and the International Institute for Energy Conservation (the collaboration of the two latest giving birth to the Collaborative Labelling and Appliance Standard Program—CLASP).

The first appliance standard regulation in sub-Saharan Africa for room air conditioners has been enacted by the Parliament. This standard is to save Ghana the equivalent of 250 MW of generating capacity in 2020 for a negligible cost, which has to be compared with the construction of the 200 MW Bui hydropower plant which cost $US 600 million.

By permanent lobbying, active collaboration with major actors and aggressive marketing targeting each sector of the country, the Energy Foundation has managed to get a central role and ensures that energy efficiency is a major component of the energy policy of Ghana.

6.6. Self-assessment exercise on energy efficiency

Exercises

1. Complete the questionnaire on energy efficiency in annex III of this module (See annex III - excel-sheet “Complete Energy Efficiency”), and carry out the exercises where mentioned (See annex III—excel-sheet “Check result Energy Efficiency”).
2. Guidance and background information are provided below to help interpret the results.

Energy efficiency coverage in the regulatory framework

The score which is calculated (See annex III—excel-sheet “Check result Energy Efficiency”) gives a rough indication of the integration of energy efficiency (EE) in the regulatory framework in your country.

Note that this score gives an indication only on whether EE is covered (yes/no) in regulation, but not on the "quality" of this coverage. The quality of the support instruments will be checked in some more detail in the performance analysis in the following section, e.g. by looking into effectiveness and efficiency.

Effectiveness and efficiency

This provides you with an overview of the financial support schemes for EE in your country.

In addition it introduces the concepts of effectiveness and efficiency with regard to the performance of a support system.

Effectiveness

Effectiveness in this context means the success of the support measure(s) in increasing the energy savings over a given period.

In order to assess the effectiveness of a given support mechanism, the growth rate in energy savings is used here as a (simplified) indication of the effectiveness of the (major) support mechanism. The energy savings before and after the start of the support mechanism are considered.

The overall energy efficiency coverage is used here regardless of the EE technology used. A differentiated approach per technology can be applied following the same principles.

Efficiency

Whereas effectiveness aims to assess the absolute effect of the support mechanism, the result does not necessarily mean the support instrument has also been cost-efficient. Cost-efficiency means how well the financial support reflects the additional cost (for investing in the EE system or product).

A rough indication can be obtained by dividing the budget for the main support instrument (MUSD) by the growth in renewable energy production (MWh) over the same period of time.

This cost can be compared to other (national or international) EE support measures and be benchmarked against them, and/or be compared to the electricity price, and as such be used as an efficiency indicator. This figure also enables to assess whether this cost can be justified, taking into account development, social and environmental policy goals. The inclusion of social and environmental aspects in support policies is elaborated in some more detail in annex III “A multi criteria analysis for investments”.

Important note: It should be emphasized once again that the tool as here presented is primarily intended to demonstrate the principles of effectiveness and efficiency as performance indicators of support instruments. A detailed analysis of the cost-efficiency of supporting policies in a given country in reality is often not such a straightforward process and requires the availability of good and sufficient data and an in-depth analysis either by the entity in charge of the support scheme(s), either by an external consultancy.

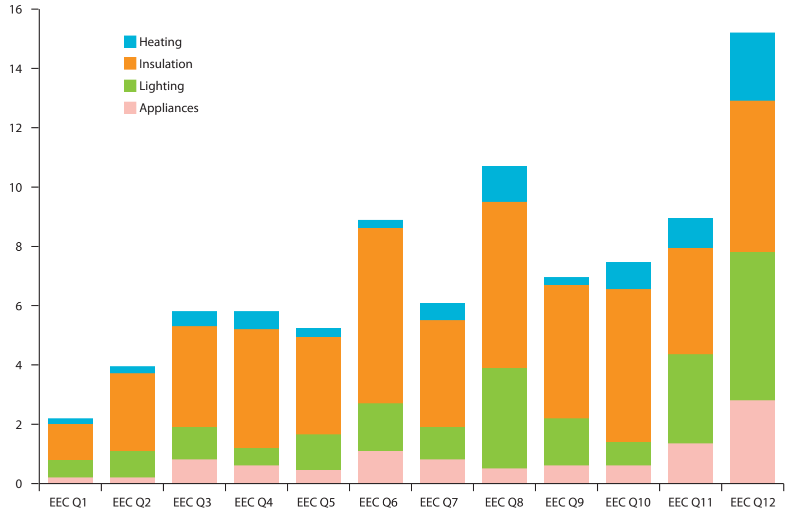
Box 8. The Energy Efficiency Commitment in the United Kingdom

The Energy Efficiency Commitment (EEC) in the United Kingdom aims to bring down energy demand in the household sector, with a specific focus on fuel poverty (i.e. 50 per cent of the energy efficiency measures must be achieved in socially vulnerably households). The framework is set out by the government Department for Environment, Food and Rural Affairs (Defra), whilst the implementation and management of the system (e.g. calculations and verifications of saved energy) is administered by the energy regulator, the Office of Gas & Electricity Markets (Ofgem).

The energy reduction target is set by the government and is imposed on electricity and gas suppliers. The first phase between 2002 and 2005 proved very effective with all suppliers achieving their target, and triggering investments worth more than $US 1 billion. With the cost being socialized over all customers, the financial impact on the energy bill could be kept below $US 7 per year (i.e. less than 1 per cent increase).

Insulation, the use of energy-efficient light-bulbs, appliances and heating systems were the most effective and cost-efficient measures, as is illustrated in the chart below (Source: Ofgem).

Chart 1: **Energy savings, by measure type, achieved each quarter during the three years of the ECC**



The cost-efficiency of the EEC is to a large extent due to the energy suppliers "outsourcing" their target to independent third parties, i.e. private companies specialized in the installation of energy efficiency measures, feasibility studies or marketing campaigns. This has stimulated innovation and has led to new business opportunities.

The third phase which runs from 2008 to 2011 is called the Carbon Emission Reduction Target (CERT), and—in addition to energy efficiency measures and reducing energy demand - focus on an increased use of micro generation for electricity and heat. The CERT is defined as a carbon emission reduction obligation on energy suppliers (instead of an energy savings target).

Source: IT Power 2007, Nera 2006, Ofgem 2005.

Box 9. **Energy savings obligation in Denmark**

An energy savings obligation of 1 per cent per year is imposed on distribution grid operators. How the target is met is left to the discretion of the grid operators, stimulating the use of cost-efficient measures. The system is managed by the Danish Energy Authority.

In 2005, the target was met by using energy efficiency measures with an average payback below 3 years. About 155 GWh of energy was saved in the first year, triggering over $US 30 million in investment. The grid operators realised their energy savings target primarily through joint campaigns and consultancy services to the private sector.

In order to increase flexibility and cost efficiency, the introduction of a system of tradable white certificates is currently being evaluated in Denmark.

Further background is available in module 16 the Case Study "Denmark: electricity distribution companies as key factors in energy efficiency policy".

Source: Danish Energy Authority and the Association of Danish Energy Companies.

7. CONCLUSION

The role of policy and regulation in Africa in principle is the same as it is in a developed country. However, the circumstances and many key factors that affect regulation are quite different from those in developed countries.

One of the main differences is that rural electrification in most African countries is still lagging behind. Rural electrification has often not been mentioned in the first electricity sector reforms, and the new regulators have focused on the existing network. Nevertheless, this is changing and rural electrification is now at the top of the political agenda.

Rural electrification agencies will have to play a very important role in this process by ensuring transparency and competition in investments made in rural areas. Unrealistic grid expansion plans will have to be discarded. It is the role of the regulator to make consumers aware of the benefits and limits of each source of electricity.

In any case, the national regulator should contract out some aspects of regulation to this agency and allow them to act on its behalf to avoid duplication of regulation or over regulation of mini-grids and stand-alone systems. Methods of regulation should vary according to the form of electrification and the type of electricity that is providing the electrical service. Apart from the advantages of renewable energy for rural electrification, renewable energy also has a role to play in the urban and industrial environment.

In order to make use of the significant energy savings potential, tailored policies and measures are required for each of the key sectors, i.e. industry, households, tertiary and public sectors. Thus far dedicated agencies and regulators to implement and administer these policies have been rare in Africa.

A key role of the regulators is to ensure that tariff setting encourages utilities to maximize the efficient-use of electricity and the use of energy saving measures. The implementation of energy saving standards and the coordination of energy saving programmes by dedicated agencies should be considered as an absolute priority due to the tremendous benefits they can bring to a country.

LEARNING OUTCOMES

Key points covered

- The institutional organization of the energy sector, and different power sector reform options.
- The place and role of sustainable energy in the reform process within the African electricity sector.
- Distributed generation: the potential for African countries and the institutional resistance to change utilities.
- How institutions and financial incentives can be adapted to promote and support renewable energy and energy efficiency in African countries.

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INTERNET RESOURCES

Afrepren: www.afrepren.org

Collaborative Labelling and Appliance Standards Program - CLASP:
www.clasponline.org/main.php

ENDA: www.enda.sn/energie

Centre for Regulation and Competition:
www.competition-regulation.org.uk/index.shtml

The Kumasi Institute of Technology and Environment - KITE: http://kiteonline.net

Global Regulatory Network: www.globalregulatorynetwork.org

International Energy Regulation Network: http:www.iern.net

Public Research Utility Center: www.purc.ufl.edu

Regulatory Assistance Project: www.raponline.org

Regional Electricity Regulators Association of Southern Africa: www.rerasadc.com

Renewable Energy Case Studies: www.martinot.info/case_studies.htm

Sustainable Energy Regulation Network: www.reeep.org/groups/sern

Sustelnet: www.electricitymarkets.info/sustelnet

UNDP: www.ke.undp.org

GLOSSARY/DEFINITION OF KEY CONCEPTS

Cogeneration	A method of using the heat that is produced as a by-product of electrical generation and that would otherwise be wasted. The heat can be used for space heating of buildings (usually in district or community heating schemes) or for industrial purposes. Utilising the heat in this way means that 70-85 per cent of the energy converted from fuelstuffs can be put to use, rather than the 30-50 per cent that is typical for electrical generation alone. Cogeneration schemes can be relatively small scale, for use at the level of a factory or hospital, or can be major power stations. The term CHP is employed in the UK

	and some other parts of Europe, while the term cogeneration is employed elsewhere in Europe, the US and other countries.
Combined heat and power (CHP)	See Cogeneration.
Demand-side management	The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. It refers only to energy and load-shape modifying activities that are undertaken in response to utility-administered programmes. It does not refer to energy and load-shape changes arising from the normal operation of the marketplace or from government-mandated energy efficiency standards. Demand-side management (DSM) covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.
Deregulation	The process of removing or reducing regulation. It is often employed in connection with the liberalization process for privatized industries. The term is sometimes used erroneously to describe the movement of publicly owned companies and industries in to the private sector. This can generally be more accurately referred to using the terms; privatization, liberalization and re-regulation.
Distributed generation	Distributed generation relies on decentralized technologies where the generator is connected directly to the low voltage distribution electricity network, instead of having to pass through the high voltage transmission electricity grid. It covers various technologies: renewable sources will usually be used as distributed electricity generation.
Distribution	The transport of low voltage electricity. This connects the transmission network with the majority of electricity consumers. The process is overseen by a distribution network operator. Management of distribution is a natural monopoly due to the economies of scale inherent to it.
Economies of density	Generally, economies wherein unit costs are lower in relation to population density. The higher the population density, the lower the likely costs of infrastructure required to provide a service. One example would be the costs associated with providing electricity networks to urban versus rural areas.
Economies of scale	In many cases, the bigger a company gets, the cheaper it is able to produce or distribute each additional unit. Generally, this is because some costs of production do not increase with each unit. These fixed costs are effectively averaged out over the cost of each unit, so that each unit produced reduces the average.
Electricity disclosure	This policy measure which includes mentioning the generation source of electricity on consumers' bills ("disclosing" the electricity

	source) is based on the assumption that in a competitive market, consumers may chose to buy their power from less environmentally damaging forms of generation rather than solely allowing their choice to be dictated by the price. Disclosure requirements can include information on the type of generation, the amount of carbon dioxide emitted per kWh or the amount of radioactive waste produced. See module 9 "Regulatory and Policy Options to Encourage Development of Renewable Energy" for some more background on "electricity disclosure" and "green power marketing".
Oligopoly	Oligopoly occurs when a number of firms dominate the market for a service or good and effectively act to maintain prices at a higher level than would be likely to occur through competition, effectively mimicking a monopoly. Oligopolies may form as a result of outright collusion, as with the formation of a cartel or may be more informal, as with the adoption of non-price competition, wherein companies in the oligopoly compete on factors other than price in order to avoid margin reducing price wars.
Energy efficiency	This can be defined in slightly different ways, and includes using less energy (kWh) to achieve the same benefits (e.g. internal temperature, industrial output etc), or using the same or a lesser amount of energy (kWh) but achieving more benefits (e.g. a warmer home, higher output). The focus tends to be on improving the welfare of the end-user.
Energy services	The provision of energy supply and measures concerned with end-use in a single package.
Energy services company (ESCO)	Companies concerned with maximizing efficient and cost-effective supply and end-use of energy for their customers. This can encompass a mixture of the following as appropriate; competitive purchasing of various fuels; CHP; end-use efficiency measures; consumption monitoring and management and others. ESCOs should be distinguished from energy supply companies; the main role of which is supplying units of gas, electricity or heat. ESCOs can also be distinguished from energy management companies whose main role is supplying energy efficiency services.
Feed-in tariffs	They offer either a minimum guaranteed price for output or a premium in addition to the market price for output. Typical features of feed-in tariffs include: • Distribution network operators are obliged to allow generators to connect to the grid, and they or retailers have to take all of a project's output at a pre-defined price. • The scheme can be open-ended, or can be put in place for a specified number of years. • The tariff schemes can be banded for different technologies,

with less developed technologies receiving higher prices for their output.

- Tariff levels can be set to decline over the years, reflecting the potential for declining technology costs.
- The level of the tariff is often the subject of an explicitly political decision about the level of tariff necessary to stimulate renewable deployment.
- The costs of the tariff can be covered by a levy per kWh on consumers, or on taxpayers, or both.

The level of the tariff tends to be set for several years at a time, often through legislation. This means that there is a high degree of certainty for investors on the returns available, and a high level of confidence about the duration of the scheme. Schemes offering a minimum guaranteed price tend to provide more certainty for investors than those which offer a premium on the market price, because of the higher degree of predictability that this affords.

Generation	The production of electricity from other energy sources. This can include coal, oil, gas, nuclear fission, wind, waste combustion and many others. Generation can be entirely run as a monopoly or be subject to competition.
Green certificates	A certificate that represents a unit of renewable electricity generated that can be used to verify the fulfilment of an obligation to source a certain percentage of renewable generation as required in Renewable Portfolio standard schemes. Trading may be allowed so that companies that under-achieve their obligation can buy certificates from those who have over-achieved.
Level the playing field	To give renewable energies the same advantages and opportunities as conventional energies.
Liberalization	Technically, the removal of restrictions on the movement of capital. It has come to refer to a policy of promoting liberal economics by limiting the role of government in the operation of the market economy. Liberalization can include privatization and deregulation/re-regulation. Typically it refers to the establishment of an industry structure to allow competition, for example, as is possible with electricity generation. The process includes the shifting of publicly owned companies into the private sector, such that provision of services is subject to greater competition or, in the case of natural monopolies to greater oversight with regard to economic efficiency.
Monopoly	The situation wherein one company has the market power to control the price or availability of a good or service. If this is unregulated,

	the company is likely to produce fewer goods or to sell goods more expensively than would be the case in a competitive environment. In practise, a monopoly may refer to an industry where one company has power to control the sector regardless of other companies or it may refer to a sector where only one company exists. It should be noted that outside natural monopolies, few monopolies are absolute and that even dominant companies may be subject to pressures on their price setting or limiting of supply. The effects of monopoly, including natural monopoly, on welfare can be limited by appropriate regulation.
Natural monopoly	A monopoly where the market can be served most cheaply by a single firm, rather than by a number of competitors. The most notable examples with regard to electricity are transmission and distribution networks, where it would be grossly inefficient in terms of capital investment to have competing networks serve the same customers.
Passive networks	The "traditional" electricity supply paradigm, wherein generators are hooked to the transmission network and then supply electricity to order, down to the level of distribution.
Privatization	The process of moving a body or institution from ownership in the public sector to ownership in the private sector. This can be carried out using different processes, for example, the sale of shares to the general public or the sale of the whole company to a specific bidder.
Quota mechanism	More generally known as a Renewable Portfolio Standard or as an obligation mechanism. The quota system is an obligation on electricity suppliers to supply a certain amount of renewable electricity. Customers may also be obliged to source a proportion of their power from renewable sources. • The percentage of the obligation can increase over time, so driving increased deployment. • Suppliers can also choose to pay a penalty rather than buy out of their obligation. • The operation of the system is supported by tradable green certificates for the output, which certify that the supplier has actually bought renewable electricity. These certificates can be sold with the power, or traded separately. In either case, the value of the certificate adds value to the actual generation. • Certificates can sometimes be banked for use in future compliance periods. • There is no requirement on suppliers to allow priority access to networks, as this is the business of distribution network operators in an unbundled system.

	In contrast to tariff systems, here the Government sets the desired level of output. A quota system avoids the Government selecting which technologies will receive the benefits, instead leaving the technical choices to the market. However, a quota system can be banded so that outputs from different technologies are rewarded differently. The level of incentive for the suppliers to comply with the obligation depends on the level of the buy-out price, which can be paid by companies as an alternative to securing new capacity and certificates. The Government sets the buy-out price, which in turn sets the certificate price. The value of renewable electricity will be further enhanced by redistributing the proceeds of the buy-out fund to companies who have met their obligation through presenting certificates.
Regulatory failure	This occurs where the costs of introducing regulation outweigh the benefits.
Regulatory risk	A risk to businesses that changes in regulation will have a negative impact on their operation. Where governments and regulators raise regulatory risk, they are likely to come under pressure to allot some form of compensation to companies who suffer as a result of regulation in order to ensure that future investment is not discouraged.
Renewable energy	The use of energy from a source that does not result in the depletion of the earth's resources whether this is from a central or local source.
Renewable Portfolio Standard (RPS)	A market-based mechanism devised by Nancy Rader and Richard Norgaard for the American Wind Energy Association in 1996. It obliges supply companies or consumers to purchase a specific amount of electricity from renewable energy sources. The key goal of such a mechanism is to minimise the costs of increasing renewable energy capacity through the stimulation of competition to fulfil obligations. The RPS mechanism is also known as a quota or obligation mechanism. Examples of the RPS include the Renewables Obligation in the UK or the Mandatory Renewable Energy Target in Australia). The market may be operated through the creation and trading of certificates (Renewable Energy Certificates).
Supply	The sale of electricity to final users. Many electricity industries do not separate the supply function from the distribution function and allow the monopoly control of both functions. Other countries or territories separate the functions to allow the use of competition within the supply function whilst separately regulating the natural monopoly of the distribution function.

Sustainable development	Development “... which meets all the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations Brundtland Commission).
Sustainable energy	Effectively, the provision of energy such that it meets the needs of the future without compromising the ability of future generations to meet their own needs (see Sustainable Development). Sustainable Energy has two key components; renewable energy and energy efficiency.
System operator	The operator of the transmission grid. Its responsibilities often include proving access to the grid for generators, managing congestion and controlling despatch.
Tariff mechanism	A mechanism to encourage the growth of renewable energy generating capacity. Notable examples are Denmark and Germany. A tariff mechanism generally provides a particular rate per kWh of electricity generated and guarantees that payments will continue for a fixed or minimum period. The tariff can be fixed beforehand, can be fixed to reduce in specific gradations over time or can be linked to the Average Electricity Tariff. Also known as a price mechanism.
Transmission	The transport of high voltage electricity. This is achieved with a transmission network (or grid). Generally the network will connect large generators to lower voltage distribution networks where it will be transported to the majority of electricity consumers. Alternatively, large-scale electricity users may connect directly to the transmission network. Management of transmission is a natural monopoly due to the economies of scale inherent to it.
Wheeling charges	Transmission charges for wheeling the power and energy generated by an independent power producer to third party consumers.

ANNEX I. A MULTI CRITERIA ANALYSIS FOR INVESTMENTS

The decision-making process of an investment should allow for a true socio-economic comparison of the most efficient technology to be made, taking into account not only its immediate financial costs, but also its environmental and social impact.

The responsibility of the long-term integrated planning of a country's energy infrastructure is best handed to an independent regulatory body, which must be able to collect data from utilities (and other relevant institutions and stakeholders) and monitor systematically their investments, before benchmarking them according to best practices and a multidimensional criteria analysis.

The principle for a sustainable framework leading to sustainable energy system (or at least a less unsustainable one)[1] basically means that apart from short-term financial, also social and environmental considerations are taken into account. These three dimensions are described below.

I. Financial and economic considerations

The idea that conventional energies are necessarily unsustainable while renewable energies would be sustainable cannot be simply assumed. The quality of the decision-process that leads to the investment in one or the other is in fact crucial, especially to avoid the over-sizing of the generation capacity and to guarantee an efficient use of the electricity generated. Conventional fuels used in small-scale projects like gas fired combined cycle plants or small-hydro installations may be considered as more sustainable sources of electricity than large plants. Being located near their end-users they can avoid grid losses.

Many renewable sources are indeed used on a small-scale and in an efficient way owing to high investment costs (e.g. solar home systems linked with energy-efficient appliances). Some renewable technologies however may be used on a larger and more remote scale (e.g. wind farms). They are also sustainable in the sense that they use the power of the sun (passive and active solar energy), wind, water or biomass, but the cost of maintenance has to be taken into account.

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[1] While it is difficult to define what "sustainable electricity" means, it is easier to describe what "unsustainable electricity" looks like: it looks like most of the world's present-day electricity systems. See W. Patterson, 1999. The total annual amount of fossil fuel consumption subsidies in the world has been estimated by the World Bank in 1992 at around $US 230 billion.

A sustainable regulatory framework is one that prescribes a comparison between all sources of energy in a given location, considering not just the short term but also the long-term aspects. Because investments in renewable sources are generally more costly than those in conventional ones, this means that an appropriate regulatory framework is the one that takes a life-cycle perspective in appraising and comparing projects.

II. Social considerations

In some countries, energy companies have been privatized and as profit-making companies they are supposed to make efficient decisions on how to best allocate their resources. However, the electricity sector has a high social impact. Issues such as access to supply for the poorest households in rural areas will not necessarily be addressed by private companies. On the contrary, they might be inclined to concentrate their services on higher income households or on industrial and commercial customers.

One of the roles of regulators and policymakers is therefore to ensure that all consumers have access to minimum energy services at a reasonable cost and within a reasonable timescale. In African countries, where the majority of rural areas are not connected to the grid, private energy companies need appropriate incentives to expand services into rural areas. A sustainable regulatory framework is therefore one that ensures that energy companies are encouraged to provide the poorest households and the most remote locations with access to energy services.

III. Environmental considerations

A sustainable regulatory framework requires that all external costs linked to the use of various technologies be internalized. This is not an exact science, but estimates can be made on the basis of expert assumptions. There is a need for standards even for so-called environment-friendly renewable energies (e.g. standards requiring recycling of the batteries from solar systems).

Renewable sources of electricity generation have an important role in a sustainable energy policy as they have a limited impact on the environment locally (in terms of health) and globally (in terms of climate change). This is unlike conventional sources such as oil, coal and gas, which have a negative impact on the environment, particularly in terms of CO_2 emissions. The treatment of nuclear waste remains uncertain. Large-scale hydro plants can also have severe negative environmental impacts.

ANNEX II. SELF-ASSESSMENT ON POWER SECTOR REFORM

This self-assessment exercise aims to assess the status of the current power in a given country and provide input and ideas to serve as inspiration for the way forward.

See section 3 of this module for experiences in sub-Saharan Africa and additional background to interpret the results.

In order to offer some guidance, the case of Zambia is mentioned as an example.

Exercises

1. Complete the questionnaire in sheet "Power Sector Reform".
2. Check the results in sheet "Check your result".
3. Based on the results, write a 1,500 words essay on an appropriate way for the power sector in your country to develop and transform.

UNIDO Module 6 Self-Assessment Spreadsheet on Power Sector Reform—Questionnaire

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
	Country:		Zambia		
	Author:		Mark Draeck		
	Name of company/ organization/institution:		IT Power Ltd.		
	Type of company/ organization/institution:		Consultancy		
	Country:		UK		
	Date:		Jan-08		
LEVEL OF COMPETITION AND UNBUNDLING					
P1	Are any of the functions “Generation”, “Transmission”, “Distribution” or “Supply to end-consumers” of electricity open for competition in your country?	Yes/No	Yes		
	If No go to P5				
P2	If Yes, are all three functions “Generation”, “Distribution” and “Supply to end-consumers” open for competition?	Yes/No	No		
	If Yes, go to P5				
P3	If No, is only “Generation” of electricity open for competition?	Yes/No	Yes		
	If Yes, go to P5	Yes/No			
P4	If No, this means at least one other function apart from “Generation” is open for (some form of) competition. Please indicate which function(s). Specify if necessary.	“Transmission”, “Distribution”,“Supply to end-consumers”			

OWNERSHIP AND CORPORATIZATION					
P5	Is the state-owned utility fully owned by the government and following public accountancy rules?	Yes/No	Yes		
	If Yes, go to P8				
P6	If No, is the utility still state-owned but has it been transformed into a corporate body with financial autonomy and applying commercial principles?	Yes/No			
	If Yes, go to P8				
P7	If No, has the state-owned utility been transformed into (one or more) fully private enterprise(s)?	Yes/No			
	If Yes, go to P8				
	If No please specify.				
ELECTRICITY LAW AMENDMENT					
P8	Is an amendment of the Electricity Law/Act passed (or proposed) in your country?	Passed/ Proposed/No	Yes		

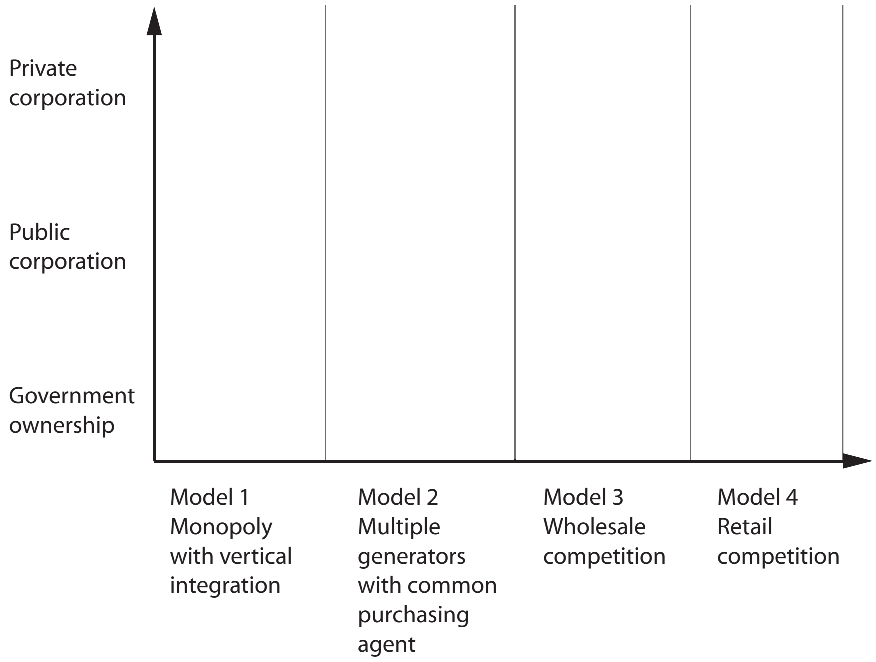
UNIDO Module 6 Self-Assessment Spreadsheet on Power Sector Reform: Results

	Country: Author: Name of company/ organization/institution: Type of company/ organization/institution: Country: Date:		Your answer	Your result	What does it mean?
POWER SECTOR REFORMS					***What should I do next?***
LEVEL OF COMPETITION AND UNBUNDLING					
P1	Are any of the functions “Generation”, “Transmission”, “Distribution” or “Supply to end-consumers” of electricity open for competition in your country?	Yes/No		If you answered “No”on P1 this means your national power sector is most likely in Model 1 on the horizontal axis of the graph “The path of electricity reform”	Model 1 means: There is no competition. Utilities are vertically integrated from generation-transmission-distribution to the end-users.
	If No go to P5				
P2	If Yes, are all three functions “Generation”, “Distribution” and “Supply to end-consumers” open for competition?	Yes/No		If you answered “Yes” on P2 this means your national power sector is most likely in Model 4 on the horizontal axis of the graph “The path of electricity reform”	Model 4 means: There is competition between generators. Open access to the transmission network Several distribution companies are able to buy directly from a producer. Distribution is separate from retail activity. End-users are able to choose their supplier.
	If Yes, go to P5				
P3	If No, is only “Generation” of electricity open for competition?	Yes/No		If you answered “Yes” on P3 this means your national power sector is most likely in Model 2 on the horizontal axis of the graph “The path of electricity reform”	Model 2 means: There is competition between generators but with one purchasing agent who has the monopoly over transmission and distribution networks and over sales to the end-users.
	If Yes, go to P5	Yes/No			
P4	If No, this means at least one other function apart from “Generation” is open for (some form of) competition. Please indicate which function(s). Specify if necessary.	“Transmission”, “Distribution”, “Supply to end-consumers”		If you answered “No” on P4 this means your national power sector is most likely in Model 3 on the horizontal axis of the graph “The path of electricity reform”. If additional specifications were mentioned, ask the trainer.	Model 3 means: There is competition between generators. There is open access to the transmission network. Several distribution companies are able to buy directly from a producer. Distribution companies keep a monopoly over end-users.

					Background: Check Module 6 Section 3 “Power Sector Reform” to provide you with background information and some African examples.
					Exercise: Develop a view on how to proceed from the situation in your country and draw the path of electricity reform for your country in the graph.
OWNERSHIP AND CORPORATIZATION					
P5	Is the state-owned utility fully owned by the government and following public accountancy rules?	Yes/No		If you answered “Yes” on P5 this means your national power sector is most likely positioned in the lower section of the vertical axis of the graph “The path of electricity reform”	The lower part on the vertical axis means the utility is government owned and is administered following public accountancy rules.
	If Yes, go to P8				
P6	If No, is the utility still state-owned but has it been transformed into a corporate body with financial autonomy and applying commercial principles?	Yes/No		If you answered “Yes” on P6 this means your national power sector is most likely positioned in the middle section of the vertical axis of the graph “The path of electricity reform”	The middle part on the vertical axis means the utility is still government owned but is managed as a corporate entity following a commercial logic based on financial autonomy. This is the first step in the “corporatization” process.
	If Yes, go to P8				
P7	If No, has the state-owned utility been transformed into (one or more) fully private enterprise(s)?	Yes/No		If you answered “Yes” on P7 this means your national power sector is most likely positioned in the upper section of the vertical axis of the graph “The path of electricity reform”	The upper part on the vertical axis means the utility is turned into a fully commercial entity with no (or very little) government ownership or involvement in the entity’s operational and financial management.
	If Yes, go to P8				
	If No please specify.			If you answered “No” on P7 this means your national power sector is probably positioned somewhere in between the mentioned situations.	Ask the trainer for help in interpretation if necessary.

			Your answer	Your result	What does it mean?
ELECTRICITY LAW AMENDMENT					
P8	Is an amendment of the Electricity Law/Act passed (or proposed) in your country?	Passed/Proposed/No		If you answered “Passed” on P8 this means a reform process is underway in your national power sector, and the Electricity Law has most likely been amended with regard to one or more of the following aspects: removing the monopoly of the national utility; the establishment of an independent regulatory body; the provision for a programme or fund on rural electrification and/or renewable energy; other	*Check what the experiences with regard to (at least one of) the amended aspects have been thus far. Based on this information develop recommendations for improvement and think about how they could be included in the path for sector reform.*
				If you answered “Proposed” on P8 this means there is an intention and a suggested way forward to reform your national power sector. The policymaking process has yet to start or is underway, and no final decisions have been taken with regard to the following aspects: removing the monopoly of the national utility; the establishment of an independent regulatory body; the provision for a programme or fund on rural electrification and/or renewable energy; other	*Check what the proposed way forward is with regard to (at least one of) the amended aspects. Identify those issues which are causing (or likely to cause) controversy and opposition, analyse why that is and think of a balanced way to proceed.*
				If you answered “No” on P8 this means most likely no reform process is underway in your country and the Electricity Law thus far has not been amended with regard to one or more of the following aspects: removing the monopoly of the national utility; the establishment of an independent regulatory body; the provision for a programme or fund on rural electrification and/or renewable energy; other	*Based on the difficulties the power sector faces in your country, prioritize the amendments you think are most urgent. Develop recommendations for (at least one of) the amended aspects and think about how they could be included in the path for sector reform.*

The path of electricity reform in your country



ANNEX III. SELF-ASSESSMENT ON REGULATION, RENEWABLE ENERGY AND ENERGY EFFICIENCY

These self-assessment exercises on regulation, renewable energy and energy efficiency are intended to allow the participant to begin to form a comprehensive picture of where their country lies in terms of sustainable energy regulation and policy development. The process of designing and implementing appropriate and effective regulations and policies is a difficult task, which requires considerable resources and time and hence the self-assessment exercise contained in this module is only meant as an initial rough measure. However, the results of this exercise could be used to begin the process of advancing the state of sustainable energy regulation and policies in the reader's country.

The (three) questionnaires are set up as partly automated excel tools which can also be used in a printed format.

The aim of these exercises is to get a comprehensive view of the situation in a specific country regarding sustainable energy:

- What has been done?
- And after identifying the gaps, what could be done?

Some questions/items remain necessarily ambivalent (e.g. how the independence of a regulator can be defined) and open to discussion among the readers. Definitions and background are given to guide the self-assessment process, although this guidance remains indicative. See sections 4, 5 and 6 of this module for experiences in sub-Saharan Africa and additional background to interpret the results.

In order to offer some guidance, the case of Zambia is mentioned as an example.

Exercises

1. Complete the questionnaire in sheet "Complete Regulation".
2. Check the results in sheet "Check Results Energy Regulation" and carry out the exercises where mentioned.
3. Complete the questionnaire in sheet "Complete Renewable Energy".
4. Check the results in sheet "Check Results Renewable Energy" and carry out the exercises where mentioned.
5. Complete the questionnaire in sheet "Complete Energy Efficiency".
6. Check the results in sheet "Check Results Energy Efficiency" and carry out the exercises where mentioned.

Glossary

CHP	Combined heat and power
DNO	Distribution network operator
DSM	Demand-side management
EE	Energy efficiency
ESCO	Energy service company
IPP	Independent power producers
PPA	Power purchase agreement
RE	Renewable energy
RET	Renewable energy technology
TSO	Transmission system operator
USD	United States dollar

UNIDO Module 6 Self-Assessment Spreadsheet on Regulation—Questionnaire

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
	Country:		Zambia		
	Author:		Mark Draeck		
	Name of company/ organization/institution:		IT Power Ltd.		
	Type of company/ organization/institution:		Consultancy		
	Country:		UK		
	Date:		Feb 08		
REGULATORY COVERAGE					
R1	What are the core responsibilities of the regulatory body in your country:				
	Monitor liberalization policy	Yes/No	Yes		
	Licensing	Yes/No	Yes		
	Manage support system for RE/EE	Yes/No	No		
	Develop standards/codes of good practice	Yes/No	Yes		
	Tariff setting	Yes/No	Yes		
	Consumer complaints	Yes/No	Yes		
	Other (If yes, please specify)	Yes/No	0		
R2a	Is the regulatory body in charge of energy planning for:				
	Urban areas	Yes/No	No		
	Grid extension to rural and remote areas	Yes/No	No		
	Off grid options for rural and remote areas	Yes/No	No		

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
R2b	***If one of the answers in R2a is No:***				
	Is the regulatory body involved in energy planning for:				
	Urban areas	Yes/No	Yes		
	Grid extension to rural and remote areas	Yes/No	Yes		
	Off grid options for rural and remote areas	Yes/No	Yes		
R3	Are any of the following agencies under supervision of the regulatory body?				
	Rural electrification agencies	Yes/No	No		
	Renewable energy agencies	Yes/No	n/a		
	Energy efficiency agencies	Yes/No	n/a		
	ESCOs	Yes/No	No		
	Other (please specify)	Yes/No	no		
R4	Does the regulatory body cover only electricity and/or gas?	Yes/No	No		
	If no, what are the other types of energy covered?				
	Traditional fuels (e.g. wood fuel)	Yes/No	Yes		
	Transport fuels	Yes/No	No		
	Other (please specify)	Yes/No	Petroleum, coal, new and renewable energy sources		
R5	Does regulation cover:				
	Generation	Yes/No	Yes		
	Transmission	Yes/No	Yes		
	Distribution	Yes/No	Yes		
	Supply	Yes/No	Yes		

PRINCIPLES OF GOOD REGULATION					
R6	Are the regulatory processes and procedures generally simple and transparent?	Yes/No/Other (Please specify)	Yes		
R7	Has the regulatory framework been stable over the last 3-5 years, i.e. state “yes” if there were no abrupt or completely unexpected changes in terms of regulation.	Yes/No/Other (Please specify)	Yes		
R8	Has the regulatory framework been sustainable, i.e have socio-economic and long-term development been taken into account when designing new regulation.	Yes/No/Other (Please specify)	Partly. There is currently no overall framework for RE and EE		
R9	How many members are on the board of directors?		7		
R10	For how many years are they appointed?		3		
R11	Are the criteria for their appointment clear and transparent?	Yes/No/Other (Please specify)	Yes		
R12	Are the criteria for their appointment objective?	Yes/No/Other (Please specify)	Yes		
R13	How many executive members work for the regulatory body?		55		
R14	How many on RE?		4		
R15	How many on EE?		4		

UNIDO Module 6 Self-Assessment Spreadsheet on Renewable Energy (RE)—Questionnaire

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
	Country:		Zambia		
	Author:		Mark Draeck		
	Name of company/ organization/institution:		IT Power Ltd.		
	Type of company/ organization/institution:		Consultancy		
	Country:		UK		
	Date:		Feb 08		
COVERAGE OF RE IN REGULATORY FRAMEWORK					
RE1	Has national legislation been passed (or proposed) regarding the stimulation of RE?	Passed/Proposed/ No/Other (Please specify)	Government's intentions were set out in National Energy policy (Feb 07). No legal approval yet		
RE2	Has the potential of RE technologies been assessed? (if Yes please specify the RETs)?	Yes/No	Yes		
RE3	Has a roadmap for RE deployment been developed?	Yes/No	Yes		
RE4	Is there an entity in charge of RE in your country?	Yes/No	Yes		
	If no go to RE5				
	If yes, is this entity: the regulatory authority/the rural electrification agency/the RE agency/other	The regulatory authority/ the rural electrification agency/the RE agency/ other (please specify)	Regulatory authority and rural electrification agency		
	Please specify which entity(-ies) covers RE in: Urban areas (on grid)	The regulatory authority/ the rural electrification agency/the RE agency/ other (please specify)	Regulatory authority		
	Rural and remote areas (on & off grid)	The regulatory authority/ the rural electrification agency/the RE agency/ other (please specify)	Regulatory authority and rural electrification agency		

RE5	With regard to rural electrification, is there an electrification plan being implemented or developed with regard to rural and remote areas?	Being implemented/ Being developed/No/ Other (please specify)	Being developed (Rural Electrification Master Plan)		
	Does this plan consider the use of RE on grid & off grid?	On grid/Off grid/Both/ No/Other (Please specify)	On grid/off grid		
RE6	With regard to rural electrification, which of the following measures are in place:				
	Decentralized off-grid programme	Yes/No	Yes		
	Concession system	Yes/No	Yes		
	Open access/third party	Yes/No	No		
	Integrated electricity planning	Yes/No	Yes		
	Transparent PPA/IPP	Yes/No	Yes		
	Realistic grid plan extension	Yes/No	Yes		
	Existence of ESCOs	Yes/No	Yes		
	Net-metering Law	Yes/No	No		
	Participatory approaches	Yes/No	Yes		
ENERGY SUBSIDIES					
RE7	What is the base tariff for domestic electricity in your country? (in USD cents per kWh)	USD cents/kWh	3.1		
	What is the base tariff for electricity for industry in your country? (in USD cents per kWh)	USD cents/kWh	3.4		
	What is the base tariff for commercial electricity in your country? (in USD cents per kWh)	USD cents/kWh	4.8		
	Are these tariffs cost-reflective?	Yes/No	No		
RE8	What was the yearly budget for subsidies for (during last year or the most recent figure available - please mention the year):				
	Conventional energy	Million USD	Not disclosed		
	Renewable energy	Million USD	Not disclosed		

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
RE9	Are there stimulating measures in use to support the use of RE in your country (on grid and/or off grid)?	Yes/No	No		
	If yes, what are these measures? Fiscal measures (e.g. tax breaks)	Yes/No	No		
	Investment subsidies	Yes/No	Yes		
	Feed-in tariff	Yes/No	Yes		
	Tenders	Yes/No	Yes		
	Obligations and targets	Yes/No	No		
	Tradable green certificates	Yes/No	No		
	Other tradable certificates (e.g. CHP certificates,…) Please specify	Yes/No	No		
	Electricity disclosure	Yes/No	No		
	Other (If yes, please specify)	Yes/No	No		
EFFECTIVENESS AND EFFICIENCY					
RE10a	What is/are the major measure/s supporting renewable energy in your country?		Tariff setting		
	For how many years has/ve this/ese measure/s been running?	# years	1		
RE11a	In what year did this measure start?		2008		
	How much renewable electricity was produced per year (in energy production—MWh) before this measure came into force?	xx MWh/year	72000		
	How much renewable electricity (in energy production—MWh) was produced per year since this measure was introduced?	xx MWh	77000		
RE12a	What was the budget per year for this measure (MUSD)?		0.4		
	Repeat the exercise for as many measures you deem relevant:				

RE10b	Measure: For how many years has this measure been running?	# years			
RE11b	In what year did this measure start?				
	How much renewable electricity was produced per year (in energy production—MWh) before this measure came into force?	xx MWh/year			
	How much renewable electricity (in energy production—MWh) was produced per year since this measure was introduced?	xx MWh			
RE12b	What was the budget per year for this measure (MUSD)?				
RE10c	Measure: For how many years has this measure been running?	# years			
RE11c	How much renewable electricity was produced per year (in energy production—MWh) before this measure came into force?	xx MWh/year			
	How much renewable electricity (in energy production—MWh) was produced per year since this measure was introduced?	xx MWh			
RE12c	What was the budget per year for this measure (MUSD)?				
NON-FINANCIAL MEASURES					
RE13	Which of the following regulations and/or measures are in place for the following RETs: ***PV***				
	Licensing	Yes/No	Yes		
	Codes of practice	Yes/No	Being developed		
	Standards	Yes/No	Being developed		
	Consumer awareness campaign	Yes/No	Being developed		

	Answer using one of these options only	Example	Use this column for your country	Comments (optional)
Solar water heaters				
Licensing	Yes/No	Yes		
Codes of practice	Yes/No	Being developed		
Standards	Yes/No	Being developed		
Consumer awareness campaign	Yes/No	Being developed		
Small hydro				
Licensing	Yes/No	Yes		
Codes of practice	Yes/No	Being developed		
Standards	Yes/No	Being developed		
Consumer awareness campaign	Yes/No	Being developed		
Wind energy				
Licensing	Yes/No	No		
Codes of practice	Yes/No	No		
Standards	Yes/No	No		
Consumer awareness campaign	Yes/No	No		
Biomass				
Licensing	Yes/No	Yes		
Codes of practice	Yes/No	Being developed		
Standards	Yes/No	Being developed		
Consumer awareness campaign	Yes/No	Being developed		
Other RET				
Licensing	Yes/No			
Codes of practice	Yes/No			
Standards	Yes/No			
Consumer awareness campaign	Yes/No			

UNIDO Module 6 Self-Assessment Spreadsheet on Energy Efficiency (EE)—Questionnaire

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
	Country:		Zambia		
	Author:		Mark Draeck		
	Name of company/ organization/institution:		IT Power Ltd.		
	Type of company/ organization/institution:		Consultancy		
	Country:		UK		
	Date:		Feb 08		
COVERAGE OF EE IN REGULATORY FRAMEWORK					
EE1	Has national legislation been passed (or proposed) regarding the stimulation of EE?	Passed/Proposed/No/ Other (Please specify)	Government's intentions were set out in National Energy policy (Feb 07). No legal approval yet		
EE2	Has the EE potential been assessed in the key sectors industry-households-tertiary-public?	Yes/No	Yes		
EE3	Has a national EE plan been developed to use the potential?	Yes/No	Yes		
EE4	Is there an entity in charge of EE in your country?	Yes/No	Yes		
	If no go to EE5				
	If yes, is this entity: the regulatory authority/the EE agency/transmission system operator (TSO)/distribution system operator (DNO)/other	The regulatory authority/ the EE agency/TSO/DNO/ Other (please specify)	The regulatory authority		

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
	Does this entity(-ies) cover EE in:				
	Industry	Yes/No	Yes		
	Households in urban areas	Yes/No	Yes		
	Households in rural areas	Yes/No	Yes		
	Tertiary sector (e.g. hotels, hospitals,...)	Yes/No	Yes		
	Public sector	Yes/No	Yes		
EE REGULATION					
EE5	Is any of the following regulations with regard to *demand-side management (DSM)* in place:				
	Integrated electricity planning	Yes/No	Yes		
	Bid competition: supply versus demand	Yes/No	Yes		
	Existence of ESCOs	Yes/No	No		
	Energy savings in public administrations	Yes/No	No		
	Other (If Yes please specify)	Yes/No			
EE6	Is any of the following types of *tariff regulation* in place?				
	Decoupling profits/sales level for utilities	Yes/No	No		
	Utilities being rewarded for energy savings	Yes/No	No		
	Tariff for cogeneration	Yes/No	No		
	Other (If Yes please specify)	Yes/No			
EE7	Are any of the following types of *load management* in place?				
	Tariff for reduction of peak demand (e.g. time-of-the-day differentiation)	Yes/No	No		
	Tariff for type of clients (e.g. industry,...)	Yes/No	Yes		
	Load factor improvement		No		
	Other (If Yes please specify)	Yes/No			

EE8	What was the yearly budget for subsidies for (during last year or the most recent figure available—please mention the year): Conventional energy (in MUSD)		Not disclosed		
	Energy efficiency (in MSUD)		Not disclosed		
EE9	Are there stimulating measures in use to stimulate EE in your country (on grid and/or off grid)?	Yes/No	No		
	If yes, what are these measures?				
	Fiscal measures (e.g. tax breaks)	Yes/No	Yes		
	Investment subsidies	Yes/No	Yes		
	Obligations and targets	Yes/No	No		
	Tradable white certificates	Yes/No	No		
	Other tradable certificates (e.g. CHP certificates,…) Please specify	Yes/No	No		
	Other (If Yes please specify)	Yes/No			
EFFECTIVENESS AND EFFICIENCY					
EE10a	What is the major measure supporting energy efficiency in your country?		Tariff setting		
	For how many years has this measure been running?		1		
EE11a	In what year did this measure start?		2007		
	How much energy was saved per year (in MWh) before this measure came into force?		50		
	How much energy (in MWh) was saved per year since this measure was introduced?		200		
EE12a	What was the budget per year for this measure (MUSD)?		0.01		
	Repeat the exercise for as many measures you deem relevant:				
EE10b	Measure:				
	For how many years has this measure been running?				

		Answer using one of these options only	Example	Use this column for your country	Comments (optional)
EE11b	In what year did this measure start?				
	How much energy was saved per year (in MWh) before this measure came into force?				
	How much energy (in MWh) was saved per year since this measure was introduced?				
EE12b	What was the budget per year for this measure (MUSD)?				
EE10c	Measure: For how many years has this measure been running?				
EE11c	In what year did this measure start?				
	How much energy was saved per year (in MWh) before this measure came into force?				
	How much energy (in MWh) was saved per year since this measure was introduced?				
EE12c	What was the budget per year for this measure (MUSD)?				
NON-FINANCIAL MEASURES					
EE13	Which of the following regulations and/or measures are in place for the following EE products/systems:		Standards and codes are mentioned in the National Energy Policy for energy efficient equipment (not specified) in different sectors		
	Air conditioning systems				
	Labels	Yes/No	No		
	Codes of practice	Yes/No	No		
	Standards	Yes/No	No		
	Consumer awareness campaign	Yes/No	No		
	Solar water heaters				
	Labels	Yes/No	No		
	Codes of practice	Yes/No	No		
	Standards	Yes/No	No		
	Consumer awareness campaign	Yes/No	No		

	Buildings				
	Labels	Yes/No	No		
	Codes of practice	Yes/No	No		
	Standards	Yes/No	No		
	Consumer awareness campaign	Yes/No	No		
	Fridges-freezers				
	Labels	Yes/No	No		
	Codes of practice	Yes/No	No		
	Standards	Yes/No	No		
	Consumer awareness campaign	Yes/No	No		
	Compact fluorescent lamps				
	Labels	Yes/No	No		
	Codes of practice	Yes/No	No		
	Standards	Yes/No	No		
	Consumer awareness campaign	Yes/No	No		
	Other EE product/system (please specify):				
	Labels	Yes/No			
	Codes of practice	Yes/No			
	Standards	Yes/No			
	Consumer awareness campaign	Yes/No			
	Other EE product/system (please specify):				
	Labels	Yes/No			
	Codes of practice	Yes/No			
	Standards	Yes/No			
	Consumer awareness campaign	Yes/No			
EE14	Are energy audits being carried out and/or subsidized in: Industry	Yes/No	No		
	Households	Yes/No	No		
	Tertiary sector (hotels, hospitals,...)	Yes/No	No		
	Public sector	Yes/No	No		

UNIDO Module 6 Self-Assessment Spreadsheet on Regulatory Frameworks: Results

	Country: Author: Name of company/organization/institution: Type of company/organization/institution: Country: Date:			*Check out your score* ↓	
			Your answer	Score calculator	Your score
REGULATORY FRAMEWORK					
REGULATORY COVERAGE					
R1	What are the core responsibilities of the regulatory body in your country: Monitor liberalization policy	Yes/No			
	Licensing	Yes/No			
	Manage support system for RE/EE	Yes/No			
	Develop dtandards/codes of good practice	Yes/No			
	Tariff setting	Yes/No			
	Consumer complaints	Yes/No			
	Other (Please specify)	Yes/No			
				If 4 or more of the mentioned 6 responsibilities are covered = 5 points; If 2 or 3 = 3 points; If only one = 1 point; If none = 0 points; If “Other” are specified ask the trainer	Score:

R2	Is the regulatory body in charge of/ involved in energy planning for: Urban areas	Yes/No			Score:
	Grid extension to rural and remote areas	Yes/No			
	Off grid options for rural and remote areas	Yes/No			
				If 3 out of 3 areas are covered = 3 points; If 2 out of 3 areas are covered = 2 points; if 1 = 1 point; if none = 0 points	
R3	Are other agencies under supervision of the regulatory body? Rural electrification agencies	Yes/No			
	Renewable energy agencies	Yes/No			
	Energy efficiency agencies	Yes/No			
	ESCOs	Yes/No			
	Other (please specify)	Yes/No			
				If 2 or more agencies are integrated in or under supervision of the regulatory body = 2 points; If 1 agency = 1 point; If none = 0 points	Score:
R4	Does the regulatory body cover only electricity and/or gas?	Yes/No			
	If no, what are the other types of energy covered?				
	Traditional fuels (e.g. wood fuel)	Yes/No			
	Transport fuels	Yes/No			
	Other (please specify)	Yes/No			

			Your answer	Score calculator	Your score
				If only electricity and/or gas is covered = 1 point; If Traditional fuels and/or Transport Fuels are covered too = 2 points; If “Other” ask the trainer	Score:
R5	Does regulation cover: Generation	Yes/No			
	Transmission	Yes/No			
	Distribution	Yes/No			
	Supply	Yes/No			
				If all four - G-T-D-S - are covered = 4 points; If three are covered = 3 points; If two are covered = 2 points; etc.	Score:
				Score on Regulatory coverage:	
PRINCIPLES OF GOOD REGULATION					
R6	Are the regulatory processes and procedures generally simple and transparent?	Yes/No/Other (Please specify)		If “Yes” = 1 point; If “Other” ask the trainer	
R7	Has the regulatory framework been stable over the last 3-5 years, i.e. there were no abrupt or completely unexpected changes in terms of regulation.	Yes/No/Other (Please specify)		If “Yes” = 1 point; If “Other” ask the trainer	

R8	Has the regulatory framework been sustainable, i.e have socio-economic and long-term developments been taken into account when designing new regulation.	Yes/No/Other (Please specify)		If “Yes” = 1 point; If “Other” ask the trainer	
R9	How many members are in the board of directors?				
R10	For how many years are they appointed?			If “years” is between 3 and 6 = 1 point	
R11	Are the criteria for their appointment clear and transparent?	Yes/No/Other (Please specify)		If “Yes” = 1 point; If “Other” ask the trainer	
R12	Are the criteria for their appointment objective?	Yes/No/Other (Please specify)		If “Yes” = 1 point; If “Other” ask the trainer	
R13	How many executive members work for the regulatory body?				
R14	How many on RE?			If R14/R13 > 15% = 1 point	
R15	How many on EE?			If R15/R13 > 15% = 1 point	
				Score on Principles of good Regulation:	Score:

UNIDO Module 6 Self-Assessment Spreadsheet on Renewable Energy: Results

	Country: Author: Name of company/ organization/institution: Type of company/ organization/institution: Country: Date:		Your answer	What does it mean?
RENEWABLE ENERGY				***What should I do next?***
COVERAGE OF RE IN REGULATORY FRAMEWORK				
RE1	Has national legislation been passed (or proposed) regarding the stimulation of RE?	Passed/Proposed/No/Other (Please specify)	Government's intentions were set out in national energy policy (Feb 07). No legal approval yet	
RE2	Has the RE potential been assessed (especially for the most important RETs)?	Yes/No	0	
RE3	Has a roadmap for RE deployment been developed?	Yes/No	Yes	
RE4	Is there an entity in charge of RE in your country?	Yes/No	Yes	
	If no go to RE5			
	If yes, is this entity: the regulatory authority/ the rural electrification agency/the RE agency/ other	The regulatory authority/the rural electrification agency/the RE agency/other (please specify)	Regulatory authority and rural electrification agency	
	Please specify which entity(-ies) covers RE in: Urban areas (on grid)	The regulatory authority/the rural electrification agency/the RE agency/other (please specify)	Regulatory authority	
	Rural and remote areas (on & off grid)	The regulatory authority/the rural electrification agency/the RE agency/other (please specify)	Regulatory authority and rural electrification agency	

RE5	With regard to rural electrification, is there an electrification plan being implemented or developed with regard to rural and remote areas?	Being implemented/Being developed/No/Other (please specify)	Being developed (rural electrification master plan)	
	Does this plan consider the use of RE on grid & off grid?	On grid/Off grid/Both/No/Other (Please specify)	On grid/off grid	
RE6	With regard to rural electrification, which of the following measures are in place:			
	Decentralized off-grid programme	Yes/No	Yes	
	Concession system	Yes/No	Yes	
	Open access/third party	Yes/No	No	
	Integrated electricity planning	Yes/No	Yes	
	Transparent PPA/IPP	Yes/No	Yes	
	Realistic grid plan extension	Yes/No	Yes	
	Existence of ESCOs	Yes/No	Yes	
	Net-metering Law	Yes/No	No	
	Participatory approaches	Yes/No	Yes	
			Score	This score gives a rough indication of the integration of renewable energy in the regulatory framework in your country. If your score is 9 or 10; excellent; If your score is 7 or 8; good; If 5 or 6; fair; If lower than 5; poor. Note that this score gives an indication only on whether RE is covered (yes/no) in regulation, but not on the "quality" of this coverage. The quality of the support instruments will be checked in some more detail in the performance analysis in the following section, e.g. by looking into effectiveness and efficiency.
				Exercise: *Choose one of the areas (e.g. legislation, regulatory entity, RE in urban or rural areas,…) and write half a page on what you think is the most urgent issue to address and what solutions could like look like.*

			Your answer	**What does it mean?** ***What should I do next?***
				Background: *Check Module 6 Section 5 “Integrating RE in the regulatory framework” to provide you with background information and some African examples. Section 5.3 in particular focuses on rural electrification.*
ENERGY SUBSIDIES				
RE7	What is the base tariff for domestic electricity in your country? (in cUSD per kWh)		o	
	Is this tariff cost-reflective?	Yes/No	o	
RE8	What was the yearly budget for subsidies for (during last year or the most recent figure available—please mention the year): Conventional energy		o	
	Renewable energy		o	
RE9	Are there stimulating measures in use to support the use of RE in your country (on grid and/or off grid)?	Yes/No	o	
	If yes, what are these measures? Fiscal measures (e.g. tax breaks)	Yes/No	o	
	Investment subsidies	Yes/No	o	
	Feed-in tariff	Yes/No	o	
	Tenders	Yes/No	o	
	Obligations and targets	Yes/No	o	
	Tradable green certificates	Yes/No	o	
	Other tradable certificates (e.g. CHP certificates,…) Please specify	Yes/No	o	
	Electricity disclosure	Yes/No	o	
	Other (If yes, please specify)	Yes/No	o	
				Exercise: *List the pros and cons for the main support instrument for RE in your country. Section 5.4 “Common support mechanisms for renewable electricity” provides you with background information and examples.*

EFFECTIVENESS AND EFFICIENCY

RE10a	What is/are the major measure/s supporting renewable energy in your country?		○	
	For how many years has/have this/these measure/s been running?		○	
RE11a	How much renewable electricity was produced per year (in energy production—MWh) before this measure came into force?		○	
	How much renewable electricity (in energy production—MWh) was produced per year since this measure was introduced?		○	[(production(year n) - production(year n -1)/(production (year n-1)]/(number of years since the measure started); The relative growth rate in RE production (%)—before and after the start of the support mechanism—shows how fast the RE production has grown (over the number of years since the measure was introduced) and gives an indication of the effectiveness of the mechanism.
RE12a	What was the budget per year for this measure (MUSD)?			The budget for the major RE measure divided by the increase in RE production over the same period of time gives an indication of the cost of the measure (in USD/kWh). This cost can be compared to other RE measures and be benchmarked against them, and/or be compared to the electricity price, and as such be used as a (rough) efficiency indicator.
				Background: *Check Module 6 Section 5.7.2 "Effectiveness and Efficiency" to interpret your result.*
				Exercise: *If effectiveness is low (‹ 5%) then list the major reasons and barriers why that is, and write half a page on how you think this can/should be improved. If effectiveness is higher then calculate effectiveness for the best performing RET in your country and explain the key reasons for its success.*

			Your answer	What does it mean? *What should I do next?*
NON-FINANCIAL MEASURES				
RE13	Which of the following regulations and/or measures are in place for the following RETs: ***PV***			
	Licensing	Yes/No	○	
	Codes of practice	Yes/No	○	
	Standards	Yes/No	○	
	Consumer awareness campaign	Yes/No	○	
	Solar water heaters			
	Licensing	Yes/No	○	
	Codes of practice	Yes/No	○	
	Standards	Yes/No	○	
	Consumer awareness campaign	Yes/No	○	
	Small hydro			
	Licensing	Yes/No	○	
	Codes of practice	Yes/No	○	
	Standards	Yes/No	○	
	Consumer awareness campaign	Yes/No	○	
	Wind energy			
	Licensing	Yes/No	○	
	Codes of practice	Yes/No	○	
	Standards	Yes/No	○	
	Consumer awareness campaign	Yes/No	○	
	Other RET			
	Licensing	Yes/No	○	
	Codes of practice	Yes/No	○	

Standards	Yes/No	o	
Consumer awareness campaign	Yes/No	o	
			This gives an idea of how well the non-financial barriers for each RET are adressed in your country.
			Background: *Check Module 6 Section 5.5 “Standards, labels and codes of practice” for additional information.*
			Exercise: *Pick the RET which is most relevant for your country and describe on half a page how it is covered in terms of non-financial barriers.*

UNIDO Module 6 Self Assessment Spreadsheet on Energy Efficiency: Results

	Country: Author: Name of company/organization/institution: Type of company/organization/institution: Country: Date:					
			Your answer	**Score calculator**	**Your score**	**What does it mean?** ***What should I do next?***
ENERGY EFFICIENCY						
COVERAGE OF EE IN REGULATORY FRAMEWORK						
EE1	Has national legislation been passed (or proposed) regarding the stimulation of EE?	Passed/Proposed/No/Other (Please specify)		Passed = 2 points; Proposed = 1 point; No = 0 points; Other = ask the trainer		
EE2	Has the EE potential been assessed in the key sectors industry-households-tertiary-public?	Yes/No		If yes = 1 point; If No = 0 points		
EE3	Has a national EE plan been developed to use the potential?	Yes/No		If yes = 1 point; If No = 0 points		
EE4	Is there an entity in charge of EE in your country?	Yes/No				
	If no go to EE5					
	If yes, is this entity: the regulatory authority/the EE agency/transmission system operator (TSO)/distribution system operator (DNO)/Other	The regulatory authority/the EE agency/TSO/DNO/Other (please specify)				
	Does this entity(-ies) cover EE in: Industry	Yes/No				
	Households in urban areas	Yes/No				
	Households in rural areas	Yes/No				
	Tertiary sector (e.g. hotels, hospitals,...)	Yes/No				
	Public sector	Yes/No				

				If at least 4 are covered = 3 points; If 2 or 3 are covered = 2 points; If 1 is covered = 1 point; If none is covered = 0 points		
				Score on Coverage of EE:		This score gives a rough indication of the integration of energy efficiency in the regulatory framework in your country. If your score is 7 or 8; excellent; If your score is 5 or 6; fair; If your score is 4 or below; poor. Note that this score gives an indication only on whether EE is covered (yes/no) in regulation, but not on the "quality" of this coverage. The quality of the support instruments will be checked in some more detail in the following sections.
						Exercise: *Choose one of the sectors (e.g. industry, tertiary,…) and write half a page on what you think is the most urgent issue to address and what solutions could like look like.*
						Background: Check Module 6 Section 6 "Integrating EE in the regulatory framework" to provide you with background information and some African examples. Also see Module 15 "Impact of different Power Sector Reforms Options on Energy Efficiency in Africa" for further reading on this subject.
EE REGULATION						
EE5	Is any of the following regulations with regard to *demand-side management (DSM)* in place: Integrated electricity planning	Yes/No	0			
	Bid competition: supply versus demand	Yes/No	0			
	Existence of ESCOs	Yes/No	0			
	Energy savings in public administrations	Yes/No	0			
	Other (Please specify)	Yes/No	0			

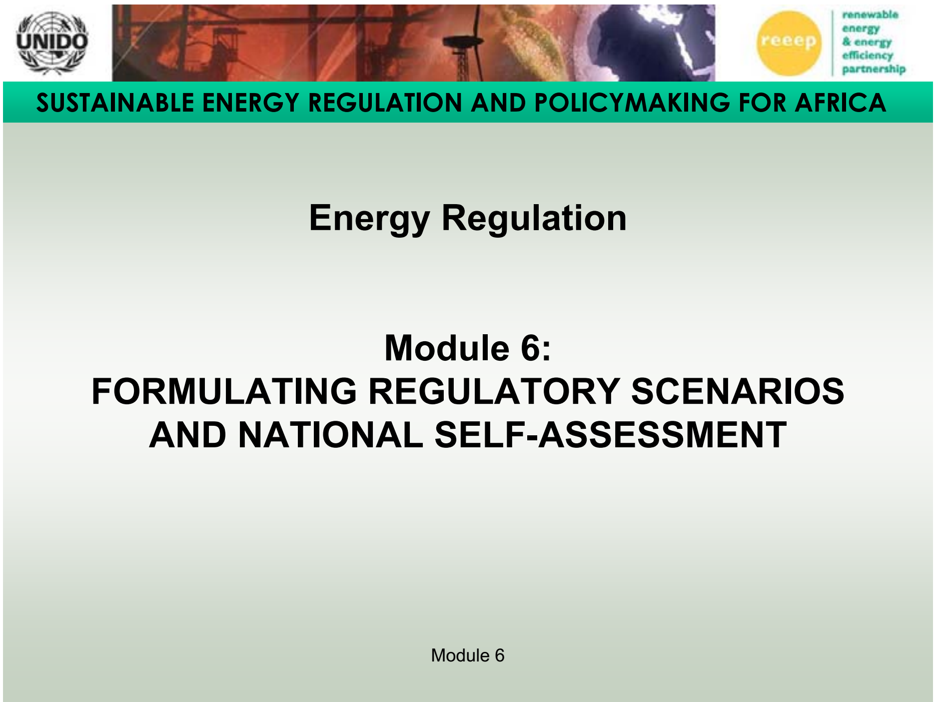
			Your answer	Score calculator	Your score	What does it mean? *What should I do next?*
EE6	Are any of the following types of *tariff regulation* in place?					
	Decoupling profits/sales level for utilities	Yes/No	0			
	Utilities being rewarded for energy savings	Yes/No	0			
	Tariff for cogeneration	Yes/No	0			
	Other (If Yes please specify)	Yes/No	0			
EE7	Is any of the following types of *load management* in place?					
	Tariff for reduction of peak demand (e.g. time-of-the-day differentiation)	Yes/No	0			
	Tariff for type of clients (e.g. industry,...)	Yes/No	0			
	Load factor improvement	Yes/No	0			
	Other (If Yes please specify)	Yes/No	0			
EE8	What was the yearly budget for subsidies for (during last year or the most recent figure available—please mention the year):					
	Conventional energy (in MUSD)		0			
	Energy efficiency (in MUSD)		0			
EE9	Are there stimulating measures in use to stimulate EE in your country (on grid and/or off grid)?	Yes/No	0			
	If yes, what are these measures?					
	Fiscal measures (e.g. tax breaks)	Yes/No	0			
	Investment subsidies	Yes/No	0			
	Obligations and targets	Yes/No	0			
	Tradable white certificates	Yes/No	0			
	Other tradable certificates (e.g. CHP certificates,...) Please specify	Yes/No	0			
	Other (If Yes please specify)	Yes/No	0			

						This provides you with an overview of the financial support schemes for EE in your country.
						Exercise: *Write half a page on how DSM and tariff setting could (further) stimulate EE in your country.*
EFFECTIVENESS AND EFFICIENCY						
EE10a	What is the major measure supporting energy efficiency in your country?					
	For how many years has this measure been running?					
EE11a	In what year did this measure start?					
	How much energy was saved per year (in MWh) before this measure came into force?					
	How much energy (in MWh) was saved per year since this measure was introduced?					[(energy savings(year n) – energy savings (year n-1)/(energy savings (year n-1)]/(number of years since the measure started); The relative growth rate (%) in EE savings (before and after the start of the support mechanism) shows how fast energy savings have grown (over the number of years since the measure was introduced) and gives an indication of the effectiveness of the mechanism.
EE12a	What was the budget per year for this measure (MUSD)?					The budget for the major EE measure divided by the increase in energy savings over the same period of time gives an indication of the cost of the measure (in USD/kWh). This cost can be compared to other EE measures and be benchmarked against them, and/or be compared to the electricity price, and as such be used as a (rough) efficiency indicator.
	Repeat the exercise for as many measures you deem relevant:					
EE10b	Measure:					
	For how many years has this measure been running?					

			Your answer	Score calculator	Your score	What does it mean? *What should I do next?*
EE11b	In what year did this measure start?					
	How much energy was saved per year (in MWh) before this measure came into force?					
	How much energy (in MWh) was saved per year since this measure was introduced?					
EE12b	What was the budget per year for this measure (MUSD)?					
EE10c	Measure: For how many years has this measure been running?					
EE11c	In what year did this measure start?					
	How much energy was saved per year (in MWh) before this measure came into force?					
	How much energy (in MWh) was saved per year since this measure was introduced?					
EE12c	What was the budget per year for this measure (MUSD)?					
						Background: *Check Module 6 Section 6.6.2 “Energy Efficiency Regulation—Effectiveness and Efficiency “ to help interpret your result.*
						Exercise: *If effectiveness is low (‹ 5%) then list the major reasons and barriers why that is, and write half a page on how you think this can/should be improved. If effectiveness is higher then calculate effectiveness for the best performing EE system or product in your country and explain the key reasons for its success.*
NON-FINANCIAL MEASURES						
EE13	Which of the following regulations and/or measures are in place for the following EE products/systems: ***Air conditioning systems***					
	Labels	Yes/No				

Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Solar water heaters					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Buildings					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Fridges-freezers					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Compact fluorescent lamps					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Other EE product/system (please specify): ……					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				
Other EE product/system (please specify): ……					
Labels	Yes/No				
Codes of practice	Yes/No				
Standards	Yes/No				
Consumer awareness campaign	Yes/No				

			Your answer	Score calculator	Your score	What does it mean? *What should I do next?*
EE14	Are energy audits being carried out and/or subsidized in: Industry	Yes/No				
	Households	Yes/No				
	Tertiary sector (hotels, hospitals, …)	Yes/No				
	Public sector	Yes/No				
						This gives an idea of how well the non-financial barriers for EE in each sector are adressed in your country.
						Background: *Check Module 6 Section 6.5 “Standards, labels and codes of practice” for additional information.*
						Exercise: *Pick the EE system or product which is most relevant for your country and describe on half a page how it is covered in terms of non-financial barriers.*

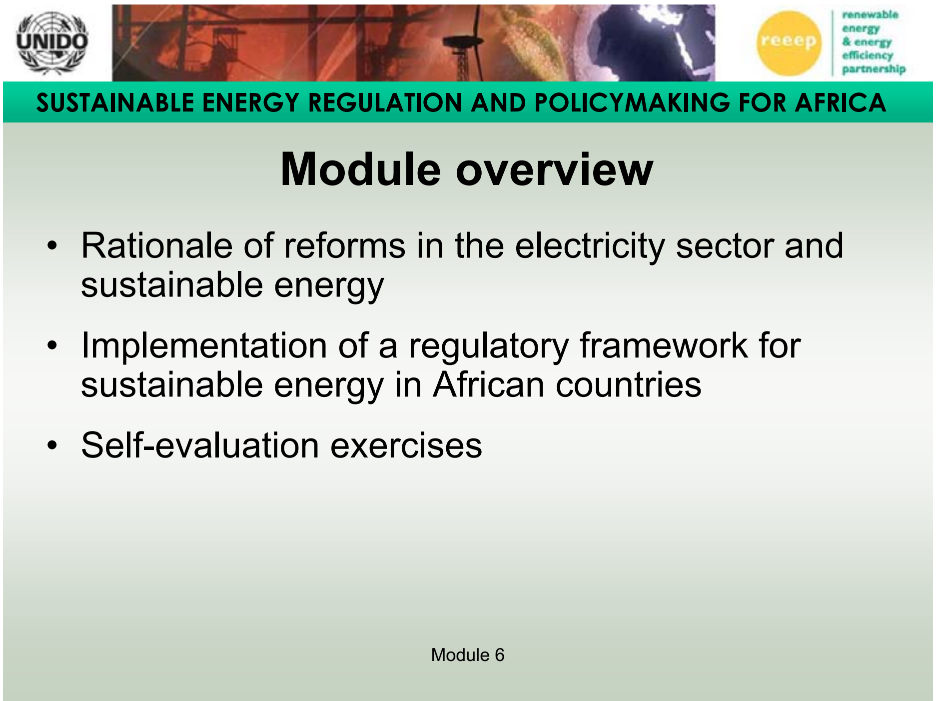


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Regulation

Module 6:
FORMULATING REGULATORY SCENARIOS
AND NATIONAL SELF-ASSESSMENT

Module 6

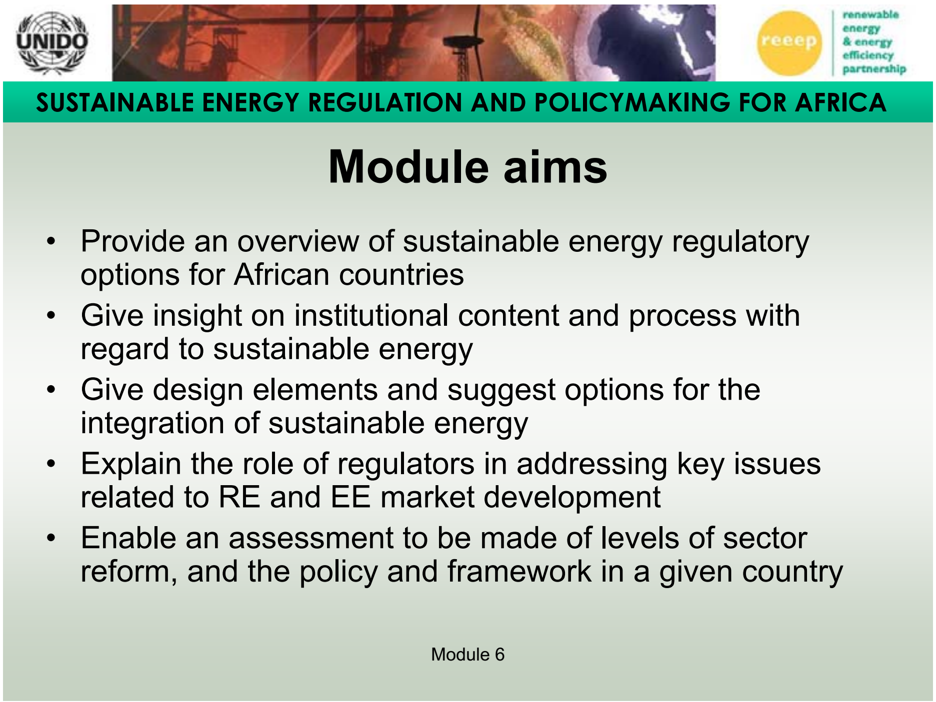


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Rationale of reforms in the electricity sector and sustainable energy
- Implementation of a regulatory framework for sustainable energy in African countries
- Self-evaluation exercises

Module 6

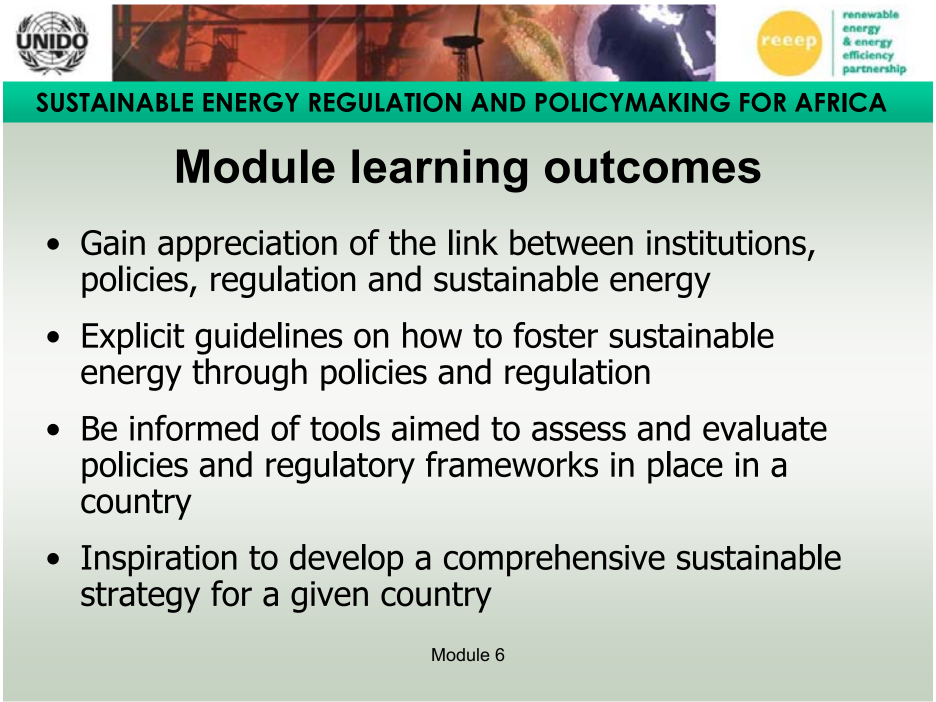


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Provide an overview of sustainable energy regulatory options for African countries
- Give insight on institutional content and process with regard to sustainable energy
- Give design elements and suggest options for the integration of sustainable energy
- Explain the role of regulators in addressing key issues related to RE and EE market development
- Enable an assessment to be made of levels of sector reform, and the policy and framework in a given country

Module 6

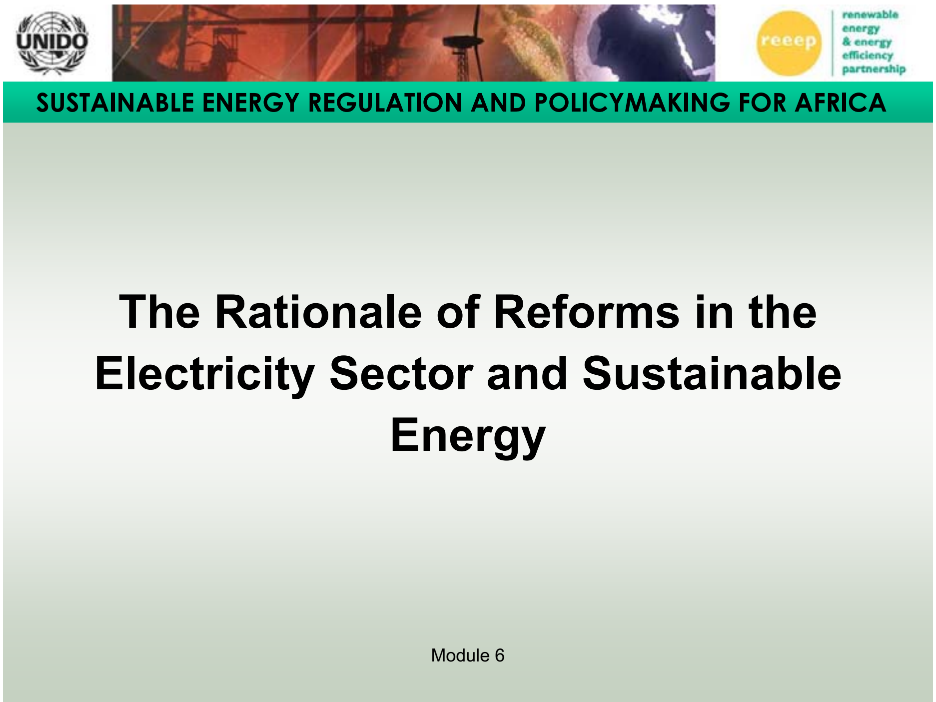


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Gain appreciation of the link between institutions, policies, regulation and sustainable energy
- Explicit guidelines on how to foster sustainable energy through policies and regulation
- Be informed of tools aimed to assess and evaluate policies and regulatory frameworks in place in a country
- Inspiration to develop a comprehensive sustainable strategy for a given country

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Rationale of Reforms in the Electricity Sector and Sustainable Energy

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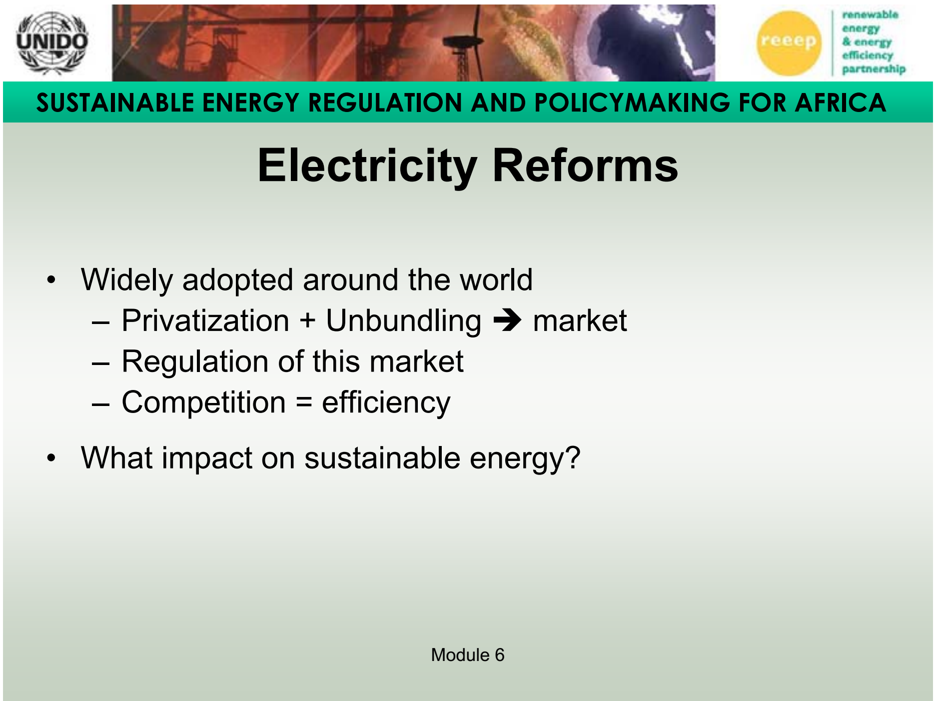

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Electricity Reforms

- Widely adopted around the world
  - Privatization + Unbundling ➔ market
  - Regulation of this market
  - Competition = efficiency
- What impact on sustainable energy?

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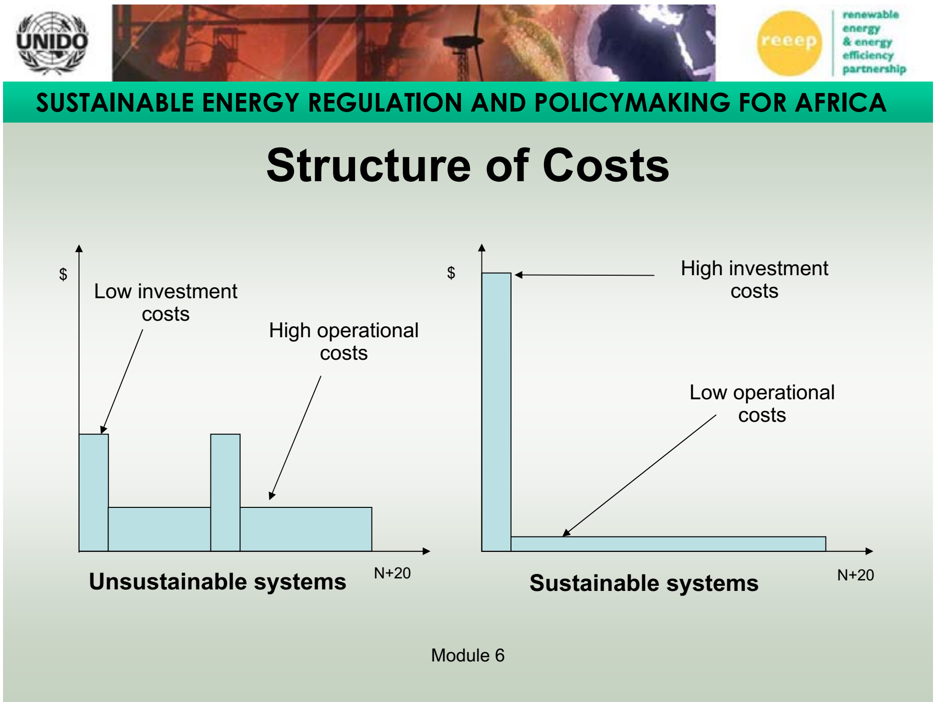
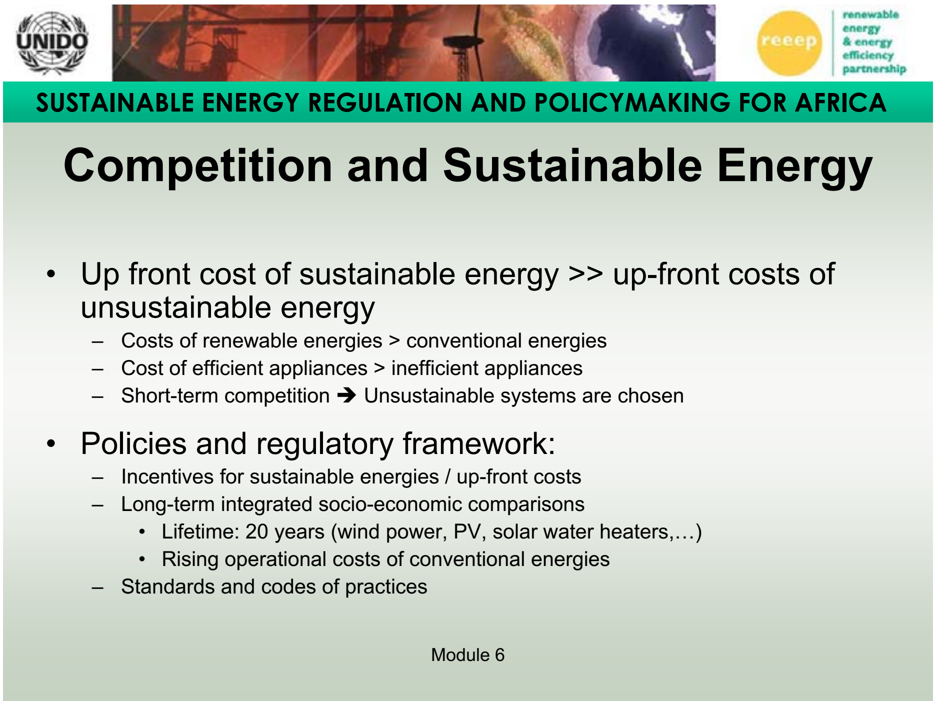


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Structure of Costs

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Competition and Sustainable Energy

- Up front cost of sustainable energy >> up-front costs of unsustainable energy
  - Costs of renewable energies > conventional energies
  - Cost of efficient appliances > inefficient appliances
  - Short-term competition ➔ Unsustainable systems are chosen
- Policies and regulatory framework:
  - Incentives for sustainable energies / up-front costs
  - Long-term integrated socio-economic comparisons
    - Lifetime: 20 years (wind power, PV, solar water heaters,…)
    - Rising operational costs of conventional energies
  - Standards and codes of practices

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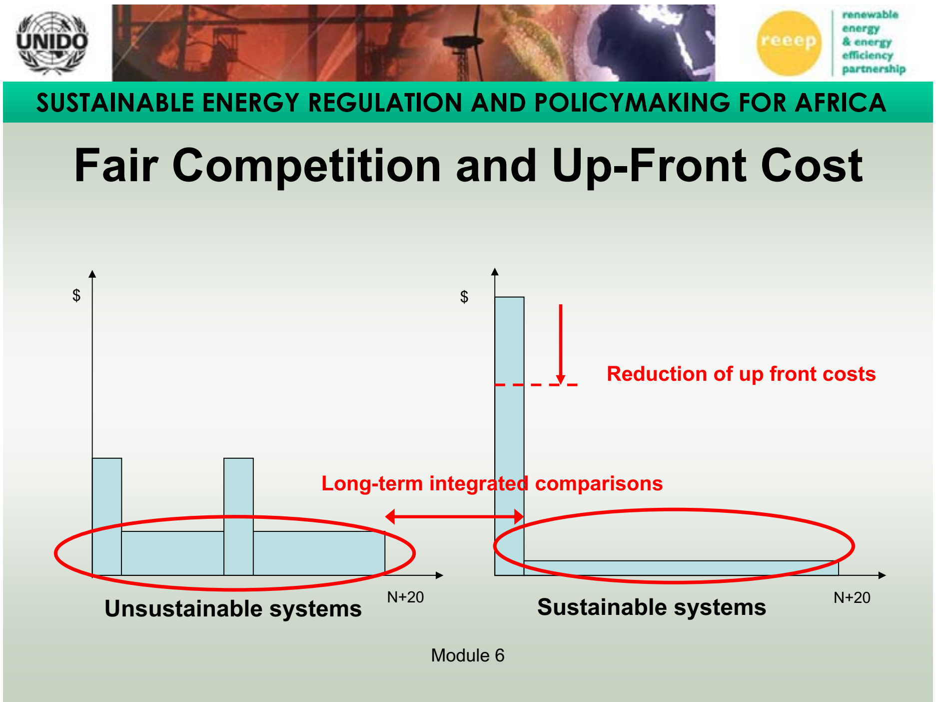


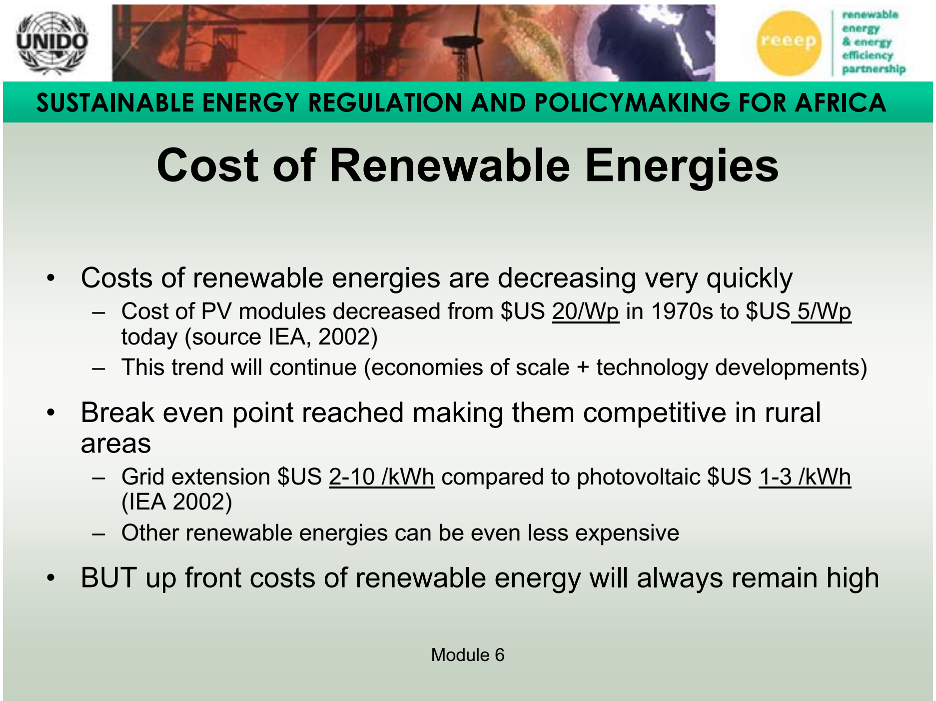
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Fair Competition and Up-Front Cost

Unsustainable systems

Sustainable systems

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Cost of Renewable Energies

- Costs of renewable energies are decreasing very quickly
  - Cost of PV modules decreased from $US 20/Wp in 1970s to $US 5/Wp today (source IEA, 2002)
  - This trend will continue (economies of scale + technology developments)
- Break even point reached making them competitive in rural areas
  - Grid extension $US 2-10 /kWh compared to photovoltaic $US 1-3 /kWh (IEA 2002)
  - Other renewable energies can be even less expensive
- BUT up front costs of renewable energy will always remain high

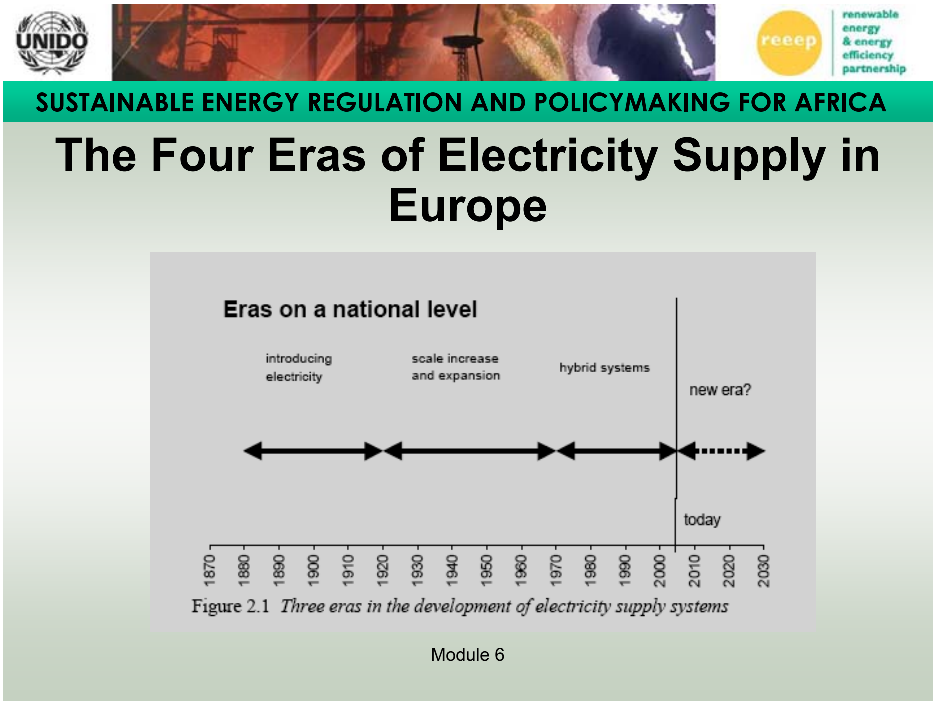
Module 6

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The History of Electrification

Four eras:

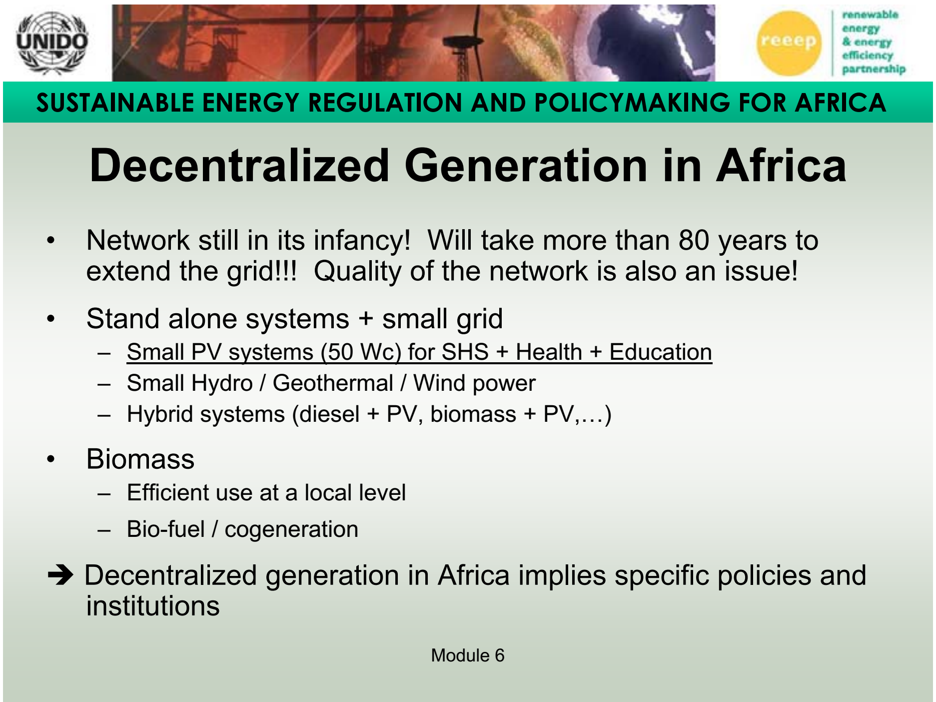
- Era of decentralized generation (1870-1920)
- Era of centralized generation (1920-1960)
- Era of hybrid system (1960-2000)
- A new era of decentralized generation (2000-…)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Four Eras of Electricity Supply in Europe

Figure 2.1 *Three eras in the development of electricity supply systems*



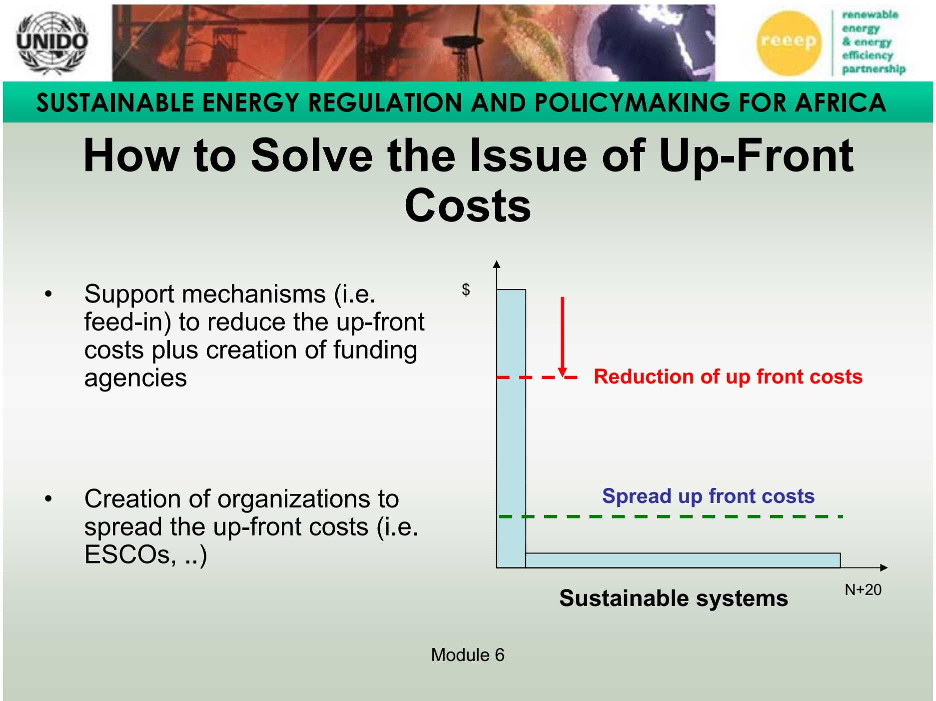
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Decentralized Generation in Africa

- Network still in its infancy! Will take more than 80 years to extend the grid!!! Quality of the network is also an issue!
- Stand alone systems + small grid
  - Small PV systems (50 Wc) for SHS + Health + Education
  - Small Hydro / Geothermal / Wind power
  - Hybrid systems (diesel + PV, biomass + PV,…)
- Biomass
  - Efficient use at a local level
  - Bio-fuel / cogeneration

➔ Decentralized generation in Africa implies specific policies and institutions

Module 6

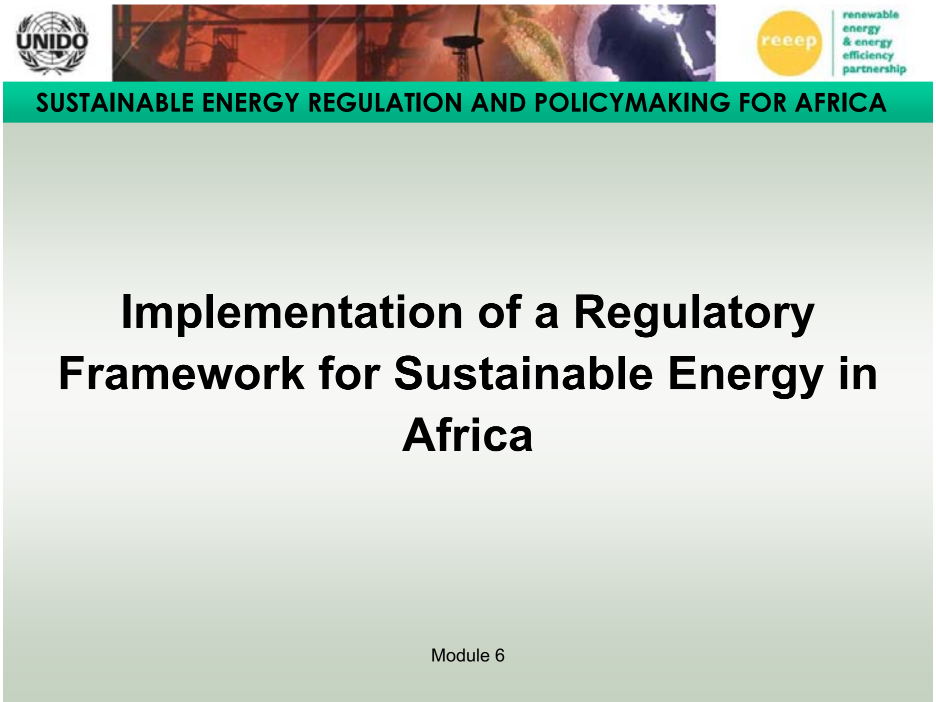


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

How to Solve the Issue of Up-Front Costs

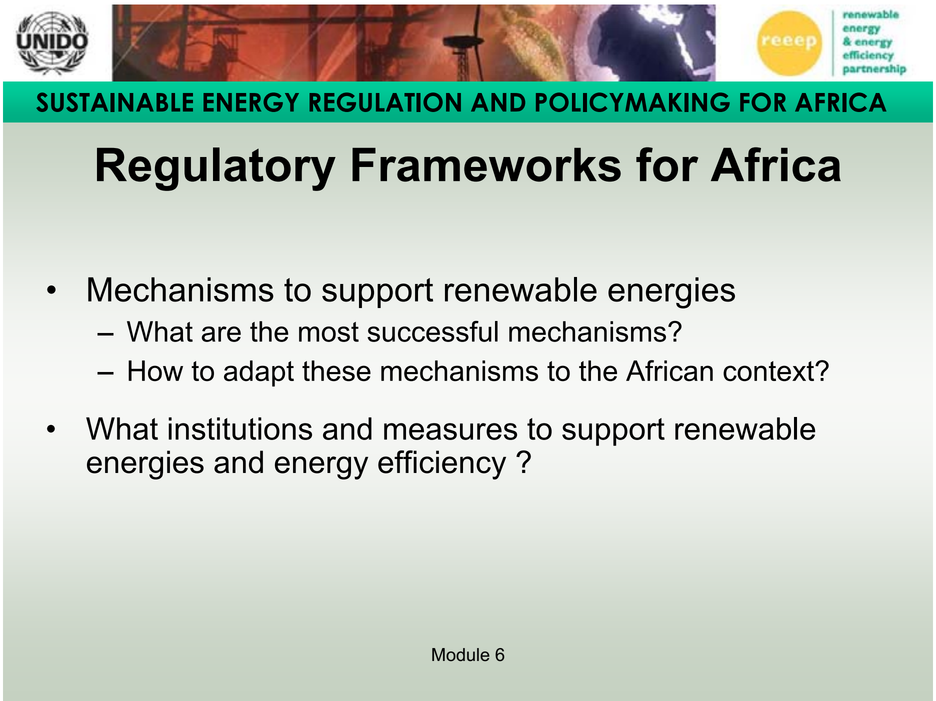
- Support mechanisms (i.e. feed-in) to reduce the up-front costs plus creation of funding agencies
- Creation of organizations to spread the up-front costs (i.e. ESCOs, ..)

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

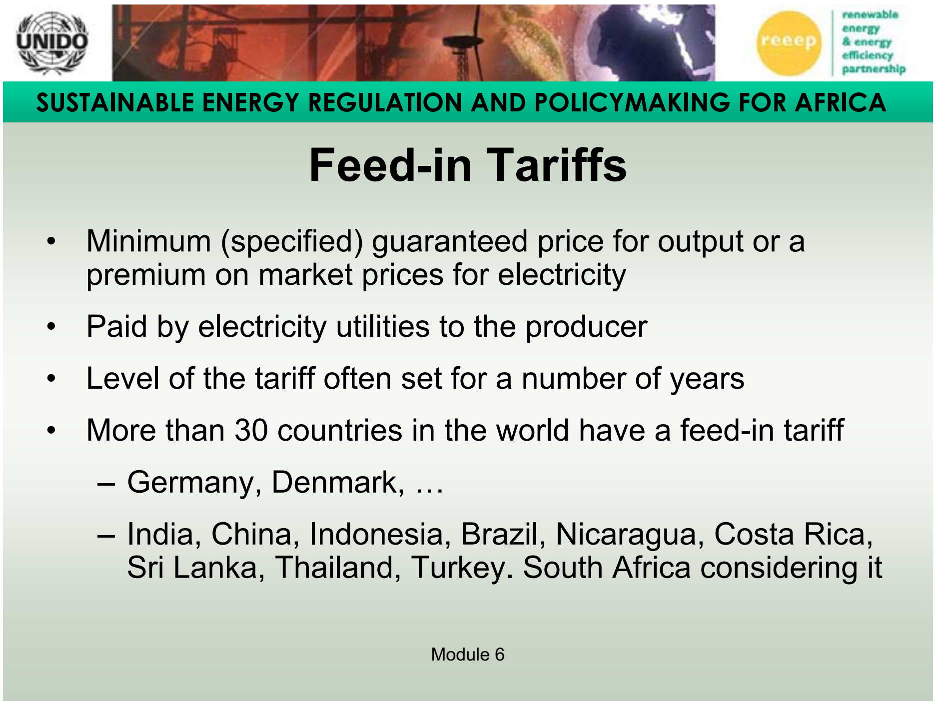
Implementation of a Regulatory Framework for Sustainable Energy in Africa



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulatory Frameworks for Africa

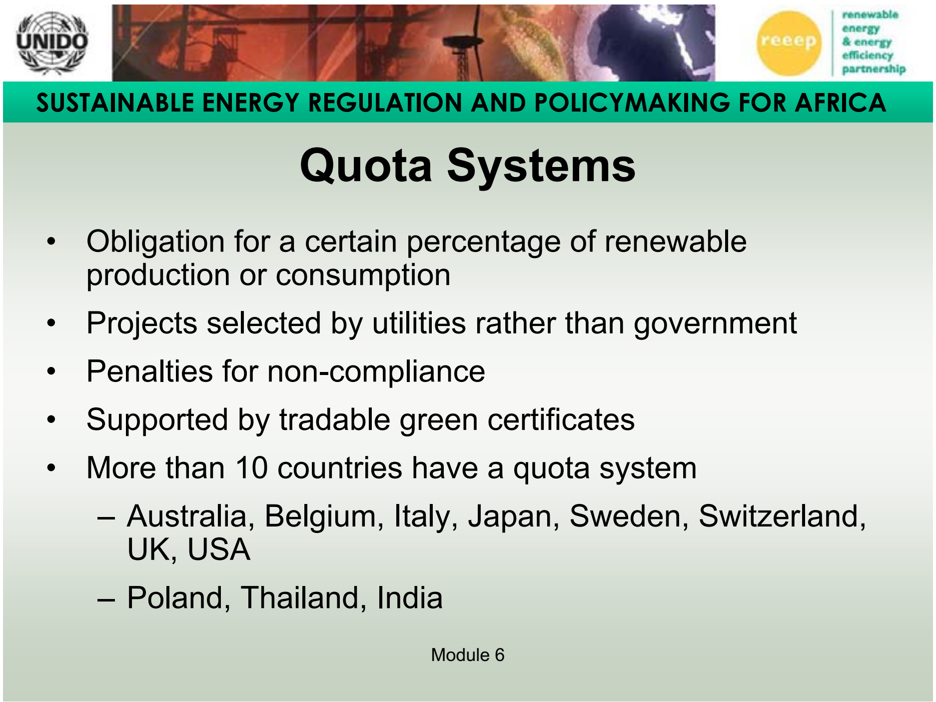
- Mechanisms to support renewable energies
  - What are the most successful mechanisms?
  - How to adapt these mechanisms to the African context?
- What institutions and measures to support renewable energies and energy efficiency ?



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Feed-in Tariffs

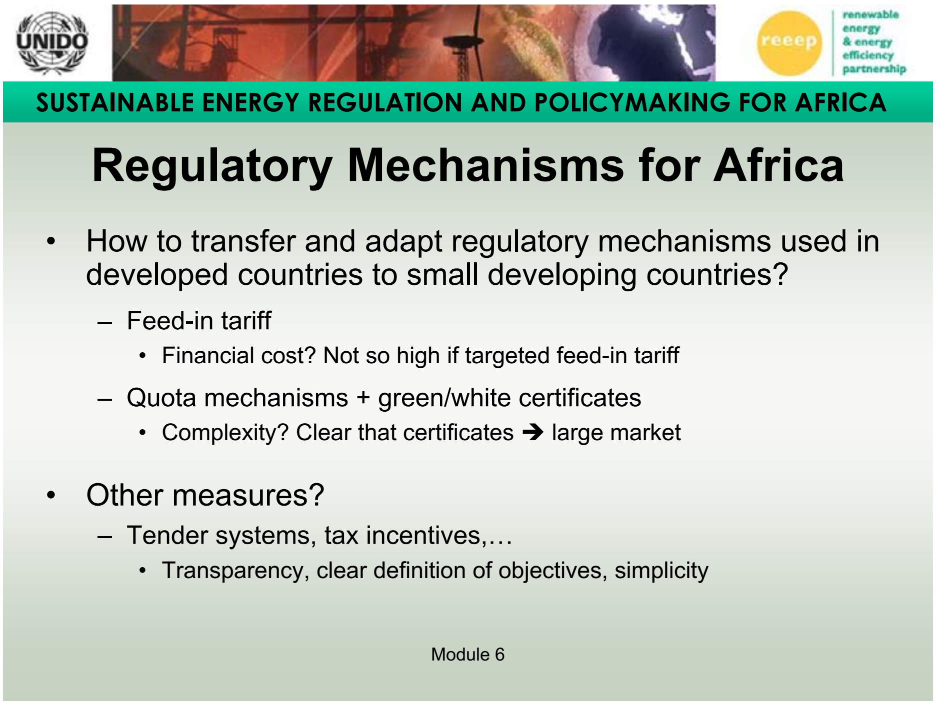
- Minimum (specified) guaranteed price for output or a premium on market prices for electricity
- Paid by electricity utilities to the producer
- Level of the tariff often set for a number of years
- More than 30 countries in the world have a feed-in tariff
  - Germany, Denmark, …
  - India, China, Indonesia, Brazil, Nicaragua, Costa Rica, Sri Lanka, Thailand, Turkey. South Africa considering it



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Quota Systems

- Obligation for a certain percentage of renewable production or consumption
- Projects selected by utilities rather than government
- Penalties for non-compliance
- Supported by tradable green certificates
- More than 10 countries have a quota system
  - Australia, Belgium, Italy, Japan, Sweden, Switzerland, UK, USA
  - Poland, Thailand, India

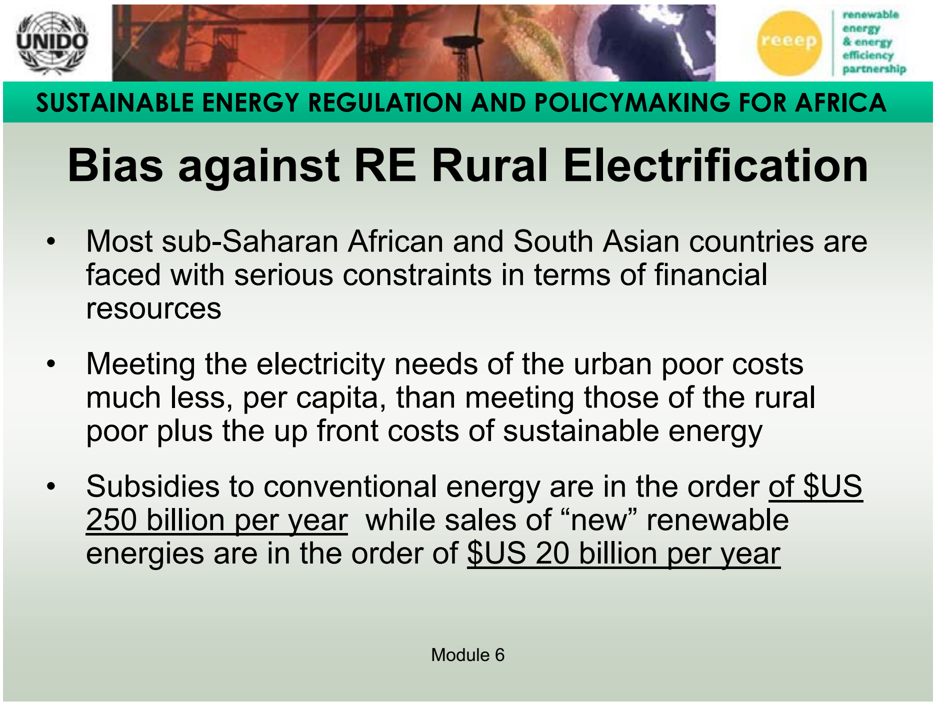


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulatory Mechanisms for Africa

- How to transfer and adapt regulatory mechanisms used in developed countries to small developing countries?
  - Feed-in tariff
    - Financial cost? Not so high if targeted feed-in tariff
  - Quota mechanisms + green/white certificates
    - Complexity? Clear that certificates ➔ large market
- Other measures?
  - Tender systems, tax incentives,…
    - Transparency, clear definition of objectives, simplicity

Module 6

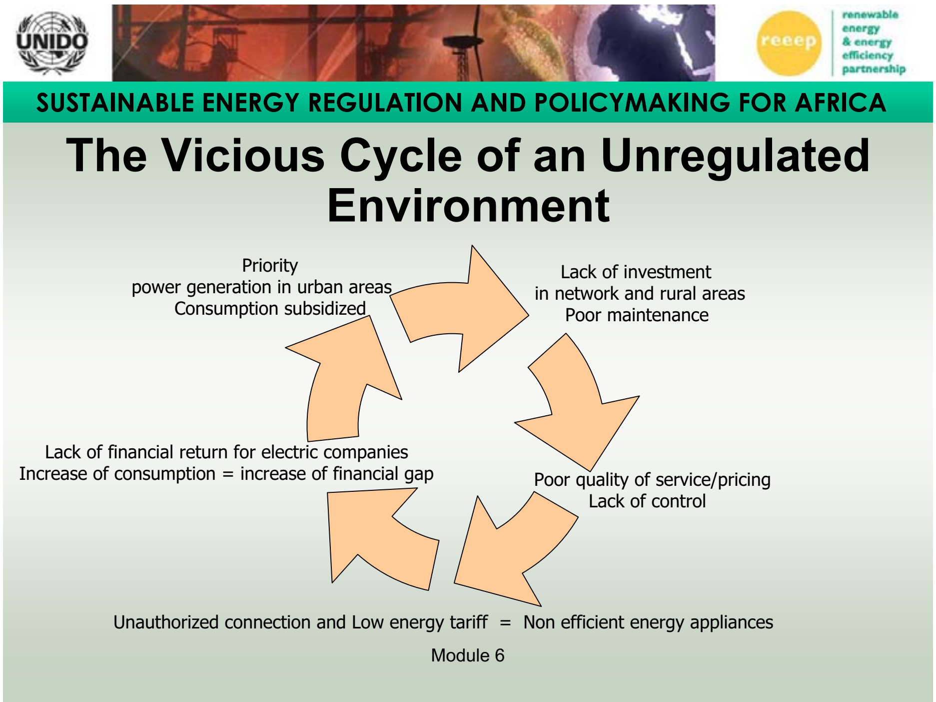


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Bias against RE Rural Electrification

- Most sub-Saharan African and South Asian countries are faced with serious constraints in terms of financial resources
- Meeting the electricity needs of the urban poor costs much less, per capita, than meeting those of the rural poor plus the up front costs of sustainable energy
- Subsidies to conventional energy are in the order of $US 250 billion per year while sales of “new” renewable energies are in the order of $US 20 billion per year

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Vicious Cycle of an Unregulated Environment

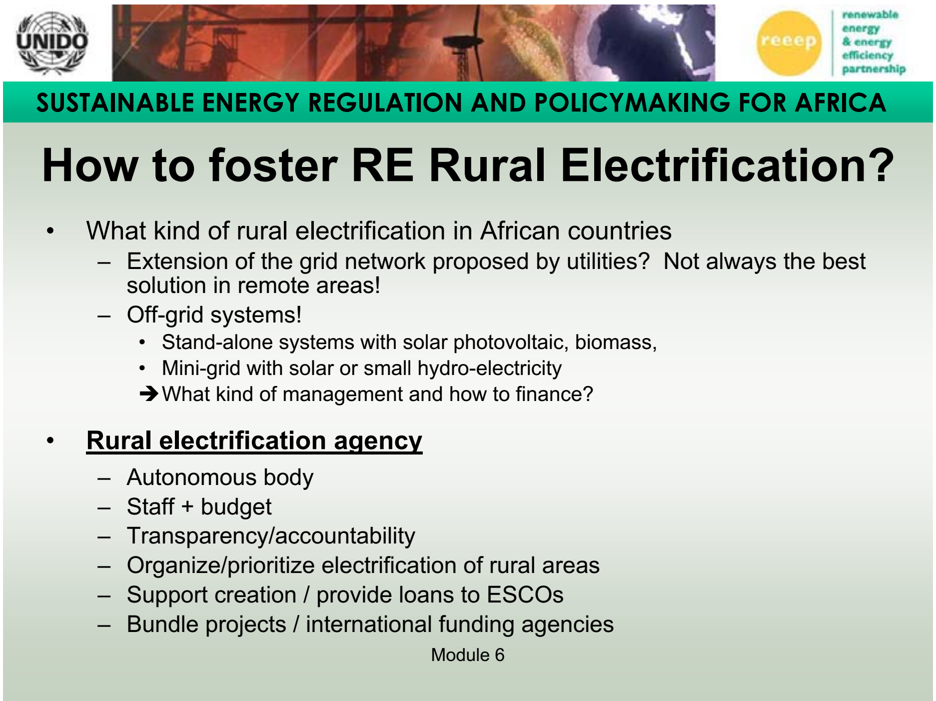
Priority
power generation in urban areas
Consumption subsidized

Lack of investment
in network and rural areas
Poor maintenance

Poor quality of service/pricing
Lack of control

Unauthorized connection and Low energy tariff = Non efficient energy appliances

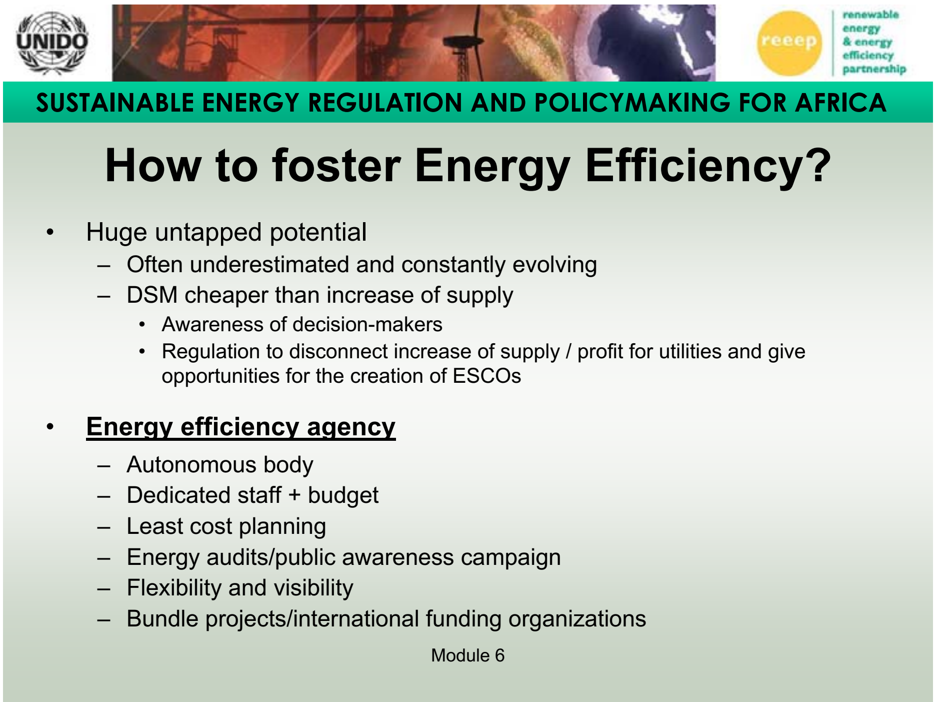
Lack of financial return for electric companies
Increase of consumption = increase of financial gap



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

How to foster RE Rural Electrification?

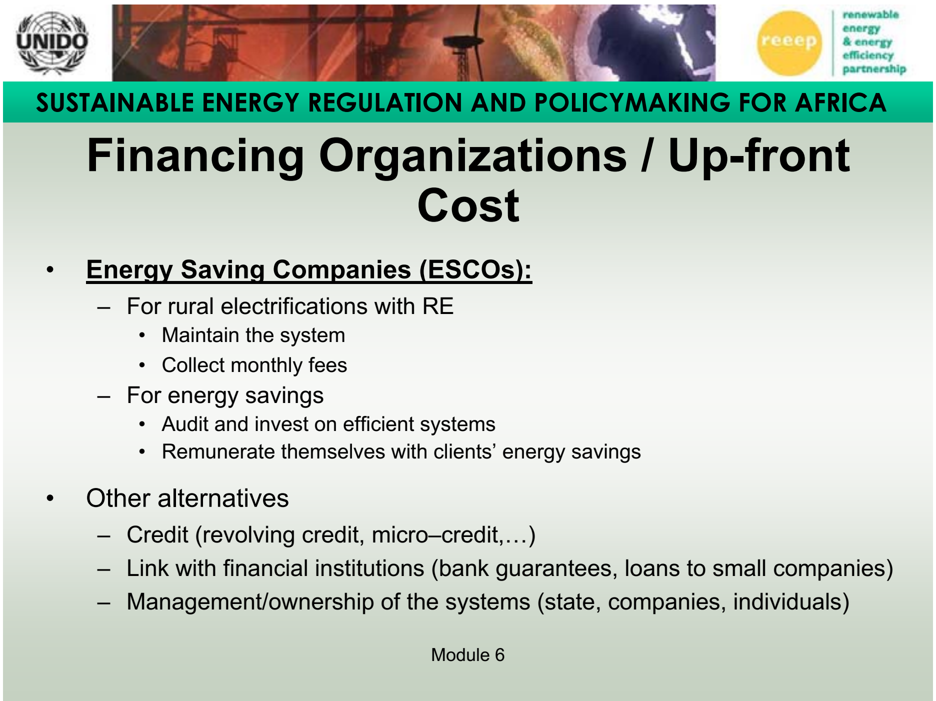
- What kind of rural electrification in African countries
  - Extension of the grid network proposed by utilities? Not always the best solution in remote areas!
  - Off-grid systems!
    - Stand-alone systems with solar photovoltaic, biomass,
    - Mini-grid with solar or small hydro-electricity
    - ➔What kind of management and how to finance?
- **Rural electrification agency**
  - Autonomous body
  - Staff + budget
  - Transparency/accountability
  - Organize/prioritize electrification of rural areas
  - Support creation / provide loans to ESCOs
  - Bundle projects / international funding agencies



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

How to foster Energy Efficiency?

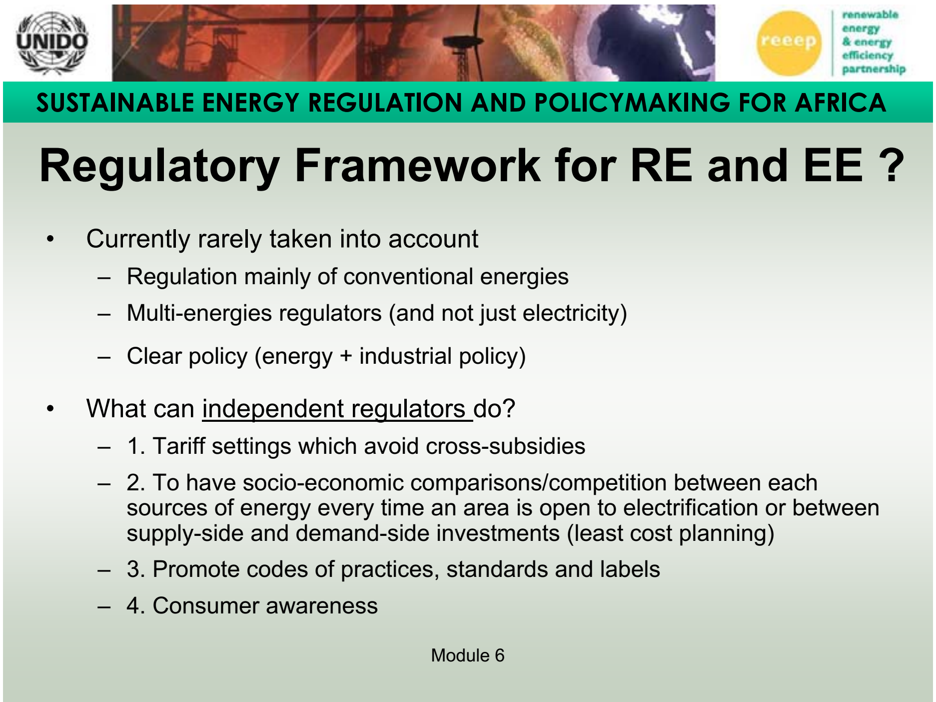
- Huge untapped potential
  - Often underestimated and constantly evolving
  - DSM cheaper than increase of supply
    - Awareness of decision-makers
    - Regulation to disconnect increase of supply / profit for utilities and give opportunities for the creation of ESCOs
- **Energy efficiency agency**
  - Autonomous body
  - Dedicated staff + budget
  - Least cost planning
  - Energy audits/public awareness campaign
  - Flexibility and visibility
  - Bundle projects/international funding organizations



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing Organizations / Up-front Cost

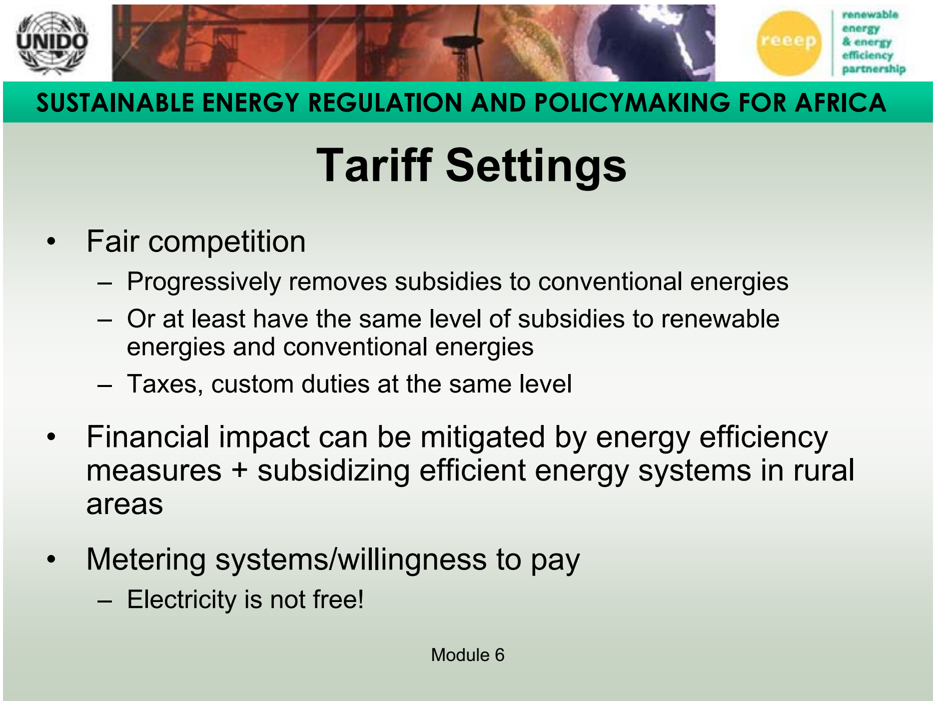
- **Energy Saving Companies (ESCOs):**
  - For rural electrifications with RE
    - Maintain the system
    - Collect monthly fees
  - For energy savings
    - Audit and invest on efficient systems
    - Remunerate themselves with clients’ energy savings
- Other alternatives
  - Credit (revolving credit, micro–credit,…)
  - Link with financial institutions (bank guarantees, loans to small companies)
  - Management/ownership of the systems (state, companies, individuals)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Regulatory Framework for RE and EE ?

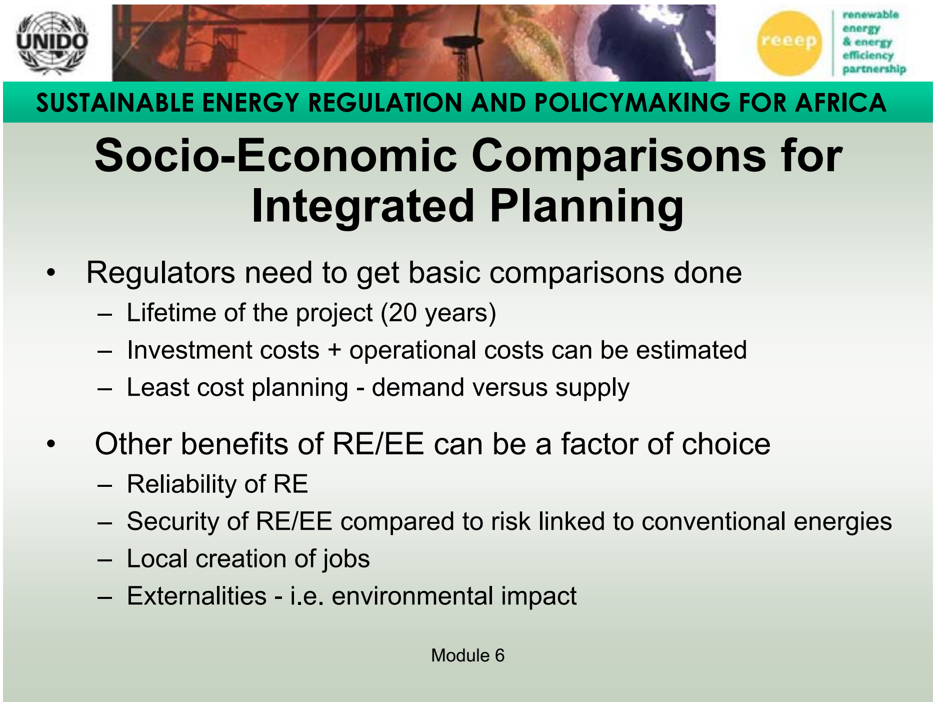
- Currently rarely taken into account
  - Regulation mainly of conventional energies
  - Multi-energies regulators (and not just electricity)
  - Clear policy (energy + industrial policy)
- What can independent regulators do?
  - 1. Tariff settings which avoid cross-subsidies
  - 2. To have socio-economic comparisons/competition between each sources of energy every time an area is open to electrification or between supply-side and demand-side investments (least cost planning)
  - 3. Promote codes of practices, standards and labels
  - 4. Consumer awareness



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Tariff Settings

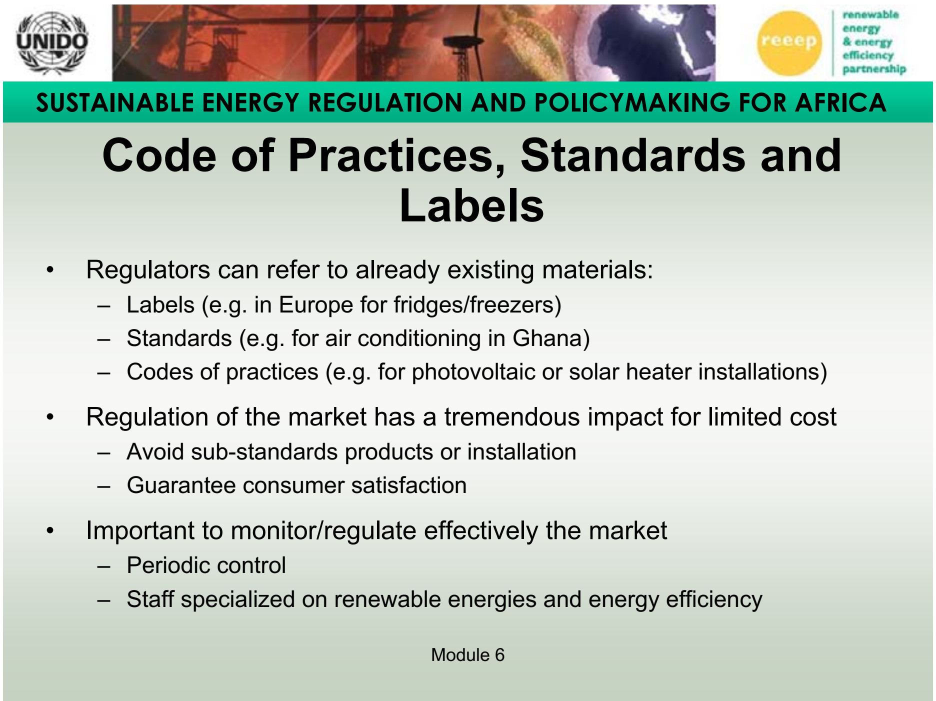
- Fair competition
  - Progressively removes subsidies to conventional energies
  - Or at least have the same level of subsidies to renewable energies and conventional energies
  - Taxes, custom duties at the same level
- Financial impact can be mitigated by energy efficiency measures + subsidizing efficient energy systems in rural areas
- Metering systems/willingness to pay
  - Electricity is not free!



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Socio-Economic Comparisons for Integrated Planning

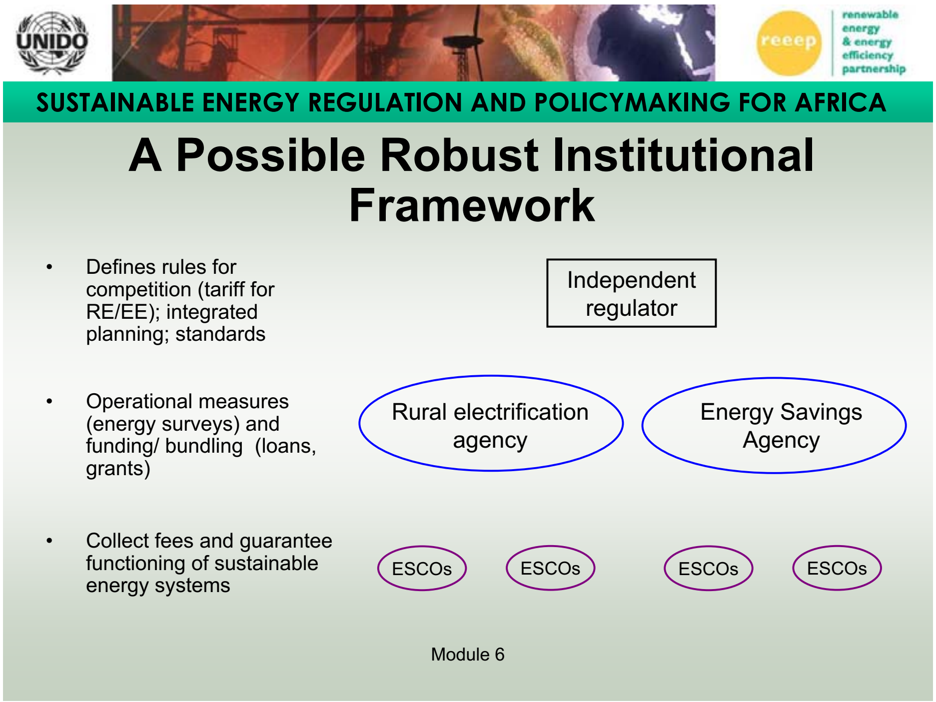
- Regulators need to get basic comparisons done
  - Lifetime of the project (20 years)
  - Investment costs + operational costs can be estimated
  - Least cost planning - demand versus supply
- Other benefits of RE/EE can be a factor of choice
  - Reliability of RE
  - Security of RE/EE compared to risk linked to conventional energies
  - Local creation of jobs
  - Externalities - i.e. environmental impact



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Code of Practices, Standards and Labels

- Regulators can refer to already existing materials:
  - Labels (e.g. in Europe for fridges/freezers)
  - Standards (e.g. for air conditioning in Ghana)
  - Codes of practices (e.g. for photovoltaic or solar heater installations)
- Regulation of the market has a tremendous impact for limited cost
  - Avoid sub-standards products or installation
  - Guarantee consumer satisfaction
- Important to monitor/regulate effectively the market
  - Periodic control
  - Staff specialized on renewable energies and energy efficiency



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

A Possible Robust Institutional Framework

- Defines rules for competition (tariff for RE/EE); integrated planning; standards
- Operational measures (energy surveys) and funding/ bundling (loans, grants)
- Collect fees and guarantee functioning of sustainable energy systems

Independent regulator

Rural electrification agency

Energy Savings Agency

ESCOs

ESCOs

ESCOs

ESCOs

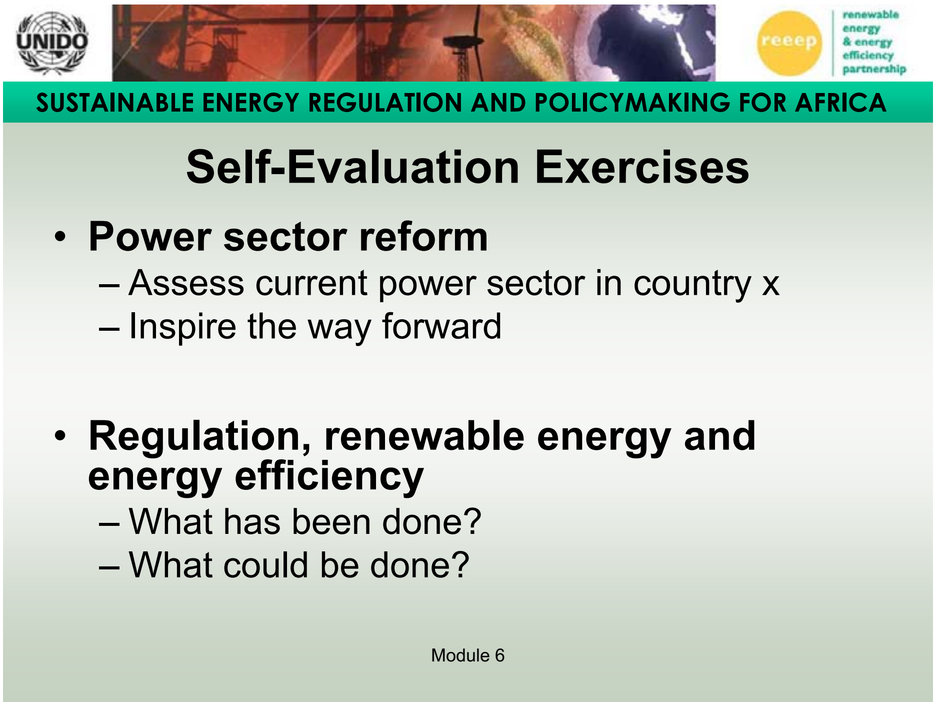
Module 6

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- New institutions / new way of thinking
  - that do marketing
  - that deliver energy services and not just kWh
  - Private/public partnership
- … with regulation for new actors
  - Adapted to small companies = introduce new actors
  - Limit the power market of existing utilities and force them to commit to sustainable energies (incentives/penalties)
- … framed by a real energy strategy/policy
  - Long-term commitment of the government
  - Energy + industrial policy (nurse a market and create jobs)

Module 6



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Self-Evaluation Exercises

- **Power sector reform**
  - Assess current power sector in country x
  - Inspire the way forward
- **Regulation, renewable energy and energy efficiency**
  - What has been done?
  - What could be done?

Module 6

Module 7

Renewable energy technologies

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

The themes dealt with in this module include:

- Outline and brief description, including fundamentals, of the different renewable energy technologies, wind, solar, bioenergy, hydro, and geothermal energy;
- General overview of renewable energy technologies and applications;
- Information on the costs of different renewable energy technologies;
- Discussion regarding common technical and non-technical barriers and issues limiting wide spread use/dissemination of renewable energy.

1.2. Module aims

The aims of the present module are as follows:

- Enable understanding of renewable energy in the broadest terms;
- Present the different technology options that fall within the definition of renewable energy, in a developing country context;
- Provide an overview of the different renewable energy technologies and their applications;
- Show the strengths and weaknesses of renewable energy technologies;
- Outline the expected costs for different renewable energy technologies;
- Review the issues affecting effective deployment of renewable energy systems.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To be able to define the different key renewable energy technologies;
- To have a broad appreciation of the potential applications for renewable energy technologies;
- To understand the strengths and weaknesses of the different renewable energy technologies and hence to have a better grasp of the benefits of renewable energy;
- To understand the basic costs for the different technologies;
- To gain an appreciation of the issues and barriers that renewable energy projects face.

2. INTRODUCTION

This module provides an outline and brief description, including fundamentals, of the different renewable energy technologies, wind, solar, bioenergy, hydro and geothermal energy. It provides a general overview of the technologies and their applications.

Electricity generation from wave and tidal energy is not discussed. The use of this technology is less relevant for developing countries as mostly these technologies are still at the prototype stage. While these technologies are not fully proven yet, promising research and development is being conducted.

The module also reviews the costs of the different technologies and discusses common technical and non-technical barriers and issues limiting the wide spread use/dissemination of renewable energy in developing countries.

The information in this module is of general interest to explain the basics of renewable energy technologies, to understand their strengths and weaknesses and hence to have a better grasp of the benefits available from, and the barriers faced by, these technologies.

3. OVERVIEW OF RENEWABLE ENERGY TECHNOLOGIES

This section provides an overview and brief description, including fundamentals, of the different renewable energy technologies, wind, solar, bioenergy, hydro, and geothermal energy.

One of the first aspects to consider is the cost of renewable energy technologies. However, this is not an easy question to answer because, as with many energy technologies, many factors affect cost and different sources of information use different criteria for estimating cost. In many cases, the environmental benefits of renewable energy technologies are difficult to take into account in terms of cost savings through less pollution and less damage to the environment. When trying to calculate the cost of these technologies is often best to take a life cycle cost approach, as these technologies often have high up-front capital costs but very low operation and maintenance costs. And of course, there is usually no fuel cost!

Table 1 below shows average energy generation costs (in kWh) for a variety of renewable energy technologies in Europe. The table clearly shows that the minimum to average generation costs for these technologies vary widely between different technologies, and within the same technology, according to differences in national markets and resource conditions. This means that one technology can be cheaper in one country than in another.

Table 1. Minimum to average generation costs for the main green electricity technologies in EU15[a]

Technology	**Range (minimum to average) of electricity generation cost (€/MWh)[b]**
Wind onshore	50-80
Small-scale hydro	40-140
Biomass using forestry residues	40-80
Agricultural biogas	60-100
Photovoltaics	› 450

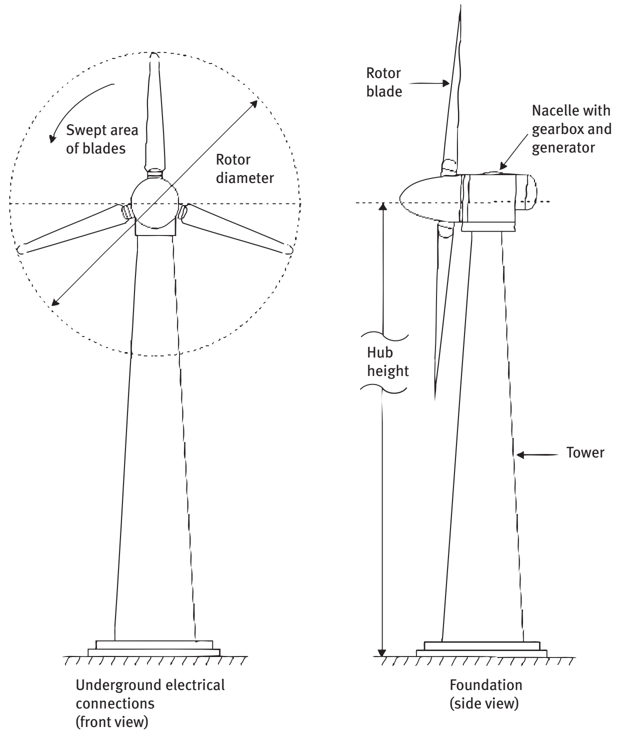
[a] COM (2005) 627 final—Communication from the European Commission – The support of electricity from renewable energy sources—annex 3 (December 2005).

[b] The calculation of generation costs and feed in tariffs is further elaborated in module 8, annex I, “Methodology and examples on how to calculate the level of feed in tariffs”.

3.1. Wind energy

A wind turbine produces power by converting the force of the wind (kinetic energy) acting on the rotor blades (rotational energy) into torque (turning force or mechanical energy). This rotational energy is used either within a generator to produce electricity or, perhaps less commonly, it is used directly for driving equipment such as milling machines or water pumps (often via conversion to linear motion for piston pumps). Water pumping applications are more common in developing countries. A schematic of a wind energy system is presented in figure I.

Figure I. Wind energy system schematic



Source: Canada Center for Mineral and Energy Technology (Ottawa, Canada, 1999).

Wind power by its nature is variable (or intermittent), therefore some form of storage or back-up is inevitably involved. This may be through:

(a) connection to an electricity grid system, which may be on a large or small (mini-grid) scale;

(b) incorporating other electricity producing energy systems (from conventional generating stations through diesel generators to other renewable energy systems);

(c) or the use of storage systems such as batteries or, for mechanical systems, storage via water held in a tank.

So long as the system is designed to have sufficient storage capacity, whether for energy or product (e.g. water pumped), to cover the periods when the supply is unable to meet the full level of demand, then an output is always available. The strengths and weaknesses of this technology are presented in table 2.

Table 2. Strengths and weaknesses of wind energy systems

Strengths	**Weaknesses**
Technology is relatively simple and robust with lifetimes of over 15 years without major new investment	Site-specific technology (requires a suitable site)
Automatic operation with low maintenance requirements	Variable power produced therefore storage/back-up required.
No fuel required (no additional costs for fuel nor delivery logistics)	High capital/initial investment costs can impede development (especially in developing countries)
Environmental impact low compared with conventional energy sources	Potential market needs to be large enough to support expertise/equipment required for implementation
Mature, well developed, technology in developed countries	Cranage and transport access problems for installation of larger systems in remote areas
The technology can be adapted for complete or part manufacture (e.g. the tower) in developing countries	

Usually wind energy systems are classified in three categories: grid-connected electricity generating, stand-alone electricity generating (often subdivided into battery-based or autonomous diesel, the later having automatic start-up when the wind speed falls, although diesel generators may also be used within stand-alone battery systems) and mechanical systems. Examples of wind power applications are illustrated in table 3.

Table 3. Examples of wind power applications and system type

Technology type (electrical/mechanical)	System	Application
Wind power – electrical	Grid connected	Supplementing mains supply
Wind power – electrical	Stand-alone, battery charging	Small home systems Small commercial/community systems Water pumping Telecommunications Navigation aids
Wind power – electrical	Stand-alone, autonomous diesel	Commercial systems Remote settlements Mini-grid systems
Wind power – mechanical	Water pumping	Drinking water supply Irrigation pumping Sea-salt production Dewatering
Wind power – mechanical	Other	Milling grain Driving other, often agricultural, machines

Wind turbines generating electricity

Several turbine types exist but presently the most common configuration has become the horizontal axis three bladed turbine (as shown in figure I above). The rotor may be positioned up or downwind (although the former is probably the most common). Modern wind turbines vary in size with two market ranges: small units rated at just a few hundred watts up to 50-80 kW in capacity, used mainly for rural and stand-alone power systems; and large units, from 150 kW up to 5 MW in capacity, used for large-scale, grid-connected systems.

Grid-connected wind turbines

Grid-connected wind turbines are certainly having a considerable impact in developed countries and in some developing countries, namely Argentina, China and India. This is mainly through large-scale installations either on land (on-shore) or in the sea on the continental shelf (off-shore). In addition, in developed countries, more smaller machines are now being grid-connected. These are usually installed to supply power to a private owner already connected to the electricity grid but who wishes to supply at least some of their own power. This principle can be used in developing countries to contribute to a more decentralized grid-network and/or to support a weak grid.

Wind turbines do, however, generate electricity intermittently in correlation to the underlying fluctuation of the wind. Because wind turbines do not produce power constantly and at their rated power (which is only achieved at higher wind speeds) capacity factors (i.e. actual annual energy output divided by the theoretical maximum output) are typically between 20 per cent to 30 per cent. One of the principal areas of concerns of wind energy is its variable power output, which can create network problems as the share of intermittent generation on the grid rises.

Stand-alone wind turbines

The most common type of stand-alone small wind electric system involves the use of a wind generator to maintain an adequate level of charge in an electrical storage battery. The battery in turn can provide electricity on demand for electrical applications such as lights, radios, refrigeration, telecommunications, etc., irrespective of whether or not the wind is blowing. A controller is also used to ensure that the batteries are not damaged by overcharging (when surplus energy is dissipated through a dump load) or excessive discharge, usually by sensing low voltage. Loads connected to the battery can either be DC or AC (via an inverter).

Small wind battery charging systems are most commonly rated at between 25-100 W for a 10m/s wind speed, and are quite small with a rotor diameter of 50 cm to 1 m. These systems are suitable for remote settlements in developing countries.

Larger stand-alone systems, incorporating larger wind electricity generators and correspondingly larger battery banks (at an increased cost) are also available, these may include other renewable energy technologies, such as PV, as well as diesel generators to ensure that the batteries are always charged and that power availability is high.

Less common is the stand-alone system which does not incorporate a battery back. This involves the use of a wind turbine with, at least, a diesel generator, which will automatically supply power when required. This has the advantage of not requiring a battery bank but the required control systems are complex.

Wind turbines for water pumping

The most common type of a mechanical wind turbine is the wind pump which uses the wind's kinetic energy to lift water. Wind pumps are typically used for water supply (livestock or human settlements), small-scale irrigation or pumping seawater for sea salt production. Here we look at the two main uses which are irrigation and water supply. There are two distinct categories of wind pump, because the technical, operational and economic requirements are generally different for these two end uses. That is not to say that a water supply wind pump cannot be used for irrigation (they quite often are) but irrigation designs are generally unsuitable for water supply duties.

Most water supply wind pumps must be ultra-reliable, to run unattended for most of the time (so they need automatic devices to prevent over-speeding in storms), and they also need the minimum of maintenance and attention and to be capable of pumping water generally from depths of 10 m to 100 m or more. A typical farm wind pump should run for over 20 years with maintenance only once every year, and without any major replacements; this is a very demanding technical requirement since typically such a wind pump must average over 80,000 operating hours before anything significant wears out; this is four to ten times the operating life of most small diesel engines or about 20 times the life of a small engine pump.

Wind pumps to this standard therefore are usually industrially manufactured from steel components and drive piston pumps via reciprocating pump rods. Inevitably they are quite expensive in relation to their power output, because of the robust nature of their construction. But American, Australian and Argentine ranchers have found the price worth paying for wind pumps that run and run without demanding much attention to the extent they can almost be forgotten about for weeks at a time. This inherent reliability for long periods is their main advantage over practically any other form of pumping system.

Irrigation duties on the other hand are seasonal (so the windmill may only be useful for a limited fraction of the year), they involve pumping much larger volumes of water through a low head, and the intrinsic value of the water is low when compared with drinking water. Therefore any wind pump developed for irrigation has to be as cheap as possible and this requirement tends to override most other considerations. Since irrigation generally involves the farmer and/or other workers being present, it is not so critical to have a machine capable of running unattended. Therefore windmills used for irrigation in the past tend to be indigenous designs that are often improvised or built by the farmer as a method of low-cost mechanization.

Most farm wind pumps, even though still in commercial production, date back to the 1920s or earlier and are therefore heavy and expensive to manufacture, and difficult to install properly in remote areas. Recently, various efforts have been made to revise the traditional farm wind pump concept into a lighter and simpler modern form. Modern designs are fabricated from standard steel stock by small engineering companies and cost (and weigh) only about half as much as traditional American or Australian machines of similar capability. It is possible therefore that through developments of this kind, costs might be kept low enough to allow the marketing of all-steel-wind-pumps that are both durable, like the traditional designs, yet cheap enough to be economic for irrigation.

However, although there have been a number of attempts to transfer this technology to developing countries, (which should in theory be an ideal transfer, the technology being a relatively low-tech, artisan based system) experiences have been mixed with only few, very small, niche markets developing.

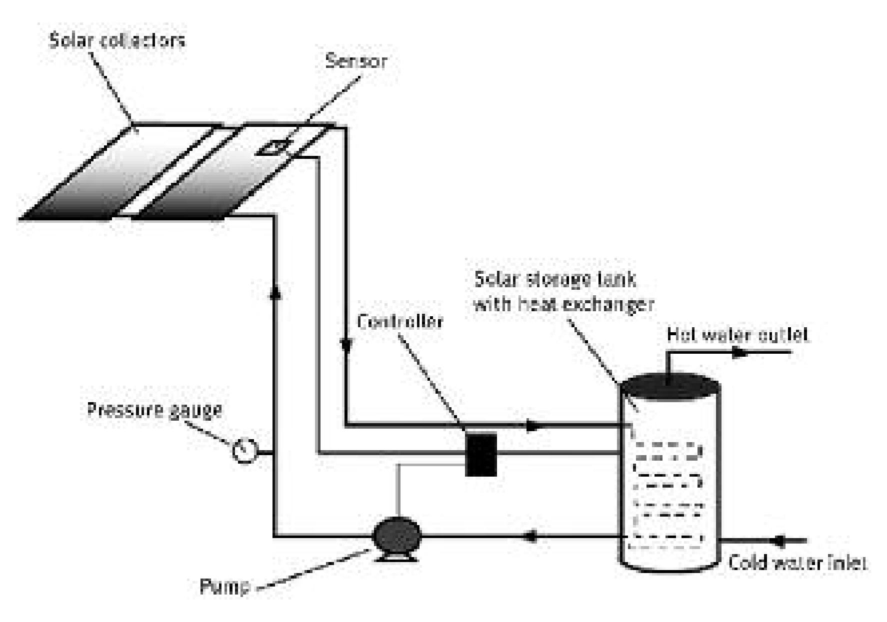
Review questions

1. What are the key advantages and disadvantages of wind energy technology?
2. What is meant by the term "stand-alone" and what is the key difference between the two different stand-alone systems described?
3. What are the key differences in the requirements for a wind pump for irrigation and a wind pump for water supply?

3.2. Solar energy

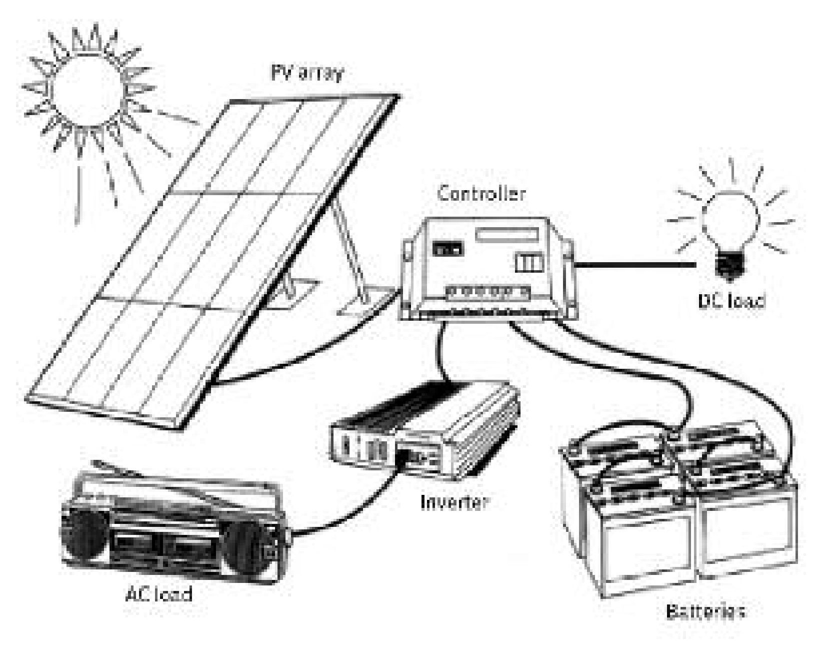
Solar energy technologies can be loosely divided into two categories: solar thermal systems (figure II shows a solar water heating system, one example of the use of solar thermal energy) and solar electric or photovoltaic (PV) systems (figure III). Examples of solar power applications are illustrated in table 4.

Figure II. Schematic of a typical solar water heating system



Source: Home energy magazine online, 1995.

Figure III. A typical PV system



Source: www.solardirect.com/pv/pvbasics/pvbasics.htm

Table 4. Examples of solar power applications and system type

Technology type (PV/solar thermal)	System	Application
PV (solar electric)	Grid connected	Supplementing mains supply
PV (solar electric)	Stand-alone	Small home systems for lighting, radio, TV, etc. Small commercial/community systems, including health care, schools, etc. Telecommunications Navigation aids Water pumping Commercial systems Remote settlements Mini-grid systems
Solar thermal	Connected to existing water and/or space heating system	Supplementing supply of hot water and/or space heating provided by the electricity grid or gas network
Solar thermal	Stand-alone	Water heating, i.e. for rural clinics Drying (often grain or other agricultural products) Cooking Distillation Cooling

Box 1. **REN21 global status report: rural (off-grid) renewable energy/water pumping: wind and solar PV**

Solar PV and wind power for water pumping, both irrigation and drinking water, are gaining widespread acceptance, and many more projects and investments are occurring. In the order of one million mechanical wind pumps are in use for water pumping, primarily in Argentina, following decades of development. Large numbers of wind pumps are also used in Africa, including in South Africa (300,000), Namibia (30,000), Cape Verde (800), Zimbabwe (650) and several other countries (another 2,000).

There are now more than 50,000 solar-PV pumps worldwide, many of these in India. Over 4,000 solar pumps (ranging from 200–2,000 W) were recently installed in rural areas as part of the Indian Solar PV Water Pumping Programme. There are an estimated 1,000 solar water pumps in use in West Africa. Donor programmes for PV-powered drinking water have appeared in Argentina, Brazil, Indonesia, Jordan, Namibia, Niger, the Philippines, Tunisia and Zimbabwe, among others.

A growing cohort of commercial projects for solar PV powered drinking water, including both pumping and purification, has appeared in recent years, notably in India, the Maldives and the Philippines. In the Maldives, a commercial pilot project anticipates sales of 1,000 litres/day, with a long-term delivered price of water to households expected to reach 0.2–0.5 cents per litre. Another recent example is on the Philippine island of Cebu. A 3-kW solar PV water pump distributes filtered and chlorinated surface water to 10 village locations. The 1,200 residents use prepaid debit cards to purchase potable water at a cost of about 3 PHP (5.5 cents) for 20 litres, or 0.3 cents/litre, a tenth of the cost of bottled water supplies. Fees collected from water sales are used to pay back an unsubsidized 10-year bank loan. The scheme could be duplicated on 10 more Philippine islands, providing potable water to 200,000 people in 40 municipalities.

Source: www.ren21.net/globalstatusreport/g2005.asp – Accessed September 2006.

Photovoltaic (PV) systems

Photovoltaic or PV devices convert sun light directly into electrical energy. The amount of energy that can be produced is directly dependent on the sunshine intensity. Thus, for example, PV devices are capable of producing electricity even in winter and even during cloudy weather albeit at a reduced rate. Natural cycles in the context of PV systems thus have three dimensions. As with many other renewable energy technologies, PV has a seasonal variation in potential electricity production with the peak in summer although in principle PV devices operating along the equator have an almost constant exploitable potential throughout the year. Secondly, electricity production varies on a diurnal basis from dawn to dusk peaking during mid-day. Finally, short-term fluctuation of weather conditions, including clouds and rain fall, impact on the interhourly amount of electricity that can be harvested. The strengths and weaknesses of this technology are presented in table 5.

Table 5. Strengths and weaknesses of PV energy systems

Strengths	Weaknesses
Technology is mature. It has high reliability and long lifetimes (power output warranties from PV panels now commonly for 25 years)	Performance is dependent on sunshine levels and local weather conditions
Automatic operation with very low maintenance requirements	Storage/back-up usually required due to fluctuating nature of sunshine levels/no power production at night.
No fuel required (no additional costs for fuel nor delivery logistics)	High capital/initial investment costs
Modular nature of PV allows for a complete range of system sizes as application dictates	Specific training and infrastructure needs
Environmental impact low compared with conventional energy sources	Energy intensity of silicon production for PV solar cells
The solar system is an easily visible sign of a high level of responsibility, environmental awareness and commitment	Provision for collection of batteries and facilities to recycle batteries are necessary
The user is less affected by rising prices for other energy sources	Use of toxic materials in some PV panels

PV devices use the chemical-electrical interaction between light radiation and a semiconductor to obtain DC electricity. The base material used to make most types of solar cell is silicon (approx. 87 per cent). The main technologies in use today are:

- Mono-crystalline silicon cells are made of silicon wavers cut from one homogenous crystal in which all silicon atoms are arranged in the same direction. These have a conversion efficiency of 12-15 per cent);
- Poly-crystalline silicon cells are poured and are cheaper and simpler to make than mono-crystalline silicon and the efficiency is lower than that of mono-crystalline cells (conversion efficiency 11-14 per cent);
- Thin film solar cells are constructed by depositing extremely thin layer of photovoltaic materials on a low-cost backing such as glass, stainless steel or plastic (conversion efficiency 5-12 per cent);
- Multiple junction cells use two or three layers of different materials in order to improve the efficiency of the module by trying to use a wider spectrum of radiation (conversion efficiency 20-30 per cent).

The building block of a PV system is a PV cell. Many PV cells are encapsulated together to form a PV panel or module. A PV array, which is the complete power-generating unit, consists of any number of PV modules/panels. Depending on their application, the system will also require major components such as a battery bank and battery controller, DC-AC power inverter, auxiliary energy source etc. Individual PV cells typically have a capacity between 5 and 300 W but systems may have a total installed capacity ranging from 10 W to 100 MW. The very modular nature of PV panels as building blocks to a PV system gives the sizing of systems an important flexibility.

Box 2. **PV for rural schools in South Africa**

A European Commission project aimed to provide off-grid electricity using PV systems to 1000 schools in the Republic of South Africa. The project started in 2000 and was completed in 2002. The firm IT Power acted as the technical assistance unit.

Photo: Chris Purcell, IT Power South Africa

The PV systems are located in remote areas of Northern Province and Eastern Cape Province (880 kWp total installed capacity). The project is the EC contribution to an existing programme by the South African Government to supply off-grid electricity to 16,400 schools in remote areas. As well as providing electricity for lighting between three and five classrooms in each school, the PV systems also provide power for audio-visual teaching aids.

Source: www.itpower.co.uk, international development section.

Solar thermal systems

Solar thermal systems use the sun's power in terms of its thermal or heat energy for heating, drying, evaporation and cooling. Many developing countries have indigenous products such as solar water heaters, solar grain dryers, etc. These are usually local rather than international products, specific to a country or even to a region. The main solar thermal systems employed in developing countries are discussed briefly below.

Solar thermal power plants

Solar thermal engines use complex concentrating solar collectors to produce high temperatures. These temperatures are high enough to produce steam, which can be used to drive steam turbines generating electricity. There is a wide variety of different designs, some use central receivers (where the solar energy is concentrated to a tower) whilst others use parabolic concentrator systems.

Although the first commercial thermal power plants have been in operation in California since the mid-1980s, many of the newer designs are still at the prototype stage being tested in pilot installations in the deserts of the United States and elsewhere. The Global Environment Facility (GEF) has supported the first planning phase of a project that is developing a concentrating solar power plant in Egypt in 2004. There are also projects in India, Mexico and Morocco that have been supported by GEF as part of a strategy to accelerate cost reduction and commercial adoption of high temperature solar thermal energy technology.

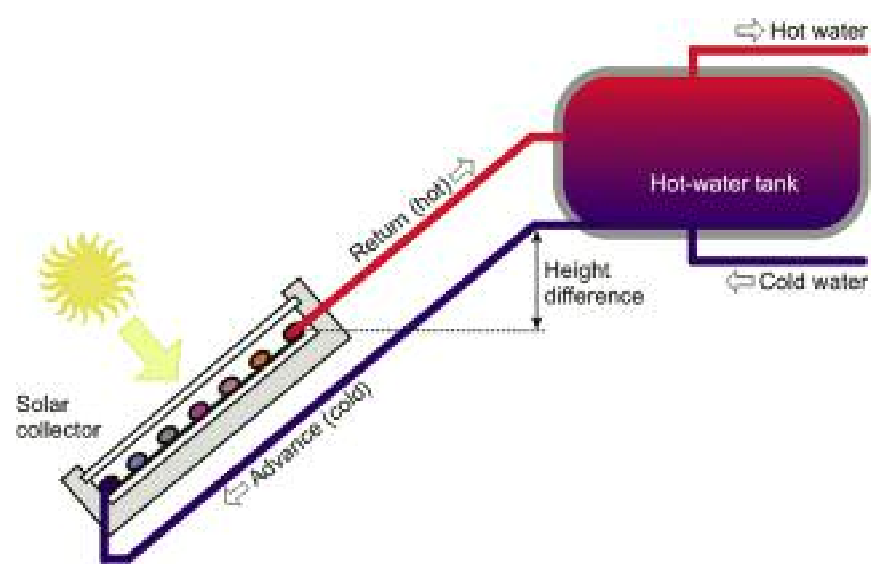
Solar water heating

Solar water heating systems (see figure II above) may be used in rural clinics, hospitals or even schools. The principle of the system is to heat water, usually in a special collector and store it in a tank until required. Collectors are designed to collect the heat in the most efficient, but cost effective way, usually into a heat transfer fluid, which then transfers its heat to the water in the storage tank. The two main types of collector are: flat plate and evacuated tube.

For example, to heat 100 litres of water through a temperature rise of 40^{o} C with a simple flat plate solar collector requires only approximately 2.5 m^2 of collector area but saves approx. 10 kg of woodfuel that would normally be required to heat this quantity of water.

The cheapest technology available and the simplest to install is a thermosiphon system, which uses the natural tendency of heated water to rise and cooler water to fall to perform the heat collection task. As the sun shines on the collector, the water inside the collector flow-tubes is heated. As it heats, this water expands slightly and becomes lighter than the cold water in the solar storage tank mounted above the collector. Gravity then pulls the heavier, cold water down from the tank and into the collector inlet. The cold water pushes the heated water through the collector outlet and into the top of the tank, thus heating the water in the tank. An example of a thermosiphon system is shown in figure IV.

Figure IV. A thermosiphon solar water heating system



Solar drying

Solar drying, in the open air, has been used for centuries. Drying may be required to preserve agricultural/food products or as a part of the production process, i.e. timber drying. Solar drying systems are those that use the sun's energy more efficiently than simple open-air drying. A comparison of drying technologies is illustrated in table 6.

Table 6. Comparison of drying technologies

	Sun drying	Solar drying	Fuelled drying
Initial cost	None	Medium	High
Operating cost	Low	Low	Medium
Temperature control	None	Poor	Good
Continuous operation	No	No	Yes
Speed of drying	Slow	Medium	Fast
Protection from pests	No	Yes	Yes

In general, solar drying is more appropriate when:

- The higher the value per ton of products dried;
- The higher the proportion of the product currently spoiled in the open air;
- The more often the drier will be used.

Solar cookers

Solar cookers can be important because of the increased scarcity of wood fuel and the problems of deforestation in many developing country regions. Solar cookers can also promote cleaner air where there is a problem with indoor cooking. There are basically two types of solar cooker: oven or stove type. As with conventional cooking stoves, solar stoves apply heat to the bottom of the cooking pot while solar ovens apply a general heat to the enclosed area which contains the cooking pot. However, there are important social issues related to the effective use of solar cookers. There will always be some change of habits required and readiness to change is an important factor that affects the potential impact of this technology.

Solar distillation

Solar distillation is a solar enhanced distillation process to produce potable water from a saline source. It can be used in areas where, for instance, drinking water is in short supply but brackish water, i.e. containing dissolved salts, is available. In general solar distillation equipment, or stills, is more economically attractive for smaller outputs. Costs increase significantly with increased output, in comparison to other technologies which have considerable economics of scale.

Solar cooling

Several forms of mature technologies are available today for solar-thermally assisted air-conditioning and cooling applications. In particular for centralized systems providing conditioned air and/or chilled water to buildings, all necessary components are commercially available. The great advantage of this solar application, especially in tropical and equatorial countries, is that the daily cooling load profile follows the solar radiation profile (i.e. office buildings).

Review questions

1. What are the similarities and what are the differences between solar thermal and PV?
2. What are the four different PV technologies in use today?
3. What are the different services that solar thermal systems can provide?

3.3. Bioenergy

Bioenergy is a general term that covers energy derived from a wide variety of material of plant or animal origin. Strictly, this includes fossil fuels but, generally, the term is used to mean renewable energy sources such as wood and wood residues, agricultural crops and residues, animal fats, and animal and human wastes, all of which can yield useful fuels either directly or after some form of conversion. There are technologies for bioenergy using liquid and gaseous fuel, as well as traditional applications of direct combustion. The conversion process can be physical (for example, drying, size, reduction or densification), thermal (as in carbonization) or chemical (as in biogas production). The end result of the conversion process may be a solid, liquid or gaseous fuel and this flexibility of choice in the physical form of the fuel is one of the advantages of bioenergy over other renewable energy sources.

The basis for all these applications is organic matter, in most cases plants and trees. There is a trend towards purposefully planted biomass energy crops, although biomass can also be collected as a by-product and residue from agricultural, forestry, industry and household waste. Bioenergy can be used for a great variety of energy needs, from heating and transport fuel to power generation.

There are numerous commercially available technologies for the conversion processes and for utilization of the end-products. Although the different types of bioenergy have features in common, they exhibit considerable variation in physical and chemical characteristics which influence their use as fuels. There is such a wide range of bioenergy systems that this module does not aim to cover and describe each one. Examples of bioenergy applications are illustrated in table 7.

Table 7. Examples of bioenergy applications

Fuel state	Application
Biogas	Supplementing mains supply (grid-connected)
Biogas	Cooking and lighting (household-scale digesters), motive power for small industry and electric needs (with gas engine)
Liquid biofuel	Transport fuel and mechanical power, particularly for agriculture; heating and electricity generation; some rural cooking fuel
Solid biomass	Cooking and lighting (direct combustion), motive power for small industry and electric needs (with electric motor)

Until the nineteenth century, biomass was the predominant fuel for providing heat and light all over the world. In industrialized countries it was then displaced by coal and later by petroleum, but in developing countries it remains the most important fuel. Some strengths and weaknesses of bioenergy, in general, are summarized in table 8.

Table 8. Strengths and weaknesses of bioenergy systems

Strengths	Weaknesses
Conversion technologies available in a wide range of power levels at different levels of technological complexity	Production can create land use competition
Fuel production and conversion technology indigenous in developing countries	Often large areas of land are required (usually low energy density)
Production can produce more jobs than other renewable energy systems of a comparable size	Production can have high fertilizer and water requirements
Conversion can be to gaseous, liquid or solid fuel	May require complex management system to ensure constant supply of resource, which is often bulky adding complexity to handling, transport and storage
Environmental impact low (overall no increase in carbon dioxide) compared with conventional energy sources	Resource production may be variable depending on local climatic/weather effects, i.e. drought.
	Likely to be uneven resource production throughout the year

Review question

1. What are the various applications associated with the different fuel states in bioenergy production?

3.4. Hydro

Hydropower is the extraction of energy from falling water (from a higher to a lower altitude) when it is made to pass through an energy conversion device, such as a water turbine or a water wheel. A water turbine converts the energy of water into mechanical energy, which in turn is often converted into electrical energy by means of a generator.

Alternatively, hydropower can also be extracted from river currents when a suitable device is placed directly in a river. The devices employed in this case are generally known as river or water current turbines[1] or a “zero head” turbine. This module will review only the former type of hydropower, as the latter has a limited potential and application.

Hydropower systems can range from tens of Watts to hundreds of Megawatts. A classification based on the size of hydropower plants is presented in table 9. However, there is no internationally recognized standard definition for hydropower sizes, so definitions can vary from one country to another.

Table 9. Classification of hydro-power size

Large-hydro	More than 100 MW and usually feeding into a large electricity grid
Medium-hydro	10 or 20 MW to 100 MW—usually feeding into a grid
Small-hydro	1 MW to 10 MW or 20 MW—definitions vary, Europe tends to use 10 MW as a maximum, China uses 20 MW and Brazil 30 MW. Usually feeding onto a grid
Mini-hydro	100 kW to 1 MW—either stand alone schemes or more often feeding into a grid
Micro-hydro	5 kW to 100 kW—usually provide power for a small community or rural industry in remote areas away from the grid.
Pico-hydro	50 W to 5 kW—usually for remote rural communities and individual households. Applications include battery charging or food processing

Large hydropower schemes often have outputs of hundreds or even thousands of megawatts but function similarly to small hydropower plants (SHP), which use the energy in falling water to produce electricity or mechanical energy using a variety of available turbine types (e.g. Pelton, Francis, Kaplan) depending on the characteristics of the river (e.g. flow, head[2]) and installation capacity. SHP is defined in many countries, though not universally, as any hydro installation rated at less than 10 MW.

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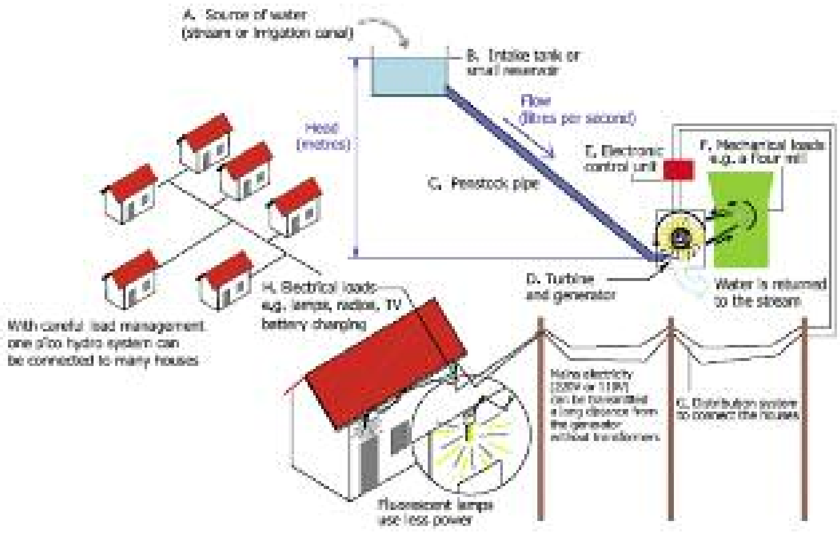
[1] Alternating Current Project, Peru, August 2000, www.tve.org/ho/doc.cfm?aid=656

[2] “Head” is the difference in elevation between upstream level (reservoir or tank) and the downstream level (usually turbine) in a hydropower scheme. It is possible to express head in either units of height (e.g. metres) or in units of pressure such as Pascals (the SI unit). See also figure V below.

On a smaller scale, used more often in rural and remote areas, micro-hydro schemes can have capacities up to 500 kW and are generally run-of-the-river developments for villages. On an even smaller scale pico-hydro systems tend to be between 50 W to 5 kW and are generally used for individual homes or clusters of households. Figure V shows a typical high head pico-hydro scheme, although this configuration is also typical of larger small-scale hydro schemes. Such small community-based systems demand a different approach to larger (SHP) hydro schemes and require a broad understanding of all the diverse technical and social elements in order to contribute successfully to the energy needs of a rural community.

Figure V. Schematic of a pico-hydro system



Hydropower, under the right circumstances, can be one of the most reliable and cost-effective renewable energy sources. The applications of small-hydro facilities include base, peak and stand-by power production or stand-alone applications. Hydroelectric plants typically generate power between 15 to 100 per cent of the time. In base loading applications, units must be able to operate at least 85 per cent of the time. SHP installations commonly last without the need for major replacement costs for 30+ years. Within the limits of water resources available, SHP installations are characterized by reliability and flexibility of operation, including fast start-up and shut-down in response to rapid demand changes. SHP electricity can be tailored to the needs of the end-use market, avoiding balance and power reliability concerns.

SHP does not have the same kinds of adverse effects on the local environment as large hydro. Nevertheless, SHP has some adverse impacts on the environment. For example when water levels in reservoirs change abruptly to meet electricity demands or in times of low flow, the short stretch of by-passed river can run dry, which might dry out aquatic organisms. Power plants often obstruct the natural migration of fish through the river system. Such effects could result in the extinction of fish populations, a fundamental change of natural flow regimes, the loss of aquatic habitats, sinking groundwater levels and a deterioration of landscapes. In order for hydropower plants to be socially and environmentally sustainable, the local and regional impacts need to be evaluated, reduced and minimized.[3] Therefore, modern construction designs typically implement mitigation measures.

The Eugene Standard[4] provides a set of criteria that hydropower plants (regardless of their installed capacity, age or mode of operation) need to comply with in order to be an environmentally sound form of power supply. Under the Standard, three basic conditions have to be met:

1. The basic requirements include (non-exhaustive list):
    (a) Hydropower utilization should not lastingly impair the ability of fish to migrate unimpeded through the affected river system.

    (b) Hydropower utilization should not result in long-term degradation in the natural diversity of plants and animals.

    (c) Power plant constructions should not irreversibly destroy protected habitats.

    (d) Power plant operation should not endanger fish or benthic organisms in affected river reaches.
2. Secondly the sustainable hydropower plant should invest money (for instance a fixed rate per kilowatt-hour produced or sold) to restore, protect or upgrade the environment surrounding the hydropower plant (so-called eco-investments).
3. Thirdly, to assess to which extent the basic requirements were met and what the eco-investments were used for, an audit and certification procedure should be carried out every year.

The strengths and weaknesses of SHP technology are presented in table 10.

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[3] The issue of hydropower and sustainability is described in full detail in the CLEAN-E report “Development of ecological standards for hydropower”. This report is available at www.eugenestandard.org/index.cfm?inc=page&id=62

[4] www.eugenestandard.org

Table 10. Strengths and weaknesses of small hydropower systems

Strengths	Weaknesses
Technology is relatively simple and robust with lifetimes of over 30 years without major investment	Very site-specific technology (requires a suitable site relatively close to the location where the new power is needed)
Overall costs can, in many cases, undercut all other alternatives	For SHP systems using small streams the maximum power is limited and cannot expand if the need grows
Automatic operation with low maintenance requirements	Droughts and changes in local water and land use can affect power output
No fuel required (no additional costs for fuel nor delivery logistics)	Although power output is generally more predictable it may fall to very low levels or even zero during the dry season
Environmental impact low compared with conventional energy sources	High capital/initial investment costs
Power is available at a fairly constant rate and at all times, subject to water resource availability	Engineering skills required may be unavailable/expensive to obtain locally
The technology can be adapted for manufacture/use in developing countries	

Review question

1. What size of hydropower plant is considered small? mini? micro? pico?

3.5. Geothermal

Geothermal is energy available as heat emitted from within the earth, usually in the form of hot water or steam. Geothermal heat has two sources: the original heat produced from the formation of the earth by gravitational collapse and the heat produced by the radioactive decay of various isotopes. It is very site dependent as the resource needs to be near surface and can be used for heating and power generation purposes. High temperature resources (150° C+) can be used for electricity generation, while low temperature resources (50-150° C) can be used for various direct uses such as district heating and industrial processing. Since the earth's crust is continuously emitting heat towards its surface at a rate of 40 million megawatts, geothermal is in principle an inexhaustible energy source, with the centre of the earth having cooled down by only about 2 per cent over the earth's lifetime of about 4 billion years.

The extraction of energy from geothermal aquifers uses naturally occurring ground water from deep porous rocks. Water can be extracted via a production borehole and, generally be disposed of via an injection hole. Another method is the extraction of heat from hot dry rock (HDR) which uses reservoirs created artificially by hydraulic fracturing. Heat is extracted by circulating water under pressure via production wells.

There are no problems of intermittency in the utilization of geothermal energy sources for direct heat applications or for electricity generation. A developed geothermal field provides what is essentially a distributed heat source, since the input to a power plant normally consists of the integrated outputs of several wells. Thus one or more wells may be shut for repairs or maintenance while others produce. Proper dimensioning of the generating plant ensures that there is always enough steam or hot water available for operation. This feature and the low operational costs are the reasons why geothermal power plants are normally used for base load power.

Natural variations of geothermal resources occur over extremely long periods, millennia or even longer time scales. However, man-induced processes lead to variations with shorter time scales, typically in the range of decades. Unwanted effects of over-exploitation and improper reinjection have been observed, especially in the early years of geothermal technology development. However, present-day geothermal technology for field characterization and modelling makes it possible to avoid improper practices, or at worst to detect their effects at an early stage before they become significant.

Environmentally, geothermal schemes are relatively benign, but typically do produce a highly corrosive brine which may need special treatment and discharge consents. There is also a possibility of noxious gases, such as hydrogen sulphide, being emitted.

Review question

1. What temperature resource is used for electricity generation in geothermal systems?

3.6. Summary

In summary, table 11 presents an overview of the technologies and applications:

Table 11. Renewable energy technologies and applications

Renewable energy technology	Energy service/application	Area of application
Wind turbines – grid-connected	Residential and industrial electricity, supplementing mains supply	Mostly urban
Wind Turbines – stand-alone	Power for lighting (homes, schools, streets), refrigeration (vaccine) and other low-to medium electric power needs (telecommunications, etc.) Occasionally mechanical power for agriculture.	Urban and rural
Wind pumps	Pumping water (for agriculture and drinking)	Mostly rural
PV (solar electric) – grid-connected	Residential and industrial electricity, supplementing mains supply	Mostly urban
PV (solar electric) – stand-alone	Power for lighting (homes, schools, streets), refrigeration (vaccine) and other low- to medium-voltage electric needs (telecommunications, etc.)	Urban and rural
Solar PV pumps	Pumping water (for agriculture and drinking)	Mostly rural
Solar thermal power plant – grid-connected	Residential and industrial electricity, supplementing mains supply	Mostly urban
Solar thermal – water heaters	Heating water	Urban and rural
Solar thermal – cookers	Cooking (for homes, commercial stoves, and ovens)	Mostly rural
Solar thermal – dryers	Drying crops	Mostly rural
Solar thermal – cooling	Air-conditioning (centralized system for buildings, etc.) Cooling for industrial processes	Mostly urban
Solid biomass	Cooking and lighting (direct combustion), motive power for small industry and electric needs (with electric motor)	Mostly rural
Liquid biofuel	Transport fuel and mechanical power, particularly for agriculture; heating and electricity generation; some rural cooking fuel	Urban and rural
Large hydro – grid-connected	Residential and industrial electricity, supplementing mains supply	Mostly urban
Small hydro	Lighting and other low-to-medium voltage electric needs (telecommunications, hand tools, etc.), process motive power for small industry (with electric motor)	Mostly rural
Geothermal	Grid electricity and large-scale heating.	Urban and rural
Village-scale	Mini-grids usually hybrid systems, solar and/or wind energy with diesel engines. Small-scale residential and commercial.	Mostly rural, some peri-urban

Discussion question/exercise

Consider the strengths and weaknesses of all of the renewable energy technologies. What are the main similarities/differences? Why do these exist?

4. OVERVIEW OF COSTS OF DIFFERENT TECHNOLOGIES

The paragraphs below present typical costs of energy generated by different technologies and also the cost per kW installed. These costs are intended to be indicative and it should be noted that costs vary greatly from country to country, or even from region to region within the same country, as they are dependent on many local factors.

4.1. Wind

Power production costs of wind-generated electricity have fallen steadily as the technology has developed. The European Wind Energy Association (2004) estimates that in Europe the cost of large-scale wind power in 2003 ranges from approximately 0.04-0.06 euro/kWh at sites with very good wind speeds to 0.07-0.1 euro/kWh at sites with low wind speeds. This calculation assumes a medium-sized turbine of 850-1,500 kW capacity, investment costs ranging from 900 to 1,150 euro/kW, O&M costs averaging 0.012 Euro/kWh over a lifetime of 20 years, and a discount rate of 7.5 per cent per annum. The cost of capital (discount or interest rate) is a particularly important factor. Wind power is a very capital intensive technology with about 75 per cent of total costs as capital up front (for a natural gas plant the share is typically 40-60 per cent). Therefore, the economic performance of a wind power project is highly dependent on the level of interest rates.

4.2. PV

Reported prices for entire PV systems vary widely and depend on many factors including system size, location, customer type, connection to an electricity grid, technical specification and the extent to which end-user prices reflect the real costs of all the components.

According to the International Energy Agency's Photovoltaic Power Systems programme (IEA PVPS), on average, system prices for the lowest cost off-grid applications are double those for the lowest cost grid-connected applications. This is attributed to the fact that the latter do not require storage batteries and associated equipment. In 2005, the lowest system prices in the off-grid sector, irrespective of the type of application, ranged from about $US 10-20 per watt. The large range of reported prices is a function of country and project specific factors. The lowest achievable installed price of grid-connected systems in 2005 also varied between countries. The average price of these systems was $US 6.6/W in 2005. In 2005 the average price of modules was around $US 4.5/W.[5]

On the basis of a payback period of 20 years (which is also the anticipated average lifetime of a system), the electricity cost is approximately $US 0.9-2/kWh for a stand-alone system and $US 0.25-0.7/kWh for a grid connected system. The most important barrier for the implementation of PV is therefore the relatively high cost. It is hoped further improvements in efficiencies and technologies will bring the cost down over the next 5 to 10 years, though for several markets, PV is already competitive, in particular for small-scale generation of electricity in off-grid remote rural areas.

4.3. Biomass

According to calculations made by the Dutch firms ECN and KEMA, stand-alone plants using biomass typically generate electricity at a cost of $US 0.06-0.09/kWh (using bio-oil CHP, 50 MW_e), and around $US 0.14/kWh (using wood chips, around 30 MW_e), up to $US 0.19/kWh for smaller power plants (< 5 MW_e, using wood chips). Investment costs are typically at $US 1000-1300/$kW_e$.

Co-firing of bio-oil or wood pellets in coal or gas fired power plants is generally cheaper, with electricity generation costs typically ranging between $US 0.05-0.08/kWh.

4.4. Hydro

Power station construction costs typically vary from about $US 1,500-4,400/kW depending on site conditions, head, water conveyance and necessary mitigation measures. According to the European Small Hydropower Association (ESHA), the average production cost in the EU-15 is $US 0.06-0.18/kWh. Maintenance costs are typically very low while no fuel costs apply.

4.5. Geothermal

According to the IEA (2004), the cost of geothermal electricity depends on a number of factors, particularly on the temperature of the geothermal fluid, which influences the size of the turbine, heat exchangers and cooling system. The IEA estimates production costs in Europe at $US 0.06-0.11/kWh for traditional geothermal plants (i.e. liquid-steam water resource) and $US 0.25-0.37/kWh for hot

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[5] Trends in photovoltaic applications in selected IEA countries between 1992 and 2005, IEA PVPS, September 2006.

dry rock systems, whereas the installed system costs range from $US 880-3,500/kW (WEA, 2000). Due to the high capital cost of such systems and their dispatchable qualities as a source of power, they are an ideal provider for base load supply.

Discussion question/exercise

What factors might cause variations of these costs in your country, i.e. subsidies, specific technology factors, such as wind speed?

5. OVERVIEW OF COMMON BARRIERS AND ISSUES LIMITING WIDESPREAD USE/DISSEMINATION OF RENEWABLE ENERGY

There are a number of issues and barriers which impede the large-scale implementation of renewable energy technologies. This section aims to summarize the key technical and non-technical issues.

5.1. Technical issues

Design and installation skills

Correct design and installation is an important factor with all renewable energy systems. Systems which have not been designed and installed correctly are unlikely to operate satisfactorily. Design may not be a problem if the renewable energy system is in simple kit form, or designed by experts, although this does pose the problem of ensuring that it is understood at the local level.

The main obstacle in developing countries comes in the area of installation and maintenance skills at the local-level. Although installing some small-scale renewable energy systems, such as wind or PV solar home systems, may not usually pose serious problems in some countries (especially when they are sold in kits which contain all the necessary components, along with instructions in the appropriate language), there are definite skills shortages in many countries and unevenness in skills capacity across a country. For example, there is a much higher concentration of installation and maintenance skills in urban areas than there is in rural areas.

Installations of small-scale renewables may in some cases be completed by the owner/user (if provided with a good instructions manual), however, a skilled technician is usually still needed in the area for maintenance and technical problem solving. For larger renewable energy installations, e.g. for a community hospital, the installation should be carried out by qualified technicians with the same thoroughness as for a conventional power supply system. This can be a problem if there is a shortage of skilled people in the country. When training technicians and end-users to install and maintain their systems there may be some hesitancy to adapt to unfamiliar technology, which will also needs to be overcome.

Quality control and warranties

Renewable energy systems available world-wide can range in quality. It is important to select systems of adequate quality, preferably approved systems (i.e. following a defined standard). Systems should be well-designed and properly sized for the specific need. They also need to be long-lasting, user-friendly and repairable by local technicians. The warranty of the renewable energy apparatus, components and overall system also needs to be considered.

Box 3. **Standards for PV technology**

Most PV modules are manufactured according to USA or European standards, and their quality is very high. International standards also exist for certain other system components. For example, the World Health Organisation, in collaboration with UNICEF, has set international standards for PV refrigerators. WHO/UNICEF funded projects will now only use PV refrigerators that have received WHO approval, which has raised the standard of available products.

Standards do not always exist for system components. This has led to the situation where the quality can vary significantly between several apparently similar devices, or between the various components within a single system. To avoid purchasing inadequate systems or components, it is advisable to prepare a set of technical specifications to define the standard required for a given application.

Maintenance and after-sales service

Maintenance of any system is vital. Some systems require little more than occasional checking of apparatus and components whilst others will require a full maintenance schedule. Preventative maintenance should be planned in full, including the arrangement of the finance necessary to complete this and to cover the costs of repairs and replacements. Maintenance is often a problem for renewable energy systems placed off-grid in rural and remote areas. In these areas, financial resources to fund maintenance are usually lacking as most rural populations have incomes too low to save money for maintenance costs, and human resources, in terms of availability skilled technicians in the field, are also lacking.

Training

Training local people to install, maintain and repair renewable energy systems is essential. There needs to be extensive training of technicians at the local level, often existing electricians, to be able to also deal with small-scale renewable energy systems (especially solar home systems). Users also may need to be educated about the renewable energy system: what it does, how it works and how to look after it. A user-manual should always be given to the end-user along with the renewable energy system. Information dissemination can also play an important role. First, it gives accurate information about what a system can or cannot do. If dissemination of information is undertaken before any system is installed, then there is less likelihood that there will be over-optimistic expectations. At the same time, raising awareness of renewable energy systems can stimulate local markets.

Local technical infrastructure development

Renewable energy projects must include infrastructure development strategies. These need to be undertaken in collaboration with the private sector and local communities. Experience has shown that there are many advantages to be gained if local businesses are involved in any project. The provision of local infrastructure support including training, parts supply and service capability is therefore vital to the success of a project.

5.2. Non-technical issues

Awareness

Most renewable energy systems are now technically mature and proven but they are sometimes still regarded as risky and complicated, as well as expensive and it is often thought that they do not work effectively. This view prevails from the early days of development when there were indeed sometimes such problems. Now renewable energy systems are affordable and often cheaper than conventional alternatives. Moreover these systems offer social (i.e. providing power for income-generating activities) and environmental benefits. The lack of awareness and understanding often reaches across the board from local (potential customers) to institutional level (government departments who might otherwise implement activities/funds to support projects) and there is a need for information dissemination at all levels.

Policy/regulatory issues

There is a lack of government support (although there are signs that this is beginning to change) both at the budgetary and regulatory levels for small and medium renewable energy technologies, especially when compared to the conventional energy sector. However, government policies promoting renewable energy technologies have increased significantly in recent years. At least 48 countries worldwide now have some type of renewable energy promotion policy, including 14 developing countries.[8] Lessons learnt indicate that the best policies are those which promote production-based incentives. Power sector regulatory policies for renewable energy should support IPP (independent power producer) frameworks that provide incentives and long-term stable tariffs.

Institutional capacity-building for micro-finance

People in rural areas want the benefits which electricity brings. However, a major problem is often a lack of capital to pay for renewable energy equipment and/or services. This can be overcome by access to appropriate local credit schemes. There are many successful financial models around the world which utilize micro-enterprise credit to finance small purchases in rural areas. Although these particularly relate to the agriculture sector, there are a number of revolving funds which are providing credit in rural areas for renewable energy purchases. These are beginning to be successfully implemented in some developing countries, but this is rather limited thus far. Financing for renewable power projects is crucial but elusive; there is a real lack of low-cost, long-term financing options.

Community involvement

Community involvement is often critical to the success of a local renewable energy project. Many such projects in developing countries have failed because the needs and wishes of the local community were not considered before the project went ahead and systems installed. If there is no feeling of community involvement or ownership, then failure rate of equipment and theft are likely to be high. Where a technology, such as a water pump or a grinding mill, will benefit an entire community, a local organization needs to take responsibility for ensuring that the technology is managed and utilized according to the needs and preferences of the entire community. Such an organization must be representative of the entire community so that all community members have the right to use the system. The organization may need to define the hours of operation of the system, the tariffs that might be levied (e.g. for water, battery-charging or milling), the maintenance to be carried out and by whom. The presence of such an organization can help to ensure that the system, and any revenue it generates, will benefit the entire community, not just a privileged few. Such a community organization is essential in situations where the local people will be contributing to

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[8] *Renewables 2005: Global Status Report*, REN21 Network Report, 2005.

the financing of the system. It will need to be set up well in advance of system installation, probably during the planning phase with community representatives.

Women in development

The vital role which women play in development is often underestimated or ignored. However, it is often women who benefit most from renewable energy systems.

Box 4. **Women and renewable energy**

Local water pumps, powered by wind or solar, mean less distance to travel to fetch water, and mean that the water is potable. Such systems can be used by the women for drinking water and irrigating their market gardens, thus providing fresh vegetables for their families, with the excess sold and bringing in additional capital for the family.

PV-powered lighting in a healthcare facility can provide better birthing facilities; increased immunization programmes, meaning lower infant mortality which lessens the perceived need for large families.

In other instances, power for lighting or machinery (e.g. sewing machines) enables women to undertake other income-generating activities. Where lighting has been provided in community centres or schools, literacy classes for women can break the poverty trap by enabling them to learn to read, write and count.

Discussion question/exercise

Based on the discussion of the strengths and weaknesses of all of the renewable energy technologies consider how these points might affect the implementation of the technologies from the social, technological and regulatory viewpoints?

6. CONCLUSION

Renewables can be used for both electricity and heat generation. There is a wide range of renewable energy technologies suitable for implementation in developing countries for a whole variety of different applications, as summarized in table 12. Renewable energy can contribute to grid-connected generation but also has a large scope for off-grid applications and can be very suitable for remote and rural applications in developing countries.

Table 12. Summary of technologies and applications

Renewable energy technology	Energy service/application
Wind – grid-connected and stand-alone turbines, wind pumps	Supplementing mains supply. Power for low to medium electric power needs. Occasionally mechanical power for agriculture purposes.
PV (solar electric) – grid-connected, stand-alone, pumps	Supplementing mains supply. Power for low electric power needs. Water pumping
Solar thermal – grid-connected, water heater, cookers, dryers, cooling	Supplementing mains supply. Heating water. Cooking. Drying crops.
Bioenergy	Supplementing mains supply. Cooking and lighting, motive power for small industry and electric needs. Transport fuel and mechanical power.
Micro and pico hydro	Low-to-medium electric power needs. Process motive power for small industry.
Geothermal	Grid electricity and large-scale heating.
Village-scale	Mini-grids usually hybrid systems (solar-wind, solar-diesel, wind-diesel, etc.). Small-scale residential and commercial electric power needs.

LEARNING RESOURCES

Key points covered

The major points covered in this module are as follows:

- Outline and brief description, including fundamentals, of the different renewable energy technologies: wind, solar, bioenergy, hydro, and geothermal energy;
- General overview of the technologies and applications;
- Information on the costs of different renewable energy technologies;
- Discussion regarding common technical and non-technical barriers and issues limiting the widespread use/dissemination of renewable energy.

Answers to review questions

Question: What are the key advantages and disadvantages of wind energy technology?

Answer: See table 2 for strengths and weaknesses

Question: What is meant by the term "stand-alone" and what is the key difference between the two different stand-alone systems described above?

Answer: Stand-alone refers to the fact that the system supplies power without support from the grid. It may be as a single technology or a hybrid (with other technologies, i.e. PV or even a diesel generator). One system incorporates energy storage via a battery bank whilst the other does not. The autonomous diesel system is designed to automatically supply power as required. It has a complex control system.

Question: What are the key differences in the requirements for a wind pump for irrigation and a wind pump for water supply?

Answer: A wind pump developed for irrigation has to be as cheap as possible. Since irrigation generally involves the farmer and/or other workers being present, it is not so critical to have a machine capable of running unattended. Therefore windmills used for irrigation in the past tend to be indigenous designs that are often improvised or built by the farmer as a method of low-cost mechanization.

Most water supply wind pumps must be ultra-reliable, to run unattended for most of the time and they also need the minimum of maintenance and attention and to be capable of pumping water generally from depths of 10 m to 100 m or more. A typical farm wind pump should run for over 20 years with maintenance only once every year, and without any major replacements.

Question: What are the similarities and what are the differences between solar thermal and PV?

Answer: Solar thermal and PV systems both convert energy from the sun into useful energy. PV devices convert sun light directly into electrical energy whilst solar thermal systems use the sun's power in terms of its thermal or heat energy for heating, drying and evaporation.

Question: What are the four different PV technologies in use today and what are their conversion efficiencies?

Answer: Mono-crystalline silicon (conversion efficiency 12-15 per cent), polycrystalline silicon (conversion efficiency 11-14 per cent), thin film (conversion efficiency 5-12 per cent), multiple junction (conversion efficiency 20-30 per cent).

Question: What are the different services that solar thermal systems can provide?

Answer: Electricity, hot water, drying, cooking, distillation, cooling

Question: What are the various applications associated with the different fuel states in bioenergy production?

Answer: See table 7: examples of bioenergy applications.

Question: What size of hydropower plant is considered small? mini? micro? pico?

Answer: See table 9: classification of hydropower plants.

Question: What temperature resource is used for electricity generation in geothermal systems?

Answer: High temperature resources (150° C and greater) can be used for electricity generation.

Presentation/suggested discussion topics

Presentation:

ENERGY REGULATION – Module 7: Renewable energy technologies

Suggested discussion topics:

1. Consider the strengths and weaknesses of all of the renewable energy technologies. What are the main similarities/differences? Why do these exist?
2. What factors might cause variations of these costs in your country, i.e. subsidies, specific technology factors, such as wind speed, etc?
3. Based on the discussion of the strengths and weaknesses of all of the renewable energy technologies consider how these points might affect the implementation of the technologies from the social, technological and regulatory view points?

Relevant case studies

1. Wind power in local government: Denmark's renewable energy island
2. Solar water heating in local government in the UK

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Water Lifting Devices: A Handbook for Users and Choosers, Peter Fraenkel and Jeremy Thake, Intermediate Technology, December 2006, ISBN 1853395382

INTERNET RESOURCES

International Energy Agency: www.iea.org

United Nations Development Programme—Energy: www.undp.org/energy

World Bank Group Energy Program: worldbank.org/energy

Renewable Energy Policy Network for the 21st Century: www.ren21.net

Danish Wind Industry Association: www.windpower.org/en/core.htm

IT Power website, international section: www.itpower.co.uk

Renewable Energy Case Studies: www.martinot.info/case_studies.htm

Renewable Energy for rural schools, health clinics and water applications:
www.enable.nu

Best practice on green energy: www.eugenestandard.org

Technical brief on solar distillation: practicalaction.org/docs/technical_information_service/
solar_distillation.pdf

More information on energy for developing countries:
practicalaction.org/?id=energy_for_the_poor

The Global Environment facility: www.gefweb.org

More information on solar thermal power plants: www.solarpaces.org

More information on solar-assisted air-conditioning of buildings:
www.iea-shc-task25.org/english/index.html

GLOSSARY/DEFINITION OF KEY CONCEPTS

Biofuels	Liquid fuels and blending components produced from biomass (plant and animal) feedstocks, used primarily for transportation.
Biogas	Gaseous fuel produced from animal and crop residues. A mixture of methane, carbon dioxide and water vapour.
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Energy services	The end use ultimately provided by energy, e.g. lighting.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.
Independent power producers (IPPs)	Privately owned power companies that produce electricity and sell it for a profit to the national grid or to a distribution utility.
Inverter	An inverter is an electronic circuit for converting direct current (DC) to alternating current (AC). Inverters are used in a wide range of applications, from small switched power supplies for a computer to large electric utility applications to transport bulk power.
Legal and regulatory framework (LRF)	Combination of the laws, institutions, rules and regulations governing the operations of the electricity industry.
Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100kW but below 1MW).
Run-of-the-river	Hydropower schemes that use natural flow of river to generate power without obstructing the flow of the river with a dam or similar structure and with little or no storage.

Semiconductor	A semiconductor is a solid whose electrical conductivity varies depending on certain conditions. Semiconductors are tremendously important technologically and economically. Silicon is the most commercially important semiconductor, though dozens of others are important as well. Silicon, in combination with a small amount of another chemical, is used in photovoltaic cells to convert sunlight to electricity.
Small hydro	Small-scale power generating systems that harness the power of falling water (‹ 10 MW).
Solar dryer	A special structure that uses the sun's energy to dry agricultural produce (fruits, vegetables, meat).
Solar photovoltaic (PV) technologies	Devices that convert the sun's energy into electricity for use in lighting, refrigeration, telecommunications, etc.
Solar thermal technologies	Devices that use the sun as the primary source of energy for heat appliances, e.g. solar water heaters, solar dryers.
Solar water heaters	Devices that use solar energy to heat water for domestic, institutional, commercial and industrial use.
Solar-assisted air-conditioning and cooling	The basic scheme of solar-thermally assisted air-conditioning and cooling systems consists of a solar collector field that traps sunlight energy, converts it to heat, and conveys that heat to a working fluid such as water. The heated water coming from the solar collector represents the heat source for the thermally driven air-conditioner or chiller. Thermally driven chiller cooling is the first and oldest form of air-conditioning and refrigeration.
Wind turbines	Devices used to generate electricity using kinetic energy from wind.
Wind pumps	Devices that use wind energy to lift water from underground sources.

Case study 1.

WIND POWER IN LOCAL GOVERNMENT: DENMARK'S RENEWABLE ENERGY ISLAND

CONTENTS

1. SUMMARY

In 1997 Samsø was appointed by the Ministry of Energy and Environment as “Denmark’s Renewable Energy Island”. The objective is that Samsø will be self-sufficient using renewable energy within a decade. As part of the plan, a wind turbine park will be erected offshore south of the island, consisting of ten 2.3 MW wind turbines, in order to compensate for energy consumed by the transport sector. The installation was completed at the beginning of 2003.

The project has been successful as a result of the initiative and enthusiasm of the local government and people and as such, the principles which lead to the establishment of an area of renewable energy development could be replicated and applied elsewhere.

The success of the work has been integrated into local educational programmes and has generated enthusiasm and awareness within the local population.

2. THE SCHEME

In 1997, as part of the Danish Energy Plan, “Energi21”, Samsø was selected by the Ministry of Energy and Environment to represent Denmark’s Renewable Energy Island with the aim of having a 100 per cent renewable energy supply for both heating and electricity within ten years. Forming part of the plan is the establishment of an off-shore wind turbine park (23 MW) to produce electricity to compensate for the fossil energy consumption in the transport sector. It is planned that fifty per cent of private cars will be converted to electricity and use the energy produced from the wind turbines.

There are already 15 x 750 kW onshore turbines on the island and so it is very difficult to get permission to build more turbines onshore. This is the case for the whole of Denmark, and is why future wind turbines are likely to be erected offshore.

3. TECHNOLOGY

Wind turbines use the energy in the wind to generate electricity. The advantages of erecting wind turbines offshore include higher average wind speeds and fewer obstructions (such as hills, buildings, etc.), which create turbulence and reduce the power the turbines produce.

The erection of 10 x 2.3 MW offshore wind turbines (Bonus Energ A/S) started in September 2002. The rotor diameter is 82.4 metres, the hub height above sea level is 61.2 metres and the weight of one unit is 3000 tons. The annual energy production of the wind farm will be 77,650 MWh/year.

The turbines have been put up in a straight row (direction north to south) at Paludans Flak, which is a reef 3.5 km south of Samsø.

4. PROJECT TEAM

In order to be able to implement and organize the "Renewable Energy Island" project, Samsø Energy Corporation (Samsø Energiselskab) was created. This is an association of representatives from the Council of Industry, the Association of Agriculture, the Board of Samsø Municipality and citizen representatives chosen by the Association of Energy and Environment of Samsø. A separate company has been established to implement the wind power project, and the local government is also a partner in this.

The initiative to apply to be Denmark's Renewable Energy Island was taken by the Chairman of the Economic Council of Samsø. In order to secure political and commercial support for the project it was decided to present the idea to the Economic Council, the Farm Holder Union and all the representatives of the local council. They all supported the idea and the three groups chose two representatives each to be part of the steering group for the project.

5. FINANCING

In general, wind turbines in Denmark are owned by private cooperatives or companies. The situation in Samsø is quite unique since the municipality owns five of the 10 turbines. Four turbines are owned by private investors and the last turbine is owned by a cooperative, in which private individuals can buy shares.

The total investment cost is approximately €34 million. The project is divided into 7765 shares each of which represent an estimated annual production of 1000 kWh and cost €426 each.

The conversion to renewable energy will become important for the local economy. An estimated saving in fuel costs of €7 million per year will be achieved. The savings will be used to purchase biofuels, manpower, services and to provide finance for local initiatives.

6. LOCAL CONDITIONS FOR RENEWABLE ENERGY

There is great potential for renewable energy on Samsø since the solar radiation and the mean wind speed are above the national average and there are also good opportunities for biomass. In addition to this, the people of the island have gained extensive experience of renewable energy through the many projects that have now been implemented.

Before the “Renewable Energy Island” project, there was already a substantial amount of renewable energy exploitation on Samsø, such as biomass and a district heating plant that has operated reliably since 1993. This helped to prevent possible uncertainties amongst the population about the project. An example of the public interest in renewable energy is that in 1997 the Council received applications for a total of 17 wind turbines from private persons. Furthermore, there had been requests for an additional 10 wind turbine projects from local Samsø inhabitants. The total electric capacity would exceed the current needs of the island.

7. OVERCOMING BARRIERS

In Denmark wind turbines cannot simply be erected anywhere as the placement of the turbines has to fit within regional and municipal planning regulations. The planning takes place at three levels in Denmark: the Ministry of Energy does national planning, the counties are responsible for regional planning and the municipalities produce local plans. After the municipality has decided whether there is space for wind power turbines, private companies can build the actual wind turbines.

Another barrier is that consideration has to be given to nature protection associations and noise transmission. This project was realizable because it was part of the “Renewable Energy Island” project, which received subsidies from the Danish Energy Agency, but also because of the close cooperation between the local authorities, energy agencies and local citizens. At the time of writing, there is very little governmental financial support for renewable energy systems, which means that local initiatives will have to keep the Samsø project running.

8. RESULTS AND IMPACTS

8.1. Environmental and educational benefits

Since the energy production of the offshore turbines is intended to be used in the transport sector, it is necessary to calculate the amount of coal needed to produce 77,650 MWh/year. The following pollution will be avoided on an annual basis:

- Carbon dioxide (CO_2) 66,300 tonnes
- Sulphur dioxide (SO_2) 226 tonnes
- Nitrogen oxides (NO_x) 223 tonnes
- Ashes and cinders 4,290 tonnes

The offshore wind turbine park will create employment of 65 man-years for the construction period and five man-years over its lifetime for the running and maintenance of the turbines.

It is intended to work with the local educational establishments to include the renewable energy project as part of the curriculum and to establish a course in the adult college concerning self-sufficiency strategies for energy combined with economic expansion initiatives in Danish councils. There is a possibility of aiming the activities towards the international market. As this is one of the first offshore wind parks in Europe, it is a very useful demonstration of the feasibility of this technology that others will be able to replicate.

8.2. Economic benefits

The economics of the wind turbine park is based upon a lifetime calculation of ten years where the actual price (including operation and maintenance) is approximately €0.1/kWh. If the turbines last for a longer period (normal turbine lifetime being at least 20 years) they will be profitable for the owners.

The more than 15,000 tourists that visit the island annually are presented with a number of brochures, exhibitions at selected renewable energy plants and offers for special energy arrangements according to season. Samsø has already become interesting for many outsiders, who are not tourists, but have heard about the initiatives for renewable energy exploitation and would like to know more.

9. REPLICATION

Two factors which mean that developments of this type are becoming more easily replicated are firstly, the economies of scale associated with the expansion of the wind energy market have resulted in lower costs and, secondly, planning issues are more widely understood and dealt with as a result of the precedents being set by projects like this.

In addition, this project has been successful mainly as a result of the initiative and enthusiasm of the local government and local people and as such, the principles which lead to the establishment of an area of renewable energy development could be replicated and applied elsewhere.[1]

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Case study 2.

SOLAR WATER HEATING IN LOCAL GOVERNMENT IN THE UK

CONTENTS

1. SUMMARY

Leicester City Council has introduced an innovative scheme to encourage building managers within the Council to install solar water heating systems on their properties. The Solar Rental Scheme offers them the chance to rent rather than purchase a system. The rental cost is linked to the amount of money saved through not purchasing gas or electricity to heat the water, thus there is no additional cost for the building manager.

The rent from panels is paid to the City Council's Energy Management billing team who use it to fund further installations by rotating the fund.

In the first instance, panels were installed in three schools within the city boundary through a partnership of Leicester City Council's Energy Team and the management of the schools as well as the Education Department. The project has also become part of the educational work within the school.

Although the scheme builds on work previously carried out by Leicester City Council, it has an easily replicated methodology which can be used, not only for solar thermal, but also for other sustainable energy technologies.

2. THE SCHEME

Leicester City Council has installed several solar thermal panels on various buildings over the past decade. However, as with many other solar installations, the cost was such that only a few panels could be installed. The Solar Rental Scheme takes advantage of a financing mechanism which is often used in the installation of energy efficiency measures—a rotating fund. This methodology allows for financing of solar panels with no additional cost to building managers, and allows money that is made from one project to be reused to finance the next project.

The barrier of cost is one of the main reasons why solar panels are not installed in much larger numbers and this project goes some way towards removing that barrier and opening up the potential for further installations.

3. TECHNOLOGY

Solar water heating systems collect energy from the sun and convert it into useful heat for many domestic and commercial applications. There are a number of different systems available, ranging from cheap self-installed models to complex, evacuated tube technologies that maximize solar potential.

There are now over 42,000 solar water heating systems operating in the UK, with the majority being used to produce domestic hot water or for heating swimming pools. Currently, about 2000 new systems are added each year. Most systems are robust and reliable, giving on average 20 years useful service.

4. PROJECT TEAM

Leicester City Council's Energy Team has experience in the implementation of solar thermal in its own buildings, having installed systems in swimming pools and on the central headquarters of the Council. The expertise of the team includes heating engineering, public awareness, policy development and energy management.

The team was able to use its engineering skills to design a system for installation in specific schools. The schools were identified through existing work in energy management audits and the installations were justified financially through the sustainable energy policies which the team had previously helped to develop. The scheme was then publicized, both inside and outside the authority.

The team also draws on experience from consultants and other partner organizations such as the manufacturer, Riomay, and a local installation company which has now developed the expertise to install further systems.

5. FINANCING

The total investment cost of the project was €48,000. The investment cost of solar systems can seem prohibitive to a building manager with limited resources and where investments, which do not payback within 2 to 3 years, they tend to get overlooked. The Solar Rental Scheme shifts the issue of initial capital outlay from the building manager to the Energy Management Team. The Energy

Management Team sources the funding to pay for the installation of the panels while the building manager pays for the service provided by these panels (i.e. hot water). The building manager can budget for the rent within a single financial year.

The Energy Management Team can source the financing in various ways:

- As part of overall building maintenance programme;
- From savings received from previous energy efficiency improvements;
- Through other sources such as utilities.

The greatest advantage of the scheme is the way it allows funding to be recycled and utilized beyond its original intention. The system of recycling funding is based on the logic of rotating funds for energy efficiency investment where savings resulting from a small investment in energy efficiency are “ring fenced” and used as investment for further improvements.

As the savings in energy costs are many times larger than the investment, the rotating fund increases in size. Smaller projects with short paybacks tend to be invested in first as a way of quickly increasing the investment fund, which allows for investment in larger and longer payback projects.

It is possible to combine the longer payback of a renewable energy system with the shorter payback of some energy efficiency investments in order to have an overall project with a larger revenue stream in proportion to a smaller capital outlay.

6. LOCAL CONDITIONS FOR RENEWABLE ENERGY

Leicester City Council was the first Unitary Council in the UK to achieve full Environmental Management Audit Scheme (EMAS) certification. Leicester City was granted the status of “Britain’s First Environment City” in 1990. Leicester Energy Strategy has a target for a 50 per cent reduction in CO_2 emissions from 1990 to 2025 and 20 per cent of all City energy coming from renewable sources by 2020. The Council’s Chief Executive made a corporate commitment to energy efficiency in 1992.

The East Midlands region’s target is 9.4 per cent of electricity to be derived from renewable energy systems by 2010. The current UK Government is developing an integrated energy policy that places emphasis on low carbon technologies and its recent review suggests that the aim will be for renewable energy systems to make a significant contribution to energy supply by 2020.

The achievement of the title of Environment City and the development of the Leicester Energy Strategy were initiated by enthusiastic staff within the organization before being adopted at a top level. This continues with delivery of targets since the work is usually initiated by the staff and then endorsed by the top level management and elected representatives.

7. OVERCOMING BARRIERS

Having worked with solar energy systems previously, the Energy Management Team has a good level of knowledge of the technology. However, where it was felt that knowledge or experience may have been lacking, this was brought in through the engineers and manufacturers who supplied and fitted the systems. As time progresses and staff become more familiar with new technologies there are savings to be made in external expertise.

The Energy Management Team has become familiar with the decision-making processes within the municipality. They have also networked closely with other staff and have become sympathetic to the priorities of other departments and individuals. This has enabled the team to approach departments and individuals in such a way that they help them achieve their energy targets while helping other partners reach their targets. For example, the installation of solar panels in schools via a rental scheme provides the school with an educational tool at no additional cost.

The Energy Management Team have used the development process to their advantage in other ways by gaining political support at a high level and having renewable energy incorporated into corporate policy.

Awareness of the new installations was maximized by publicizing the work to the local community and also to other municipalities. This was achieved by working closely with the local press and radio and through established channels of communication with other municipalities such as national, regional and local fora.

8. RESULTS AND IMPACTS

The three initial installations in schools have been completed successfully. The trial has enabled the Energy Management Team to determine various parameters of real usage of the systems, e.g. the level of energy generated by the solar water heating systems, how much water was used, how much will need to be charged for a rental scheme to be viable. The data gathered and successful completion of the trial mean that further installations are now going ahead during 2003.

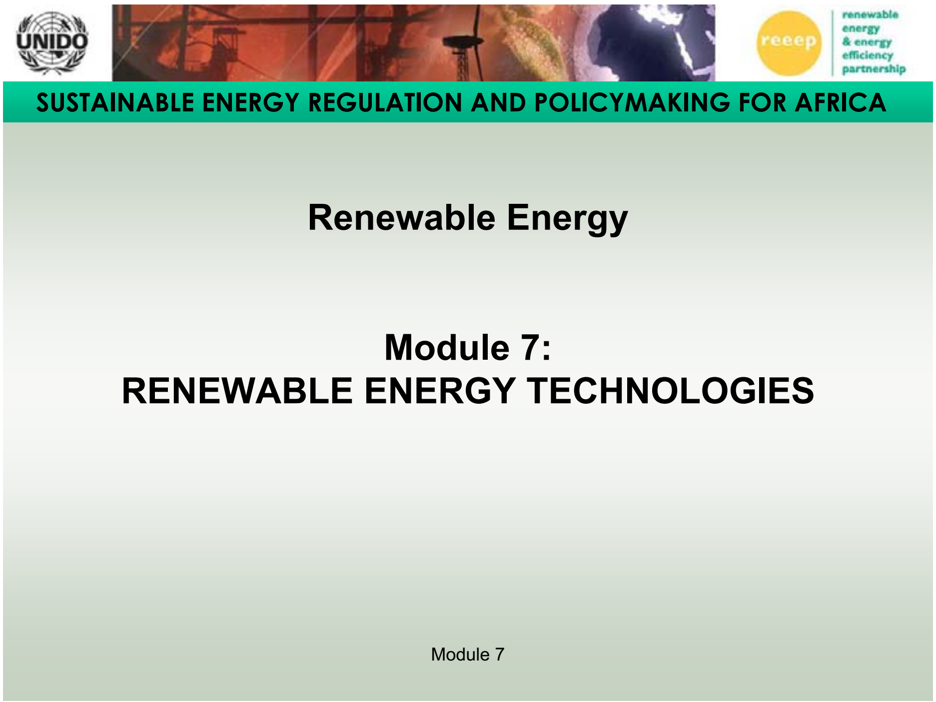
Whilst the project is still ongoing, it has already produced significant benefits. Through the installation of solar water heating systems on council buildings, local contractors develop skills which can then be used in other sectors. Following the success of the initial phase, the methodology has been extended to the domestic sector where solar water heaters are installed on homes in conjunction with energy efficiency measures, helping to reduce fuel costs and alleviate fuel poverty.

The carbon savings resulting from this work are relatively small in the short-term. However, they are significant because, having broken down the main barrier of cost, the scheme opens up huge potential for further installations across the city and beyond.

9. REPLICATION

Replication of this project by other local governments would be straightforward because the technology used in this installation is not new and there are numerous experienced installation companies in most European countries. Many local governments will have experience of this type of funding mechanism because it has been widely used in the financing of energy efficiency improvements. For those without previous experience, it is straightforward and simple to implement once the initial capital investment is secured.

It should be noted that while the experience of the team certainly helped with this scheme, it is possible to replicate this without the staff numbers or experience because this can be bought in from other organizations.

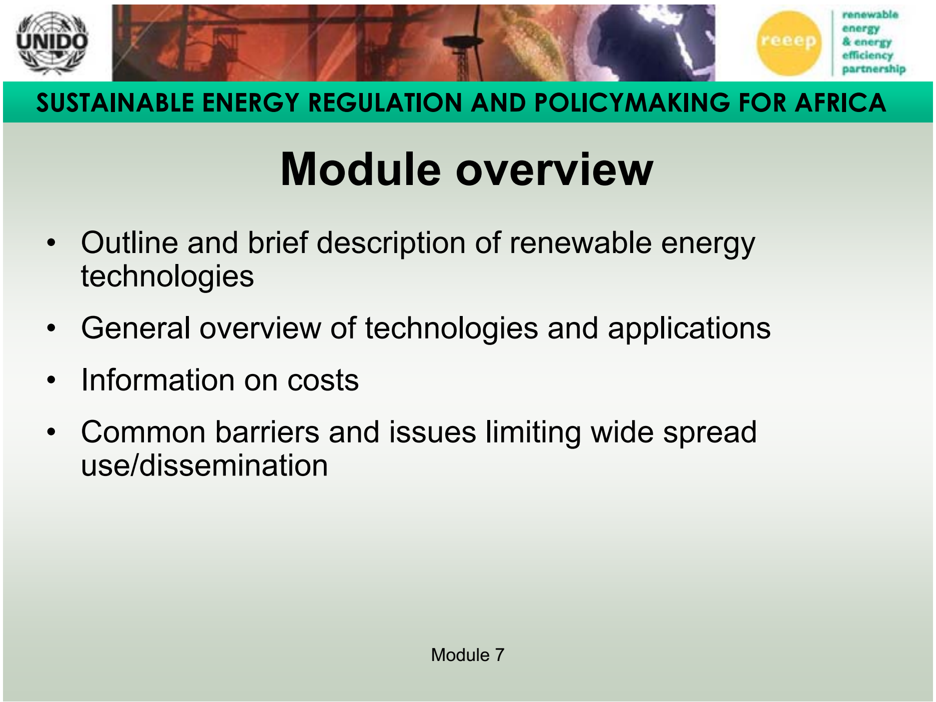


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy

Module 7:
RENEWABLE ENERGY TECHNOLOGIES

Module 7

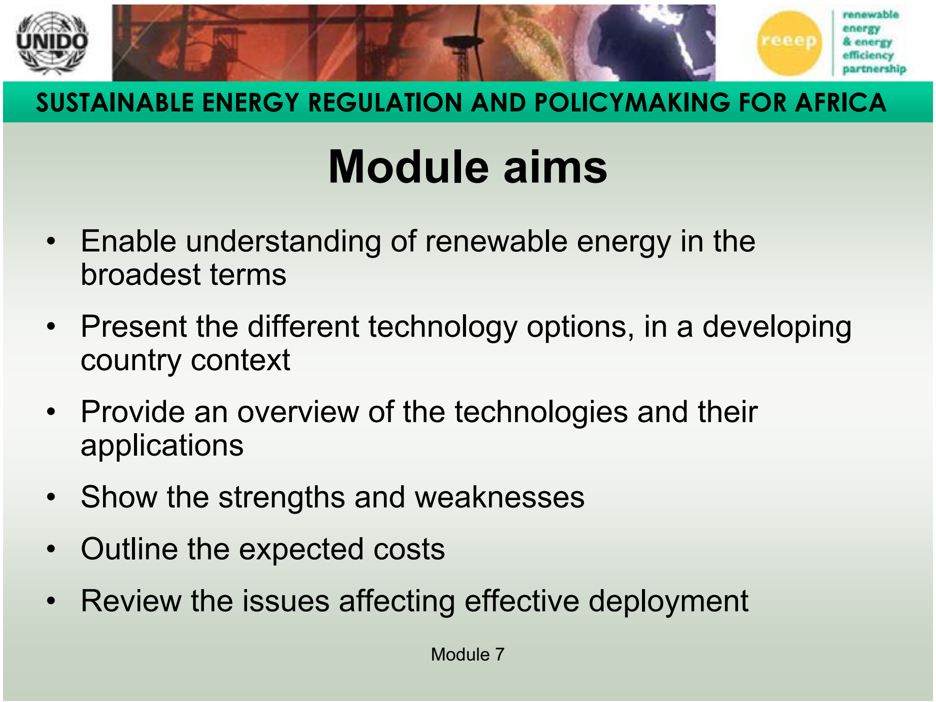


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Outline and brief description of renewable energy technologies
- General overview of technologies and applications
- Information on costs
- Common barriers and issues limiting wide spread use/dissemination

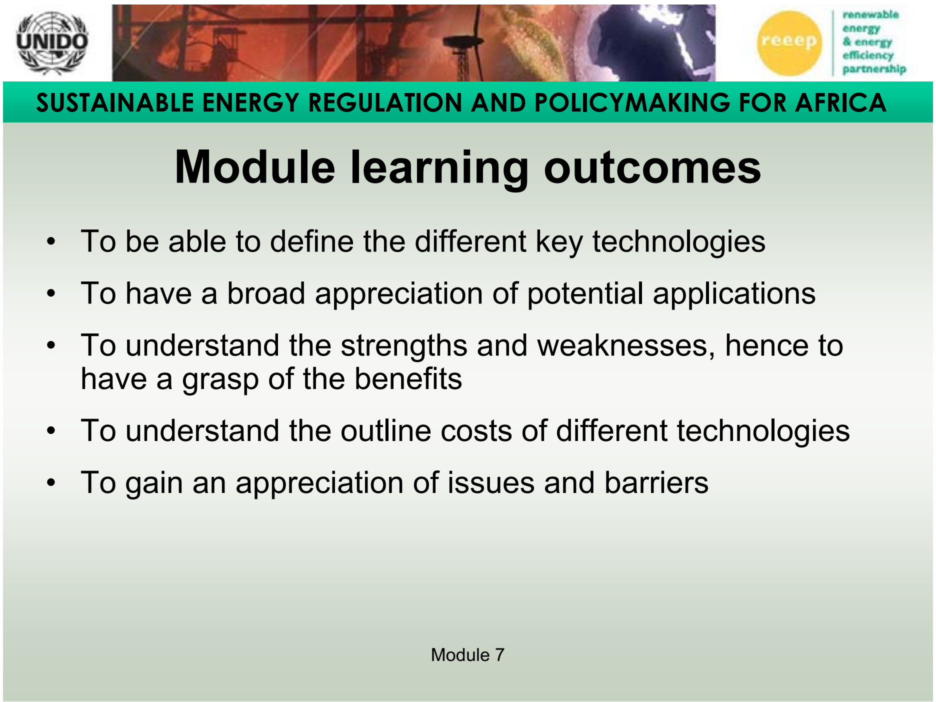
Module 7



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

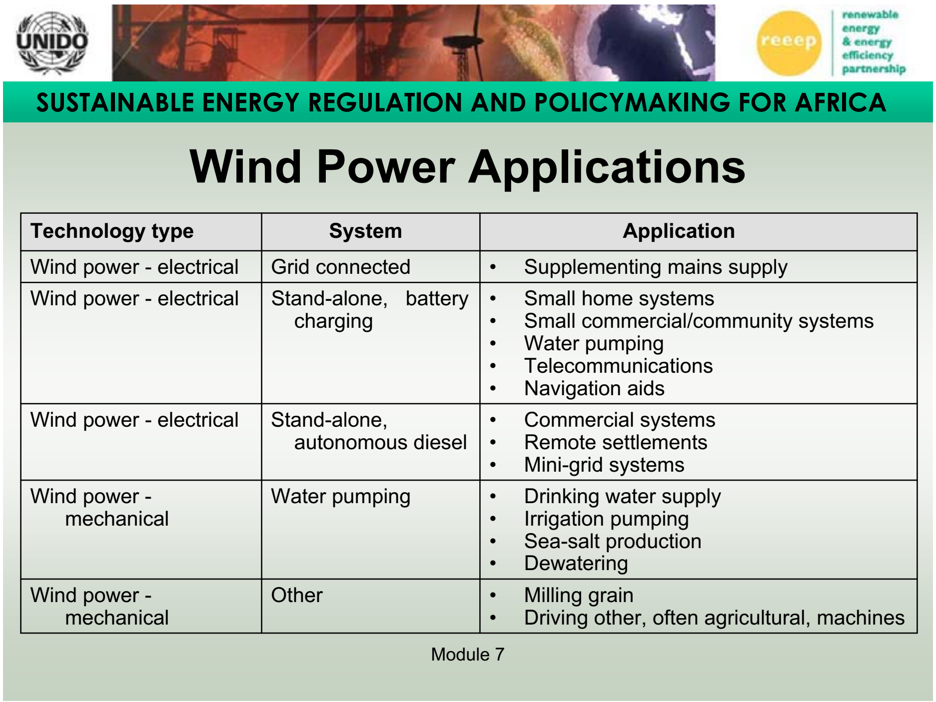
- Enable understanding of renewable energy in the broadest terms
- Present the different technology options, in a developing country context
- Provide an overview of the technologies and their applications
- Show the strengths and weaknesses
- Outline the expected costs
- Review the issues affecting effective deployment



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define the different key technologies
- To have a broad appreciation of potential applications
- To understand the strengths and weaknesses, hence to have a grasp of the benefits
- To understand the outline costs of different technologies
- To gain an appreciation of issues and barriers



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Wind Power Applications

Technology type	System	Application
Wind power - electrical	Grid connected	Supplementing mains supply
Wind power - electrical	Stand-alone, battery charging	Small home systems Small commercial/community systems Water pumping Telecommunications Navigation aids
Wind power - electrical	Stand-alone, autonomous diesel	Commercial systems Remote settlements Mini-grid systems
Wind power - mechanical	Water pumping	Drinking water supply Irrigation pumping Sea-salt production Dewatering
Wind power - mechanical	Other	Milling grain Driving other, often agricultural, machines

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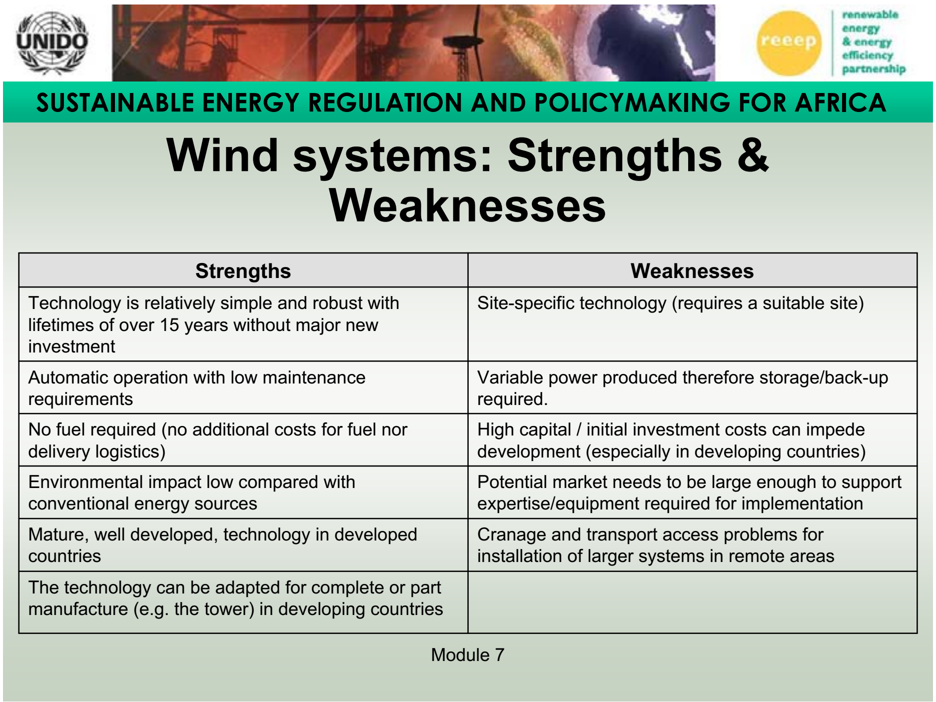

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Wind systems: Strengths & Weaknesses

Strengths	Weaknesses
Technology is relatively simple and robust with lifetimes of over 15 years without major new investment	Site-specific technology (requires a suitable site)
Automatic operation with low maintenance requirements	Variable power produced therefore storage/back-up required.
No fuel required (no additional costs for fuel nor delivery logistics)	High capital / initial investment costs can impede development (especially in developing countries)
Environmental impact low compared with conventional energy sources	Potential market needs to be large enough to support expertise/equipment required for implementation
Mature, well developed, technology in developed countries	Cranage and transport access problems for installation of larger systems in remote areas
The technology can be adapted for complete or part manufacture (e.g. the tower) in developing countries	

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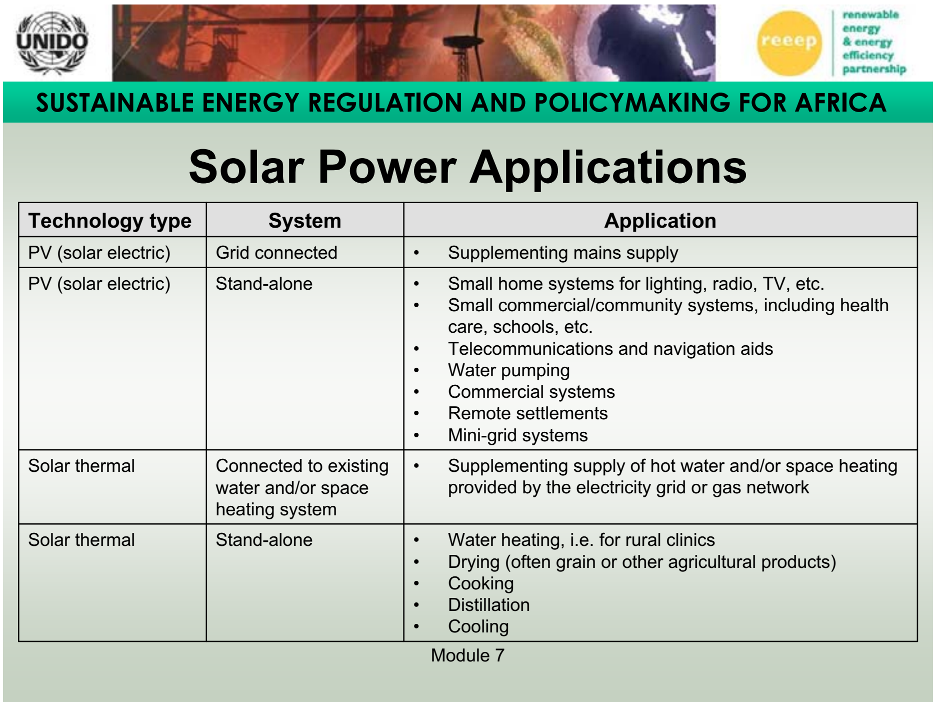

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Solar Power Applications

Technology type	System	Application
PV (solar electric)	Grid connected	• Supplementing mains supply
PV (solar electric)	Stand-alone	• Small home systems for lighting, radio, TV, etc. • Small commercial/community systems, including health care, schools, etc. • Telecommunications and navigation aids • Water pumping • Commercial systems • Remote settlements • Mini-grid systems
Solar thermal	Connected to existing water and/or space heating system	• Supplementing supply of hot water and/or space heating provided by the electricity grid or gas network
Solar thermal	Stand-alone	• Water heating, i.e. for rural clinics • Drying (often grain or other agricultural products) • Cooking • Distillation • Cooling

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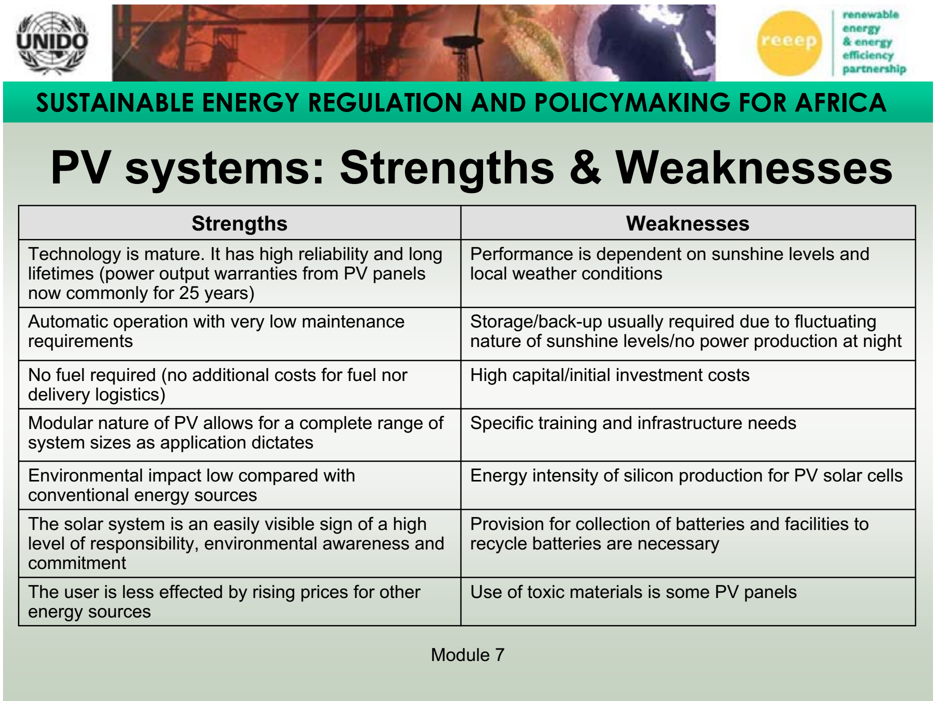

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

PV systems: Strengths & Weaknesses

Strengths	Weaknesses
Technology is mature. It has high reliability and long lifetimes (power output warranties from PV panels now commonly for 25 years)	Performance is dependent on sunshine levels and local weather conditions
Automatic operation with very low maintenance requirements	Storage/back-up usually required due to fluctuating nature of sunshine levels/no power production at night
No fuel required (no additional costs for fuel nor delivery logistics)	High capital/initial investment costs
Modular nature of PV allows for a complete range of system sizes as application dictates	Specific training and infrastructure needs
Environmental impact low compared with conventional energy sources	Energy intensity of silicon production for PV solar cells
The solar system is an easily visible sign of a high level of responsibility, environmental awareness and commitment	Provision for collection of batteries and facilities to recycle batteries are necessary
The user is less effected by rising prices for other energy sources	Use of toxic materials is some PV panels

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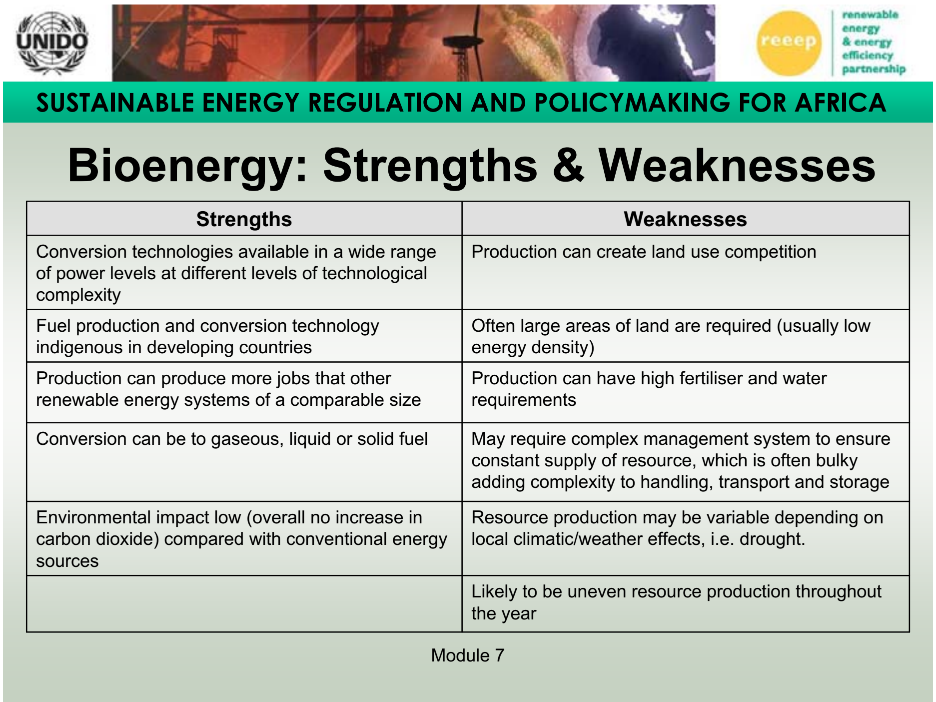

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Bioenergy: Strengths & Weaknesses

Strengths	Weaknesses
Conversion technologies available in a wide range of power levels at different levels of technological complexity	Production can create land use competition
Fuel production and conversion technology indigenous in developing countries	Often large areas of land are required (usually low energy density)
Production can produce more jobs that other renewable energy systems of a comparable size	Production can have high fertiliser and water requirements
Conversion can be to gaseous, liquid or solid fuel	May require complex management system to ensure constant supply of resource, which is often bulky adding complexity to handling, transport and storage
Environmental impact low (overall no increase in carbon dioxide) compared with conventional energy sources	Resource production may be variable depending on local climatic/weather effects, i.e. drought.
	Likely to be uneven resource production throughout the year

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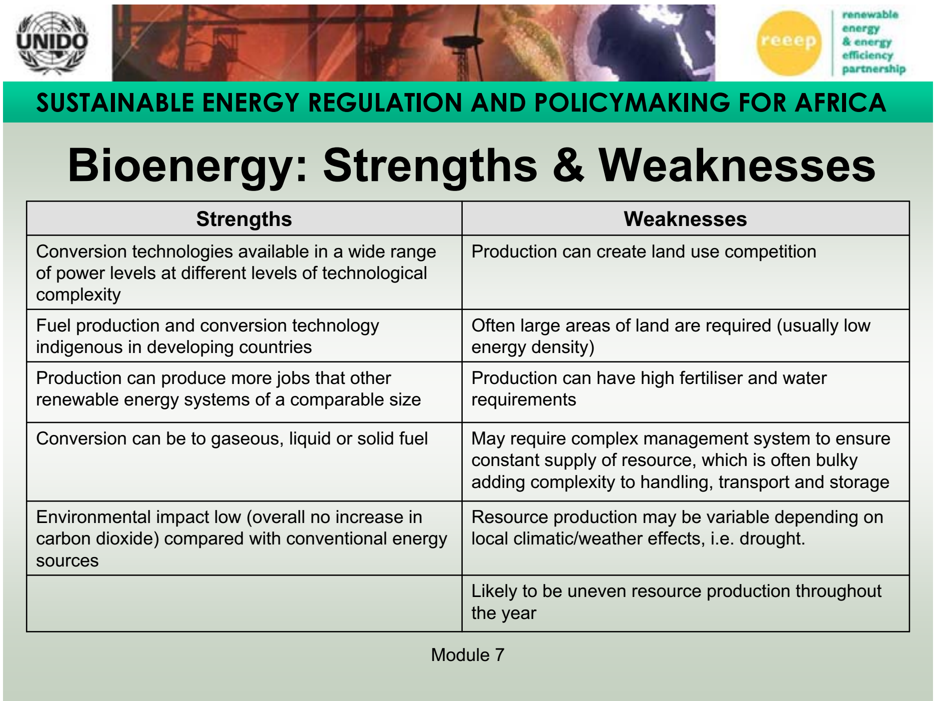

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

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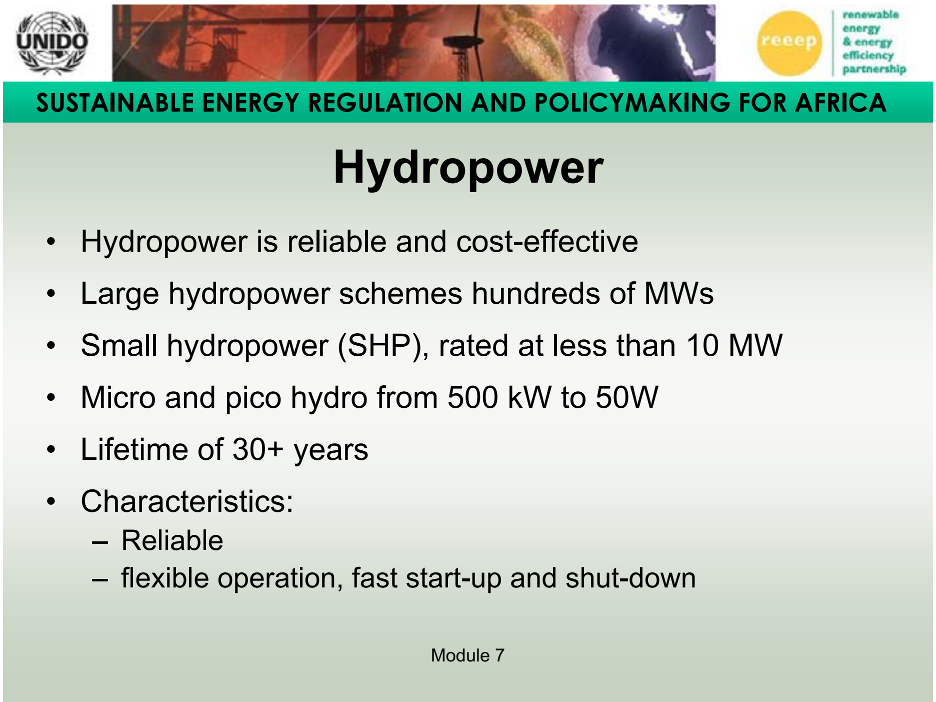

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Hydropower

- Hydropower is reliable and cost-effective
- Large hydropower schemes hundreds of MWs
- Small hydropower (SHP), rated at less than 10 MW
- Micro and pico hydro from 500 kW to 50W
- Lifetime of 30+ years
- Characteristics:
  - Reliable
  - flexible operation, fast start-up and shut-down

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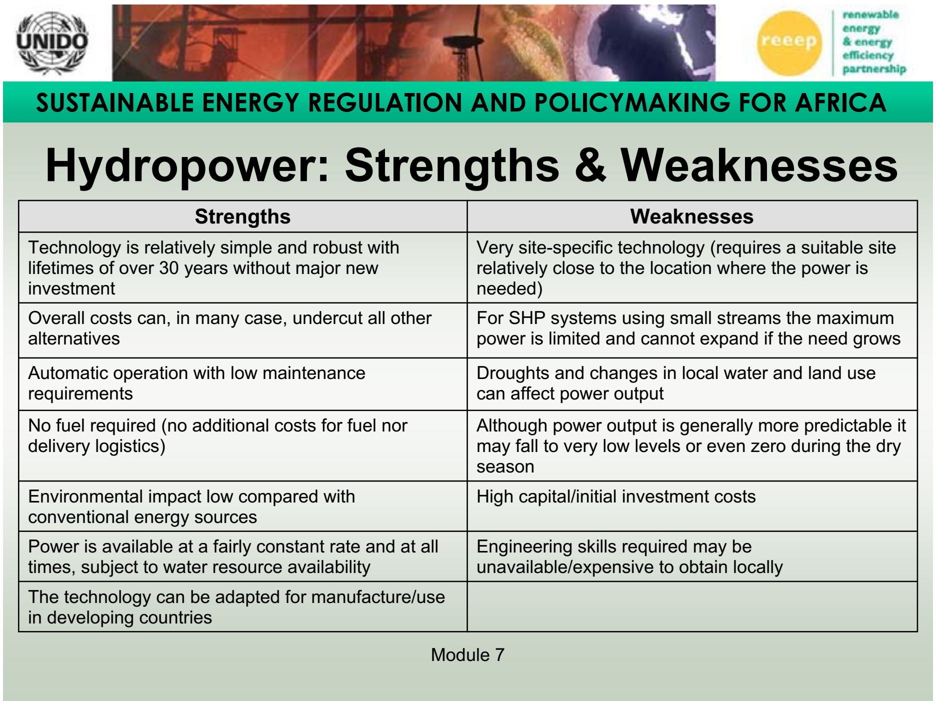

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Hydropower: Strengths & Weaknesses

Strengths	Weaknesses
Technology is relatively simple and robust with lifetimes of over 30 years without major new investment	Very site-specific technology (requires a suitable site relatively close to the location where the power is needed)
Overall costs can, in many case, undercut all other alternatives	For SHP systems using small streams the maximum power is limited and cannot expand if the need grows
Automatic operation with low maintenance requirements	Droughts and changes in local water and land use can affect power output
No fuel required (no additional costs for fuel nor delivery logistics)	Although power output is generally more predictable it may fall to very low levels or even zero during the dry season
Environmental impact low compared with conventional energy sources	High capital/initial investment costs
Power is available at a fairly constant rate and at all times, subject to water resource availability	Engineering skills required may be unavailable/expensive to obtain locally
The technology can be adapted for manufacture/use in developing countries	

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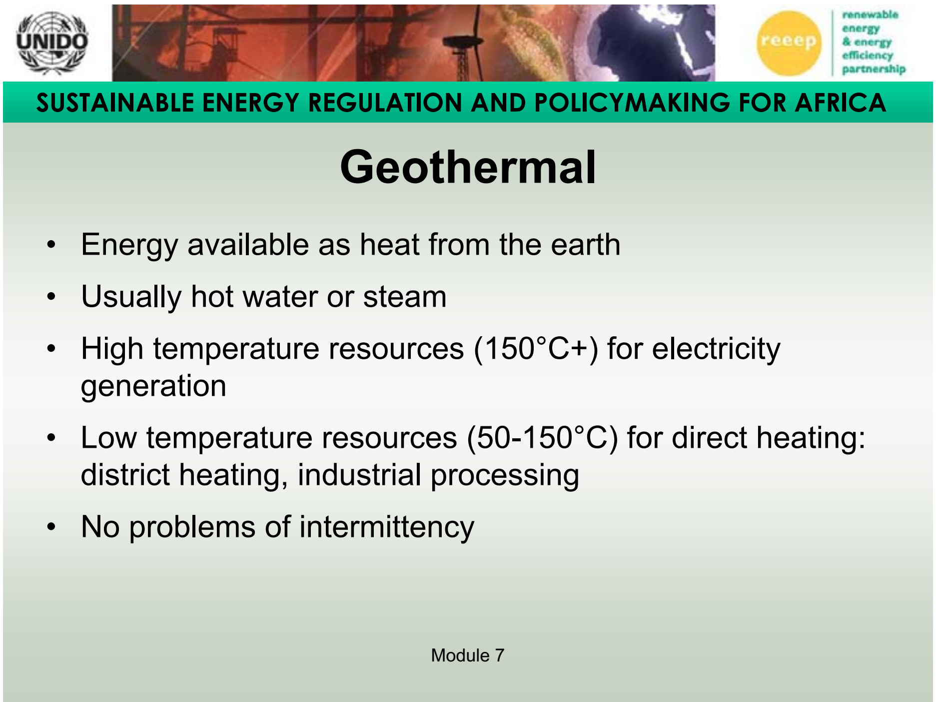

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Geothermal

- Energy available as heat from the earth
- Usually hot water or steam
- High temperature resources (150°C+) for electricity generation
- Low temperature resources (50-150°C) for direct heating: district heating, industrial processing
- No problems of intermittency

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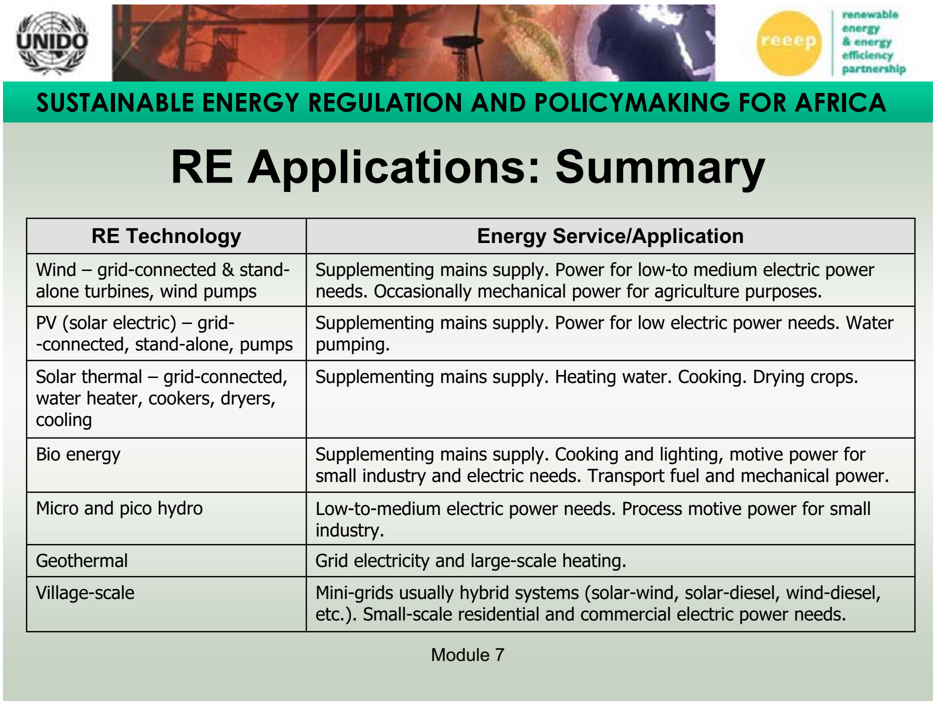

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

RE Applications: Summary

RE Technology	Energy Service/Application
Wind – grid-connected & stand-alone turbines, wind pumps	Supplementing mains supply. Power for low-to medium electric power needs. Occasionally mechanical power for agriculture purposes.
PV (solar electric) – grid--connected, stand-alone, pumps	Supplementing mains supply. Power for low electric power needs. Water pumping.
Solar thermal – grid-connected, water heater, cookers, dryers, cooling	Supplementing mains supply. Heating water. Cooking. Drying crops.
Bio energy	Supplementing mains supply. Cooking and lighting, motive power for small industry and electric needs. Transport fuel and mechanical power.
Micro and pico hydro	Low-to-medium electric power needs. Process motive power for small industry.
Geothermal	Grid electricity and large-scale heating.
Village-scale	Mini-grids usually hybrid systems (solar-wind, solar-diesel, wind-diesel, etc.). Small-scale residential and commercial electric power needs.

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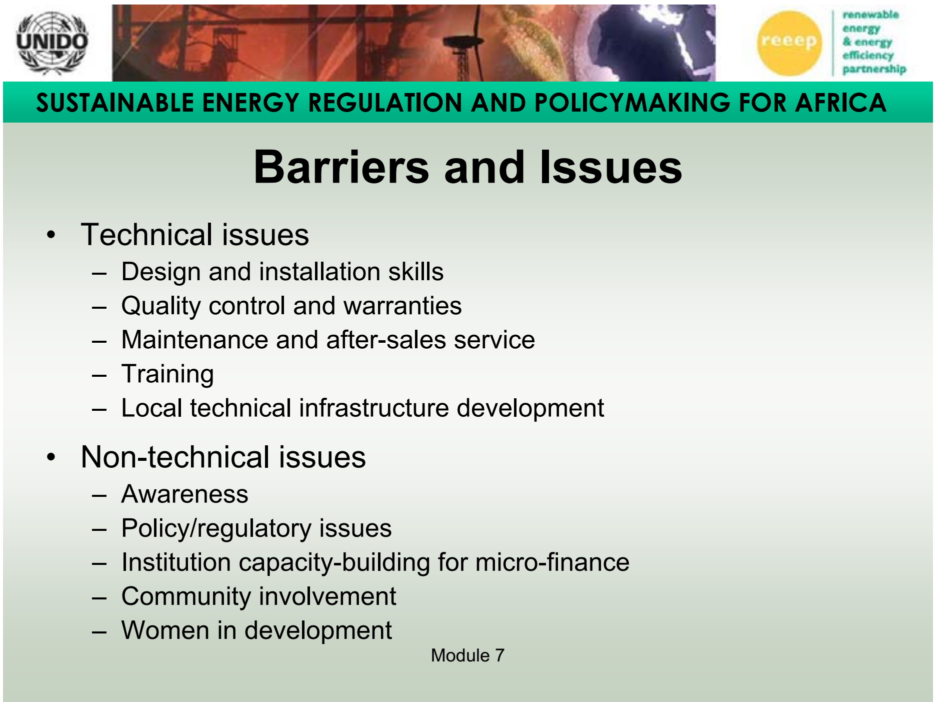

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Barriers and Issues

- Technical issues
  - Design and installation skills
  - Quality control and warranties
  - Maintenance and after-sales service
  - Training
  - Local technical infrastructure development
- Non-technical issues
  - Awareness
  - Policy/regulatory issues
  - Institution capacity-building for micro-finance
  - Community involvement
  - Women in development

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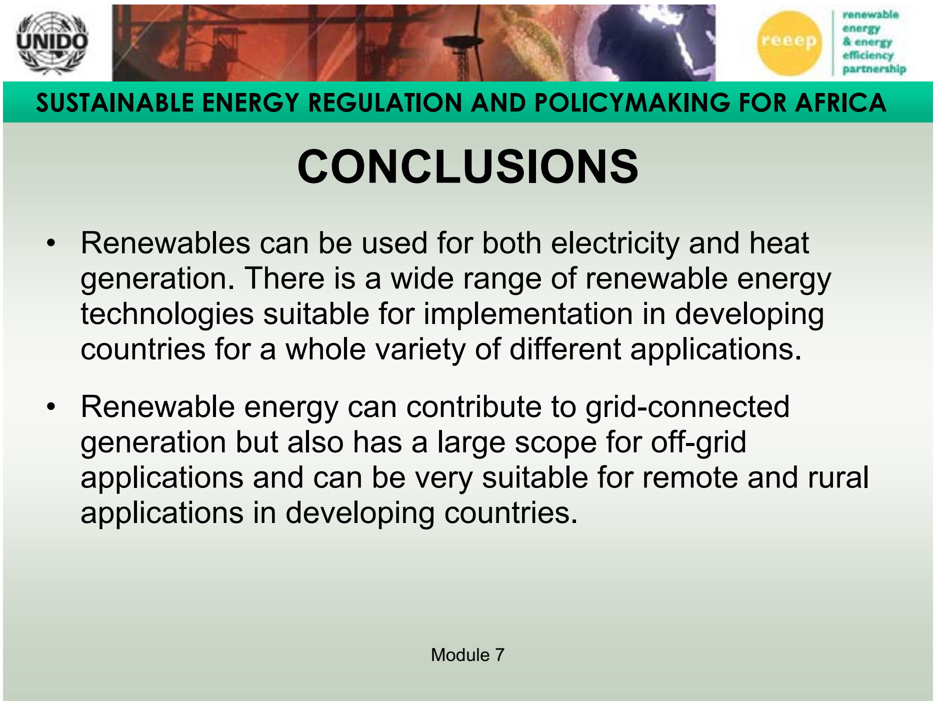

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Renewables can be used for both electricity and heat generation. There is a wide range of renewable energy technologies suitable for implementation in developing countries for a whole variety of different applications.
- Renewable energy can contribute to grid-connected generation but also has a large scope for off-grid applications and can be very suitable for remote and rural applications in developing countries.

Module 7

Module 8

Impact of different power sector reform options on renewables

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Power sector reforms were largely designed to increase the electricity generation capacity and to ensure profitability of the power sector. The promotion of the use of renewables in electricity generation was largely left out of this reform process.

However, various reform options present opportunities and/or barriers to the promotion of renewables.

This module will discuss how various reform options impact on the promotion of renewable energy, and will provide examples from both industrialized and African countries to illustrate the findings.

1.2. Module aims

The aims of the present module are:

- To highlight the positive and negative impacts of different power sector reform options on renewables. Specifically, this module focuses on the impact of the following reform options:
  - Unbundling (vertical and horizontal)
  - Electricity law amendment
  - IPPs development
  - Corporatization
  - Management contracting
- To provide examples, where relevant, of countries that have implemented the aforementioned reform options and the results achieved with respect to renewable energy technologies (RETs).

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To understand the impact and potential benefits and drawbacks of the various power sector reform options with regard to renewable energy.
- To draw lessons from the case studies provided.

2. INTRODUCTION

As power sector reforms cover the whole energy sector and aim to (re)organize the very institutional structure of the power sector, these policies inevitably interfere with renewable energy policies. In general power sector reforms take place at a broader and higher level than renewable energy policies; whereas power sector reforms can be regarded as determining the institutional and market infrastructure of the power sector, renewable energy policies are instruments aiming to make the infrastructure work in favour of renewable energy.

Unsurprisingly, streamlining both sets and levels of policies is a true and multidimensional challenge. Power reform options were primarily designed to increase electricity generation capacity and to enhance the financial health of the utilities, rather than to promote renewables.

Renewable energy systems for electricity generation tend to be decentralized, small-scale in nature and located in rural and sometimes remote areas. Power system planners are generally used to and comfortable with centralized and large-scale electricity generation options, and remain largely unfamiliar with renewable energy options.

For example, the severe generation capacity shortfalls in several African countries did not trigger the potentially significant role for renewable energy in addressing the issue. Instead Independent Power Producers (IPPs) have been brought in to install relatively large power generation systems using fossil fuel-based thermal plants only. Consequently, renewables have not attracted significant level of investment.

However, various reform options present opportunities and/or barriers to the promotion of renewables. This module discusses the impact of different power sector reform options on renewables. It is structured into sections each describing a specific reform option in detail.

3. IMPACT OF ELECTRICITY LAW AMENDMENT AND UNBUNDLING ON RENEWABLE ENERGY

3.1. Electricity Law Amendment

Electricity Law Amendment is the first and basic step in which the framework and the key principles of the policy objectives are outlined. With regard to power sector reforms these could for instance include the rationale and the policy strategy behind the unbundling of the national integrated energy infrastructure, or the establishment, the definition of its role and financing of an independent energy regulator. As for renewable energy, the framework might include targets for renewable as well as the major principles to reach the target (e.g. socialization of extra costs, tailored tariff structures).

Overall Electricity Law Amendment should outline what the longer term policy aims are and who is expected to play which role. The details of how the according support instruments would then be implemented are to be further elaborated and described in downstream policy and regulation.

A review of amended Electricity Acts in several sub-Saharan African countries reveals that most of them do not explicitly mention or promote the use of renewable energy in electricity generation. Countries with vigorous renewable energy programmes have amended their Electricity Acts to explicitly promote renewable energy, including Ghana, Kenya, Namibia and Uganda. In these countries, the amended Electricity Acts have played an essential role in the promotion of renewable energy. The existing examples are discussed in some more detail below.

Renewable energy legally embedded in rural electrification strategies in Uganda

The Electricity Act in Uganda explicitly promotes the use of renewable energy for electricity supply, especially in rural areas. The Electricity Act stipulates that the Minister of Energy and Minerals should incorporate renewables in the “Rural Electrification Strategy and Plan” which is approved by the Cabinet. This requirement is further strengthened by the obligation for the Minister to annually report on the progress to the Parliament. Section 64 (2) of the Ugandan Electricity Act states that (Republic of Uganda, 1999):

> “The Minister shall, once in each year, submit to Parliament, an annual report on the progress and achievement of the [Rural Electrification Strategy and] Plan which shall contain, information relating to -
>
> ...
>
> *(c)* the renewable energy power generation for sale to the main grid and for mini-grids; and
>
> *(d)* the installation of solar photo voltaic systems for isolated settlements that cannot be economically connected to the grid.”

Priority funding for renewable energy in Ghana and Uganda

The amended Electricity Acts give priority to the funding of renewables based electricity generation investments especially for rural electrification purposes. In Ghana, Section 42 of the Energy Commission Act stipulates that (Republic of Ghana, 1997):

> “Monies of the [Energy] Fund shall be applied as follows:
>
> ...
>
> *(b)* promotion of projects for the development and utilisation of renewable energy resources, including solar energy;”

The Ugandan Electricity Act is even more emphatic on the funding of renewables by stipulating that (Republic of Uganda, 1999; Section 66(2e):

> The Minister shall determine the criteria and the appropriate level of the [Rural Electrification Fund] subsidy, taking into account -
>
> ...
>
> *(f)* the extent to which the proposed activity makes appropriate use of renewable energy resources.

Light-handed regulation in Kenya, Uganda, Namibia and Zambia

The amended Electricity Acts in Kenya, Uganda, Namibia and Zambia appear to minimize regulatory requirements for investors interested in the installation of small-scale electricity generation power plants. This development aims to favour electricity generation from renewables, especially for own consumption.

In Kenya, renewables incorporated in a hybrid system not exceeding 1 MW at medium transmission voltage do not require to go through the rigorous licensing procedure. According to the Kenyan Electricity Act, an “authorisation” from the Minister of Energy is sufficient (Republic of Kenya, 1998). In Uganda, electricity generation plants not exceeding 0.5 MW only require registration with the Electricity Regulatory Authority (Republic of Uganda, 1999) while in Namibia, no generation license is required for electricity generation equipment below 500 kVA for own use (Republic of Namibia, 2000).

Environmental provisions in Kenya

Finally, amendments to the Electricity Acts have contributed to more environmentally friendly electricity generation. This is well illustrated in the case of Kenya's (see box 1 and case study 1 of this module[1]) geothermal installations by comparing the so-called Olkaria I plant—a pre-reform installation with Olkaria II and III plants, which are post-reform installations.

Box 1. **Impact of Electricity Act Amendment on renewable energy—Case of Geothermal energy in Kenya**

The environmental impacts of using geothermal power that are of concern include: air quality, water pollution, land disturbance, aesthetic or visual impacts, and noise emissions. Being within the Hale's Gate National Park (HGNP) means that the issue of human disturbance or resettlement did not arise. However, with regard to disturbance to the fauna and flora, the experience from Olkaria I showed a minimal impact on the flora provided that any disturbed sites were restored to as near as their original states as possible. Olkaria II and III have made major improvements in respect of possible disturbance to the flora in accordance to the Electricity Act of 1997, which clearly stipulates provisions for environmental assessments before construction. By piping and re-injecting all waste water rather than using open ditches as was the case with Olkaria I, the new approach in Olkaria II and III prevents new vegetation from colonizing the neighbouring areas. This issue is discussed further in the following paragraph.

The visual impacts associated with the power plant itself and the steam gathering pipes, of which there are considerable lengths, have been minimized by using a colour scheme that blends in with the surroundings. The purpose of this is to maintain the natural beauty of the Park. The EIA report indicates that this has not affected tourist activities in HGNP adversely. The socio-economic and environmental impact in this regard can therefore be considered neutral.

With regard to air quality, the gaseous emissions from geothermal power production that are of interest in this context are mainly carbon dioxide - CO_2 (96%), hydrogen sulphide - H_2S (~4%) and tiny quantities of hydrogen - H_2, methane - CH_4 and nitrogen - N_2. The most hazardous of these is hydrogen sulphide, of which the

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[1] See module 9 "Regulatory and Policy Options to encourage the Development of Renewable Energy" - case study 1 "Geothermal development in Kenya" for more details.

ground level concentrations in the Olkaria area have been determined in the EIA for the Olkaria II and III projects to be below hazardous levels for workers and the local population. Further to this, the design for the Olkaria II and III projects will result in better dispersion of the gaseous emissions than was the case with Olkaria I.

The disposal of residual waters for Olkaria II and III project is by re-injection through re-injection wells into the geothermal reservoir, which is a vast improvement over disposal into gullies and natural water ways as practiced in the Olkaria I project. Re-injection ensures that the spent brine does not come into contact with surface water consumed by humans and livestock; further it cannot alter the natural composition of surface waters and upset the natural balance of the local ecosystem. A further advantage of re-injection is the recharge of the reservoir and maintenance of reservoir pressure and steam rates over a longer period of time.

These two cases serve to illustrate the major departure in the way electric power is produced and supplied in the two eras: with the Olkaria I project illustrating pre-reform practices and Olkaria II and III projects illustrating post-reform practices. It is apparent that the reform process has had a markedly different and positive impact on the environment.

Discussion question/exercise

Discuss the impact of electricity law amendment on renewable energy in your country

3.2. Unbundling

The rationale for unbundling is to enhance overall operational efficiency of the power sector by separating the core business units of generation, transmission and distribution into legally and operationally distinct and independent entities. As mentioned in module 4, there are two types of unbundling: vertical unbundling and horizontal unbundling. As there is limited implementation of horizontal unbundling, this section will largely discuss the impacts of vertical unbundling based on the available examples.

Power sector reforms do not directly impact on renewable energy policies, but rather provide a sector structure on which to build policies and regulation. With regard to renewable energy the process of vertical unbundling[2] typically resulted in:

- The creation of an independent energy regulator which is in charge of overlooking and monitoring the reform process. The regulator is usually a public or semi-public body;
- The creation of a Transmission System Operator (TSO), effectively keeping a monopoly on the transmission infrastructure;
- The creation of Distribution Network Operators (DNOs), usually with effective monopolies on the distribution network in their assigned territories;
- The liberalization of electricity generation and supply.

In European countries the policies encouraging renewable energy are built on this vertically unbundled organization of the electricity sector; i.e. the targeted share of renewable energy (in quota systems) and energy disclosure requirements are imposed most often on suppliers of energy, and guaranteed tariffs need to be paid for by the TSO or DNOs (in feed-in and guaranteed tariff systems). Electricity generators—existing or new—are usually encouraged to make use of renewable energy, e.g. through feed-in tariffs, quota systems, tax incentives, priority access to the grid.[3]

Figure 1 presents an overview of who generally does what with regard to renewable energy in a typical energy sector in Europe which has changed from a nationalised and integrated situation to the current (partly or fully) unbundled situation.

It should be noted that the above is primarily intended to give insight in the current situation in a lot of OECD countries, and in how unbundling has enabled renewable energy policies and regulations to be implemented. This situation is not proclaimed as being generally applicable or appropriate, as it is not at all straightforward how power sector reforms and renewable energy policies could or should be aligned; for example in Europe both are subject to fierce and ongoing debate—especially with regard to the creation of a single European energy market. The situation in different EU member states varies from fully liberalized and very competitive markets (e.g. United Kingdom and Nordic countries) to

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[2] Vertical unbundling refers to the process of separating vertically integrated utilities into independent generation, transmission and distribution companies. See module 4 “The reform of the power sector in Africa” for more background.

[3] See module 9 “Regulatory and Policy Options to encourage the Development of Renewable Energy” for more background on Feed-in tariffs, quota systems and electricity disclosure, as well as the Case for more details on how these systems are organised.

national situations where the market is characterized by one or some dominating companies, or where still vertically integrated and/or nationalized companies exist (e.g. Belgium, France, Germany).

Accordingly no clear conclusions can be drawn on whether a similar sector organization is likely or appropriate in the African context.

Based on the limited examples available the impact of vertical unbundling on renewables in Africa is largely positive. One of the best examples to illustrate the positive impacts is found in Kenya. Following the unbundling of the power sector, KenGen was established to manage the generation component of the formerly integrated utility, largely comprised of large-scale hydropower plants. Prior to the aforementioned unbundling, the utility made it very difficult for entities with surplus renewables-based electricity to sell it to the utility at an economical tariff.

On several occasions, negotiations between the utility and sugar mills fell through largely because the utility was adamant not to offer an attractive tariff. The reasons given were that the fuel—bagasse—was a waste product and therefore, had little economical value. The fact that sugarcane was not available for crushing throughout the year (available only for 10 months) also led the utility to consider the potential electricity generated from the sugar mills to be "intermittent".

However, following unbundling and faced with severe capacity shortfall due to recurring drought, KenGen has been showing significant interest in renewables - an attribute that the formerly vertically integrated utility lacked. For instance, the utility has invested in the expansion of geothermal electricity generation capacity. In addition, KenGen has pledged to partner with the private sector and is willing to invest up to 50 per cent of the capital costs for attractive small-hydro and bagasse-based cogeneration projects. This is another attribute missing in the formerly integrated utility.

Therefore, based on the Kenyan case example, we can draw the following lessons pertaining to the impact of power sector reforms on renewables:

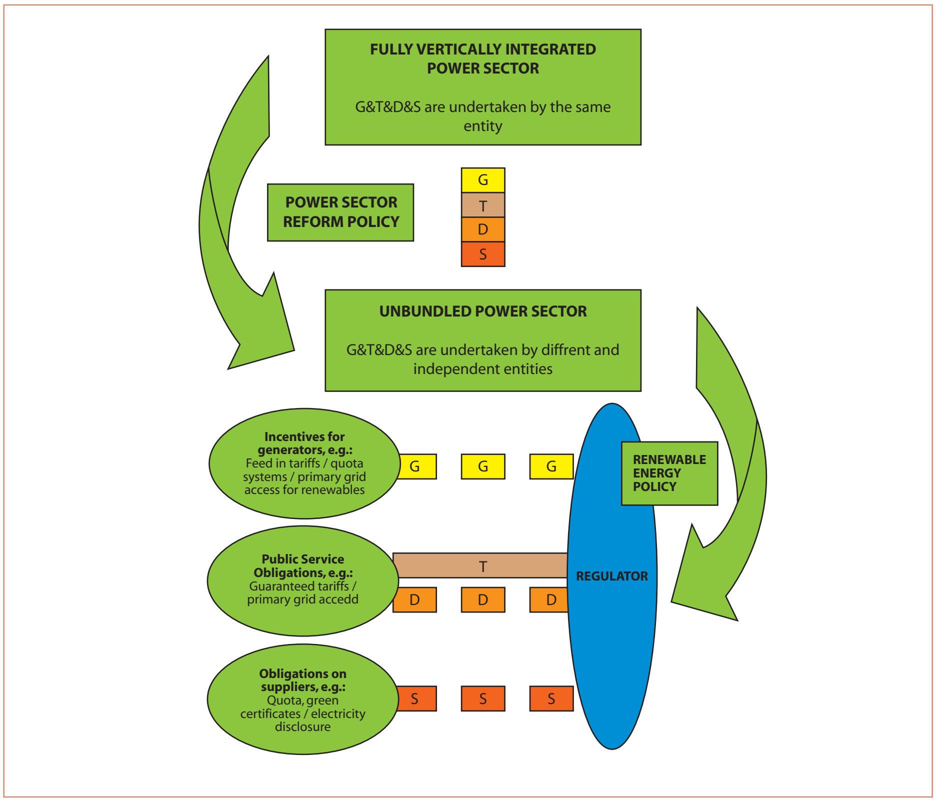
- Vertical unbundling opens up opportunities for sourcing electricity from renewables.
- Vertical unbundling also encourages the generation utility to make maximum use of least cost options as a way of ensuring profitability. In Kenya, geothermal generation is the least cost electricity generation option and hence making its exploitation is very attractive.

- This form of unbundling appears to encourage diversification of electricity generation options and the maximization of available resources in the country (including small-scale decentralized renewable energy generation options) to ensure generation utility meets its contractual obligations to the transmission and/or distribution companies.

A potential draw back of vertical unbundling is that the generation utility is largely designed to serve the interconnected grid system. Therefore, there is a likelihood of power system planners giving priority to large-scale centralized generation systems which invariably precludes renewables.

In countries where unbundling has been implemented parallel to a dedicated rural electrification programme, for example, Kenya, South Africa, Ghana, Namibia, Uganda, Malawi, and Zambia, there is a positive impact on renewables, especially small-scale renewables for electricity generation such as small-hydro and solar PVs. Renewables for rural electrification are attractive because their output relatively matches the low electricity demand levels in rural areas.

Figure I. Typical roles and functions in an unbundled power sector with regard to renewable energy



G: Generation; T: Transmission; D: Distribution; S: Supply
Source: IT Power

One way in which rural electrification programmes have promoted the use of renewables is by incorporating them in the programmes mainly as a pre-electrification option. Ghana's Off-Grid Solar PV Electrification project and UNDP/GEF/Renewable Energy Services Project (RESPRO) are good examples of how renewables can be incorporated in the rural electrification programme. Under the aforementioned projects, over 3,500 solar systems were installed in remote rural communities for domestic lighting, TV and radio operation, vaccine refrigeration and lighting in rural health centres, street lighting, battery charging and water pumping (Ahiataku-Togobo, undated; see also module 10 – case study 1).

Renewables have also been found attractive in the establishment of mini-grids in rural areas. For example, in Uganda, small-hydro systems have been utilized to supply electricity to rural northern parts of the country. In Kenya, the National Energy Policy provides for the anticipated Rural Electrification Authority to incorporate renewables such as small-hydro, wind, cogeneration, etc., for rural electrification. In Central Kenya, there are community-based small-hydro mini-grid pilot projects in operation.

Discussion question/exercise

Discuss the impact of unbundling on renewable energy in your country

4. IMPACT OF INDEPENDENT POWER PRODUCERS ON RENEWABLE ENERGY

As mentioned earlier, one of the drivers of power sector reforms in Africa was to increase electricity generation capacity through private investment. This means allowing independent power producers (IPPs) to generate electricity. IPPs have tended to be introduced in unreformed sectors, and can be regarded as a reform option which—in principle—could play a key role in triggering the vast renewable energy potential in sub-Saharan African.

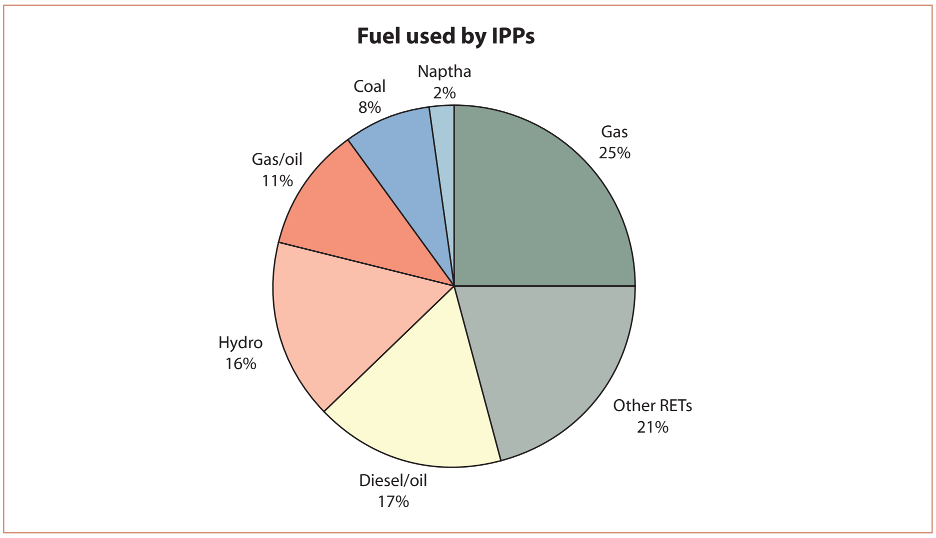
Although the majority of IPPs (implemented and proposed) turned out to be fossil fuel-based, still 37 per cent of the total installed capacity of all the implemented and planned IPP investments are using renewable energy-based electricity generation options such as hydro, wind, bagasse-based cogeneration and geothermal (based on recent estimates by AFREPREN—see figure 2). Hydropower accounts for 16 per cent of the total installed capacity while other renewables including wind, bagasse-based cogeneration and geothermal contribute 21 per cent. This indicates that the IPP option deserves further attention and encouragement, as it can play a catalyzing role in both power sector reform and renewable energy deployment.

In some OECD countries where the generation and supply market is still dominated by one or two companies, it was observed renewable energy policies activated independent initiatives, even using renewable energy based plants. The rationale behind these initiatives was to use renewable energy projects as a way into a still largely integrated power sector, and to build a client base by distinguishing themselves from the historically dominant utility. These initiatives could be in the form of relatively small scale projects through new companies, or as larger scale projects through joint ventures between small and an established national or foreign utility. Such initiatives can actually be regarded as sharpening competition as a result of renewable energy policies; in this case it could thus be stated renewable energy policies—to some extent—have supported the unbundling and liberalization policy—rather than the other way round.

Something similar in principle is possible in Africa; in cases where the integrated national utility—through its historical dominance and lack of competition—does not proactively consider renewable energy opportunities, encouraging new and independent players to step in could trigger the increased use of renewable energy sources. The introduction of IPPs could be considered a first step, leading the way towards more drastic reforms, e.g. in terms of unbundling integrated utilities.

Partially due to the opportunities presented by power sector reforms, some interesting new developments in sub-Saharan Africa are described in more detail in the paragraphs and boxes below.

Figure II. Proportion of installed capacity of IPPs by fuel used in Africa (2002)



Source: Karekezi et al, 2004

The agro-industrial sector especially in eastern and southern Africa appears to have generated a significant amount of interest in IPP development. For example, in Mauritius, the sugar industry over the past decade has evolved to become a significant IPP subsector through the sale of excess electricity generated from bagasse. Over 30 per cent of the firm installed capacity in the country comes from the sugar industry[4] (Deepchand, 2006). Following this success story, UNEP in collaboration with ADB and AFREPREN/FWD are working on a project to promote IPP development in the sugar industry in eastern and southern Africa (see http://cogen.unep.org).

A similar development is observed in the tea processing industry in eastern and southern Africa. Spearheaded by the East African Tea Trade Association and UNEP, the tea industry has indicated significant interest in developing small hydropower-based IPP projects. It is a well-known fact that the bulk of existing, albeit under-utilized, small-hydropower projects have traditionally been found in tea-growing areas. However, the now more liberal regulatory dispensation appears to be motivating the tea industry to revamp existing small-hydropower installations as well as invest in new power plants (see http://greeningtea.unep.org).

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[4] A detailed case study on cogeneration development in Mauritius has been provided separately (module 2: case study 1).

Box 2. **Mini grids for rural electrification in Zambia**

The Zambian power sector is still largely dominated by the national and vertically integrated utility Zesco, with currently two fossil-fuel-based IPPs in place, both selling their electricity directly to Zesco.

However, the Electricity Act was amended with a clear angle towards the use of renewable energy, and an independent regulator is in place, aiming to establish a favourable framework in terms of tariff setting, licensing and technical support.

A pioneering and potentially promising example is the small hydro (700 kW) project at Zengamina in the north west of Zambia, which opened in July 2007 and which provides electricity through a mini grid to the hospital, school and individual households of the local community. This example proves especially interesting for the electrification of remote and rural areas—Zengamina is 380 kilometers away from the existing grid and is this not likely to be connected in the foreseeable future. Given the scale of the mini grids, generation, distribution and supply in the first instance would remain bundled, with the regulator overlooking and monitoring both tariff calculations and technical regulations. The long-term option in this scenario could still be for these mini grids to become part of the expanding central grid.

The situation needs to be assessed in light of the specificity of the Zambian situation; due to increasing electricity demand at both industrial (e.g. copper mines) and household level, substantial investments in the energy sector are needed to tackle looming power deficits. At the same time rural areas in Zambia are currently at only 3 per cent electrification rate. The national energy strategy 2030 (in progress) foresees an important role for renewable energy to address these challenges.

Electricity tariffs have been kept artificially low in Zambia over the last decades. A deliberate policy is now in place to (gradually) increase tariffs to cost reflective levels, and the Energy Regulation Board—the independent energy regulator in Zambia—principally supports tailored and cost-reflective tariffs for renewable energy-based mini grids.

Still, consolidation of announced measures (e.g. long-term policy objectives with regard to electrification and the establishment of a dedicated renewable energy agency) and further regulations (e.g. training and capacity-building for local staff and tax holidays for equipment) are needed to replicate this kind of projects and attract significant investment.

UNIDO as part of its efforts to help establish a favourable policy and regulatory framework for renewable energy in Zambia is in the process of developing three mini grids in different areas in Zambia, using small hydro power (1 MW), biomass (1 MWe) and PV (40 kWp), in cooperation with the Zambian government and GEF. All of these projects are expected to be operational by 2009.

Source: UNIDO Workshop on Tariff setting and Private Sector Participation in the Renewable Energy Sector in Zambia, Lusaka, November 2007

An important amendment of the electricity act in the few countries, which have adopted reforms, is the setting up of standard PPA. A standard PPA, in principle limits market uncertainty, which stands in the way of substantial investment in renewable energy-based electricity generation in the region. In Nepal, market uncertainty was overcome by instituting a "standard PPA"—a "standard offer" from the national utility to purchase all energy produced by specific renewable energy-based IPPs at a pre-announced price as described in box 3. The absence of such a "standard offer" inhibits the scaling up of small renewable energy investments in the power sector to their full market potential.

Box 3. **Standard PPAs for Small Hydropower Development: Small Hydropower Development in Nepal**

As a direct result of the liberalization in the power sector brought about by the Electricity Act (1992), international Independent Power Producers (IPPs) invested in two medium hydropower projects in 1995: the Khimiti Hydro Electric Project (60 MW) and Bhote Koshi HEP (36 MW). The PPAs for these projects were negotiated on a case-by-case basis between the utility and the IPP. In October 1998, the government of the time announced that the national utility, Nepal Electricity Authority (NEA), would purchase all energy produced by small producers (5 MW or below) at a standard "Power Puchase Agreement" (PPA). By early 1999, the first small hydro IPPs began to carry out feasibility studies and approach financial institutions with the standard PPA in hand. The first financial closure by local banks took place in 2000 and the Syange project (183 kW) was on line in January 2002 followed by the Piluwa Khola (3 MW) project by October 2003.

A "standard PPA" can to a certain extent be compared to a feed-in tariff, i.e. tariffs offering either a minimum guaranteed price for output or a premium on the market price for output. In either case, electricity utilities are obliged to allow generators to connect to the grid, and to buy all of a project's output at a predefined (and cost-reflective) price. This and other instruments are described in more detail in module 9 "Regulatory and Policy Options to encourage the development of Renewable Energy".

A possible way forward for power sectors in Africa—including the aspects as described above—is presented schematically in figure 3.

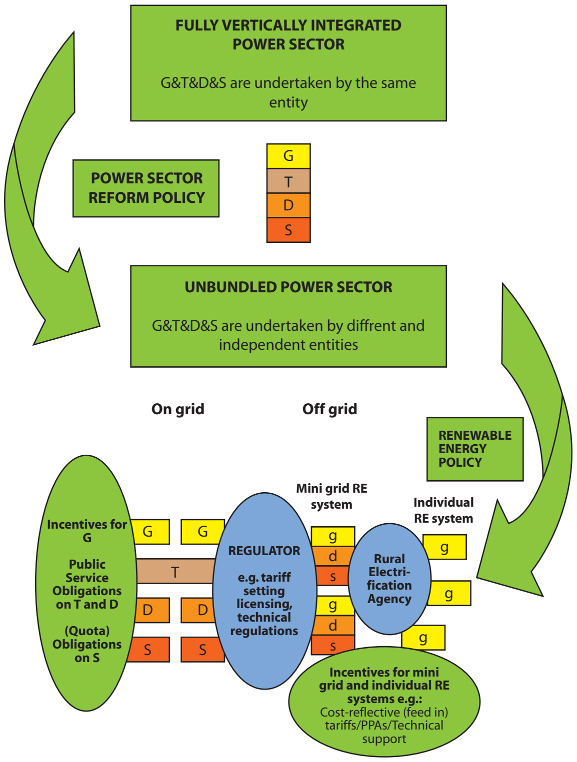
Food for thought

If examples such as those described in box 2 and box 3 for Zambia and Nepal became common practice, new questions could be raised; how in the longer term should mini grids be integrated in the expanding grid; how would and should this relate to unbundling in general, which party would ideally be in charge of which task in such a scenario? A typical mini grid in fact can be regarded as a "vertically integrated" entity, with distribution, supply and generation taken care of by the same organization. This makes sense given the small scale, but in the longer term different institutional and organizational setups are thinkable to streamline the operation of the central grid and an increasing number of mini grids, e.g. what would be the role of the national utility with regard to distribution (and transmission) in such a scenario and how does this relate to the role of the regulator's activities and the rural electrification agency.

Discussion question/exercise

Discuss the impact of independent power producers on renewable energy in your country.

Figure III. Power sector reform and renewable energy: possible way forward for Africa



G: Generation; T: Transmission; D: Distribution; S: Supply

Source: IT Power

5. IMPACT OF CORPORATIZATION ON RENEWABLE ENERGY

As mentioned in module 4, the rationale for corporatization is to ensure that the utility is run as a business, i.e. to be profitable. The reasons why the corporatization of utilities has contributed largely negatively on the promotion of renewable energy for electricity generation situation has occurred can be analysed as follows:

- The focus on profit making implies that corporatized utilities tend to avoid investments involving relatively high upfront costs. As, on a per kW basis, renewables tend to have relatively higher upfront costs compared to conventional systems, they appear to be less attractive. It is thereby forgotten to assess the costs over the full lifetime of the project—where for instance lower fuel costs can make the investment in renewables more attractive;
- Corporatization also encourages utilities to make investments in generation only when the IRR/payback period is attractive. However, power planners in the utilities erroneously have the notion that all renewable energy systems do not have attractive IRRs/payback periods. Most renewable energy sources are site specific and, therefore, certain sites can have very attractive characteristics. There is thus scope to train power planners with adequate and updated information on different renewable energy technologies, in order to enable them to make informed technology choices;
- The profit-making motive also contributes to the utility's desire to minimize their operational costs. One way of doing this is offering to buy electricity generated from renewables at below market value citing relatively low or no cost on the fuel used (e.g. small hydro, bagasse-based cogeneration, wind, etc). Another reason given is that some renewable technologies have "intermittent" electricity generation patterns. The unattractive price of electricity offered by the utilities discourages potential renewable energy-based IPPs, especially entities with excess electricity generation capacity such as sugar mills (using bagasse-based cogeneration) and tea factories (with small-hydro installations).

However, there are ways in which corporatization can positively impact on renewable energy (Kozloff, undated):

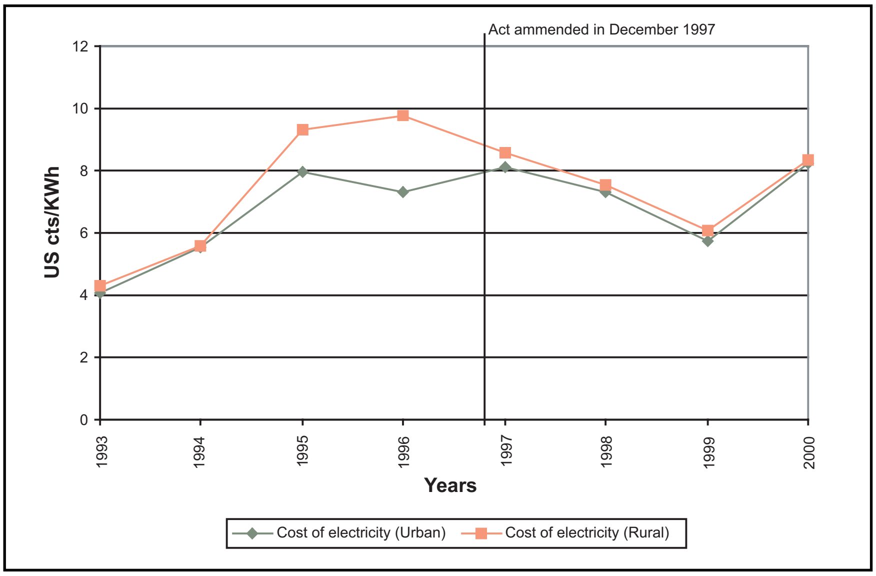
- Corporatization implies that the utility applies the principle of full cost recovery. Therefore, a corporatized utility can use renewables for electricity generation and charge a tariff that is commensurate to the cost of electricity supply. The following box uses the case of Kenya to demonstrate how the distribution utility is applying the principle of full cost recovery.

- Secondly, a corporatized utility is likely to identify and implement least-cost electricity generation options especially for rural electrification. As mentioned earlier, some renewables for electricity generation are located in remote rural areas and can be competitive in such locations over other options such as thermal generation. Therefore, a corporatized utility might encourage the development of renewables in such situations.

Box 4. The impact of full recovery of cost of electricity supply in rural Kenya

The figure below depicts the trend in tariff-related reforms in Kenya that took place prior to the amendment of the Electricity Act.[a]

Cost of electricity to the end-user in Kenya[b]



[a] As of November 1993, tariffs stood at 35 per cent of LRMC

[b] The end-user cost of electricity takes into account inflation at constant 1995 prices and foreign exchange losses.

Source: Computed using data from KPLC (1992, 1997, 2002); Kinuthia, 2003

As shown above, 1994 marks the year that the first major tariff reform was instituted to ensure full cost recovery i.e. to ensure cost recovery by bringing the tariffs closer to the long-run marginal cost (LRMC) levels. At this time, the cost of electricity for both rural and urban households was the same. However, the introduction of cost-reflective tariffs gradually increased the cost of electricity and during 1994 to 2000, rural households (generally poorer than urban households) were paying more for electricity than their urban counterparts (Karekezi, et al, 2005).

Discussion question/exercise

Discuss the impact of corporatization/commercialization on renewables in your country.

6. IMPACT OF MANAGEMENT CONTRACTING ON RENEWABLE ENERGY

Management contracting has been adopted in different economic sectors and therefore can have different meanings. In the energy sector it refers to outsourcing a number of the national utility's managerial functions to a private entity, with the government remaining the owner of the assets. It transfers responsibility for the operation and maintenance of government-owned businesses to a private entity.

Management contracts can take different forms but the simplest involve paying a private firm a fixed fee for performing managerial tasks. More sophisticated management contracts can introduce greater incentives for efficiency by defining performance targets and basing remuneration at least in part on their fulfilment.

Management contracts largely impact on the promotion of renewable energy in the same way as corporatization due to the following reasons:

- Consultants usually hired to manage the utility have the key task of making the utility profitable—the same objective as corporatization—and enhancing operational efficiency.
- Usually management contracts last for a relatively short period of about two years[5] to manage existing utility assets and any assets procured during their tenure. Therefore, management contractors have limited decision-making powers especially pertaining to investments in new generation.

However, the prescribed role of the management contractors appears to make their real impact on renewables neutral. This is because the targets of the management contractors usually revolve around enhancing operational efficiency of the utility especially in the distribution segment.

Secondly, management contractors have limited decision-making powers pertaining to the investment in new generation facilities. The decision mainly lies in the hands of the utility's Board of Directors and Government. Therefore, management contractors do not significantly influence the decision on whether or not to install new renewable energy-based power plants.

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[5] An exception is the case of Côte d'Ivoire whereby management contracts of 15 years have been issued.

Discussion question/exercise

Discuss the impact of management contracting on renewables in your country.

7. CONCLUSION

In overall terms, power sector reforms are policies happening at a broader and higher level than renewable energy policies. As these reforms aim to change the institutional structure and organization of the whole energy sector, they inevitably influence (and in some cases even counteract) renewable energy policies. This is true not only in Africa, but also in most industrialized countries, where the interactions with renewable energy policies prove often complex and difficult to streamline.

When looking into the different impacts reform policies can have on renewable energy, it turned out that the potentially positive impact of most of the reform options was not or not fully exploited. For example, Amended Electricity Acts in most African countries generally do not explicitly promote the use of renewables for electricity generation, and the introduction of independent power producers (IPPs) could have been designed to have a more specific focus on renewable energy projects rather than on fossil-fuel based or large scale hydro projects.

Still the conclusion is that IPPs as well as (especially vertical) unbundling offer good opportunities for building support instruments for the promotion of renewables. It was presented how renewable energy policies are organized in a typically unbundled energy sector, and how some of these institutional aspects could facilitate and accelerate renewable energy deployment in the African context.

For instance, the case of Zambia is interesting and promising, with an Electricity Act amended towards an increased use of renewable energy, and an independent regulator in place who can establish a favourable framework in terms of tariff setting, licensing and technical support for renewables. Other countries with interesting examples of how to promote renewables in a reformed power sector include Ghana, Kenya, Namibia and Uganda.

LEARNING RESOURCES

Key points covered

- In general, power reform options were and are not primarily designed to promote renewable energy.
- However, various reform options appear to present opportunities to the promotion of the promotion of renewables. On the other hand some appear not to affect renewables in any way.
- The impact of vertical unbundling on renewables is largely positive, but can still be improved.
- Severe generation capacity shortfalls have urged several African countries to stimulate IPPs. This only partially triggered an increased use of renewables as these IPPs primarily installed relatively large power generation systems and have largely opted for fossil-fuel thermal generation options. Still the concept of IPPs can play an important role in the strengthening of renewable energy policies.
- A review of amended Electricity Acts in several sub-Saharan African countries reveals that most of them do not explicitly mention or promote the use of renewable energy in electricity generation. However, the few countries with vigorous renewable energy programmes appear to have the amended their Electricity Acts to explicitly promote renewable energy.

Answers to review questions

Question: Discuss the impact of unbundling on renewable energy in your country.

Question: Discuss the impact of independent power producers on renewable energy in your country.

Question: Discuss the impact of electricity law amendment on renewable energy in your country.

Question: Discuss the impact of corporatization on renewable energy in your country.

Question: Discuss the impact of management contract on renewables in your country.

NB: The questions provided above are all discussion questions and the answers are therefore, country specific. Trainees are encouraged to answer the relevant questions on the basis of their respective countries and/or countries whose reform process they are more conversant with.

Exercise

1. According to you, have power sector reform had an impact on renewable energy? Using relevant documents provide a 2–3 page essay of your response.
2. Different power sector reform options had different impacts on renewable energy development in Africa. Using examples from the region, discuss their impacts and separate those which had negative impacts from the ones with positive impacts.
3. In general, have energy sector reforms had impacts on the power?

Presentation/suggested discussion topic

See separate file:

RENEWABLE ENERGY – module 8: Impact of Power Sector Reform on Renewable Energy (Presentation)

Suggested discussion topic: In your opinion, have power sector reforms enhanced or impaired the electricity sector? What role do you see that renewables can play in enhancing the electricity sector? Which power sector reform option has contributed most to the improvement or deterioration of the electricity sector in Africa?

Relevant case studies

1. Case Study 1: Geothermal Development in Kenya

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INTERNET RESOURCES

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2. http://greeningtea.unep.org - Greening the Tea Industry in East Africa Project
3. www.afrepren.org - African Energy Policy Research Network
4. www.reeep.org - Renewable Energy and Energy Efficiency Partnership
5. www.afurnet.org - African Forum for Utility Regulation
6. www.rerasadc.com - Regional Electricity Regulators Association of Southern Africa
7. www.ieiglobal.org - International Energy Initiative
8. www.wri.org - World Resources Institute

GLOSSARY/DEFINITION OF KEY CONCEPTS

Bagasse	The fibrous residue of sugar cane left after the extraction of juice and often used as a fuel in cogeneration installation.
Cogeneration	Simultaneous production of electricity and heat energy.
Complete government ownership	When the Government owns all the generation, transmission and distribution assets within a national utility.
Complete horizontal unbundling (provincial utilities which are vertically integrated)	When each province owns a utility that undertakes electricity generation, transmission and distribution in vertically integrated operations.
Complete private ownership	When all generation, transmission and distribution entities in the country are wholly owned by the private sector.
Complete vertically unbundling	When the generation, transmission and distribution entities are independent companies.
Corporatization	This is the act of transforming a state owned utility into a limited liability corporate body often with the Government as the main shareholder.

Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Distribution	Delivery of electricity to the customer's home or business through low voltage distribution lines.
Direct access	The ability of a customer to purchase electricity or other energy sources directly from a supplier other than their traditional supplier.
Electricity/power sector reforms:	Deliberate changes in the structure and ownership of the electricity sector aimed at improving performance, efficiency and investment.
Electricity regulator	The agency in charge of monitoring the electricity sector.
Electrification:	This is the process of connecting additional households, institutions and enterprises to the national grid.
Energy Ministry/ Department	The Government body that provides policy directives with regard to the energy sector.
Energy services	The end-use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Energy supply	Amount of energy available for use by the various sectors in a country.
Fossil fuel	An energy source formed in the Earth’s crust from decayed organic material e.g. petroleum, coal, and natural gas.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth. The fluids are extracted by drilling and/or pumping.

Independent power producers (IPPs)	Privately owned power companies that produce electricity and sell it for a profit to the national grid or to a distribution utility.
Interconnected system	An integrated electricity generation, transmission and distribution network.
Isolated/self-contained system	A stand-alone electricity generation, transmission and distribution network serving a confined part of a country or region.
Legal and regulatory framework (LRF)	Combination of the laws, institutions, rules and regulations governing the operations of the electricity industry.
Levelized energy costs	The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelied in real dollars (i.e. adjusted to remove the impact of inflation)
Liberalisation	The removal of restrictions on entry and exit of the electricity industry making it open to any prospective and interested players. Often implies reduced state intervention.
Licensing	The act of issuing licenses allowing investors to operate legitimately within the electricity sector, usually as IPPs or IPDs.
Management capability	Having adequate skills to efficiently and profitably run an electricity generation/distribution enterprise.
Management contract	The outsourcing of managerial functions of the utility to a private entity, with the Government after remaining the owner of the assets.
Modern energy	Refers to high quality energy sources e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biofuels.

Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100kW but below 1MW).
National grid	The network of electricity transmission and distribution cables used in the conveyance of electricity within a country.
National utility	An entity which undertakes electricity generation, transmission and distribution nationwide. It is usually wholly or partially state-owned.
Open access	A regulatory mandate to allow others to use a utility's transmission and distribution facilities to move bulk power from one point to another on a non-discriminatory basis for a cost-based fee.
Small hydro	Small-scale power generating systems that harness the power of falling water (1-15MW).
Small power producer (SPP)	This is a power producer who generates electricity using renewable energy (wood, waste, conventional hydroelectric, wind, solar, and geothermal) as a primary energy source.
Technical capability	Having adequate skills to operate and maintain equipment used in a power utility.
Unbundling	The process of breaking-up a vertically integrated public utility into either different entities of generation, transmission and distribution, or into regional companies within the country.
Utility	An entity partially or wholly involved in electricity generation, transmission, and/or distribution.
Vertically integrated utility	An entity that undertakes electricity generation, transmission and distribution.

Case study 1.

GEOTHERMAL DEVELOPMENT IN KENYA

CONTENTS

1. INTRODUCTION

Kenya is the first country in Africa to tap geothermal resources for energy. The geothermal resource lies beneath the vast East African Rift Valley. The present production area of Olkaria covers 11 km² and has an estimated steam potential for 400 MW years. A total of 53 MWe of electricity is currently being generated from geothermal steam in the Olkaria area. This accounts for about 5.1 per cent of the nation's electricity consumption. A total of 301 MW is planned for generation by the year 2009.

The geothermal resource occurs in an area that has environmentally sensitive areas. The Olkaria field is in the middle of a game park and a highly productive farm area. Economic activities in this area have attracted a large human population. The exploration and exploitation of this resource should therefore be carried out with minimum negative impacts on the environment and the local communities. This case study is designed to assess the socio-economic and environmental impacts brought about by the development of the Olkaria East geothermal plant,[1] which has been in operation for the last 20 years.

The 15 years of the first power plant operation at Olkaria has shown that with proper management, geothermal energy production can go hand in hand with conservation. Analysis of geothermal hydrogen sulphide and carbon dioxide emissions shows that they are below the World Health Organization harmful levels. Geothermal brine cation and anions concentrations from the present geothermal wells in Olkaria are not very high to warrant environmental risk. Heavy metal concentrations in potable water are below acceptable levels and therefore geothermal fluid may not be hazardous to the environment. Noise levels vary from 32-44dB(A) away from the station and 50-60dB(A) around the power station.

Attempts have been made not to fence off migration paths of animals by burying pipes underground or elevating them to allow free movement of animals. Sensitive habitats for animals and birds such as breeding, feeding and resting sites have also been preserved.

No adverse impacts by the project on the local communities have been reported. Proper operational management by the geothermal plant operators is in place to stem any possible conflict with the surrounding community. This includes fencing off the plant premises to prevent injury to the community and their animals, and

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[1] A geothermal plant is a plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that drives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by either drilling and/or pumping (AFREPREN, 2004).

the holding of regular meetings between the project management and the community. KenGen, the power utility has made some attempts to provide the community with infrastructures such as piped water, transport, shops and schools. In addition, there has been increased sale of souvenirs to tourists at the cultural centre, and creation of a market for their animal products.

However, there are a few concerns that have been raised by the Maasai community. Out of the 500 people employed at the plant, only seven are from the local Maasai community. This is equivalent to 1.4 per cent of the total workforce at the plant. These seven comprise of one copy typist, one clerk, one driver, one office messenger and three watchmen. The community felt that the project should have economically empowered them by providing more employment opportunities.

2. BACKGROUND TO GEOTHERMAL ENERGY IN KENYA

Africa is endowed with 9,000 megawatts of geothermal potential (hot water and steam based). Using today's technology, Africa has the potential to generate 2,500 MW of energy from geothermal power (Karekezi and Kithyoma, 2005).

Table 1. Geothermal potential for selected African countries

Couyntry	Potential Generation in MW
Kenya	2,000
Ethiopia	>1,000
Algeria	700
Djibouti	230–860
Uganda	450
United Republic of Tanzania	150

Source: Karekezi and Kithyoma, 2005

Of this geothermal power potential, only 127 MW has been tapped in Kenya, and less than 2.0 MW in Ethiopia. These estimates of existing geothermal power generating capacity do not include direct thermal use of geothermal energy, which is widely practised in North Africa (Karekezi and Kithyoma, 2005).

Starting in 1981, Kenya was the first country in Africa to exploit geothermal[2] resources for electricity generation. After some inconclusive initial exploration at Olkaria in the 1950s, interest revived during the 1970s. A feasibility study carried out to evaluate Olkaria's potential for generating electricity found that the geothermal field covered 80 km2 with sufficient steam for 25,000 MW-years (with reinjection, this potential could be indefinite). The present area, covering 11 km^2, has steam for 400 MW-years. So far, 103 geothermal wells have been drilled in Kenya for exploration, production, monitoring and re-injection. Of these, 97 wells are in the Olkaria area and the rest in the Eburru field (Karekezi and Kithyoma, 2005).

Out of the total 127 MW of installed capacity, Kenya Electricity Generating Company, KenGen, Kenya's public utility company, has an installed capacity of 115 MW and OrPower 4, an independent power producer, has an installed capacity of 12 MW. Together, these plants meet 11 per cent of the national electricity supply, once again demonstrating the viability of the 10 per cent renewable energy target proposed at the 2002 WSSD conference (Karekezi and Kithyoma, 2005).

3. MAIN DESCRIPTIONS OF GEOTHERMAL ENERGY IN KENYA

3.1. History of geothermal resource development

With over 11,000 MW of installed geothermal power worldwide, geothermal energy utilization is a well-proven and mature technology. At Lardarello in Italy, one of the oldest geothermal plants has operated since 1904 in a cost-competitive manner. Countries such as Indonesia, Japan, Mexico, the Philippines and the United States of America have substantially exploited their geothermal energy resources (Karekezi and Kithyoma, 2005).

In Kenya, geothermal development was not included in the country's power plans until 1986, after the successful completion of Olkaria I geothermal power station. Since then, it features prominently in all major policy documents. In recent years, substantial amounts of money have been set aside for geothermal resource exploration (Karekezi and Kithyoma, 2005).

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[2] Geothermal energy is the natural heat from the earth's interior stored in rocks and water within the earth's crust. This energy can be extracted by drilling wells to tap concentrations of steam at high pressures and at depths shallow enough to be economically justifiable. The steam is then piped to turbines to generate electricity (Karekezi and Kithyoma, 2005).

Exploration for geothermal energy in Kenya started in the 1960s with surface exploration that culminated in two geothermal wells being drilled at Olkaria. In the early 1970's, more geological and geophysical work was carried out between Lake Bogoria and Olkaria. This survey identified several areas suitable for geothermal prospecting and by 1973, drilling of deep exploratory wells commenced with funds from UNDP. Additional wells were thereafter drilled to provide enough steam for the generation of electricity, and in June 1981 the first 15 MWe generating unit was commissioned. This was the first geothermal power plant in Africa. The second 15 MWe unit was commissioned in November 1982 and the third unit in March 1985, raising the total to 45 MWe. Olkaria 1 (figure I) is owned and operated by KenGen. Since 1997, private companies have entered into the generation of electricity using geothermal resources. Currently Orpower 4 Inc. is generating 12 MWe with plans to generate a total of 64 MWe in the next few years in the Olkaria West field (Karekezi and Kithyoma, 2005).

A number of wells have been drilled at Olkaria NE field and connected to Olkaria II power station (figure II). Currently, the proven power from this field is about 80 MWe for 25 years using conventional condensing turbine and single stage steam separation. However, the field is capable of producing more than 100MWe from the 8.8 km2 site. The field was committed to the development of a 64 MW Olkaria II power station under public investment. The plant was commissioned in early 2004. So far, 103 geothermal wells have been drilled for exploration, production, monitoring and re-injection with depths varying between 180 to 2,600 metres. All these wells are in Olkaria and Eburru (Karekezi and Kithyoma, 2005).

Studies reveal that most of the medium and high temperature (1400C) geothermal systems in Kenya are located within the Kenya rift. Table 2 summarizes the exploration status for the various geothermal prospects. Currently only the Olkaria geothermal field is being developed (Karekezi and Kithyoma, 2005).

Figure I. The Olkaria I power station in Kenya

Figure II. Panoramic view of Olkaria II power plant in Kenya

Table 2. Exploration status of the geothermal prospects other than Olkaria and Eburru

Prospect	Reconnaissance	Surface studies	Wells sited	Wells drilled
Olkaria domes	Yes	Yes	3	3
Longonot	Yes	Yes	1	No
Suswa	Yes	Yes	3	No
Menengai	Yes	Partial	No	No
Badlands	Yes	Partial	No	No
Arus	Yes	No	No	No
Lake Bogoria	Yes	No	No	No
Korosi	Yes	No	No	No
Paka	Yes	No	No	No
Silali	Yes	No	No	No
Emuruangogolak	Yes	No	No	No
Namarunu	Yes	No	No	No
Barrier volcano	Yes	No	No	No
Lake Magadi	Yes	No	No	No

4. CURRENT AND FUTURE ROLE OF GEOTHERMAL ENERGY IN KENYA

The Least Cost Power Development Plan (LCPDP) in 2000 emphasizes that geothermal energy is recognized as an important energy source for the future (table 3). By 2019, geothermal energy is envisaged to have increased by 504 MW (Karekezi and Kithyoma, 2005).

If the plans in table 3 are actualized, the total installed electric capacity will stand at about 2,700 MW by 2020 (authors calculation). The geothermal resource would contribute about 631 MW, representing 23.4 per cent of the total national electricity supply. These figures include current installed geothermal capacity (Karekezi and Kithyoma, 2005).

As mentioned earlier, this study set out to examine the viability of geothermal energy contributing 5 per cent of power supply in Kenya. This sub-section summarizes the potential of geothermal energy resources (Karekezi and Kithyoma, 2005).

Table 3. Summary of additional planned power generation (2004–2019)

	MW			
Fiscal year	Hydro	Geothermal	Diesel	Total
2004	60	56		116
2005				
2006			40	40
2007		64		64
2008	80.6		20	100.6
2009		64		64
2010	140			140
2011		64	20	84
2012			80	80
2013		64	20	84
2014			100	100
2015		64	20	84
2016			100	100
2017		64	40	104
2018			150	150
2019		64	60	124
Totals	280.6	504	650	1434.6

Adapted from KPLC, 2001
Source: Karekezi and Kithyoma, 2005

4.1. Theoretical potential of the geothermal resource

For purposes of this case study, theoretical potential is defined as the preliminary assessed potential based on the surface geothermal manifestations considering the area where these manifestations have been observed and using the current available technology, mainly the single or double flash power method. On this basis, the theoretical geothermal potential has been estimated at 2000 MW across the whole Kenyan Rift valley, as shown in table 4 (Karekezi and Kithyoma, 2005).

Only Olkaria and Eburru have been drilled to establish their accurate power potential. In effect, this means that the full geothermal potential of the Rift valley may be significantly higher or lower than the figures in table 4 (Karekezi and Kithyoma, 2005).

Table 4. Geothermal energy potential in selected fields in Kenya

Prospect	Potential
Olkaria	520MW
Eburru	200 MW
Badlands	20 MW
Longonot	200 MW
Menengai	200 MW
L. Bogoria	20 MW
Korosi	100 MW
Chepchuk	20 MW
Bake	100 MW
Silali	300 MW
Emuruagolok	200 MW
Namarunu	20 MW
Barrier Volcano	100 MW
Total	2000 MW

Source: World Bank, 1983 and BCSE, 2003 in Karekezi and Kithyoma, 2005

4.2. Technical potential of the geothermal resource

The technical potential relates to the confirmed level of extractable power from a prospect that has been rigorously assessed through exploratory and production drilling from the standpoint of the best available technology at the time. From the literature review done in this case study, a technical potential to generate over 600 MW currently exists (author's estimates). This estimate was made while taking into account various constraints ranging from inaccessible prospect sites owing to difficult terrain, distance to the nearest transmission infrastructure, and prohibitive costs of development due to low geothermal fluid thresholds.[3] However, with the ongoing global advances in technology improvement, much higher technical potentials than those estimated here are likely to become evident over time (Karekezi and Kithyoma, 2005).

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[3] Low levels of steam pressure at which geothermal resource exploitation is not economically viable.

5. FINANCING OF GEOTHERMAL DEVELOPMENT

5.1. Current and projected investments

The latest national power development plan anticipates an additional 504 MW from geothermal energy by 2019. To achieve this, investment would be required in geothermal resource identification and assessment and power plant construction and commissioning (Karekezi and Kithyoma, 2005).

Assuming a unit installation cost of $US 2,700 per kilowatt (KenGen, undated),[4] the associated investment cost would amount to about $US 1.3 billion. It has been estimated that it costs roughly $US 1.3 million to drill a geothermal well in the Rift valley setting irrespective of whether the well produces 1 or 10 MW of steam power (KenGen, 2002). Currently, the average production of wells at Olkaria generates between 1 and 3 MW. There are however, cases where a well produces as much as 10 MW, due to differences in subsurface conditions (Karekezi and Kithyoma, 2005).

In the past, geothermal projects were implemented in a multiple contract method where construction, procurement, design and project management contracts were separately awarded. The trend is gradually moving away from the multi-contract implementation method to the single turnkey engineering-procurement-construction (EPC) method. EPC is reported to allow more room for vendor innovations, thus reducing cost and overrun risks, as well as giving a single point responsibility and liability for plant performance (Karekezi and Kithyoma, 2005).

5.2. Economic issues of geothermal energy

The cost of geothermal energy is an important indicator of its economic viability. The cost includes direct capital costs, indirect costs and operation and maintenance. The direct costs relate to exploration, steam field development and power plant construction. Indirect costs relate to access to infrastructure, power transmission and distribution and expatriate fees. These costs vary depending on site-specific parameters and the level of development of infrastructure (Karekezi and Kithyoma, 2005).

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[4] KenGen, undated. Installation of new, large-scale geothermal generating plant: Potential CDM Project. Project case study. Cost of Olkaria II's 64 MW geothermal project was $US 174 million, the cost per MW is approximately $US 2.7 million

According to the World Bank (www.worldbank.energy/geothermal/technology.htm), operation and maintenance costs of geothermal steam fields and power plants of various sizes generally range from 0.15 to 1.4 US cents per kilowatt-hour. This cost does not include the cost of new make-up wells, which are normally required over time to make up for the gradual production decline from the original wells. The rate of this decline varies depending on the nature and size of the field but ranges between 5 per cent and 10 per cent per annum. For instance, the Olkaria I field has experienced a 4 per cent annual decline (Karekezi and Kithyoma, 2005).

The levelized energy costs in Kenya varies depending on the source of power, even though the consumer tariffs are adjusted to cover the higher cost interconnected power. For example in the year 2000, the bulk tariff for hydropower and geothermal energy was Ksh. 2.36 ($US 0.03/kWh) compared to Ksh. 8.26 ($US 0.106/kWh) from fossil fuel-based electricity. The consumer tariffs are set on the basis of long run marginal cost (LRMC) principle. The use of LRMC commenced in 1994 when the average tariff was raised from 35 per cent to 55 per cent, then subsequently to 75 per cent in 1996 and finally to about 100 per cent of LRMC in 1999 (Karekezi and Kithyoma, 2005).

In terms of investment costs, a geothermal project in Kenya was found to cost about $US 2,700 per kilowatt, which is less than the $US 3,000 per kilowatt for fossil-based generation plants. In the case of geothermal, there are high initial capital investments followed by low maintenance and operation costs. The reverse is the case for fossil generated power, which among other things suffers unpredictable operational and maintenance costs (Karekezi and Kithyoma, 2005).

Geothermal energy option is thus associated with positive economic benefits above other conventional energy sources especially in cases where it replaces fossil-fuel generated power. These include (Karekezi and Kithyoma, 2005):

(a) Foreign exchange savings owing to the foregone fossil fuel that would otherwise be purchased for power generation;

(b) An availability factor of about 100 per cent, making it a stable and secure base-load power, which cannot be matched by other sources. It is neither susceptible to drought nor is it subject to the direct effects of the globally volatile fossil fuel prices.

6. KEY SUCCESSES OF GEOTHERMAL ENERGY IN KENYA

6.1. Potential for local assembly and manufacture of geothermal equipment

Construction of geothermal power plants requires heavy equipment. Table 5 shows the different types of equipment for various geothermal plants. This study found that at present, virtually all tools and equipment for geothermal resource exploration and development in Kenya are imported. However, with the increased attention to the development of geothermal energy, limited local assembly and manufacturing of power plant components, (up to about 10 per cent in the short and medium-term) is feasible since the basic technical capacity is already available. A recent market acceleration forum for geothermal energy in the East African region concluded that the economics of investing in local manufacture of geothermal energy exploitation hardware would be favourable considering the widening geothermal activity in the region. To achieve this, member countries agreed to formulate and implement deliberate enabling policies (Karekezi and Kithyoma, 2005).

The development of geothermal energy also triggers the proliferation of small and medium- scale service enterprises to provide goods and services for construction, maintenance and operation. Harnessing of geothermal energy resource would be accompanied by a creation of niche markets, especially on the aspect of direct geothermal energy applications, and therefore emergence of energy service companies to take advantage of emerging opportunities. This is also already taking place, albeit at a slow pace (Karekezi and Kithyoma, 2005).

6.2. Employment and job creation

The development of indigenous energy supply systems stimulates local economies by creating the impetus for increased enterprise and job creation. This is especially so where community interests and participation are incorporated in the project conception, implementation and operation (Karekezi and Kithyoma, 2005).

An accurate number of individuals directly employed in geothermal energy is not easy to determine, given that many service and specialist development companies that work in this field also work in related industries such as oil exploration and ground water management. Secondly, the demand for specific services tends to be cyclical because geothermal developments are not continuous. The

Table 5. Major equipment items for geothermal power plants

	Types of energy conversion system			
Equipment	**Dry Steam**	**Single Flash**	**Double Flash**	**Basic Binary**
Steam and/or brine supply				
Down hole pumps	No	No (Poss)	No (Poss)	Yes
Wellhead valves & controls	Yes	Yes	Yes	Yes
Silencers	Yes	Yes	Yes	No
Sand/particle remover	Yes	No	No	Yes
Steam piping	Yes	Yes	Yes	No
Steam cyclone separators	No	Yes	Yes	No
Flash vessels	No	No	Yes	No
Brine piping	No	Yes	Yes	Yes
Brine booster pumps	No	Poss	Poss	Poss
Final moisture separator	Yes	Yes	Yes	No
Heat exchangers				
Evaporators	No	No	No	Yes
Condensers	Yes	Yes	Yes	Yes
Turbine-generator & controls				
Steam turbine	Yes	Yes	Yes	No
Organic vapour turbine	No	No	No	Yes
Diesel-admission turbine	No	No	Yes	No
Control system	Yes	Yes	Yes	Yes
Plant pumps				
Condensate	Yes	Yes	Yes	Yes
Cooling water circulation	Yes	Yes	Yes	Yes
Brine injection	No	No (Poss)	Yes	Yes
Non-condensable gas removal				
Steam jet ejectors	Yes	Yes	Yes	No
Compressors	Poss	Poss	Poss	No
Vacuum pumps	Poss	Poss	Poss	No
Cooling towers				
Wet type	Yes (No)	Yes	Yes	Poss
Dry type	No	No	No	Poss

Notes: Yes = generally used, No = generally not used, Poss = Possibly used under certain circumstances.
Source: DiPippo R, 1999 in Karekezi and Kithyoma, 2005

equipment suppliers, such as turbine and pump manufacturers, pipe fabricators and control hardware companies supply these items only as part of their product range (Karekezi and Kithyoma, 2005).

A crude estimate of additional jobs related to geothermal energy was made on the basis of generating 504 MW by 2019. It is assumed that for the plant and infrastructure construction alone, 2,016 construction jobs could be created in fifteen years while a further 856 jobs would be created for the operation and maintenance of the plant (Karekezi and Kithyoma, 2005).

Currently, a workforce of 493 persons is deployed at the Olkaria power stations. This works out at about 4 jobs per MW. This number compares favourably with the labour estimates above, bearing in mind that some of the personnel are assigned to other exploration activities (Karekezi and Kithyoma, 2005).

6.3. Useful uses of geothermal heat

Whereas emphasis on geothermal energy use in Kenya has been on electric power generation, there are other potential uses that can have direct impacts on poverty reduction. For instance, a geothermal heat resource is being used at a low-level in a horticultural farm near Lake Naivasha to control nighttime humidity levels in order to alleviate the incidence of fungal diseases. Similarly, low-temperature geothermal steam is used in Eburru for the drying of pyrethrum flowers and for various domestic purposes including water for livestock, drinking and irrigation. Such local uses of low-temperature geothermal heat may yield tangible poverty alleviation benefits (Karekezi and Kithyoma, 2005).

6.4. Favourable effects on external debt

Imports of oil constitute one of the largest indirect determinants of external debt. The importation of petroleum products accounts for about 25 per cent of the national import bill and therefore has a direct relationship with the status of the national external debt. The outstanding external debt of Kenya was estimated at $US 6.56 billion at the end of 1999. The growing debt has forced the country to limit its external borrowing to only concessionary loans. The continued repayment of loans has led to reduced resources available for domestic development. The external debt burden thus constitutes a serious obstacle to growth and employment creation (Karekezi and Kithyoma, 2005).

The high dependence on hydropower, coupled with occasional droughts, affects the quantity and quality of power services and synergistically triggers other adverse macro-economic effects. During power crises, the natural fallback has been fast-tracked thermal power installations, but these have negative economic implications. Table 6 shows the fraction of the national budget that goes toward fossil fuel import. This study found that the quantity of fossil fuel used in power generation constitutes about 5 per cent of the fossil fuels imported (authors' estimates). This significantly contributes to the accumulation of the external debt (Karekezi and Kithyoma, 2005).

The supply of geothermal power is important as a replacement of imported fossil fuels and could result in significant foreign exchange savings. Ordinarily, part of the revenue proceeds from the sale of geothermal power is used in permanent debt servicing besides the normal plant operation and maintenance (Karekezi and Kithyoma, 2005).

Table 6. Relationship between national annual budget and fossil-fuel import bill

Financial year	Annual national import bill (Million Ksh)	Annual fossil fuel import bill fuel (Million Ksh)	Proportion of fossil import bill to national budget
1990/91	39,448	9,356	23.7
1991/92	43,598	9,564	21.9
1992/93	52,821	12,174	23.0
1993/94	65,462	24,493	37.4
1994/95	87,027	17,817	20.5
1995/96	96,842	19,054	19.7
1996/97	107,806	23,866	22.1
1997/98	123,258	28,998	23.5
1998/99	120,085	30,699	25.6
1999/2000	124,528	39,345	31.6
2000/2001	155,505	63,112	40.6
2001/2002	156,531	56,767	36.3
2002/2003	180,825	43,957	24.3

Source: Karekezi and Kithyoma, 2005

6.5. Reduced effect on environmental degradation and pollution

The promotion of environmentally clean energy is an important key to sustainable energy development. The environmental friendliness of geothermal power stands out against the conventional fossil fuel based power sources. Geothermal power plants have been reported to release negligible quantity of carbon dioxide compared to emission from oil-fired plants as illustrated in figure III (Karekezi and Kithyoma, 2005).

Assuming that 0.25 kg of carbon is avoided from fossil fuel generation for every kilowatt-hour of geothermal electricity supplied, and an availability factor of 98 per cent, Kenya's 127 MW installed geothermal capacity is already contributing to avoidance of about 272,567 tonnes[5] of carbon per year. Taking the value of

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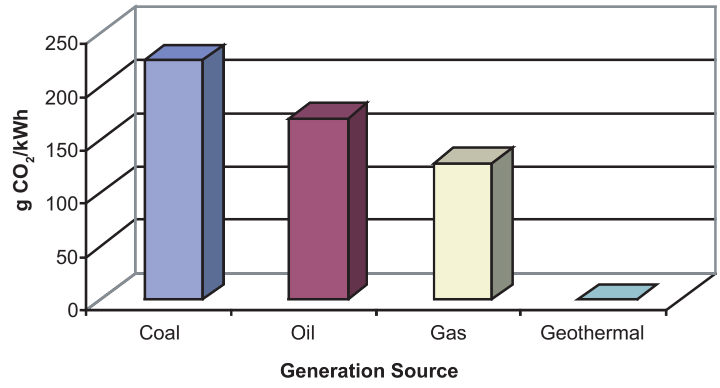
[5] Formula used is: 127 MW * 0.98 Availability Factor * 8,760 hours * 0.25 ton of carbon per MWh = 272,567 tonnes

Figure III. Comparison of CO2 emissions between geothermal and fossil-fuelled power generation in g per kWh



Source: Karekezi and Kithyoma, 2005

carbon to be $US 10 per ton, there would be an accruing certified emission reduction units (CERU) revenue stream worth $US 2.3 million per year, which Kenya could be earning within the framework of emissions trading arrangement under the Kyoto Protocol (Karekezi and Kithyoma, 2005).

Geothermal plants also have low sulphur emission rates. The newest generation of geothermal power plants are said to emit only 0.66 kg of sulphur dioxide per MWh of electricity generated. No combustion by-products such as nitrogen oxides are emitted. Geothermal facilities require limited land space for development. For instance, an average geothermal power plant uses 1–8 acres per megawatt compared to an average nuclear plant, which uses 5–10 acres per MW, or coal-fired plant, which requires 19 acres per MW (Karekezi and Kithyoma, 2005).

Geothermal energy development leads to reduced pressure on water resources to generate power and therefore makes more water available for other competing economic needs. In addition, provision of geothermal power has direct benefits for education and health. As more electricity is made available from geothermal plants, and with supporting policies, more rural schools and hospitals can be connected to the grid. In addition, geothermal-based enterprises provide employment opportunities for the local community (Karekezi and Kithyoma, 2005).

Even though geothermal energy is a relatively clean energy source, its development can have negative impacts, which if not mitigated, can make geothermal energy exploitation not environmentally viable. For example, geothermal energy utilization can cause surface disturbances, physical effects due to fluid withdrawal, noise and the emission of chemicals. At Olkaria, these environmental impacts have been mitigated by using several measures such as reducing the drill pad sizes, rehabilitating the opened areas by planting grass and trees, and putting in place monitoring programmes. These programmes assist in checking the unforeseen impacts that appear during the operational phase of a geothermal development. With the new Environmental Management and Coordination Act, KenGen has put in place an effective Environmental Management System (EMS) and is in the process of seeking ISO 14000 certification (Karekezi and Kithyoma, 2005).

7. CONCLUSIONS

7.1. The impact of geothermal energy

Significant environmental concerns associated with geothermal energy include those to do with site preparation, such as noise pollution during the drilling of wells and the disposal of drilling fluids, which require large sediment-settling lagoons (Open University, 1994).

However, geothermal power exploitation is preferred and has numerous advantages over other energy sources. Among the benefits of geothermal power are near-zero emissions (true for modern closed cycle systems that re-inject water back to the earth's crust), and very little space requirement per unit of power generated in contrast to other energy sources such as coal or hydro-dam based electric power (see also following table 7)[6] (Karekezi and Kithyoma, 2005).

Table 7. Land use requirements for different energy technologies

Technology	Land occupied (m2 per MWh)
Coal (including pit coal mining)	3,700
Solar thermal	3,600
Photovoltaic	3,200
Wind (land with turbine and roads)	1,300
Geothermal	400

Source: Karekezi and Kithyoma, 2005

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[6] It has to be noted that table 7 refers to energy and not power produced. In order to get the space requirements per unit of power, the availability factor of the various technologies should be taken into account.

Geothermal plays a vital role in minimizing fuel imports by providing an alternative to thermal-based electricity and offers diversification in energy generation, thus strengthening energy security (Karekezi and Kithyoma, 2005).

Geothermal resource development and exploitation can create significant job and enterprise opportunities both directly and indirectly. In 2002, the 45 MW plant at Olkaria I (Kenya) had created 493 jobs: 15 scientists, 21 engineers, 82 technicians, 175 artisans/craftsmen and 200 support staff, which translates to 10.96 jobs/MW in operations and maintenance (Karekezi and Kithyoma, 2005).

Geothermal power has the combined environmental advantages of very low emissions (modern closed cycle systems re-inject the used water back into the earth's crust) and a very low land requirement when compared to conventional energy sources (Karekezi and Kithyoma, 2005).

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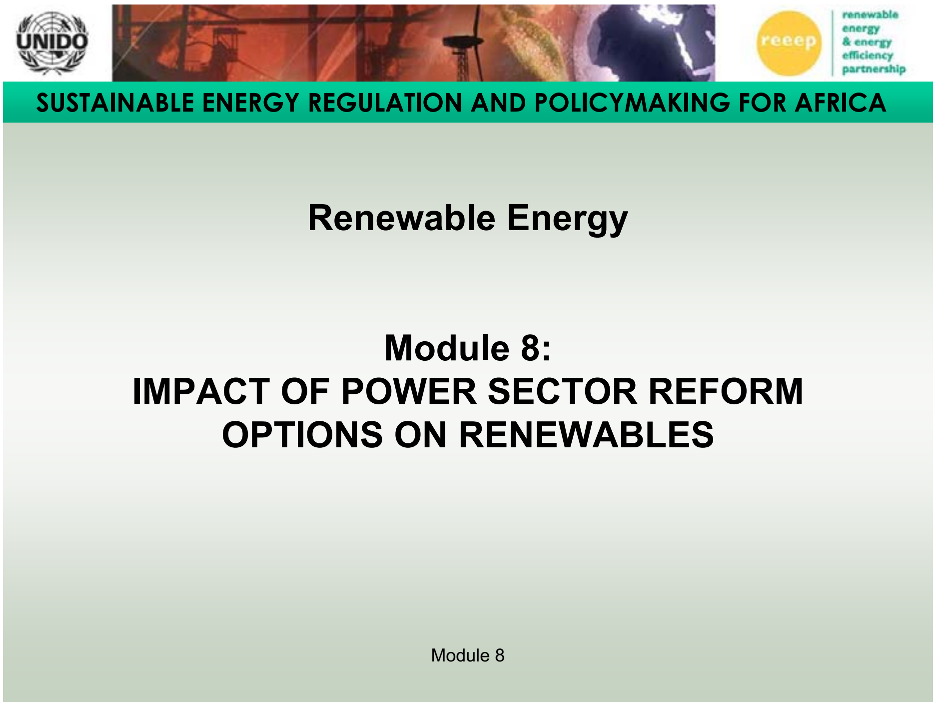
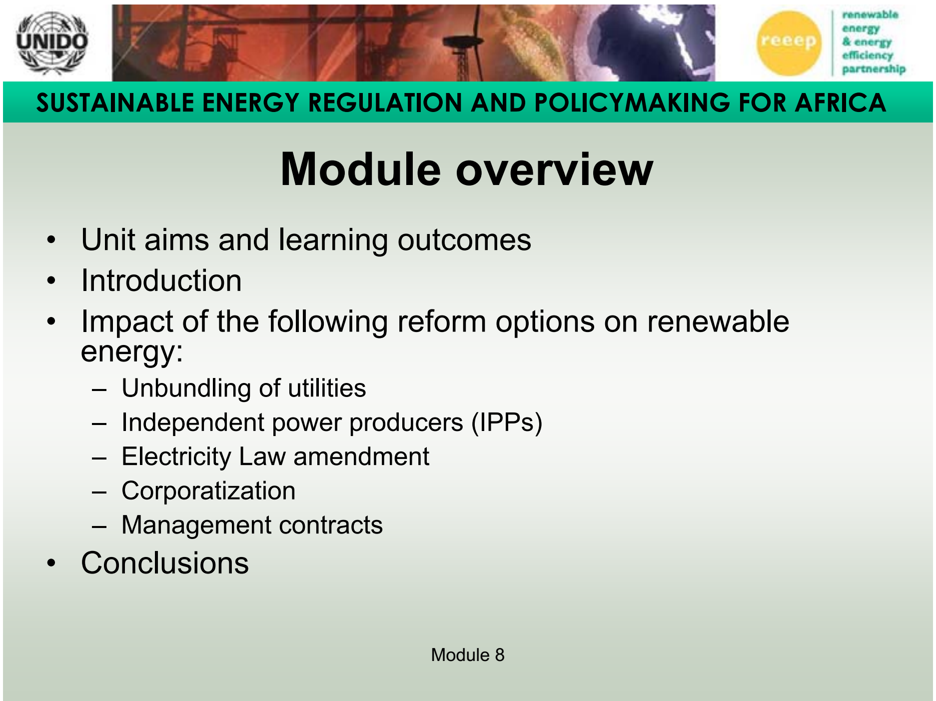


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy

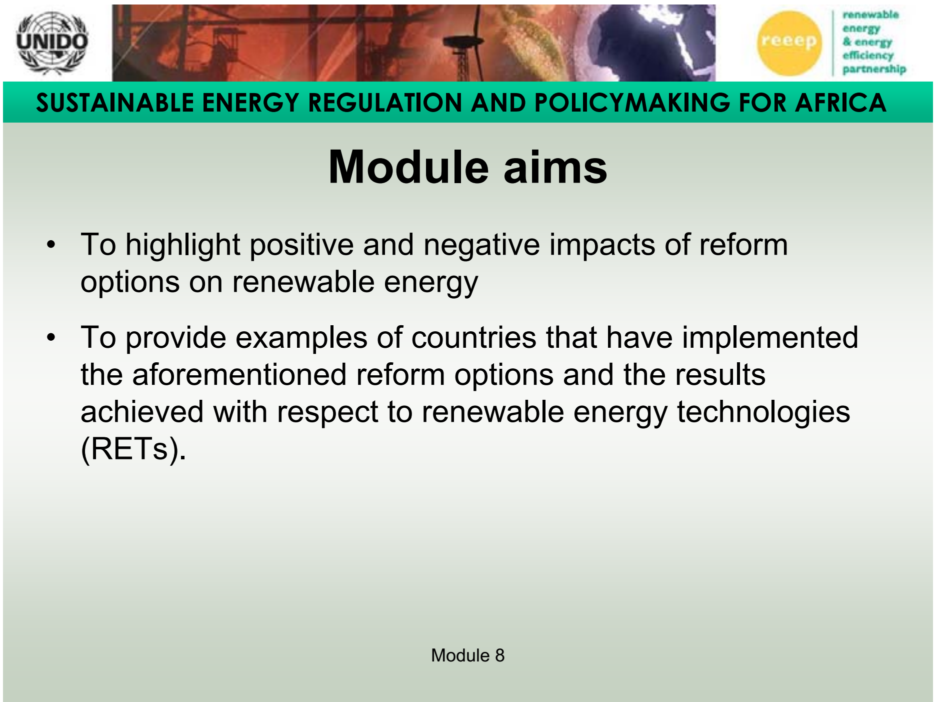
Module 8:
IMPACT OF POWER SECTOR REFORM OPTIONS ON RENEWABLES



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

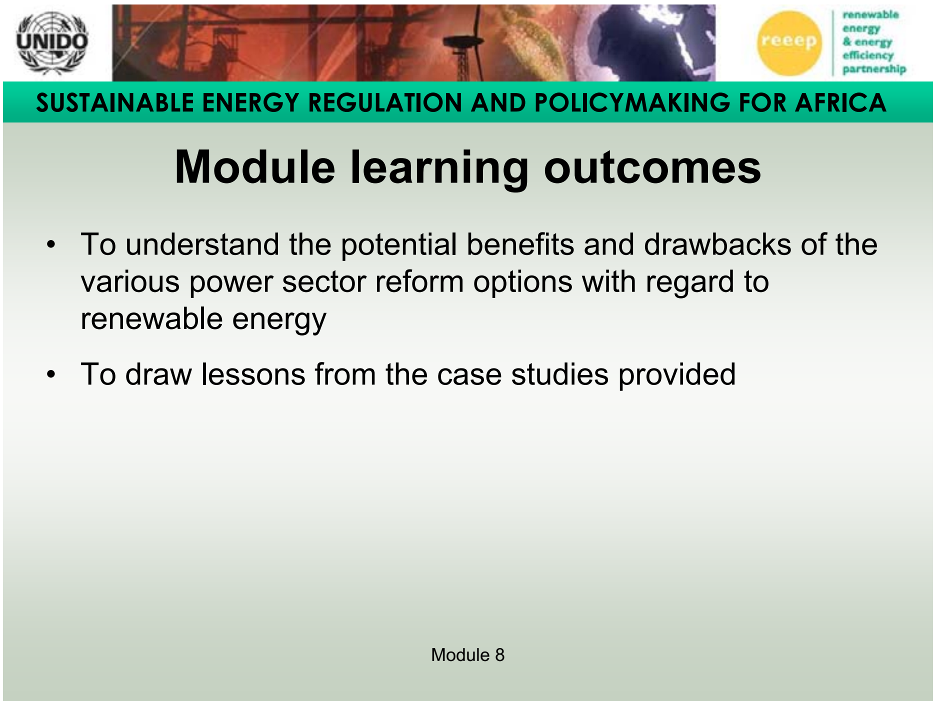
- Unit aims and learning outcomes
- Introduction
- Impact of the following reform options on renewable energy:
  - Unbundling of utilities
  - Independent power producers (IPPs)
  - Electricity Law amendment
  - Corporatization
  - Management contracts
- Conclusions



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

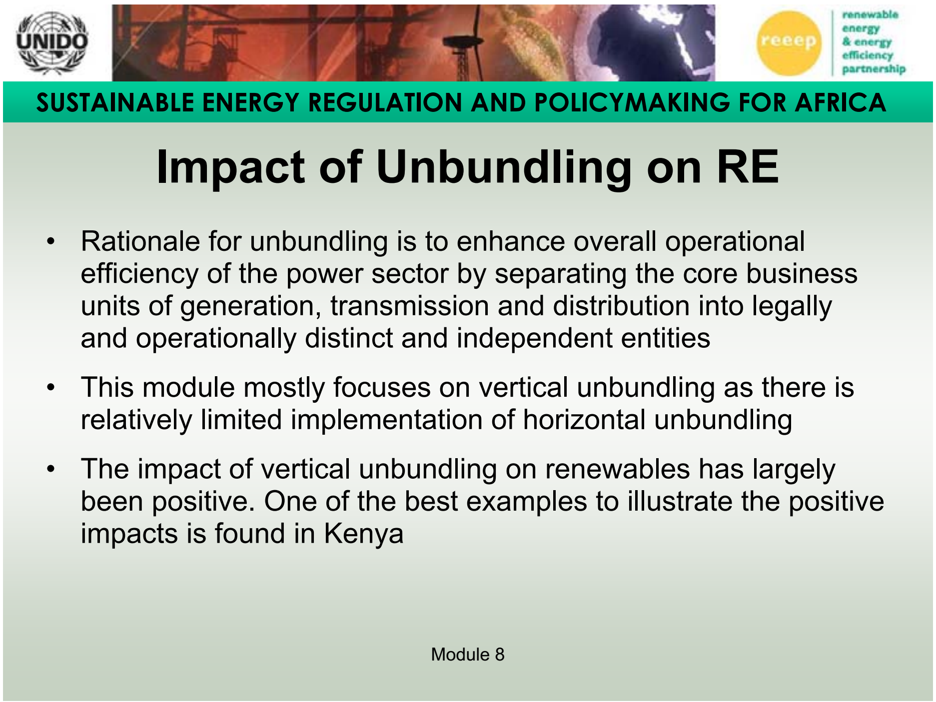
- To highlight positive and negative impacts of reform options on renewable energy
- To provide examples of countries that have implemented the aforementioned reform options and the results achieved with respect to renewable energy technologies (RETs).



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

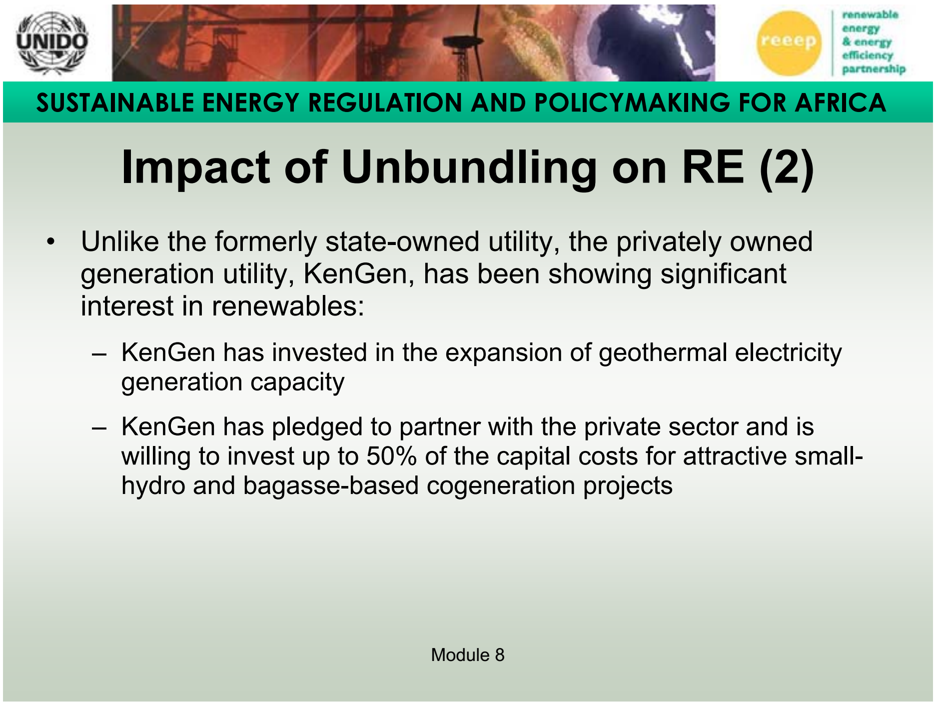
- To understand the potential benefits and drawbacks of the various power sector reform options with regard to renewable energy
- To draw lessons from the case studies provided



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on RE

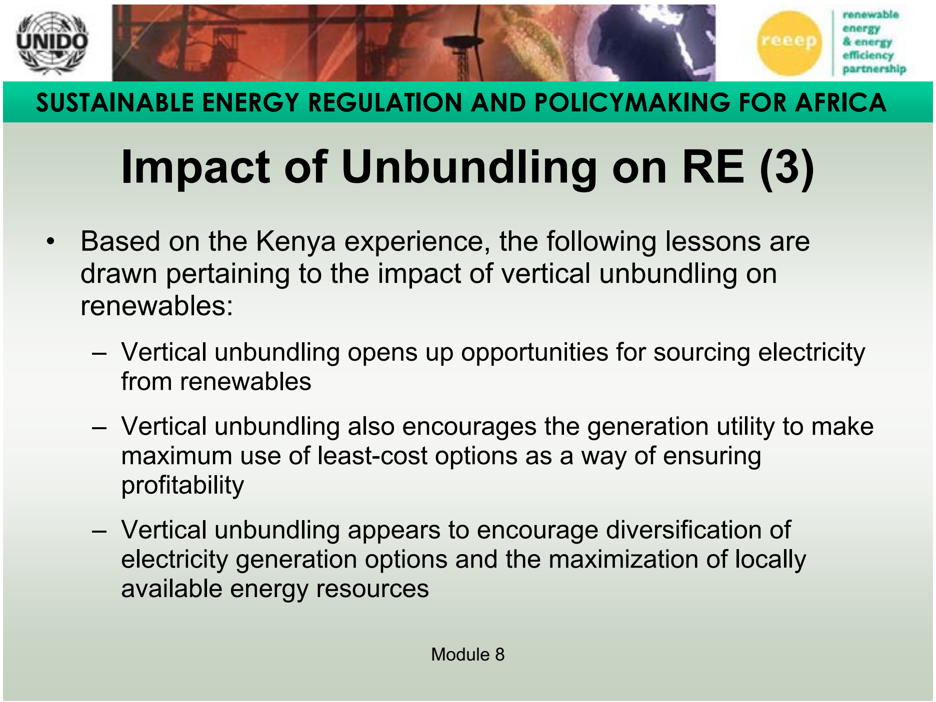
- Rationale for unbundling is to enhance overall operational efficiency of the power sector by separating the core business units of generation, transmission and distribution into legally and operationally distinct and independent entities
- This module mostly focuses on vertical unbundling as there is relatively limited implementation of horizontal unbundling
- The impact of vertical unbundling on renewables has largely been positive. One of the best examples to illustrate the positive impacts is found in Kenya



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on RE (2)

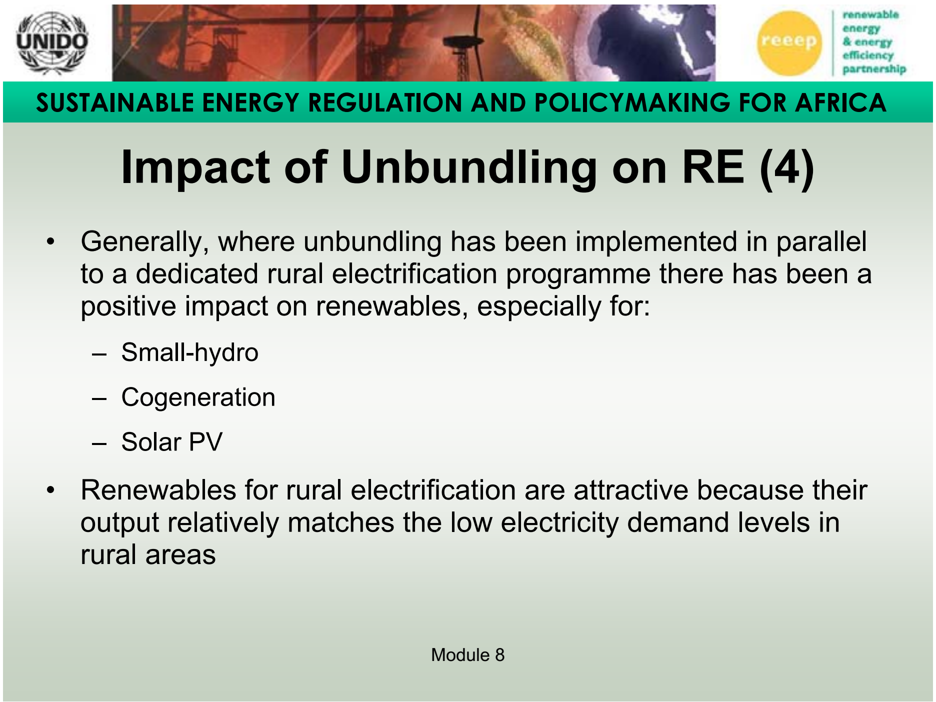
- Unlike the formerly state-owned utility, the privately owned generation utility, KenGen, has been showing significant interest in renewables:
  - KenGen has invested in the expansion of geothermal electricity generation capacity
  - KenGen has pledged to partner with the private sector and is willing to invest up to 50% of the capital costs for attractive small-hydro and bagasse-based cogeneration projects



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on RE (3)

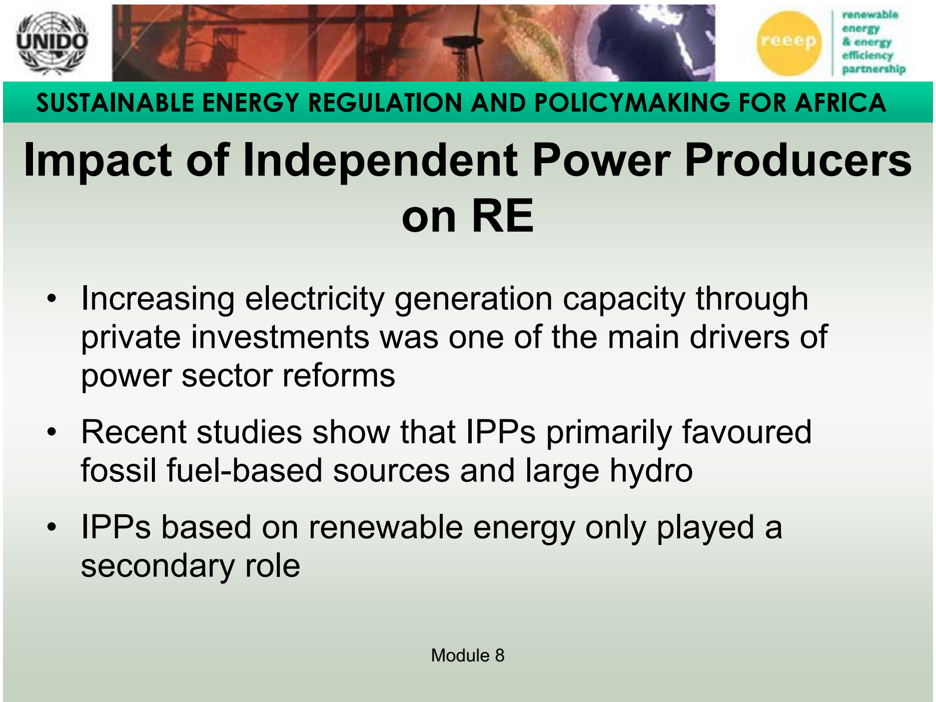
- Based on the Kenya experience, the following lessons are drawn pertaining to the impact of vertical unbundling on renewables:
  - Vertical unbundling opens up opportunities for sourcing electricity from renewables
  - Vertical unbundling also encourages the generation utility to make maximum use of least-cost options as a way of ensuring profitability
  - Vertical unbundling appears to encourage diversification of electricity generation options and the maximization of locally available energy resources



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on RE (4)

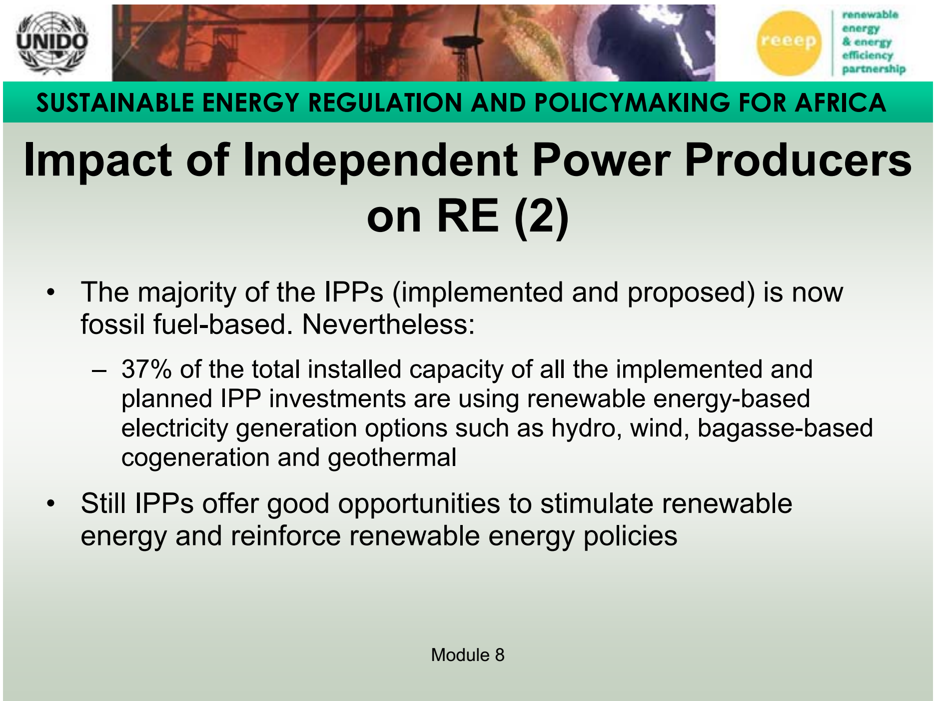
- Generally, where unbundling has been implemented in parallel to a dedicated rural electrification programme there has been a positive impact on renewables, especially for:
  - Small-hydro
  - Cogeneration
  - Solar PV
- Renewables for rural electrification are attractive because their output relatively matches the low electricity demand levels in rural areas



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Independent Power Producers on RE

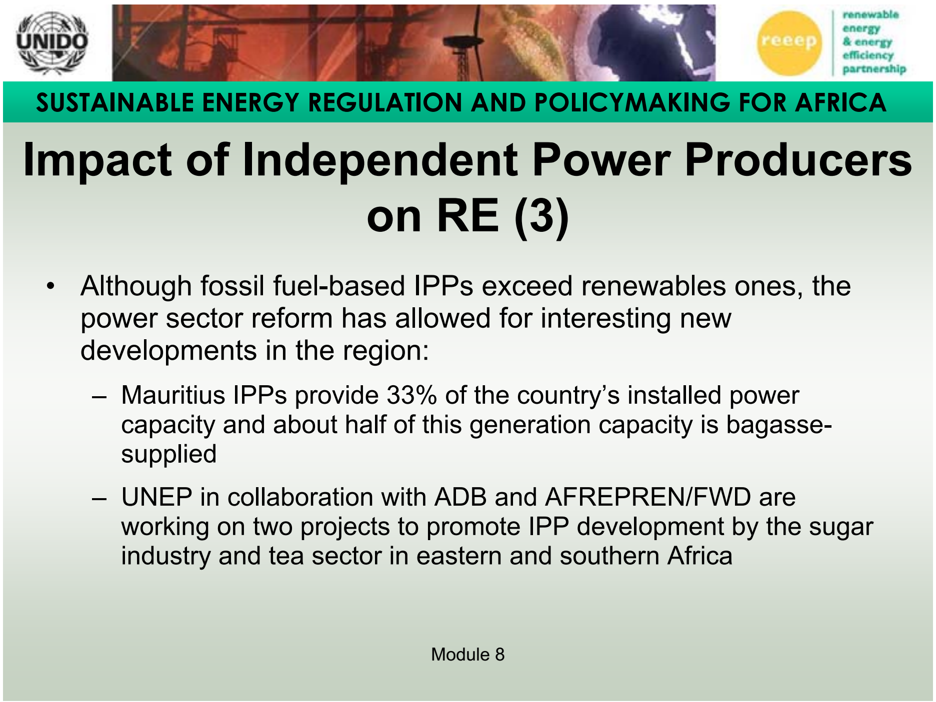
- Increasing electricity generation capacity through private investments was one of the main drivers of power sector reforms
- Recent studies show that IPPs primarily favoured fossil fuel-based sources and large hydro
- IPPs based on renewable energy only played a secondary role



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Independent Power Producers on RE (2)

- The majority of the IPPs (implemented and proposed) is now fossil fuel-based. Nevertheless:
  - 37% of the total installed capacity of all the implemented and planned IPP investments are using renewable energy-based electricity generation options such as hydro, wind, bagasse-based cogeneration and geothermal
- Still IPPs offer good opportunities to stimulate renewable energy and reinforce renewable energy policies



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Independent Power Producers on RE (3)

- Although fossil fuel-based IPPs exceed renewables ones, the power sector reform has allowed for interesting new developments in the region:
  - Mauritius IPPs provide 33% of the country's installed power capacity and about half of this generation capacity is bagasse-supplied
  - UNEP in collaboration with ADB and AFREPREN/FWD are working on two projects to promote IPP development by the sugar industry and tea sector in eastern and southern Africa

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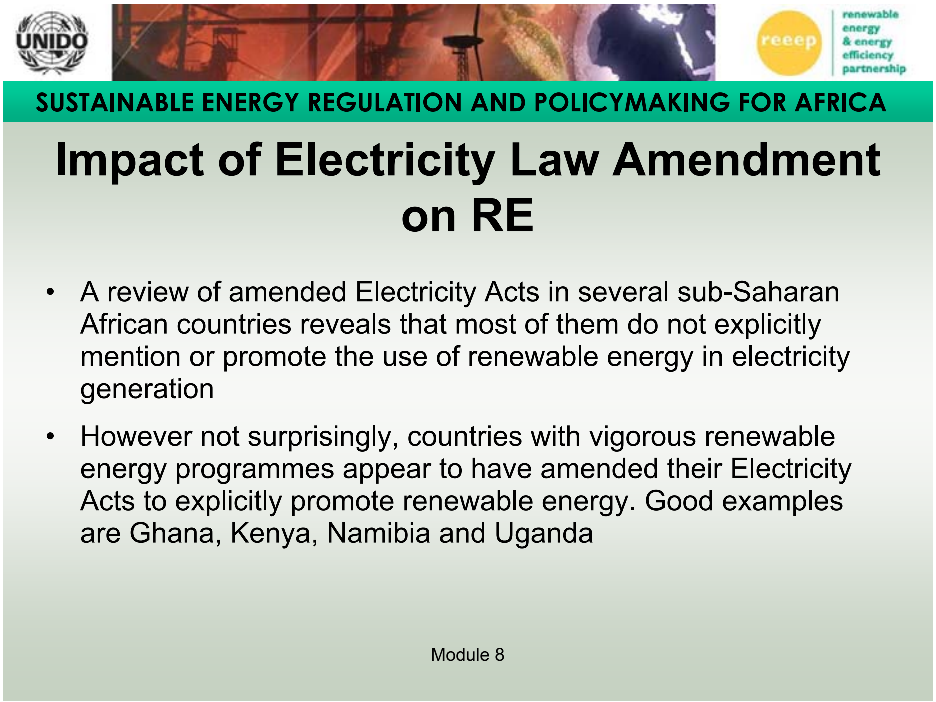

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on RE

- A review of amended Electricity Acts in several sub-Saharan African countries reveals that most of them do not explicitly mention or promote the use of renewable energy in electricity generation
- However not surprisingly, countries with vigorous renewable energy programmes appear to have amended their Electricity Acts to explicitly promote renewable energy. Good examples are Ghana, Kenya, Namibia and Uganda

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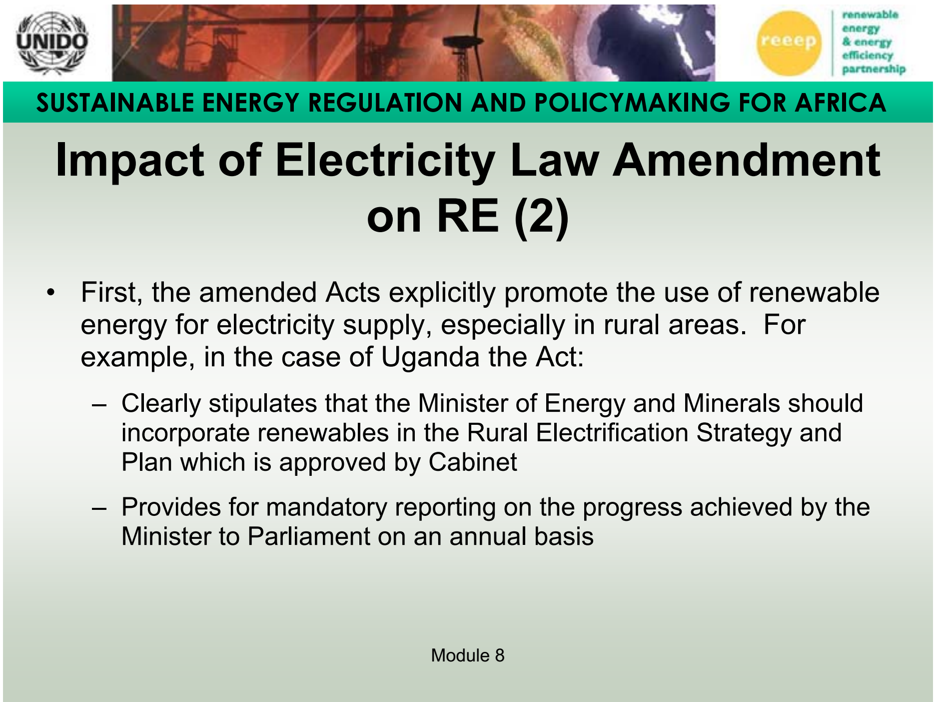
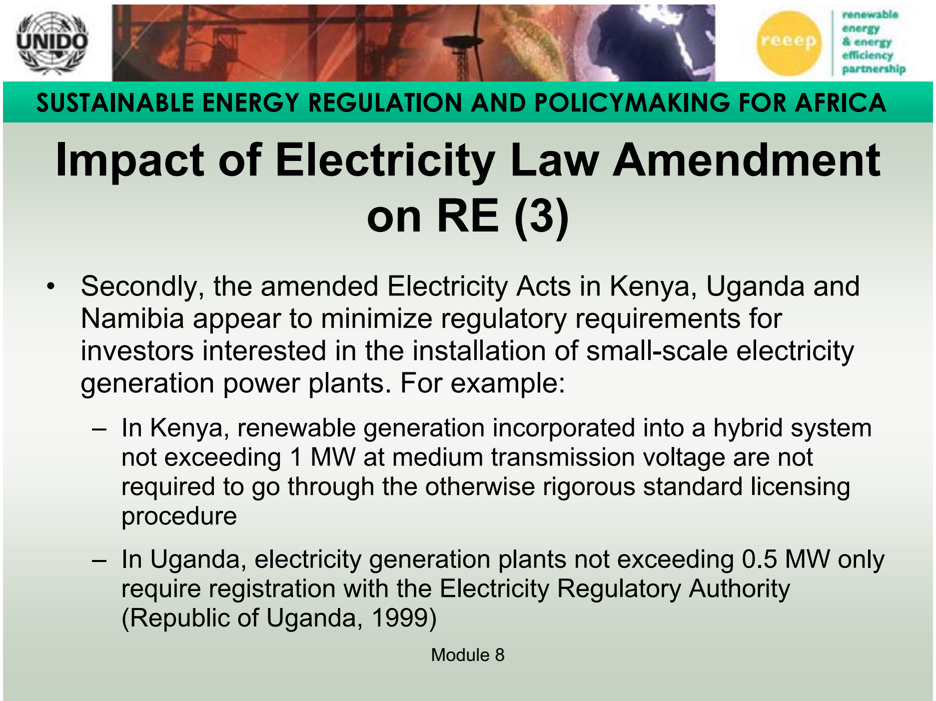


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on RE (2)

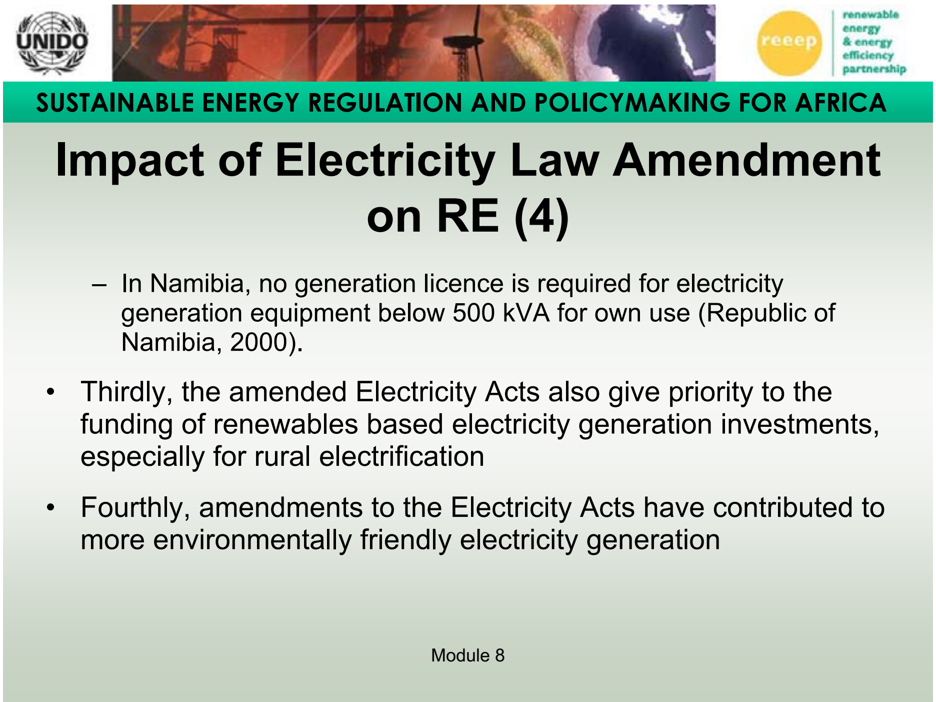
- First, the amended Acts explicitly promote the use of renewable energy for electricity supply, especially in rural areas. For example, in the case of Uganda the Act:
  - Clearly stipulates that the Minister of Energy and Minerals should incorporate renewables in the Rural Electrification Strategy and Plan which is approved by Cabinet
  - Provides for mandatory reporting on the progress achieved by the Minister to Parliament on an annual basis



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on RE (3)

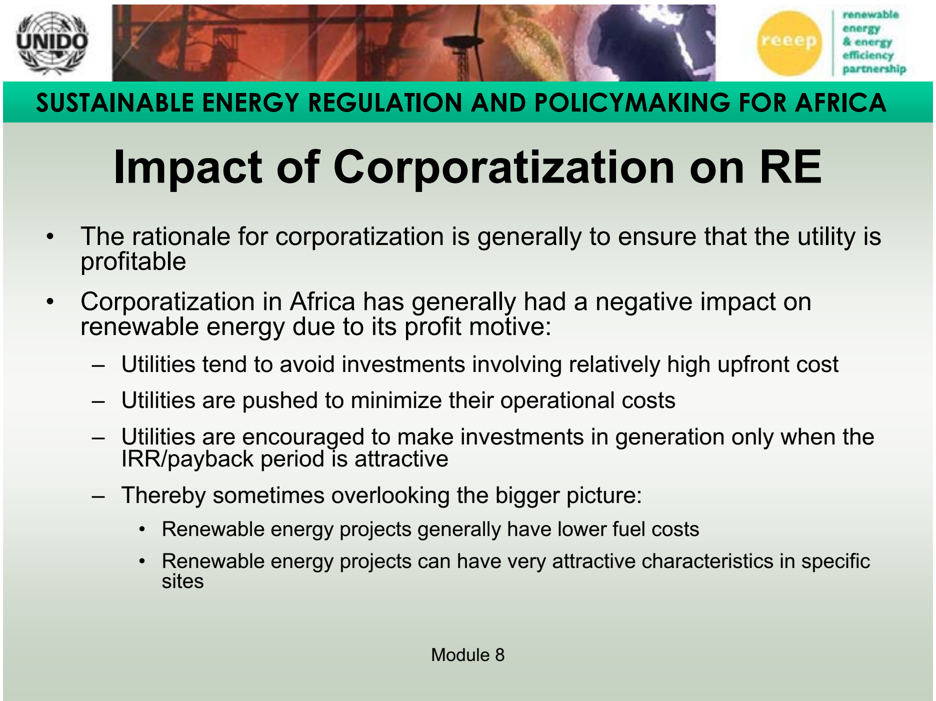
- Secondly, the amended Electricity Acts in Kenya, Uganda and Namibia appear to minimize regulatory requirements for investors interested in the installation of small-scale electricity generation power plants. For example:
  - In Kenya, renewable generation incorporated into a hybrid system not exceeding 1 MW at medium transmission voltage are not required to go through the otherwise rigorous standard licensing procedure
  - In Uganda, electricity generation plants not exceeding 0.5 MW only require registration with the Electricity Regulatory Authority (Republic of Uganda, 1999)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on RE (4)

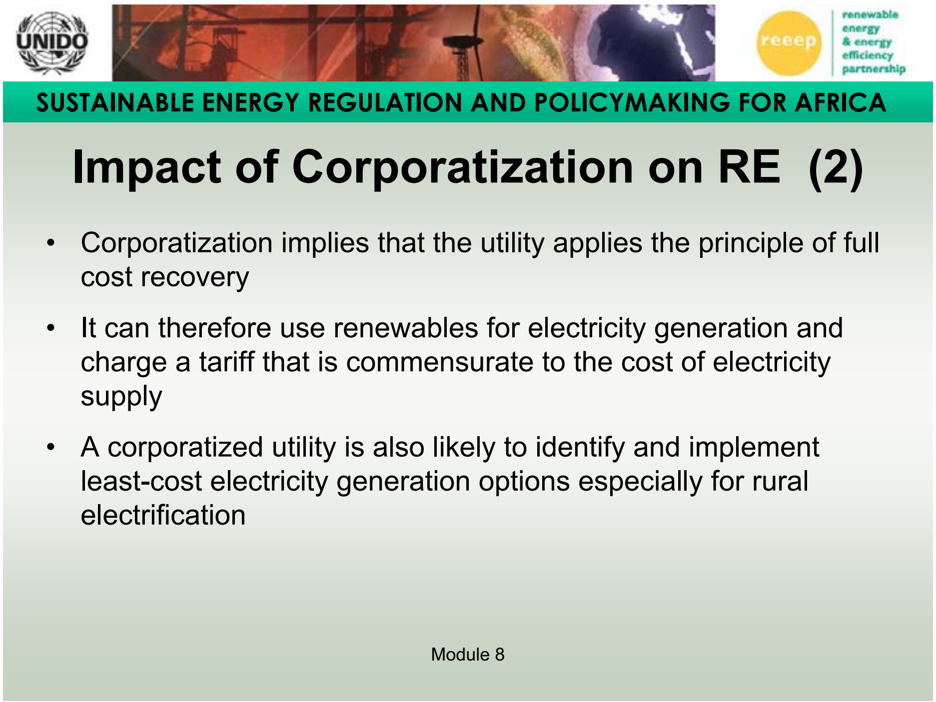
  - In Namibia, no generation licence is required for electricity generation equipment below 500 kVA for own use (Republic of Namibia, 2000).
- Thirdly, the amended Electricity Acts also give priority to the funding of renewables based electricity generation investments, especially for rural electrification
- Fourthly, amendments to the Electricity Acts have contributed to more environmentally friendly electricity generation



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Corporatization on RE

- The rationale for corporatization is generally to ensure that the utility is profitable
- Corporatization in Africa has generally had a negative impact on renewable energy due to its profit motive:
  - Utilities tend to avoid investments involving relatively high upfront cost
  - Utilities are pushed to minimize their operational costs
  - Utilities are encouraged to make investments in generation only when the IRR/payback period is attractive
  - Thereby sometimes overlooking the bigger picture:
    - Renewable energy projects generally have lower fuel costs
    - Renewable energy projects can have very attractive characteristics in specific sites



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Corporatization on RE (2)

- Corporatization implies that the utility applies the principle of full cost recovery
- It can therefore use renewables for electricity generation and charge a tariff that is commensurate to the cost of electricity supply
- A corporatized utility is also likely to identify and implement least-cost electricity generation options especially for rural electrification

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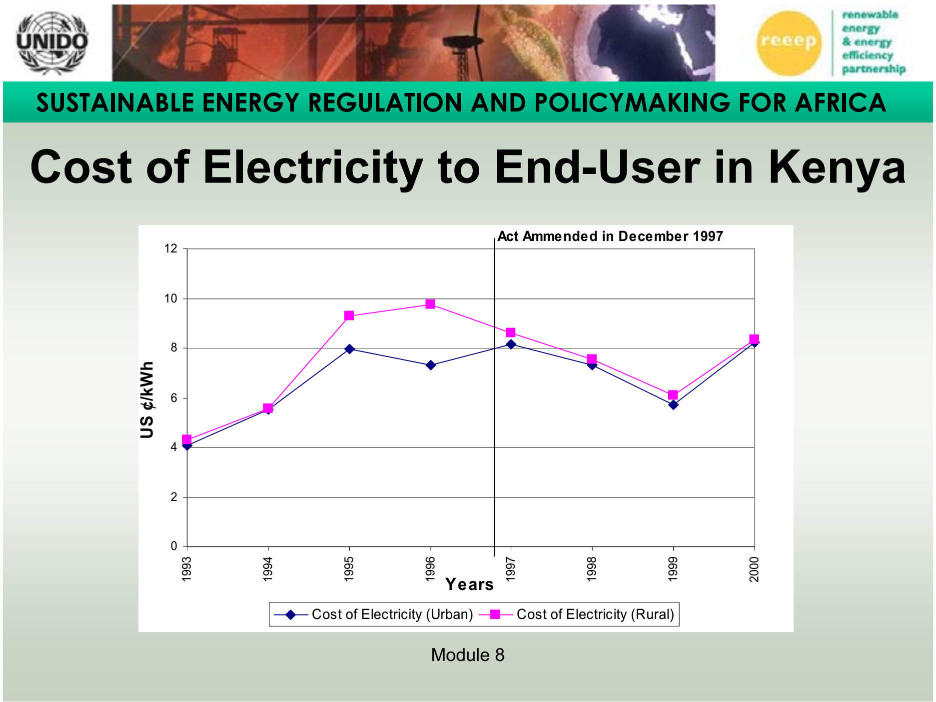

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Cost of Electricity to End-User in Kenya

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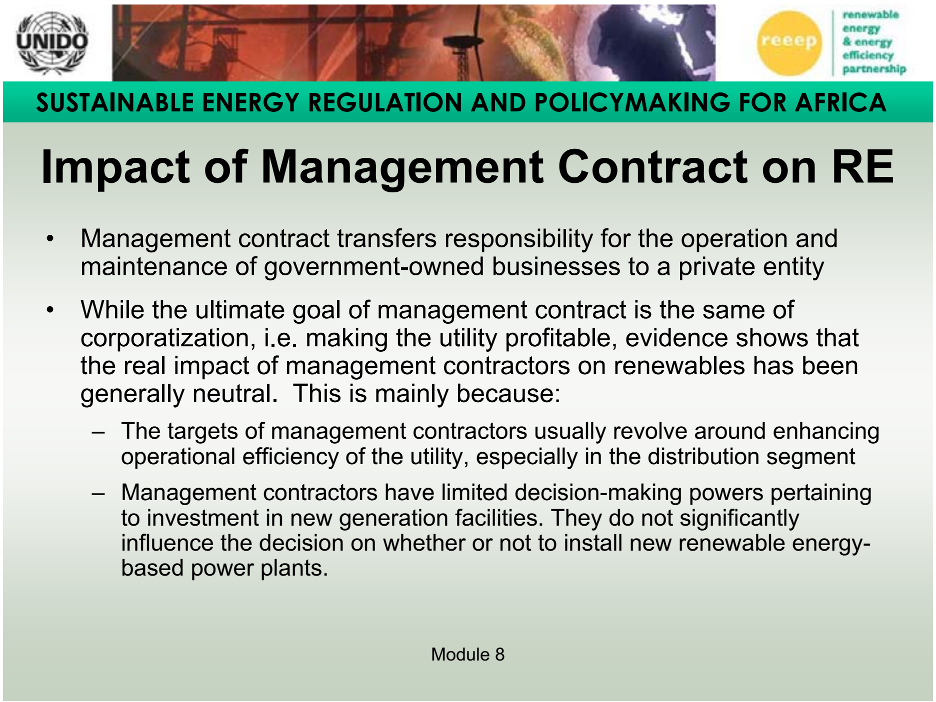
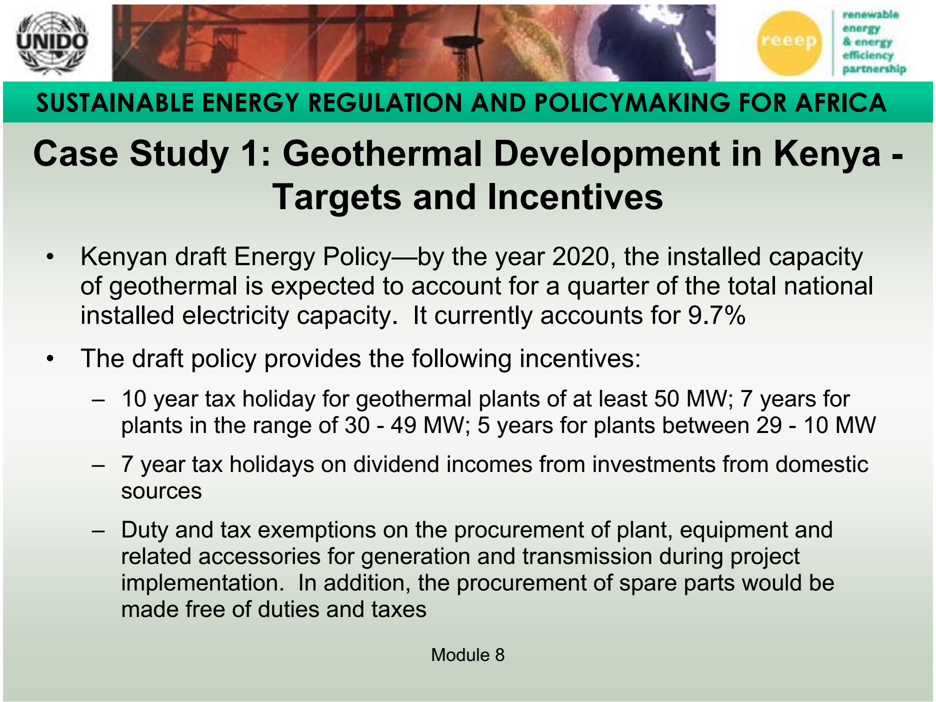


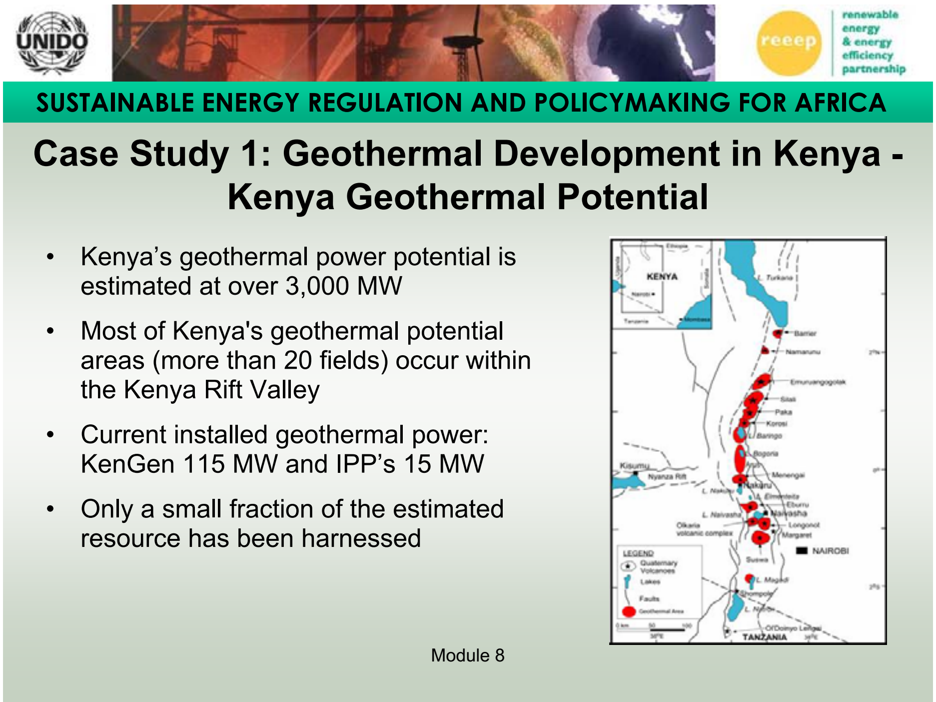
Impact of Management Contract on RE

- Management contract transfers responsibility for the operation and maintenance of government-owned businesses to a private entity
- While the ultimate goal of management contract is the same of corporatization, i.e. making the utility profitable, evidence shows that the real impact of management contractors on renewables has been generally neutral. This is mainly because:
  - The targets of management contractors usually revolve around enhancing operational efficiency of the utility, especially in the distribution segment
  - Management contractors have limited decision-making powers pertaining to investment in new generation facilities. They do not significantly influence the decision on whether or not to install new renewable energy-based power plants.



Case Study 1: Geothermal Development in Kenya - Targets and Incentives

- Kenyan draft Energy Policy—by the year 2020, the installed capacity of geothermal is expected to account for a quarter of the total national installed electricity capacity. It currently accounts for 9.7%
- The draft policy provides the following incentives:
  - 10 year tax holiday for geothermal plants of at least 50 MW; 7 years for plants in the range of 30 - 49 MW; 5 years for plants between 29 - 10 MW
  - 7 year tax holidays on dividend incomes from investments from domestic sources
  - Duty and tax exemptions on the procurement of plant, equipment and related accessories for generation and transmission during project implementation. In addition, the procurement of spare parts would be made free of duties and taxes



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Geothermal Development in Kenya - Kenya Geothermal Potential

- Kenya’s geothermal power potential is estimated at over 3,000 MW
- Most of Kenya's geothermal potential areas (more than 20 fields) occur within the Kenya Rift Valley
- Current installed geothermal power: KenGen 115 MW and IPP’s 15 MW
- Only a small fraction of the estimated resource has been harnessed

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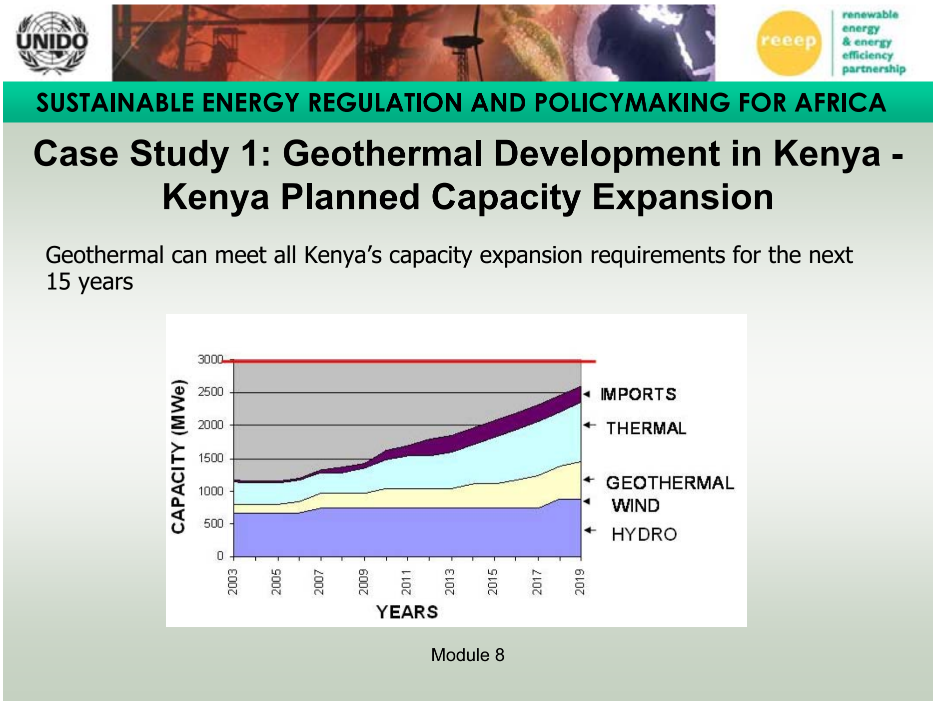

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Geothermal Development in Kenya - Kenya Planned Capacity Expansion

Geothermal can meet all Kenya’s capacity expansion requirements for the next 15 years

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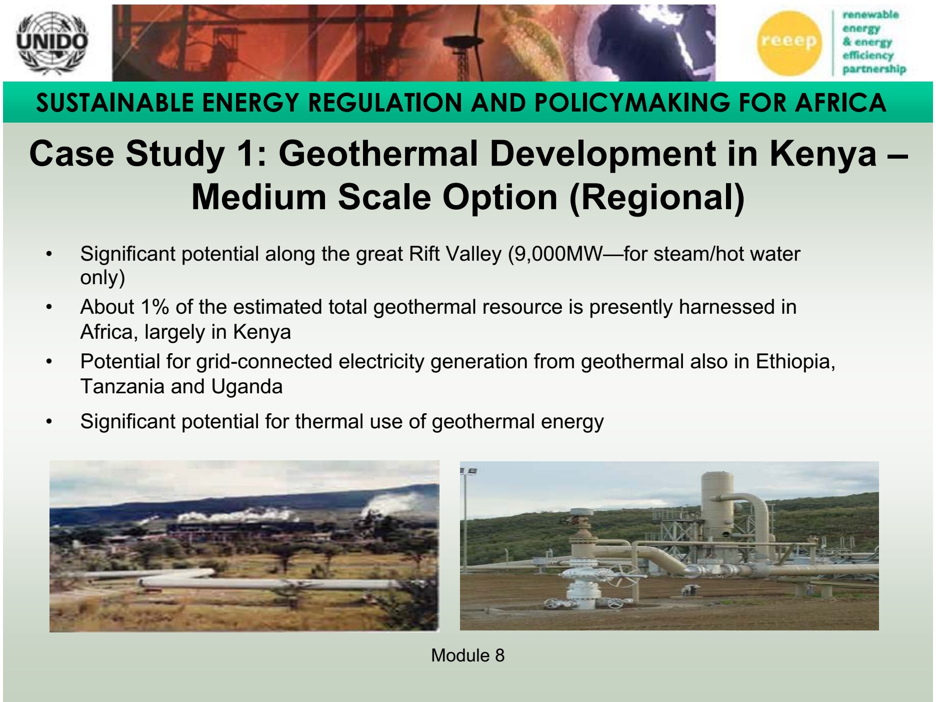

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Geothermal Development in Kenya – Medium Scale Option (Regional)

- Significant potential along the great Rift Valley (9,000MW—for steam/hot water only)
- About 1% of the estimated total geothermal resource is presently harnessed in Africa, largely in Kenya
- Potential for grid-connected electricity generation from geothermal also in Ethiopia, Tanzania and Uganda
- Significant potential for thermal use of geothermal energy

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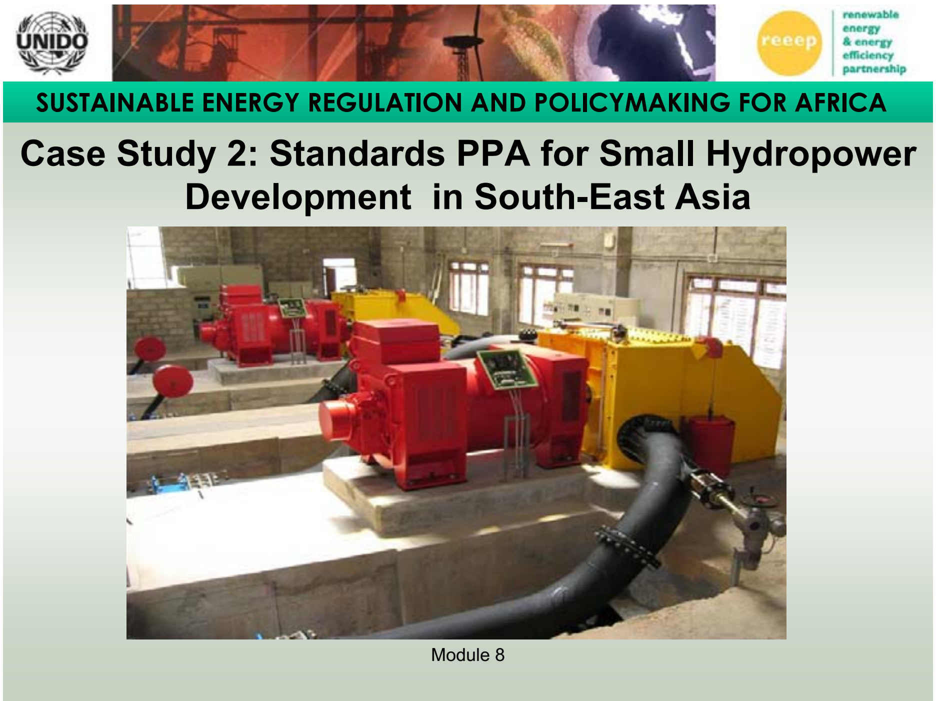

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Standards PPA for Small Hydropower Development in South-East Asia

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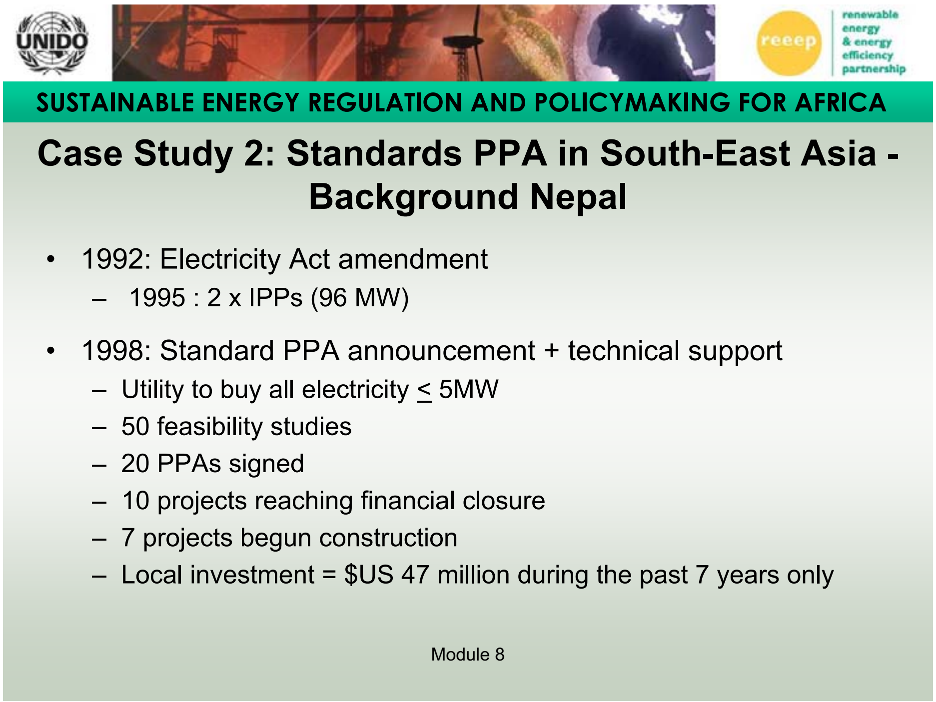

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Standards PPA in South-East Asia - Background Nepal

- 1992: Electricity Act amendment
  - 1995 : 2 x IPPs (96 MW)
- 1998: Standard PPA announcement + technical support
  - Utility to buy all electricity $\leq$ 5MW
  - 50 feasibility studies
  - 20 PPAs signed
  - 10 projects reaching financial closure
  - 7 projects begun construction
  - Local investment = $US 47 million during the past 7 years only

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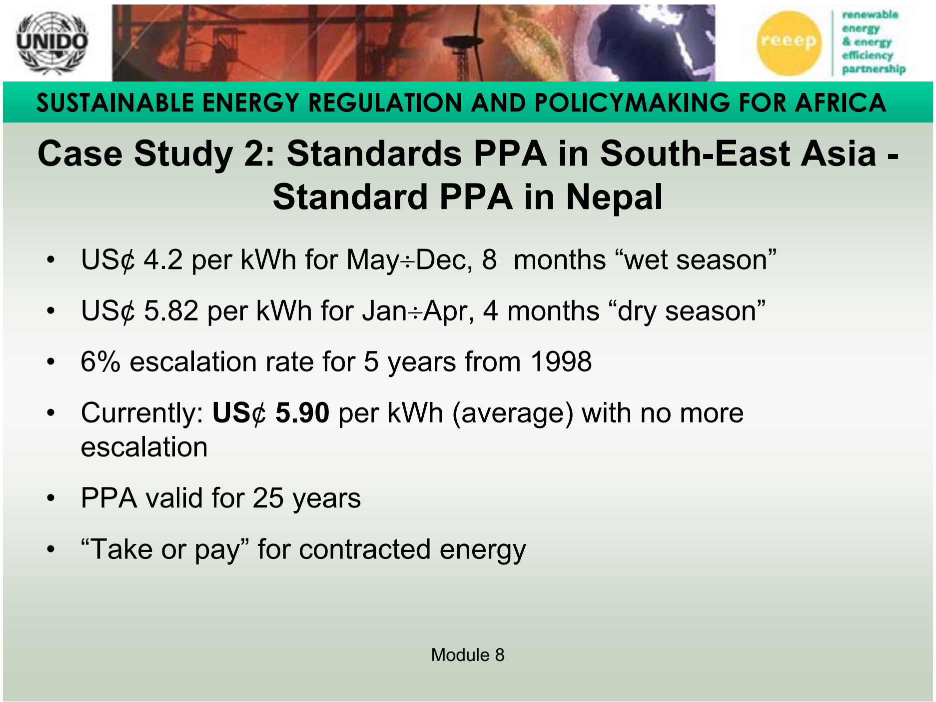

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Standards PPA in South-East Asia - Standard PPA in Nepal

- US¢ 4.2 per kWh for May÷Dec, 8 months “wet season”
- US¢ 5.82 per kWh for Jan÷Apr, 4 months “dry season”
- 6% escalation rate for 5 years from 1998
- Currently: **US¢ 5.90** per kWh (average) with no more escalation
- PPA valid for 25 years
- “Take or pay” for contracted energy

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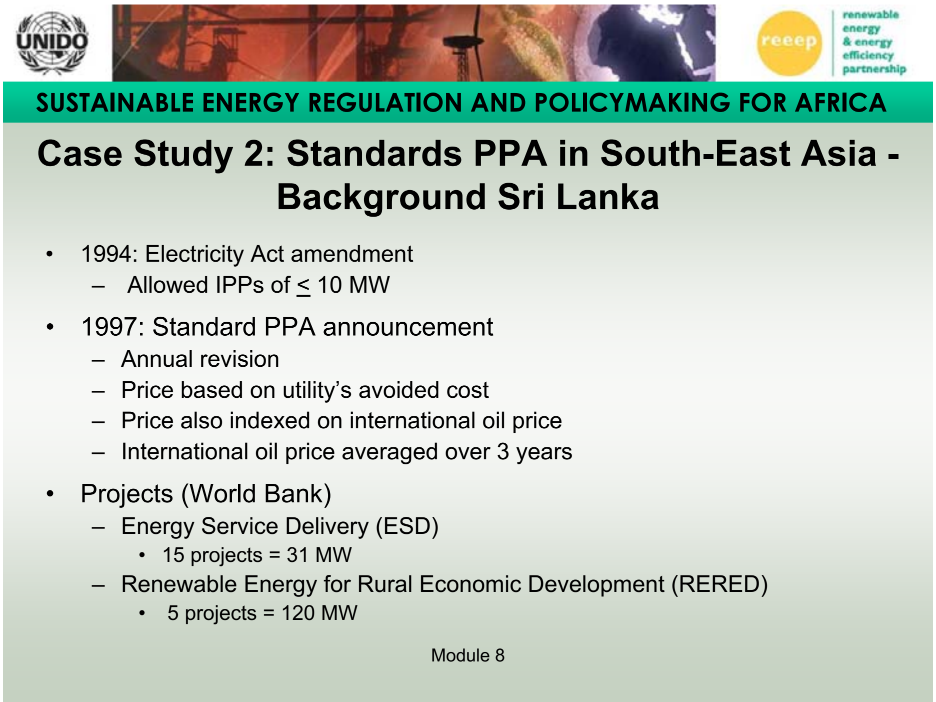

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Standards PPA in South-East Asia - Background Sri Lanka

- 1994: Electricity Act amendment
  - Allowed IPPs of ≤ 10 MW
- 1997: Standard PPA announcement
  - Annual revision
  - Price based on utility's avoided cost
  - Price also indexed on international oil price
  - International oil price averaged over 3 years
- Projects (World Bank)
  - Energy Service Delivery (ESD)
    - 15 projects = 31 MW
  - Renewable Energy for Rural Economic Development (RERED)
    - 5 projects = 120 MW

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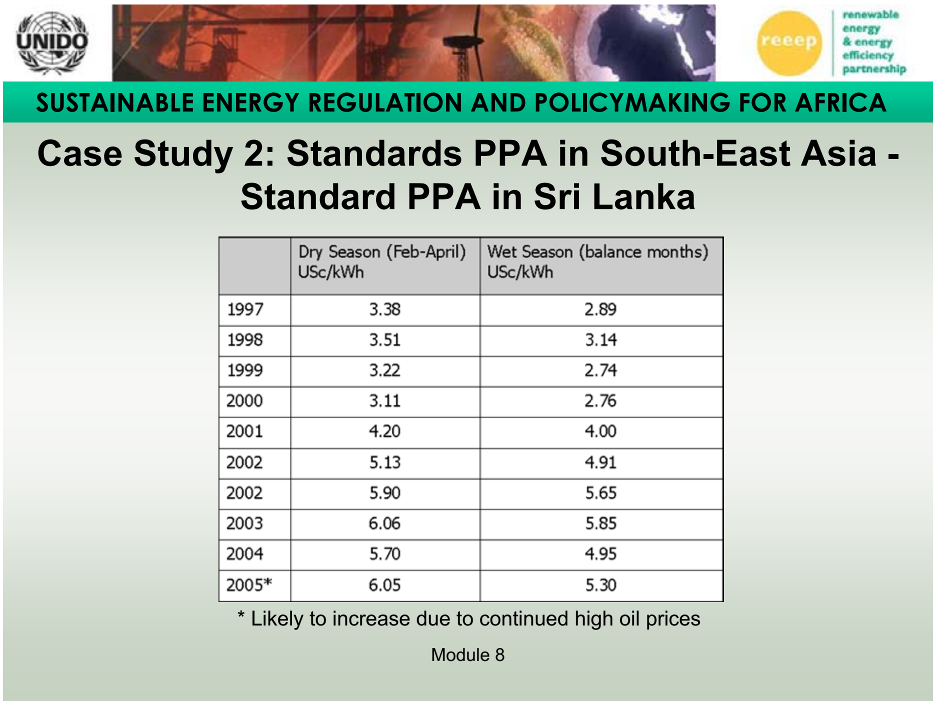

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Standards PPA in South-East Asia - Standard PPA in Sri Lanka

	Dry Season (Feb-April) USc/kWh	Wet Season (balance months) USc/kWh
1997	3.38	2.89
1998	3.51	3.14
1999	3.22	2.74
2000	3.11	2.76
2001	4.20	4.00
2002	5.13	4.91
2002	5.90	5.65
2003	6.06	5.85
2004	5.70	4.95
2005*	6.05	5.30

* Likely to increase due to continued high oil prices

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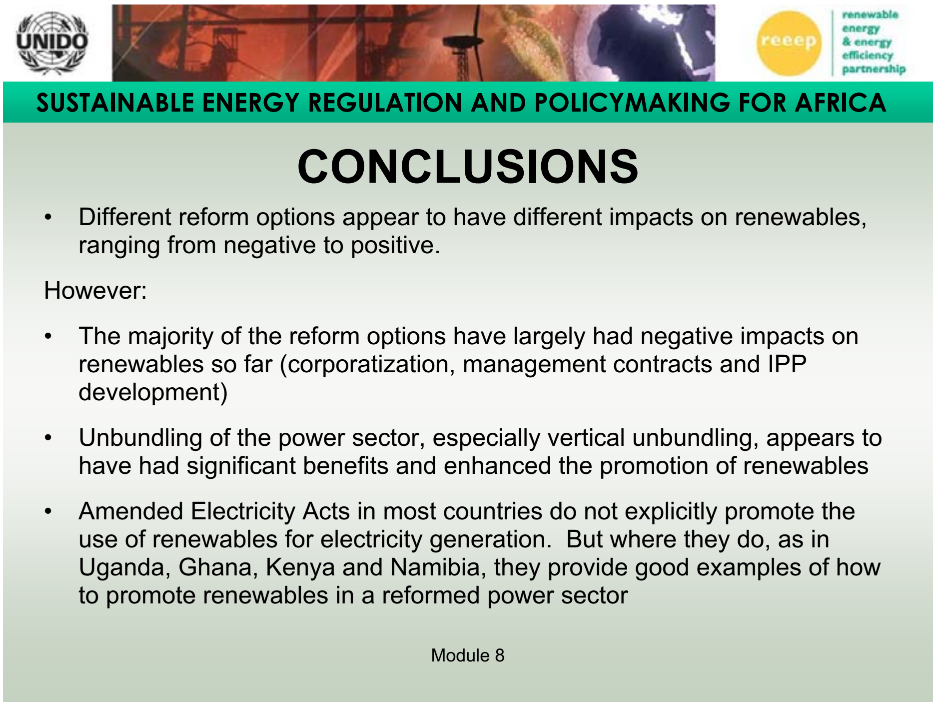

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Different reform options appear to have different impacts on renewables, ranging from negative to positive.

However:

- The majority of the reform options have largely had negative impacts on renewables so far (corporatization, management contracts and IPP development)
- Unbundling of the power sector, especially vertical unbundling, appears to have had significant benefits and enhanced the promotion of renewables
- Amended Electricity Acts in most countries do not explicitly promote the use of renewables for electricity generation. But where they do, as in Uganda, Ghana, Kenya and Namibia, they provide good examples of how to promote renewables in a reformed power sector

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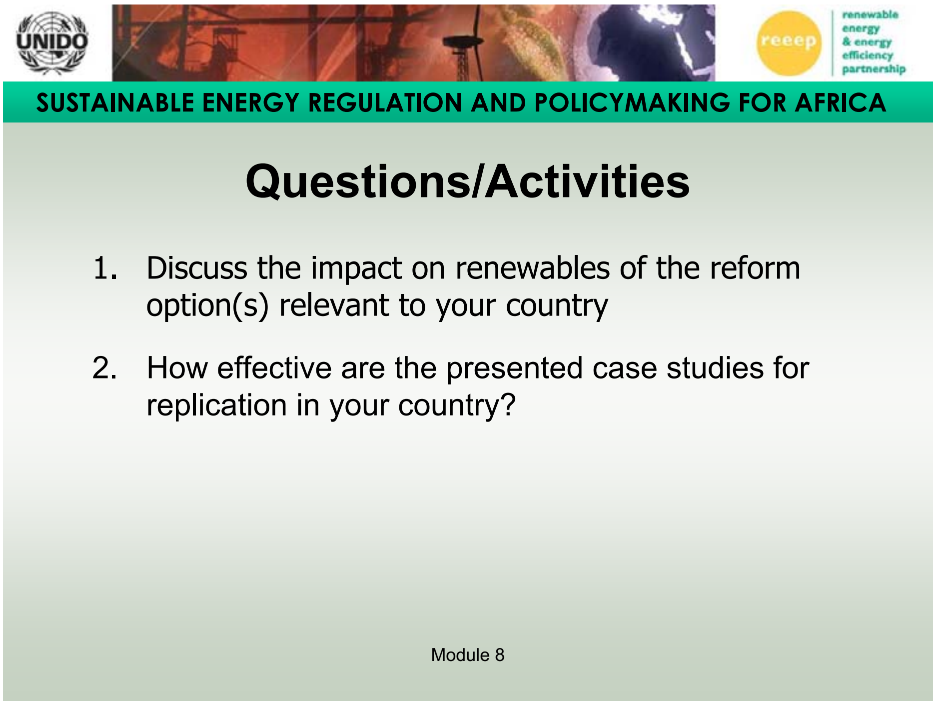

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

1. Discuss the impact on renewables of the reform option(s) relevant to your country
2. How effective are the presented case studies for replication in your country?

Module 8

Module 9

Regulatory and policy options to encourage development of renewable energy

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Why support renewable energy? There are many answers to this question. Renewable energy can aid security of supply. Small-scale renewable energy projects can contribute to a government's social agenda, for example by increasing access to electricity. On a broader social and political level, the development of a renewable energy industry can create jobs and enhance technical expertise. Renewables can also deliver additional local, regional and global environmental benefits.

This module examines types of regulatory/support mechanisms for renewable energy and the design issues that are involved in these mechanisms. The module will also give examples of the mechanisms in practice and provide information on the pros and cons of each system. Most mechanisms of this type have only been functioning for a short while with very limited application in Africa. Consequently, conclusions on their success or failure are hard to draw. Sometimes the best solution is to use a combination of mechanisms to support renewable energy development in a country.

1.2. Module aims

This module has the following aims:

- To provide an overview of the different advantages that a clear renewable energy policy can provide, and its possible interaction with other policies;
- To explain what the key building blocks are when designing a regulatory/support mechanism;
- To give an overview of the different possible approaches;
- To show how these have been implemented in different African countries.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to explain that a renewable energy policy can provide advantages and support a range of environmental and other policies;
- To understand which design elements are key to the success of the regulatory/support mechanism;

- To understand different approaches to designing a regulatory/support mechanism;
- To be able to argue which regulatory or policy approach suits best, given the national or regional situation

2. INTRODUCTION

This module gives an overview of the most common regulatory and policy support mechanisms for promoting the deployment of sustainable energy technologies and encouraging increased capacity and output.

The mechanisms described in this module are usually applied where there is at least some degree of liberalization in the energy system (e.g. even if the major energy company is still a state-owned monopoly, other generators are allowed to enter the market): in non-liberalized systems, new technologies can be adopted by state-owned generators in response to government demands, rather than through the use of specific regulatory/support mechanisms to drive their uptake.

The mechanisms discussed can be divided into two categories, as follows:

1. Regulatory/support options that are immediately applicable to many sub-Saharan African countries[1]:
    - Establishing "standard" power purchase agreements (PPAs);
    - Ensuring long-term electricity generation licences and PPAs;
    - Developing a favourable tariff setting and adjustment formula;
    - "Light-handed" regulation;
    - Setting explicit targets for the share of renewables in the electricity generation mix;
    - Enacting explicit regulations that encourage local private participation in renewable energy development;
    - Providing subsidies to renewable energy-based power systems especially those located in rural areas (e.g. accessing existing rural electrification funds).
2. Other regulatory/support mechanisms implemented in developed countries that may be applicable to sub-Saharan African countries in the future:
    - Feed-in tariffs (such as those in Germany and Denmark);
    - Quota mechanisms (such as the renewable obligation in the UK and various other countries);
    - Tender schemes (Ireland);
    - Voluntary mechanisms such as green certificates (Netherlands);
    - Various hybrid schemes involving two of the above mechanisms (Spain).

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[1] Because of its advanced industrial/technological status and strong internal economy backed by a sophisticated legal and regulatory regime, South Africa is an exception in sub-Saharan Africa as it can often successfully adopt regulatory/support mechanisms that are deployed in developed economies.

The main focus is on mechanisms used in electricity systems, as this is where the use of such mechanisms is currently most common. They can be used to drive capacity increases for electricity from renewable energy sources and combined heat and power (CHP), although in practice most schemes to date have been restricted to renewable energies. They could also be used to encourage the production of heat from renewable energy and CHP, although again to date, the focus has been on electricity. Finally, in theory the mechanisms could also be used to drive the adoption of sustainable energy technologies in other energy areas, for example the use of a quota obligation to promote renewable fuels in transport, or the provision of heat.

Although different examples of each mechanism have characteristics in common, it should be emphasized that no two schemes are identical. Differences arise because of different markets, energy systems and political intentions in different countries. The descriptions concentrate on the general characteristics of the mechanisms, rather than on specific details of how they are implemented in different countries (some of these country specific details are covered in the case studies).

In addition, each type of mechanism has different strengths and weaknesses, and will tend to encourage the development of sustainable technologies in a particular way. The extent to which weaknesses become serious defects depends to a great extent on the interaction between the mechanism and other policy efforts. These include for example, R&D support, capital grants, production tax credits and soft loans, as well as broader measures such as changes to planning regimes. Therefore where appropriate, the importance of other supportive mechanisms is also highlighted.

Many sustainable energy regulatory/support mechanisms—especially those discussed here—are relatively new policy and regulatory areas, so the evidence on their performance is not yet definitive. This is particular of sub-Saharan Africa where many of the regulatory options widely deployed in industrialized countries are yet to be tried. The purpose here is not to argue that a specific mechanism is the most effective model for any given country, or that the weaknesses demonstrated in the design of some support mechanisms in some countries mean that the actual mechanism is not a viable way of promoting the development of sustainable energy. Instead, the purpose is to give a broad overview of the different main mechanisms, and highlight some of the more significant generic strengths and weaknesses. The accompanying case studies enable specific issues to be followed up in more detail.

3. WHY SUPPORT RENEWABLE ENERGY?

The adoption of sustainable energy policies can bring advantages to both a country and an energy system:

- Renewable projects in particular can aid security of supply—both by reducing the need for imported fuels, and by increasing the diversity of a national generating portfolio—a key benefit to many sub-Saharan countries that are dependant on large-scale hydropower and thus exposed to drought-related energy risks.
- Small-scale sustainable projects—CHP or renewable—can contribute to a government's social agenda, for example by reducing fuel poverty, or by increasing access to electricity.
- Distributed generation (renewable electricity and CHP not connected to long distance transmission networks) offers benefits in terms of reduced losses over transmission wires and, in countries without major distribution and transmission networks, the possibility of avoiding the costs of building such infrastructure. This can increase the economic efficiency of systems, although this benefit is not always reflected in the prices offered for sustainable energy.
- On a broader social and political level, the development of a sustainable energy industry can create jobs and enhance technical expertise. Building a viable domestic energy supply chain can also offer export opportunities in a rapidly expanding international market.
- Renewable energy deployment can deliver additional local, regional and global environmental benefits.

However, many renewable energy technologies are relatively new, and still developing. Although costs of some technologies (especially wind) have fallen dramatically, they still need financial support to compete with established, conventional generation in most situations.

This problem is exacerbated by the fact that there is not a “level playing field” in the treatment of conventional and renewable energy technologies. This inequality notably includes the failure to take account of the costs of risks (higher oil prices and drought-related hydropower crises) associated with conventional generating technologies when costing generation. Conventional generators benefit from the failure to take these risks into account.

In addition, the different operating characteristics of some renewable energy technologies—for example, the intermittency of wind or some CHP projects—mean that they can conflict with the operating characteristics of established systems, which are designed for constant, predictable output from large-scale, centralized generating plants. The differences can, for example, lead to increased operating costs for distributors. Distributors may reflect these increased operating costs in the power purchase agreements (PPAs) they sign with generators, possibly at a level, which is in excess of the real system costs of intermittency. This effectively creates penalties for producing intermittent power.

Many of the issues ultimately relate to financial risks to investors: the financial risks of building and operating new, relatively untested technologies in liberalized systems mean that investors may be wary of financing new projects where the return on their investments is uncertain. They will be unwilling to put money into potentially risky renewable energy projects, if they have other less risky investment opportunities. The key question for evaluating the different mechanisms for supporting renewable energy technologies is therefore whether or not they will create sufficient investor confidence to develop projects (see box 1 below for perspectives of risks from the private sector).

Box 1. **Private-sector perspective**

"The three most important 'deal breakers' to private investors have been found to be:

- Insufficient legal protection and framework for protection of investor rights.
- Lack of payment discipline and enforcement.
- Too few guarantees from governments or multilateral institutions."

> *Regulation in Africa – Investors and Operators Regulatory Concerns, Mr. T. Horvei, Chief Executive , SAD-ELEC (Pty) South Africa, Report of the Proceedings of the 2nd Annual Conference of the African Forum of Regulators (AFUR), March 2005*

Key regulatory risks experienced by investors

- Weak and ever-changing regulatory frameworks.
- Right of government to override regulatory decisions.
- Lack of clarity about power of regulator.
- Regulator without necessary minimum skills, capacity and competence.
- Unilateral regulatory decisions undermining project and investment returns.
- Playing field tilted in favour of dominant industry player (most often a state-owned enterprise).

> *(Extract from the AFUR discussion paper "Infrastructure Investment and Regulation in Africa – Investors and Operators' Regulatory Concerns" presented at the AFUR 2nd annual conference)*

4. DESIGN ISSUES FOR REGULATORY/ SUPPORT MECHANISMS

As well as the need to encourage investor confidence, there are also other important factors for policymakers and regulators to take into account when evaluating different regulatory/support mechanisms. Some of these are summarized below:

- Will the scheme be effective in reducing investment risks to enable the deployment of renewable energy technologies, while encouraging investors? This is a fundamental requirement, although the advantages given to renewable technologies should not be disproportionately costly to consumers or taxpayers.
- Will these costs be spread fairly across business, individual consumers and government?
- Whether the mechanism is an effective means of meeting any target set for renewable energy generation.
- Whether the mechanism will encourage new renewable energy plants, or whether it just encourages the installation of new capacity.
- How will the mechanism interact with other energy policy measures such as R&D programmes or investment support schemes (in the few African countries where such programmes/schemes exist)?
- Will the mechanism encourage reducing prices for new technologies over time, through reducing or compensating for market failures or through technological development?
- Will it be sufficiently flexible to take technological developments and reducing costs into account in the future, so avoiding the potential for developers to make windfall profits?
- Will it offer the potential for commercial or technical opportunities, for example, the development of a domestic manufacturing industry?
- Whether it will encourage a range of renewable energy technologies, or whether it will concentrate only on one.
- Whether it will encourage new entry into electricity generation.
- Whether the scheme will be transparent for all users.
- Whether it will allow exports/imports of power.

The weight given to these design issues will obviously depend on the priorities and intentions of individual governments, and the final choice of mechanism will have to take them all into account. For example, if costs to consumers are a central concern, policymakers may want to implement a competitive mechanism such as the quota system. On the other hand, if achieving specific levels of output are a key driver, then less competition-focused mechanisms such as feed-in tariffs may be more appropriate.

In order for the scheme to be effective, those involved will also need a good understanding of the characteristics of renewable energy generation technologies, the workings of the broader electricity system, and broader issues such as the potential for innovation or declining technology costs.

5. TYPES OF REGULATORY AND POLICY SUPPORT MECHANISMS

This section gives a brief overview of the different characteristics of some of the main regulatory and policy support mechanisms. This is a generalized overview and it should be borne in mind that in reality the detail of different schemes can vary considerably. It should be read together with the more detailed descriptions of individual programmes, which are given in the case studies. The types of regulatory/support mechanisms are categorized into two: firstly, mechanisms that are immediately applicable to sub-Saharan African countries; and secondly, other mechanisms implemented in the developed world that may be applicable to the African region in the future.

5.1. Short-term regulatory/support mechanisms

The mechanisms discussed under this section are those that have either been implemented in some African countries or in other developing countries. These mechanisms to a large extent are relatively straightforward for African regulatory agencies to implement and may not need significant changes to the Electricity Act.

These include:

- Establishing “standard” power purchase agreements (PPAs);
- Ensuring long-term electricity generation licences and PPAs;
- Developing a favourable tariff setting and adjustment formula;
- “Light-handed” regulation.
- Setting explicit targets for the share of renewables in the electricity generation mix;
- Enacting explicit regulations that encourage local private participation in renewable energy development;
- Providing subsidies to renewable energy-based power systems especially those located in rural areas (e.g. tapping into rural electrification funds).

Establishing “standard” power purchase agreements (PPAs)

In principle, most sub-Saharan African countries are committed to private sector supply of power to the national grid. However, negotiations with the utility to purchase energy from small producers tend to be cumbersome and the tariff offered unattractive to develop renewable energy projects to their full potential.

This market uncertainty stands in the way of substantial investment in renewable energy-based electricity generation in the region. In South Asia (Nepal and Sri Lanka), market uncertainty was overcome by instituting a “standard PPA”—a “standard offer” from the national utility to purchase all energy produced by specific renewable energy-based independent power producers (IPP) at a pre-announced price. This is somewhat akin to the feed-in tariff legislation implemented in developed countries such as Germany. The absence of such a “standard offer” inhibits the scaling up of small renewable energy investments in the power sector to their full market potential (UNEP/GEF, 2006).

The lack of clear rules to allow the sale of power produced from sustainable energy systems discourages investment opportunities in renewable energy-based electricity generation. In particular, lack of commitment from the utility to purchase excess power produced at an attractive feed-in tariff can often limit the renewable energy project to a size, which is less than optimal in terms of the available resources. Similarly, lack of regulatory measures to encourage agro-processing industries to sell excess power to neighbouring rural communities results in sub-optimally sized projects.

Ensuring long-term electricity generation licenses and PPAs for IPPs

In most sub-Saharan African countries with IPPs, typically, generation licences are issued for varying periods of 7 to 15 years. This implies that the investors have a very limited period of time to recoup their costs and make a decent margin. Issuing longer-term electricity generation licences and PPAs to independent power producers (e.g. 15-30 years) can ensure that the feed-in price of electricity charged by the investors of sustainable energy systems is moderated. This is essentially because, longer-term agreements allow for sufficient time for the investor to payoff project financing debts as well as providing adequate amortization periods for the equipment.

Developing a favourable tariff setting and adjustment formula

The calculation of the feed-in tariff on the basis of the cost of the fuel can result in very low feed-in tariffs offered to renewable energy development as the cost of renewable fuel is often very low or sometimes free but with higher equipment costs. A more favourable tariff setting and adjustment formula is one that takes into account the “avoided cost” of installing competing thermal power plants. For example, in Mauritius, the Government set up a technical committee at the Ministry of Energy to address the issue of energy pricing and power purchase agreements for bagasse-based cogeneration. In the price setting mechanism, the committees worked on the basis of the cost of a 22 MW diesel power plant. On this basis, the utility was directed to determine the tariff at the "avoided cost" for the diesel power plant, which in turn became a standard feed-in price for electricity generated by the sugar mills.

"Light-handed" regulation

"Light-handed" regulation refers to the regulatory agency's deliberate action to either "ignore" or make less stringent provisions for a player or group of players. In this case, it would entail the regulatory agency explicitly exempting or significantly reducing the statutory requirements of investors in sustainable energy. For example, the regulatory agency may waive the need for licensing small to medium scale renewable energy investments below a certain threshold (in the case of Nepal, initially the threshold was 100 kW capacity but was eventually increased to 1 MW).

Setting targets[2] for the share of renewables in the electricity generation mix

To mitigate the negative trend of having an excessively large share of IPPs generating electricity from fossil fuel-based power plants or large-scale hydro plants (that can be prone to drought-related risks), the regulatory agencies in collaboration with the Ministries of Energy can set explicit targets for the share of electricity generation from proven renewable energy technologies such as hydro, wind, solar PV, biomass-based cogeneration and geothermal. Kenya provides a model example where such targets have been set. The Government of Kenya has set a target of 25 per cent of electricity generation to come from geothermal energy by the year 2020. Consequently, an IPP is actively exploiting this resource as part of a broad investment effort aimed at meeting the year 2020 target.

Enacting explicit regulations that encourage local private participation in renewable energy development

The examples of Kenya, Mauritius and Zimbabwe demonstrate the potential financial and technical capability and viability of local private investors in the power sector. This is corroborated by findings from recent AFREPREN/FWD studies which indicate that local private investors can own and operate small to medium-scale entities in the power sector, either on their own or with foreign partners (see

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[2] Targets should not be confused with "quotas" which are discussed separately. "Targets" are usually set at the policy level, while "quotas" are often backed up by legislation and might imply certain consequences befalling a specified party for failure to meet the "quotas" or exceeding them.

Marandu and Kayo, 2004). Appropriate policy and financial incentives such as enactment of lower entry requirements, tax holidays and lighter regulation of initial public offers (IPOs) can encourage local private investment in a privatized electricity industry. The ideal entry point, as in the case of Zimbabwe and Mauritius, is likely to be in renewable energy systems such as small hydro and wind energy sources as well as through local cogeneration in agro-based industries.

Providing subsidies to renewable energy-based power systems

Although developing renewable energy-based power systems in rural areas can register poor returns on investment, linking decentralized renewable energy power plants to rural electrification provides local benefits and increases the sustainability of such projects. However, adding the rural electrification component increases capital costs and also lowers the overall load factor of the power plant by increasing demand during peak hours and using small amounts of power during the rest of the day. In order to provide a reasonable return on investment, the capital cost of rural electrification needs to be covered in part or fully by subsidies in the form of grants by the government sourced from rural electrification funds or from donors.

A number of governments (primarily Uganda but also Kenya and Tanzania) in the region have put in place grants for private companies that expand rural electrification services, particularly those using renewables for electricity generation. The Ugandan government under its Energy for Rural Transformation (ERT) Programme will pay the additional cost accrued to the private power developer for providing rural electrification. One example of this is the West Nile Rural Electrification Company, which in April 2003 was awarded the concession of the West Nile region. This company is investing in a 3.5 MW small hydro project with partial grant support from the ERT. Three other energy service companies (ESCOs) in Uganda are investing in new generation capacity on similar terms.

Review question

1. Name at least five regulatory/support mechanisms that can encourage renewable energy development in the African power sector in the short term.

5.2. Medium to long-term regulatory/support mechanisms

These support mechanisms are largely implemented in the developed world. Some of them require sophisticated implementation strategies and, in some cases, enactment of new laws or significant changes to the Electricity Act. As mentioned earlier, with the exception of South Africa and possibly Mauritius, few sub-Saharan African (SSA) countries have implemented these regulatory/support options. In many SSA countries, the sophisticated regulatory and legal prerequisites that are required are yet to be put in place.

Feed-in tariffs

Feed-in tariffs offer either a minimum guaranteed price for output or a premium on the market price for output. In either case, electricity utilities are obliged to allow generators to connect to the grid, and to buy all of a project's output at a pre-defined price.

Key features:

- The scheme can be open-ended, or can be put in place for a specified number of years.
- The tariff schemes can be banded for different technologies, with less developed technologies receiving higher prices for their output.
- The level of the tariff can be set by assessing several factors such as:
    The avoided cost to the utility of building its own new plant;
    The end price to the consumer;
    A more explicit political decision about the level of tariff necessary to stimulate renewable deployment.
- The costs of the tariff can be covered by a levy per kWh on consumers, or on taxpayers, or both.
- Tariff levels can be set to decline over the years, reflecting the potential for declining technology costs.

The level of the tariff tends to be set for several years at a time, often through legislation, meaning that there is a high degree of certainty for investors on the returns available, and a high level of confidence about the duration of the scheme. Schemes offering a minimum guaranteed price tend to provide more certainty for investors than those which offer a premium on the market price, this being due to the higher degree of predictability that this affords.

The level of deployment of technologies is not set in advance, but instead is driven by the level of the premium in the tariff price. In other words, the government sets the price for the output from renewable energy generators, but lets the market determine the level of output. This in turn means that the total costs of the scheme are not known in advance because the costs will depend on the success of the mechanism in driving new capacity. Having said that, it would be possible to make sensible predictions about the amount of new capacity likely to be stimulated and hence the costs, based on the prices set in the tariffs.

Similarly, the length of a scheme can mean that technological developments over the course of a few years allow participants to make windfall profits in the last few years. A degree of flexibility should therefore be designed in to any scheme to ensure that the tariffs are not set unreasonably high, especially in the later years of a scheme.

The design of a tariff scheme may have to take into account the availability of renewable resources. For example, areas of high wind will obviously prove more attractive to developers seeking to maximize their returns. This can mean that networks in areas with high wind resources are targeted by developers, which in turn means that the customers of the network in that area are potentially subject to higher prices than network customers in areas with less wind. The tariff scheme can be designed to minimize this by offering higher prices for wind output in areas with less wind resources, so encouraging developers to site projects there. Alternatively, in order to distribute the financial impact equally over consumers and to avoid significant differences in price, the levy to finance the feed-in scheme can be equally covered by all the existing networks (cf. Germany).

As well as the level to which the tariff is set, the success of such schemes can depend on:

- Access charges to the grid—transmission or distribution.
- Any limits set on capacity.
- The ease of siting projects—i.e. getting approvals through planning systems.

Quota mechanisms

Quota mechanisms, also known as renewable portfolio standards (RPS), are an obligation for electricity suppliers to take a certain amount of sustainable power, or for customers to source a proportion of their power from renewable energy sources.

Key features:

- The percentage can increase over time, driving increased deployment.
- Utilities can also choose to pay a penalty rather than buy their allocation of the obligation.
- No requirement for utilities to allow priority access to networks.
- The operation of the system is supported by tradable green certificates for the output, which certify that the supplier has actually bought renewables-based power. These certificates can be sold with the power, or traded separately. In either case, the value of the certificate adds value to the actual generation. Green certificate markets are discussed in more detail below.
- Certificates could be banked for use in future compliance periods. This banking period is usually limited (generally five years).

In contrast to tariff systems, the government sets the desired level of output, and allows the market to decide the price that will be paid for it. A quota system avoids the government selecting which technologies will receive the benefits, instead leaving the technical choices to the market.

The level of incentive for the utilities to comply with the obligation depends on the level of the penalty payment set—the higher the cost for non-compliance, the more incentive to buy renewables-based power.

The value of renewables-based power can be further enhanced by redistributing any of the money paid as penalties to companies who have met their obligation. Utilities decide how best to meet this obligation, and what projects they will contract with if they chose to buy renewables-based power. Not surprisingly, utilities will chose to contract with the cheapest forms of generation, so meeting their obligation in the most cost effective way. This will keep the cost to companies and consumers down. In addition, there is no requirement for utilities to sign long-term contracts with generators for their output. The short-term nature of the market can act as a disincentive to investment across the board.

The need to negotiate deals with utilities for their output implies a degree of expertise and resources for developers. This may limit new entry into the system, or at least limit entry to relatively large, well-resourced entities. In addition, new entry by smaller companies may be limited by the investment risks inherent in the mechanism, effectively meaning that only large companies with diverse portfolios are able to participate. Both of these problems can be addressed by ensuring the availability of consolidation services to allow smaller developers to pool their output, reducing individual participation costs and risks.

If certificates can be banked from one compliance period to the next, careful monitoring will be needed to ensure that no gaming takes place, and that there is not a tendency for the development of renewable energy to enter a "boom and bust" cycle.

Quota mechanisms are relatively new, so there is limited evidence on their performance. However, it appears that the emphasis on the market can have two particularly significant impacts for generating technologies:

- Only the cheapest forms of generation will receive contracts.
- Less developed—and therefore riskier—technologies will not receive contracts, so limiting their future development and deployment.

If a government wants to support a diverse portfolio of renewable energy technologies, including developing technologies, other support mechanisms (such as capital grants) will be required to compensate for the short-term nature of the market.

Review question

What are the main differences between a feed-in tariff system and a quota system?

Tender schemes

Under a tendering scheme, competitive bids are put forward to government for individual renewable energy projects, following a call for tenders launched by the government.

Key features:

- Suppliers are obliged to buy a certain amount of renewable power at a premium price.
- Although specific characteristics vary, it is likely that the government will:

  Set an overall target for renewables-based generation, adding specified limits for individual technologies within that.

  Set a specified time for contracts for the generation, during which time they will receive a premium price.
- The winning contracts are selected by the government, usually on the basis of cost, although in some schemes other factors such as technical quality and socio-economic aspects also play a role.

- Successful projects can either:

  Receive the price they have bid, or

  A “strike” price based on an assessment of developers needs.

- Can be banded to encourage the development of newer technologies.

Because there is a guaranteed premium for a set period of time, tender schemes can increase investor confidence in renewable energy projects. This is, of course, highly depended on the length of the contact and the price offered. However, the bureaucracy of the schemes and the government tender processes can act as a disincentive to put projects forward, as this implies significant project development costs without a guaranteed contract.

In addition, tender schemes tend to be stop/start, with months or even years between different bidding rounds. This can create a “boom and bust” environment for developers, who may be active for some periods, but without new projects for others. This in turn can discourage the emergence of a domestic renewable manufacturing industry, as there is no certainty about the frequency of the periods of “boom”.

Voluntary mechanisms

Green certificates

As well as operating with a quota system, green certificates can be used in voluntary markets to support renewable-based generation. The certificates can be traded separately from the power and sold to consumers who are willing to pay the additional cost to support sustainable energies. However, in the case of voluntary markets, the success of the scheme will rely on consumer awareness and willingness to pay the additional cost. Voluntary schemes pre-suppose a high-level of environmental public awareness—which is virtually absent in most of sub-Saharan Africa.

Because of their voluntary nature, green certificate schemes do not necessarily provide confidence to investors to develop new projects. Green certificate schemes therefore rely heavily on the success of other support measures (e.g. grants, soft loans, tax credits) in order to provide this confidence and to keep costs low enough to make sustainable generation attractive to consumers. Other strategies, such as the disclosure of the generating source and green power marketing can complement voluntary green certificate markets—these are outlined below.

Disclosure

In addition, green certificates schemes can be supported by policy measures such as the disclosure of the generation source of electricity on consumers' bills. Disclosure is based on the assumption that in a competitive market, consumers may chose to buy their power from less environmentally damaging forms of generation rather than solely allowing their choice to be dictated by the price. Disclosure requirements can include information on the type of generation, the amount of carbon dioxide emitted per kWh or the amount of radioactive waste produced.

Green power

A related issue is selling "green" power to consumers in markets where consumers can chose their supplier. This assumes the presence of a retail competitive power market—this has yet to be tried in Africa. This is again based on the premise that some consumers would include environmental performance in their choice of power supplier.

Green power schemes offer a way for suppliers to differentiate their product, and often to charge a premium for it over market prices for "brown power". In some markets, such as the UK, this has led to a situation where suppliers are obliged to provide a certain proportion of their power from renewable sources under the renewable obligation, but some have chosen to fulfil this obligation by marketing the green power separately from their standard product and to charge a premium for it. This approach allows them to offset any additional costs of contracting for renewable output—or even to profit from the fact that they are obliged to contract for it. Other companies have chosen to contract for green power in addition to any renewable obligation they might have.

Voluntary schemes rely on support from other measures to drive a viable market. Information provided to environmentally conscious consumers could act as a driver, as can the marketing opportunities of supplying green electricity.

Concerns have been raised that green power schemes do not necessarily encourage new construction, but rather maintain output from older schemes. This can be avoided by devising schemes, which explicitly state that revenue from a scheme will be used to build new renewable projects.

Various hybrid schemes involving two of the above mechanisms

Some countries—notably Spain and Belgium—have chosen a mixture of support mechanisms to drive renewable energy development. The strength of this approach is that it allows the strengths of individual mechanisms to be adopted, and for the weaknesses to be compensated for by other measures.

The flexibility of hybrid schemes also allows investors to choose which aspect of the scheme suits their finances and the type of project best.

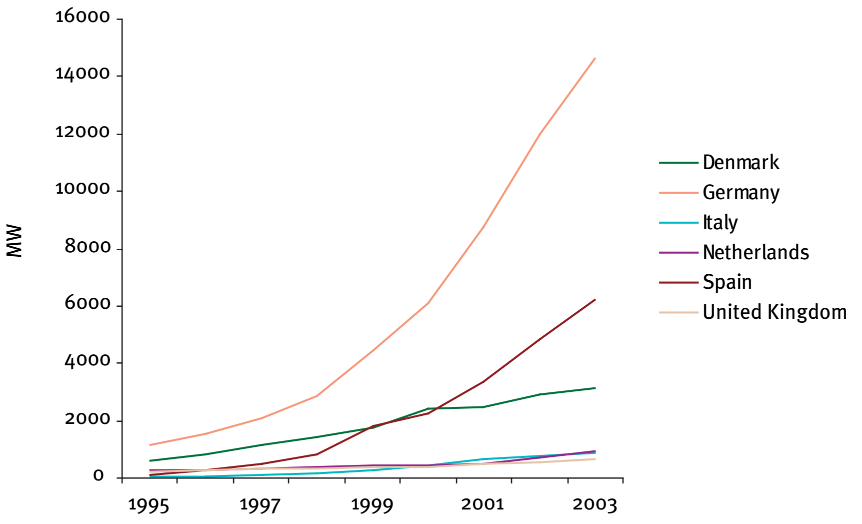
5.3. Regulatory and policy support mechanisms in practice

Regulatory/support mechanisms for renewable technologies are relatively new policy and regulatory measures, and have often been in place for only a few years. In Africa, the experience with such mechanisms is even more limited. Given the length of time it can take to develop new projects, evidence of their success or otherwise can therefore only be presented as indicative.

In addition, many of the support mechanisms in place have tended to concentrate on wind power, as this the most developed renewable technology. This means that other renewable technologies, which may be more appropriate in other countries, may have been neglected by the available support measures.

However, on the basis of the schemes to date, it appears that tariff schemes have been more successful than tender and quota schemes at encouraging the deployment of wind power in particular—installed capacity of onshore wind in Denmark, Germany and latterly Spain far outweigh installed capacity in other countries which have adopted more of the competitive tender and quota mechanisms (see figure I).

Figure I. Onshore wind cumulative installed capacity (MW)



In comparison, countries which have used quota or tender systems show a far lower level of development. This is not entirely unexpected, given the investor certainty ensured by fixed payment tariffs. However, it should be noted that there may also be local factors related to the design or wider policy contexts of specific schemes that have contributed to the different rates of development—it may not just be down to an inherent superiority of one type of mechanism over another.

So, for example, the ease of getting planning permission for projects or connecting projects to networks can directly affect the rate at which renewable energy projects are implemented. Similarly, the uncertainty created by the possibility of future changes to schemes can also reduce investor certainty. Some of these issues are highlighted in the individual case studies.

It is important therefore to remember that the interaction between the mechanisms outlined above and other policy measures in place to support renewable energy will play a vital role in the success of any programme to encourage the deployment of sustainable energy technologies.

Review question

Describe in short the main support mechanisms for renewable energy.

Discussion question/exercise

Given the particular situation in your country, which of the described support mechanisms might prove most useful? Describe the particular situation and give reasons for the support mechanism(s) chosen.

Bear in mind that investor confidence is a crucial aspect, and that you can combine aspects from different support mechanisms.

6. EXAMPLES OF REGULATORY AND POLICY SUPPORT MECHANISMS IN AFRICA AND OTHER DEVELOPING COUNTRIES

6.1. Mauritius: standard feed-in prices for bagasse-based cogeneration

Efforts have consistently been made over the past 40 years in Mauritius to exploit this bagasse-based cogeneration for energy generation. St. Antoine Sugar Factory became the first exporter of electricity to the grid in 1957, when around 0.28 GWh was sold to the Central Electricity Board (CEB)—the national electricity utility.

In early 1980s, two other bagasse-energy generation projects were implemented. The first one was a sugar factory located at Médine, with an installed capacity of 10 MW to supply around 6 MW to the grid. It was designed to generate what is termed as “continuous power” that is, using bagasse as feedstock for combustion, during the cane-crushing season only.

The second was in 1982 when another factory—FUEL—commissioned a power plant with 21.7 MW of installed capacity. This plant exported electricity all year-round, using bagasse as feedstock for combustion during the crop season and coal during the intercrop season. This arrangement was termed “firm power”. With the successful operation of these two units, the amount of electricity generated from bagasse reached 70 GWh/year.

As the significant potential for cogeneration became apparent, there was a need to have a standard feed-in electricity price to avoid the need for each sugar factory to independently negotiate with CEB. Therefore, the Government set up a technical committee at the Ministry of Energy to address the issue of energy pricing as well as a power purchase agreement (PPA). To develop a price setting mechanism, the Committee worked on the basis of the cost of diesel plant of 22 MW capacity—the next planned installation by CEB. Consequently, the Committee determined the avoided costs and recommended the kWh price for electricity generated from cogeneration.

For the “continuous” power plants, the price of the electricity was set to about US$ 0.04 and was indexed to the price of oil. These plants have PPAs for 15 years with provisions for the supply of a minimum of 16 GWh every crop season, the export of 45 MW of power to the grid. Other provisions include a power intake of 3.5 MW daily during off-peak and a bonus/penalty for minimum power supply/default.

The “firm” power plants have slightly longer PPAs of 18 years to supply 180 GWh of energy per year. The minimum from bagasse is 45 GWh. During the crop period, the minimum power is 11 MW as semi-base load and 17 MW for two hours during evening peak. Power during the off crop season is 13 and 18 MW respectively. The kWh price is about 0.055 US cents, indexed to the price of coal and the exchange rate of the US$ and the euro.

Furthermore, there is a provision to ensure that the utility also buys intermittently available electricity from the sugar factories. However, the price for intermittent power is frozen at US$ 0.006 per kWh so as to discourage this highly inefficient mode of electricity generation. As the price setting mechanism has to provide for a value of the fuel utilized, the bagasse used for generation purposes is priced at Rs100 (or US$ 3.7) per tonne.

The overall effect of the standard feed-in electricity tariffs has been the gradual phasing out of intermittent electricity generation and shifting towards continuous as well as firm power. Tables 1 and 2 show the evolution of the electricity generated from bagasse/coal and equivalent amount of bagasse used over the 1988-1998 period. This is the period during which bagasse-energy development was a high priority issue in the Mauritian sugar industry. On the whole, electricity generated from bagasse has increased by more than three-fold over the ten-year period.

In parallel to the incentives for bagasse-based cogeneration, policy measures have been introduced to increase the efficiency in electricity production. Those measures include:

- A performance linked export duty rebate payable by millers related to their efforts in energy conservation to generate surplus bagasse and in energy generation, preferably, firm power.
- Income tax exemption on revenue derived from the sale of bagasse electricity, and capital allowances for investments in energy efficiency.

In response to these incentives and policies, the sugar industry has implemented a number of measures to efficiently use energy in sugar cane processing, e.g. improved sugar recovery, the enhancement of the calorific value of bagasse, reduction in power consumption in the prime movers of sugar manufacturing equipment, reduction in process heat consumption in juice heating and evaporation, adoption of continuous processes, factory computerization and process automation.

Table 1. Evolution of electricity production from the sugar industry (GWh) and kWh/tonne cane

Power	Fuel source	Year										
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Firm	Bagasse	41	26	18	39	50	39	44	46	70	66	112*
	Coal	34	68	45	54	43	40	46	41	10	23	62
Continuous	Bagasse	19	20	24	21	28	27	28	30	33	53	109
Intermittent	Bagasse	12	10	11	10	6	4	4	5	7	6	4
Total GWh (bagasse)		72	56	53	70	84	70	76	81	110	125	225
Total GWh (bagasse and coal)		106	124	98	124	127	110	122	122	120	148	287
Total tonne cane (x 106)		5.52	5.44	5.55	5.62	5.78	5.40	4.81	5.16	5.26	5.79	5.78
kWh/tc		13	10	10	12	15	13	16	16	21	22	39

Source: Deepchand, 2003.

*Includes 30 GWh of electricity generated in 1999 from Crop 1998 stored bagasse.

Table 2. Evolution of equivalent tonnage of bagasse (X 10^3) used for electricity export

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Firm	93	58	40	88	114	90	100	104	160	149	254
Continuous	49	51	59	53	70	68	70	76	83	133	272
Intermittent	34	30	30	29	18	11	11	14	21	17	10
Total	176	139	129	170	202	169	181	194	264	299	536

Source: Deepchand, 2003.

6.2. Kenya: explicit target for share of renewables—case of geothermal energy

Starting in 1981, Kenya was the first country in Africa to exploit geothermal resources for electricity generation. After some inconclusive initial exploration at Olkaria in the 1950s, interest revived during the 1970s. A feasibility study carried out to evaluate Olkaria's potential for generating electricity found that the geothermal field covered 80 km² and could provide steam sufficient to provide 25,000 MW of generation capacity (assuming re-injection which would make it fully renewable). So far, 103 geothermal wells have been drilled in Kenya for exploration, production, monitoring and re-injection. Of these, 97 wells are in the Olkaria area and the rest in the Eburru field (Mariita, 2002; Mbuthi 2004).

The draft National Energy Policy provides a target for the contribution of geothermal electricity generation in Kenya. The policy provides that by the year 2020, the installed capacity of geothermal energy is expected to account for a quarter of the total installed generation capacity up from the current 9.7 per cent (Mbuthi and Andambi, 2004). Consequently, to encourage investment in geothermal development for electricity generation, the energy policy provides the following incentives (Republic of Kenya, 2004):

- Ten-year tax holiday for geothermal plants of at least 50 MW; seven years for plants in the range of 30-49 MW; and five years for plants between 29-10 MW.
- Seven-year tax holiday on dividend incomes from investments made from domestic sources.
- Duty and tax exemptions on the procurement of plant equipment and related accessories for generation and transmission during project implementation. In addition, the procurement of spare parts would be made free of duties and taxes.

Consequently, Kenya's geothermal energy developed has realized an installed capacity of 127 MW, of which 12 MW is exploited by ORMAT International, an independent private power producer (KPLC, 2003; Mbuthi and Andambi, 2004).

6.3. South-east Asia: standard PPAs for small hydropower development

Small hydropower development in Nepal

As a direct result of the liberalization in the power sector brought about by the Electricity Act (1992), international independent power producers (IPPs) invested in two medium hydropower projects in 1995: the Khimiti Hydro Electric Project (60 MW) and Bhote Koshi HEP (36 MW). The PPAs for these projects were negotiated on a case-by-case basis between the utility and the IPP. In October 1998, the government of the time announced that the national utility, Nepal Electricity Authority (NEA), would purchase all energy produced by small producers (5 MW or below) at a standard "power puchase agreement (PPA)"[3]. By early 1999, the first small hydro IPPs began to carry out feasibility studies and approach financial institutions with the standard PPA in hand. The first financial closure by local banks took place in 2000 and the Syange project (183 kW) was on line in January 2002 followed by the Piluwa Khola (3 MW) project October 2003.

Even after the standard PPA was announced, prospective IPPs remained skeptical about the credibility of the utility's offer. There was only limited confidence

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[3] The rate was Rs 3.00 (4 US cents) for the dry season and Rs 4.25 (5.7 US cents) with an escalation of 6 per cent per year for five years on the local currency rate.

that small hydropower could be developed into a profitable sector at the rates being offered. Support was provided by Winrock International and GTZ to entrepreneurs and their engineering consultants by sharing feasibility costs, providing free technical reviews of feasibility studies and site construction, and by helping them negotiate with the utility, banks and insurance companies.

After the "standard PPA" was announced, over 50 feasibility studies were completed, 20 PPAs signed, 10 projects reached financial closure, and seven projects have commenced construction resulting in five completed projects. The projects that were financed after the "standard PPA" came into force are marked in bold in the table below. Once the barrier of market uncertainty for the produced electricity was removed through the "standard PPA" and developers gained confidence in the sector, hydropower has become attractive as an investment sector to both private developers and financing institutions, despite the ongoing insurgency in the countryside. All financing for these hydropower projects has come from local banks. Nepal has seen an investment by local banks of some US$ 47 million in new small hydropower projects in the last seven years, of which US$ 13 million has gone to smaller projects under the "standard PPA".

Table 3. Private sector investment in small hydro in Nepal

Projects	Size (MW)	Date of commissioning	Total cost (US$M)	Local financing (US$M)
Khudi	4.0	June 2006	6.36	4.47
Sisne	0.75	2006	1.4	0.99
Chaku	1.5	Jun 2005	1.64	1.15
Sun Koshi	2.6	Mar 2005	3.6	2.51
Rairang	0.5	2004	0.45	0.29
Piluwa	3.0	Oct 2003	5.5	3.16
Chilime	20	Aug 2003	30	19.86
Indrawati	7.5	2002	20.5	14.29
Syange	0.2	Jan 2002	0.3	0.16
Jhimruk	12	1995	20	Norwegian grant
Andhi Khola	5.1	1991	3.8	Norwegian grant

Note: Jhimruk and Andhi Khola have been privatized and are now operated by the Butwal Power Company.

Small hydropower development in Sri Lanka

In 1996, as part of the liberalization in the power sector started in 1994 by the Sri Lankan government, the Central Electricity Board (CEB) allowed the grid connection of private small hydro (<10 MW) and issued a "standard PPA" starting in

1997 and revised annually. The rate on the PPA was determined by the avoided cost of fuel at the CEB thermal plants and hence to the international price of petroleum fuel. The international fuel prices were averaged over three years to avoid large spikes which often occur in petroleum prices. This means that private small hydropower developers are paid only for the energy (MWh) they produced and not for the capacity (MW) which they also contribute to the system. Despite this, returns on investment were found to be attractive with simple payback periods typically of around 3-4 years or less. The published feed-in tariff is shown in the table below. It is likely that the persistent high price of petroleum products will help to contribute to continued and increased returns to investors.

Table 4. PPA feed-in electricity prices in Sri Lanka for small hydropower

	Dry season (Feb.-April) Rs/kWh	Wet season (balance months) Rs/kWh
1997	3.38	2.89
1998	3.51	3.14
1999	3.22	2.74
2000	3.11	2.76
2001	4.20	4.00
2002	5.13	4.91
2002	5.90	5.65
2003	6.06	5.85
2004	5.70	4.95
2005	6.05	5.30

US$ 1 = SL Rs 100, so the Rs can be read as US cents.

6.4. Photovoltaic energy service companies in Zambia[4]

Introduction

The following example is the result of a well-thought out scheme that has been implemented in the Eastern Province of Zambia. The programme of rural electrification in Zambia shows that the concept of ESCOs offers an interesting policy tool and could be replicated in other countries.

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[4] Lemaire X. (2006) Case Study: Photovoltaic Energy Service Companies in Zambia. Centre for Management under Regulation, Warwick Business School.

Energy service companies (ESCOs)

The concept of ESCOs[5] was launched in 1998 in the Eastern Province of Zambia with the support of the Swedish International Development Agency (SIDA). In the first version of the project, the Zambian government would buy the photovoltaic solar systems that are lent to an energy service company, which could have up to 20 years to reimburse the loan from the government (initially a donation from the international agency).[6] The ESCO installs solar equipment in households and small shops and charges a limited fee. Then, the ESCO gets a monthly payment for the systems. A battery fund has been created to replace the batteries regularly.

Unlike conventional installers, these small enterprises are not paid for the installation of a product—the initial fee covers just a small part of the cost of installation—instead they are paid for the delivery of an energy service to their clients. In this scheme, ESCOs are given incentives to ensure a continued operation of the systems, as the customers pay only for the time that the service is provided. In fact, ESCOs are not operationally far from conventional utilities who would charge a low cost of connection to the grid and receive a monthly payment from their customers for the delivery of electricity.

Key ESCO aspects

The selection of the enterprises to become ESCOs was done in 1999. Now three autonomous ESCOs exist in the districts near the border with Mozambique and Malawi: one in Nyimba—operational in 2000 (NESCO), one in Lundazi—operational in 2001 (LESCO) and one in Chipata—operational in 2002 (CHESCO).

ESCOs are small structures with a director/project manager, two finance/administrative staff and 2-3 technicians. ESCOs photovoltaic systems include currently a 50 Wp panel with a 90-105 Ah battery. Each ESCO has its own history and faces specific constraints due to its location.

In Lundazi, LESCO has 150 systems, out of which 70 are currently operating. The other systems are not working mainly due to battery problems. The majority of battery failures are in the Zambia National Service Camp. LESCO is facing financial problems due to non-payment of the monthly service fee by this institution.

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[5] The project described in this case study is mainly funded by the Swedish International Development Agency (SIDA) with the technical assistance of the Stockholm Environment Institute and the University of Zambia.

[6] In 2005, the formal ownership of the solar systems has been transferred to ESCOs and it has been decided that the capital will have to be reimbursed in 10 years instead of 20 years, but with a 50 per cent capital subsidy. In the future, ESCOs will get a loan from a credit facilitator and buy directly the solar systems.

In Chipata, CHESCO has 150 systems, out of which 140 systems are currently working. CHESCO has faced a lot of difficulties with the tokens of a SIEMENS prepayment system. Every time the charged tokens were not recognized, the client had to return to CHESCO's office in Chipata from sometimes as far as 60 km and CHESCO had to give them extra days of electricity as compensation.

In Nyimba, NESCO has 100 systems, 94 systems are currently working. NESCO was the first ESCO established, and now seems to have a good knowledge of the systems.

To establish comparisons, the cost of connection to the grid with ZESCO is 300,000 ZMK (US$ 91) in the capital Lusaka, 500,000 ZMK (152 US$) in Nyimba and 800,000 ZMK (US$ 244) in Lundazi. The monthly payment for grid electricity depends of course on the level of consumption, but is on average far less than the monthly service fee charged by ESCOs for solar energy, especially for the kind of appliances used. The low residential consumer monthly tariff of ZESCO is 18,000 ZMK (US$ 5). This is due notably to the fact that electricity from the grid is highly subsidized in Zambia.

A positive commercial relationship with clients

400 clients are now paying a monthly fee to the ESCOs for solar photovoltaic electricity. Each ESCO has a waiting list of 400-500 clients. Solar systems enable small businesses to extend their hours of work and therefore to improve their income generation. For households, solar systems improve the quality of life by supplying basic needs such as light, TV and radio. The impact of a basic service such as light seems to be tremendous, especially for pupils who can study during the night. According to the latest available data, there has been a good payment record, no acts of vandalism and very few solar panels have been stolen, this being due to strong social control. Nevertheless, due to default of payment, a limited number of solar systems have been repossessed.

Technicians of ESCOs have to go every month to visit the clients and collect fees (except for prepaid systems). It means therefore that an inspection of the installation is conducted monthly. This also enables ESCOs to have regular feedback from their customers.

Persistent technical problems that are or can be solved

The main technical problem comes as usual from the batteries and the regulators. For various reasons, very few batteries from the first installations are still working. The initial design of the different systems and the quality of some batteries seems the issue. At the start, the ESCOs lacked the capacity and the necessary qualifications to maintain the systems. There could be also a tendency to overuse the systems, especially in businesses. Now, it seems that with a change of the kind of batteries used, the training of ESCO technicians in order to enable them to design the systems, and the dissemination of information to clients who are now more aware of the possibilities and limits of their solar system, these initial technical difficulties are about to be solved.

Financial uncertainty for ESCOs

ESCOs get a long-term loan that has to be refunded. ESCOs charge an installation fee that represents less than 10 per cent of the cost of the system (which is about US$ 900). The monthly fee is currently around US$ 10-13, which seems to be the maximum that clients are willing to pay. This covers the running costs (servicing, maintenance) of the ESCOs, but cannot cover all the capital costs. In fact, now that the ownership of the installations is progressively and officially transferred to the ESCOs, it has been agreed that 50 per cent of the capital cost will finally have to be subsidized for the first installations and 25 per cent for the new installations that the ESCOs will buy from now on (Swedpower, 2005, p. 5). Some uncertainty seems to remain on the future of the exemption of VAT for ESCOs.

Moreover, the inflation rate in Zambia is still around 20 per cent per year (compared to 400 per cent at the beginning of the 1990s).[7] ESCOs are importing all the components of solar systems that are paid for in US dollars while they are being paid in local currency by customers who cannot easily absorb successive increase of the monthly fee. This creates considerable distortion for ESCOs.[8]

Important points for replication

Even if ESCOs in Zambia are just starting to be fully operational, some lessons can already be drawn from this case.

The choice of location

In the Eastern Province of Zambia, the rural population is wealthier than in other parts of Zambia. The initial survey showed that 75 per cent of the respondents

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[7] As the money invested in local currency is quickly devalued, some ESCOS have launched a small business (of soft drinks) to make money and keep the capital. The battery fund is deposited in US dollars.

[8] The current fee charged by ESCOs even after successive increases, is around 40-45,000 Kwacha. It should be at 52,000 Kwacha to match the initial fee value charged by the ESCOs the year they started to be operational based on exchange rate changes.

in this area were willing to pay US$ 5 per month for electricity (for an average monthly income of US$ 42 in 1998). In poorer places, the contribution capacity of households will be lower. Therefore, the possibility of replication seems to be limited for the moment to the relatively wealthier places in Africa.

The maintenance scheme also implies that solar systems are not installed into large area, so that ESCOs can regularly access all the systems for maintenance and to collect the fees. They need to have a sufficient number of clients (150-200) to be profitable. Another point to take into account is any planned grid extension that can affect the economics of ESCOs. However, competition from grid connected conventional electricity does not mean necessarily the bankruptcy of ESCOs working in the area, as ESCOs will have clients situated in the outskirts of the main towns who will never be connected (for example, the centres of Lundazi, Chipata and now Nyimba are connected to the grid while households on the outskirts are not).

The commercial scheme

Initially, only one kind of basic system chosen by the Department of Energy was offered: a 50 Wp panel with a 90-105 Ah battery to enable the connection of four bulbs and a power point for a small TV/radio. Now ESCOs tend to provide a more diversified range to meet the needs of their clients. It seems that there will be three standard sets:

- The current 50-70 Wp with a 100 Ah battery without inverter.
- 80-120 Wp and a 150 Ah battery with maybe a small inverter.
- 120-150 Wp for a system with a refrigerator.

It is also important to take into account the fact that for some groups of clients such as farmers, income can vary considerably during the year. Therefore, payment of the debt by ESCOs may have to be made on a basis other than monthly, e.g. quarterly or annually.

Providing electricity to institutions such as schools, health centres and the army may be a priority from a social point of view, but that raises the question of the capacity and the willingness of these institutions to pay the ESCOs on a regular basis.

Training, public awareness and the choice of equipment

As usual in solar energy, the fact that solar systems need to be sized to the consumption requirement of the users implies a good understanding by the clients of the possibilities and the limits of their solar systems. It appears that it is better to leave the choice of the system to the companies that can then build direct relations with the suppliers. Therefore, competitive tender at a governmental level for the purchase of photovoltaic systems, even if it can reduce prices by a bulk purchase, may have to be avoided. Moreover, competitive tenders tend to exclude local companies in favour of international companies. Direct purchase may favour the creation of a local network of solar companies.

The training of the technicians is also crucial to enable them to adjust the regulation of solar systems. Most of the problems linked to the batteries are not just linked to the product itself and could have been solved with correct training. Now that technicians are trained in the design of systems, ESCOs in Zambia will purchase their equipment directly.

Financial uncertainty and capital costs

Although technical problems are being solved, ESCOs in Zambia are still facing financial uncertainty due to macro-economic conditions, which are out of their control. This situation of excessive inflation is not specific to Zambia and proves to be quite damaging for small companies. Furthermore, the capital cost for solar electricity, as for conventional electricity, still needs to be subsidized as the purchasing power of inhabitants remains low and there are no local financial institutions ready to give loans to small rural companies.

Conclusion

The success of the market-driven concept of ESCOs demonstrates that with a suitable financing scheme, households and businesses can afford solar photovoltaic systems. Initial funding from the national government (supported by international agencies) is essential, but once provided, the concept of ESCOs seems to be capable of solving the eternal problems of up-front costs and maintenance. This example tends to prove that after enabling the establishment of a network of local entrepreneurs, solar systems can be maintained and can deliver a real service.

In a first phase, the initial funding can be worked out as a direct subsidy, a soft loan (to be reimbursed over a long period of time), tax exemptions, or a combination of those. Whilst it is most likely ESCOs will continue to depend at least partly on external funding, the aim should be to decrease ESCOs financial dependency towards the mid and longer term. One way to increase their income could be the broadening of their client portfolio and the diversification of the services offered.

The regulator should carry out reviews of the financial and operational performance of the ESCOs on a regular basis, and should come up with clear recommendations for the ESCOs, as is done in the case of Zambia by the Energy Regulation Board (ERB).

7. CONCLUSION

Renewable energy technologies tend to be less developed than “conventional” electricity generation technologies. The use of regulatory and policy support mechanisms is a necessity for driving the new technologies towards commercial viability by encouraging deployment and reducing investor risk.

LEARNING RESOURCES

Key points covered

These are the key points covered in this module:

- The advantages and benefits of supporting renewable energy through regulatory and policy measures.
- The main issues to address when designing a policy instrument to support renewable energy.
- The existing policy instruments to support renewable energy, including feed-in tariffs, quota mechanisms amongst others.
- The advantages and disadvantages for each of these policy instruments. Provision of information enabling the reader to consider, in a given country, which (or combination) of system(s) would suit their national situation best.
- Experiences from Europe, Africa and other developing countries.

Answers to review questions

Question: Name at least five regulatory/support mechanisms that can encourage renewable energy development in the African power sector in the short term.

Answer:

- Establishing “standard” power purchase agreements (PPAs)
- Ensuring long-term electricity generation licences and PPAs
- Developing a favourable tariff setting and adjustment formula
- “Light-handed” regulation
- Setting explicit targets for the share of renewables in the electricity generation mix
- Enacting explicit regulations that encourage local private participation in renewable energy development
- Providing subsidies to renewable energy-based power systems

Question: What are the main differences between a feed-in tariff system and a quota system?

Answer: A feed-in tariff system provides certainty on the price for green electricity, as this price is fixed over a certain period. A feed-in tariff system does not provide certainty on the level of green electricity that will be supplied. The fixed premium is the incentive for investors.

A quota system provides certainty on the level of green electricity that will be supplied, as the target is fixed, as well as a fine for non-compliance. A quota system does not provide certainty on the price for green electricity, as the price will be determined by supply and demand in the tradable certificate market. The target and the fine are the incentive for investors.

In theory, a quota system with tradable certificates is more efficient, as it stimulates the market players to develop the cheapest technologies. On top of that, the trade of certificates could improve efficiency between different regions or countries. On the other hand, the feed-in tariff system has proved very successful for wind energy on land in Germany and Spain, mainly thanks to the investor confidence that the system provides.

Question: Describe in short the main support mechanisms for renewable energy.

Answer:

A feed-in tariff system: see answer above.

A quota system: see answer above.

Tender schemes:

The government organizes tenders for individual renewable energy projects. The best proposal gets the approval to develop the project. The developer gets a lot of certainty about his project and about the income for his project (as a fixed premium for the green electricity will be paid by the suppliers). On the other hand, this system does not provide a continuous incentive for new renewable energy projects, which hinders the development of a full-grown green electricity market.

Voluntary mechanisms:

The system is based on customers' willingness to pay a higher price for green electricity. The system relies on the consumer's awareness of the advantages of green electricity and the disadvantages of other forms of electricity. The marketing and labelling of green electricity are key aspects in this support mechanism.

Hybrid schemes involving two of the mentioned support mechanisms:

A support scheme can make use of aspects of the different support mechanisms to correct a shortcoming of one of the individual support mechanisms.

For instance, when a quota system does not provide enough investor confidence because of a lack of a fully-grown certificate market, the government can introduce a minimum price for certificates to protect a developer from a cash flow problem should the certificate price decrease dramatically. This happened for instance in Flanders, Belgium.

To avoid this, in a feed-in scheme, the incentive for innovation would fade (because the price is fixed for a long period). The fixed premium can be decreased over time (for instance, five per cent per year for new projects) so the learning curve of the technology would not be harmed.

Exercise

What support mechanisms for renewable energy exist in your country? Are these directed towards electricity, heat or both? What have been the results so far and what suggestions would you make to improve the system?

Take into account that you should avoid changing the fundamental design of the system, as this would undermine investor confidence.

Write a 2-3 page essay answering these questions.

Presentation/suggested discussion topic

Presentation:

ENERGY REGULATION – Module 9: Regulatory measures for renewable energy

Suggested discussion topic:

Given the particular situation in your country, which of the described support mechanisms might prove most useful? Bear in mind that investor confidence is a crucial aspect, and that you can combine aspects from different support mechanisms.

Relevant case studies

1. Germany: feed-in mechanisms
2. Spain: support mechnisms for wind energy
3. Denmark: support mechanisms for wind energy
4. Ghana: status of renewable energy
5. Zambia: power sector reform and renewables
6. UK: renewables obligation

See annexes in separate files.

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INTERNET RESOURCES

The Global Regulatory Network (GRN) strengthens regional associations and promotes the understanding of complex regulatory practices: www.globalregulatorynetwork.org

Public Utility Research Center: www.purc.org

African Forum of Utility Regulators: www.afurnet.org

Centre of Regulation and Competition: www.competition-regulation.org.uk

European Renewable Energy Council (EREC): www.erec-renewables.org

European Energy Regulators (CEER): www.ceer-eu.org

Electricity Control Board of Namibia (ECB): www.ecb.org.na

Energy Regulation Board of Zambia (ERB): www.erb.org.zm

Kenyan Electricity Regulatory Board: www.erb.go.ke

GLOSSARY/DEFINITION OF KEY CONCEPTS

CHP, combined heat and power, cogeneration	A method of using the heat that is produced as a by-product of electrical generation and that would otherwise be wasted. The heat can be used for space heating of buildings (usually in district or community heating schemes) or for industrial purposes. Utilizing heat in this way means that 70-85 per cent of the energy converted from fuel can be put to use rather than the 30-50 per cent that is typical for electrical generation alone. Cogeneration schemes can be relatively of small-scale, for use at the level of a factory or hospital, or they can be major power stations. The term CHP is employed in the United Kingdom and some other parts of Europe, while the term cogeneration is employed elsewhere in Europe, the United States and other countries worldwide.
Consolidation services	Independent services enabling generators, including smaller generators, to combine their output and negotiate better terms for its sale.
Deregulation	The process of removing or reducing regulation. It is often employed in connection with the liberalization process for privatized industries.
Energy services	The provision of energy supply and measures concerned with end-use in a single package.
Energy services company (ESCO)	Companies concerned with maximizing efficient and cost-effective supply and end-use of energy for their customers. This can encompass a mixture of the following as appropriate: competitive purchasing of various fuels; CHP; end-use efficiency measures; consumption monitoring and management and others. ESCOs should be distinguished from energy supply companies whose main role is to supply units of gas, electricity or heat. ESCOs can also be distinguished from energy management companies whose main role is to supply energy efficiency services.
Liberalization	Technically, the removal of restrictions on the movement of capital. It has come to refer to a policy of promoting liberal economics by limiting the role of government in the operation of the market economy. Liberalization can include privatization and deregulation/re-regulation. Typically, it refers to the establishment of an industry structure to allow competition. The process includes the shifting of publicly-owned

	companies into the private sector, such that provision of services is subject to greater competition or, in the case of natural monopolies to greater oversight with regard to economic efficiency.
Monopoly	The situation where one company has the market power to control the price or availability of a good or service.
Quota mechanisms	More generally known as a renewable portfolio standard or as an obligation mechanism.
Renewable energy	The use of energy from a source that does not result in the depletion of the earth's resources whether this is from a central or local source.
Renewable energy certificates (RECs)	A certificate that represents a unit of renewable electricity generated that can be used to verify the fulfilment of an obligation to source a certain percentage of renewable generation as required in renewable portfolio standard schemes. Trading may be allowed so that companies that underachieve their obligation can buy certificates from those who have overachieved.
Renewable portfolio standard	A market-based mechanism devised by Nancy Rader and Richard Norgaard for the American Wind Energy Association in 1996. It obliges supply companies or consumers to purchase a specific amount of electricity from renewable energy sources. The key goal of such a mechanism is to minimize the costs of increasing renewable energy capacity through the stimulation of competition to fulfil obligations. The RPS mechanism is also known as a quota or obligation mechanism. Examples of the RPS include the renewables obligation in the United Kingdom or the mandatory renewable energy target in Australia). The market may be operated through the creation and trading of certificates (renewable energy certificates).
Shallow connection charges	In essence these types of charges mean that generators pay only for the equipment needed to make the physical connection of their generation plant to the grid network, and that all other costs are the responsibility of the distribution network operator (DNO). This principle is usually introduced to stimulate distributed generation, and should be accompanied with the development of a transparent mechanism for the recovery of costs incurred by DNOs relating to the necessary reinforcement of the grid network (the "deep" cost elements).

Strike price	A reference price as agreed between electricity retailers (buyers) and electricity generators (sellers) in their "contracts for difference". If the resulting wholesale price index (as referenced in the contract) in any time period is higher than the "strike" price, the generator will refund the difference between the "strike" price and the actual price for that period. Similarly a retailer will refund the difference to the generator when the actual price is less than the "strike price". Market players use this type of contract to protect themselves from volatility in price and volume of electricity.
Tariff mechanism	A mechanism to encourage the growth of renewable energy generating capacity. Notable examples are Denmark and Germany. A tariff mechanism generally provides a particular rate per kWh of electricity generated and guarantees that payments will continue for a fixed or minimum period. The tariff can be fixed beforehand, can be fixed to reduce in specific gradations over time or can be linked to the average electricity tariff. Also known as a price mechanism.
Tender mechanism	A mechanism to encourage the growth of renewable energy where competitive bids are put forward to government for individual sustainable energy projects. Suppliers are obliged to buy a certain amount of renewable power at a premium price. Although specific characteristics vary, it is likely that in the framework of this kind of policy the government will set an overall target for sustainable generation, and then specified limits for individual technologies within that and also set a specified time for contracts for the generation, during which time they will receive a premium price. The government, usually on the basis of cost, selects the winning contracts although in some schemes other factors such as technical quality and socio-economic aspects also play a role.

ANNEX I. METHODOLOGY AND EXAMPLES ON HOW TO CALCULATE THE LEVEL OF FEED-IN TARIFFS

Methodology

Introduction

A feed-in tariff (FIT) is a pre-defined guaranteed minimum price or a guaranteed premium on the market price for every kWh of green electricity generated. The tariff scheme is usually differentiated for different green electricity production technologies, with less developed technologies receiving higher prices for their output. The scheme is usually defined for a specified number of years, but again this can vary depending on the technology.

Overall aim

The overall aim when designing a set of feed-in tariffs is to fix a premium tariff which:

- **Covers the extra cost** of electricity production using the given technology (thus stimulating investment)
- While at the same time **avoids over-subsidizing** the given technology (thus creating windfall profits and making the system more costly).

Relevant parameters

As is illustrated in table 1, the minimum to average generation costs for renewable energies vary widely among different technologies, and within the same technology, according to differences in the national market and resource conditions.

Table 1. Minimum to average generation costs for the main green electricity technologies in EU15[1]

Technology	Range of electricity generation cost (€/MWh)
Wind onshore	50-80
Small-scale hydro	40-140
Biomass using forestry residues	40-80
Agricultural biogas	60-100
Photovoltaics	> 450

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[1] COM(2005) 627 final - Communication form the European Commission—The support of electricity from renewable energy sources—Annex 3 (December 2005).

The most relevant parameters are on the one hand plant-specific data, and more general parameters on the other. The most influential parameters when determining the generation costs are:

- Investment costs
- Full load hours
- Fuel price (in the case of biomass)
- Interest rate
- Expected return on equity

A non-exhaustive list of relevant parameters is presented below, as several tens of variables can be of influence depending on the given technology or on the country in question.

Plant-specific data:

- Investment costs
- Operational costs
- Energetic efficiency
- Full load hours
- Fuel price (in the case of biomass-fired plants)

General parameters:

- Depreciation time
- Interest rate
- Expected return on equity
- Tax regime

Other relevant parameters:

- Electricity price
- The level of support instruments (other than the feed-in tariffs, e.g. investment subsidies/tax incentives)
- The period during which the feed-in tariff is guaranteed

Because of the great amount of different variables, the renewable energy generation costs are generally calculated specifically. For this purpose a number of projects have developed mathematical models.[2]

A simplified calculation based on the most crucial parameters is presented in “Examples” lower in this annex.

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[2] The Green-X and FORRES 2020 projects developed rather complex mathematical models to calculate generation costs. In the Netherlands a detailed methodology was developed by ECN to calculate the feed-in tariffs for new renewable electricity projects in 2004 and 2005 (www.ecn.nl).

Determine the feed-in tariffs

Once the generation costs per technology are known, the level of the feed-in tariff can be fixed accordingly.

Policy considerations

The level of the tariff can finally be influenced by the explicit political decision to stimulate renewable deployment. For instance a national government can decide to introduce higher feed-in tariffs to reach a certain share of renewable electricity by a given year, or to activate a virtually non-existent sector, or to establish the renewable energy policy as an umbrella policy aiming to improve on other policies such as energy poverty, education, health care and gender issues.

Examples

The following examples intend to illustrate the methodology to calculate the feed-in tariff for some of the green electricity production technologies, rather than describing in detail the existing mathematical models. The presented calculations are highly simplified in order to visualize the methodology, as they take into account only a few of the different relevant variables. It is stressed that further modelling is required when actually fixing the feed-in tariff levels for a given country.

On-shore wind energy

First thing to do is to determine what a typical wind energy project in the given country or region would look like. In this example a following typical project[3] is considered:

Capacity (kW_e)	1500
Full load hours/year	2000
Investment cost (€/kW_e)	1100
Operation and maintenance cost (€/kW_e/year)	40
Interest rate r (per cent)	6.5
Duration of support t (years)	10
Feed-in tariff (€/kWh)	?

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[3] Only “investment cost” and “maintenance cost” could be seen as generally applicable. “Full load hours” depend on site-specific wind data and need to be measured on a case-by-case basis. A rough estimate can be made based on national or regional wind data, whenever available. “Interest rate” can vary depending on financial markets conditions. “Duration of support” is a design element of the feed-in scheme and can vary according to the technology. For instance the duration is typically 10 years for wind, and 20 years for PV.

The basis to calculate feed-in tariffs is the approach of net present value (NPV). NPV calculation is a standard method to consider whether a potential investment project should be undertaken or not. The interest rate is used to establish what the value of future cash flows is in today's money. A project is considered viable whenever the present value of all cash inflows minus the present value of all cash outflows (which equals the net present value), is greater than zero. This method is described in the following equation:

$$NPV = \sum{}^{*} [(INCOME/year - COST/year) / (1+ r)^{t}] - INVESTMENT\ COSTS$$

$^{*}\sum$ running over the duration of the support scheme.

Income/year

The feed-in tariff is considered to be the only form of income:[4]

⇨ 1500 (kW) * 2000 (hrs) * FIT (€/kWh)

Cost/year

As costs, the operation and maintenance cost are considered:

⇨ 1500 (kW) * 40 (€/kW) = 60,000 €

Investment cost

⇨ 1500 (kW) * 1100 (€/kW) = 1,650,000 €

Calculation of the feed-in tariff

$\sum [(3{,}000{,}000 * FIT - 60{,}000) / (1.065)^{t}] - 1{,}650{,}000 = 0$

⇨ FIT = 0.095 €/kWh = 95 €/MWh

The calculated FIT is slightly higher than could normally be expected for a typical wind energy project. This is mainly due to the fact that no other income than the feed-in tariff was considered in the simplified calculation. Usually investment subsidies, tax credits or the physical electricity sold to the market provide additional income. Also higher full load hours can significantly decrease the feed-in tariff. For instance coastal or typical hilly areas can reach up to 3500 full load hours.

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[4] Depending on the case, additional income can be provided by investment subsidies or tax credits. The selling of the physical electricity to the electricity market needs to be taken into account as a form of income, depending on the design of the feed-in tariff scheme. For instance in Germany the feed-in tariff includes the value of the physical electricity, whilst in the Netherlands the feed-in tariff is calculated without taking into account the income from the selling of the physical electricity. In Spain, a green electricity producer can choose between a fixed premium per kWh and a premium that is calculated as a percentage of the average electricity price.

Photovoltaic energy—autonomous

A typical example is considered below:

Capacity (kW_p)	2
Full load hours/year	1250[5]
Investment cost (€/kW_p)	10.000[6]
Operation and maintenance cost (€/kW_e/year)	0[7]
Interest rate *r* (per cent)	6.5
Duration of support *t* (years)	20
Feed-in tariff (€/kWh)	?

Income/year

Following the same approach in the wind energy case, the income is:

⇨ 2 (kW) * 1250 (hrs) * FIT (€/kWh)

Investment cost

⇨ 2 (kW) * 10,000 (€/kW) = 20,000 €

Calculation of the feed-in tariff

$\sum [(2{,}500 * FIT) / (1.065)^t] - 20.000 = 0$

⇨ FIT = 0.72 €/kWh = 720 €/MWh

Photovoltaic energy—grid connected

The same example considered as a grid-connected system (instead of an autonomous system[8]) offers the following result.

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[5] An average of 800 full load hours is typical for a country such as Germany. In Morocco full load hours can be as high as 1500, and in some specific regions in the world (like deserts), even 2000 full load hours are possible. See "Energy from the Desert", www.iea-pvps.org. The maintenance cost is very low for a PV installation, and is therefore neglected in the example.

[6] The investment cost can vary significantly depending on the specific situation, on the use of batteries or a diesel generator to decrease intermittency. For more details on costs of PV systems, see European Roadmap for PV R&D, PVNET, paris.fe.uni-lj.si/pvnet/files/PVNET_Roadmap_Dec2002.pdf #search=%22PVNET%22.

[7] The maintenance cost is very low for PV installations, and is therefore neglected in the example.

[8] A grid-connected system does not need a battery and battery charger.

Capacity (kW_p)	2
Full load hours/year	1250
Investment cost (€/kW_p)	6500
Operation and maintenance cost (€/kW_e/year)	0
Interest rate *r* (per cent)	6.5
Duration of support *t* (years)	20
Feed-in tariff (€/kWh)	?

Income/year

⇨ 2 (kW) * 1250 (hrs) * FIT (€/kWh)

Investment cost

⇨ 2 (kW) * 6500 (€/kW) = 13.000 €

Calculation of the feed-in tariff

$\sum [(2.500 * FIT) / (1,065)^t] - 13.000 = 0$

⇨ FIT = 0.470 €/kWh = 470 €/MWh

Biofuel

An example of a 10,000 kW_e installation is considered using biofuel (palm oil)[9] in a condensing steam turbine.

Capacity (kW_e)	10,000
Full load hours/year	6000[10]
Investment cost (€/kW_e)	800
Operation and maintenance cost (€/kW_e/year)	120
Fuel cost (€/GJ)	10[11]
Interest rate *r* (per cent)	6.5
Duration of support *t* (years)	10
Feed-in tariff (€/kWh)	?

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[9] ECN-C—05-016 – Small-scale independent electricity installations using biomass (2005), www.ecn.nl. VITO – Onrendabele toppen van duurzame elektriciteitsopties in Vlaanderen (2005), www.energiesparen.be

[10] In principle even higher full load hours (>7000) are reachable, provided there is a continuous fuel supply (generally guaranteed through contracts). In reality, such installations do not always run at full capacity yet and need regular stops for maintenance.

[11] The price of crude palm oil in January 2007 was circa 360 euros/ton CPO (www.mpoc.org.my). If then an energy content of 37 GJ/ton is assumed, the cost per ton comes at circa 10 euros.

Income/year

Following the same approach as above, the income is:

⇨ 10,000 (kW) * 6000 (hrs) * FIT (€/kWh)

Cost/year

Fuel cost: 10 €/GJ

Electricity production: 60,000,000 kWh = 540,000 GJ
(1 kWh = 3.6 MJ, efficiency of energy conversion assumed at 40 per cent)

⇨ Fuel cost/year: 5,400,000 €

⇨ Operation and maintenance cost/year: 10,000 * 120 = 1,200,000 €

Investment cost

⇨ 10,000 (kW) * 800 (€/kW) = 8,000,000 €

Calculation of the feed-in tariff

$\sum [(60{,}000{,}000 * FIT - 1{,}200{,}000 - 5{,}400{,}000) / (1.065)^t] - 8{,}000{,}000 = 0$

⇨ FIT = 0.127 €/kWh = 127 €/MWh

Small-scale hydro[12]

Capacity (kW_e)	100
Full load hours/year	6000
Investment cost (€/kW_e)	2500
Operation and maintenance cost (per cent of investment)	3
Interest rate *r* (per cent)	6.5
Duration of support *t* (years)	10
Feed-in tariff (€/kWh)	?

Income/year

Following the same approach as before, the income is:

⇨ 100 (kW) * 6000 (hrs) * FIT (€/kWh)

Cost/year

Operation and maintenance cost /year: 100 (kW) * 2500 (€/kW) * 0.03 = 7500€

Investment cost

⇨ 100 (kW) * 2500 (€/kW) = 250,000 €

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[12] State-of-the-art of small hydropower – European Small Hydro Association – www.esha.be

Calculation of the feed-in tariff

$\sum [(600{,}000 * \text{FIT} - 7500) / (1.065)^t] - 250{,}000 = 0$

⇨ FIT = 0.063 €/kWh = 63 €/MWh

ANNEX II. STRUCTURE OF THE ELECTRICITY PRICE

The price for the supplied electricity finally paid by the end-consumer is significantly higher than the generation cost. The price structure for electricity generally consists of four components:

- Generation cost
- Transmission and distribution cost
- Taxes and levies
- Profit and return on equity for investors

Generation costs

The generation costs are the costs necessary to produce the electricity, as described above (e.g. investment costs, fuel cost, operation and maintenance cost, etc.).

Transmission and distribution costs

The transmission and distribution costs are the costs related to the transport of the electricity to the end-consumer. The supplier needs to pay the transmission and distribution grid operator for using the grid. The supplier integrates these costs in electricity bills to the end-consumer.

Taxes and levies

As for any product, tax needs to be paid for supplied electricity. In most cases, additional levies are applied by the government, usually as a percentage per supplied kWh. These levies can include contributes to finance:

- The operation of the energy regulator
- The treatment of nuclear waste
- Social and environmental public obligations

Other components can influence the price of electricity, for instance the balancing costs (especially for wind energy).

Transmission and distribution costs, taxes and levies are applicable for any type of electricity generation, both fossil-based, nuclear and renewable energy. Therefore these costs do not influence the level of the feed-in tariff, and should not be included in the feed-in tariff calculations.

Profit and return on equity for investors

Finally a profit and return on equity component is part of the electricity price.

Case study 1.

GERMAN FEED-IN MECHANISMS

CONTENTS

1. INTRODUCTION

Germany currently has more installed wind energy capacity than any other country. In late 2003, Germany had a total of 14000 MW of installed capacity (WPM, 2004). It has had a very rapid deployment rate, though this is now slowing as good onshore sites become rarer. Before 1990 Germany had invested significant funds in renewable energy R&D with little practical results. Since 1990, the use of particular financial mechanisms, most notably the long-term availability of a tariff mechanism, has seen the strong practical results indicated by the statistics for increasing wind energy exploitation. Germany has employed a number of support mechanisms in the last fifteen years, each of which has supported renewable energy technologies including biomass, solar power, hydropower, geothermal energy and energy derived from landfill gas, sewage treatment and coal-bed methane from coal mines (Federal Ministry for the Environment 2000). Different levels of compensation apply with regard to each technology. This case study will primarily deal with support mechanisms as they have applied to wind energy as this provides the best example of an applied policy engendering positive results.

2. REGULATION IN GERMANY

It is worth noting that regulation in Germany has until recently relied upon interpretation of legislation by either the courts or by the Federal Cartel Office (FCO)—or both. A regulatory agency was established in 2004 but the full range of its powers has not yet been brought to bear. The lack of a regulator has meant that support mechanisms for RE have been subject to some drawn out court cases as utilities have tried to avoid costs.

3. ELECTRICITY FEED-IN LAW 1991

Germany's first significant mechanism for encouraging wind energy exploitation came with the introduction of the *Stromeinspeisungsgesetz* or Electricity Feed-In Law (EFL) on 1 January 1991. This forced German distribution network operators (DNOs) to purchase all electricity offered to them from a range of renewable sources, with wind-generated electricity to be paid a price equal to 90 per cent of the average price charged to end-users over the year. The price was paid by the local company and was passed on to local consumers. This was an example of a “renewable energy feed-in tariff” (REFIT), mechanism. Under the EFL, each DNO had an effective catchment area within which it was obliged to pay the tariff to the generators of renewable-based electricity from any qualifying projects within that area.

The EFL laid down that the actual connection of the generator to the grid be paid for by the project developer, with the utility responsible for arranging and financing its own affairs in order to be capable of utilizing the electricity delivered to its grid network. The main sticking point that arose was that the DNOs, opposed as they were to the law overall, submitted excessive bills for grid connection. The EFL was supported by a 100 MW subsidy programme, which was rapidly extended to a 250 MW programme as a result of the high-level of response it encountered. The programme provided an additional operating subsidy of €0.031/kWh on top of the EFL-mandated price, at the time equal to €0.084/kWh.

The resulting €0.151/kWh available was thus very substantial. Anderson for example makes a comparison with the rates of around €0.046-0.051/kWh that were available to American projects at the time and with which they were able to operate profitably (Anderson, 1995). The result in Germany was that the programme was heavily oversubscribed. Anderson suggests that by applying a lower level of remuneration, considerably more capacity could have been incentivized without any greater cost having to be borne by the consumer. Setting the level of remuneration can be regarded as one of the key problems with the tariff mechanism—setting it high means that investors can earn an unnecessarily high rate of return whilst setting it too low means the mechanism will fail to stimulate investors.

4. THE RENEWABLE ENERGY LAW 1998

The EFL was changed to some degree in 1998 to become the Erneuerbare Energien Gesetz (EEG), which has been commonly translated as the “Act on Granting Priority to Renewable Energy Sources”, though it literally translates as “Renewable Energy Law”. The change in the legislation on renewables took place at the same time as the new German legislation regarding the liberalization of the German energy market (Mallon 2000). The EEG effectively acted to bring the EFL into line with the new legislation introduced to reform the energy sector. The immediate effect of the EEG was to place a cap on renewables, such that they may not supply more than 10 per cent of electricity in Germany.

The new tariff scheme, detailed in the EEG law, was adopted in 2000. The EEG lays down pricing mechanisms for the support of a range of renewable energy technologies, with a specific pricing mechanism applied to each. It also redefines the regulations regarding the financial and institutional support of wind energy.

The EEG law restates the obligation on distribution network owners regarding connection of renewable energy generators to the grid where such a connection is requested. The nearest grid owners to a proposed site are obliged to connect a new generator to their grid. Whilst the generator owner is liable for the costs of connection to the grid, the bill submitted to the generator for this function is made subject to oversight by the Federal Cartel Office (FCO) to ensure that the cost is a reasonable reflection of the actual costs. The grid owner is liable for any costs relating to the upgrading of the grid to facilitate the new generator. That is, the German system uses shallow connection charging for renewable electricity generation.

The EEG Act compels the grid owners to purchase electricity produced by the renewable energy generators within the pricing mechanism laid down within the Act. The new act also contains provision to address one of the most contentious aspects of the old EFL Act, establishing a national equalization scheme. The national equalization scheme makes compulsory the payment of compensation to those distribution and transmission network owners which bear above average costs of paying for renewable energy sources from those which make purchases below the average. This removes the system set up under the EFL, whereby the costs borne by local network operators could only be passed on to their own consumers. This socialization of costs is administered by the network operators themselves, with the law enabling network operators to require each other be independently audited to assess the actual costs of purchasing renewable electricity (Bechberger and Reiche 2004).

The EEG also changed the mechanism for calculating the base price paid for wind-generated electricity. The previous flat payment of 90 per cent of the final consumer tariff is replaced by initial fixed payments of €0.088/kWh for the first five years, with the potential for an extension of this period dependent on the actual performance of the turbine. Wholesale electricity prices in Germany are typically €0.02/kWh.

This has the effect of producing a scale of payment dependent on the quality of the location of the wind turbine and, it is hoped, ensuring that efficiently operated turbines can be run profitably, while inefficiently run turbines can not. The effects of this may well be an increase in the number of sites that can be profitably operated, and, it is speculated, may act to increase the further penetration of turbines to sites further from the coast. Regardless of when the higher payments cease, the turbines should, at least in theory, continue to be paid at a rate of €0.059/kWh for a minimum period of twenty years. Whilst the lower rate is below that paid under the old EFL mechanism, which had dropped to around €0.08/kWh by early 2000, the initial higher rate exceeds it significantly. This approach should act to provide more of a return during the early stages of turbine operation, thus aiding in obtaining capital. Turbines already in operation will also switch to the new tariff scheme, though with an amendment to reflect their status as already having received some subsidy.

The EEG also draws offshore wind projects into the payment mechanism specifically, placing support for offshore installations alongside onshore projects, but with the initial rate of €0.088/kWh available for the first nine years of operation. It would appear that the nearest distribution network owners to offshore installations will be compelled to provide connection to the national grid, as with onshore installations (German Federal Environment Ministry, 2000). As with onshore wind, the network operators will be reimbursed for costs under the equalization provision of the EEG. The EEG is estimated to add €0.001/kWh to German electricity prices.

The results of the new law were positive and expansion of German wind energy capacity has continued up to 2004. However, the mechanism has been subject to a much-delayed review since January 2003. The result is likely to see further changes in the level of tariff paid across the board for renewably generated electricity. Current proposals would see a slight drop in onshore payments, from €0.088/kWh to €0.087/kWh guaranteed for the first five years, with €0.055 thereafter instead of €0.059. Offshore wind would receive a slightly higher tariff of €0.091/kWh with a guaranteed availability of twelve years instead of nine provided turbines are in place by 2010. Turbines already installed are subject to the tariff in place when they were first brought online. Such guarantees are important for ensuring the security of income and to avoid discouraging new investment.

Those technologies which are currently less mature receive different rates than wind. The highest rate is currently that paid to photovoltaic generation of electricity, which currently attracts compensation of €0.434/kWh. Other technologies currently attract similar rates to onshore wind energy. Lindenberger and Schulz estimate that the overall costs of the EEG will rise as shown in table 1. It should be noted that these figures do not take into account the implicit cost savings relating to electricity purchase from sources which are displaced by the RE sources. Nor do they take into account any system costs and benefits associated with the operation of increased distributed generation on electricity networks.

Table 1. Projected annual subsidy within the EEG

Year	Hydropower Mio €	Windpower Mio €	Biomass Mio €	PV Mio €	Total Mio €
2000	348	692	67	17	1125
2001	426	952	132	30	1540
2002	443	1565	170	54	2232
2003	460	1993	201	76	2731
2004	476	2331	232	98	3137
2005	493	2598	263	118	3472
2006	510	2822	293	137	3762
2007	527	3040	323	155	4045
2008	544	3263	353	172	4331
2009	560	3502	382	189	4633
2010	577	3764	412	205	4957

Source: Lindenberger and Schulz, 2003.

5. OTHER MECHANISMS TO SUPPORT RENEWABLES IN GERMANY

Initial efforts in German RE policy were also aided with the application of capital grants in the period 1990-1996. Efforts are currently being assisted with the use of two tax-related instruments:

- Income tax relief: the Income Tax Enforcement Decree allows a deduction to be made against production costs resulting from investment in RES in buildings.
- Ecological tax reform: this increases taxes on various motor fuels and on electricity. This benefits biofuel production, though adds costs to electricity from renewable energy sources, due to the difficulty in differentiating such electricity once it is in the system. To compensate for this, the German Government has introduced the Market Incentive Programme, which acts to provide investment subsidies and additional low-rate loans to various renewable sources. (Bechberger and Reiche 2004).

The central mechanisms for the support of renewable energy in Germany are further bolstered by various other mechanisms at the regional level. Since the 1990s these have included additional low-rate loans and other investment subsidies available within specific regions.

6. CONCLUSION

The German feed-in laws and associated mechanisms have been very successful at stimulating growth in wind energy deployment. The early phases of these laws could be criticized for having imposed high costs on consumers although subsequent revisions have reduced the level of subsidy and hence costs.

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Case study 2.

SPAIN: SUPPORT MECHANISMS FOR WIND ENERGY

CONTENTS

1. INTRODUCTION

Spain is the country that has seen the greatest expansion of wind energy utilization of recent years. Spain currently has the second largest installed capacity of electricity generated from wind, with a capacity of 5780 MW installed by late 2003, with the large majority of this expansion occurring since 1995. The main expansion of Spain's wind generation occurred following the introduction of a tariff mechanism in 1994. The level of this expansion is demonstrated in table 1:

Table 1. Spanish installed wind turbine capacity

Year	MW
1995	115
1996	221
1997	512
1998	834
1999	1530
2000	2099
2001	3335
2002	4830
Late 2003	5780

Spain began the 1990s with a stated target for further installation of wind energy equal to 275 MW of capacity to be in place by 2000. This objective was exceeded in 1997. The current target for wind in Spain is to have 8974 MW installed by 2010, as part of the effort to reach the 12 per cent target for renewable energy set by the European Union (McGovern 2000). In general, estimates of likely rates of expansion have fallen short of the actual rates. The IEA, for example, expected that installed capacity could be as high as 750 MW by 2000 in a report published in 1998 (IEA, 1998), the same year that figure was actually exceeded.

2. GOVERNANCE OF SPANISH POLICY

Responsibility for Spanish policy relating to renewable energy lies with the Institute for the Diversification and Conservation of Energy, (Instituto para la Diversificación y Ahorro de la Energía—IDAE), a "semi-autonomous" organization operated through the Ministry of Industry.

The main regulatory body for all energy sources in Spain is the National Energy Commission (Comisión Nacional de Energía—CNE). CNE is attached to the Ministry of Economy. It acts to set budgets, to ensure that licences are complied with and to settle any disputes arising from regulation. CNE is responsible for oversight of the legislatively mandated payments made to renewable energy sources.

2.1. Spanish renewable energy policy

Spanish policy at the national level has been founded on the twin pillars of a REFIT-style subsidy scheme and of generous capital subsidies. However, regional policies have also played an important role in both making wind energy projects economic and in encouraging the growth of new turbine manufacturers.

One important aspect of Spanish law, which already favoured renewables in the mid 1990s, was the existence of an obligation introduced in 1987 via Royal Decree, on distribution companies to purchase all electricity from independent power producers at a fixed rate. The intended effect of this being to minimize any problems that Spanish wind turbine owners might face from utilities hostile to the use of renewables.

Spanish wind energy development, and renewable energy development generally, is under the purview of a national renewable energy plan, which forms one aspect of the Energy Savings and Efficiency Plan (PAEE).

A wide-ranging national policy on renewables effectively began in 1994 with Royal Decree 2366/1994. This formed the legal basis for the provision of feed-in tariffs for electricity from renewable sources with a capacity under 100MW. The decree instituted a tariff at a rate of 80-90 per cent of the average final consumer price paid for electricity, with the specific rate calculated on an annual basis. Until the late 1990s this was typically calculated to equal 88.5 per cent. In 1994, application of this rate amounted to an increase in the tariff available to wind from the 10 peseta/kWh (€0.063/kWh) rate typically paid to IPPs, up to 11.57 pta/kWh (€0.073/kWh). The tariff was guaranteed to be paid for a five-year period in order to provide increased stability to the market and to thus help encourage investment.

A 1997 adjustment altered the payment scheme, effectively offering developers a choice of two payment schemes. They could opt to receive either a fixed price, in 1997 this being equal to €0.066/kWh, or a variable price based on the average price paid by consumers for all electricity consumed domestically in Spain, plus an environmental bonus. In 1997 this variable price worked out to €0.034/kWh, with an environmental bonus of €0.032/kWh, making the two practically the same, though this was not a matter of deliberate policy (Wind Directions 1999). This figure was also intended to include a consideration for those avoided costs for the distributor, which would otherwise be incurred in the process of purchasing from traditional large-scale generators (Cerveny and Resch, 1998). Controversially, the payment was reduced, by an average of 5.48 per cent, at the end of 1999 as part of a round of government cuts (WPM 2000).

The adjustment made in 1997, introduced as part of a general electricity law through Royal Decree 54/1997, included the codicil that the new payment regime would apply only to those installations with a maximum generating capacity of 50 MW. Any problem which this might have presented to new large-scale projects appears to have been circumvented through the breaking down of projects into pieces resulting in components with generating capacities less than this limit and presenting them as being separate, even where they are practically adjacent. Further regulation concerning payments stems from Royal Decree 2818/1998.

In addition to the creation of a REFIT-style support mechanism, the 1994 decree also divided electrical distribution from generation as well as establishing a moratorium on nuclear plant construction. Alongside the REFIT-style mechanism for subsidizing electrical production from wind generators, there is a second policy pillar aimed at supporting growth in the use of wind energy, and growth of an industry to exploit it. The IDAE oversees the allocation of capital grants to projects intending to install less than 20MW of wind turbine capacity, with public capital invested with the aim of attracting private capital to meet the majority of any costs.

In 1997, IDAE made US$ 70.6 Million available to such projects, offering up to 40 per cent of costs. Funding was announced to be preferred for those projects in remote areas with poor levels of grid connectivity.

2.2. Changes to Spanish policy

The Spanish government has proposed changes to the way that wind is subsidized in Spain in 2004. The new law will see the premium option—where the payment is related to the electricity market price—changed to instead offer generators the chance to trade on the open market for electricity. The price they achieve will then be supplemented with a premium payment equal to 40 per cent of the electricity sector's average billing price per kWh for the entirely of its supply for the year (known as the Average Electricity Tariff—AET). (McGovern 2004). The total cost for electricity in Spain in 2002 was around €0.13/kWh before tax and €0.155/kWh after tax. (Eurostat 2003)

The fixed price choice is also subject to change. The subsidy available had previously been held between 80-90 per cent of the AET, tending towards the 90 per cent figure. However, there always remained the potential for a review to see this reduced to 80 per cent, with obvious economic implications for investors. The new law will fix payments at 90 per cent of the AET for the first five years of plant operation, dropping to 85 per cent for the next ten years and then 80 per cent for the remainder of the plant's life. This new set-up is intended to stabilize security of investment in new projects.

A third option allowing generators to stick with the old arrangements will also be open to generators until 2007.

It is likely that the market option will allow companies more revenue, though with fewer guarantees than are available with the fixed price option due to the risk that the generator may not be able to sell its electricity. The mixture of mechanisms in this way allows generators to choose the support that best suits their project, as well as allowing the Spanish Government to incentivize companies towards acting competitively and removing the prioritization of the electricity from renewable sources and thus reducing the level of interference that they offer to free market trading of electricity generally. Effectively, having the choice will allow generators to take into account their own need for security of revenue against the potential for greater revenue at greater risk. It is likely that generators will have the opportunity to switch between options on an annual basis.

The viability of the market scheme will depend on how capable the generators prove to be within the market, as well as on the particular conditions applicable within the market relating to the ability of the wind generators to effectively deliver power to a schedule, and the penalties that apply for failure to do so. What these conditions will be are not yet clear.

3. CONCLUSION

Using a feed-in scheme plus some other support systems, Spain has been successful in increasing its wind energy utilization. The changes announced in 2004 will bring in a hybrid support scheme that offers a middle way between feed-in/tariff schemes and obligation/certificate schemes, that is likely to be of interest to many other countries looking to balance the costs and benefits of each type of support mechanism.

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Case study 3.

DENMARK: SUPPORT MECHANISMS FOR WIND ENERGY

CONTENTS

1. INTRODUCTION

Denmark can be regarded as a leader in both policies to increase the generating capacity of wind energy, and in the manufacture of wind energy technology. It currently has enough capacity in place to generate 18 per cent of its electricity in an average wind year.

Denmark has a long history of utilizing wind energy for energy generation purposes. Both World Wars saw Denmark develop electricity generation as a substitute for the fossil fuels to which it lacked access. The late 1970s and 1980s saw Demark look to wind energy again as a possible energy source which would enable it to take more control over its energy security and reduce the environmental impact of its energy use. Government efforts in R&D were matched with an interest from an environmental movement seeking an alternative to nuclear power. This led to both a grass roots movement interested in developing the technology and government policies to encourage the use of wind generators. Increases in Danish wind energy capacity are shown in the table.

2. INITIAL POLICIES FOR DENMARK

Table 1. The Danish domestic market, 1983-1990

Year	MW capacity – Denmark domestic market sales	Number of turbines sold to Danish domestic market
1983	20.6	919
1984	7.2	216
1985	23.1	326
1986	31.7	358
1987	33	311
1988	82	457
1989	65.7	469
1990	81	432

As Danish capacity was produced domestically, sales can be taken to correlate with total installed capacity in those years. (FDV, 1999)

Karnøe attributes this growth to the following changes in the national institutional set-up that acted to increase the profitability of wind power projects:

(a) The increased reimbursement of energy excise tax (1984) due to falling oil prices.

(b) New prices for sales to the grid.

(c) A 20 per cent direct subsidy to dispersed installations (reduced from 30 per cent) but a 50 per cent subsidy to installations in wind farms.

(Karnoe, 1990)

3. THE LAW FOR WIND TURBINES 1992

The Law for Wind Turbines, enacted in 1992, was the first Danish policy to introduce a full subsidy mechanism. It established a fixed tariff rate to be paid by the utilities for any wind generated electricity.

The Act also formalized the allotment of responsibility for meeting the costs of grid connection for wind turbines, an issue that had previously engendered considerable controversy. The law stipulated that turbine owners would henceforth be responsible for costs of grid connection, with the distribution utilities responsible for strengthening the grid so that the connection was workable. In fact, this actually set up a system of shallow connection charging with utilities having to strengthen the grid in the specific area in which the wind farm was to be constructed, and thus bearing the majority of the cost burden. While the agreement originally applied only to turbines under 150 kW, then under 250 kW, it was later relaxed to apply across the board (Gipe, 1995).

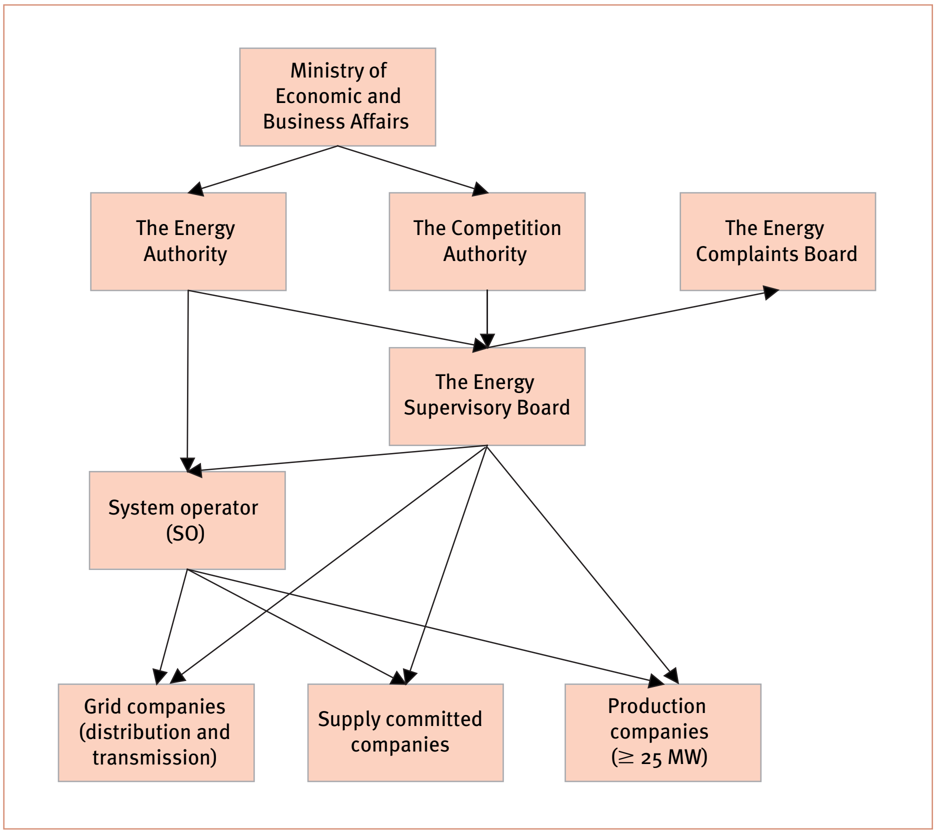
The Act fixed the amount the utilities had to pay for wind-generated electricity at 85 per cent of that charged to a local, average retail consumer with an annual consumption of 20,000 kWh. This amounted to €0.044/kWh, but turbines received up to DKK €0.081/kWh by the end of the scheme in 2000 as the result of the addition of a CO_2 tax compensation of €0.014/kWh and an energy tax compensation of €0.022/kWh (Kjær, 1999). This price compares with the price of €0.028/kWh that electricity could attract with the Nordic power exchange in 2003.

Further measures to increase the available sites include a Government mandate to each region. This has resulted in the identification of more potential onshore sites than was expected, with the likelihood that these will be developed in the next few years.

4. ENERGY REGULATION IN DENMARK

The regulatory structure for the electricity sector in Denmark is shown in figure I below. The Energy Authority regulates the distribution network operators (DNOs) and deals with any complaints. The Minister grants licences. The system operators are responsible for prioritization relating to renewables on the grid and for balancing the system.

Figure I. Regulatory governance bodies within the Danish electricity supply sector



5. CHANGES IN DANISH ENERGY POLICY

Danish energy policy, including that relating to wind energy and other renewable energy sources was brought up to date with Energy21, published in 1996. This laid down Danish targets for onshore wind energy of 1500MW to be in place by

2005 (Danish Energy and Environment Ministry, 1996). Danish onshore capacity moved beyond the projected 1500 MW onshore capacity in 1999 (WPM, 2000). Additional capacity gains are being made as smaller turbines are replaced with larger ones. Energy21 also laid down an offshore wind target of 4 GW. Denmark currently has the world's largest offshore farm, 160 MW at Horns Rev and has granted contracts for a number of others to be constructed.

Fixed-price tariffs remained as the central pillar of subsidization until 1 January 2000, when they were set to be displaced by a renewable portfolio standard (RPS). In addition to the higher price paid during the life of the tariff, wind was also exempted from—or rather compensated for—the imposition of energy and CO_2 taxes. Both of these measures helped to make wind more competitive with respect to conventional electricity generators.

However, the attempted adoption of the market-based RPS undermined the perceived security of investment in wind energy in Denmark. Sales of turbines immediately dropped to zero in 2000, threatening both Danish targets for renewable installation and the Danish manufacturing industry, which had come to dominate its domestic market sector.

At this point it is worth noting that the Danish turbine manufacturing industry, with the advantages it gained from its historical experience and a bottom-up approach to developing its technology was best placed to capitalize on the continuous expansion of the worldwide wind energy industry in the 1990s. The wind turbine manufacturing industry is now Denmark's third largest export industry. Also, aside from wind energy Denmark relies on coal for much of its energy and so has relatively high greenhouse gas emissions on a per capita basis.

The Danish Government could not afford to ignore either the undermining of the home market for wind or the effect this would have on Danish environmental commitments. The Government rapidly readopted the tariff-based mechanism in 2001, albeit with some changes to reflect the improved nature of the technology and to reduce the rising level of overall costs within the tariff mechanism. A parliamentary hearing in September 2001 led the Government to conclude that re-attempting to adopt the RPS mechanism was impracticable at that stage.

After 2001, the reformed support mechanism for wind energy in Denmark provided a fixed price system with an environmental premium per kWh in addition to the market electricity price. The system became somewhat more complex as the result of efforts to cut down on the overall costs of subsidies to wind. Settlement prices changes such that they had several components:

- Base Price: €¢4.42/kWh. In cases where turbines were no longer entitled to the base price, they were effectively compelled to seek a price on the market.

- Subsidy 1: €¢1.34/kWh
- Subsidy 2: €¢2.28/kWh
- Special Price: By arrangement
- Green Certificates: Subject to the future development of a green market. Until that point entitlement to subsidy 1 as a default position.

Entitlement to each of these components is related to ownership, plant capacity, plant age and historical plant output. An overview of entitlement is shown in table 2.

Table 2. Settlement of wind turbines

	Settlement price
Utility owned	
Grid connected before January 1, 2000	Market price plus a variable subsidy adding up to 8.04 €-cents. An upper limit of the variable subsidy of 6.43 €-cents has been imposed. Grid connected after January 1, 2000 The base price, subsidy 1 and 2 are given until further notice.
Owned by collective supply companies	
Grid connected before January 1, 2000	Subsidy 1 is given until further notice
Grid connected after January 1, 2000	The base price, subsidy 1 and 2 are given until further notice.
Non-utility owned	
Existing turbines	Turbines less than 10 years old are entitled to the base price and subsidy 1. The base price and subsidy 1 were given as a minimum until January 1, 2003. Furthermore, subsidy 2 is given until the full-load hours share has been used but not later than 2012. If the full load share has not been used within 10 years the subsidy is reduced to 1.34 €-cent/kWh. Turbines that are no longer entitled to the base price, subsidy 1 and 2 are entitled to Green Certificates.
New turbines connected to the grid before December 31, 2002	Base price until 22,000 full-load hours have been produced. In addition, the turbines are entitled to green certificates.
New turbines connected to the grid after December 31, 2002	Green certificates
Offshore turbines	Base price, subsidy 1 and 2 until further notice.

Source: Techwise, 2002.

Notes: 1) "Until further notice" means until the European Commission has defined new rules for grid connection and settlement of renewable production facilities. 2) Collective supply companies are defined as: Distribution companies, Supply-committed companies, Transmission Companies and SR-Companies. 3) Existing turbines are defined as turbines bought on a binding contract before December 31, 1999 and which are requested to be grid connected before August 21, 2000. 4) The full-load hour share is defined as 25,000 hours for turbines with a capacity of 200 kW or less, 15,000 hours for turbines with a capacity between 201 and 599 kW and 12,000 hours for turbines with a capacity in excess of 600 kW.

The average domestic electricity price in Denmark for small-scale consumers in 2003 was €0.2558/kWh after tax, making it the most expensive in the European Union. However domestic energy use is heavily taxed in Denmark and the pre-tax price of €0.134/kWh is comparatively low for the EU. (Eurostat, 2003) The prices available within the tariff were effectively 30 per cent lower for new turbines than the prices paid for turbines already generating. (ECN, 2003).

It was planned that Denmark would attempt to switch over to a green trading mechanism from 1 January 2003, however, this deadline was not met, and instead a scheme wherein wind turbines erected after 1 January 2003 receive the market price plus ~€¢1.34/kWh was instituted. The scheme includes a maximum allowable price of €¢4.83/kWh. Turbines that qualify for the subsidy are eligible to receive it for up to twenty years. (Techwise, 2002).

Electricity from biomass maintains the feed-in tariff of 8.1 ct/kWh. The premium for renewables is financed as an addition to the electricity price per kWh, shared equally among all electricity consumers in relation to their electricity use. The result of the return to the more stable tariff mechanism was a boom year for installation and sales of wind turbines in Denmark, with over 400 MW of increased wind capacity.

Denmark typically has a spinning reserve[1] of around 20 per cent of the load and this has generally been sufficient to cope with any fluctuations in the output of wind power. Interconnection with Norway and Sweden, both with large amounts of hydropower has proved to complement the Danish system, with output from hydropower easily able to be altered to respond to windpower output. Nevertheless Denmark has had to be at the forefront of developing new technology to deal with balancing the distribution and transmission grids with high levels of intermittent generation. Neilsen gives consideration to the technical problems associated with this (Neilsen, 2002a; Neilsen, 2002b).

6. CONCLUSION

The Danish renewables support mechanisms have led to the substantial development of wind power and its use of feed-in type mechanisms (with guaranteed prices and connection agreements) has also favoured small-scale wind development much of which was undertaken through community ownership. Even in 2004

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[1] Generating capacity which is currently unused but is synchronized with the network such that it can be brought on line to respond to system needs instantaneously.

around 75 per cent of wind power in the country is produced by turbines owned by communities and individuals. Attempts to change the mechanisms have caused setbacks and the current (2004) system can be seen as attempting to incorporate elements of feed-in and certificate/obligation systems to overcome the disadvantages of each.

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Case study 4.

RENEWABLE ENERGY IN GHANA

CONTENTS

1. BACKGROUND

1.1. Energy generation

Ghana's first major generation project was the Akosombo hydroelectric dam, commissioned in 1965 with an initial output of 588 MW. Prior to this, several small diesel plants were in operation, providing services to local communities, mines, industries, hospitals and educational institutions around the country. These smaller and more expensive plants were phased out as cheap electricity gradually became available through the national grid. Power output from Akosombo was increased to 912 MW in 1972; followed in 1982 by the addition of 160 MW from a second hydroelectric plant located at Kpong, downstream from Akosombo.

In 1998, poor rainfall in the catchment area of the Akosombo dam led to sharply reduced output from the plant, and two foreign companies, Cummins Ltd. and Aggrekko Ltd. were contracted to run two 30 MW diesel power plants to feed power directly into the national grid. These plants were classified as "Emergency Power Producers" and were eventually shut down in 2000 when the electricity supplied by Volta River Authority (VRA) increased to normal levels. However, a 30 MW diesel plant, commissioned in 1992, is run by VRA in Tema.

Further expansion took place in 1999 with the completion of a 330 MW-combined Cycle Thermal Plant at Aboadze in south-western Ghana. Output at the Aboadze plant was increased in 2000 with the addition of a 220 MW simple cycle thermal generator using waste heat from the original turbines. The expanded plant is jointly owned by the Volta River Authority and CMS Energy of Michigan, USA. In 2000, the Government purchased a 125 MW power barge to generate electricity from natural gas from the Tano fields but this is yet to be commissioned. Table 1 shows the installed capacity of electricity generating plants in the country in 2005.

Table 1. Installed capacity of generating plants (2005)

Generation plants	Type of plant	Fuel	Capacity (MW)
1. Akosombo	Hydro	Hydro	1,038
2. Kpong	Hydro	Hydro	160
3. Takoradi thermal plant	Thermal	LCO/gas	330
4. TICO (CMS/VRA plant at Takoradi)	Thermal	LCO/gas	220
5. Tema diesel plant	Thermal	Diesel	30

Ghana's electricity grid is interconnected with those of the neighbouring countries of Benin, Burkina Faso, Côte d'Ivoire and Togo. Before 1995, Ghana had a surplus of electric power, allowing VRA to export electricity to Compagnie Ivoirienne d'Électricité (CIE) of Côte d'Ivoire and Communaté Électrique du Bénin (CEB) of Togo and Benin. However, as demand grew within Ghana, the country began to face an electricity deficit. VRA now augments electric power supply by buying from Côte d'Ivoire, which has expanded its generation capacity. VRA imports up to 250 MW of power from Côte d'Ivoire, and transmits power onwards to Togo and Benin.

Power purchases from CIE have been mixed, with VRA having to import more power during times of crises, for example, during the 1998 drought, which led to a drastic fall in hydro-capacity from Akosombo. Table 2 below shows the source of power supply by VRA to the Ghanaian market in 2005.

Table 1. Power supply to the Ghanaian electricity market by VRA in 2003[1]

Generation source	Electricity generated (GWh)
Hydro	3,884
Thermal	2,015
Purchased from CIE	940
Total	6,839

There is also some standby generation capacity available. Notably, mining company Anglogold-Ashanti has a 21 MW diesel plant at Obuasi, and the Tema Oil Refinery operates a 6.5 MW diesel plant at Tema. The Volta Reservoir received substantially above-average inflows during 1999, enabling output from Akosombo and Kpong to be raised from 3,830 GWh in 1998 to 5,169 GWh in 1999. By 2003, the water level in the lake fell again to as low as 237 feet in July and about 247 feet in November. The minimum operating level of the dam is 248 feet.

1.2. Transmission and distribution

VRA owns and operates the nationwide transmission system and the distribution system for northern Ghana. The distribution system in southern Ghana is managed by the Electricity Company of Ghana (ECG). As of December 2003, the existing transmission network system comprised of 36 substations and approximately 4,000 km of 161 KV and 69 KV lines. This includes 129 km of double-circuit 161 KV interconnection to Togo and Benin. There is also a single 220 km circuit, being a 225 KV inter-tie with Côte d'Ivoire's transmission network. The distribution system comprises 8,000 km of sub-transmission lines, 30,000 km of distribution networks with 22 bulk supply points and 1,800 MVA of installed transformer capacity.

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[1] VRA Annual Report, 2003.

1.3. Energy consumption

In 2004, Ghanaians consumed a total of 5,158 GWh of electricity supplied by VRA. VRA has two main customers: the Volta Aluminium Company (VALCO), which is the largest industrial customer, and ECG, the largest non-industrial customer. VRA also supplies power to some mining concerns and other industries. In 2002, VALCO took up to 32 per cent of the power sold by VRA. Production at VALCO was closed in May 2003, following a breakdown in negotiations between the government and VALCO's parent company Kaiser Aluminum at the end of VALCO's energy contract. Extra electricity became available to VRA as a result of the smelter shutdown. In October 2004 VALCO was bought by the Government of Ghana and subsequently reopened on a reduced scale in September 2005 under a joint venture agreement with the US company ALCOA.

ECG distributes power to households and industries in the heavily populated southern part of Ghana. The utility presently has about 1.1 million customers, of which about 80 per cent are residential and the remaining 20 per cent include industrial customers, the military, and other public facilities. The distribution network has relatively high losses of about 26 per cent, including about 15 per cent non-technical losses. This indicates that a significant amount of distributed power is lost through illegal connections and wastage.

2. ENERGY REGULATION IN GHANA

2.1. Institutional structure of the energy sector

The energy sector in Ghana is managed at different levels by the organizations detailed below. For simplicity, the various institutions are grouped under policy, regulatory, operational and support institutions. Some of their roles overlap—for example the roles of the Energy Commission and the Environmental Protection Agency in licensing petrol filling stations.

Policy institutions

- The Ministry of Energy: As part of the executive arm of Government, the Ministry is the ultimate body responsible for development of energy policy for Ghana. The ministry is responsible for developing and implementing energy sector policy in Ghana, and also supervises the operations of the agencies associated with the sector.

Regulatory institutions

These include:

- The Energy Commission (EC): An independent agency responsible for licensing, regulating and monitoring private and public entities operating in the energy sector. The commission also collects and analyses energy data and contributes to the development of energy policy for Ghana. EC was established in 1997 in accordance with the recommendations of the Power Sector Reforms Commission (PSRC).
- The Public Utilities Regulatory Commission (PURC): An independent agency set up as recommended by the Power Sector Reforms Commission (PSRC) to oversee the performance of the public utilities. PURC is mandated to protect the interest of consumers and to examine and approve the rates chargeable by the utilities.[2]
- Environmental Protection Agency (EPA): Responsible for establishing, monitoring and enforcing environmental policies for the country. EPA has oversight responsibility in any activity that is likely to have an environmental impact. EPA monitors the activities involved in the production and use of energy.

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[2] Public Utilities Regulatory Commission Act, 1997 (Act 538).

- National Petroleum Tender Board: Supervision of international competitive bidding and award of contracts for the procurement of crude oil and petroleum products for Tema Oil Refinery.

Operational institutions

- The Volta River Authority (VRA): This wholly state-owned entity is responsible for generation and transmission of electricity in Ghana. VRA was established in 1961 under the Volta River Development Act (Act 46) to generate electric power by means of the water in the river Volta, and to supply electricity through a transmission system.[3]
- The Electricity Company of Ghana (ECG): 100 per cent state-owned entity responsible for distribution of electricity to consumers in southern Ghana, namely in the Ashanti, Central, Greater Accra, Eastern and Volta Regions. Established in 1967, ECG, the nation's main electricity distributor, is responsible for providing line connection to domestic and certain categories of industrial consumers. ECG is responsible for billing and maintaining a reliable supply of electricity to its customers.
- The Northern Electrification Department (NED): Established in 1997 as a subsidiary of VRA, it is responsible for power distribution in northern Ghana, serving the Brong-Ahafo, Northern, Upper East and Upper West Regions.
- Tema Oil Refinery (TOR): Responsible for the importation of crude oil and petroleum products. Also undertakes the refining of all the crude oil imported into the country and bulk sale of petroleum products to OMCs and bulk consumers. TOR was incorporated in 1960 under the companies' code of Ghana.

Support institutions

- The Energy Foundation (EF) Ghana: Established in November 1997 by the Private Enterprise Foundation in collaboration with the Government of Ghana, the Energy Foundation is a non-profit institution with the goal of promoting sustainable development and efficient consumption of energy as a key strategy to manage Ghana's growing energy needs in a sustainable manner. The Foundation offers energy efficiency and renewable energy advice and support to residential, industrial and commercial energy consumers in Ghana.
- Ghana National Petroleum Corporation (GNPC): Established by law in 1983 to promote the exploration and development of petroleum resources in Ghana,[4] GNPC is currently responsible for oil and gas exploration and production.

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[3] The Forty-Sixth Act of the Parliament of the Republic of Ghana (The Volta River Development Act, 1961).

[4] The Ghana National Petroleum Corporation Law (PNDC Law 64).

- Bulk Oil Storage and Transportation Company (BOST): Bulk Oil Storage and Transportation is a Government-owned, limited liability company that undertakes planning for storing and managing strategic stocks of petroleum products. BOST runs several storage depots in the port cities of Tema and Takoradi, and in seven other locations around the country. In addition, BOST is responsible for primary distribution of the products. Funding for maintaining the reserves comes from a special levy on petroleum products.
- Oil marketing companies (OMCs) and retail outlets: The oil marketing companies are responsible for distribution and marketing of petroleum products, mainly through small retail outlets countrywide.

2.2. Status of energy sector reforms, current policies

There have been a number of energy sector reforms in Ghana over the years, mostly focusing on the power subsector: expanding capacity and extending the electrical grid across the nation and to smaller communities. These efforts have been largely successful and have led to the electrification of all district capitals under the National Electrification Programme. Although renewable energy has not featured prominently in the reforms, its role has largely been to supplement the national grid by providing power as a stopgap measure and for providing electricity to inaccessible communities.

The most recent energy sector reforms were started in 1997, when the World Bank indicated that support would no longer be provided for electricity projects in developing countries unless there was a clear commitment by the Government to reforming the sector. While the reforms were undertaken primarily to secure an IDA credit for the construction of the 330 MW Takoradi thermal plant, there was also a view to secure private participation in the development of future electricity infrastructure. At the time that the reforms were instituted, there was very little external investment in energy, which led to poor quality service and poor financial performance by utilities. In broad terms, the reforms sought to achieve the main goals listed below:

1. Establish a new, effective regulatory framework;
2. Allow for competition in the generation and wholesale supply of power;
3. Commercialize existing state-owned power utilities, enhance their management and accountability, and secure private sector participation;
4. Unbundle the utilities;
5. Minimize the Government’s role and use of public resources in the sector, particularly through subsidies;

6. Use available public resources to improve the cost effectiveness of transmission and distribution projects under the National Electrification Scheme.

These reforms were expected to lead to increased access to electricity in all sectors of the economy and increased efficiency in the delivery of power to consumers. Some achievements of the reforms include the conversion of the Electricity Corporation of Ghana into a limited liability company under the Statutory Corporations Act (1993). In addition, thermal power generation has been opened up for private sector participation and competition. The expected influx of private investment to the electricity sector has not yet occurred, in spite of the high growth in demand and the need for additional capacity. So far, there has been only one private sector power generation plant; the Takoradi International Power Company (TICO), with a 220 MW capacity. It was constructed in 2000, and is owned jointly by VRA (10 per cent) and CMS Energy (90 per cent). It draws its source from the Takoradi thermal plant, which is owned fully by VRA.

The reforms also led to the creation of a new classification of “bulk customers” by the Energy Commission. Beginning 2004, the EC defined bulk customers of electricity in the mining and manufacturing industries as those customers who are able to negotiate power supply contracts directly with VRA and ECG or any other licensed independent power producer with a framework of wheeling charges and other guidelines determined by the PURC. This is expected to give such customers more flexibility and better pricing based on their high levels of consumption.

The power sector reforms have also led to the introduction of the Embedded Generation Facility (EGF) concept. By definition, an EGF is a power generation unit supplying power at low to medium voltage to an electricity substation within a particular distribution system. For example, during the 1997-98 power crises, two private companies—Aggreko Ltd. and Cummins Ltd.—each provided 30 MW power from diesel generation sets directly into the 33 kV distribution network. The Embedded Generation Facility also allows for renewable energy power producers to supply power at local levels.

2.3. Rural electrification

Ghana’s Government embarked upon the Economic Recovery Programme (ERP) in the 1980s. These reforms included the establishment of a National Electrification Scheme (NES) in 1989 with the aim of providing nationwide access to electricity by 2020. Under this scheme all communities with populations above 500 were to have access to electricity. Over the years, funding for NES has been mainly through grants, concessionary credit, government sources, and the national electrification fund levy. The levy of ¢1.7/KWh (US¢ 0.02/KWh) is paid by grid electricity consumers and generates about ¢9.8 billion (US$ 1.1 million) per year. However, heavy donor reliance has meant that specific electrification projects have been undertaken only when funding became available.

An extension to the NES for rural electrification is the Self Help Electrification Project (SHEP). SHEP allows for the electrification of communities not directly covered under NES but which are within 20 km of an existing or planned 11 kV or 33 kV transmission line. The community is required to provide a certain minimum contribution to the project, usually in the form of wooden poles for the distribution wires. Government would then provide additional assistance to complete the project. The average tariff for electricity for urban consumers is between 5.2-8.2 US¢/kWh, but rural subscribers pay about US$ 1.00 as a connection fee to the electricity supplier and then a subsidized lifeline tariff of about $2.00/month for consumption of up to 50 KWh/month. This amounts to about US¢ 4.0/KWh. The extra costs for connecting rural communities (transmission, distribution and service drop costs) are covered by Government under the NES.

Before the launch of NES in 1990, only 478 (11 per cent) out of 4,221 identified communities nationwide had access to electricity. Of the 110 district capitals at the time, only 46 were on the national grid. Between 1991 and 1994, the initial phases of SHEP 1 and SHEP 2 were completed, with the connection of 50 and 250 communities to the grid respectively. SHEP 3 was launched in 1995, and covered almost 1,400 communities nationwide. By the end of 1999, all 110 district capitals were electrified; and over 450 communities (52 per cent) also had power. By 2004, 3,500 communities had access to power, representing 65 per cent of the total. Presently, all communities with populations greater than 3,000 are connected to the grid. As a result of the ongoing electrification scheme, access to electricity in the country had reached about 48 per cent by 2003, which is among the highest in sub-Saharan Africa.

The rural electrification drive may receive a boost with the recent announcement by the Minister of Energy of the arrival of US$ 15 million worth of equipment, with an additional US$ 30 million earmarked to support the project.[5] Also, the Government recently announced its intention to shift the focus of the National Electrification Scheme (NES) to ensure that rural communities used the supplied power to boost economic activities.[6]

So far, many rural communities have benefited from the available electric power, even though power supply to the rural areas has been unreliable with frequent

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[5] "All Set For Bui Dam To Take Off", Daily Graphic, October 28, 2005.

[6] "Government To Shift Focus Of National Electrification Scheme", Daily Graphic, Sept. 28, 2005.

power outages and low voltage situations. However, many households consider the current electricity tariffs as unaffordable.[7]

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[7] Amissah-Arthur, Jabesh; Anamuah Amonoo, Jojo. *Study of the Social and Poverty Impacts of Energy Interventions on Rural Communities in Ghana*. Kumasi Institute of Technology (KITE), April 2004.

3. RENEWABLE ENERGY

Although several efforts have been made through feasibility and pilot programmes, there has not been a concerted policy regime that specifically targets renewable energy technologies (RETs). Moreover, none of the electrification programmes have included renewable energy as an alternative source of power. This has meant that renewables remain in the hands of individuals with little government support. In spite of the EGF facility introduced under the reforms, there is no process in place presently for individuals or cooperatives to feed the power generated from renewable energy systems into the national grid. Some of the significant initiatives with regards to renewables are outlined below.

The earliest effort to harness renewables came in the wake of the global energy crisis of the 1970s, when the Government of Ghana created a special committee on energy resources. This marked the beginning of the Government's interest in diversifying Ghana's energy sources, and pursuing a developmental programme in renewable energy technologies.

In 1983, the Government instituted the National Energy Board (NEB) by enacting a law (PNDC Law 62). The Board was to oversee the development of renewable energy resources. Also, NEB's scope of activities spanned energy conservation (electricity and petroleum) and demand management. A total of 135 projects were undertaken by NEB, 29 of them being in renewables.

The NEB was abolished in 1991, and until 1996 when another policy document was put in place, the activities of NEB were carried out by the Ministry of Mines and Energy. In 1996, the Energy Sector Development Programme (ESDP) was initiated.

Under the ESDP, the Renewable Energy Development Programme (REDP) was set up to promote the development of RETs and the renewables industry, as well as to build a database on renewable energy activities in Ghana. REDP supported a number of biomass and solar energy projects.

ESDP has been the overall policy regime regulating the development of RE technologies in Ghana to date. However, ESDP is to be replaced with the National Renewable Energy Strategy (NRES) being formulated with the support of the Danish International Development Agency (DANIDA). This is under the Strategic National Energy Programme (SNEP), which is intended to dictate the direction of the development of energy in Ghana from 2000-2020.

The current energy policy document is the Strategic National Energy Programme. SNEP is projected to span a twenty-year period, 2000-2020. In 2003, a technology catalogue for SNEP was published, in which the goal of SNEP was stated as:

> "... to contribute to the development of a sound and well regulated commercial energy market that will provide sufficient, viable, efficient and least cost energy services for social welfare and economic activities through the formulation of a comprehensive plan that will identify the optimal path for the development, utilisation and efficient management of the country's energy resources."[8]

The document identifies the following RETs as viable projects that warrant attention:

- Solar water heaters;
- Biomass—charcoal kilns, sawdust briquetting, biomass gasification, palletizing, biogas plants, pyrolysis;
- Grid/off grid solar systems;
- Grid/off grid wind turbines;
- Off-grid small hydro;
- Landfill gas power plants.

Renewable energy contributes an insignificant part of electricity supply in Ghana. For example, by 2001, the estimated over 4,000 off-grid PV systems installed nationwide had a total capacity of 1MW, compared to the grid capacity of over 1,700 MW in 2003.[9] Besides the major hydroelectric plants, electricity generated from RETs is used at the individual household or institution level, and does not enter the supply grid. The different renewable energy technologies and according case studies in Ghana are described below.

3.1. Biomass

The combustion of biomass is the primary means of energy for most of the Ghanaian population. In the rural areas, fuel wood for cooking accounts for 57 per cent and charcoal 30 per cent of energy consumption. Charcoal is also the fuel of choice for cooking in the urban areas. Efforts in the renewable energy field have focused on developing and deploying new technologies to make biomass combustion safer and more efficient.

More advanced uses of biomass involve the conversion of biomass into other forms before being used for energy generation. In ovens and furnaces, biomass is typically used in the form of charcoal, sawdust briquettes, and gas. Gas can be generated directly for use in a gasification plant, or in a biogas plant. A small number of biogas plants have been installed in Ghana, and the Kwame Nkrumah University of Science and Technology (KNUST) has built research prototypes of viable biomass converters.

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[8] Strategic National Energy Plan 2000-2020 Technology Catalogue, April 2003.

[9] Electricity Sector Overview; Ghana Energy Commission.

At least three palm-oil mills have biomass-fired power plants for generating electricity from palm fruit residues. These have a total generating capacity of 1.5 MW. Also, at least one sawmill runs a plant based on wood residue, while another such plant lies abandoned.[10] According to the technology catalogue of SNEP, there are many commercial biomass cogeneration plants available in Ghana, operating mainly in off-grid locations.

One of the most famous biogas projects in Ghana is the "Integrated Rural Energy and Environment Project" commissioned in 1990 at Appolonia in the Greater Accra region. This pilot project was to produce biogas from human and animal waste, and the gas used to produce electricity and also for cooking. The system provided electricity to five social centres, a school, 21 houses, and 15 streetlights. This project has shown itself to be unsustainable, and has come to a standstill.[11] Recently, worldwide interest has been directed at biofuels. A promising plant is *Jatropha curcas*, which grows in arid conditions and yields seeds that can be processed into biodiesel. This fuel has been shown to run in conventional engines. Currently, a Jatropha oil-extracting project is running on a pilot basis in Yaakrom in the Brong Ahafo region. In 2005, DaimlerChrysler and UNESCO announced funding for a research project, Jatropha Energy Development for Rural Communities in Ghana. The project will be undertaken by a team from KNUST and Cambridge University and aims to establish a small-scale industry for the development of Jatropha diesel to serve rural communities.[12] The authors are unaware of any company that offers any biomass technologies for sale at this time.

3.2. Solar electricity

Solar photovoltaics (PVs) are by far the most popular renewable energy application. Solar electricity has been shown to be technically viable, but due to the high initial costs there has not been a widespread application of PV systems nationwide. PV systems have been used to provide electric power mainly for health centres and for homes. Some PV systems have also been installed for commercial applications such as telecommunication repeater stations, water pumping, and battery charging. Furthermore, the solar lantern is quite well received, and had the cost been lower, would have been a viable competitor to the kerosene lantern. In the urban areas, PV systems are often used in electricity back-up systems in areas where grid reliability is low. Also, a few wealthy individuals invest in PV systems for their homes in order to diversify their energy sources.

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[10] *Renewable Energy Development Programme*, Draft National Renewable Energy Strategy, Ministry of Energy, Energy Commission, and DANIDA. October 2003.

[11] E. K. Ackom, *Technical & Economic Viability Analysis of Renewable Energy Technologies in Ghana*. PhD Thesis. Brandenburg University of Technology, 2005.

[12] www.mondialogo.org/106.html

Currently, there are a number of private companies offering renewable energy technologies and services in Ghana. Most of them are involved in solar electricity, and mainly sell to private urban households. The companies sell discrete components such as panels and balance of system (BOS) parts: batteries, inverters, chargers, solar lanterns, and submersible pumps. However, some companies offer full system design, installation and maintenance. A few companies offer installation and maintenance services only.

Recently, some opportunities were created for the private sector to supply large quantities of solar PV equipment. For example, in 2005, the Ministry of Education required 300 solar home systems for its Non-formal Education Division (NFED). The supply and installation of the pre-designed PV systems was put to a competitive tender.

Several projects have deployed solar PV systems to provide electricity services to off-grid communities. Notable projects are the Renewable Energy Services Project (RESPRO) in the East Mamprusi district. This project started in February 1999 and was originally expected to last three years after which RESPRO would become a public sector company providing rural energy services for a fee. Although the project phase formally ended on 31 March 2003, the Ministry has continued to support the programme.

RESPRO has installed and is operating solar PV systems in over one hundred communities in thirteen districts of the three Northern regions and Brong-Ahafo region. Table 3 shows the total number of installations under RESPRO.[13]

Table 3. Number of installations carried out under RESPRO

Solar home systems	2,200
School systems	42
Clinics systems	6
Water pumping system	1
Street lighting	24
Total	**2,273**

Another solar electricity initiative is the Solar Rural Electrification Project run by the Ministry of Energy between July 1998 and December 2000. More than 1,500 systems were installed in several communities in the Volta, Eastern, Upper West, Greater Accra and Northern Regions. Some of these communities have since been connected to the national grid, and the Ministry intends to relocate those PV systems to other districts where they are needed.

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[13] Ministry of Energy: www.energymin.gov.gh

The Ministry has also installed a number of PV street/area lighting projects in the rural areas. This application of PV has been found to benefit the community as a whole, suggesting a higher social impact vs. cost ratio than individual home systems. For example, a single street or area lamp placed at a lorry station or the village centre extends hours of business for food vendors and bus operators. The maintenance of such projects can be put under the local authority or the transport union, and this can be more sustainable in the long run.

Table 4 summarizes the extent of PV deployment in Ghana. The RESPRO project is item 4 on the list, appearing as the Rural Energy Services Company (RESCO).

Table 4. List of PV projects in Ghana[14]

Organization	Project
Danida/MOH Solar Project	PV refrigeration, lighting, water pumping and heating, *Equip* rural or small health sectors with reliable tech.
CIDA-UR/UST Renewable Energy Project	Small-home-systems (SHS), battery charging, water distillation
UST/GTZ solar pump project	Radial flow centrifugal water pump
MOME [special unit, in close collaboration with the Volta Authority (VRA/NED)] UNDP/GEF	UNDP/GEF, GEF grant of $2.5 mil. Ghana Gov. $0.5 million for establishment of RE-based rural energy services company River (RESCO) to provide off-grid solar electrification to initially 13 villages
MOME	2 solar service centres Funding through a $185 million (306,177 million Cedis) syndicated loan provided by IDA, ORET of Netherlands, DANIDA, Nordic Development Fund (NDF) and Caisse Francaise de Developpement (CFD), the rest of 105,066 million Cedis was to be the local component of the programme
MOME Wachiau Project	2.1 kW solar battery charging centre Battery operated home systems (BOHS)
MOME Spanish Solar Project	Concessionary loan of the Spanish Government of $5 million for off-grid solar electrification of 10 villages, Home, school & community systems, water pumps, streetlights
MOME Solar Thermal Projects	Crop dryers for reduction of post-harvest losses Improve quality of agric. produce for high export prices
CIDA-University Of Regina, in collaboration with the University of Science and Technology of Ghana	Solar service centres (SSC), installed in rural communities since 3.1995 CN$ 1.24 , of which CIDA (Canadian International Development Agency) contributes $900,000 with the remaining amount donated by the participating universities
The Ghana Solar Energy society (GHASES)/GEF also Ghases/Women's World Banking	GEF Small Grants Project and Women's World Banking micro-credit scheme Training/marketing for improved charcoal stove; administration of a micro-credit scheme
Sun oven	Production and marketing of solar ovens

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[14] www.areed.org/country/ghana/ghana.pdf

The estimated 4,600 PV projects are summarized according to application in table 5.

Table 5. PV systems in Ghana according to application

Application	Quantity
Lighting	4270
Vaccine refrigeration	210
Water pumping	80
Telecommunication repeater stations	63
Radio transceivers	34
Battery charging stations	20
Rural telephone systems	3
Grid-connected power generation*	1

*This unit, installed at the Ministry of Energy, is experiencing technical problems.

3.3. Solar thermal technology

Thermal applications of solar energy are limited to small systems for the provision of hot water from solar water heaters (SWHs). Solar water heaters have been installed in individual homes, hospitals and hotels, but this has been on a small scale because cheaper water-heating alternatives such as electric water heaters are available.[11]

Solar drying of foodstuffs is widespread and is the traditional form of storing many types of food, but this is usually rudimentary—foodstuffs are spread out in the sun or hung in barns to dry. A number of solar crop driers have been manufactured and trails have shown them to be a viable application of solar energy in Ghana.[10]

3.4. Wind energy

Ghana's wind resources are confined to narrow stretches along the eastern coastline and offshore; but the speeds are moderate. Even so, it is still expected that wind energy can be harnessed to provide electricity in commercial quantities[8, 11].

A number of private companies in Ghana sell small wind turbines (systems ‹ 50 kW have been advertised).

In 2004, Enterprise Works Ltd. launched the "Ghana Wind Energy Project", a demonstration project of 12 wind turbines (600-1,000 Wp) installed along the eastern coast of Ghana. The Global Environment Facility and the World Bank provided funding. Six of these wind turbines were locally manufactured, with the intention of developing local technical capacity in the fabrication of small wind turbine systems.

3.5. Mini/micro hydro generation

Studies conducted in Ghana over the past three decades have shown that there exists a theoretical availability of up to 25 MW of micro hydropower from 70 sites.[10] However, recent studies have shown that a number of these sites are fed from water sources that tend to dry up for a number of months in the year. Some of the other sites have been found to be economically unfeasible.[11] Currently, one of the feasible sites is being developed, and a 30 kW system expected to be established soon.[15]

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[15] Personal communication with Mr. W. Ahiataku-Togobo.

4. CONCLUSIONS

The penetration of renewable energy technologies (RET) in Ghana could have been extensive by now if the barriers to the successful application of these technologies had been dealt with earlier. Some of the barriers had to do with the cost of the technology (which is rapidly reducing), but other barriers have to do with financial arrangements, government policies and customer education.

Many years of heavily subsidized petroleum and electricity costs have made RE options, especially PV, uncompetitive and therefore the sector was unable to attract sufficient private sector investment. The few companies dealing in RETs are unable to generate enough sales to keep them running, since the people who need their services most cannot afford them.

The Government launched a number of pilot projects, which subsequently failed. By their very nature, these projects could be seen as a “test of concepts” and therefore failure was an “acceptable” option. However, the authors are of the opinion that certain mechanisms could have been put in place to ensure the success of such projects. For example, the biogas project at Appolonia had certain difficulties with the provision of sufficient dung. Also, the tariffs paid by the consumers at Appolonia were insufficient and could not keep the plant running. Thus the facility has been out of use for considerable time, even though electricity continues to be provided by fuelling the generators with regular diesel fuel.

The RESPRO is also reported to have run into difficulties, where many of the installations have batteries that are run down but cannot be replaced due to lack of funds. Once again, it would appear that the tariff regime is unable to sustain the project.

The Ghana Wind Energy Project launched by Enterprise Works ran into technical difficulties when some of the electronic components at various sites were damaged during windstorms.

5. KEY RECOMMENDATIONS

Based on observations and interviews in Ghana, several key areas have been identified as needing attention. The areas listed below are not intended to be comprehensive, and do not take into account efforts that may be presently underway at the government level which were not made known to the authors during the course of their research.

Firstly, it is recommended that future energy policies be reviewed to incorporate renewable energy technologies as part of the energy mix. The present situation where large-scale grid electricity is planned separately from decentralized renewable sources has hindered the development of the sector and perhaps reduced the number of communities that could have been electrified.

As part of the planning process, it is recommended that firm numerical targets be established for the proportion of total electrical energy that will come from RETs. When a target it set, it will allow resources to be mobilized and foster policies and programmes to achieve this goal.

The present tax waiver on solar generating sets was found to be restrictive and has not led to the expected increase in the development of solar energy in Ghana. It may be worth considering the removal of these duty and tax waivers on RETs, and apply the funds instead to an RET fund to support viable renewable energy projects. Having a fund for renewable technologies will allow careful evaluation of projects for feasibility and economic benefit. The selected projects will also be fully funded and are likely to be on a scale that will be sustainable.

It would be necessary for the Energy Commission to clarify regulations regarding independent power producers and the Embedded Generation Facility to allow private operators to evaluate the opportunities present in the energy sector and make investment decisions. Lack of clarity may be preventing much needed investments. The regulator should also make provisions to make it easier for cooperatives to generate their own power using renewable resources. Furthermore it will be necessary to provide technical support to communities that have natural resources and are interested in establishing their own generation facilities. This particularly applies in the case of mini and micro-hydro resources.

The classification of energy producers should be refined to distinguish small operators from large ones. This does not necessarily mean compromising on environmental and performance standards, but it will allow smaller companies to be incorporated into the mainstream energy sector. Under the current situation, smaller energy service companies do not benefit from the resources of the Energy Commission because the barriers to recognition are too high.

To make RETs more practical and visible in the lives of ordinary people, it would be necessary to move emphasis away from pilot projects to viable and functional entities. The abundance of pilot programmes in the past has created the impression that renewable energy technologies are an exotic curiosity and far removed from the real world. By selecting proven technologies and establishing viable businesses around them, policymakers and industry can start to change this perception.

Finally, renewable energy technologies should be incorporated into the NEP and SHEP programmes as soon as possible. There should be a single electrification programme in which several alternative power sources are available. Communities and programme managers can together then choose the best options for each community. This will also prevent the situation where people on the grid are subsidized, but those who choose to use RETs are made to bear the full cost of their installations.

Case study 5.

ZAMBIA: INSTITUTIONAL FRAMEWORK AND STATUS OF RENEWABLE ENERGY

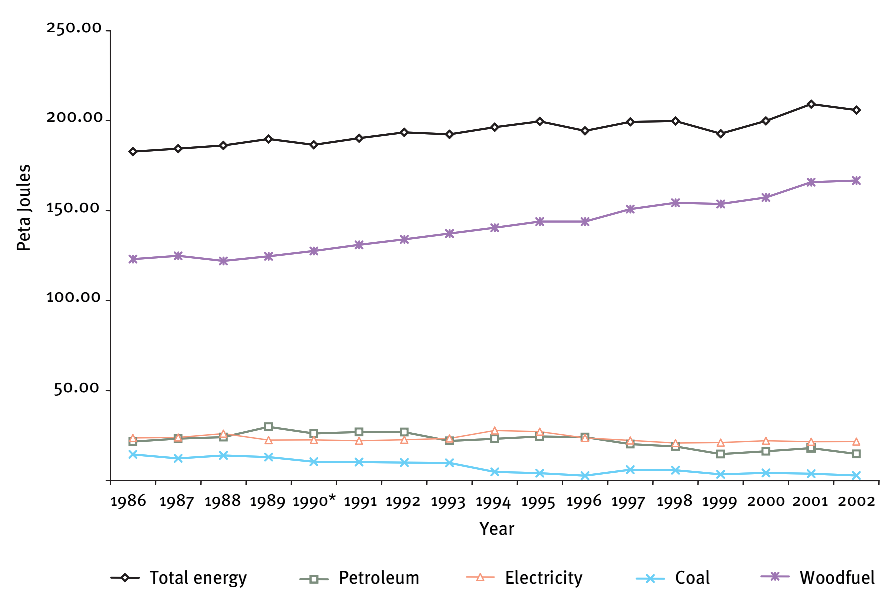
CONTENTS

1. BACKGROUND

1.1. Energy consumption

The overall energy consumption trends for Zambia between 1986 and 2002 are given in figure I.

Figure I. Energy consumption trends (1986-2002)



Source: Department of Energy, Energy Bulletin 1990-2003.

There has been a moderate growth in total energy consumption between 1986 and 2002. The increase has mainly been attributed to wood fuel utilization in the household sector as a result of increasing population.

However, petroleum and coal consumption trends witnessed a decline due mainly to a corresponding decline in economic activities, especially after 1991, when the country experienced industrial company closures following the privatization programme. The closures were mainly a consequence of opening the market to international goods and services, thereby making some local goods and services uncompetitive.

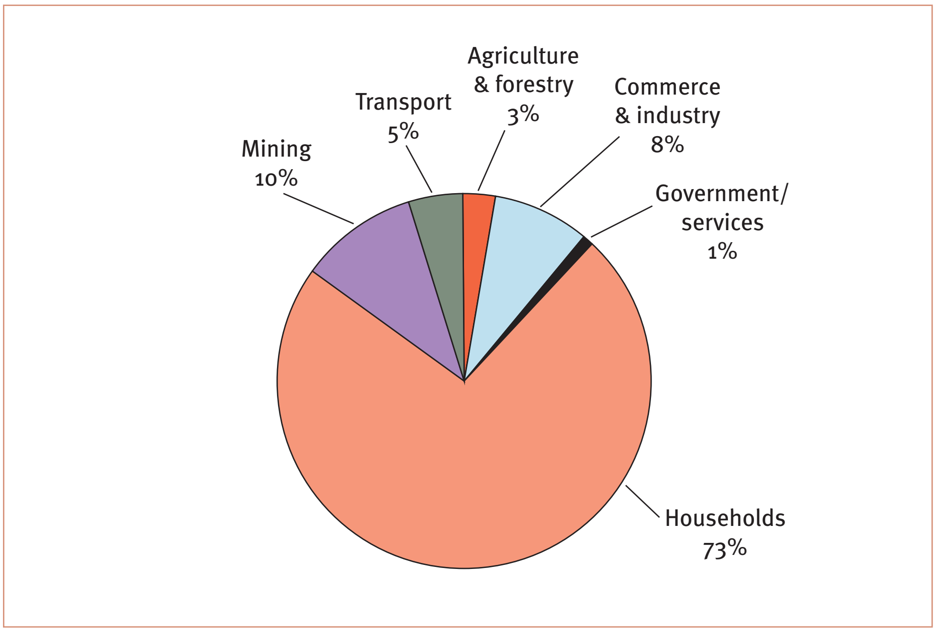
The overall energy consumption by sector for Zambia is illustrated in table 1 and figure II for the year 2000.

Table 1. Energy consumption by sector (year 2000)

Sector	Peta Joules	Per cent
Agriculture and forestry	5.75	2.8
Commerce and industry	17.06	8.3
Government/services	2.29	1.1
Households	150.56	73
Mining	20.99	10.2
Transport	9.67	4.7
TOTAL	206.33	100

Source: Department of Energy, Energy Bulletin 1990-2003.

Figure II. Sectoral energy consumption chart (2000)



The energy consumption pattern in Zambia is dominated by households and mining. As shown in table 1 and figure II, households account for 73.0 per cent of total final energy consumption in 2000. The largest share of energy consumption by households is attributed to firewood as illustrated in figure I, which indicates the overall importance of firewood in the provision of energy in Zambia. The mining sector, second in importance in terms of energy consumption, accounted for 10.2 per cent of total final consumption, followed by industry 8.3 per cent and transport 4.7 per cent.

1.2. Energy supply

Zambia is well endowed with hydropower resources. The main river catchment areas that have been developed are the Zambezi and Kafue. On the Kafue River, Zambia has developed the Kafue Gorge hydroelectric scheme (900 MW); on the Zambezi River, Kariba North Bank (600 MW) and Victoria Falls power station (108 MW). Small/mini-hydro power stations serve the rural areas. The significant ones are Lusiwasi (12 MW), Chishimba falls (6 MW), Musonda falls (5 MW) and Lunzua (0.75 MW). The main power stations are interconnected into the main grid via a 330 and 220 kV network. There is an untapped hydropower potential of about 6000 MW. Table 2 shows total installed electricity generation capacity in 2004.

Table 2. Installed electricity generation capacity (2004)

No.	Description	Capacity (MW)	Type
1	Kafue Gorge	900	Hydro
2	Kariba North Bank	600	Hydro
3	Victoria Falls	108	Hydro
4	Lunsemfwa and Mulungushi	38	Hydro
5	Small hydros	24	Hydro
6	Isolated generation	10	Diesel
7	Gas turbine (stand-by)	80	Gas
	Total installed capacity	**1760**	

The country also has large deposits of coal at Maamba in the south of the country, along the Zambezi valley with deposits estimated at 30 million tons. Other areas where coal deposits have been located are Lwangua North, Luano, Lukusashi, Chunga and Lubaba. These deposits are estimated at several hundred thousand tons each. Due to production constraints and lack of investment funds, the design output of 1.2 million tons per annum of beneficiated and saleable coal has drastically dropped over the last years. Coal only contributes about 6 per cent of the country's energy needs, mainly in the mining and industrial sectors. At domestic sector level, research has been completed aimed at developing suitable appliances that can use coal briquettes.

Peat is another potential source of energy in the country. A general cartographic analysis reveals that there are peat land areas along the Zambezi and Kafue river valleys. However, there has not been a systematic investigation of the resource to date, therefore its use in Zambia cannot be quantified.

Zambia receives a lot of sunshine, such that solar power presents itself as a substitute to other energy sources. It is competitive when remote areas are being considered, especially for water pumping, electrifying village communities and refrigeration in health clinics. The main constraint is the initial investment cost, which is quite prohibitive. The other form of renewable energy source is wind power. Today in Zambia its use is basically limited to water pumping.

Wood fuel and charcoal are estimated to meet the energy needs of about 70 per cent of the rural and urban population. The copper mines utilize nearly 2000 tons of charcoal annually in the refineries.

Petroleum is not indigenous to Zambia. This has to be imported as crude and refined into petrol, kerosene, diesel, aviation gas, and heavy fuel oil. Petroleum has to be imported at international prices, transported through a 1500 km pipeline to the refinery in Ndola. The refinery has a processing capacity of 1.0 million tons per year.

2. ENERGY REGULATION

The current institutional and legal framework for the energy sector is a result of the liberalization and reform process that started with the first ever National Energy Policy, released in 1994 (NEP1994). The Government's liberalization of various sectors of the Zambian economy at the beginning of the 1990s was the main driving force of the reforms in the energy sector. New laws, namely the Energy Regulation Act (1995), the Electricity Act (1995) and the Rural Electrification Act (2003) were enacted to facilitate liberalization and to ensure consistency of the energy sector with other sectors.

The Energy Regulation Act provides for the establishment of the sector regulator, the Energy Regulation Board (ERB), and defines its functions and powers. The ERB is the sole licensing authority for operators in the energy sector and is responsible for close monitoring and supervision of such operators. The ERB is also responsible for monitoring the level and structure of competition, market entry issues (i.e. the ease of market entry) and investigating and remedying consumer complaints. In order for the ERB to execute its mandate, the Board works with other statutory bodies such as the Environmental Council of Zambia, the Zambia Competition Commission and the Zambia Bureau of Standards. This therefore means that the legal and regulatory framework of the power sector also needs to recognize the legislation of these institutions namely: the Environmental and Pollution Act, the Zambia Competition Commission Act and the Zambia Bureau of Standards Act.

The Electricity Act provides the framework within which the electricity sector will operate. It abolished the statutory monopoly that the state-owned utility ZESCO Limited had enjoyed in the electricity subsector and provides for new entrants. The act sets out the rights and obligations of the electricity supply companies and those of the consumer.

The Rural Electrification Act established the Rural Electrification Authority, an institution responsible for implementing rural electrification, as well as defining its functions and establishing the Rural Electrification Fund.

Furthermore, a new awareness of the integrated nature of energy in economic development has prompted the review of the existing policy and the formulation of the 2005 National Energy Policy (NEP2005). The NEP2005 sets out the Government's intentions in the energy sector, these being aimed at ensuring that the sector's latent potential to drive economic growth and reduce poverty is fully harnessed. The NEP2005 is still under consideration by Government.

Some of the gaps in the current legal and regulatory framework include:

- Open access to the transmission grid by independent power producers (IPPs) is difficult to implement because the transmission system operator, ZESCO Limited, has a vested interest in maintaining control and owns most of the generating power stations.
- About 70 per cent of power sales in the country are covered under long-term agreements between ZESCO, CEC and the mines, thus reducing the scope for competition amongst new entrants.
- There is lack of an established and well-functioning electricity market for the sale and purchase of power. Consumers do not have power supply choices.
- The Framework Incentive Package for promoting private power investments is not backed by law.
- Sub-economic tariffs.
- Cross-subsidization in tariffs.

Since the promulgation of the Energy Regulation Act and the Electricity Act in 1995, two prominent private companies have entered the power sector, namely the Copperbelt Energy Corporation (CEC) and the Lunsemfwa & Mulungushi hydropower company. Both companies operate under licence from the ERB. However, the power tariffs were negotiated between parties under various long-term power purchase agreements.

The Rural Electrification Authority (REA) was also established following the promulgation of the Rural Electrification Act of 2003. The REA is still in its early stages of development. The REA is expected to spearhead the development and application of renewables for rural electrification in Zambia.

3. RENEWABLE ENERGY

Renewable energy sources are increasingly being used in Zambia but still remain insignificant in terms of contribution to the total national energy supply. Some of the past and current renewable energy initiatives are detailed in annex 1 of this case study. There is no specific legal framework dealing with renewable energy sources in their entirety, however, renewables are regulated under the Energy Regulation Act and when used for electricity generation, the Electricity Act also applies. These pieces of legislation, in their present state, are not adequate to regulate and promote renewable energy.

Although Zambia is endowed with many renewable sources of energy, efforts to harness these resources have been minimal. This is despite the fact that renewable sources of energy, particularly solar and wind energy, are widely available and have the potential to improve the living standards of rural population.

Some of the constraints to a wider use of new and renewable sources of energy include:

- Lack of awareness among the general population about the renewable sources of energy technologies;
- Lack of an institutional framework for resource mobilization, system planning and expansion;
- High initial costs;
- Inadequate adaptive research on NRSE technologies to Zambian situation;
- Lack of end-user acceptability;
- Inadequate demonstration projects;
- Lack of specialized training.

Some of the policies and regulatory measures that the Government has embarked on to promote renewable energy development are:

- Establishment of the Rural Electrification Authority (REA) is expected to effectively accelerate the implementation and mobilization of funds for renewable energy for rural areas.
- Government's deliberate policy to deal with the current inadequate information about available renewable energy resources and applicable technologies, poor dissemination of information, low literacy levels and a lack of awareness of potential business opportunities among entrepreneurs.
- Government's policy to ensure that energy prices reflect costs of providing energy and also to take into account principles of fairness and equity.

The above policy measures, which are contained in the proposed NEP2005, are adequate to promote the development and deployment of renewable energy if they are backed by the appropriate legal, regulatory and institutional frameworks. In addition, the government will need to take further deliberate measures to build the necessary capacity at various policymaking levels within both the government itself and the Energy Regulation Board and the Rural Electrification Authority in order to achieve an effective regulatory environment for the promotion of renewables.

4. CONCLUSIONS

The power sector in Zambia has been going through a dramatic change from a totally state-controlled business with vertically integrated subsector monopolies to a free market with competition and private sector investment. An appropriate legal and regulatory framework has been established through legislative instruments, such as the Energy Regulation Act and the Electricity Act. A sector regulator, the Energy Regulation Board, was established in 1997 as an independent and sole licensing authority for operators in the energy sector. A Rural Electrification Act was passed in 2003 and a Rural Electrification Authority established.

Zambia does not have a specific legal framework dealing with renewable energy technologies (RETs) in their entirety. However, these are regulated under the Energy Regulation Act and the Electricity Act. A specific framework for the promotion and development of RETs is necessary.

The major constraints to a wider use of RETs include: *(a)* lack of awareness about RETs; *(b)* high initial costs; *(c)* inadequate adaptive research on RE technologies to the Zambian situation; *(d)* lack of end-user acceptability; *(e)* inadequate demonstration projects; and *(f)* lack of specialized training.

The National Energy Policy of 1994 (NEP1994) clearly spells out policy measures needed to accelerate the development of renewable energy. These include:

- Promotion of education and training in renewable energy at various levels;
- Promotion of information dissemination about renewable energy;
- Promotion of renewable energy technological development.

The proposed National Energy Policy of 2005 (NEP2005) further recommends:

- Strengthening of the institutional framework for research and development of RETs;
- Application of appropriate financial and fiscal instruments for stimulating the implementation of RETs;
- Actively involve women in decision-making and planning in renewable energy programmes and activities;
- Promotion of biomass technologies for electricity generation.

The above policy measures are contained in the proposed new national policy (the NEP2005). Consequently the above policies have not yet been implemented a significant degree. However, it is expected that this situation will be addressed now that the Rural Electrification Authority has been established.

Zambia is currently undertaking a series of renewable energy projects such as the African Rural Energy Enterprise Development (AREED), Access to Energy Services (IAES), and ESCO projects. These are pilot projects from which important lessons have been learnt. The ESCO project in Eastern Province can for example now be extended countrywide given further financial and technical assistance. The same can be said about the other projects.

5. KEY RECOMMENDATIONS

Policy changes that would better promote renewable energy technologies can be summarized as follows:

- Deliberate and clear policy to build and strengthen awareness on renewable energy technologies (RETs) at the policymaker level through appropriate training and other capacity-building activities.
- Build capacity within the relevant regulatory agencies on the techniques to promote RETs through appropriate regulation.
- Minimize financial constraints and create attractive investment incentives for the private sector to participate in the provision of RET solutions to the energy sector problems by introducing tax incentives and smart subsidies for example. This would greatly compliment the Government's own funding and the current 3 per cent rural electrification levy.
- Strengthen institutions currently involved with the development of RETs including the Rural Electrification Authority (REA). Comprehensive capacity-building is required at REA at this stage.
- Ensure that electricity tariffs are cost reflective with a view to encouraging private investment.
- Build an effective communication infrastructure to ensure that there is adequate information available about RETs to the general public. Awareness of the business opportunities available to entrepreneurs.
- Ensure that experiences gained from some of the pilot projects that the Government has already undertaken (such as PV-ESCOs, AREED, and IAES) are used as examples of the application of renewable energy providing successful and sustainable solutions.
- Consider a renewable energy policy as an opportunity to address other policies such as employment, gender issues and energy poverty (especially in rural areas).

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ANNEX. CURRENT RENEWABLE ENERGY INITIATIVES

Energy service companies

The ESCO project was a new approach for providing electric light and other basic services to people in rural areas through solar photovoltaic (PV) systems. The approach was based on the Energy Service Company (ESCO) approach. The main objective was to create a sustainable market by which the people in rural areas would access the services provided by solar photovoltaic technology at a fee. The project was initiated by the Government of Zambia (through the Department of Energy) in 1998 with financial support from the Swedish International Development Agency (SIDA) and technical assistance from the Stockholm Environment Institute (SEI).

This project was executed in three phases: Phase I (June 1998–June 2000), Phase II (October 2001–December 2003) and Phase III (September 2004–September 2005). The project is currently at the reporting stage of Phase III.

AREED

The AREED Initiative is a multi-country initiative and was established in 2000 by a group of multi-lateral (UNEP and the UNF), international companies/NGOs (primarily E&Co) and national government partners (Ghana, Mali, Senegal, United Republic of Tanzania and Zambia). It is being implemented by E&Co and seeks to develop new sustainable energy enterprises that use clean, efficient and renewable energy technologies to meet the energy needs of the rural poor, thereby reducing the environmental and health consequences of existing energy use patterns.

The main objectives of AREED are:

- To create rural energy enterprises and to build the capacity of NGOs and institutions to facilitate enterprise development.
- To provide early stage funding and enterprise development services to entrepreneurs, build capacity in African NGOs to work with clean energy enterprises and work with financial institutions to assess the rural energy business sector as well as integrate enterprise investments into their portfolios.

In order to achieve the above objectives, AREED has the following components in its portfolio:

- Training and tools to help entrepreneurs start and develop energy businesses;
- Enterprise start-up support in areas such as business planning, structuring and financing;
- Seed capital for early stage enterprise development;
- Assistance in sourcing second stage financing.
- Partnerships with banks and NGOs involved in rural energy development.

The AREED initiative has begun operations in Botswana, Ghana, Senegal and Zambia. It is working in-country with a number of local partners, including ENDA in Senegal, KITE in Ghana, CEEEZ in Lusaka and the Mali Folkecenter.

Increased Access to Energy Services Project (IAES)

The Government, through the Ministry of Energy and Water Development (MEWD), recognizes the need for increasing rural and peri-urban access to electricity and information communication technology (ICT) as a strategy to reduce poverty in these areas. As part of the implementation strategy, the government embarked on the Increased Access to Energy Services Project (IAES) financed by World Bank, Global Environmental facility, other donors, and the Prototype Carbon Fund.

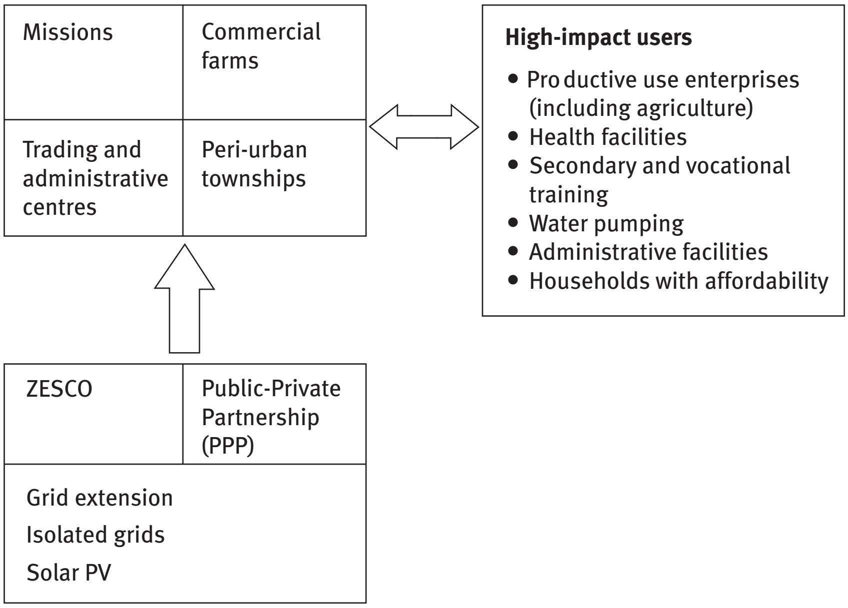
IAES project objectives and design strategy

The objective of the project is to provide for investment and technical assistance/capacity building activities to enable the scaling-up of access to electricity and ICT services in rural and peri-urban areas to maximize development impact: *(a)* income generation by SMEs through productive uses (farm and non-farm), and *(b)* improved quality of life emphasizing the effectiveness of social services (such as health, education) and administrative service.

The underlying approach of the IAES project is to expand access via public-private partnerships in a commercially oriented manner, i.e. with focus on cost recovery. It is recognized that there is a need for “smart” subsidies that address the up-front capital cost investment requirements and the initial transaction costs to encourage entrepreneurial activity while maintaining efficiency of operations and promoting output. The level and terms of the capital subsidy may differ according to project characteristics—including underlying prospects for economic growth and investment risks. GEF provided financial support will be available for developing local hydro and other renewable energy generation for sale to the grid and to independent grids.

The scale-up strategy for designing delivery mechanisms and targeting the limited resources (credit and grants) is driven by the consideration of maximizing the development impact on growth and poverty within the prevailing sectoral context and taking into account emerging changes that can be characterized as a “break from the past” in Government policies for the sector.

This means (see schematic below) geographically targeted introduction of electricity and ICT services at established centers of economic and/or social activities for the benefit of large numbers of people drawn to those centers from the respective catchment areas. Such concentrations of activity and centers of day-to-day life for most rural people are missions, farm blocks, trading and administrative centers (including postal centers) and peri-urban townships. As appropriate, they would also include community centers and zonal resource centers.



Finally, another key aspect of project design is consistent with the Government's emerging policy thrusts and initiatives that aim to engineer a "break from the past", by opening up key infrastructure sectors of the economy to new entrants while at the same time strengthening the existing parastatal players. In keeping with this, the IAES project aims to target a third of the IDA credit for rural electrification investments and the bulk of GEF grant resources for enabling rural electrification and renewable energy investments via public-private partnerships (PPP). Specifically, the project would develop and strengthen two parallel and complementary service delivery modalities and sector players: ZESCO and new entrants that are non-ZESCO sponsors. The latter potentially include sponsors of subprojects and investments such as mission groups, other private sponsors, and creditworthy NGOs as well as community-based organizations with bankable business plans.

A key preparation activity is to prepare and offer on a competitive basis, the opportunity to undertake pre-defined rural and peri-urban electrification schemes, or "subprojects", designated as Priority Rural Electrification Projects (PREPs).

Case study 6.

UNITED KINGDOM RENEWABLES OBLIGATION

CONTENTS

1. POLICY AND INDUSTRY STRUCTURE

The lead government department on energy policy in the United Kingdom is the Department of Trade and Industry (DTI) and it is here that renewables policy is mainly developed. However, the Department for the Environment, Food and Rural Affairs (DEFRA) is the lead government department on climate change and environmental issues and it also has the lead on energy efficiency.

The electricity and gas industries were privatized in the United Kingdom in the late 1980s. There have been a number of changes in the energy market since privatization but the structure as at mid-2005 was as follows: six large integrated gas and electricity supply and generation companies and a number of smaller companies involved in generation and/or supply; nine electricity distribution companies (distribution network operators—DNOs) in England and Wales; a single gas transportation and electricity transmission company for England and Wales (that also does gas transportation in Scotland); two integrated electricity distribution, transmission and generation companies in Scotland, (they are also two of the gas and electricity suppliers that serve Scotland, England and Wales). The whole industry is regulated by the Gas and Electricity Markets Authority (more commonly known as the Office of Gas and Electricity Markets (Ofgem)) which is an independent regulator established by an Act of Parliament. There has been full retail competition since the late 1990s and price controls were removed from the household retail market in 2002. (Note that the situation in Northern Ireland is different where there is a separate market and regulator.)

The United Kingdom Government's Energy White Paper, published in 2003, makes a strong commitment to environmental as well as economic and social goals for energy policy. The United Kingdom is signed up to the Kyoto protocol (that requires greenhouse gas emissions to be cut by 12.5 per cent compared to 1990 levels by 2010) and has also set more internally demanding targets (20 per cent reduction by 2010) for reducing carbon dioxide emissions. It has a number of policies and programmes to foster the development of renewable energy and energy efficiency to help achieve a low carbon economy.

2. THE NON-FOSSIL FUEL OBLIGATION (NFFO)

The United Kingdom's first programme to support renewable energy was the Non-Fossil Fuel Obligation (NFFO) introduced in 1990. The NFFO was primarily established to subsidize nuclear power, which the Government had been unable to privatize along with the rest of the electricity industry, as the electricity generation companies would not have been viable as private companies if they included the nuclear power stations. However, the Government decided to broaden the obligation to include specified renewable energy technologies. The Electricity Act 1989, enabled the raising of a fossil fuel levy (i.e. on all fossil—coal, gas and oil—fuel generated electricity) to pay for the NFFO. The NFFO operated via bidding for support in various technology bands—developers of eligible types of renewable electricity generation bid for support and those who were successful received subsidy payments (which varied according to the technology) on top of the market price that they would otherwise be paid. However, this scheme stimulated only small amounts of renewable energy generation—up from 1.8 per cent of total electricity generated in 1990 to 2.5 per cent of electricity in 2000).

Following the election of a new Government in 1997, support for renewable energy was reviewed was the aim of overcoming three main problems with the NFFO:

- Limited development of renewable energy (some commentators have argued that this was largely due to the low-cost cap imposed on support via the NFFO rather than the nature of the mechanism itself);
- Ending the must-take or priority access contracts that renewable energy generators who received support via the NFFO received—these were felt to separate them too much from the reality of the marketplace;
- That a support mechanism shouldn’t “pick winners” by giving different levels of support to different technologies.

(Mitchell and Connor, 2004)

The result of the review was the establishment of the renewables obligation.

3. RENEWABLES OBLIGATION

The renewables obligation was introduced in 2002 to boost the amount of electricity generated from renewable energy. The United Kingdom has set itself a target to generate 10 per cent of its electricity from renewable sources by 2010 and 15 per cent by 2015, as part of its commitment to reducing greenhouse gas emissions. The renewables obligation is the main policy instrument to achieve this and its main feature is that electricity suppliers (retailers) have to source a set percentage of the electricity that they sell to customers from renewable sources. This started at 3 per cent in 2002 and will rise to 15 per cent by 2015 in line with the national target.

The current main sources of renewable electricity generation that are eligible for the financial support provided by the renewables obligation are:

- Hydroelectricity power stations with a capacity of less than 20 megawatts;
- Wind farms both onshore and offshore;
- Electricity generated from landfill gas and sewage gas;
- Electricity generated by burning energy crops and other natural waste, and until 2016, electricity generated from power plants which co-fire such material with coal.

Over time generation from other technologies such as wave and tidal power plants, which are also eligible, is predicted to increase.

The 2010 target only includes electricity generated from sources eligible for the renewables obligation. It therefore excludes electricity generated by large hydroelectricity power stations and some forms of energy from waste (notably incineration).

The legal basis for the renewables obligation (RO) is contained in Section 32 of the Electricity Act 1989 (as amended in 2000) which enables the Secretary of State, by order, to impose an obligation on suppliers (“the Renewables Obligation”). This power has been devolved to the Scottish Executive in respect of suppliers in Scotland (Renewables Obligation Scotland (ROS)). The RO and the ROS came into effect on 1 April 2002 and are scheduled to stay in place until 31 March 2027. An obligation period runs from 1 April to 31 March each year. The Gas and Electricity Markets Authority (Ofgem) is responsible for the administration of the orders.

The orders place a legal obligation on each licensed electricity supplier to produce evidence that either it has supplied a specified proportion of its electricity supplies from renewable energy sources to customers in the United Kingdom, or that another electricity supplier has done so, or, that between them, they have done so. Section 32B of the Act allows for “green certificates” to be issued under section 32 orders. Such certificates certify that a generating station has generated from renewable sources an amount of electricity and that it has been supplied to customers in the United Kingdom. These are known as Renewables Obligation Certificates (“ROCs”) (issued under the RO) or Scottish Renewables Obligation Certificates (“SROCs”) (issued under the ROS). These certificates can be purchased separately from the electricity in respect of which they were issued. So suppliers can meet this obligation by contracting with renewable energy generators to buy their output directly (and receive “green certificates” for doing so), or by buying the ROCs separately from the renewable power generated. Alternatively, a supplier can discharge its Renewables Obligation, in whole or in part, by paying the buy-out price to a central fund. The proceeds of the buy-out fund are divided between those suppliers who have met the obligation by obtaining the required number of green certificates, so providing an additional value to ROCs.

In order for ROCs to be issued, the generating station that generates the electricity must be accredited by Ofgem as capable of generating electricity from eligible renewable sources. The participation of a generating station in the scheme is voluntary and there are certain criteria that need to be met before a station can be accredited. The orders set out what sources of electricity are eligible renewable sources and also specify the exclusion of certain types of generating stations, e.g. stations incinerating waste. Time limits for eligibility are placed on stations co-firing, i.e. burning biomass and fossil fuel to generate electricity.

Suppliers are required to produce evidence of compliance with their renewables obligation to Ofgem by 1 October each year. Evidence can be via ROCs or SROCs.

4. PRICES AND COSTS OF THE RENEWABLES OBLIGATION

Unlike the feed-in scheme in Germany, the renewables obligation does not guarantee connection nor specify the price that renewable generators will be paid for the electricity that they generate—this is set by the market for all electricity generation and is usually agreed in bilateral contracts between generators and suppliers. However, in addition to the market price for renewable electricity, generators can sell their ROCs/SROCs to suppliers who have to meet their obligations or pay the buy-out price. The buy-out price (which is set in the order and rises each year in line with the retail price index (RPI)) thus sets the basic price for ROCs—so long as demand for ROCs exceeds supply. However, as suppliers who meet their obligations via ROCs will also get extra revenue from the buy-out fund, this further increases what they are willing to pay for ROCs/SROCs. Together therefore, these features increase the market value of renewable generation. The following prices illustrate this.

Illustrative prices for renewable energy under the RO:

- The market price for the electricity (which can be sold separately from the ROC)—this has varied significantly since 2002 from around 1.5p/kWh to 4p/kWh.
- 3p/kWh for the ROC (the buy out price started at £30/MWh or 3p/KWh).
- 1.5p/kWh for the extra revenue from the recycled buy-out fund.

Thus the renewable electricity generators can obtain significant additional revenue from the RO.

The buy-out price is intended to act as a cap on the costs to be charged to consumers. In 2003/2004, the total renewables obligation across the United Kingdom was 13,627,412 MWh. The simple calculation of multiplying this by £30.51 gives a total cost to consumers of around £416 million.

Total public support for the renewables industry (through the renewables obligation, capital grants and research and development support) is expected to average £700 million per annum between 2003 and 2006. Around two-thirds of this will come through the renewables obligation, the cost of which is met by electricity consumers and will reach up to £1 billion per annum by 2010 (the equivalent of a 5.7 per cent increase in the price of electricity).

The cost of reducing carbon dioxide emissions through the renewables obligation is currently higher than other policy mechanisms which primarily incentivize energy efficiency. However, the renewables obligation is not just in place to meet the Government's climate change objectives. Its other goal is to promote diversity and security of energy supplies. It is recognized that technologies that are not mature will have higher costs, but that as they develop, these costs should come down.

Another cost issue is that the renewables obligation provides the same level of financial support for all eligible renewable projects. The Government adopted this approach to ensure that the most economic renewable energy projects are developed first, while minimizing Government intervention in the market. A consequence is that some projects using the lowest cost technologies (onshore wind and landfill gas) at the best sites receive more support from the renewables obligation than necessary to see them developed. The Department of Trade and Industry is looking at this issue for new sites in its review of the renewables obligation.

5. IMPACT OF THE RENEWABLES OBLIGATION

The renewables obligation has increased the total renewable electricity generating capacity in the UK from 1400 MW in 2002 to 2400 MW in 2004. A rough breakdown of this is as follows:

Onshore wind – 600 MW

Landfill gas – 600 MW

Co-firing – 500 MW

Biomass – 150 MW

Hydro (<20 MW net capacity) – 400 MW

Others (mainly offshore wind, micro-hydro, sewage gas) – 250 MW

At the end of the first obligation period (March 2003), there were 505 accredited generating stations and 616 at the end of the second obligation period. 257 of the accredited generation stations were landfill gas, with over 100 accredited for onshore wind and for hydro (those generating stations with a declared net capacity of 20 MW or below and which are not micro-hydro). However, the capacities accredited for landfill gas and onshore wind are very similar, which demonstrates that landfill gas generating stations accredited under the RO tend to be smaller in capacity than onshore wind generating stations. Sewage gas and micro-hydro generating stations are also generally smaller whilst co-fired and biomass generating stations are among the larger capacity generating stations Ofgem accredits, although the statistics for co-firing reflect an estimate of the renewable capacity based on the biomass element.

The distribution of ROCs issued is as shown in the following table:

Table 1. ROCs issued by technology

Technology	RO 2002-03 (percentage)	RO 2003-04 (percentage)
Landfill gas	48	40
Onshore wind	20	16
Hydro (< 20 MW)	9	17
Co-firing	8	10
Biomass	11	10
Other	4	9

Source: Ofgem, Annual reports on the renewables obligation.

As the following table shows, a significant proportion of the renewables obligation is being met by companies paying into the buy-out fund rather than contracting for renewables capacity. This has been one of the criticisms of the RO—that it is not stimulating as much renewable capacity as the total obligation figure suggests. However, by paying into the buy-out fund, the value of renewable capacity is increased and this may be making this capacity more secure.

Table 2. A comparison of RO compliance figures over the 1st and 2nd obligation periods

	2002/2003	2003/2004
Total obligation (TWh)	8,393,972	12,387,720
ROCs and SROCs produced (£ mlln)	4,973,091	6,914,524
Buy-out paid (£ mlln)	78,853,260	157,960,978
Buy-out not paid (£ mlln)	23,773,170	9,026,231
Percentage obligation met by ROCs or SROCs	59	56
Buy-out distributed and late payment fund (£ mlln)	79,251,930	158,466,502
Buy-out paid per ROC or SROC produced (£)	15.94	22.92
What a ROC or SROC was “worth” to a supplier (£)	45.94	53.43

Source: Ofgem, 2nd annual report on the renewables obligation.

6. OTHER SUPPORT FOR RENEWABLES

The fact that the RO does not pay different prices for different technologies means that suppliers tend to favour the least costly forms of renewables (currently landfill gas and onshore wind) which can be viewed as an advantage on cost-effectiveness grounds. However, this does mean that it may not promote as much diversity as schemes that pay higher prices for less mature technologies. The UK Government is tackling this issue via a range of other schemes of funding for renewables—typically capital grants to offset the extra costs of technologies such as offshore wind, biomass, wave and tidal power, and photo-voltaic. These include grants for large and medium-scale schemes and some grants for small and micro-scale technologies.

Examples include:

- Bioenergy has received £55 million in capital grants to support 22 projects, although not all of these are proceeding due to various difficulties in making them commercially viable.
- The offshore wind scheme has allocated capital grants of £117 million to 12 projects, two of which are now fully operational. The remaining projects are expected to come on stream in the next three years, providing total capacity of over 1,000 megawatts, enough to supply more than 600,000 households.

7. WILL THE UK MEET ITS RENEWABLES TARGET?

By April 2004 (two years after the introduction of the renewables obligation), the level of electricity supplied from eligible renewable sources was 2.4 per cent, significantly lower than the obligation level of 4.3 per cent. In the early phases therefore, the RO has been underperforming in terms of delivering new renewable electricity capacity. Various estimates have been made of whether the rate of growth will increase sufficiently for the 2010 target of 10 per cent electricity from renewable sources to be achieved. These range from 7.5 per cent (House of Lords Science and Technology Committee) to close to 10 per cent on the most optimistic of a range of estimates produced for the National Audit Office (NAO, 2005). According to the NAO the main challenges to achieving the 2010 target are:

- Whether revised planning guidance for England facilitates the planning process for new renewable energy sites;
- Whether the upgrading of the electricity transmission and distribution networks, required to accommodate new renewable generation, is planned, funded and installed on time;
- Whether investor confidence in the way the renewables obligation is working is maintained;
- Whether financial support provided through capital grants and the research and development programme fulfil their respective objectives.

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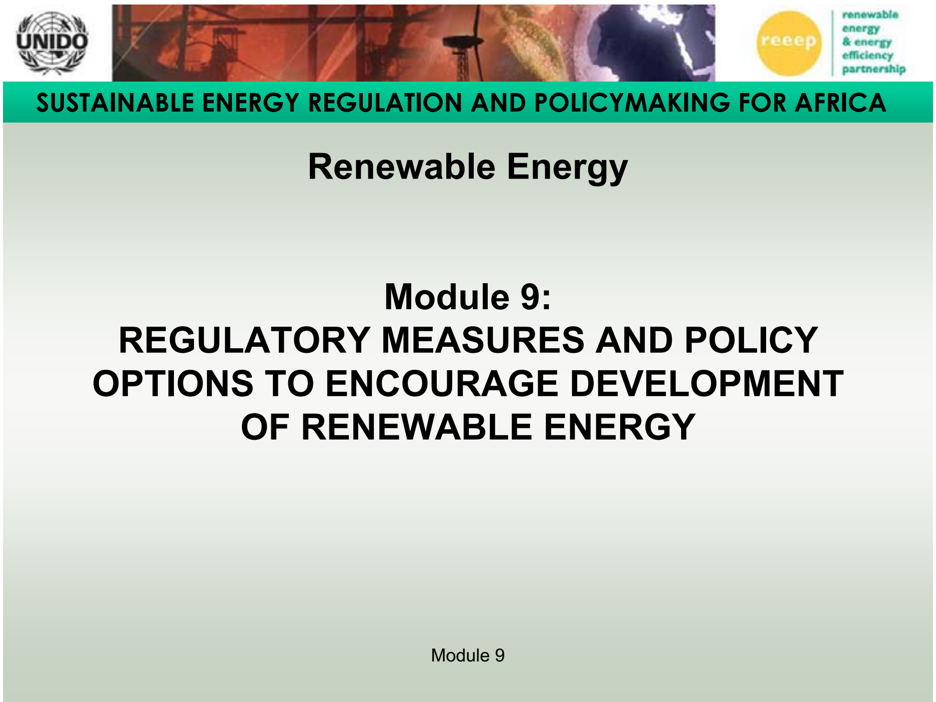
House of Lords Science and Technology Committee. Renewable Energy: Practicalities. 4th Report of Session 2003-04 HL Paper 126-I (15 July 2004) Available on the parliamentary website (www.parliament.uk).

National Audit Office. DTI: Renewable Energy. Report by the Comptroller and Auditor General HC 210 2004-2005 (11 February 2005). Available on the NAO website (www.nao.gov.uk).

Comprehensive information on the renewables obligation including the annual report on progress is available on the Ofgem website (www.ofgem.gov.uk).

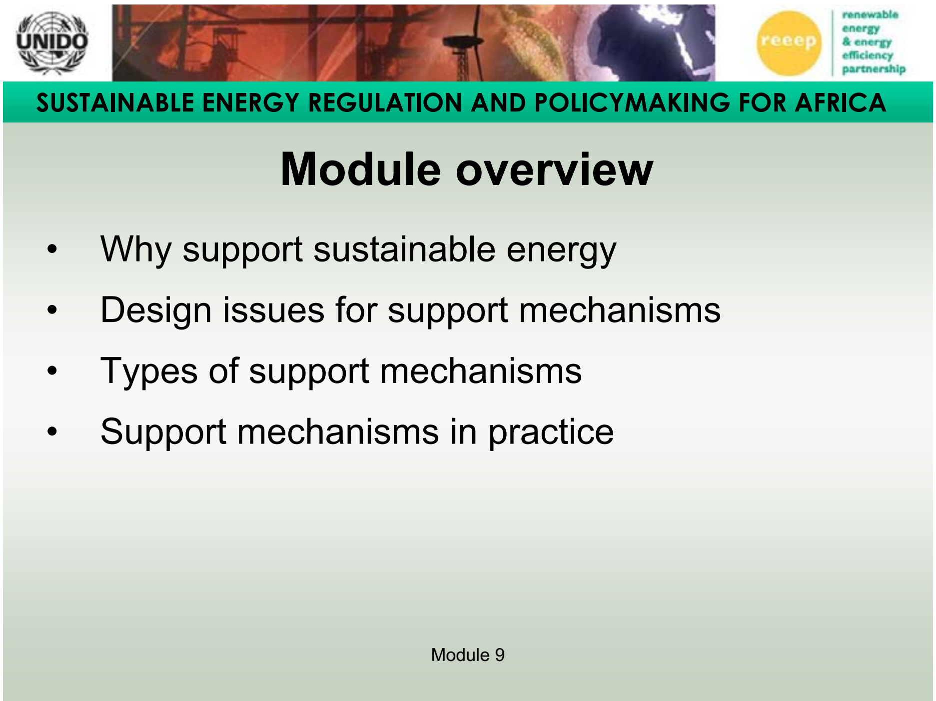
See also the website for the Department of Trade and Industry (www.dti.gov.uk/energy).



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy

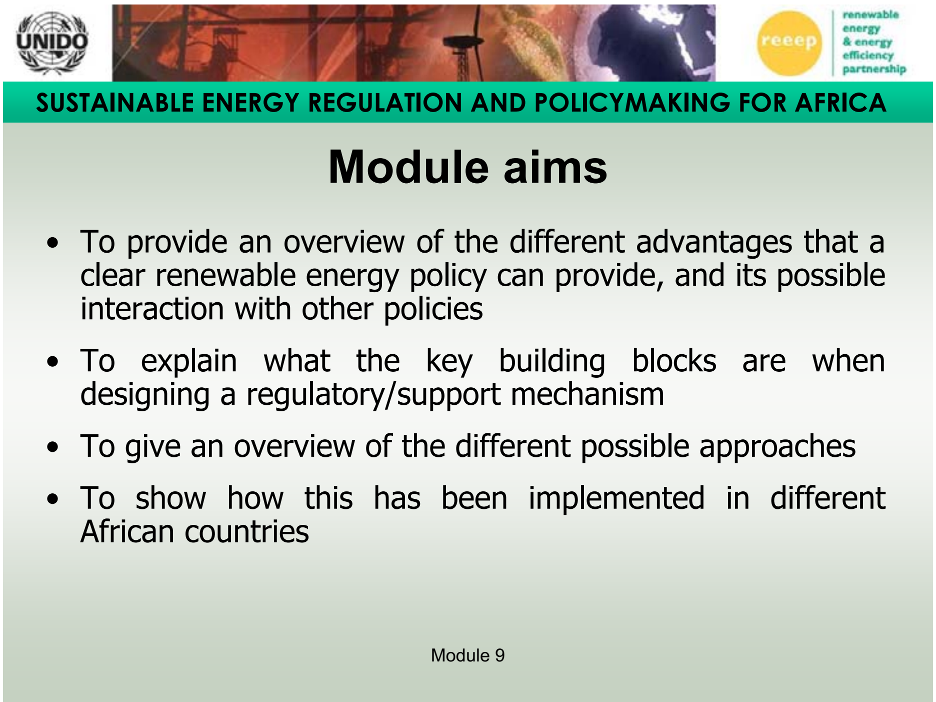
Module 9:
REGULATORY MEASURES AND POLICY OPTIONS TO ENCOURAGE DEVELOPMENT OF RENEWABLE ENERGY



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

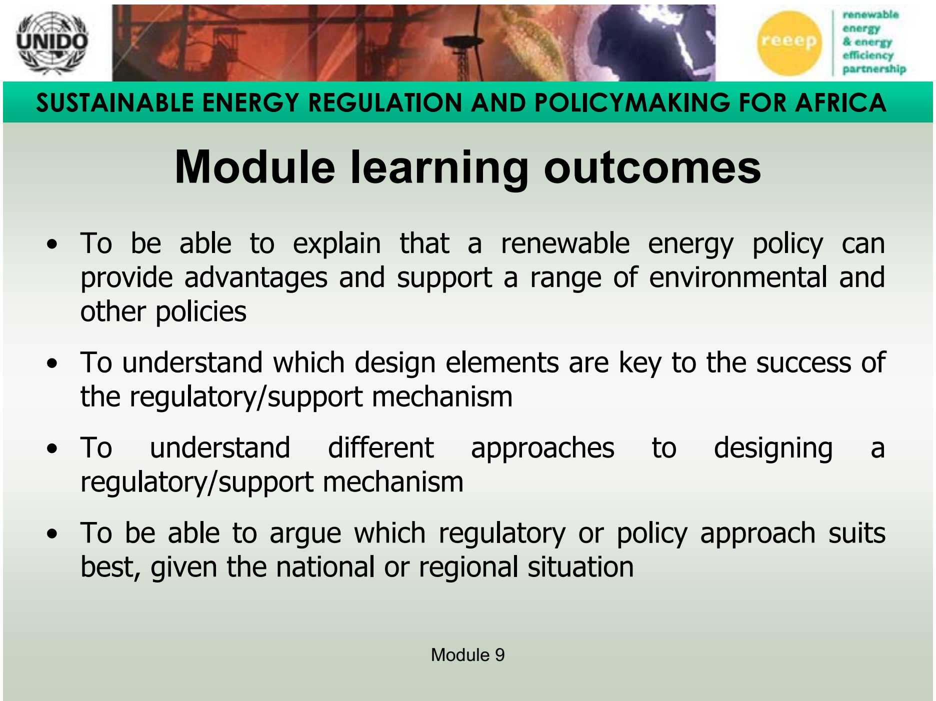
- Why support sustainable energy
- Design issues for support mechanisms
- Types of support mechanisms
- Support mechanisms in practice



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

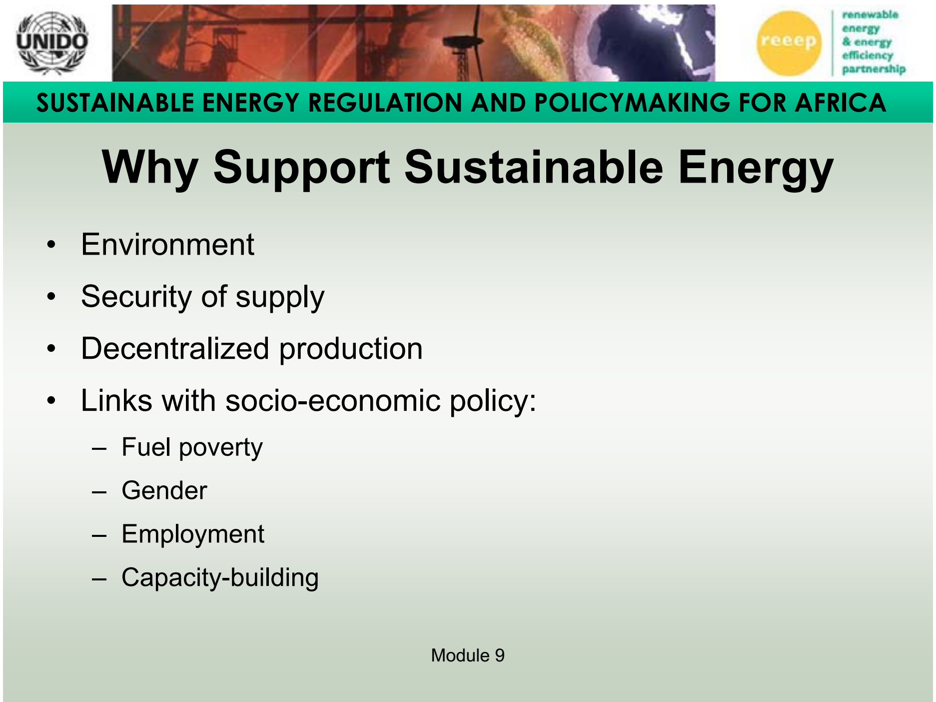
- To provide an overview of the different advantages that a clear renewable energy policy can provide, and its possible interaction with other policies
- To explain what the key building blocks are when designing a regulatory/support mechanism
- To give an overview of the different possible approaches
- To show how this has been implemented in different African countries



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

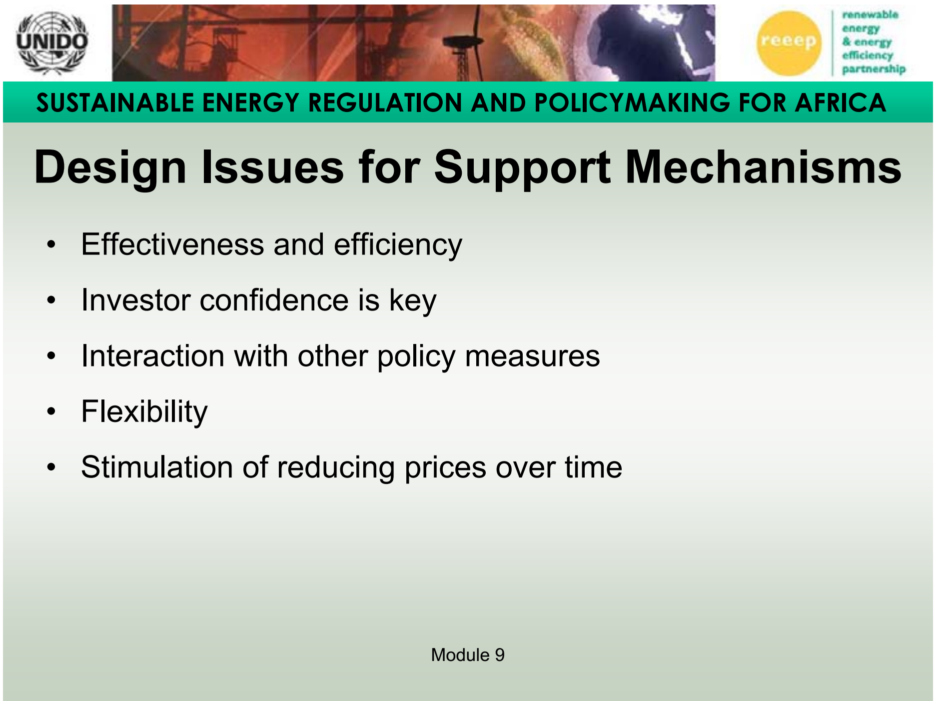
- To be able to explain that a renewable energy policy can provide advantages and support a range of environmental and other policies
- To understand which design elements are key to the success of the regulatory/support mechanism
- To understand different approaches to designing a regulatory/support mechanism
- To be able to argue which regulatory or policy approach suits best, given the national or regional situation



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Support Sustainable Energy

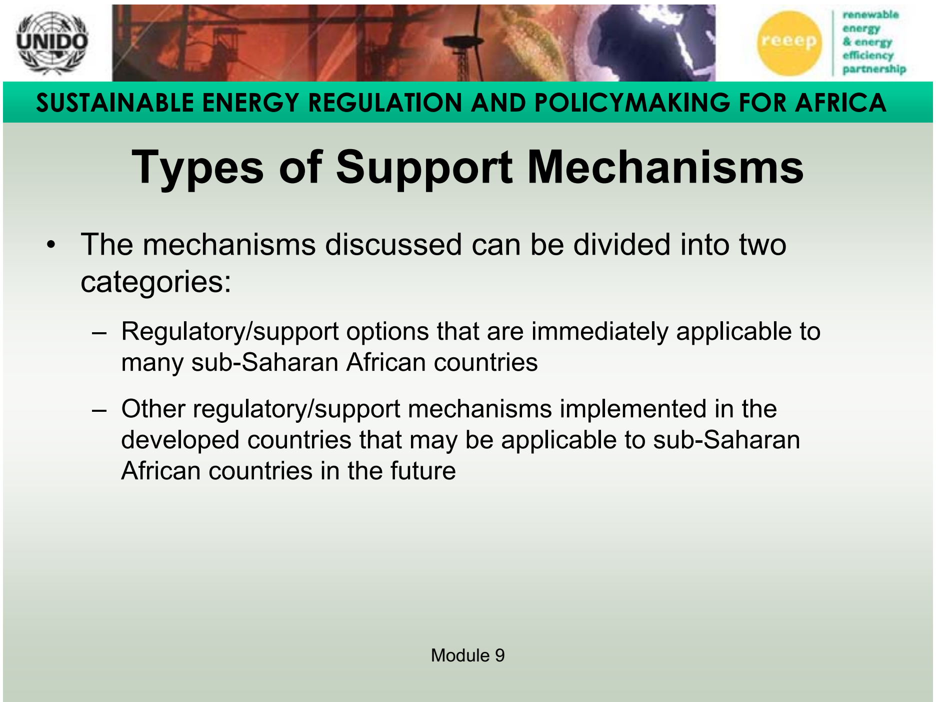
- Environment
- Security of supply
- Decentralized production
- Links with socio-economic policy:
  - Fuel poverty
  - Gender
  - Employment
  - Capacity-building



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Design Issues for Support Mechanisms

- Effectiveness and efficiency
- Investor confidence is key
- Interaction with other policy measures
- Flexibility
- Stimulation of reducing prices over time



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types of Support Mechanisms

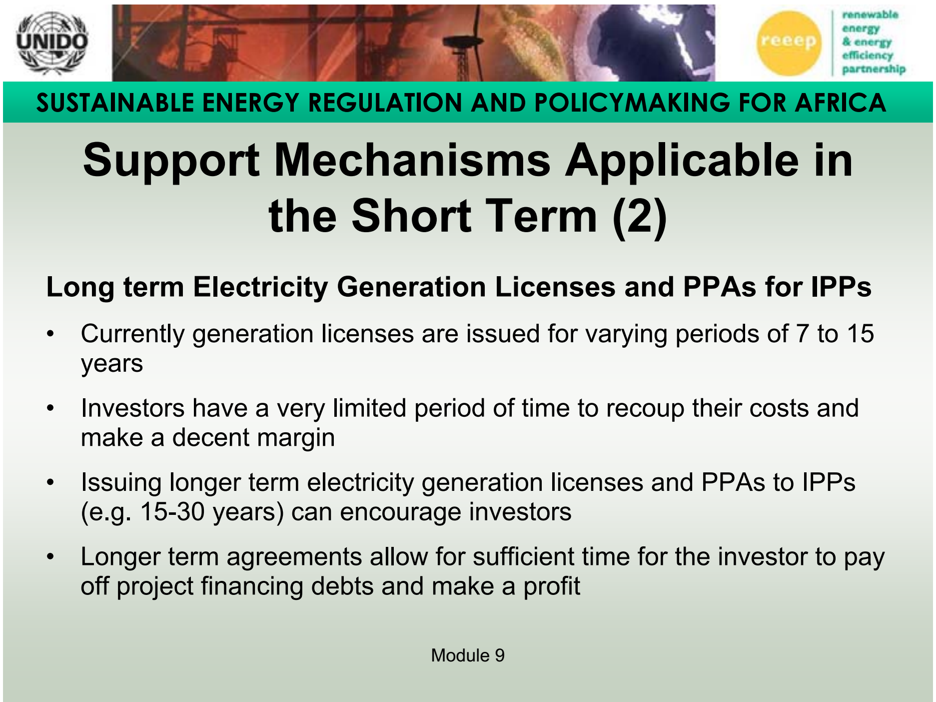
- The mechanisms discussed can be divided into two categories:
  - Regulatory/support options that are immediately applicable to many sub-Saharan African countries
  - Other regulatory/support mechanisms implemented in the developed countries that may be applicable to sub-Saharan African countries in the future

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term

Establishing “standard” Power Purchase Agreement (PPAs)

- Eliminate cumbersome negotiations
- Institute a “Standard PPA” - a “standard offer” from the national utility to purchase all energy produced by specific renewable energy-based Independent Power Producers (IPP) at a pre-announced price
- Set clear rules to allow the sale of power produced to encourage investment in renewables



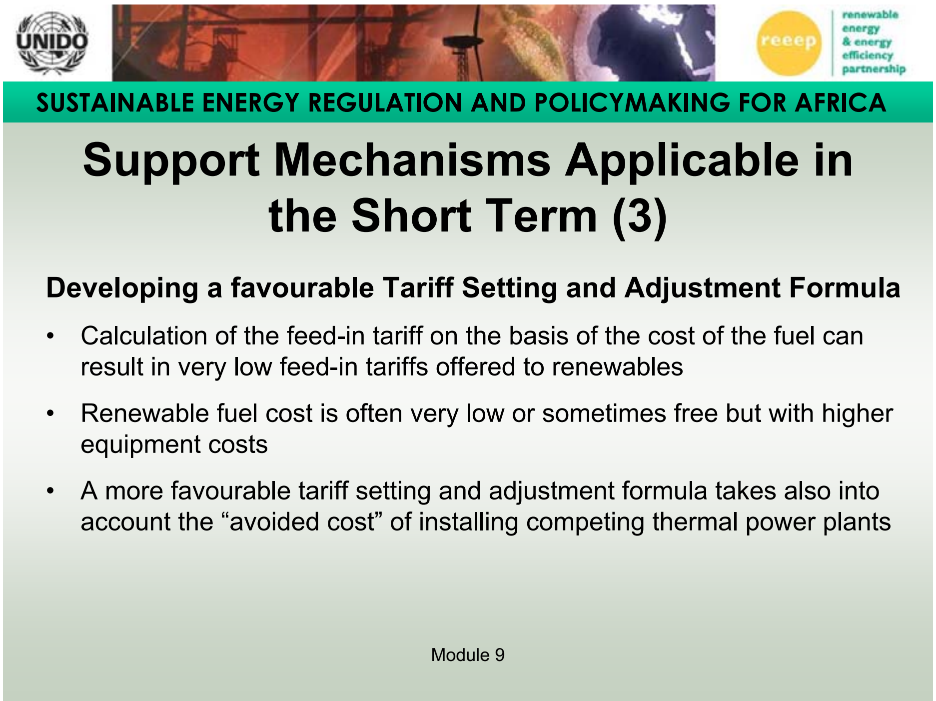
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (2)

Long term Electricity Generation Licenses and PPAs for IPPs

- Currently generation licenses are issued for varying periods of 7 to 15 years
- Investors have a very limited period of time to recoup their costs and make a decent margin
- Issuing longer term electricity generation licenses and PPAs to IPPs (e.g. 15-30 years) can encourage investors
- Longer term agreements allow for sufficient time for the investor to pay off project financing debts and make a profit

Module 9



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (3)

Developing a favourable Tariff Setting and Adjustment Formula

- Calculation of the feed-in tariff on the basis of the cost of the fuel can result in very low feed-in tariffs offered to renewables
- Renewable fuel cost is often very low or sometimes free but with higher equipment costs
- A more favourable tariff setting and adjustment formula takes also into account the “avoided cost” of installing competing thermal power plants

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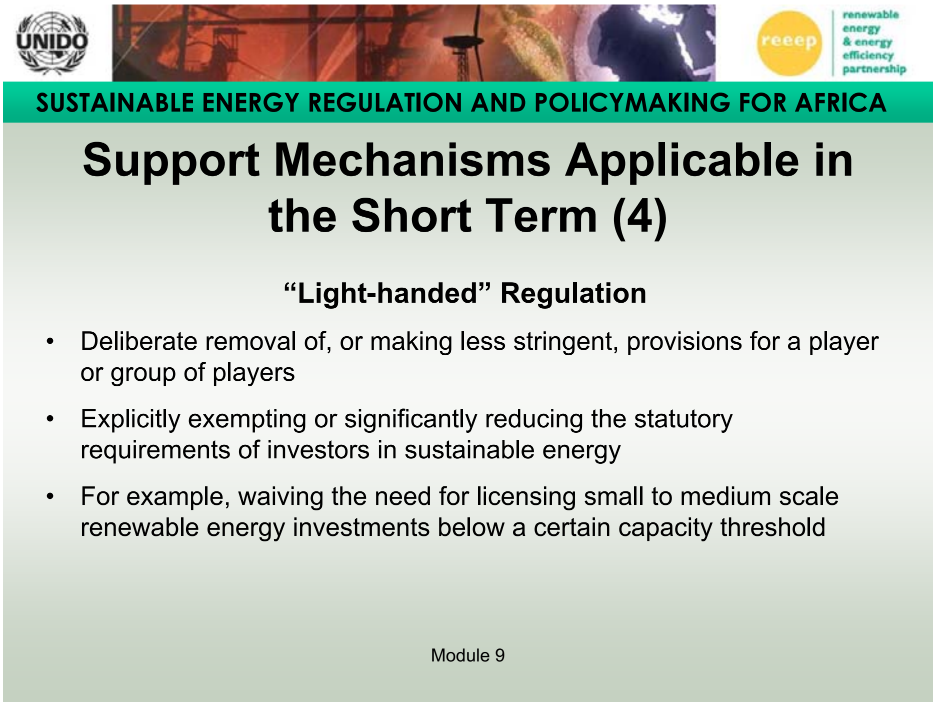

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (4)

“Light-handed” Regulation

- Deliberate removal of, or making less stringent, provisions for a player or group of players
- Explicitly exempting or significantly reducing the statutory requirements of investors in sustainable energy
- For example, waiving the need for licensing small to medium scale renewable energy investments below a certain capacity threshold

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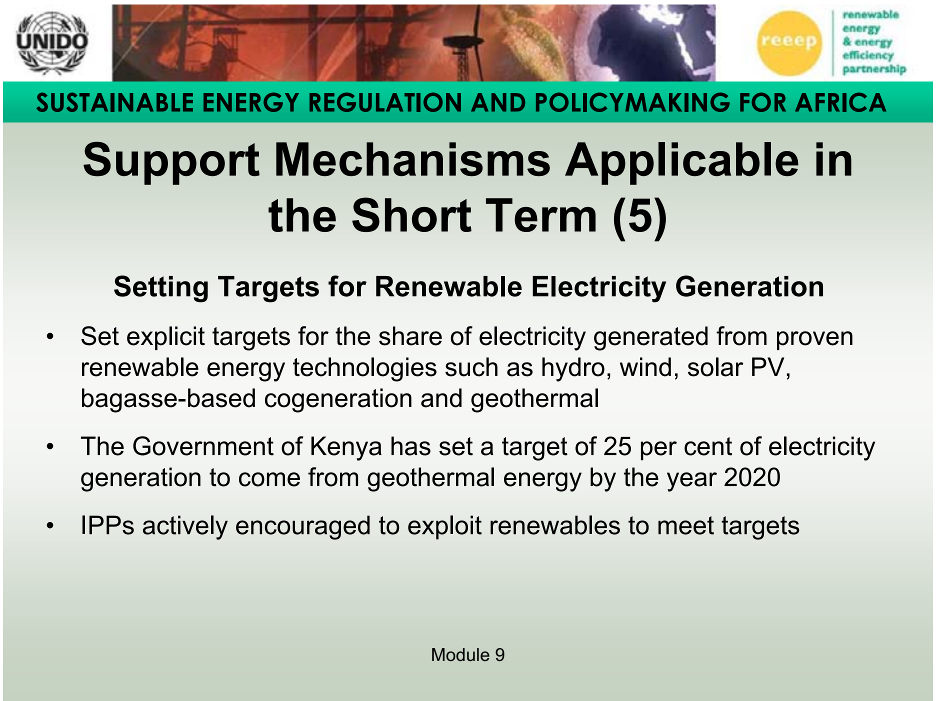

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (5)

Setting Targets for Renewable Electricity Generation

- Set explicit targets for the share of electricity generated from proven renewable energy technologies such as hydro, wind, solar PV, bagasse-based cogeneration and geothermal
- The Government of Kenya has set a target of 25 per cent of electricity generation to come from geothermal energy by the year 2020
- IPPs actively encouraged to exploit renewables to meet targets

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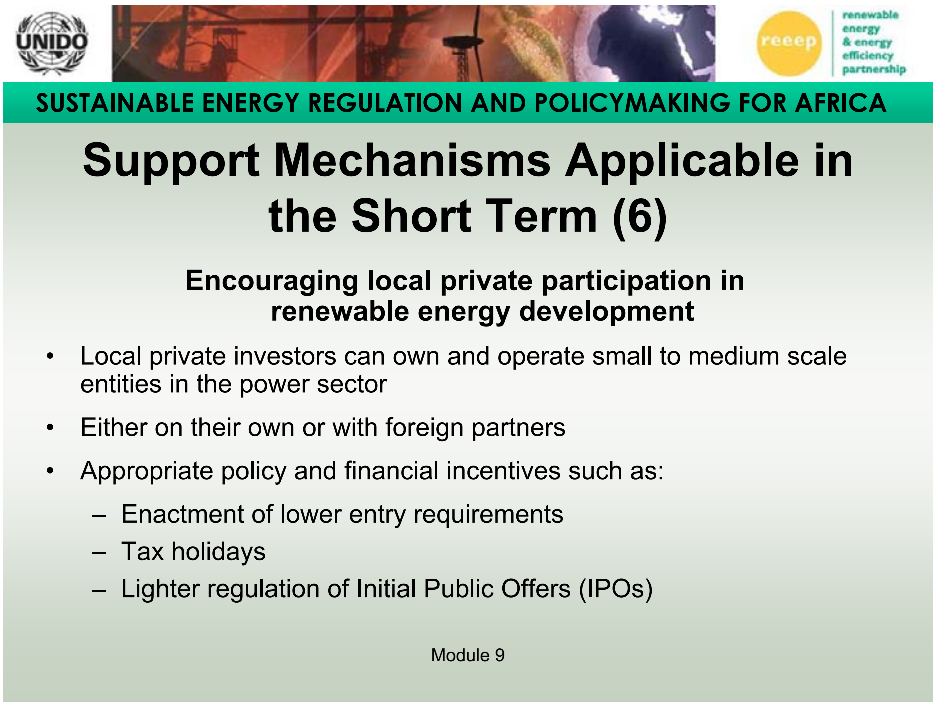

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (6)

Encouraging local private participation in renewable energy development

- Local private investors can own and operate small to medium scale entities in the power sector
- Either on their own or with foreign partners
- Appropriate policy and financial incentives such as:
  - Enactment of lower entry requirements
  - Tax holidays
  - Lighter regulation of Initial Public Offers (IPOs)

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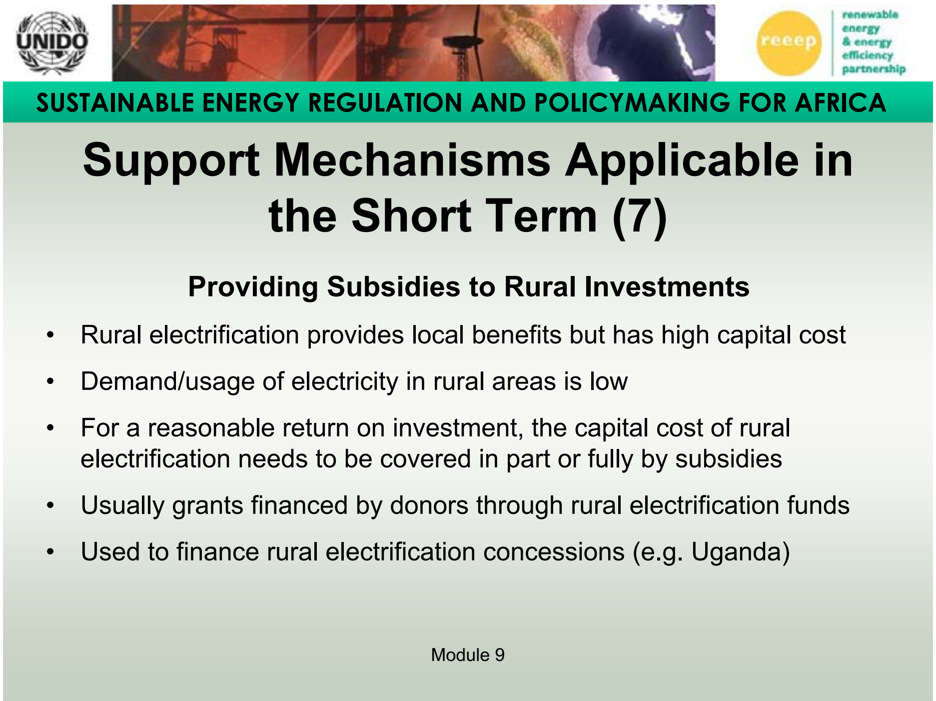

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (7)

Providing Subsidies to Rural Investments

- Rural electrification provides local benefits but has high capital cost
- Demand/usage of electricity in rural areas is low
- For a reasonable return on investment, the capital cost of rural electrification needs to be covered in part or fully by subsidies
- Usually grants financed by donors through rural electrification funds
- Used to finance rural electrification concessions (e.g. Uganda)

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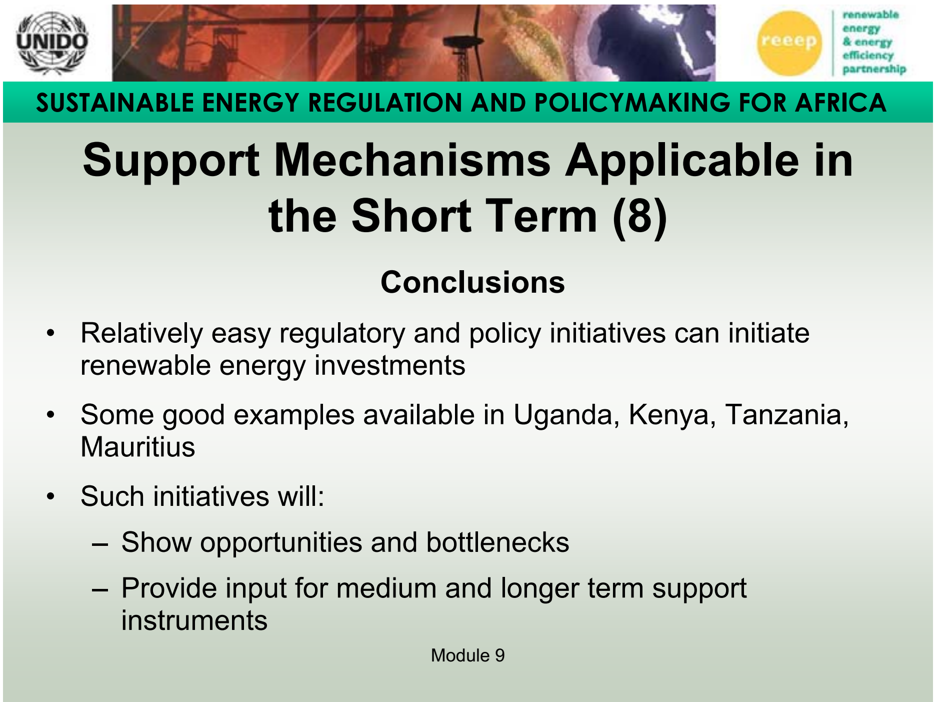
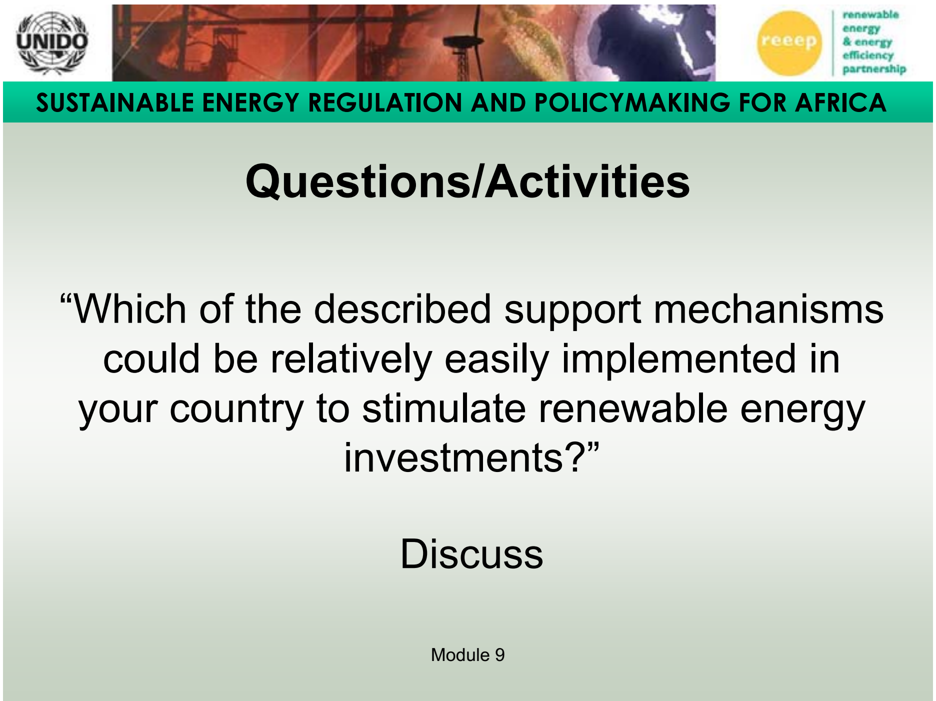


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Short Term (8)

Conclusions

- Relatively easy regulatory and policy initiatives can initiate renewable energy investments
- Some good examples available in Uganda, Kenya, Tanzania, Mauritius
- Such initiatives will:
  - Show opportunities and bottlenecks
  - Provide input for medium and longer term support instruments

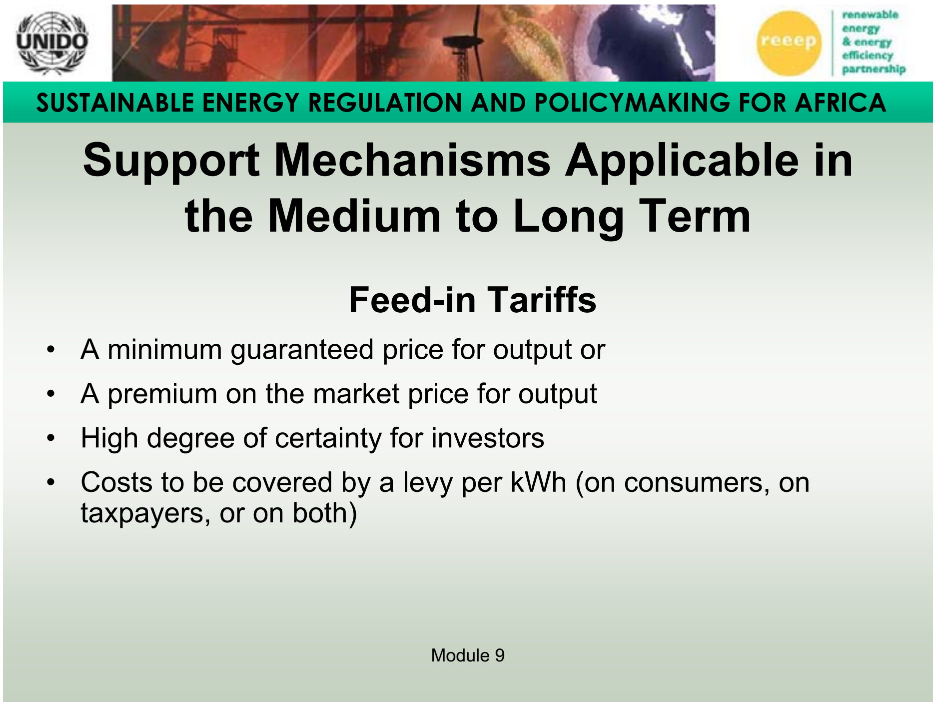


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

“Which of the described support mechanisms could be relatively easily implemented in your country to stimulate renewable energy investments?”

Discuss

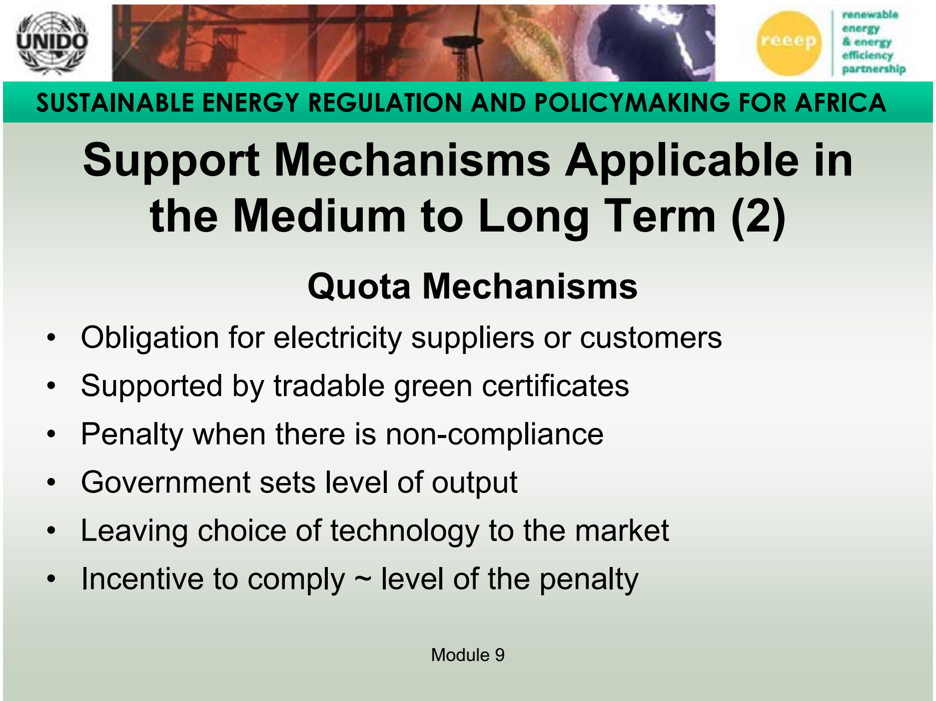


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Medium to Long Term

Feed-in Tariffs

- A minimum guaranteed price for output or
- A premium on the market price for output
- High degree of certainty for investors
- Costs to be covered by a levy per kWh (on consumers, on taxpayers, or on both)

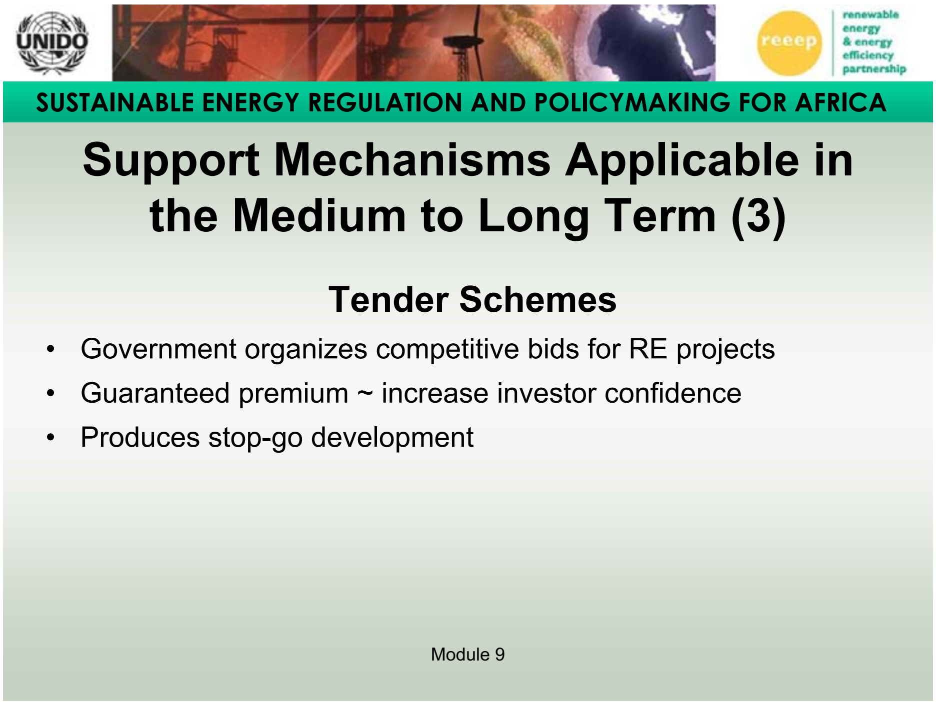


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Medium to Long Term (2)

Quota Mechanisms

- Obligation for electricity suppliers or customers
- Supported by tradable green certificates
- Penalty when there is non-compliance
- Government sets level of output
- Leaving choice of technology to the market
- Incentive to comply ~ level of the penalty



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Medium to Long Term (3)

Tender Schemes

- Government organizes competitive bids for RE projects
- Guaranteed premium ~ increase investor confidence
- Produces stop-go development

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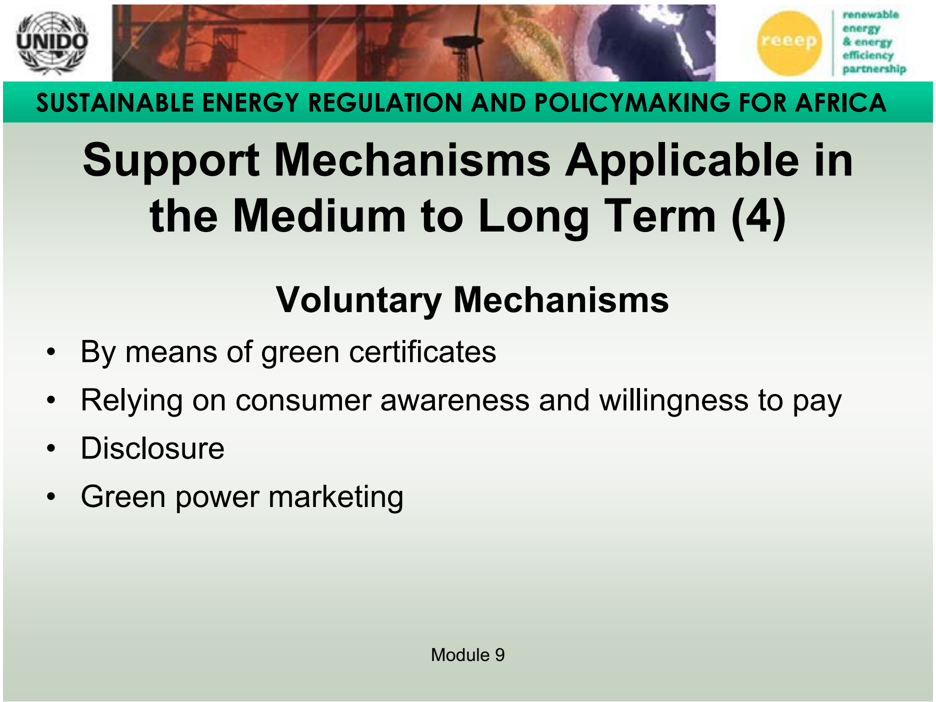


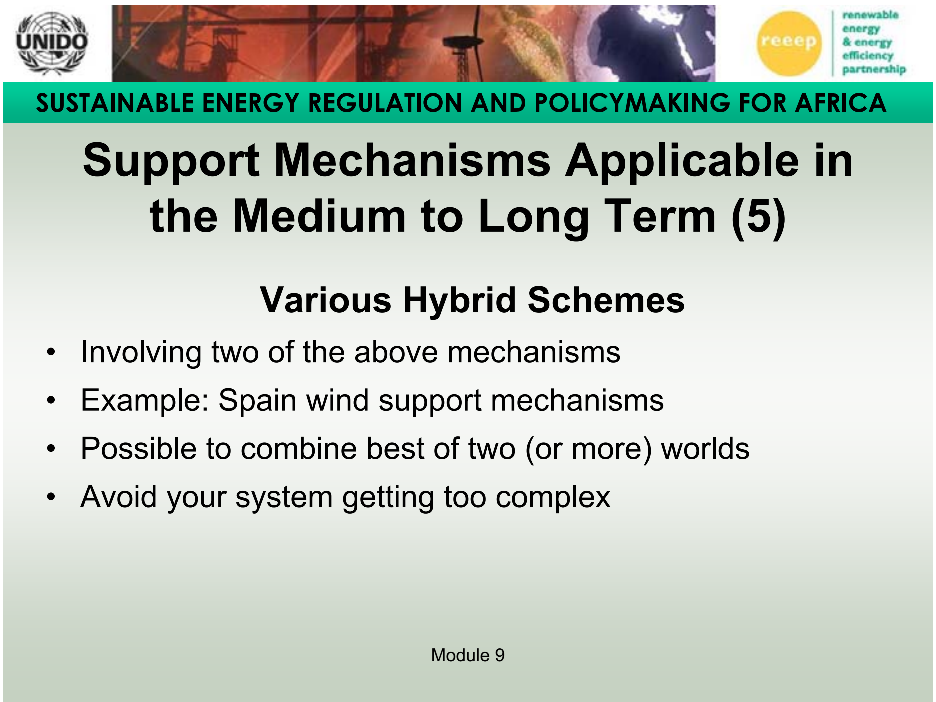
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Medium to Long Term (4)

Voluntary Mechanisms

- By means of green certificates
- Relying on consumer awareness and willingness to pay
- Disclosure
- Green power marketing

Module 9

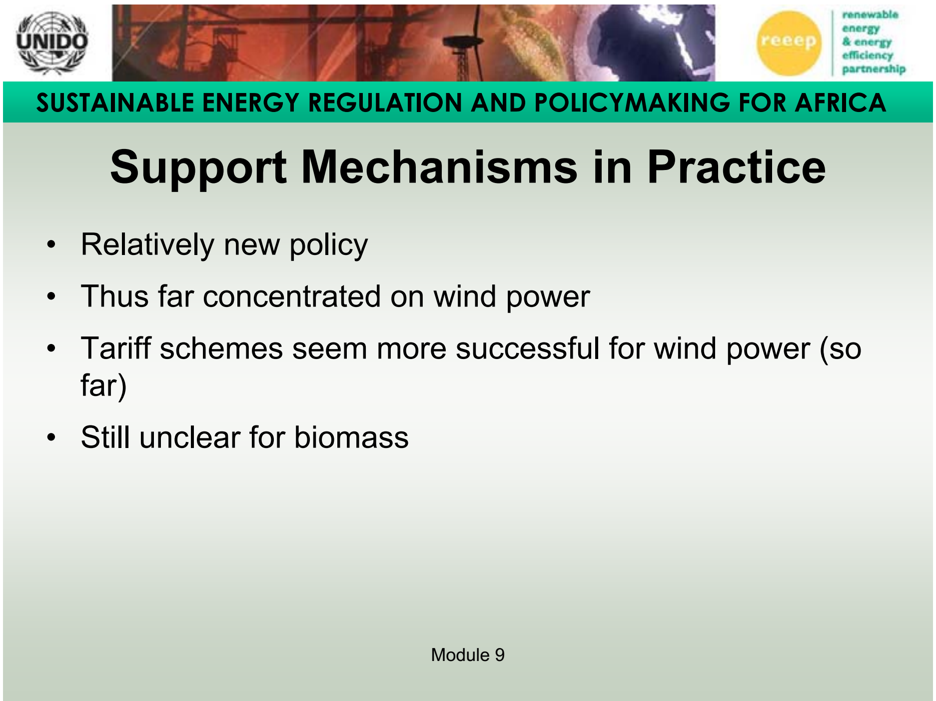


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms Applicable in the Medium to Long Term (5)

Various Hybrid Schemes

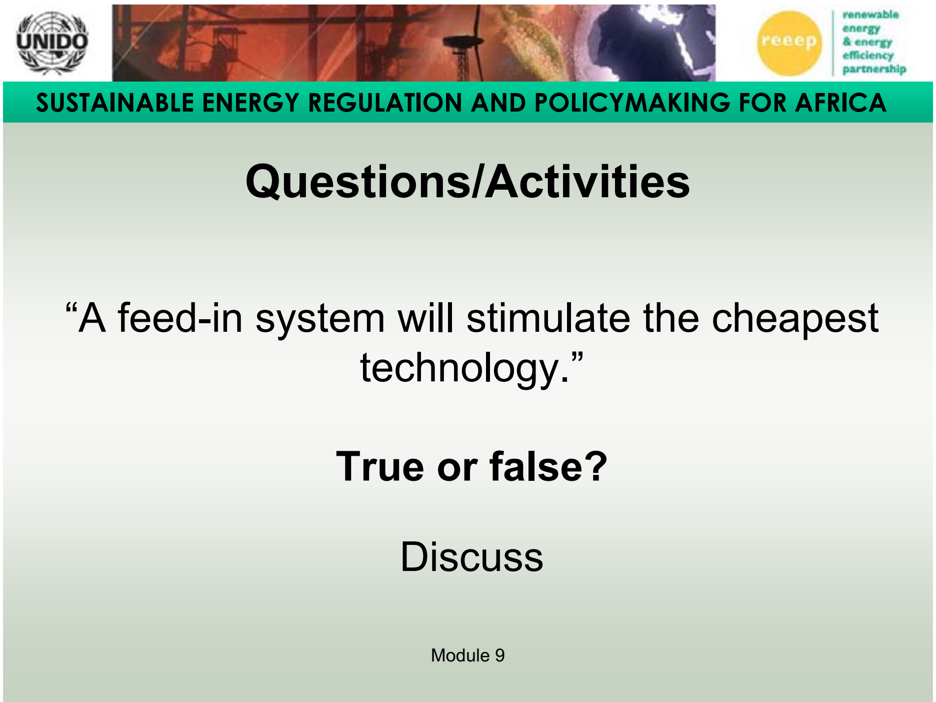
- Involving two of the above mechanisms
- Example: Spain wind support mechanisms
- Possible to combine best of two (or more) worlds
- Avoid your system getting too complex



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Support Mechanisms in Practice

- Relatively new policy
- Thus far concentrated on wind power
- Tariff schemes seem more successful for wind power (so far)
- Still unclear for biomass



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

“A feed-in system will stimulate the cheapest technology.”

True or false?

Discuss

Module 10

Increasing access to energy services in rural areas

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

The main themes described in this module are as follows:

- Introduction to the issue of access to energy services in rural areas.
- The Millennium Development Goals (MDGs) and their links to energy: examining the importance of energy to the completion of the MDGs and the role of development agencies and their policies.
- Policy options for increasing access to energy services in rural areas: looking at the basic energy needs in rural areas and examining the issues associated with increasing energy access and examining the policy instruments for improving energy services in rural areas, including the role of intermediation, the role of subsidies and pricing.
- Business models and private sector participation for increasing access to energy in rural areas are examined including market based models, control and command model, private company participation and subsidies.
- Case studies from Bangladesh, Brazil, China, Dominican Republic, Indonesia and Morocco are presented.

1.2. Module aims

This module aims to do the following:

- To introduce the issue of energy access in rural areas and the importance of energy for the achievement of the MDGs.
- To outline the basic energy needs in rural areas and some of the barriers preventing increased energy access to rural populations.
- To provide some examples of policy instruments for improving energy services in rural areas.
- To outline business models and private sector participation schemes for increasing access to energy in rural areas.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to show the links between rural development and energy access and progress towards achievement of the MDGs.

- To understand basic energy needs in rural areas and be able to describe some of the barriers preventing improved energy access to rural populations.
- To describe some policy instruments that could help improve energy access in rural areas.
- To be knowledgeable about how different business models and private company participation in programmes and schemes can help improve energy access in rural areas in a sustainable way.

2. INTRODUCTION

As the world finds itself at the beginning of a modern 21st century, for poor people in developing countries, a host of developmental and environmental problems still remain. In 2002, 10 years after the Rio de Janeiro Earth Summit and the adoption of Agenda 21,[1] the "Rio Declaration on Environment and Development", by more than 178 Governments, it was recognized that we are still far from ending the economic and environmental marginalization that afflicts billions of people. Despite the prosperity of the 1990s, the divide between rich and poor is widening in many countries, undermining social and economic stability.[2]

Even the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 is widely thought not to have achieved many of its aims, possibly because its objectives were quite far reaching. Specifically in the energy field, a Declaration for the International Conference for Renewable Energies[3] at the recent Bonn Renewables 2004 Conference concluded:

> "The WSSD was not successful in bringing the world closer to achieving the goals of poverty eradication, increasing gender equity, providing all people with clean and affordable energy services or avoiding dangerous climate change. This failure was a tremendous let-down to billions of people. The Bonn Conference offers a second chance to provide energy services to those people without and to begin to set the world on a pathway to avoid catastrophic climate change. This chance must not be wasted."[4]

An assessment of the current state of the world indicates that neither environment nor development has fared well. While awareness of environmental issues has increased and remarkable progress can be cited in niches such as wind power, nearly all global environmental indicators continue to be headed in the wrong direction. In particular, many social issues have advanced slowly, with a six-fold increase in deaths from HIV/AIDS and some 14,000-30,000 people continuing to die each day from water-borne diseases.[5]

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[1] Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment.

[2] Christopher Flavin, Worldwatch President, 2002.

[3] a common position of CURES (Citizens United for Renewable Energy and Sustainability), a network of NGOs created to monitor the energy-related international processes in the follow-up of the Johannesburg Summit.

[4] CURES, THE FUTURE IS RENEWABLE – Declaration for the International Conference for Renewable Energies (Renewables 2004), 2004.

[5] Gary Gardner, *State of the World 2002* (Worldwatch) – Chapter 1: The Challenge for Johannesburg: Creating a More Secure World, February 2002, ISBN: 0-393-32279-3.

The economic boom of the last 15 years has continued to damage natural systems and the increasingly visible evidence of environmental deterioration is only the tip of a much more dangerous problem: the growing inequities in wealth and income between countries and within countries, inequities that will generate enormous social unrest and pressure for change. The Worldwatch Institute has recently argued that to solve the earth's environmental problems, the problems of the world's poor peoples must be simultaneously addressed.[6]

However, nearly half of the world's populations live in rural areas, nearly 90 per cent of them – over 2.9 billion[7] – in the developing countries. The vast majority of these people are still dependent on the traditional fuels of wood, dung and crop residues, often using primitive and inefficient technologies. Nearly 2 billion do not yet have access to electricity. For many, this combination barely allows fulfilment of the basic human needs of nutrition, warmth and light, let alone the possibility of harnessing energy for productive uses which might begin to permit escape from the cycle of poverty.

Demographic trends risk exacerbating the situation. Most of today's 2 billion people are without adequate cooking and electricity services in rural areas, but urban populations are projected to grow more rapidly, estimated to be 60 per cent of the population by 2030.[8] Far from easing rural energy poverty, this is likely to reinforce policy-makers' preoccupation with urban issues, while increasing competition for rural energy supplies.

Dependence on traditional fuels will long remain a reality, given its level of present use (reaching over 95 per cent in some countries). It is not so much their use that is wrong, as the manner in which they are being managed and used, which is not always at a sustainable rate. Inefficient technologies and appliances mean that precious fuelwood resources are wasted and indoor smoke pollution severely impairs health. The burden of this traditional energy use falls disproportionately on women.

It is calculated that an amount of energy roughly equivalent to 7 per cent of the world's total electricity production today could cover all basic human needs if it were distributed evenly over the world's population (World Energy Council). In an age of apparently advanced technological and management skills, we have failed in this relatively modest challenge. It is essential that a gradual transition to modern energy systems (which may utilize traditional energy sources) must be achieved if sustainable economic activity is to be realized in rural areas.

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[6] Worldwatch Institute – State of the World 2001, January 2001, ISBN: 0-393-04866-7.

[7] The Challenge of Rural Energy Poverty in Developing Countries, Copyright © 1999, World Energy Council and Food and Agriculture Organization of the United Nations.

[8] UN Habitat, 19 September 2004, BBC World.

This module considers populations in rural areas and how the expansion of energy services for them can link to sustainable development. It also presents some case studies in China, Indonesia, India, Brazil and other very populous nations with high total energy consumption. The module also looks at the policies countries use for increasing access to energy services in rural areas.

3. APPROACHING ENERGY SERVICES FOR RURAL AREAS OF DEVELOPING COUNTRIES

3.1. The extent of rural areas

The difficulty in approaching rural areas for study is that there is no international standard or agreed definition of urban and rural areas that would be applicable to all countries or even to countries in a single region. There are a wide-range of definitions of what urban areas are; an "urban" area could be a village as small as only 1,000 inhabitants or a large administrative city, depending on which country is considered.[9] However, taking indicators on human settlements compiled by the UN Statistics Division,[10] and discounting populations of developed countries, table 1 summarizes the extent of rural populations in 114 countries that are considered in this document, showing the 12 most populous countries that make up nearly three-quarters of the total population of 5 billion by themselves.[11]

At some three billion (about 46 per cent of the world's population) representing 59 per cent of developing country populations, the true extent of rural areas can be appreciated. The rural numbers do not rise considerably from 2004 to 2010 due to the general trend of migration to urban areas.[12] The proportion of rural people actually decreases over this period, but people in rural areas still make up more than half of total developing country populations.

3.2. The situation of access to energy services

When approaching "energy" for rural areas many people think of this in terms of provision of electricity or "bringing in the power grid". But energy covers a number of different forms, for example, direct light, heating, cooling, shaft power as well as electricity, and for a huge number of different tasks (cooking, lighting, water pumping, refrigeration and communications) and end-users (domestic, businesses, basic social services, transportation etc.). Because energy is just the

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[9] Demographic Yearbook 2001, Table 6 – see unstats.un.org/unsd/demographic/sconcerns/densurb/Defintion_of%20Urban.pdf.

[10] unstats.un.org/unsd/demographic/products/socind/hum-sets.htm – 12 July 2004.

[11] in order of size – China, India, Indonesia, Brazil, Pakistan, Bangladesh, Nigeria, Mexico, Vietnam, Philippines, Egypt, Ethiopia.

[12] all except in the central Asian former Russian states, Gambia, Palau and Sri Lanka.

Table 1. Summary of rural populations across 114 developing countries, showing the 12 most populous countries

	Total			Rural population		Rural percentage	
Continent and country (with rank)	Population (1,000s) 2004	Perc. share	Population (1000s) 2010 (est)	(1,000s) 2004	(1,000s) 2010 (est.)	2004	2010 (est)
N. Africa	**150,025**	**3.01%**	**167,039**	**73,911**	**79,443**	**49.3%**	**47.6%**
11. Egypt	73,389	1.47%	82,599	42,566	47,767	58%	57.8%
SS. Africa	**710,696**	**14.26%**	**814,923**	**457,172**	**497,325**	**64.3%**	**61.0%**
12. Ethiopia	72,420	1.45%	83,789	60,833	69,196	84.0%	82.6%
7. Nigeria	127,117	2.55%	147,676	67,372	71,389	53.0%	48.3%
C. Asia	**253,848**	**5.09%**	**280,062**	**110,812**	**118,066**	**43.7%**	**42.2%**
South Asia	**1,435,804**	**28.81%**	**1,586,200**	**1,035,454**	**1,120,715**	**72.1%**	**70.7%**
6. Bangladesh	149,665	3.00%	168,745	113,745	124,669	76.0%	73.9%
2. India	1,081,229	21.7%	1,182,962	778,485	836,740	72.0%	70.7%
5. Pakistan	157,315	3.16%	181,797	103,828	116,378	66.0%	64.0%
SE. Asia	**1,887,952**	**37.89%**	**1,995,525**	**1,132,813**	**1,095,983**	**60.0%**	**54.9%**
1. China	1,313,309	26.35%	1,371,892	801,118	762,964	61.0%	55.6%
3. Indonesia	222,611	4.47%	239,980	120,210	114,001	54.0%	47.5%
10. Philippines	81,408	1.63%	90,552	31,749	31,276	39.0%	34.5%
9. Vietnam	82,481	1.66%	89,392	61,036	63,645	74.0%	71.2%
S. America	**367,003**	**7.36%**	**398,372**	**69,508**	**65,022**	**18.9%**	**16.3%**
4. Brazil	180,655	3.63%	194,519	30,711	26,628	17.0%	13.7%
C. America	**175,905**	**3.53%**	**192,768**	**58,072**	**60,549**	**33.0%**	**31.4%**
8. Mexico	104,931	2.11%	114,397	26,233	26,821	25.0%	23.4%
Pacific	**2132**	**0.04%**	**2345**	**1351**	**1434**	**63.4%**	**61.2%**
TOTAL	**4,983,365**	**100%**	**5,437,234**	**2,939,093**	**3,038,537**	**59.0%**	**55.9%**

"ability to work", demand for energy is a "derived demand"; people do not want energy in itself but the "energy services" provided. This wide range of services is made possible by different fuels and technology and can have a major impact in facilitating livelihoods, improving health and education in rural areas of developing countries and helping to reduce poverty.[13]

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[13] DFID – Energy for the Poor, Underpinning the Millennium Goals, Aug 2002, page 7.

The rate of electrification and use of traditional fuels for cooking, two of the most significant benchmarks for energy provision, are not overlaid in table 1 as specific electrification rates in rural areas are difficult to obtain in so many countries, and statistics on the use of biomass per country are even less available, although cooking comprises 95 per cent of energy use in LDCs.

However, the World Energy Assessment estimates that between 1970 and 1990, rural electrification programmes reached about 800 million additional people and some 500 million saw their lives improve substantially through the use of better methods for cooking and other rural energy tasks.[14] While much of the rural electrification programmes were through grid connection, the amount of renewables now being utilized in LDCs has been estimated to be providing the extra energy services needed to about 25 million people. The renewable energy capacity is made up of 1 million solar home systems (SHS), 150,000 PV and wind powered clinics and schools, 50,000 domestic wind turbines, 300,000 solar lanterns (in India alone), 150,000 family-hydro units (in China and Vietnam) and hundreds of thousands PV and wind water pumps.[15]

But despite the enormous efforts to improve energy services to rural populations (including the use of renewables) in the past thirty to forty years, the un-served population has not decreased significantly in absolute numbers – about two billion people still rely on traditional biomass for cooking and lack clean, safe fuels[16] and 1.7 billion have yet to achieve any electrification.[17]

So, energy provision for all remains a key problem and challenge for billions of poor people who often have a limited choice of technologies that convert energy into useful services. The technologies most readily available to them are typically inefficient or low quality.[18] So they end up paying much more per unit of useful energy service than the more well off.

On the face of it, this challenge looks formidable, yet to meet the basic cooking needs of two billion people would correspond to no more than 1 per cent of global commercial energy consumption[19] and to provide the basic electricity needs of off-grid households and enterprises is certainly technologically achievable and, using the right financing instruments, often financially viable.

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[14] World Energy Assessment: Overview 2004 Update – United Nations Development Programme, United Nations Department of Economic and Social Affairs, World Energy Council, 2004, page 59.

[15] Greenpeace/The Body Shop – Power to tackle poverty, June 2001, ISBN 9073361745, page 9.

[16] Greenpeace/The Body Shop – Power to tackle poverty.

[17] World Energy Assessment, 2002 – United Nations Development Programme, United Nations Department of Economic and Social Affairs, World Energy Council, 2002.

[18] DFID – Energy for the Poor, page 7.

[19] Reddy (1999), quoted in WEA, 2002.

For example, the G8 Renewable Energy (RE) Task Force has a target of one billion additional people to be served with renewables in the decade to 2012, through concerted action intended to result in the improvement in the efficiency of traditional biomass use for cooking for up to 200 million people, access to electricity from renewable sources to up to 300 million people in rural areas of developing countries and service to up to 500 million people connected to electricity grids world-wide.[20] The UNDP aims to halve the number of people without access to commercial energy by 2015 and Greenpeace with the Body Shop have proposed that two billion people be provided with RE by 2012.[21]

But even with the will and the technological capability for extending energy services into rural areas, there remain immense problems in carrying this through. The issue lies in the inequalities that poor populations face in many aspects of their lives; economic, social and political, and access to energy is yet another extra challenge that these people face.

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[20] G8 Task Force Final Report, July 2002.

[21] Greenpeace/The Body Shop – Power to tackle poverty.

4. THE MILLENNIUM DEVELOPMENT GOALS

The current situation, laid out above, calls for all possible actions to be taken to improve energy access for rural populations, and none is more important than the Millennium Development Goals (MDGs). This is fast becoming common understanding by many agencies concerned with the sector and the linking of MDGs to energy services in rural areas is now being looked at carefully by many.

MDGs were first thought of and compiled during international conferences and summits held in the 1990s, initially known as the International Development Goals. Then in September 2000 the 189 member States of the United Nations unanimously adopted the Millennium Declaration.[22] Following consultations among international agencies, including the World Bank, IMF, OECD, and specialized agencies of the UN, the General Assembly recognized MDGs as part of the road map for implementing the Millennium Declaration.

MDGs cover eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality; improving maternal health; combating HIV/AIDS, malaria and other diseases; ensuring environmental sustainability; and developing a global partnership for development.[23] In summary MDGs:

> “commit the international community to an expanded vision of development, one that vigorously promotes human development as the key to sustaining social and economic progress in all countries, and recognizes the importance of creating a global partnership for development. The goals have been commonly accepted as a framework for measuring development progress.”[24]

The detail of the MDGs is shown in annex 1; they have aspirational targets in 18 important areas with 48 indicators to monitor progress to 2015. Better access to energy is not a specific goal within the MDGs but there are indicators that refer to energy in the goal of ensuring environmental sustainability and energy is an aspect that runs through many of the targets in the MDGs. Many development agencies, for example DFID, have noted how energy can play a crucial role in underpinning efforts to achieve the MDGs and improving the lives of the poor people across the world.[25]

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[22] see www.un.org/millennium

[23] www.oecd.org/document/41/0,2340,en_2649_34585_1907625_1_1_1_1,00.html

[24] www.developmentgoals.com/About_the_goals.htm

[25] DFID – Energy for the Poor, Executive Summary

Review question

1. What are the eight Millennium Development Goals?

5. LINKAGE OF ENERGY TO THE MDGs

Many institutions have considered the MDGs and integrated the important linkages of energy services to them. In fact, as energy services are essential ingredients of all three pillars of sustainable development (economic, social and environmental, as below), they can be an input to all MDGs:

- **Economic sustainability** assumes that social and environmental aspects of sustainable development must be defined economically;
- **Social sustainability** assumes that economic and environmental aspects must be defined by taking into account social considerations (i.e. equal opportunities for all);
- **Environmental sustainability** assumes that the economic and social aspects are defined by considering environmental constraints;
- The **long-term perspective** assumes social, economic and environmental aspects can be sustained through generations and views remain consistent with the majority of the population.[26]

5.1. Development agencies

A number of development agencies are helping to facilitate the MDGs, not so much through direct involvement in their management, as in the financing of market studies and the development of business plans to assist private sector interests in establishing and operating energy services for rural people. These efforts are aimed at addressing uncertainty and providing the necessary interface between poor communities, energy services and private capital.

Department for International Development – UK

The UK's Department for International Development's (DFID) document "Energy for the Poor" clearly outlines a matrix of energy and the MDGs, drawing on case studies to reinforce the linkages.[27] Broadly this shows that:

- **To halve extreme poverty** – access to energy services facilitates economic development – micro-enterprise, livelihood activities beyond daylight hours,

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[26] SOPAC/ICCEPT Pacific Islands Biomass Energy Resource Assessment Training Course

[27] DFID – Energy for the Poor, Annex 1

locally owned businesses, which will create employment – and assists in bridging the "digital divide".

- **To reduce hunger and improve access to safe drinking water** – energy services can improve access to pumped drinking water and 95 per cent of staple foods need cooking before they can be eaten.
- **To reduce child and maternal mortality; and to reduce diseases** – energy is a key component of a functioning health system, for example, lighting operating theatres, refrigeration of vaccines and other medicines, sterilization of equipment and transport to health clinics.
- **To achieve universal primary education; and to promote gender equality and empowerment of women** – energy services reduce the time spent by women and children (especially girls) on basic survival activities (gathering firewood, fetching water, cooking, etc.); lighting permits home study, increases security and enables the use of educational media and communications in schools, including information and communication technologies (ICTs).
- **Environmental sustainability** – improved energy efficiency and use of cleaner alternatives can help to achieve sustainable use of natural resources, as well as reducing emissions, which protects the local and global environment.

United Nations

The UN has taken the energy-MDGs nexus forward under their Millennium Project, which over a period of three years will work on a plan of implementation that will help all developing countries to meet the MDGs and thereby substantially improve the human condition by 2015. Ten thematically-orientated Task Forces perform the bulk of the research, within which energy is represented.[28] In October 2004 a workshop in the USA defined the energy services and corresponding targets required to meet the MDGs in the poorest countries with a special emphasis on sub-Saharan Africa. The recommendations on how the scaling up of access to improved energy services is to play an essential role in meeting the MDGs, are described in the report "Energy Services for the Millennium Development Goals"[29] (November 2005).

Global Village Energy Partnership

The Global Village Energy Partnership (GVEP)[30] has also stressed the following as the key areas of linkage of energy provision in rural areas to the MDGs:

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[28] www.unmillenniumproject.org

[29] www.energyandenvironment.undp.org

[30] see www.gvep.org

- **Energy and poverty**
  - Modern energy releases time spent gathering fuel;
  - Energy is needed from small and household enterprises;
  - Energy services are business opportunity for ESCOs;
  - Communications and TV enable improved knowledge.

- **Energy and hunger**
  - The requirement of energy for cooking is huge – it comprises 95 per cent of energy use in LDCs and a third of the world's population still rely on traditional fuels for cooking;
  - Modern energy for cooking (LPG, electricity) can reduce reliance on biomass.

- **Energy and Education**
  - Collection of fuel wood takes up a lot of time, especially for women;
  - Improved lighting helps home and class study;
  - Educational aids can be supported with electricity;
  - Electricity for ICTs improve school effectiveness;
  - Modern energy means better quality of life for teachers.

- **Energy and mortality**
  - Lighting is an absolute priority for maternity services;
  - Electricity is needed for pumped and boiled water;
  - Reduced air pollution from reduced use of biomass;
  - Reduces hunger;
  - Refrigeration for vaccines and food preservation;
  - Safe water supply.

- **Energy and environment**
  - Local domestic environment improved with modern energy services;
  - Land degradation reduced with less biomass used for cooking;
  - Local pollution reduced (especially in built-up areas);
  - Renewable energy and energy efficiency help alleviate global warming and climate change;
  - Development and environment prerogatives of following clean energy path.

REEEP

The Renewable Energy and Energy Efficiency Partnership (REEEP)[31] is a coalition of progressive governments, businesses and organizations committed to accelerating the development of renewable and energy efficiency systems (REES), which also contribute to rural energy, rural sustainable development as well as the MDGs. The visions of REEEP are:

- **Energy security.** Dependence on imported fossil fuels leaves many countries vulnerable to disruption in supply and the accompanying economic and development impact. Increased use of efficient and renewables systems improves energy security, by boosting resource productivity, avoiding excessive dependence on imported fuels, developing local sources and diversifying energy portfolios and suppliers.
- **Economic development.** Lack of access to sustainable energy constrains opportunities for economic development and improved living conditions. Renewables and energy efficiency systems support a sustained GDP growth by improving economic and environmental performance, enhancing technological innovation and creating new commercial opportunities.
- **Social equity.** Access to and use of energy is marked by an uneven distribution in many countries, and between the rich and poor within them. Developing distributed energy generation and sustainable renewable systems can enable more equitable access to energy services and create new job opportunities, especially in rural areas.
- **Environmental protection.** Most current energy generation and use results in serious health and environmental impacts at local, regional, and global levels – including climate change – which threatens human well-being and ecosystems. Accelerating energy efficiency improvements and deployment of sustainable renewable energy results in significantly lower environmental pollution.

The European Commission

The European Commission has recently established a series of programmes and funds aimed specifically at dealing with energy access for poverty reduction. These are amongst others, the COOPENER programme, the European Union Energy Initiative for Poverty Eradication and Sustainable Development (EUEI)[32] and the ACP-EU Energy Facility.

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[31] see www.reeep.org

[32] see www.euei.org

The actions of the COOPENER programme focus on institutional frameworks and aim to support and stimulate the activities of the EUEI and to contribute to the achievement of the Millennium Development Goals (MDGs). To complement activities of strengthening institutional capacity for improved access to energy services, the EU has also initiated the ACP-EU Energy Facility, which provides co-funding for energy and poverty actions in order to achieve the MDGs.

A budget of 225 million Euro has been allocated for the ACP-EU Energy Facility. Of this budget, five million has been set aside for the EUEI Partnership and Dialogue Facility to support EUEI upstream dialogue for exemplary policy, capacity building and partnership development. The remaining 220 million is designated to improving rural people's access to modern energy services in sub-Saharan Africa as well as support energy efficiency and renewable energy investments in the Caribbean and Pacific Island States. The bulk of the funding, at least 60 per cent, is intended for co-financing in sub-Saharan Africa.

Box 1. **Linking energy and national development to the MDGs: a regional energy access plan in East Africa**

In August 2005 the Ministers of Energy in the East African Community (EAC) endorsed a document titled "Scaling up Modern Energy Services in East Africa to alleviate poverty and meet the Millennium Development Goals".

This document outlines priority energy services that need to be scaled up in East Africa in order to meet the Millennium Development Goals. The EAC has taken on the challenge of developing a regional strategy and implementation framework, leading to an investment portfolio to achieve these targets – a process that is supported by the UNDP.

Four energy targets are identified in the "Scale-up document":

- Target 1: Enable the use of modern fuels for 50 per cent of those who at present use traditional biomass for cooking. Support efforts to develop and adopt the use of improved cook stoves, means to reduce indoor air pollution, and measures to increase sustainable biomass production.
- Target 2: Access to reliable modern energy services for all urban and peri-urban poor.
- Target 3: Electricity for services such as lighting, refrigeration, information and communication technology, and water treatment and supply for schools, clinics, hospitals and community centres.
- Target 4: Access to mechanical power within the community for all communities for productive uses.

The endorsement of the document by the ministries of energy marked the beginning of the next phase: to define the process and further develop the regional strategy and the implementation framework, including the institutional framework for moving forward.

Several activities necessary to develop a regional strategic framework for East African countries to meet objectives for scaling up access to modern energy services through the development of MDG-based investment programmes have been identified, including the following:

- Agreement on an implementation framework to meet the four targets including planning capacity at relevant administrative levels;
- Strategies to mobilize financial resources to implement the formulated energy policies;
- Learning from the Economic Community Of West African States (ECOWAS) experience in defining a regional energy strategy.

In order to foster the processes envisaged in the scale-up document, the Energy Committee of the EAC in December 2005 decided to develop a regional strategic framework for the Scale-up Initiative. This process was set underway at a regional workshop in March 2006, which was followed by a meeting of the Energy Committee. Furthermore, the EAC decided to communicate its engagement in energy issues for development by presenting the Scale-up Initiative as its regional energy programme at the Commission for Sustainable Development, CSD-14 held in New York 1–12 May 2006.

Related to this is the ENABLE project,[33] funded by the European Commission's COOPENER Programme, which aims to support and stimulate the activities of the European Union Energy Initiative for Poverty Eradication and Sustainable Development (EUEI) and contribute to the achievement of the Millennium Development Goals (MDGs). The aim of the ENABLE project is to build capacity in energy in the health, water and education sectors for poverty reduction in sub-Saharan Africa and to support the development of cross sector planning tools and their implementation.

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[33] www.enable.nu – accessed July 2006

6. POLICY OPTIONS FOR INCREASING ACCESS TO ENERGY SERVICES IN RURAL AREAS

6.1. Basic needs of energy in rural areas[34]

The benefits deriving from energy services are often diverse and complex. They range from:

- The direct benefits of contributing to increased production and reducing "sweat energy";
- The contribution that energy can make to health and human capital, for example in terms of pumping water or provision of lighting and other services to health facilities and schools;
- More intangible benefits of "security" (via street lighting, back-up energy supplies, or pumped water reducing risks from drought);
- A sense of "inclusion" in the modern economy (via communications media).

These basic needs and energy sources are listed in table 2 below.

A wide range of devices convert primary sources of energy into various "services" but this process always has a cost (both for conversion processes and because of efficiency losses). The cost of "useful energy" can be quite different from the cost of the "primary energy" or fuel. Therefore it is important to refer to the provision of energy services rather than merely the supply of energy.

It is important to note that as people become richer and proceed through the "energy transition" that introduce new, more convenient and efficient sources of energy into their lives, they may well continue using the traditional energy sources as well. This is in part for cultural reasons and in part to minimize the risk of interruption in supply (for example back-up diesel generator to cover the risk of cuts in power from the electricity grid). This multiple fuel use means that the impact of fuel switching and efficiency improvements is often not as substantial as models and policies might predict.

This is perhaps at its most extreme with cooking, where households may graduate to LPG but women still use wood and charcoal to cook certain types of food. Even very poor households may retain a variety of options to reduce the costs or

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[34] EnPoGen Report, Energy, Poverty and Gender: a Review of the Evidence and Case Studies in Rural China, 2003.

risks associated with a particular fuel/technology system. For example, in poor rural China it is not difficult to find households with a solar water collector, biogas digester, and both coal and residue burning stoves.

Table 2. Typical end uses by energy source in developing countries[35]

	Income Level		
	Low	Medium	High
Household			
Cooking	Wood, residues and dung	Wood, charcoal, residues, dung, kerosene, biogas	Wood, charcoal, kerosene, LPG, coal
Lighting	Candles, kerosene, none	Candles, kerosene	Kerosene, electricity
Space heating	Wood, residues, dung, none	Wood, residues, dung	Wood, residues, dung, coal
Other appliances – radio/television	None	Grid electricity and batteries	Grid electricity and batteries
Space cooling and refrigeration	None	Electricity (fans)	Electricity, kerosene, LPG
Agriculture			
Tilling	Human labour	Draft animals	Animal, gasoline, diesel
Irrigation	Human labour	Draft animals	Diesel, grid electricity
Processing	Human labour	Draft animals	Diesel, grid electricity
Industry			
Milling/mechanical	Human labour	Human labour, draft animals	Grid electricity, diesel, gasoline
Process heat	Wood, residues	Coal, charcoal, wood and residues	Coal, charcoal, wood, kerosene, residues
Cooling/ Refrigeration	None	None	Grid electricity LPG, kerosene
Services			
Transport	Human labour	Draft animals	Diesel, gasoline
Telephone	None	Batteries	Grid electricity

6.2. The problems of increasing the ability to pay for improved energy services in rural areas

Large numbers of people in effect suffer from a “vicious circle” of energy poverty where they are “energy poor” because they do not have the means to buy improved energy services, even if they have access to them (in the sense of being in close proximity to a supply). Furthermore, even people who can afford improved energy supplies still may not be able to afford the “conversion technology” that makes that energy useful (for example, a stove, radio, light bulb or motor). This can be illustrated diagrammatically (see figure I below).

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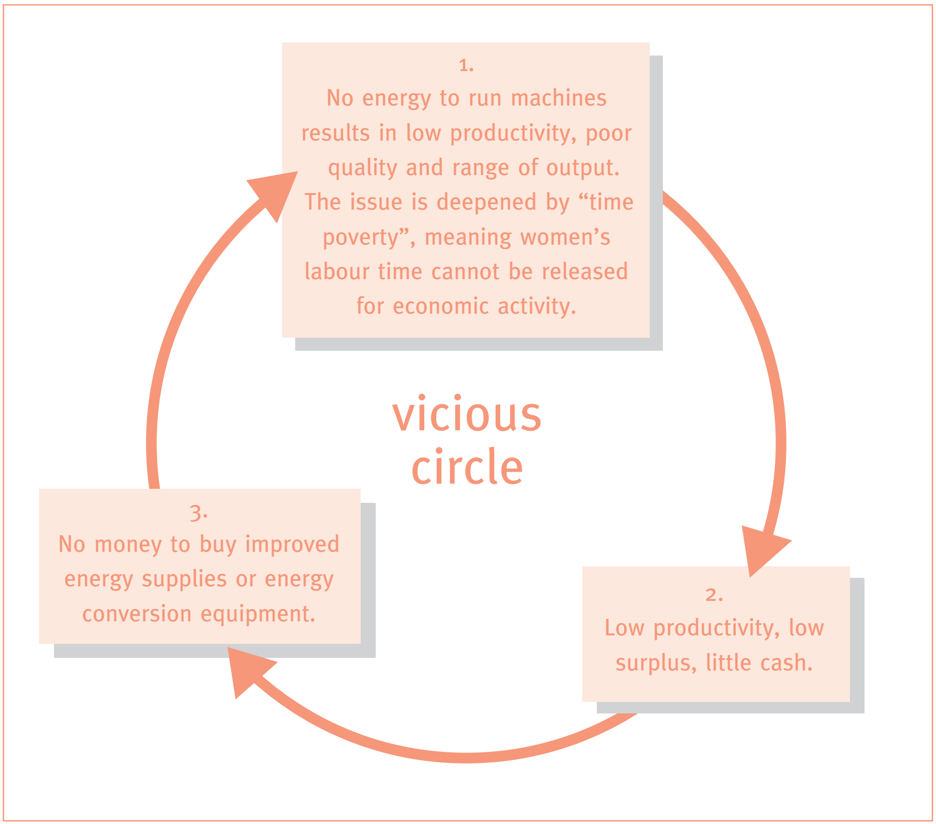
[35] Based on World Bank, 1996, Rural Energy and Development, World Bank Publication, page 25.

Increased access to cash becomes crucial because improved energy services at the household level frequently necessitate switching to an energy technology that costs money from one that does not. Even where improvement in lighting results in cash savings because the new source replaces more costly but less effective supplies (such as batteries and candles), there is frequently a net increase in money expenditures because people make more use of the improved energy services.

This means that attempts to reduce energy poverty (particularly using electricity supply technologies) face a particularly difficult issue in terms of the stated preferences of intended beneficiaries. When rural people express their needs for improved energy services they often give high priority to lighting, a perfectly understandable position for those forced to live much of their lives in the semi-darkness provided by candles or kerosene. But the most financially sustainable decentralized electricity supply options are likely to be those which provide power to productive enterprises that can sell their products/services profitably.[36]

Figure I. The vicious circle of energy poverty



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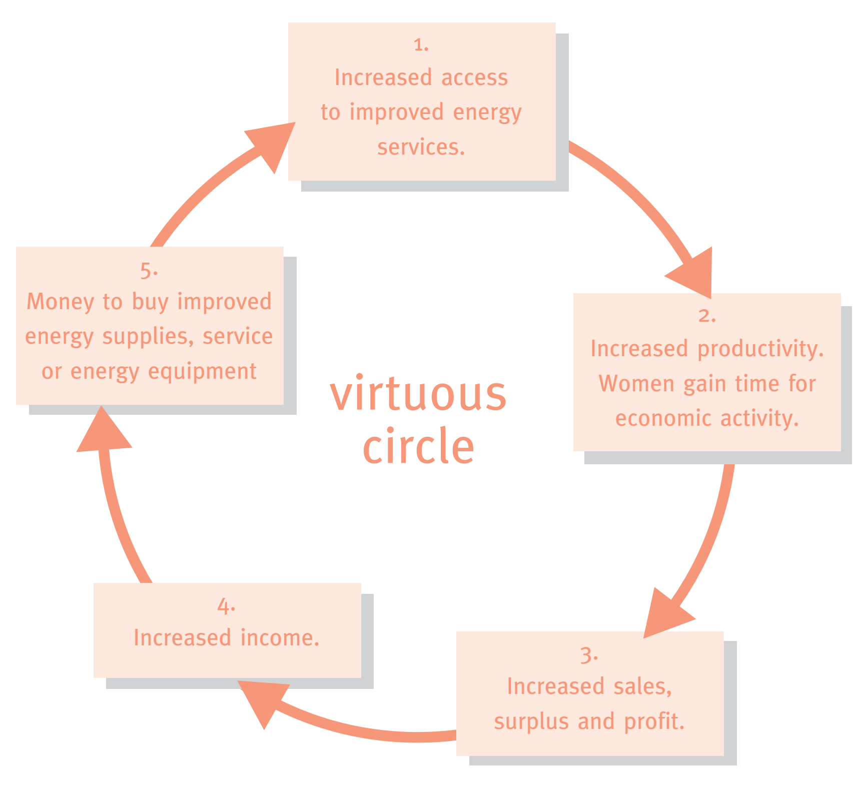
[36] Generally village wealth will not increase unless goods and services can be sold outside the village, this implies that roads and transport are likely to be necessary "complementary inputs".

An important conclusion follows from this. The cycle of energy poverty will often be broken only by combining improved energy services with end uses that generate cash incomes. These are likely to be the productive energy end-uses that enhance production activities, either by increasing productivity, extending the range of outputs or improving output quality. This might be labelled a "virtuous circle" and is illustrated in figure II.

Clearly the vicious cycle of energy poverty (as with other forms of poverty) can be broken through the redistribution of wealth by means of grants and subsidies. But the level of funds available from government, aid donors and non-governmental organizations is likely to be far less than those required to provide all people with adequate energy services.

There is a further consideration, that is, when planning pro-poor energy interventions it is important to consider the means of using the energy to secure cash incomes at an early stage of the development process, and only subsequently to see how the impact of improved energy services can be extended to the other aspects of sustainable livelihoods. It has proven extremely difficult to produce

Figure II. A virtuous circle to break out of energy poverty



financially sustainable results with energy projects if they are started with the mind set of "social development" (akin to feeder roads, clinics and schools) that are free at the point of service.[37] Such projects often fail when the governments, aid agencies and NGOs who finance such schemes initially cannot sustain their support for recurrent expenditures.

Review question

1. What are the typical basic energy needs in rural areas?

6.3. Policy and regulatory instruments for improving energy services in rural areas

The role of intermediation

There are clearly many ways in which the overall energy supply and use system might be conceptualized. The most effective method with which to increase energy services in rural areas is the policy instrument. The approach extends the idea of financial intermediation, technical intermediation, social intermediation and organizational intermediation.

Financial intermediation: involves putting in place all the elements of a financial package to build and operate decentralized rural energy supply companies (RESCOs) in place. The process is sometimes referred to as "financial engineering" and covers:

- The transaction costs of assembling the equity and securing loans;
- Obtaining subsidies;
- The assessment and assurance of the financial viability of schemes;
- Assessment and assurance of the financial credibility of borrower;
- The management of guarantees;
- The establishment of collateral ("financial conditioning");
- The management of loan repayment and dividends to equity holders.

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[37] Though it is clear that in recent years attempts have been made to place such services on a more financially sustainable basis.

Financial intermediation can also be used to cover whole schemes rather than just investment in an individual plant. In this way projects can be "bundled" together in away which:

- Makes them attractive to finance agencies;
- Establishes the supply of finance on a "wholesale" basis from aid agencies, governments, and development banks;
- Creates the mechanisms to convert these flows into a supply of retail finance (equity and loan finance at the project level).

Technical intermediation: involves both improving the technical options by undertaking research and development activities and importing the technology and know-how "down" through the development of capacities to supply the necessary goods and services. These goods and services include:

- Site selection;
- System design;
- Technology selection and acquisition;
- Construction and installation of civil, mechanical and electrical components;
- Operation & maintenance;
- Trouble shooting, overhaul and refurbishment.

Organizational intermediation: involves not only the initiation and implementation of programmes, but also lobbying for the policy change required to construct an "environment" of regulation and support in which the energy technology and the various players can thrive. This involves putting in place the necessary infrastructure, and getting the incentives correct in order to encourage owners, contractors, and financiers. Organizational intermediation must include the development of regulatory support and incentive structures, which can specifically address the energy needs of the poor in rural areas.

Organizational intermediation is usefully distinguished from social intermediation which involves the identification of owners and beneficiaries of projects and the "community development" necessary to enable a group of people to acquire the capabilities to take on and run each individual investment project obtaining for them a voice in project identification, design and management of programmes.

The role of subsidies

In addition to overall poverty in rural areas, the number and range of "intermediation tasks", low density of demand and remoteness of location, raises the costs and reduces profitability of energy supplies to rural areas. Furthermore a certain amount of "social overhead investment" almost always has to be put in place to support such schemes (training, technical assistance, capacity building within communities). The burden of these overheads will be particularly high for innovative schemes, though they may eventually be spread across a large number of enterprises.

A report from The World Bank confirms the view held by many people involved in the practical implementation of rural energy schemes when it says that:

> *It is illusory to expect that increasing access to electricity for a significant part of the population traditionally excluded from grid-based electricity can be financed only by the private sector.*[38]

If the cost of energy is too expensive for poor people who need it, then the issue of subsidies and/or grants cannot be avoided. The political acceptability of subsidies has undergone wild fluctuations in recent years. All governments provide subsidies, and it is clear that some have done more harm than good (destroying markets and benefiting people who are already better off). However, the essential question that has emerged from the ideological posturing of recent years is less about the rights and wrongs of subsidies in principle, but rather as to whether a particular form of subsidy is actually likely to achieve its intended purpose.

The arguments for using money that is supplied at less than full commercial rates of interest are overwhelming if large numbers of people are to be given access to improved energy services. This "soft money" will be required to enable people with insufficient purchasing power to gain access to electricity, and to other more convenient forms of energy.

If the case can be made for subsidies, experience suggests that the use of soft money can both help the expansion of decentralized energy supply options and harm them. As always, the "devil is in the detail" and in the specifics of each context. Hence the phrase "smart subsidies"[39] has been coined to put some distance between current forms of subsidy and the earlier forms, for example subsidies on grid-based electricity, kerosene and diesel, that have been shown to stultify innovation, destroy markets and support the already more well off.

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[38] Best Practice Manual: Promoting Decentralised Electrification Investment, ESMAP World Bank, 1999, Page 10.

[39] The term "smart subsidies" was first coined by Charles Feinstein at the World Bank, and details of what is involved can be found in Best Practice Manual: Promoting Decentralized Electrification Investment, ESMAP World Bank, 1999.

A large number of technology driven schemes currently adopt a strategy of trying to increase sales through subsidy. This is particularly the case with photovoltaics. It is argued that increased sales will reduce the cost of production and, more importantly, enable the overhead costs of providing technical support and supplying retail credit to be spread over a larger number of unit sales. The evident danger of such an approach is that “soft” money intended for social investment is often used to subsidize the costs of these supply options for those who could readily afford to pay the true cost if they genuinely regarded this as a priority area of expenditure. Furthermore the use of subsidies linked to a particular supplier can “pollute the well” for other entrants to the market. In essence “smart subsidies: should:

- Follow pre-established rules that are clear, and transparent to all parties;
- Focus on increasing access by lowering the initial costs (technical advice, capital investment) rather than lowering the operating costs;
- Provide strong cost minimization incentives such as retaining the commercial orientation to reduce costs;
- Remain technologically neutral;
- Cover all aspects of the project including end-use investments, particularly to encourage pro-poor end-uses; and
- Use “cross subsidies” within the project to pay for lifeline charges or tariffs and other “pro-poor” recurrent cost subsidies (e.g. enable transfer from richer sections of the community, and commercial users to marginal connections).

Pricing

Perhaps, one of the most critical issues in rural energy development is the non--monetized nature of many aspects of the rural economy, in particular, the bulk of energy supplies in the form of fuel-wood and other biomass fuels. The limited cash that rural people do have needs to be spent on a variety of goods: because energy has traditionally been considered a free resource, it may not enjoy the highest priority. At the same time, the introduction into rural societies of modern energy sources carries a cash price.

While the ability and the willingness of rural people to make the transition from traditional to modern energy sources may be contingent upon their financial resources, their prospects of achieving higher income levels are, in turn, often constrained by the extent to which such a transition is achieved. Energy and rural development may thus find themselves in a state of mutual dependence, and represent one aspect of the poverty cycle that pervades many rural areas. Breaking this deadlock is one of the major challenges faced by developing countries in developing their rural areas.

Pricing rural energy services is a dilemma issue. High prices for the services will be beyond the affordability of rural people and low pricing will result in it being difficult to induce the necessary investment from commercial banks and private investors. In most cases, the immediate priority of dealing with rural energy poverty is to provide a minimum amount of energy to meet people's basic needs, irrespective of their ability to bear the costs of supply and delivery.

So subsidies on prices are one measure used to lower the cost of energy service in rural area. For example, in the Chinese village solar power programme implementation, the government proposed a price subsidy, so that the rural people only pay the operating cost, and the government will pay the investment cost. Even so, most of the households still need to pay about RMB 2 per kWh in contrast to the grid power sales price of about RMB 0.5 per kWh. This is still beyond the affordability of rural poor; therefore some households in the PV powered villages are turning back to candles or kerosene.

In the longer term, it is necessary to accelerate the "modernization" of the rural energy sector, to facilitate and sustain productive economic activities in rural areas, which will hopefully ensure economic and financial sustainability and increase rural people's self-reliance.

The enabling environment

The local government clearly plays a crucial role in the provision of subsidies, even where it has been "rolled back" from direct involvement in providing energy services to poor people. However, subsidies should not be considered in isolation from other aspects of government intervention. Although the climate is growing more favourable to decentralized energy supply options, in most countries the existing regulatory framework is often the major barrier to such development. It can be hostile, contradictory or uncertain. Taxes and subsidies still often undermine markets, rather than encourage them. The supporting infrastructure of training institutions, or finance may be non-existent or inaccessible. Competitors may be able to gain privileged access to subsidies that enable them to sell their products below cost. Without changes to this policy environment, the flow of private sector finance and innovation will be restricted. These are the areas currently at the focus of much analysis, innovation and reform.

The role of the energy regulator

The overall role for an energy sector regulator in a liberalizing power market is to ensure a levelled playing field and to overlook the proper functioning of the power market.

Often the regulator is involved in the implementation of the energy policies as adopted by the national government. Therefore the regulator should be handed the mandate and the resources to develop regulatory instruments and coordinate the consultation process with the key stakeholders.

This mandate typically includes the following tasks:

- Set up the collaboration and consultation process with the key stakeholders in order to integrate the planning of the rural electrification system and the transmission system. The key stakeholders include the Rural Electrification Authority (REA) and the Transmission and Distribution System Operator (TSO and DSO);
- Explore how the use of renewable energy and energy efficiency technologies can be best approached in the Grid Code;
- Help creating the enabling environment to attract private capital into the national power sector, by identifying gaps in the legislative and regulatory framework and by formulating recommendations accordingly;
- Initiate and review the development process of the Grid Code;
- The setting of tariffs and technical standards.

Review questions

1. What is financial intermediation?
2. What is meant by an “enabling environment”?

7. DIFFERENT MODELS FOR INCREASING ENERGY SERVICES IN RURAL AREAS

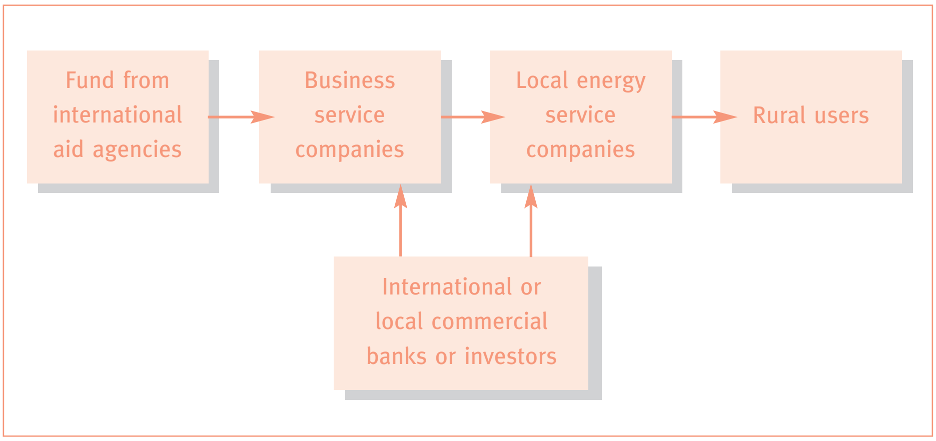
Although some developing countries long ago recognized the importance of energy in rural development, it was only following the so-called energy crisis in the early 1970s that rural development policy-makers began to show greater concern for the energy constraints facing them.

As the world suddenly entered an era of rising energy prices and unstable petroleum-based fuel supplies, these factors threatened to accelerate the perceived gradual environmental depletion associated with rural people's heavy reliance on fuel-wood and agricultural residues to meet their basic energy needs. As supplies of petroleum-based fuels became more costly and unreliable, it was believed that people would have to switch back to traditional or nature energy sources. Therefore the option in the most developing countries became to increase energy services by using different business models.

7.1. Market-based models

There are very limited successful stories for increasing energy services in a sustainable fashion to rural areas using a market-based model, due to the distributed service and limited profit on investment in this area. However, international aid agencies have developed several market based business models to increase energy access to rural areas. The general implementational flow of most market-based models is shown in figure III.

Figure III. Implementational flow of market based models



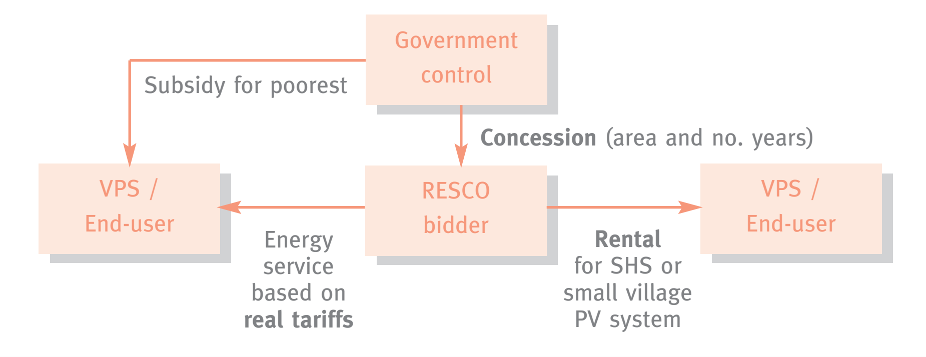
In the successful market-based model, the role of the business service companies is crucial, as they need to develop market-based ideas and get seed money from the aid agencies and then attract money from commercial banks. Following this, a local rural energy service company (RESCO) should be set up, with the support of business service companies. In the market-based policy option, the international aid fund still plays an important role. E&Co (of the USA) is typical of a business service company involved in rural electrification and other rural energy services in developing countries.

Box 2. **E&Co. model**

E&Co's mission is to promote a transition to a New Energy Paradigm that is based on the implementation of clean, economically sound energy projects that reach rural as well as urban populations in developing countries. Energy is a key factor in economic development. Modern, clean energy services allow for quality of life improvements, environmental protection and income generation. Modern energy services have direct benefits (lighting, cooling, motor power) but more important is the fact that modern energy services have indirect benefits (educational, community and income producing activities) and induced benefits (such as the creation of enterprises to install and service energy systems and the training of local technicians). E&Co's strategy is to support viable clean energy enterprises that ensure the delivery of affordable and reliable energy services to these communities. E&Co works to demonstrate that this delivery can be market driven and commercial. E&Co's efforts in Africa are structured to apply the lessons learned through experience in providing enterprise development services and $6 million of investment to more than 50 enterprises in 25 developing countries to the markets of Africa.

Other market-based models could be the "concession approach" and "rental approach" as shown in figure IV.[40]

Figure IV. Concession and rental approach of market-based models



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[40] VPS means Village Power Supplier

A concession approach has been demonstrated in Argentina,[41] where an award would be given to the most qualified RESCO bidder to provide the energy services as a regulated monopoly in a certain areas and over a certain number of years thereby operating in a "controlled" free-market environment. The tariffs should be real, reflecting the actual costs of service, but subsidies for electricity used could be extended to the poorest (based on household spending for lighting in the absence of electricity or on household willingness to pay) and then reduced over time during the concession period.

In a rental approach, as SOLUZ have shown in Honduras and Dominican Republic,[42] the RESCO shoulders the costs of the equipment meaning the customer would never own the system, but they would have to show their repayment capacity while paying rent on it. If the energy service agreement needs to be cancelled, it can be by giving advance notice and when payment is discontinued a technician can transfer the system to another customer. The disadvantage is that this approach can generally only be used for equipment that can be easily relocated, for example, for SHS and small village PV systems.

7.2. Government-led model

A government-led model can take on several forms. For example, for the Mexico PRONOSOL programme, the government maintained control of the programme and the private sector only participated as a vendor of goods and services and never as the owner-operator. A "bottom-up" approach was taken allowing awareness building on RE and participation of communities, and this effort has increased the rural electrification level with over 40,000 SHS disseminated.

For the Chile PER (Programa de Electrificación Rural or Rural Electrification Programme), the government led with a subsidy approach which was only for the initial investment and did not include O&M costs for which tariffs were set high enough to cover. The actual financing for the energy systems (decided by lowest cost to provide electricity) was 10 per cent from users, 20 per cent to 30 per cent from a distribution company (responsible for O&M) and 60 per cent to 70 per cent subsidy from the state. Although new electricity supply was provided to more than 90,000 households, exceeding targets, most projects were on-grid extension and diesel systems for off-grid rather than renewables.

A similar model has also been found in China to finance energy services in rural areas. Apart from the government controlling the financial model, market elements

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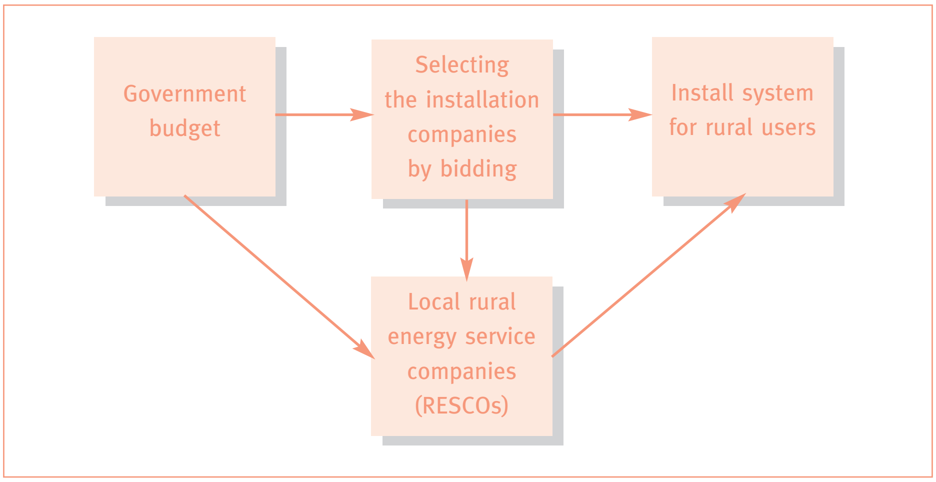
[41] The programmes are PAEPRA (1995-2000) and PERMER (2000-2005).

[42] www.soluzusa.com

are included in the policy options. In 2001, the Chinese government launched a village power programme, to install 700 village power systems with central and local government financial inputs. The financial flow in this government-led model is shown in figure V.

Figure V. Government-led model in China – financial flow



In this model, the government is the financial agency and the installation company and the local service company play a crucial role for supply energy service in the rural areas. However, the sustainability of this model depends very much on continuing government support.

7.3. Private company participation

Increasingly in developing countries the task of ensuring adequate energy supplies is being left to the private sector. This is primarily the result of structural adjustment programmes, central to which is the privatization of publicly owned utilities and the elimination of costly subsidies. In the absence of carefully defined contractual relationships between the new private utilities and the state, reliance on the private sector to provide energy services to the rural poor may result in their continued neglect, since potential returns on investment in rural areas may be lower than in other areas, or non-existent in some extreme cases. Despite this there are examples of private commercial RE successes in the provision of energy services in rural areas: SELCO (Solar Energy Light Company), active in India, Sri Lanka and Viet Nam,[43] and SOLUZ are good models, using fee-for-service and customer financing and leasing approaches.

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[43] www.selco-intl.com/where-we-operate.html

Box 3. **Village power model in China**

In 2002, in order to meet the power needs of public utilities and residents of un-electrified townships in remote, border regions of Western China, the National Development and Reform Commission (NDRC) initiated its Township Electrification Programme. Of the 1,065 townships included in the programme, 688 were targeted for the construction of PV power stations, with a total installed capacity of 20 MW. Small-scale hydropower stations were planned for 377 townships, with a total installed capacity of 264 MW.

Since initiation of the project, progress has been smooth in all areas of work. At present, nearly all of the PV stations have been constructed and are now generating power; and the majority of planned hydropower stations are in the midst of construction. The townships encompassed in the Township Electrification Programme are spread across 12 provinces (or provincial level municipalities). The total investment for the programme is 4.7 billion Renminbi / 607 million USD, of which 2.96 billion Renminbi / 382 million USD is provided by Government bonds. The programme is divided into two phases; the first phase includes 699 projects and the second phase has 366 projects. (Figures in USD are estimates based on the February 2007 exchange rate: 1.00 China Renminbi (CNY) = 0.1291 USD)

The Township Electrification Programme represents the first time that the Government of China has used stand-alone renewable energy power generation systems on a large-scale to resolve the electricity needs of un-electrified areas, realizing a transition away from pilots and experiments in the use of such RE systems. At the same time, the programme has, to a large extent, stimulated the rapid development of China's PV industry. The programme's success is evidenced by the fact that China's capacity for production of PV modules has increased ten fold in just the past three years.

Box 4. **SOLUZ model**

Soluz Honduras and Soluz Dominicana, subsidiaries of Soluz, Inc., began operations in July 1998 and have supplied over 5,000 PV systems. Soluz Honduras's revenues are from the sale of PV equipment and services to rural customers in local currency. The company is capitalized with equity and debt financing. The company sells SHS for cash or on credit and provides electricity services on a fee-for-service basis, which is becoming more and more popular.

In the Dominican Republic, Soluz is cooperating with an NGO on a rural credit programme that finances some customers in their geographical area. They also use their own capital to extend credit. However, the fee-for-service offer is really now the most common choice by customers. By maintaining ownership of the PV system assets, Soluz is able to provide them at affordable monthly rents, ranging from 10 – 20 US$ per month, prices equivalent to that now paid for kerosene, dry cell batteries and the re-charging of car batteries for TV usage.

Box 5. **SELCO model**

SELCO provides technologies and financing services for developing country markets. Wireless technologies such as solar PV demand little physical infrastructure, but require skilled rural men and women to introduce, supply, service, and finance solar electricity systems. The SELCO model does this by combining three essential elements:

- **Products:** Small-scale modular wireless technologies such as solar photovoltaics (PV) are used. The systems offer advanced, inexpensive lighting, electricity, water pumping, water heating, communications, computing, and entertainment. These products can be purchased for individual homes and businesses. They do not require connection to a larger network.
- **Service:** Customers are met where they live. With its extensive network of service agents, it is able to provide at-home design consultation, installation and after-sales service on all products sold.
- **Finance:** Customers are helped to finance their purchases. It partners with rural banks, leasing companies and micro-finance organizations to provide the necessary credit to their customers.

Combining these three elements creates a virtuous cycle: Using high-quality products reduces the cost of ongoing service and maintenance. With high quality products and ongoing service, customers are able to receive financing for their purchases. By providing a combination of product, service and finance, the SELCO model is able to offer lighting and electricity at a monthly price comparable to using traditional, less effective sources.

Another successful story of private participation for increasing energy service for rural areas is the small hydro power (SHP) programme in China. SHP development initially requires a large investment in construction, but it is a cost effective option in the long term. Some of the strategies adopted in promoting private financing of China’s SHP development, especially in the smaller sized SHPs, include:

- **“Multi-channel, multi-level and multi-structure” fund raising:** The Chinese government has directed that local people should seek funds from individuals, co-operatives, companies and any other external sources for the development of SHP. Foreign investors are also encouraged to invest in SHP stations. The principle of “who invests, who owns, who benefits” aims to allow investors from multiple levels and areas to gain by investing in SHP.
- **Share-holding and cooperative systems:** Since the beginning of the 1990s, most of the SHP stations in China have been developed under a shareholding system. This system has become very effective in attracting funds. Table 3 shows the proportion of different SHP ownership systems in China.

Table 3. SHP stations by ownership in China

Ownership		State ownership	Private ownership	Total
Station	Number	8,244	34,783	43,027
	%	19.2	80.8	100
Installed capacity	MW	17,500	8,762	26,262
	%	66.6	33.4	100
Annual output	GWh	62,954	24,187	87,141
	%	72.2	27.8	100

- **Government grants:** All levels of government in China release several million Renminbi each year as grants for SHP development. Other preferential policies, such as soft loans and rural electrification schemes further support SHP development. However, government support is decreasing in significance for funding SHP activities.
- **Fund raising by local communities:** Local people are usually willing to contribute to the development of nearby SHP resources with the potential to provide local benefits. The Chinese government has prioritized assisting and organizing the local people to realize SHP stations and local grids below 10kV. Locals without funds also offer free labour for the construction of stations and grids.
- **Bank loans:** In the past ten years, financial companies and banks have gradually become the major source of funds for SHP development. With the development of the market economy, the banks and other financial institutions have become more committed to the funding of SHP. In 2001, loans from banks reached a proportion of 51.9 per cent of funds supplied.

7.4. Subsidies

Finally, subsidies, which are provided by the central and local governments, are one of the most popular economic incentives for increasing energy for rural areas in developing countries. The typical subsidies are as follows:

- **Management and administration:** Governments would finance the agencies, which manage the energy planning, regulation and price as well as other services for increasing energy to rural areas, such as IREDA[44] and the Ministry of Non-conventional Energy Sources (MNES) of India. In China, the Rural Energy Offices (REOs) have about 100,000 staff at different levels for renewable energy development, the total administration cost of which was in 1998, about RMB 1.5 billion (180 million $US, 1998 exchange rate), a substantial subsidy for RE development.

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[44] Indian Renewable Energy Development Agency Ltd. – iredaltd.com/

- **Direct cost for R&D:** There are some subsidies for rural energy research and development in many developing countries. Again, taking China as an example, the annual budget for biogas, small hydropower and improved stoves is about RMB 100 million RMB (13 million $US, 2007 April exchange rate).
- **Projects subsidies:** In some cases, special financial agencies have been set up for rural energy project financing, such as IREDA in India, which offers soft-term loans varying at present from 2.5–14 per cent. Since 1987, IREDA secured international funding for the solar photovoltaic and thermal, small hydro and wind sectors through the World Bank and the Asian Development Bank. As a government agency, IREDA started cautiously, taking bank guarantees from the beneficiary for releasing credits in any of the modes available with them. By mid 1998, IREDA had sanctioned 963 projects covering over 300 million $US and the loan recovery rate has been as high as 99 per cent.

8. EXPERIENCES WITH INCREASING ENERGY SERVICES IN RURAL AREAS

8.1. China

Rural energy integration programme[45]

Starting in the 1980s, the Chinese Government began rural energy construction work that focused on renewable energy. The main areas of work were in promoting energy efficient stoves, rural biogas digesters, fuel wood forests and solar energy. As a result, at present the coverage of energy efficient stoves in China's rural areas is over 95 per cent and biogas work has moved from merely resolving energy needs to being a key component in the development of ecological agriculture and rural sanitation. The Chinese Government has been investing over RMB 1 billion (US$ 130 million, 2007 April exchange rate) annually in the building of rural biogas digesters, with emphasis on providing these subsidies to biogas work in China's western regions, thus benefiting the development of renewable energy in China's rural areas.

The principle of "suiting local conditions, developing diverse energy resources, utilizing energy resources in an integrated manner and striving for economic returns" has existed in rural energy development for 20 years to develop firewood and coal-saving stoves, household biogas digesters, small-scale hydropower stations and fuel wood plantations. Funds were allocated accordingly by both the central and local financial departments for rural energy development.

In order to fit in with the development of rural energy resources, concerned departments under the State Council and local government at all levels have successively set up institutions and agencies for rural energy management and technical extension. During the periods of the Sixth and the Seventh Five-Year Plans, trial projects of integrated rural energy development were successfully carried out in 18 counties, covering an area of over 30,000 square kilometres and touching the lives of 10.8 million people. During the Eighth Five-Year Plan period, China, by launching the "100 County Project", i.e. 138 integrated rural energy development counties, promoted the rural energy development in an all-round way.

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[45] Lu Ming, Ministry of Agriculture, R.R. China rural energy development in China and its role in sustainable rural development, 2003.

The Chinese Government attaches great importance to rural energy development and its goals have been clearly specified in “China Agenda 21” and the National People’s Congress have adopted the Ninth Five-Year Plan, in which it was reiterated to: “speed up the commercialization process of the rural energy industry, popularize firewood and coal-saving stoves and coal for domestic use, set up an energy industry, improve service systems and encourage the use of small hydropower stations, wind energy, solar energy, geothermal energy and biomass energy in light of local conditions”. Thus, the rural energy development programme has benefited the most of the rural population with following indicators:

- 97 per cent of the households have been connected with electricity;
- More than 10 million biogas digesters installed to provide gas for cooking and other energy services in rural areas;
- 95 per cent of households have been serviced with energy saving stoves or improved stoves for wood saving.

Small hydro power for rural electrification[46]

The use of small-scale hydropower to achieve rural electrification is a major characteristic of renewable energy development in China. In the 1950s, the Chinese Government began to develop small-scale hydropower in rural areas. In the 1980s, the Government began rural electrification pilots focused on small-scale hydropower. At present, there are over 600 counties (accounting for 30 per cent of all China’s counties) that rely mainly on small-scale hydropower for electricity and a there is a programme for 400 more counties (see figure VI).

Each year, the Chinese Government invests RMB 300 million (US$ 39 million, 2007 April exchange rate) in the development of small-scale hydropower, attracting additional investments from local governments, enterprises, and individuals of over 100 billion Renminbi (US$ 13 billion, 2007 April exchange rate). The total installed capacity of small hydropower in China is now over 30 GW. At present, in order to create synergies with the Sloping Cropland Conversion Programme and the Western Development Programme, the Chinese Government is in the midst of formulating a plan to replace fuel wood with electricity in rural areas of Western China by developing small-scale hydropower and thus improving the ecological environment as well as promoting economic development.

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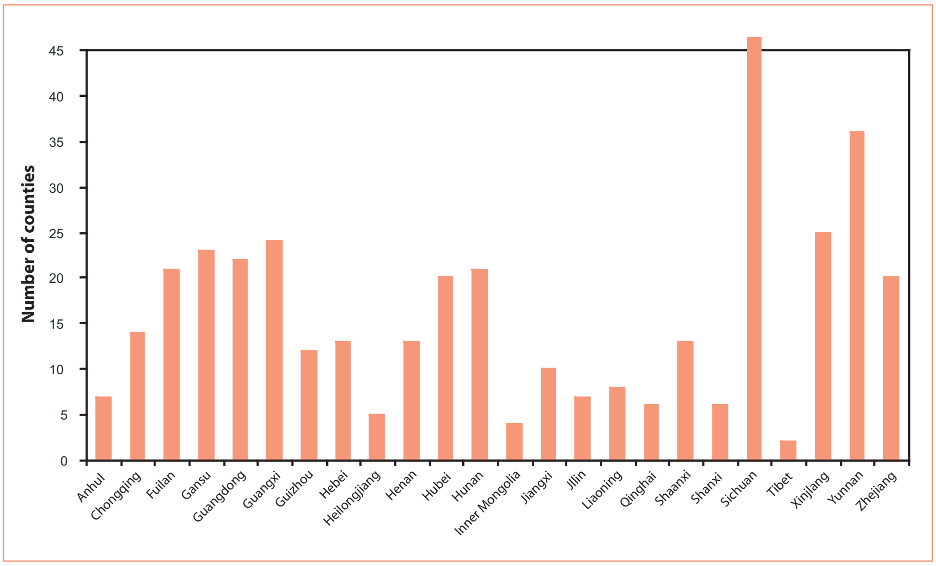
[46] China Renewable Energy Review, Bonn Renewable Energy Conference, 2004

Figure VI. 400 Counties electrification programme with SHP (China)



The township brightness programme

China's renewable energy industry has grown steadily over the last decade, and a principal target of technological advancement has been rural village and household-scale power systems. Nationally, almost 97 per cent of Chinese households have access to electricity and yet there are still 30 million people without access to the power grid. To address this need, village systems based on photovoltaic (PV) and wind power provide a cost-effective alternative to grid extension in these areas, and have been the focus of Chinese rural electrification initiatives in recent years. In late 2001, China launched an ambitious renewable energy-based rural electrification programme known as Song Dian Dao Xiang (SDDX), literally "Sending Electricity to Townships." In just 20 months, the programme electrified more than 1000 townships in nine western provinces, bringing power to nearly one million people and providing the basis for rural economic development. Installation was completed in June 2003 and consisted of 20 MW from PV, 840 kW from wind, and 200 MW from small hydropower (in Hunan and Yunnan provinces) – see table 4 below. The government provided US$ 240 million or RMB 2 billion, to subsidize the capital costs of equipment, and is now drafting guidelines for tariffs and system ownership.

The next phase of this initiative will be the Village Electrification Programme, which is tar-geted for 2005-2010 and will electrify another 20,000 villages in China's off-grid western region. Capacity building will be an important component of this phase, and NDRC will work with international and local agencies to develop and implement a training programme for national and local-level engineers and technicians. Other inputs that will be critical to overall programme sustainability

Figure VII. Examples of SDDX installations in China

Table 4. Preliminary SDDX installation information by province in China

Province	Number of townships	Installed capacity	Total investment	NDRC* grant	Provincial grant
		(kW)	(CNY million)	(%)	(%)
Xinjiang	48	1,932.45	177	50	50
Qinghai	86	2,600	266	80	20
Gansu	12	1,230	113	50	50
Inner Mongolia	39	1,362	68	50	50
Shaanxi	10	70	8	50	50
Sichuan	51	1,600	180	50	50
Tibet	350	6,700	800	100	0
Total	**596**	**15,494.45**	**1,612**		

* National Development and Reform Commission

include system design, productive use components, load management, system monitoring, reliable batteries and appropriate tariffs. The Township Electrification Programme is one of the largest renewable energy-based rural electrification programmes in the world and it has enough critical mass to create a truly robust and sustainable renewable energy infrastructure in China, especially for PV. The program represents an important launch point, as the lessons learned will have an immediate impact not only on future objectives of rural electrification, but also ostensibly on renewable energy programmes worldwide.

China rural energy enterprise development[47]

The China Rural Energy Enterprise Development Initiative (CREED) project seeks to create a sustainable energy development path for rural people in the Northwest

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[47] www.c-reed.org/

part of Yunnan province and neighbouring areas in Western China. CREED also aims to help alleviate environmental problems such as deforestation and biodiversity loss caused by the unsustainable collection of fuel wood in an area known for its rich biological diversity.

CREED builds on the approach being used successfully in the UNF-funded AREED project in Africa and B-REED project in Northeast Brazil, but that approach had to be adapted because of the different political, geographic, economic, and cultural characteristics of Western China. CREED aims to influence broader energy and development initiatives that are underway in China and to redirect existing sources of financing so as to achieve sustainable energy goals.

CREED will invest in new small entrepreneurs to offer energy services to rural customers based on energy technologies and practices that are environmentally more sustainable than current approaches. Adopting a method developed by project partner E&Co. of coupling enterprise development services with closely targeted financing, the CREED initiative will help start and support new businesses that supply improved energy to the rural poor. CREED will also work with local partners towards rural energy services by providing support for consumer credit and income generation activities so that poor families will have the means – and incentive – to purchase and use better alternatives. These two main thrusts of the project will be carried out in a way that helps a variety of Chinese partners to continue the approach and that anchors it in Chinese Government policies and programmes that are themselves strengthened through the project.

8.2. Other countries

Brazil-REED project[48]

The Brazil Rural Energy Enterprise Development programme (B-REED), with funding from the United Nations Foundation, has been initiated as a partnership between the United Nations Environment Programme (UNEP), in partnership with its Collaborating Centre on Energy and Environment (UCCEE) and energy investment company E&Co. B-REED seeks to develop new sustainable energy enterprises by working with NGOs and development organizations that use clean, efficient and/or sustainable energy technologies to meet the energy needs of populations under-served by traditional means, thereby reducing the environmental and health consequences of existing energy use patterns, while stimulating local economic growth.

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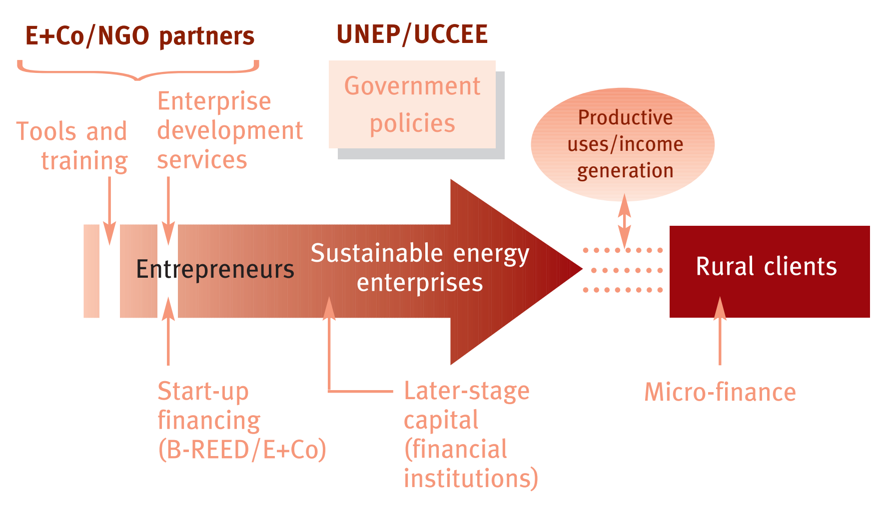
[48] www.b-reed.org/

The B-REED approach offers rural energy entrepreneurs looking to enter or expand into the sustainable energy business, a combination of enterprise development services and start-up financing in the form of debt or equity. This enables them to transform their business plans into early stage companies capable of accessing mainstream financing. B-REED provides this assistance by helping build successful businesses that can promote clean energy technologies to rural Brazilian customers. The objective is to build capacity within these organizations to identify potential energy projects and to provide follow-up business support services to these entrepreneurs. B-REED includes training, hands-on business development services and, for the most promising businesses, early-stage investment and assistance in securing later stage commercial financing.

B-REED will also work closely with financial institutions to enhance their capacity to integrate clean energy enterprises into their investment portfolios. This will be accomplished through workshops and specific hands-on tools centred on rural energy markets and sustainable energy enterprises, appropriate project finance models, financial analysis and risk management issues.

The B-REED (Rural Energy Enterprise Development) Approach is shown below:

Figure VIII. B-REED Approach



B-REED applies a particular hands-on approach of enterprise development, similar to venture capital on a smaller scale and with social/environmental ends, for example:

- The first B-REED support to an entrepreneur might be a modest loan (e.g. $15,000) to support the preparation of a business plan. If this looks promising, a second financing could assist in the company's start-up; this transaction might involve an additional loan or the purchase of an equity stake in the company. In this initial period, significant in-kind support is provided including a B-REED representative working closely with the company's management. The support increases the probability that a more "bankable" project can eventually be presented to financial investors and partners.

Grameen Shakti in Bangladesh[49]

The Grameen Bank of Bangladesh, a reputable and effective micro-lending agency, with over 1000 branches and two million members, initiated a programme in 1996 to provide credit for renewable energy systems to serve those without access to electricity, through a non-profit rural energy company, Grameen Shakti. Loans are made for solar photovoltaic home systems, which call for a small down payment. Grameen Shakti's first initiative has been a 1000 unit project to determine a number of important points concerning household solar photovoltaics. These include:

- The technical performance of these systems in rural Bangladesh;
- Their acceptance by the poor;
- The income-generating potential of the extended workday;
- The affordability of such systems, especially when technical improvements and economies of scale are factored in;
- The training, monitoring and evaluation expertise requirements to successfully expand this experience should it prove successful.

More than 72000 solar home systems have been installed as of September 2006, and an average of 2000 such systems are being sold every month. Twelve technological centres have been set up (with plans to set up an additional 18) and already 2000 women have been trained as solar system technicians.

A similar approach is considered for bio-digesters and solar thermal applications. Research is being conducted for the development of a high quality solar water heater, a solar cooker, a solar drier etc. A 1500 liter capacity solar water heater was already installed on the roof of a dormitory.[50]

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[49] WEC report, the Challenge of Rural Energy Poverty in Developing Countries, 1999

[50] www.gshakti.com

Solar home systems in Indonesia

The high initial cost of renewable energy systems requires financing mechanisms to make them affordable to consumers. With this in mind, PT Sudimara Energi Surya, based in Indonesia, has been successful in selling solar photovoltaic home systems in rural Indonesia using innovative credit arrangements and services. Between 1993 and 1995, Sudimara sold over 7800 solar panels to rural customers, through a network of local service centres that are responsible for sales, service and credits. The average monthly payment being made on these solar systems is less than the monthly costs of conventional energy systems. Additionally, consumers obtained improved levels of energy services. Thus far, there has been a 100 per cent collection rate on the loans.

By combining all of the operational and financial functions at the local level, it is possible to open up new markets and also serve the needs of rural communities. Building a good relationship with the customers and providing services that are both inexpensive and easy to access maximizes sales and distribution. In addition, this type of programme has helped to build capacity and expertise in the country by manufacturing and assembling system components in Indonesia. Once the appropriate mechanisms are set up to provide alternatives to the local community, experience has shown that there are significant numbers of consumers who are willing to pay the full cost to purchase these solar home systems.

Solar rural electrification in Morocco

The Taqa Noor initiative is establishing a local photovoltaic industry and market infrastructure for solar rural electrification in Morocco. It involves two separate companies, Taqa Holding and NOOR Web, and includes a scheme for establishing micro-utility enterprises at the village level, as well as a trading company, which will create a critical mass for investment in photovoltaic technology and delivery systems.

The goal of each company is to offer dispersed, remote rural villagers a few kWh at a sustainable price, comparable to their actual spending power and buying habits. This will result in a number of different solar photovoltaic products being offered through village-based franchises. Each has a central battery charging station and will market single photovoltaic lanterns, 5 W and larger household systems, selling via appropriate cash, credit and leasing schemes. The project has been designed to incorporate the best of what has been demonstrated in Central America, China and India with a philosophy of reaching all rural income levels.

9. CONCLUSION

A key form of intervention in the bid to increase the access of rural people to energy services is financing. Many renewable technologies best suited to providing energy services to remote rural areas use non-monetized fuel, but have a prohibitive initial capital cost. At the same time, many developing country governments are actively promoting the replacement of fuel-wood by subsidizing other energy sources. However, the success of such fuel substitution and energy access programmes basically depends on two factors largely beyond government control: economic growth and the corresponding increase in personal incomes that would permit consumers to switch fuels. The substitution process in many countries is hampered by high import costs resulting from the inefficient procurement of small quantities of renewable energy technologies.

Subsidies are a conventional means to overcoming the financial obstacles, but this approach presents various difficulties. The welfare objective embodied in subsidies for rural electricity, or commonly used fuels such as kerosene, LPG and diesel, can often fail in its purpose, because of the diversion of these energy sources to unintended uses, or their disproportionate use by the more affluent, who could anyway afford the real costs of energy supply.

A reduction or removal of pricing subsidies to overcome this problem is, however, not straightforward because of its potential adverse impacts on the poor. The partial withdrawal of kerosene price subsidies in Sri Lanka and Myanmar, for example, forced people in some rural areas to return to the use of fuel-wood. Both these countries suffer from deforestation and this could have serious environmental implications for them in the long run.

Private sector participation is always the most important option for energy access to rural people, and in the most of the developing countries, private investments become the crucial measure to ensure the energy supply to rural people.

There is a clear need for planning integration between rural electrification authorities, ministries and transmission and distribution system operators. An independent or semi-independent energy regulator, being an essential partner for the national government in implementing the energy policies, should be handed the mandate and the resources to coordinate the consultation process.

In summary, rural development in general and rural energy specifically need to be given much higher priority by policy makers and regulatory agencies; rural energy development must be decentralized to put rural people themselves at the heart of planning and implementation; and rural energy development must be integrated with other aspects of rural development.

LEARNING RESOURCES

Key points covered

This module covers the following key points:

- The issue of energy access in rural areas is closely linked to rural development and to the achievement of the Millennium Development Goals.
- Policy instruments for improving energy services in rural areas include intermediation, subsidies and pricing.
- There is a clear need for planning integration between rural electrification authorities, ministries and transmission and distribution system operators. A independent or semi-independent energy regulator should be handed the mandate and the resources to coordinate this consultation process.
- Business models and private sector participation for increasing access to energy in rural areas include market-based models, control and command models, private company participation and subsidies.
- Financing is key to increasing access to energy in rural areas.
- Many renewable technologies best suited to providing energy services to remote rural areas use non-monetised fuel, but have a prohibitive initial capital cost.
- Private sector participation and private investment is a crucial measure to ensure the energy supply to rural people.
- Rural development in general and rural energy development specifically needs to be given much higher priority by policy-makers.
- Rural energy development must be decentralized to put rural people themselves at the heart of planning and implementation.
- Rural energy development should be an integral part of the overall national transmission and distribution network development planning.
- Rural energy development must be integrated with other aspects of rural development.

Answers to review questions

Question: What are the eight Millennium Development Goals?

Answer:

1. Eradicating extreme poverty and hunger
2. Achieving universal primary education
3. Promoting gender equality and empowering women
4. Reducing child mortality
5. Improving maternal health
6. Combating HIV/AIDS, malaria and other diseases
7. Ensuring environmental sustainability
8. Developing a global partnership for development

Question: What typical basic energy needs in rural areas?

Answer: See table 2.

Question: What is financial intermediation?

Answer: Financial intermediation involves putting in place all the elements of a financial package to build and operate decentralized rural energy supply companies (eg. RESCOs). The process is sometimes referred to as "financial engineering" and covers: the transaction costs of assembling the equity and securing loans; obtaining subsidies; the assessment and assurance of the financial viability of schemes; assessment and assurance of the financial credibility of borrower; the management of guarantees; the establishment of collateral ("financial conditioning"); and the management of loan repayment and dividends to equity holders.

Financial intermediation can also be used to cover whole schemes rather than just investment in an individual plant. In this way projects can be "bundled" together in away which: makes them attractive to finance agencies; establishes the supply of finance on a "wholesale" basis from aid agencies, governments, and development banks; and creates the mechanisms to convert these flows into a supply of retail finance (equity and loan finance at the project level).

Question: What is meant by an "enabling environment"?

Answer: A regulatory and institutional framework that is not a barrier to development of rural/decentralized energy services, i.e. it should encourage private companies, be clear and consistent when dealing with all actors in the power/energy sector and be constant and open to minimal political interference. Taxes and subsidies should be used with care to encourage investments, not undermine markets. A supporting infrastructure of training institutions and/ or finance should be put in place and made accessible to all.

Exercises

1. Given that the MDGs do not mention energy specifically as a target, can you put together a table showing for each MDG target how energy can contribute to the achievement of that target.
2. Research an example of a project/programme situation where basic human services were improved (sanitation, health, water supply, education, etc.) and show the role of energy in achieving the improvement. Would the project have been possible without energy?
   Write a 2–3 page essay.
3. Research the question of the use of subsidies to improve rural energy access. What are the advantages and disadvantages of using subsidies? What are "smart" subsidies?
   Write a 2–3 page essay.

Presentation/suggested discussion topics

Presentation:

RENEWABLE ENERGY – Module 10: Increasing access to energy in rural areas

Suggested discussion topic:

How can international aid funds best be used to improve access to energy services for the poorest rural populations in order to achieve the MDGs?

Relevant case studies

1. Ghana Solar (PV) Electrification Case Study
2. Ghana Wind Energy Case Study
3. Zambia PV-ESCOs Case Study
4. Rural Electrification in Brazil

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"The Challenge of Rural Energy Poverty in Developing Countries", Copyright © 1999, World Energy Council and Food and Agriculture Organization of the United Nations.

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Gary Gardner, State of the World 2002 (Worldwatch) – Chapter 01: The Challenge for Johannesburg: Creating a More Secure World, February 2002, ISBN: 0-393-32279-3.

World Energy Council "The Challenge of Rural Energy Poverty in Developing Countries" www.worldenergy.org/wec-geis/publications/reports/rural/exec_summary/exec_summary.asp

Worldwatch Institute – State of the World 2001, January 2001, ISBN: 0-393-04866-7.

INTERNET RESOURCES

The ENABLE project: building capacity in energy in the health, water and education sectors for poverty reduction in sub-Saharan Africa: www.enable.nu

Global Village Energy Partnership: www.gvep.org

The G8 Renewable Energy Task Force: www.worldenergy.org/wec-geis/focus/renew/g8.asp

Greenpeace International: www.greenpeace.org/international

The UK Government's Department for International Development (DFID): www.dfid.gov.uk

United Nations Statistics division: unstats.un.org/unsd/default.htm

United Nations Human Settlement Programme: www.unchs.org

Worldwatch Institute, Independent research for an environmentally sustainable and socially just society: www.worldwatch.org

Renewable Energy and Energy Efficiency Partnership: www.reeep.org

The EU Energy Initiative: www.euei.org

Agenda 21: www.un.org/esa/sustdev/documents/agenda21/index.htm

The World Bank Group: www.worldbank.org

The Millennium Development Goals: www.un.org/millenniumgoals

GLOSSARY/DEFINITION OF KEY CONCEPTS

Rural electrification	Extending the electricity service to rural areas, usually not connected to the national distribution grid. This can be achieved through three main methods: extension of the national grid, isolated mini-grids or individual household systems
Energy services	The provision of energy supply and measures concerned with end-use in a single package.
Energy services company (ESCO)	Companies concerned with maximizing efficient and cost-effective supply and end-use of energy for their customers.
Renewable energy	The use of energy from a source that does not result in the depletion of the earth's resources whether this is from a central or local source.
Supplier	A company that buys electricity from a generator, or via a third party, to supply to an electricity consumer. Suppliers are known as retailers in some countries.
Supply	The sale of electricity to final users.
Sustainable development	"That which meets all the needs of the present without compromising the ability of future generations to meet their own needs" *U.N. Brundtland Commission*.
Sustainable energy	The provision of energy such that the criteria for sustainable development are fulfilled. Sustainable energy has two components: renewable energy and energy efficiency.
Financial intermediation	Involves putting in place all the elements of a financial package to build and operate decentralized rural energy supply companies (RESCOs). The process is sometimes referred to as "financial engineering". Financial intermediation can also be used to cover whole schemes rather than just investment in an individual plant.
Technical intermediation	Involves both improving the technical options by undertaking research and development activities and importing the technology and know-how "down" through the development of capacities to supply the necessary goods and services.

Organizational intermediation	Involves not only the initiation and implementation of programmes, but also lobbying for the policy change required to construct an “environment” of regulation and support in which the energy technology and the various players can thrive. This involves putting in place the necessary infrastructure, and getting the incentives correct in order to encourage owners, contractors, and financiers. Organizational intermediation must include the development of regulatory support and incentive structures, which can specifically address the energy needs of the poor in rural areas. Organizational intermediation is usefully distinguished from social intermediation which involves the identification of owners and beneficiaries of projects and the “community development” necessary to enable a group of people to acquire the capabilities to take on and run each individual investment project obtaining for them a voice in project identification, design and management of programmes.

10. ANNEX 1 – DETAILS OF THE MILLENNIUM DEVELOPMENT GOALS

Goals and targets		Indicators
Goal 1	**Eradicate extreme poverty and hunger**	
	Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day	1(a). Proportion of population below $1 a day 1(b). National poverty headcount ratio 2. Poverty gap ratio at $1 a day (incidence x depth of poverty) 3. Share of poorest quintile in national consumption
	Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	4. Prevalence of underweight in children (under five years of age) 5. Proportion of population below minimum level of dietary energy consumption
Goal 2	**Achieve universal primary education**	
	Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	6. Net enrolment ratio in primary education 7(a). Proportion of pupils starting grade 1 who reach grade 5 7(b.) Primary completion rate 8. Literacy rate of 15 to 24-year-olds
Goal 3	**Promote gender equality and empower women**	
	Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and in all levels of education no later than 2015	9. Ratio of girls to boys in primary, secondary, and tertiary education 10. Ratio of literate females to males among 15- to 24-year-olds 11. Share of women in wage employment in the non-agricultural sector 12. Proportion of seats held by women in national parliament
Goal 4	**Reduce child mortality**	
	Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	13. Under-five mortality rate 14. Infant mortality rate 15. Proportion of one-year-old children immunized against measles
Goal 5	**Improve maternal health**	
	Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	16. Maternal mortality ratio 17. Proportion of births attended by skilled health personnel
Goal 6	**Combat HIV/AIDS, malaria, and other diseases**	
	Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	18. HIV prevalence among 15- to 24-year-old pregnant women 19. Condom use rate of the contraceptive prevalence rate 19(a). Condom use at last high-risk sex 19(b). Percentage of population aged 15-24 with comprehensive correct knowledge of HIV/AIDS 19(c). Contraceptive prevalence rate 20. Ratio of school attendance of orphans to school attendance on non-orphans aged 10-14

	Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	21. Prevalence and death rates associated with malaria 22. Proportion of population in malaria-risk areas using effective malaria prevention and treatment measures 23. Prevalence and death rates associated with tuberculosis 24. Proportion of tuberculosis cases detected and cured under directly observed treatment short course (DOTS)
Goal 7	**Ensure environmental sustainability**	
	Target 9: Integrate the principles of sustainable development into country policies and programme and reverse the loss of environmental resources	25. Proportion of land area covered by forest 26. Ratio of area protected to maintain biological diversity to surface area 27. Energy use per unit of GDP 28. Carbon dioxide emissions (per capita) and consumption of ozone-depleting chlorofluorocarbons 29. Proportion of population using solid fuels
	Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	30. Proportion of population with sustainable access to an improved water source, urban and rural 31. Proportion of population with access to improved sanitation
	Target 11: Have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers	32. Proportion of households with access to secure tenure
Goal 8	**Develop a global partnership for development**	
	Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system (includes a commitment to good governance, development, and poverty reduction—both nationally and internationally) Target 13: Address the special needs of the least developed countries (includes tariff-and quota-free access for exports enhanced programme of debt relief for HIPC and cancellation of official bilateral debt, and more generous ODA for countries committed to poverty reduction)	Some of the indicators listed below will be monitored separately for the least developed countries, Africa, landlocked countries, and small island developing states. **Official development assistance** 33. Net ODA total and to least developed countries, as a percentage of OECD/DAC donors' gross income 34. Proportion of bilateral, sector-allocable ODA of OECD/DAC donors for basic social services (basic education, primary health care, nutrition, safe water, and sanitation) 35. Proportion of bilateral ODA of OECD/DAC donors that is untied 36. ODA received in landlocked countries as proportion of their GNI 37. ODA received in small island developing states as proportion of their GNI
	Target 14: Address the special needs of landlocked countries and small island developing states (through the Programme of Action for the Sustainable Development of Small Island Developing States and 22nd General Assembly provisions)	**Market access** 38. Proportion of total developed country imports (excluding arms) from developing countries and least developed countries admitted free of duties 39. Average tariffs imposed by developed countries on agricultural products and clothing from developing countries 40. Agricultural support estimate for OECD countries as a percentage of their GDP 41. Proportion of ODA provided to help build trade capacity.

	Target 15: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term	**Debt sustainability** 42. Total number of countries that have reached their HIPC decision points and completion points (cumulative) 43. Debt relief committed under HIPC initiative, US$ 44. Debt service as a percentage of exports of goods and services
	Target 16: In cooperation with developing countries, develop and implement strategies for decent and productive work for youth Target 17: In cooperation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries Target 18: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications	**Other** 45. Unemployment rate of 15- to 24-year-olds, male and female and total 46. Proportion of population with access to affordable, essential drugs on a sustainable basis 47. Telephone lines and cellular subscribers per 100 population 48(a). Personal computers in use per 100 population 48(b). Internet users per 100 population

11. ANNEX 2 – PLANNING FOR RURAL ELECTRIFICATION

Introduction

Sub-Saharan Africa currently has very low rural access to electricity. In the next few years it is anticipated that electrification projects will be undertaken in many sub-Saharan countries. In most cases these will involve private sector partners as operators and investors, and will be supported in some measure using subsidies where necessary. In each country a government ministry or agency will be responsible for managing the rural electrification process. In most countries this will be the Ministry of Energy and/or the Rural Electrification Agency (REA). This government organization will have to carry out the following tasks:

- Select priority areas for electrification;
- Make informed decisions about which technology options are most suitable for electrification of particular areas;
- Cluster projects into viable clusters for operation to reduce costs and the need for subsidies;
- Define a mechanism for which electrification projects should be prioritized and should receive scarce capital subsidy funds.

It is important that there are clear transparent criteria for the selection of priority areas for rural electrification in each country. Having such criteria in place will create confidence with the institutional stakeholders, the private sector and general public. This is important for creating the right climate for new investments.

This annex will briefly give an overview of possible criteria for planning rural electrification and give some examples of how they can be used. The information in this Annex is given as an indicative method of how rural electrification can be planned. The method used will vary in each country according local conditions.

Objectives for electrification

The limited financial resources available for rural electrification in most African countries mean that for any electrification programme it is important to minimize the costs of rural electrification by using a least-cost approach, considering both investment and operation and maintenance (O&M) costs. Electricity provision may use a combination of grid extensions, isolated grid, and off-grid approaches. Least-cost generation and supply options include diesel generators, grid extension, small hydropower, wind power, solar photovoltaics and other renewable energy technologies. The objectives for a rural electrification programme could take many approaches. Some examples are listed below:

- Maximizing the number of financially sustainable household connections that can be achieved using a limited subsidy resource (focuses on the number of households);
- Maximize number households to be reached, with minimum subsidy (promote maximum private sector investment);
- Maximize the socio-economic benefit to be achieved through electrification of households, institutions, social services and enterprises – requires rating of a wide range of possible benefits (this reduces the emphasis on the number of households connected);
- Maximize economic benefit of electrification (will tend to place even less focus on household connections, more on enterprises/industry);
- Least-capital cost electrification (sometimes used for grid electrification planning, if there is lack of information on consumption, and thus little basis to differentiate life-cycle revenues and costs);
- Take a least cost approach to O&M to maximize sustainability of operations (allow substantial capital subsidy to reduce O&M).

Benefit points system of analysis

One way to support decision-making on technology selection, and specifically whether grid technology is likely to be viable for certain clusters of loads; a simple rule of thumb can be developed using "*benefits points*" (BP).[1] Each potential electrification project would accrue a number of "*economic benefit points*" in order to take in to account social and economic benefits that arise from rural electrification. A system of allocating "benefit points" can be developed in order to try and quantify these social benefits as well.

For example, a "benefit points" system essentially allocates one point to the electrification of a rural household and then compares the electrification of other institutions and industries against this reference. As an example, electrification of a small shop or another trader is considered to provide three times more economic benefit as a household on the basis of the potential for increased income generation that may accrue through electrification. So a small shop is allocated three benefit points. The electrification of a health centre might accrue 70 benefit points.

The benefits point allocation system aims to take into account both the size of the load (in kWh for energy consumption or kW for power demand), its contribution to the overall financial feasibility of the line extension, as well as its weighting for social benefits. The benefit points for proposed projects are then summed to assess the total potential benefit of a particular project.

The benefits of point analysis will prove useful in the rural electrification process and will be mentioned wherever appropriate in the following section.

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[1] This system was first proposed for use in Namibia and South Africa and has been adapted for use in Uganda.

Rural electrification criteria

The criteria for rural electrification planning must be developed through a step-by-step process. An example process of criteria development is presented here:

Step 1: Identification of national development plan priority areas
Step 2: First pass technology assessment
Step 3: Project clustering and identification
Step 4: Project prioritisation
Step 5: Regional equity adjustment

Each of these steps has a specific output in order to facilitate the development of the rural electrification plan for the country. A diagram showing the steps and their outputs is given in figure I.

Step 1: National development plan priority areas

The first step in the process of selecting priority areas for electrification is to identify regions that have been prioritized for economic development: these may include special development zones etc.

These regions are sometimes laid out in a country's National Development Plan and other national development planning documents are worth examining such as agricultural development plans, poverty eradication action plans, etc. From these kinds of documents priority regions for electrification can be identified such as regional or district headquarters, regions with many agricultural projects, areas with large industrial loads and trading centres.

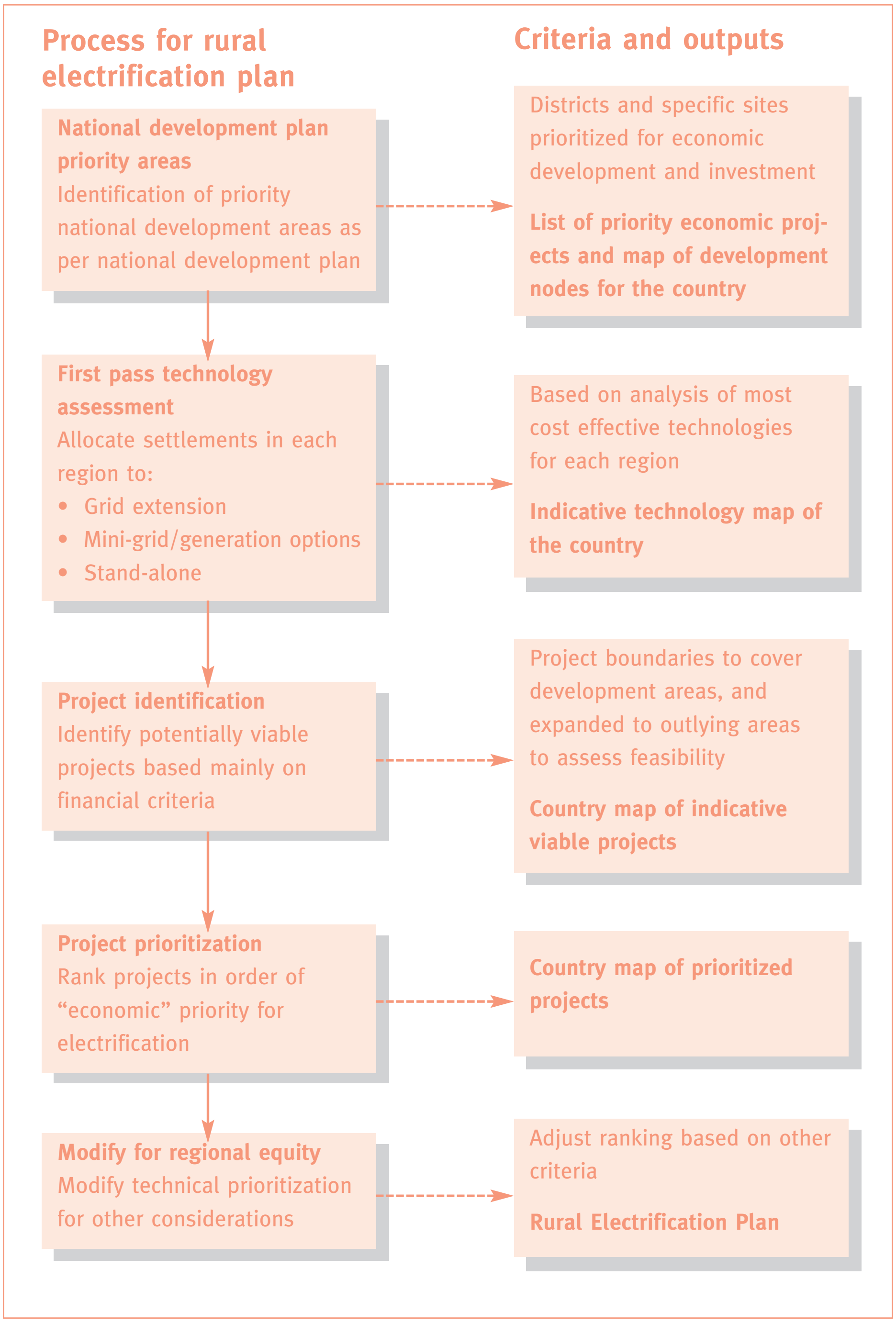
In addition to this, it is essential to integrate the rural electrification planning with the transmission and distribution network planning. This requires close cooperation and coordination between the Rural Electrification Agency, the Ministry in question (usually the Ministry of Energy) and the Transmission and Distribution System Operator.

Step 2: First pass technology assessment

The first pass technology assessment is an important output of the process of planning rural electrification. This will provide a map of the country detailing:

- Current and planned electricity transmission and distribution networks;
- Planned future and potential additional generation capacity;
- Unexploited local resources such as small, mini and micro-hydro sites, as well as solar, wind and biomass resources.

Figure I. Diagram showing steps in the development of rural electrification criteria



Coupled with an assessment of potential electricity demand from institutional data (locations of health centres, schools, businesses, trading centres etc) and population data, as well as socio-economic profiles, a provisional assessment of the most cost-effective electrification means will be identified.

The main outputs of the technology assessment and costing will give generalized life-cycle costings for energy supply for typical installations (e.g. grid-connection, mini-grids, stand-alone diesel, stand-alone solar power). At this stage, the costing should be unsubsidised, representing the whole life costs of electricity supply.

Step 3: Project identification, clustering & financial pre-feasibility

Proposed projects may be initially ranked according to the number of benefits points they may accrue. A potential project with a large number of benefit points would be seen to provide greater overall benefits than one with far less accrued.

However, it is vital for the sustainability of rural electrification that projects are financially viable in the long-term. The identification of potentially viable projects will be based mainly on financial criteria and will follow the process shown in figure II. The scale of projects for viable operation can also be defined by a minimum number of benefit points.

Step 4: Project prioritization

Packaging of projects into rural electrification priorities is a more detailed process with detailed project pre-feasibility analysis. Projects must meet certain minimum criteria. Theoretically, there are many potential criteria for project prioritization. For example:

- Numbers of connections anticipated;
- Average capital cost per connection made for each line (already disproved as a suitable criteria, but still widely used);
- Financial viability – Financial Internal Rate of Return (FIRR);
- Subsidy required to make “line” affordable (or essentially, FIRR);
- Economic Internal Rate of Return (EIRR) (complex if done for each project).

Prioritization may be done on individual grid line extensions, parts of lines, or even on clusters and groups of lines, as well as on mini-grid systems. A simplified three-step project prioritisation approach is summarized below:

1. The life cycle cost of the project is determined (i.e., the total project cost over a given time period, e.g. 20 years). This includes both capital expenditure (Capex) and operational expenditure (Opex). The net present value[2] of the total subsidy[3] required to make the project profitable is then determined: typically this would mean an internal rate of return of not less than 20 per cent for the equity invested. In the case of diesel-based systems the subsidy may be a substantial operational subsidy over the system life.

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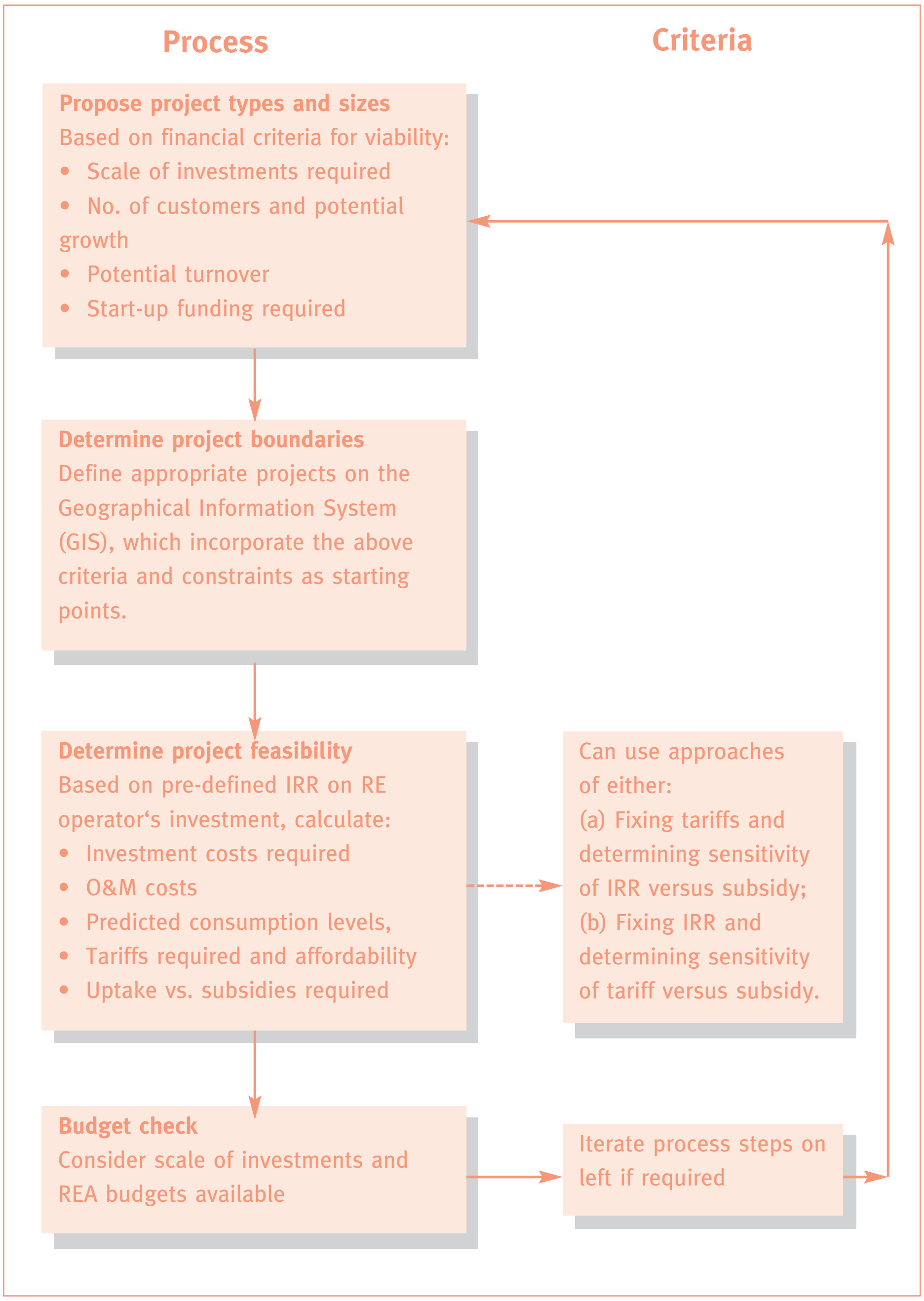
[2] The NPV is defined as the total of the project in today’s terms including future capital replacement costs.

[3] It may be appropriate to use the NPV of the total project cost.

Figure II. Process for project identification and financial feasibility analysis



2. Each project will accrue a number of "economic benefit points" in order to take in to account social benefits that arise from rural electrification. These social benefits are not accounted for in a strict financial analysis of a project and so it is important they are taken into account when prioritizing projects. The system of allocating benefit points has been discussed previously.

3. The NPV of the total subsidy is divided by the total number of benefit points that have accrued, giving a cost per benefit point of the project.

Once projects have been selected and packaged for development by the Ministry of Energy and/or the REA (or other appropriate body) the real prioritization will depend on the response and on specific requirements from private investors and the financial institutions.

The following are examples of criteria that can be used for further analysis and prioritization:

4. *Capital Cost per Connection* analysis does not take into account the Life Cycle Costing (LCC) or overall project viability, so projects, which could well, be viable may still show the highest *Capital Cost per Connection*. This approach to prioritization is thus very limited.
5. *Subsidy Analysis* takes into account the full LCC and O&M costs, as well as determining the subsidy that which will result in setting tariffs at affordable levels. Projects that require no subsidy are clearly favoured over those requiring large subsidy. The *Subsidy Required per Connection* shows clearly which projects are most viable and which are not, but does not always clearly rank the projects.
6. *Benefit Points Analysis* gives a more useful overall ranking.
7. If projects do not fit within these Benefit Point Analysis Criteria, then it is possible that some of the less economical lines or components would have to be excluded from the project.
8. A further criterion for ranking would be that projects must have a minimum number of BPs to be considered. If this were not done, large numbers of applications involving many tiny projects may result in the larger projects being neglected.

Step 5: Regional equity adjustment

Following the prioritization of projects, the rankings could then be adjusted depending on other external influencing criteria:

- Funding contributions from non-government sources;
- Transmission grid and distribution network transfer capacity and security of supply;
- Supply capacity available, scheduled load-shedding;
- Generation capacity expansion programmes;
- Grid and network expansion programmes;
- Distributed (“in-project”) electricity generation;
- Respective proportions of costs of transmission/distribution reinforcement and reticulation;
- Political expectations;
- Poverty alleviation policy and projects;
- Regional equity (see further comments below).

Electrification projects should be considered as necessary conditions for development, but not as sufficient conditions, and there are usually other overriding conditions. Priorities that are considered more important for rural development than electricity include basic health services, elementary schools, water supply, and feeder roads. Therefore, it is usual to identify priority areas where electrification would have a significant beneficial impact, rather than electrifying for the sake of maximizing the number of connections. The benefit points approach aims to incorporate this view.

Several criteria that provide a definite planning framework are listed below (adapted from Thom (1998)):

- Criteria in support of economic growth:
  - Allocate resources based in part on contribution by regions to the national economy (Gross Geographic Product, GGP);
  - Allocate resources based on maximizing the macro-economic impact of electrification undertaken;
  - Electrification projects contributing to economic growth – identify specific development projects that have high economic potential.

- Criteria in support of socio-economic development:
  - Allocate resources to regions having a higher proportion of non-electrified facilities (health centres, schools etc.), where providing services would lead to greater benefits;
  - Allocate resources where there are complementary development initiatives in the regions, to enhance the impact of electrification;
  - Allocate resources according to general poverty levels. (Note that electrification may not be the most urgent or best way of addressing poverty, and projects may be more sustainable in wealthier regions rather);
  - Allocate resources according to the number of non-electrified households in regions (expressed as a percentage of total households in region);
  - Allocate resources according to the articulated demand for electrification. (note that this is open to political manipulation).

- Other Criteria related to regional allocation of electrification resources:
  - Limitations on the practicality of supplying electricity to the regions (lack of transmission infrastructure or power supply capacity);
  - Avoidance of destabilized regions – as it will be difficult to establish financially viable projects in these regions. Note however that some countries have used electrification to help promote stability and establish a sense of belonging;

- The argument that results is that electrification projects have the most significant positive impacts if they are part of a larger development plan for a specific area or region.

Conclusion

The development of rural electrification planning and criteria to aid planning is a complex subject. The aim in this document is to present an example of a relatively simple and transparent process that could be used for rural electrification planning. The process described follows a five-stage filtering process:

- Identification of priority development nodes, usually political priorities and part of a national development plan;
- Technology mapping based on least-cost supply and life-cycle criteria;
- Project identification, clustering and costing based on criteria for financial viability;
- Project prioritization based on economic criteria;
- Adjustment for regional equity based on political imperatives.

While the costing, financial viability and economic criteria are obviously very important, a simplified economic benefit points (BP) system can also be developed to make the system more transparent. The economic benefit points allocation should be based on sectoral priorities in local government, health, education, agriculture and water sectors covered in the national development plans, poverty eradication documents, etc.

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Case study 1.

GHANA: EAST MAMPRUSI SOLAR PROJECT (RESPRO)

CONTENTS

1. BACKGROUND

Renewable energy (excluding large-hydro) currently contributes an insignificant part of electricity supply in Ghana. For example, by 2001, the estimated 4,000 off-grid PV systems installed nationwide had a total capacity of 1MW, compared to the grid capacity of over 1,700MW in 2003.[1] Electricity generated from renewable energy is used at the individual household or institution level, and the systems are usually not connected to the grid.

Renewable energy technologies (RETs) are not currently targeted for development under a concerted policy regime in Ghana. Moreover, none of the electrification programmes undertaken to date have included renewable energy as an alternative source of power. This situation means that development of renewables remains largely in the hands of individuals with little government support. There is no process in place presently for individuals or cooperatives to feed the power generated from renewable energy systems into the national grid. However, several efforts have been made through feasibility and pilot programmes to develop experience with renewables. One such project is the East Mamprusi Solar Project (RESPRO) described in this case study.

2. INTRODUCTION

The East Mamprusi Solar Project, also known as the Renewable Energy Services Project (RESPRO), is a joint project between the Global Environment Facility (GEF) and the Government of Ghana. It was designed to provide electricity to off-grid communities in the East Mamprusi District of the Northern Region of Ghana using solar PV technology. In addition, the project was meant to demonstrate the feasibility of using renewable energy technologies to provide electricity in off-grid rural areas.

3. PROJECT DESCRIPTION

The communities selected under the RESPRO project were not scheduled for connection to the electricity grid under the national rural electrification programme, and electrification was to be achieved using PV systems. The project also intended

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[1] Electricity Sector Overview; Ghana Energy Commission

to start a renewable services industry based on returns from the consumers. About 2000 households had solar home systems (SHS) installed under the RESPRO project. Streetlights, a water pump, vaccine refrigerators and lighting for clinics and schools were also powered by PV systems.

Establishing community grid systems (mini-grid) was found to be too expensive due to the dispersed nature of the settlements and households, and therefore single units were installed for each location. The units consisted of small SHS for up to four lighting points. Users had the option of purchasing larger systems on their own. The project was based on a utility model with each user paying a flat monthly fee to the RESPRO project. This fee was pegged in US dollars (USD) based on the cost of the systems, and was initially the cedi (Ghanaian currency) equivalent of 5 USD.

3.1. Financial support

The project was implemented by the Ministry of Mines and Energy and was funded in part by the Government of Ghana (GOG) and the Global Environmental Facility (GEF) through the United Nations Development Programme (UNDP) with technical support from the National Renewable Laboratory (NREL) of the US Department of Energy. The financial contributions were as follows:

- 2.5 million USD GEF grant funds;
- 0.5 million USD Government of Ghana (including 300,000 USD in PV equipment).

Other institutions involved in the project implementation are Volta River Authority (VRA) and Kwame Nkrumah University of Science and Technology (KNUST).

3.2. Status of the project

The project has shown the feasibility of using renewable energy to provide remote rural areas with electricity. Technical expertise in PV systems has been acquired, and there is increased public knowledge about renewable energy technologies being used to provide energy solutions.

The consumers wished to use the solar energy for appliances such as electric irons, colour television, fridges and for machinery like grain mills, but the energy provided by the installed systems is insufficient to run these devices. Thus, individuals have the perception that PV systems are “inferior”, and that by installing PV systems, the communities have been prevented from acquiring the “real thing” in the form of grid connection.

Even though there is a general complaint that the tariffs are high, the tariffs are not economical, and cannot recover cost, maintain the systems, or make profit, even though one of the objectives of the project was to demonstrate commercial viability. At the current tariff levels, it would take an unreasonable length of time to recover costs. In addition, the seasonal incomes of the farming population affect the payment of tariffs on schedule. Since most of the project inputs and accessories are imported, the poor financial position of the project has led to shortages of spare parts, which has led to delays in maintenance work. The project has therefore failed to demonstrate commercial viability.

The contribution of the project to global environmental change is insignificant since emissions from biomass combustion persist because the energy needs for cooking are still met by using wood, the installed PV systems being too small to sustain electric cookers and other alternatives like LPG not being available.

The project started of with two engineers and three technicians. However, when the project coverage area was increased there was no corresponding increase in the number of staff, putting pressure on the staff. Also, only four vehicles were available and this reduced the mobility of the technical staff. Repairs and maintenance schedules were not strictly followed and some faults are not promptly repaired.

One of the objectives of the project was to encourage private sector participation but this has not materialized to any significant extent. The expected reduction in the growth of thermal energy generation as envisaged in the project document may not materialize.

3.3. Benefits

A number of project activities had been achieved at the end of the project. The project was initially targeted at communities in the East Mamprusi District, but by the end of the project 219 communities in the three northern regions had benefited from the project against the original 13 communities.

In total about six clinics, forty-two schools, one water pump, twenty-four streetlights, and 1876 home systems were installed. Some of the immediate benefits were improved health services, easy access to water, night-time study at schools, improved productivity and socialization at night, and improved security, for example from burglaries. A number of small-scale ventures which benefited from the PV units are chemical shops, drinking bars, petty goods stores, barber shops, tailoring shops, a petrol filling station, and so on.

The PV systems made it possible to use radio and TV sets, which improved access to information and provided alternate types of entertainment to the communities.

4. CONCLUSION

The RESPRO project is arguably the most ambitious solar PV project in Ghana to date. The number of installations that were completed in a relatively short period of time is commendable, particularly considering the widely dispersed populations in northern Ghana. However, it is unlikely that the project will be sustained in the long term due to some of the problems outlined above. Some of these are summarized below:

- High monthly cost to consumers;
- Insufficient resources for effective maintenance of systems;
- Low involvement of the private sector;
- Some of the equipment used had high failure rates, leading to higher maintenance costs.

Of particular concern is the way in which the project competed with the National Electrification Programme (NEP), instead of complementing it. Many potential users did not get involved because they expected electricity to do more for them than just lighting. They also believed that if they waited long enough, the NEP would end up covering them.

In spite of these problems, there are several important lessons to be learned from this project, including the mode of deployment (utility versus outright purchase), the attitudes of rural populations to individual solar systems, and the importance of maintenance in RET deployment. It is hoped that these lessons will be carried into future large-scale projects.

Case study 2.

GHANA WIND ENERGY PROJECT

CONTENTS

1. BACKGROUND

Renewable energy (excluding large-hydro) currently contributes an insignificant part of electricity supply in Ghana. For example, by 2001, the estimated 4,000 off-grid PV systems installed nationwide had a total capacity of 1MW, compared to the grid capacity of over 1,700MW in 2003.[1] Electricity generated from renewable energy is used at the individual household or institution level, and the systems are usually not connected to the grid.

Renewable energy technologies (RETs) are not currently targeted for development under a concerted policy regime in Ghana. Moreover, none of the electrification programmes undertaken to date have included renewable energy as an alternative source of power. This situation means that development of renewables remains largely in the hands of individuals with little government support. There is no process in place presently for individuals or cooperatives to feed the power generated from renewable energy systems into the national grid. However, several efforts have been made through feasibility and pilot programmes to develop experience with renewables. One such project is the wind energy project described in this case study.

2. PROJECT DESCRIPTION

2.1. Introduction

Wind energy is becoming a mature technology for electricity generation across the world. In Ghana, wind energy is one of the renewable energy options considered as viable to be exploited for electricity generation. Even though the wind speeds in Ghana are quite low in general, tests have shown that along the coast there is sufficient wind to power small turbines.

The Ghana Wind Energy Project intends to provide power to off-grid communities by using locally manufactured wind turbines, which, in addition to being cheaper than imported models, will create the required technical capacity locally for the development of the technology.

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[1] Electricity Sector Overview; Ghana Energy Commission

EnterpriseWorks Worldwide (EWW) collaborated with two private sector partners, Rural Energy and Environment Systems (REES, Ghana) and Scoraig Wind Electric (UK), to develop a local supply chain for locally manufactured wind turbines. This involved training a group of technicians, manufacturing a number of turbines, setting demonstration sites, and launching an information campaign on the project.

To start the project, EWW brought in a consultant from Scoraig Wind Electric in July 2004 to train a group of 17 Ghanaian craftsman and technicians from four separate business enterprises in the manufacture of 500-watt wind turbines. After manufacturing one demonstration unit, which was erected on the premises of the Industrial Research Institute of CSIR in Accra, ten other turbines were mounted in eight demonstration sites located in off-grid communities along the coast.

It was intended that, after a six-month assessment period, the user would be offered the unit for sale either as a direct purchase or through a credit scheme arranged by the African Rural Energy Enterprise Development (AREED) initiative.

In addition, once the concept was shown to be viable, EnterpriseWorks intended to seek funding for a large-scale expansion of the project by marketing the wind turbines, training more manufacturers, and providing business advice and credit to customers and manufacturers. The initial target market for the wind turbines is large agricultural companies. The project implementers hope to stimulate the creation of a new industry and create more job opportunities.

2.2. Aim

The aim of the wind energy project is to provide electricity for off-grid rural areas in Ghana, thereby improving the inhabitants quality of life and providing a means of livelihood, and to develop local capacity in the fabrication of small wind turbines.

2.3. Financial support

The World Bank funded the Wind Energy Project. EnterpriseWorks Worldwide won funding of US$ 179,000 from the World Bank Development Marketplace Place Competition of 2003.

Technical support also came from the Council for Scientific and Industrial Research (CSIR).

2.4. Status of the project

According to the Completion Report submitted to the World Bank in July 2005, the implementers consider the project as 50-69 per cent successful.[2] [3]

Five of the turbines were locally manufactured, and were installed with locally manufactured inverters and charger/controllers, while the batteries were imported. The local turbines are rated 500Wp. In order to provide a basis for comparison, five (5) 1000Wp imported wind turbines were also installed. In all, ten systems were installed at eight locations along the coast.

Only three out of the five locally manufactured turbines worked satisfactorily and were operational by the end of the first year of the project. It was found that electronic components in the inverter or charger/controller were damaged by power surges during windstorms. Also, some of the systems were not properly sized, leading to overloading and rapid discharge of the batteries. At four locations the battery bank was doubled to meet the energy demand.

Maintenance costs for the units are also high, and the high cost of transporting technicians to the remote sites to service the units has led to three of the units being dismantled and returned to stores. These are now being offered for sale.

To reduce cost, angle iron was used to build the frames instead of galvanized steel, and this has led to some corrosion. Corrosion has also been noticed in some of the other metal parts.

2.5. Benefits

The wind turbines were installed at a school, a drinking spot, a battery-charging centre and a church. Apart from using the electricity generated for running these places, the power is also used for domestic purposes such as lighting and the operation of electrical appliances such as TVs and radios.

Since the school is better lit at night, security has improved. Electricity is now available for TV and radio sets for information dissemination.

The battery charging centres provide employment as well as spreading the benefit of wind power, because when charged, the batteries are used to provide electric power for TV sets and radios in other homes. Prior to the establishment of

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[2] ”*Winds of Change*”, www.worldbank.org

[3] DM 2003 Project Completion Report [July/15/2005] www.developmentmarketplace.org

the wind turbine, battery charging was undertaken at Ada, which required crossing the river. This inconvenience has now been removed.

Communication is improved and there are more forms of entertainment through easy access to television, radio and a video theatre.

In addition, the wind turbines have successfully introduced the communities to alternative energy. Apart from the equipment failures, which had the effect of eroding public confidence in the technology, the usefulness of wind-generated power was well appreciated.

3. CONCLUSION

This project was a bold initiative that sought to bring electric power to the off-grid communities with no other means of electricity. Also, the project intended to establish local capacity in the production of small wind turbines, with a view to reducing system costs and also creating employment.

The wind turbines were supposed to generate enough confidence in their users so that they would buy the units after some months. This indicates that the electricity should be seen as a means of enhancing productivity and profitability. Cottage industries should benefit from such systems. However, the question of rural poverty and ability-to-pay arises once again.

Case study 3.

ZAMBIA PV ENERGY SERVICE COMPANIES

CONTENTS

1. BACKGROUND

Access to electricity in the rural areas of Zambia is as low as 2 per cent. In order to address this situation and increase access to electricity and reduce poverty, the Government of the Republic of Zambia (GRZ) incorporated the installation of photovoltaic (PV) solar systems in the rural electrification programme. Zambia has an average of 2000-3000 hours of sunshine per year. In order to accelerate the rural electrification programme, the Government established the Rural Electrification Authority in 2003 following the promulgation of the Rural Electrification Act (2003).

In 1998, GRZ initiated a pilot project called "Providing Electricity Services using Photovoltaic Systems through Energy Service Companies in Rural Areas of Zambia" also known as "The Zambia PV-ESCO project". The project was undertaken by the Ministry of Energy and Water Development (MEWD), the Swedish International Development Agency (Sida) and the Stockholm Environment Institute (SEI).

The main objective of this project was to identify the framework and conditions necessary to successfully provide electricity services to rural areas through rural-based energy service companies (ESCOs). The project would provide policy-makers and planners in Zambia with the information required to enable private sector to participate in rural electrification using a fee-for-service approach.

This case study describes the Zambia PV-ESCOs pilot project, examines its first six years of operation and highlights lessons learnt.

2. PROJECT DESCRIPTION

The project design was influenced by experiences in other parts of the world where PV systems have proved too expensive and unsustainable for the rural poor.

The Zambia PV-ESCOs pilot project was initiated in June 1998 by the MEWD with financial assistance from Sida and the technical assistance from SEI. The strategy was to provide energy services through already existing and viable rural-based companies. These companies would install solar-based systems in domestic houses and other commercial buildings and provide the necessary maintenance and technical support. The clients would not purchase the PV systems but rather pay a monthly rental for the use of the PV system and the service provided by the service company.

The project was implemented in the rural districts of Nyimba, Petauke, Chipata and Lundazi located in the eastern province of Zambia. The selected towns were identified not to be well serviced by the national electricity grid and had relatively enterprising rural populations and a potentially strong agricultural industry.

The project was executed in three phases (as at February 2006).

2.1. Project Phase I

The first phrase of the project took place between June 1998 and June 2000.

The first phase focused on laying the foundation for the identification and development of independent PV ESCOs in Zambia by:

- Analyzing the socio-economic and market environment in which the ESCOs would operate, with a focus on the demand and existing supply of PV systems;
- Soliciting and evaluating applications from the would be ESCOs;
- Securing credit for the ESCOs to finance initial purchase of PV systems;
- Providing technical and business training to ESCOs to ensure long-term viability.

During this phase, three ESCOs were identified and trained. At the end of phase I, one of the ESCOs had commenced operations and enrolled 75 clients on a fee-for-service basis.

A house equipped with a solar home system in Lundazi – Eastern Zambia

Source: Department of Energy, Zambia.

The original idea that the ESCOs would be able to obtain the necessary start-up capital from commercial banks to procure their initial PV systems was abandoned due to the high interest on commercial loans which were around 40 per cent annually. These loan conditions would have made it impossible for the companies to be profitable in the early stages of their development. To address this, the Government procured PV systems and loaned them to the ESCOs using grant funds obtained from Sida.

2.2. Project Phase II

Phase II of the project lasted from October 2001 to December 2003 and was focused on establishing the framework and conditions necessary to sustain the ESCOs and extend the project to other parts of Zambia. The most important component of this framework was the establishment of a funding facility to lend to ESCOs on terms that would make them sustainable. The funds would be applied towards expanding existing ESCOs as well as establishing new ones. Secondly the facility would also provide capacity building for the ESCOs in business management and PV technical skills.

By the end of phase II, three ESCOs were operational with about 100 to 150 clients each. ESCOs continued to receive training. The issues regarding loan repayment and transfer of ownership of the PV systems were discussed. Due to the low number of clients serviced by each ESCO, it was not possible for the ESCOs to generate sufficient profit and cash flow to repay the loans. Consequently the issue of ownership transfer remained unresolved at the end of phase II.

The objective of extending the project to other parts of Zambia could also not be achieved because the guidelines for repayment of the old debts and availability of new credit remained unresolved.

2.3. Project Phase III

Phase III of the project lasted from September 2004 to September 2005. The main objective of phase III was to consolidate the experiences from the first two phases and develop the necessary framework to ensure long-term sustainability of the PV-ESCOs concept. The following were the main areas of focus:

- Develop credit agreements between the MEWD and the ESCOs to provide for the repayment of start-up capital and the ownership transfer of the PV systems;

Women and children wait to have their maize ground by a diesel hammer mill. The shed is equipped with PV – powered lighting to allow grinding after dark.

Source: Department of Energy, Zambia

- Provide means for the ESCOs to expand their business through the purchasing of more PV systems to enhance their financial viability;
- Strengthen the capacity of the ESCOs to operate independently in the Zambian solar market, particularly in the area of equipment purchases from PV suppliers.

During phase III, the issues of capital repayment and ownership transfer were resolved through an agreement between Government and ESCOs governing the repayment of the start-up loans. The project further developed a framework for administering new credit to enable ESCOs to expand their operations and move closer to being self-sustaining with minimum government assistance. The new credit also provides for formation of new ESCOs who would also receive training in technical and managerial skills.

3. CONCLUSION

- The project succeeded in setting up four ESCOs in the eastern province of Zambia. These companies have generated significant interest in PV systems for rural electrification in the area. Each ESCO has a long waiting list of households, businesses and institutions that are interested in becoming clients of the ESCOs.
- It is evident from the Zambia PV-ESCOs pilot project that for the PV-ESCOs concept in rural areas to succeed, a special funding facility to provide sufficient start-up capital to ESCOs on favorable terms must be established. It is

not viable for ESCOs to obtain such loans on standard commercial bank terms because of the high start-up capital required to procure PV systems. In addition the new ESCOs need to be equipped with both managerial and technical skills. This capacity would enable them manage their businesses profitably, be able to repay old loans and qualify for fresh loans to expand. In some cases, it might be necessary to introduce smart subsidies especially during the start-up period.

- The viability of ESCOs would greatly depend on the number of customers that they could enroll in order to reach economies of scale, service their start-up loans and remain profitable. As of March 2006, the ESCOs had not yet managed to attract enough customers to reach economies of scale or profitability to make them self-sustaining. This was due to lack of additional capital to procure more PV units to service those potential customers already on the waiting lists.
- The experience gained from this project has provided valuable information on how the rural population can benefit from access to energy services and in the necessary framework required to ensure that the PV-ESCO concept is successful.
- The ESCOs are gaining experience on how to manage a business profitably. ESCO clients are very happy with the energy service that they are receiving, and it is helping them to improve their lifestyles by allowing more working hours and providing business opportunities.
- The next stage should be the extension of the PV-ESCOs concept to a national-scale. This is possible provided a framework to fund new ESCOs and expand the existing ones to profitable levels is put in place.

4. REFERENCES

Zambia National Energy Policy 1994

Proposed Zambia National Energy Policy 2005

Stockholm Environment Institute, “Private Energy Services in Rural Areas – Experiences from the Zambia PV ESCOs Project”, prepared for the Department of Energy, Ministry of Energy and Water Development, Government of the Republic of Zambia.

Case study 4.

BRAZIL'S RURAL ELECTRIFICATION PROGRAMMES

CONTENTS

1. INTRODUCTION

In 1993, the Brazilian electricity sector initiated a restructuring process by unbundling the generation, transmission and distribution components of the existing companies. This ultimately led to the privatization of most distribution assets and some of the generation assets. However, little attention was paid to the process of expanding services to low-income and rural areas. This case study provides successful examples of policy, regulatory and institutional arrangements that facilitate the expansion of electricity supply to low-income consumers and rural areas.

The federal government and other donors support a variety of initiatives designed to promote rural electrification. Federal programmes include PRODEEM (managed by the Ministry of Mines and Energy), Luz no Campo (managed by Eletrobrás), and Luz para Todos, which expects to provide full electrification in the country by 2008. There are also rural electrification activities under several non-sectoral and decentralized initiatives. In addition, the National Bank of Social and Economic Development (BNDES) is structuring credits to finance electrical interconnection to rural households that already incur significant expenditures on kerosene and batteries and could afford a US$ 4 per month electricity bill.

Diesel oil consumed for electricity generation in isolated areas is subsidized through the Fuel Consumption Account – CCC (Conta de Consumo de Combustível). This account is funded by energy utilities from special taxes on electricity bills for households in the interlinked system. The CCC helps to expand electricity access to isolated communities. In 1998, the CCC was extended to renewable energy projects in isolated communities which totally or partially substitute diesel generation.

2. THE PRODEEM PROGRAMME

The Programa de Desenvolvimento Energético de Estados e Municípios — PRODEEM (Energy Development of States and Municipalities Programme) — is the main government sponsored programme that aims to promote off-grid electrification of villages. Established by a presidential decree in 1994, PRODEEM is sponsored by international donors and is implemented mainly through Brazilian utilities. It consists of several pilot off-grid electrification initiatives using photovoltaic (PV), wind or hybrid systems, and also conventional fossil fuels in remote villages. From 1996 to 2000, PRODEEM provided 3 MW in solar photovoltaic (PV) panels to 3,050 villages, benefiting 604,000 people on the basis of a total investment of US$ 7 million from National Treasury funds. The total budget was US$ 20 million for 2001, when 1,086 systems were installed, with another 3,000 community systems being put out to tender by way of international bidding — with a winning bid of almost US$ 12.5 million for equipment and installation, plus operation and maintenance for three years.

PRODEEM is a centralized project that uses a topdown approach to identify sites and install equipment. The federal government procured photovoltaic panels that were allocated free of charge to municipalities upon demand. Instead of electrifying individual households, the programme focuses on schools, health facilities and other community installations. Traditionally focused on PV systems, more recently PRODEEM has started to sponsor mini-grid pilot projects (with hydro and biomass generation) to test different service provision models.

3. THE “LUZ NO CAMPO” PROGRAMME

Both the executive and legislative branches of the federal government decided it was necessary to launch a programme parallel to the PRODEEM initiative in order to create incentives and obligations for new concessionaires to invest in rural electrification and to supply services to low-income consumers. In 1999, the state-owned utility Eletrobrás, under the coordination of the Ministry of Mines and Energy, launched Luz no Campo (Light in the Countryside), to finance the electrification of one million rural consumers over a three-year period exclusively through grid extension.

This programme was a response to the standstill that beset rural electrification after the restructuring of the power sector. It aimed to provide electricity to five million people living in one million rural households by 2007, using US$ 650 million of reserves from the Reserva Global de Reversão (RGR) dedicated to electricity generation, transmission and distribution.

In 1996, Law 9427 decreed that 50 per cent of the resources of RGR should be directed to the North, Northeast, and Midwest regions. Half of these resources were to be allocated to programmes for rural electrification and energy efficiency for low-income users. In the same year, another law made concessionaires responsible for the cost of providing services to new consumers. Consumers would only have to meet tariffs.

In April 2002, the Brazilian Congress passed Law 10438, which provided for the reduction of tariffs to low-income consumers, the establishment of targets for concessionaires, and the granting of permission to permit-holders to provide full coverage. The law also created a national fund, the Energy Development Account (CDE —Conta de Desenvolvimento Energético), to promote universal access and use of innovative sources of energy. The Agência Nacional de Energia Elétrica (ANEEL) —the National Electricity Regulatory Agency— is expected to pass the necessary regulation to implement the law, whereby concessionaires must provide full coverage under a target plan. In parallel, the Ministry of Mines and Energy is preparing a programme to accelerate universal access by ensuring additional resources and by creating rules for the use of the CDE.

Financial resources from CDE can be granted to accelerate the achievement of the targets. ANEEL will monitor the progress and the results achieved by utilities in the implementation of electrification programmes. Those not meeting the targets will be subject to sanctions, mainly a reduction in tariff increase, when the tariffs are periodically reviewed by ANEEL.

On top of the financial resources provided by the CDE, substantial investments are expected from distributors, particularly in the case of the municipalities whose current rate of electrification is below 75 per cent. The income loss from defaults on energy bills is one the main concerns of distributors, as this loss reduces the distributor's capacity to invest.

4. THE “LUZ PARA TODOS” PROGRAMME

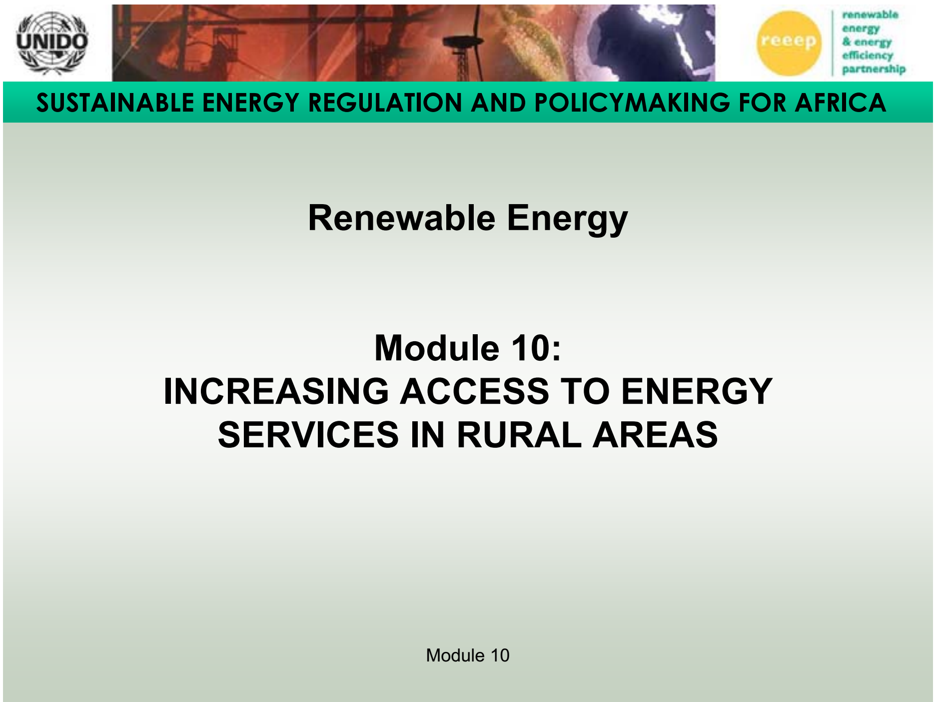
In November 2003 the Brazilian government announced the Luz para Todos (Light for All) programme to supply electricity throughout Brazil to 12 million people as yet unconnected to any transmission grid. The main objective of Luz para Todos is social inclusion through access to electricity supply. It is an important step towards achieving universal access to electrical energy services. This programme is implemented through partnerships between the federal government, the state governments and the concessionaires.

The first stage of the programme has scheduled total investments of US$ 843 million funded by the federal government (US$ 543 million), concessionaires (US$ 188 million) and state governments (US$ 112 million). Upon signature of contracts, 10 per cent of the value of the contracts is made available to concessionaires. Eletrobrás monitors the progress of the work. In the first stage, 567,000 new connections were being made, giving 2.8 million people access to a regular electricity supply. The plan is for 12 million people to be reached by 2008. Besides accelerating universal access to electric energy, the Luz para Todos programme will allow for the generation of about 115,000 indirect and direct jobs, according to an estimate by the Ministry of Mines and Energy.

5. DECENTRALIZED INITIATIVES

The allocations included in the national budget favouring the Ministry of Agriculture are another important source of funding for rural electrification. These funds are provided by the federal budget to the municipal administrations on a non-refundable basis. The funds finance grid infrastructure investments for a total of 42,750 community associations in 1,400 of the total 1,600 rural municipalities in north-east Brazil. Communities make their own development decisions through a process that promotes and depends on community organizations. The projects include grid-connected rural electrification projects and off-grid solar systems, in addition to a plethora of other rural development projects.

A key issue related to these projects is sustainability. Unless the associations are strongly organized, their projects are difficult to maintain. The case of grid-connected systems is less troublesome as they are absorbed by concessionaires, who are obliged to maintain them.

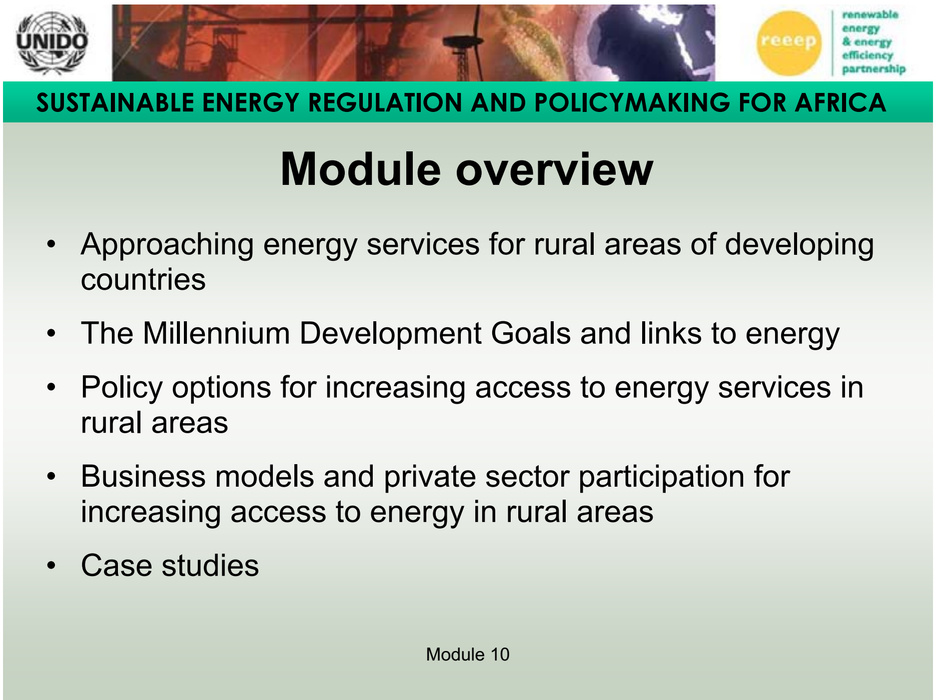


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy

Module 10:
INCREASING ACCESS TO ENERGY SERVICES IN RURAL AREAS

Module 10

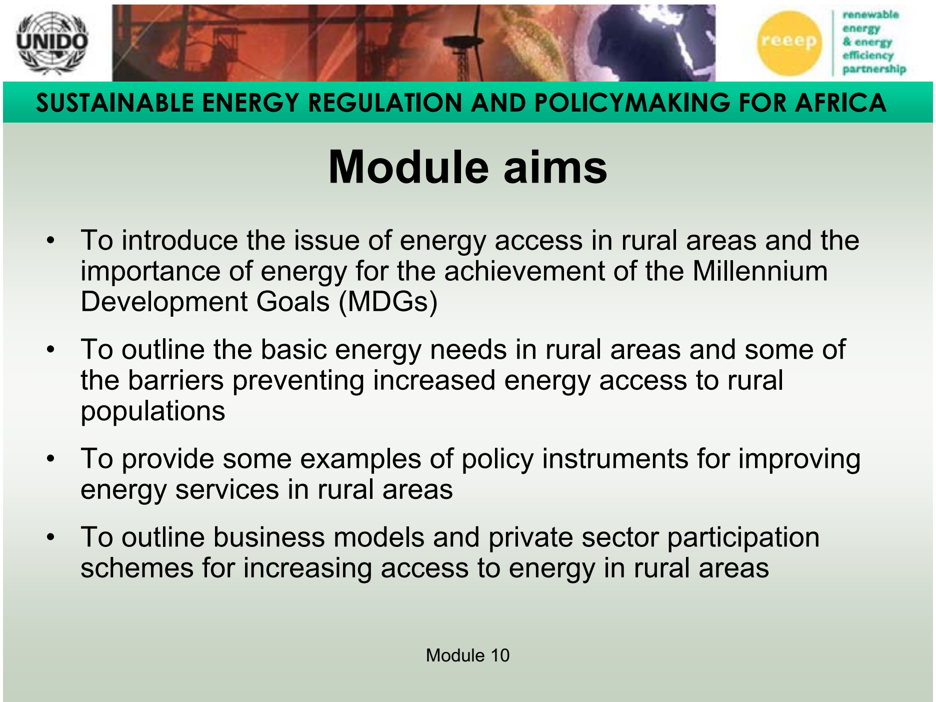


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Approaching energy services for rural areas of developing countries
- The Millennium Development Goals and links to energy
- Policy options for increasing access to energy services in rural areas
- Business models and private sector participation for increasing access to energy in rural areas
- Case studies

Module 10



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To introduce the issue of energy access in rural areas and the importance of energy for the achievement of the Millennium Development Goals (MDGs)
- To outline the basic energy needs in rural areas and some of the barriers preventing increased energy access to rural populations
- To provide some examples of policy instruments for improving energy services in rural areas
- To outline business models and private sector participation schemes for increasing access to energy in rural areas

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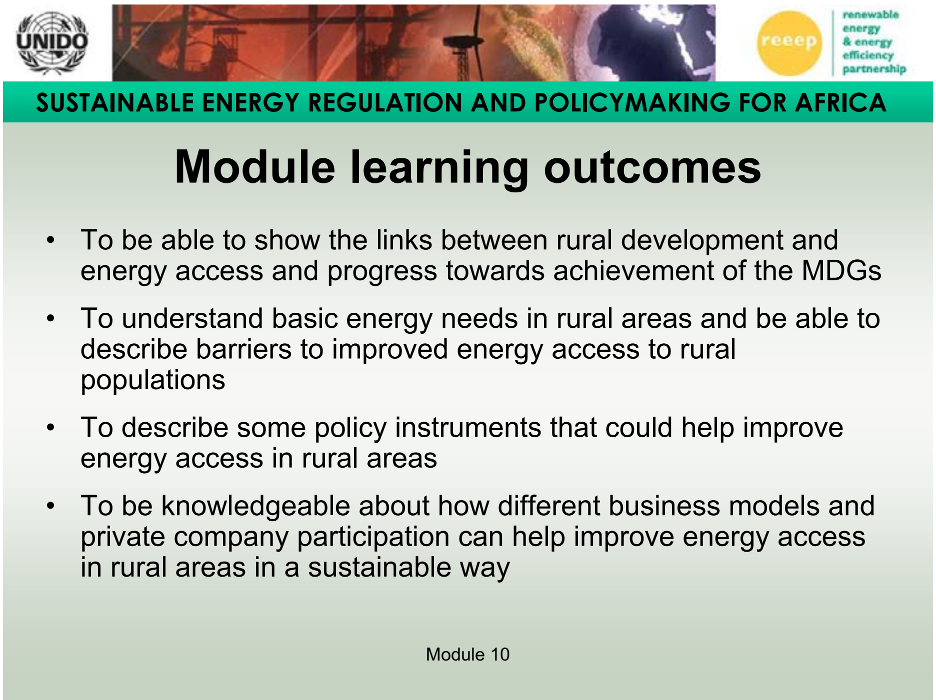

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to show the links between rural development and energy access and progress towards achievement of the MDGs
- To understand basic energy needs in rural areas and be able to describe barriers to improved energy access to rural populations
- To describe some policy instruments that could help improve energy access in rural areas
- To be knowledgeable about how different business models and private company participation can help improve energy access in rural areas in a sustainable way

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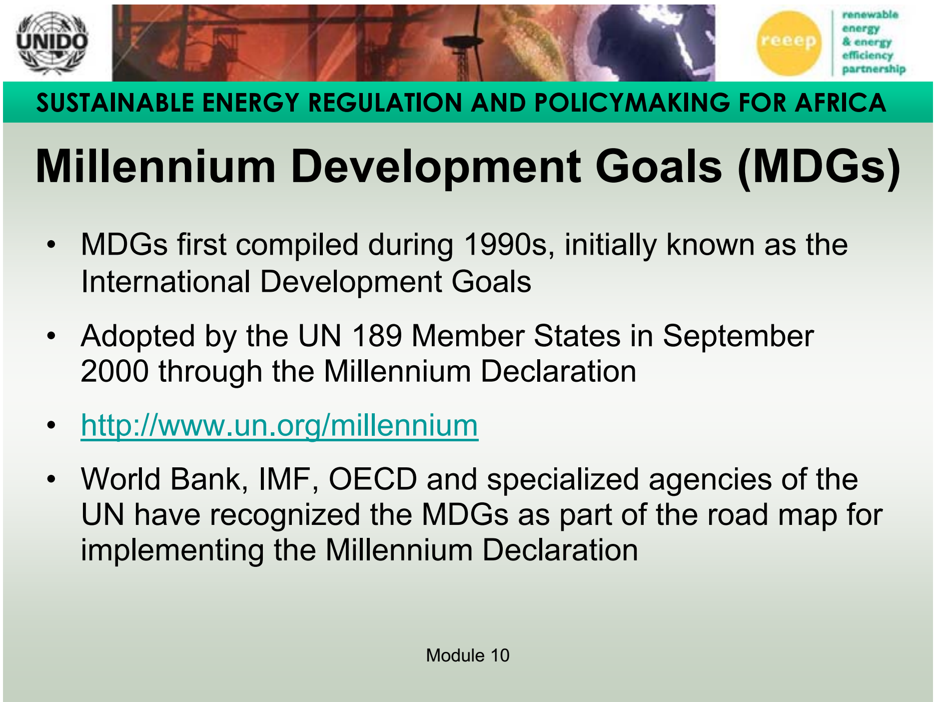

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Millennium Development Goals (MDGs)

- MDGs first compiled during 1990s, initially known as the International Development Goals
- Adopted by the UN 189 Member States in September 2000 through the Millennium Declaration
- http://www.un.org/millennium
- World Bank, IMF, OECD and specialized agencies of the UN have recognized the MDGs as part of the road map for implementing the Millennium Declaration

Module 10

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Millennium Development Goals (2)

- In summary the MDGs:

  “Commit the international community to an expanded vision of development, one that vigorously promotes human development as the key to sustaining social and economic progress in all countries, and recognizes the importance of creating a global partnership for development. The goals have been commonly accepted as a framework for measuring development progress.”

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Millennium Development Goals (3)

1. Eradicating extreme poverty and hunger
2. Achieving universal primary education
3. Promoting gender equality and empowering women
4. Reducing child mortality
5. Improving maternal health
6. Combating HIV/AIDS, malaria and other diseases
7. Ensuring environmental sustainability
8. Developing a global partnership for development

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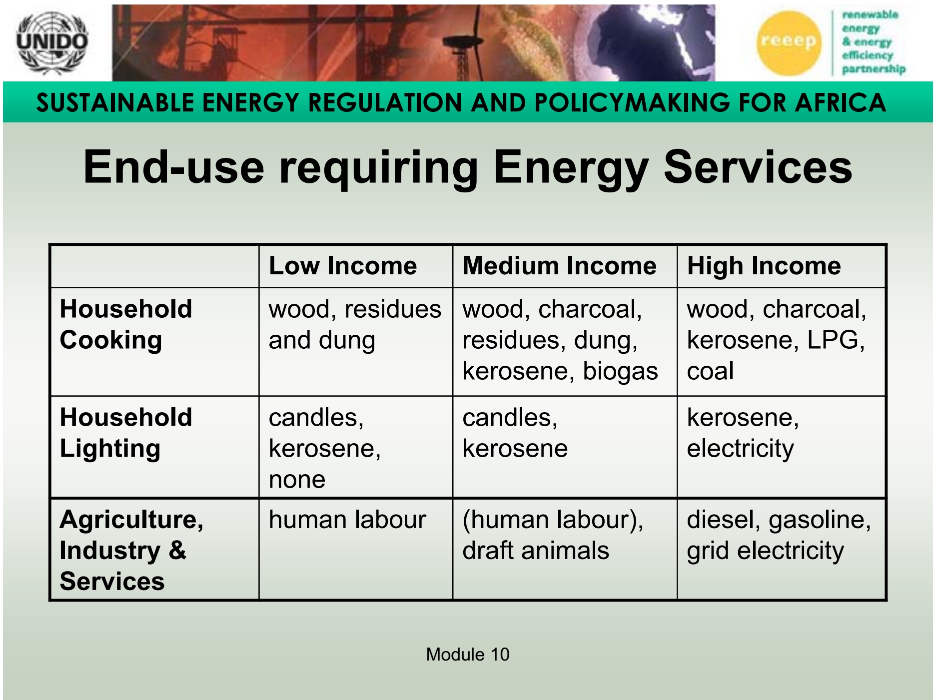
Millennium Development Goals (4)

- Aspirational targets in 18 important areas with 48 indicators to monitor progress to 2015
- Better access to energy is not a specific goal within the MDGs but there are indicators that refer to energy and energy runs through many of the targets

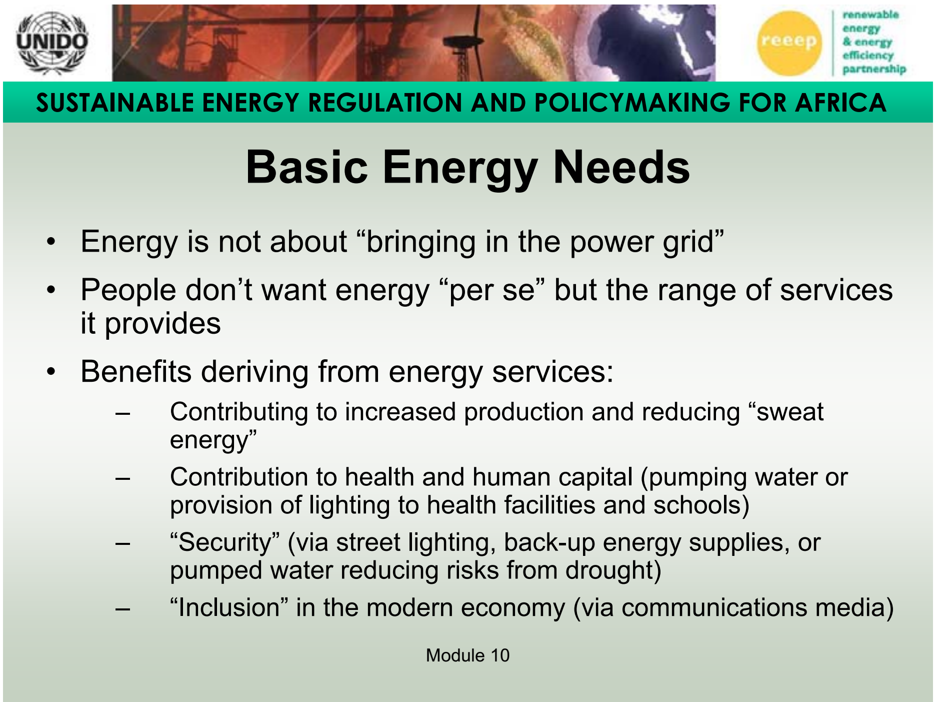
Energy and MDGs

- DFID have noted how energy can play a crucial role in underpinning efforts to achieve the MDGs
- UN—Millennium Project
- GVEP
- REEEP
- The European Commission
- Development Agencies—provide interface between poor communities, energy services and private capital



End-use requiring Energy Services

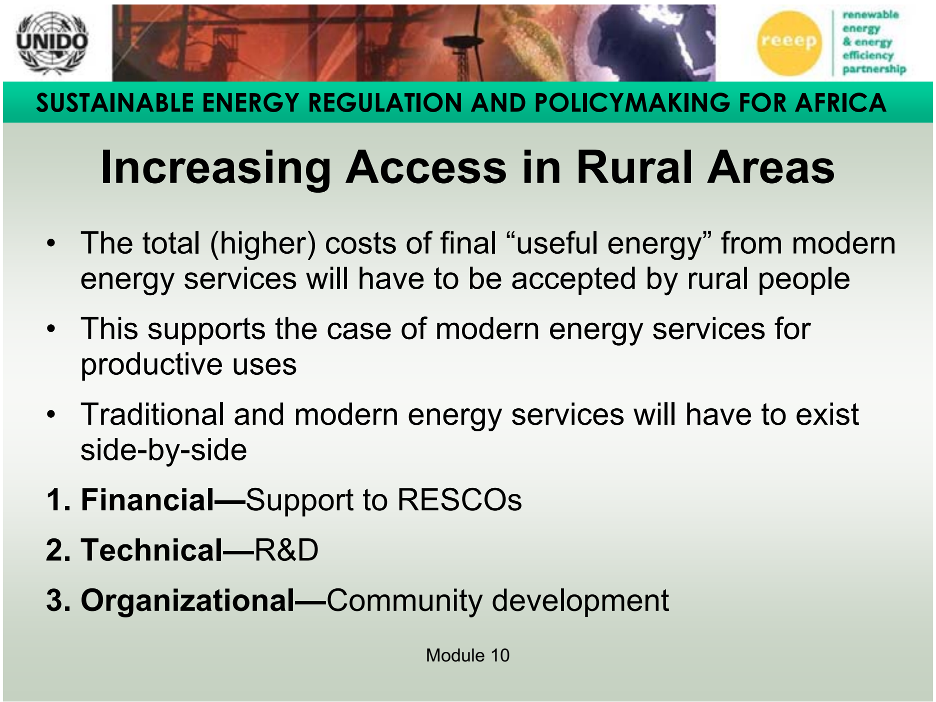
	Low Income	**Medium Income**	**High Income**
Household Cooking	wood, residues and dung	wood, charcoal, residues, dung, kerosene, biogas	wood, charcoal, kerosene, LPG, coal
Household Lighting	candles, kerosene, none	candles, kerosene	kerosene, electricity
Agriculture, Industry & Services	human labour	(human labour), draft animals	diesel, gasoline, grid electricity



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Basic Energy Needs

- Energy is not about “bringing in the power grid”
- People don’t want energy “per se” but the range of services it provides
- Benefits deriving from energy services:
  - Contributing to increased production and reducing “sweat energy”
  - Contribution to health and human capital (pumping water or provision of lighting to health facilities and schools)
  - “Security” (via street lighting, back-up energy supplies, or pumped water reducing risks from drought)
  - “Inclusion” in the modern economy (via communications media)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Increasing Access in Rural Areas

- The total (higher) costs of final “useful energy” from modern energy services will have to be accepted by rural people
- This supports the case of modern energy services for productive uses
- Traditional and modern energy services will have to exist side-by-side

1. **Financial—**Support to RESCOs
2. **Technical—**R&D
3. **Organizational—**Community development

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Smart Subsidies

- To lower the initial costs (technical advice, capital investment) rather than lowering the operating costs
- Technologically neutral
- Include for end-use investments, particularly to encourage pro-poor productive uses
- “Cross subsidies” within the project to enable transfer from richer sections of the community, and commercial users to marginal connections

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What is a RESCO?

- “Rural Energy Service Company”
    - Private company
    - NGO
    - Government body
    - Entrepreneur
    - Peoples cooperative
    - Public-private partnership
    - Utility
- A RESCO, in whatever form, is a **business entity**

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

RESCOs Good Practices

- Large menu of rural energy options
- Focus on “application” not “technology”
- Aware of user’s “capacity” and “willingness” to pay
- Build up long term relationships with end-users
- Develop “peripheral” activities (e.g. tourism)

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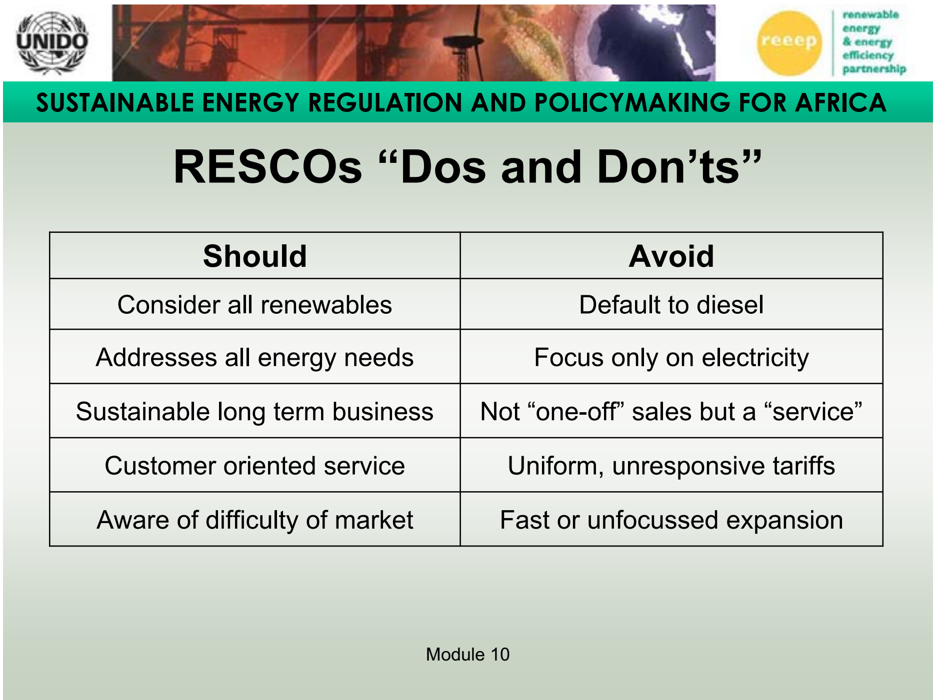


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

RESCOs “Dos and Don’ts”

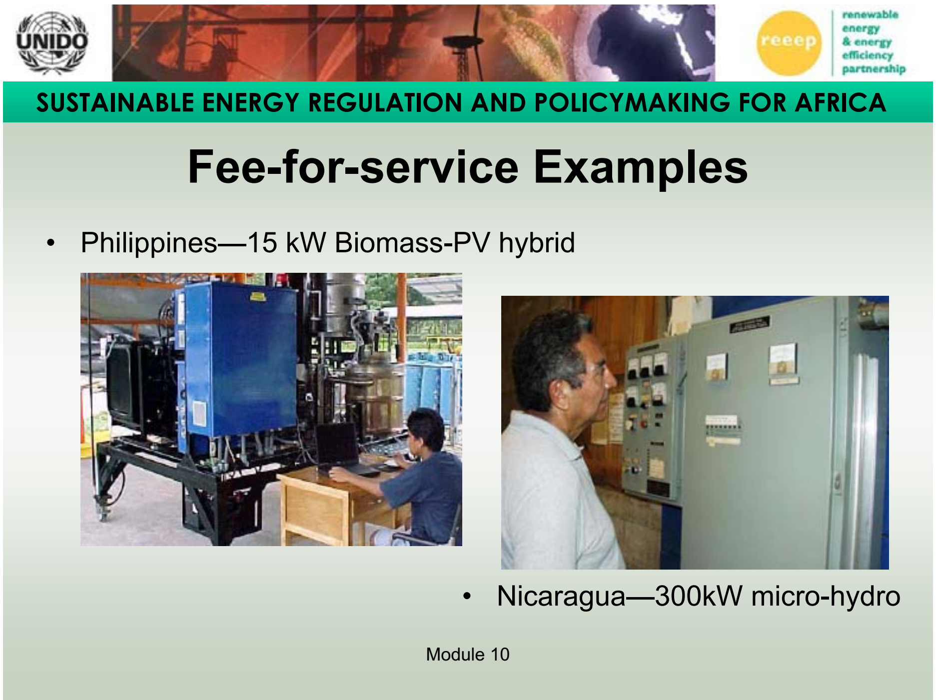
Should	Avoid
Consider all renewables	Default to diesel
Addresses all energy needs	Focus only on electricity
Sustainable long term business	Not “one-off” sales but a “service”
Customer oriented service	Uniform, unresponsive tariffs
Aware of difficulty of market	Fast or unfocussed expansion

Module 10

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

International RESCOs Review

- Types of Business Model:
  - Fee-for-service
  - Customer leasing
  - Concessions
  - Bottom-up / decentralized
  - State control



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Fee-for-service Examples

- Philippines—15 kW Biomass-PV hybrid
- Nicaragua—300kW micro-hydro

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Customer Leasing Examples

- SELCO (India, Sri Lanka, Vietnam)

- SOLUZ (Honduras)

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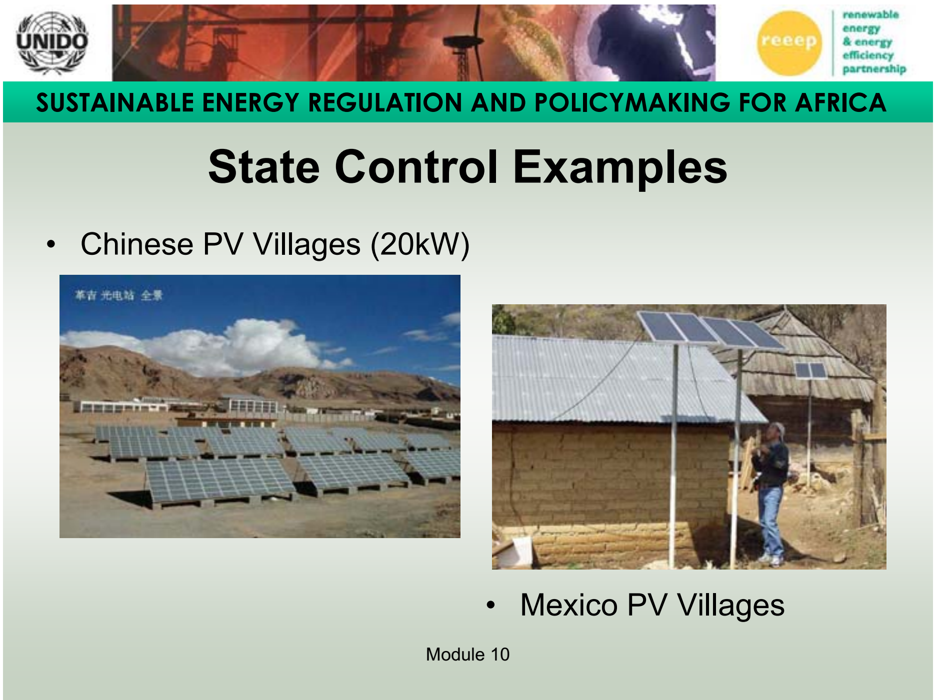

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

State Control Examples

- Chinese PV Villages (20kW)

- Mexico PV Villages

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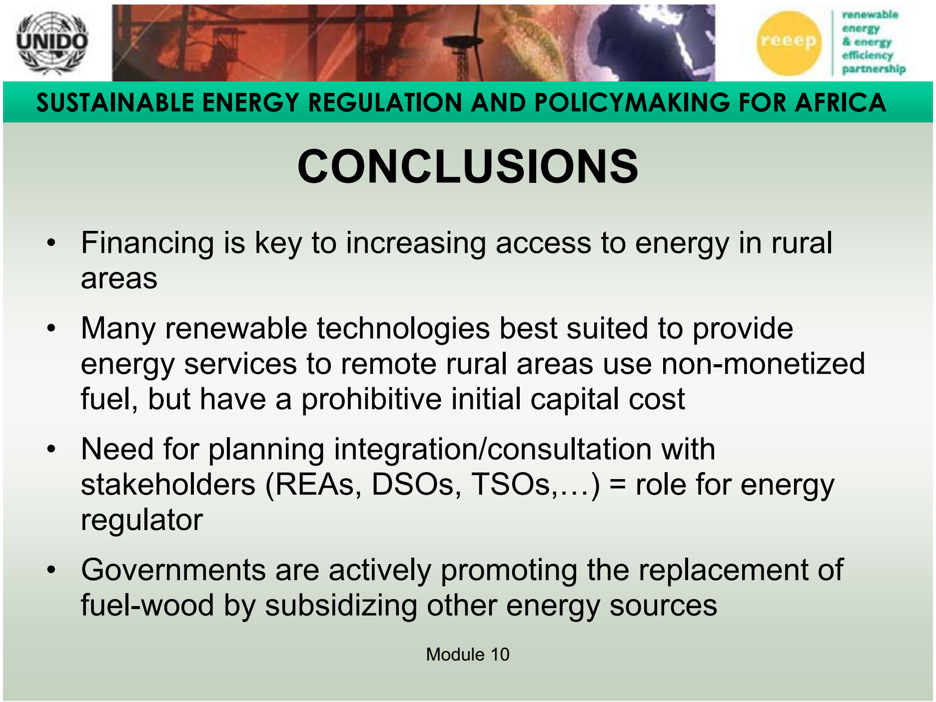
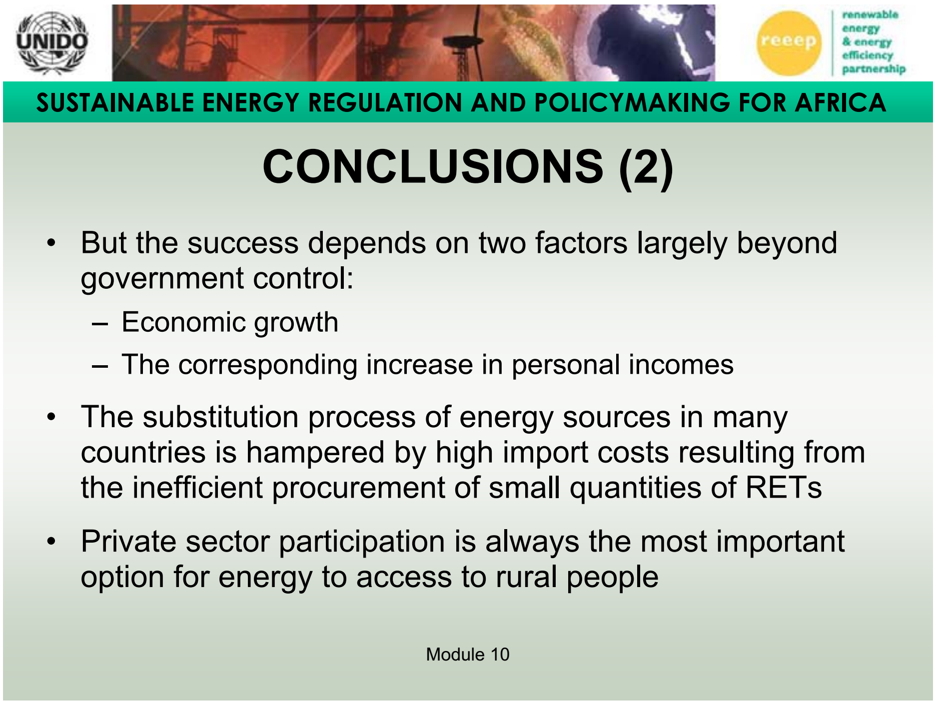


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Financing is key to increasing access to energy in rural areas
- Many renewable technologies best suited to provide energy services to remote rural areas use non-monetized fuel, but have a prohibitive initial capital cost
- Need for planning integration/consultation with stakeholders (REAs, DSOs, TSOs,…) = role for energy regulator
- Governments are actively promoting the replacement of fuel-wood by subsidizing other energy sources

Module 10

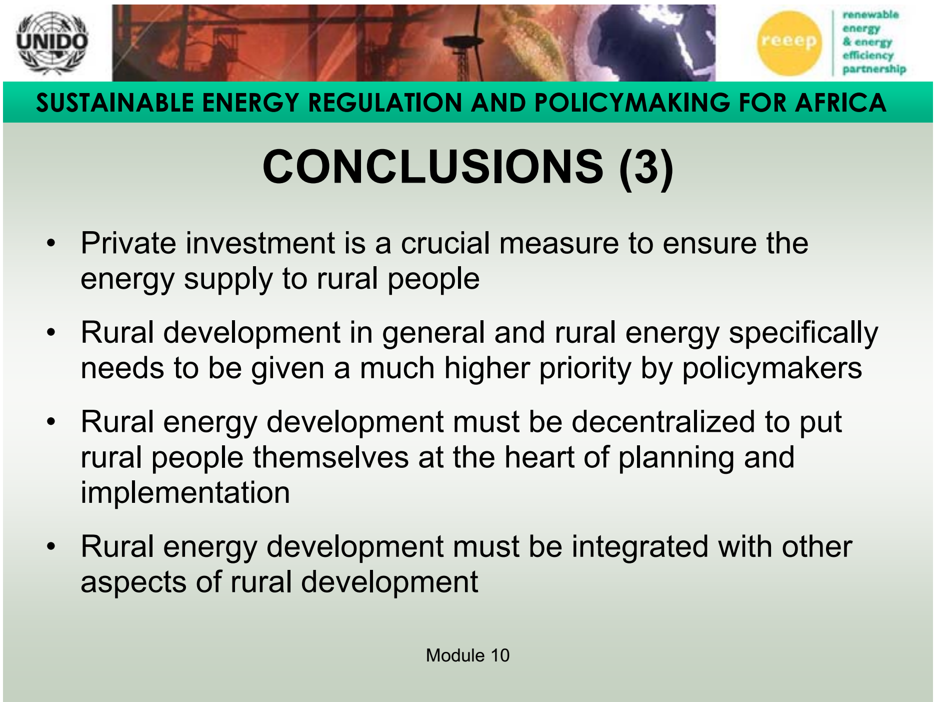


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS (2)

- But the success depends on two factors largely beyond government control:
  - Economic growth
  - The corresponding increase in personal incomes
- The substitution process of energy sources in many countries is hampered by high import costs resulting from the inefficient procurement of small quantities of RETs
- Private sector participation is always the most important option for energy to access to rural people

Module 10



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS (3)

- Private investment is a crucial measure to ensure the energy supply to rural people
- Rural development in general and rural energy specifically needs to be given a much higher priority by policymakers
- Rural energy development must be decentralized to put rural people themselves at the heart of planning and implementation
- Rural energy development must be integrated with other aspects of rural development

Module 10

Module 11

Distributed generation: options and approaches

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

The main themes described in this module are as follows:

- Outline and brief description of the different scenarios for power supply to rural areas.
- Overview of the technologies for renewable energy based mini-grid systems, including wind, hydro and PV, biomass systems and hybrid systems.
- Information on requirements for successful implementation of renewable energy mini-grid systems.
- Discussion regarding institutional and framework issues which are required to support the implementation of mini-grid systems.

1.2. Module aims

This module aims to:

- Explain the options for power supply to rural areas, with a basic comparative analysis.
- Enable understanding of the principles of mini-grid systems.
- Present the different technological options for use in mini-grid systems.
- Outline the expected costs for different options.
- Provide an overview of the issues involved in the successful implementation of mini-grid systems, technical and non-technical.
- Review the institutional and framework issues affecting the effective deployment of mini-grid systems.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to define the different scenarios for power supply to rural areas.
- To understand the potential technologies used in mini-grid systems.

- To have a broad appreciation of outline costs for the different technologies.
- To appreciate the key issues to be considered when considering a mini-grid project.
- To gain an appreciation of the policy and other institutional issues and frameworks that will provide support to mini-grid projects.

2. INTRODUCTION

This module provides an outline and description of distributed generation; otherwise known as distributed-grid or mini-grid systems. It considers the options and technologies used in distributed-grid systems.

The module also reviews the requirements for planning such systems and the issues to consider. Finally it reviews the mechanisms required on the policy, fiscal and infrastructure level to support effective implementation of distributed grid systems.

The information contained in this module is intended to explain the basic operation of such systems, to understand their strengths and weaknesses and hence to have a better grasp of the benefits and the barriers faced by them.

3. ELECTRICITY SUPPLY SCENARIOS

About a third of the world's population, over 1.6 billion people,[1] do not have access to electricity and rely almost exclusively on wood, agricultural residues and animal dung to meet their energy needs.

These people basically have three options or scenarios for the provision of electricity:

- Utility network grid-connection (via grid extension);
- Stand-alone systems;
- Distributed-grid systems (often known as mini-grid systems).

3.1. Utility network grid-connection

Established electricity systems tend to rely on centralized generation from large plants which are often some distance from the point of use. Much of this generation is supplied by fossil fuel plants, and the power transported over transmission lines to "passive" distribution networks which deliver the power to the end-user.

In many developing countries a national or regional utility company or companies are charged with the provision of access to electricity. Often these companies struggle to keep up with growing electricity demand within the areas already forming part of the grid network, usually urban, with the consequence that extension of the grid to rural and even peri-urban, populations, which have high service costs per customer and a low ability to meet cost-recovery tariffs, do not get connected.

Early electricity systems in developed countries did use distributed generation – power plants were located within a mile or so of their load on low voltage lines. The development of transformers and the adoption of high voltage transmission lines using alternating current allowed lines to transmit power over longer distances. Coupled with this, rapid improvements in generating technologies, in particular steam turbines, meant that larger plants could be built allowing economies of scale in generation. Universal supply became possible, and politically and economically desirable.

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[1] World Energy Outlook 2002, International Energy Agency, Paris, France, 2002, www.iea.org

Developing countries have tended to follow this model. However, these characteristics are not the inevitable result of wanting to supply electricity, but rather are the product of political, economic and technical forces.

3.2. Stand-alone systems

The most common type of small-scale stand-alone system involves the use of renewable energy power source (i.e. a wind generator or PV array), to maintain an adequate level of charge in an electrical storage battery. The battery in turn can provide electricity on demand for electrical applications such as lights, radios, refrigeration, telecommunications, etc., irrespective of whether or not the wind is blowing or the sun shining. A controller is also used to ensure that the batteries are not damaged by overcharging (when surplus energy is dissipated through a dump load) or excessive discharge, usually by sensing low voltage. Load connected to the battery can either be DC or AC (via an inverter).

Small stand-alone charging systems are suitable for remote households in developing countries. Larger stand-alone systems (and potentially more than one renewable energy power source and correspondingly larger battery banks – at an increased cost) are also available, and may include a diesel generator to ensure that the batteries are always charged and that power availability is high.

Less common is the stand-alone system which does not incorporate a battery. This involves the use of a wind turbine with, at least, a diesel generator, which will automatically supply power when required. This has the advantage of not requiring a battery bank but control the systems are complex.

3.3. Distributed-grid (mini-grid) systems

Distributed-grid or mini-grid systems are decentralized power plants, effectively larger stand-alone systems, which supply power to isolated groups of householders, communities or even larger groupings. They involve a local grid-network for the supply of power.

Connecting the utility grid to remote regions usually requires electricity transportation over long distances to a dispersed population. For this reason mini-grid systems can provide more cost-effective electrification than grid-extension for such areas. Mini-grid systems can not only provide access to household electricity in rural areas, but also contribute to income generation, i.e. small-scale industry, and social needs, i.e. clinics. They can be used for the generation of motive power, heat, and other energy requirements. They may also contribute to changes that benefit the local economics and the environment.

A typical village mini-grid system would provide a village with energy for various applications:

- Electricity for lighting and appliances (radio, TV, computer, etc), in homes and public buildings such as schools and clinics;
- Electrical power (or mechanical power common from hydro-powered systems) for local industries;
- Electrical power (or mechanical power common from hydro-powered systems) for agricultural value-adding industries and labour saving activities;
- Electricity for lighting and general uses in public spaces, i.e. health centres, and for collective events.

3.4. Summary

These are clearly three very different approaches and comparisons are difficult to make with such diverse systems. However, table 1 below does aim to review the main issues.

Table 1. Providing electricity to rural communities: issues in relation to the different scenarios

Issues	Grid-connection	Stand-alone	Mini-grid
Power availability	May be power outages	Usually readily available	Readily available
Transmission and distribution costs	High	Nil	Low
Infrastructure	Significant for fuel supplies & electricity distribution	None	Small and more straight forward
Site selection/new plant development	Large plant – selection and procurement challenging although well understood	Usually based on location of need but may also be site specific	Based on location of need but may also be site specific, less complicated than plant for grid-connection
Environmental impact	High although newer generation systems offer improvements	Low	Usually low depending on the power source

Review questions

1. What are the three scenarios available for the supply of electricity to rural communities?
2. What are the advantages and disadvantages of each approach?

4. OPTIONS FOR MINI-GRID SYSTEMS

4.1. General considerations

Options for mini-grid systems can of course be non-renewable, i.e. diesel-based mini-grids. However, diesel generators can be expensive to operate and environmentally damaging. Renewable energy mini-grid systems may use only renewable energy technologies, especially hydro-power in suitable locations, although they are frequently combined with a diesel generator called into action only when essential.

This hybrid arrangement offers all the benefits of renewable energy in respect of low operation and maintenance costs, but additionally ensures a more secure supply: any system incorporating renewable energy usually has high investment but low operating costs, and is environmentally benign. However, two advantages of most renewable energy systems, i.e. simplicity and reliability, may be negated by the addition of rotating machinery or over-complicated hybrid system control.

There is now sufficient experience in a number of developing countries, particularly in Asia, providing successful examples of a wide-range of renewable energy based mini-grid systems. It is recognized, however, that mini-grid systems are generally more difficult to implement than grid extension or stand-alone systems. Reasons include: lack of understanding and limited knowledge of regulatory frameworks. There are also very site specific aspects requiring considerable preparation and development in order to match local requirements with the technologies. Technical assistance may be required for system design and for training for operation.

Box 1. **Township electrification programme**

To provide a solution for the lack of electricity access within China, especially in rural areas, the China's State Development and Planning Commission (renamed in 2003 to the National Development and Reform Commission (NDRC)) launched a renewable energy-based rural electrification programme called Song Dian Dao Xiang – "Sending Electricity to Townships". This programme included the installation of 20 MW from PV system, 840 MW from wind and 200 MW from hydropower. In just 20 months, electricity to more than 1000 townships in nine western China provinces – Xinjian, Qinghai, Gansu, Inner Mongolia, Shaanxi, Sichuan, Hunan, Yunnan and Tibet was realized – supplying power to nearly one million people and providing the base for rural economic development. The government have subsidised the capital costs of equipment by providing US$ 240 million.

Source: Renewable Energy in China: Township Electrification Program, NERL (National Renewable Energy Laboratory), www.nerl.gov, 2004

Box 2. **Solar energy for village electrification in China**

To provide a solution to the energy problem in Qinghai Shenge village, a PV mini-grid energy system was installed. All houses in the village were electrified by a single PV system that has an inverter, hence AC electricity is consumed. The houses are also connected in a mini-grid system through power lines that are strung through the village. The PV system, which has a total capacity of 7.5 kWp, produces power for local government offices and the basic needs of the village at all times. The electricity is used first to charge batteries, where the energy is stored for later use. This is usually in the evenings when the villagers return home. During the summer time when the young men travel long distances with the animals they raise, the total energy consumption is noticeably lower. The system loads include lighting, televisions and radios, as well as washing machines and other community equipment such as communication devices and a ground satellite receiver. Although the system provides electricity for normal everyday consumption, there are some restrictions. For example, the use of the washing machine is limited to two hours a week. Overall the technical performance of the system has been very good with only a limited number of initial problems. Now the system is running well.

Source: Deployment of Photovoltaic Technologies: Co-operation with Developing Countries – 16 Case Studies on the Deployment of Photovoltaic Technologies in Developing Countries, IEA-PVPS, 2003.

Box 3. **China brightness rural electrification programme**

China has been playing an active role in the Brightness Programme (designed to bring electricity to rural areas) since it was established in 1996 during the World Solar Peak Conference in Zimbabwe. China's Brightness Project Implementation Planning was established in 1998 to provide electricity for the remote areas of Gansu, Qinghai, Inner Mongolia, Tibet and Xinjiang using both household and village systems.

The programme aims to provide electricity for 23 million people by 2010 using renewable energy technologies like wind and solar PV generation, with a goal of providing 100 watts of capacity per person.

This programme has been progressing in stages, and in its first stage it has already achieved the following results: *(a)* 1,780,000 household systems, 2000 village systems and 200 station systems installed; *(b)* established national and local government offices financing approaches and practical financing mechanisms; *(c)* established industrialized production enterprises which can fulfil market demands; *(d)* set up a distribution and service network and marketing mechanisms; and *(e)* installed technical training systems with different levels of training for local technicians and engineers.

Source: Renewable Energy in China: Brightness Rural Electrification Program, NERL (National Renewable Energy Laboratory), www.nrel.gov, 2004

4.2. Mini-hydro powered systems

Hydropower based mini-grid systems usually use small hydropower plants, often the run-of-river type, usually without a dam. Therefore, they usually avoid the adverse effects on the local environment large-scale dams are often associated with.

Such schemes usually comprise three core elements:

- Civil works: to divert the water, channels and piping to take water to the power generation equipment (penstock), the power house building and the water exit channel;
- Power generation equipment: turbine and drive system (turbine, generator and/or mechanical devices), generator, controller, inverter and electrical switchgear;
- Power distribution system: to distribute the electricity, usually by a main distribution line to a central point, then by sub-distribution lines and consumer service connections to consumption points. Small village systems may use a battery bank for energy storage, voltage stability and services to remote customers.

In order to assess the viability of a hydro-powered system, information must be gathered on the resource, usually obtained locally through agencies such as the local forest and water resources groups. Several years of information should be gathered and calculations based on average data. Water resources can vary very significantly depending on the season and even year by year. An international database of small hydropower resources has been developed and maintained by the IEA (see Internet resources). The website provides data for potential and developed sites, GIS searching capabilities, country profiles, international contacts for small hydro and a world small-hydro resource atlas.

According to the World Bank's Renewable Energy Toolkit (REToolkit),[2] the costs of mini-hydro power systems vary considerably as the result of many site-specific design and performance related factors. One survey found the average capital cost (in constant $US 1998) of the sample investigated to be $US 965 per kW for plants used for mechanical power and $US 3,085 per kW for plants generating electricity, including the costs of transmission, which can clearly vary.

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[2] web.worldbank.org

4.3. Hybrid powered systems

Hybrid powered systems are formed from a combination of wind, PV, hydro and diesel power, e.g. PV/diesel, wind/diesel or PV/wind. These systems were originally developed for telecommunications applications in remote sites. However, telecommunication applications require extreme reliability, which results in expensive systems unsuited to rural electrification.

The basis for hybrid systems is the need to have a more reliable supply of energy. Although a stand-alone renewable energy system will generally have some means of storing energy to accommodate a pre-defined period of insufficient sunshine or wind (for PV and wind powered systems respectively), unfortunately there may still be exceptional periods of poor weather when an alternative source is required to guarantee power production. Hybrid systems combine a renewable energy generator with another power source – typically a diesel generator – although occasionally another renewable supply such as a wind turbine is applied.

The options for hybrid-powered systems are most commonly:

- PV-diesel hybrids
- Wind-PV-diesel hybrids
- Wind-diesel hybrids

These systems can be developed as retrofits of existing diesel mini-grid systems or as new integrated designs. In general, well-designed hybrid systems will substantially reduce diesel fuel consumption while increasing system reliability. This can be of particular importance to existing diesel mini-grid system where the fuel is subsidised to support these systems, creating a burden on the Government resources.

In addition to the diesel generator and the renewable energy generator, hybrid systems consist of a battery bank for energy storage, a control system and particular system architecture that allows optimal use of all components. Hybrid systems have been shown to:

- Provide electricity more cheaply than grid extension;
- Be as or even more reliable than grid power;
- Operate more effectively than diesel-only systems;
- Be modular and relatively easily assembled from standardized packages.

In order to assess the viability of a wind or solar (PV) powered systems, information must be gathered on the resource, usually obtained locally. General solar resource data exist for hundreds of locations worldwide, and can be interpolated to a particular project location as an estimate. However, wind and other renewable resource data remain very site specific.

Hybrid systems are potentially very cost-effective solutions to rural AC electricity needs. For low load applications (<10 kWh/day), wind/PV hybrid systems are very attractive. For larger applications, wind/diesel hybrids are very attractive as long as a reasonable wind resource is available. Bilateral and multilateral finance and market stimulation programmes should be based on best service at least cost.[3]

The cost of hybrid systems is currently high compared to conventional diesel mini-grid systems. However, as is typical for emerging technologies and markets, systems design and industry structure will continue to evolve in concert with the growth in demand, technology development funding, and costs which can be expected to decrease significantly[4]. Renewable energy systems, and specifically wind and PV, have complementary characteristics for mini-grid systems when compared with diesel powered systems, as shown in table 2 below.

Table 2. Relevant characteristics of wind/solar vs. diesel for mini-grid systems

Characteristic	Wind/solar	Diesel
Capital cost	High	Low
Operating cost	Low	High
Logistics burden	Low	High
Maintenance requirements	Low	High
Available on-demand	No	Yes

4.4. Biomass powered systems

Biomass powered mini-grid systems are usually based on either combustion or gasification technologies. Direct combustion systems may use steam turbines and if so, are generally used for only the larger applications. Biomass gasification systems produce a synthesis gas, which can be burned in a gas or diesel engine to provide electricity or motive power or burned in a boiler or furnace to provide heat. These systems can be used in a variety of sizes, ranging from kilowatts to megawatts.

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[3] World Bank REToolkit

[4] Prospects for Distributed Electricity Generation, Congressional Budget Office, www.cbo.gov

Box 4. **Power wind/diesel hybrid pilot project in Xiao Qing Dao village**

To provide electricity to the Village of Xiao Qing Dao, the US department of Energy (DOE), the National Renewable Energy Laboratory (NREL) and the State Power Corporation of China (SPCC) developed and installed a pilot wind/diesel/battery hybrid system. The system consisted of four 10 kW wind turbines connected with a 30 kW diesel generator to a 40 kW inverter and a battery bank. Xiao Qind Dao, also called "Little Green Island" is a small island with approximately 370 people where most residents earn their livelihood from fishing and fish farming.

Prior to the project implementation the village residents depended on a 13 kW diesel engine-run generator, which provided 3–4 hours of intermittent electricity during the night only used to power low-wattage lighting and satellite TVs. The hybrid system, installed in November 2000, provided electricity for 24 hours which powers street lighting, good quality indoor lighting, refrigerators, cable TVs, washing machines as well as other electronic equipment. Despite the increase in quality of life, the current electricity is provided at a lower cost. With the hybrid system, island residents pay between one and two Yuan (US$ 0.13 and 0.26)/kWh (depending if the system relying only on wind power or if the diesel generator is used). The village used to pay three Yuan (US$ 0.39)/kWh by the previous system.

In a post-installation assessment the residents of Xiao Qing Dao village reported a high level of satisfaction and the hybrid system showed good performance. With the application of this project, residents have been able to raise their incomes through the use of refrigerators for preserving fish for sale. Also, since the system was installed eleven children have gone to college and have even continued to graduate. The children's success was attributed to the high-quality lighting, which increased daily study time.

Source: Renewable Energy in China: Xiao Qing Dao Village Power Wind/Diesel Hybrid Pilot Project, NERL (National Renewable Energy Laboratory), www.nrel.gov, 2006.

The first consideration must be to review the feedstock available and hence to tailor the technology and system design to this. Feedstock characteristics that are likely to affect the design and technology selection include energy content, particle size distribution, moisture content, organic and non-organic (ash) content and chemical composition. The feedstock may need preparation (i.e. drying). In larger systems, feedstock preparation may be partly or fully automated. Systems in developing countries usually implement manual or mechanized feedstock handling, but they are not generally automated.

The assessment of biomass resources obviously requires a very local input. National and even regional level assessments do exist and may be useful to determine the likely feedstock for a particular area. However, the biomass supply chain must be investigated in detail at local level as part of the project development process. The biomass feedstock may be forest residues, agricultural residues, mill wastes or energy crops. Long-term project viability requires the development of supply agreements with specific suppliers for amounts, prices and set time-frames. The significant costs for collection and transportation, storage and handling also need careful consideration.

Biomass combustion

Combustion systems burn biomass fuel in a boiler or engine, the former producing steam that is expanded in a turbine to produce power, the latter using shaft

Box 5. **Case Study: Village power using biofuel in India as a replacement for diesel**

In the remote village of Chalpadi in the Indian State of Andhra Pradesh, oil extracted from the seeds of the local *pongamia pinnata* tree is being used as biofuel to run an off-the-shelf diesel engine that provides power to a community run village electrification mini-grid. The town originally received the diesel engine from the Indian government, as part of its rural electrification programme, but when the cost of diesel became prohibitive, the town turned to the idea of extracting oil from pongamia seeds as a source of fuel to power the generator instead of diesel.

Villagers now “pay” for the operation of the generator and their electricity by collecting the seeds needed to make the biofuel. A women’s self-help group responsible for the operation and maintenance of the engine, levies a weekly tariff of seven kilograms of pangamia seed per family. In April 2003, the town sold 900 tonnes of carbon-dioxide equivalent verified emission reductions (CERs) to Germany. The sale fetched the community $4,164.00, equal to a year’s worth of income for every family in the village.

The state government has plans to replicate the project in some 100 villages. In addition, the federal government of India is actively encouraging biofuel production sources from pongamia and other oilseed-bearing tree species. The next phase of the Indian project is to form women’s associations that will produce the seed, process the biofuel, and use the fuel to power irrigation pumps. The woman’s associations will then sell water to local farmers as a woman-owned business enterprise.

Source: Increasing Energy Access in Developing Countries: The Role of Distributed Generation, the Business Council for Sustainable Energy and the US Agency for International Development, May 2004 power via a generator (for electricity production) directly. Much of current biomass power generation is based on direct combustion in small, biomass-only plants with relatively low electric efficiency (in the order of 20 per cent).

Where heat is needed, either in northern climates for winter heating or for small industry use, combined heat and power (CHP) applications can be cost-effective. Total system efficiencies for CHP can approach 90 per cent.

Biomass gasification

Gasification is the process by which a synthesis gas (syngas) is produced from biomass material. This gas can then be burnt in an engine to provide power. Products for modular systems are now emerging onto the commercial market. System sizes range from 3kW to 5MW. There are numerous applications in India alone, including village power, industrial process heat and electricity, and even grid electricity supply.

Review questions

1. What are the key system layouts for renewable energy based mini-grid systems?

2. Why are hybrid-powered systems attractive?

5. PLANNING THE APPROACH

5.1. Technical issues

When choosing a power supply system for a rural community there are several technical factors, in addition to the available resource, that have to be considered.

Distance from the utility grid

If the community to be connected is relatively close to the existing grid, then the cost of extending the grid will need to be compared to the likely cost of a mini-grid system. There is often a cut-off distance at which grid extension is not viable, or difficulties on the terrain between the grid and the community, such as mountains or marshes, can make line extension very difficult.

System power losses

Grid extension may also require improvement of the transmission system to reduce losses; this is a recognized problem in some areas where the grid has been extended to rural areas, especially using lower voltage transmission lines, 11kVA or 33kVA, over very long distances. This may limit the line extension and hence prompt the decision to install a mini-grid system. In some rural and even urban areas electricity theft is also a problem.

This results in:

- Poor service to rural communities due to frequent load shedding;
- High cost electricity;
- Instability in the power supply, with fluctuating voltage and frequency.

Load characteristics

The density of the load is the quantity of power demanded in a specified area. A high electricity demand in a small area may justify grid extension. Rural communities may however be dispersed and require or be able to afford, only limited amounts of electricity. A very dispersed grouping may indicate that small individual stand-alone systems, such as solar (PV) home systems, may be more appropriate. Another alternative would be a central battery charging station.

Demand-side management and base/peak load issues

The level of power supplied to the utility grid network is often not sufficient to meet demand. Even in cases where the base load needs are fully met there may be problems supplying the peak loads. In these situations, priority is invariably given to the larger cities. Any supply to rural areas is therefore frequently of an inferior quality, with frequent load shedding at peak hours. Distributed generation will ensure that this does not become an issue. Grid extension without due consideration of this issue will exacerbate this problem.

Many rural communities use electricity almost exclusively for lighting in the evening. This means that the revenue collected by the power companies from the rural community will be very low. Using the available power for income-generating activities as well as lighting makes grid extension more financially viable; however, one advantage of community-owned mini-grid systems is that the development of productive end uses for the power can be better planned into the development of the system.

5.2. Non-technical issues

Economics and billing

The decision to extend the grid and connect rural customers will ultimately be based on the cost to the utility. Rural electrification is often subsidized, either by the other customers or by the government. Utilities often have a cut-off point for the distance that the grid line can be viably extended for a given number of consumers, which will be based mainly on the cost of the line extension.

Mini-grid systems, especially those incorporating renewable energy technologies, often have high capital costs for equipment and initial set-up of the distribution system. For community systems this can be covered, at least in part, by a low interest loan or grant. The financing available will affect the end product.

All systems need to have a payment strategy developed before implementation, whether they are financed by the government, donor projects or by the local community. This is important because billing and tariff collection have been found to be a particular problem in rural areas. Utilities have problems because the cost of reading meters and collecting tariffs can be higher than the revenue collected from the rural communities who use electricity for lighting only. This is often the case when the revenue collector has to travel from a central office in town. Revenue collection costs can be reduced by households with metered connection supplying electricity to nearby households, either legally or illegally. However, this can lead to exploitation of the sub-connected, usually the poorer households, by the metered consumer charging excessive amounts for the electricity supplied.

There are a number of solutions that can specifically help low-income households to obtain electricity connection and help utilities to meet their required return on investment, these may use tariff systems that do not involve meter readings, but on the capacity of power supplied to individual houses. This is usually regulated by:

- Circuit-breakers;
- Load limiters;
- Prefabricated wiring systems;
- Community involvement tariff reforms, for instance, payment at a local shop.

Ownership and management

Experience has shown that, if there is consultation with the local community before any system is installed, and responsibility for its operation and

Table 3. Pros and cons of centralized and decentralized ownership and management of rural power supply[5]

For	Against
Centralized management of grid	
Financial risk on utility	No stake in power supply, so lack of interest in maintaining it.
Management capacity already exists	Operation and maintenance staff often brought in from outside community.
Technical capacity already exists	Bureaucratic management. Repairs take longer because they must be approved by central management. Tariff collection expensive. No load management. Disputes between utility & community possible.
Decentralized management (community-owned stand-alone scheme)	
Interests in continual operation of scheme	Financial risk placed on community.
Load management possible	Technical training required.
Flexible tariffs possible	Management training required.
Repairs made quickly	Outside assistance required for major repairs (costly).
Less bureaucracy	Local disputes possible if management breaks down.
Local person employed as operator	
Local people provide labour, reducing initial capital required for scheme.	

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[5] *Rural Energy Services: A handbook for sustainable energy development*, Teressa Anderson, Alison Doig, Dai Rees & Smail Khennas, IT Publications, 1999. ISBN 1 85339 462 9

maintenance given to the community, then the system will be more likely to work well and there will be less chance of vandalism. Contributions in kind (e.g. providing labour for installation) can also be important for community ownership.

The other option for a mini-grid system is private ownership and operation. The pros and cons of each approach are summarized in table 3.

Discussion question

Consider the pros and cons of centralized and decentralized ownership and management of rural power supply. How might the difficulties be mitigated?

6. INSTITUTIONAL ISSUES

Institutional issues are important for rural energy development in general and mini-grid systems in particular. Four of the main issues are discussed here but this selection is not exhaustive.

6.1. Government policy

Government policies to support the development of rural electricity supply are crucial to successful implementation.

6.2. Effective implementing agencies

An effective implementing agency dedicated to and dealing with issues related to rural electrification has been shown to be critical to successful rural electrification. The exact institutional structure, however, does not appear to be critical, as a variety of approaches have been successful. Generally agencies will be responsible for managing any rural electrification fund, conducting rural electrification planning, providing technical services, and promoting rural electrification.

The most successful model has been for those agencies which have a high degree of independence when operating and whose primary role is to pursue rural electrification, to create standards and to evaluate proposals for investment. Such institutions are often also responsible for defining the roles of grid extension vs. off-grid systems, and contributing to separate regulatory frameworks including tariff structures and subsidy schemes for grid extension and off-grid options.

With autonomy, responsibility is also required, meaning that a rural electrification agency having its own budget and control over access to materials and labour, should also be strictly accountable for meeting defined targets.

The exact institutional structure does not appear to be critical, as a variety of approaches have been successful. They include a separate rural electrification authority (Bangladesh); setting up rural electric cooperatives (Costa Rica); allocating rural electrification to a department of the national distribution company (Thailand); or delegating it to the regional offices of the utility (Tunisia).[6]

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[6] Rural Electrification in the developing world: A summary of lessons from successful programs, ESMAP, 2004

The issue of an integrated collaboration mechanism between the rural electrification agency, the energy regulator and grid operators is explained into some more detail in module 10 “Increasing access to energy services in rural areas”.

6.3. Attracting investment/reducing risk

It is important that utility companies and/or private-sector rural energy service companies at the community or regional-level are involved in rural electrification, including mini-grid systems. The high costs and potentially low returns are often unattractive and therefore, policy, institutional and monetary support is required to make involvement attractive. This support will usually include some form of risk mitigation.

Practical measures may include market assessments (ensuring that the potential market is more clearly understood), grants (hence reducing the initial investment required) concessions (exclusive right to provide electricity services to the customers in its service territory) and risk guarantees (this may only be partial to reduce long-term financial risk).

6.4. Local institutional structures

Community-based ownership models, i.e. cooperatives, often offer a good solution to meet local needs, especially for mini-grid systems. However, training and guidance is often required for all aspects of the project, from setting-up the organisation to installing the system, developing a workable tariff structure and training for maintenance.

Review question

1. What are four of the main institutional issues that are important for rural energy development in general and mini-grid systems in particular?

Box 6. **Policies for sustainable energy solutions – geothermal power development in the Eastern Caribbean**

The Eastern Caribbean Geothermal Development Project (Geo-Caraïbes Project) was launched to overcome the barriers to development of geothermal energy in the Eastern Caribbean. The Geo-Caraïbes Project Countries – Dominica, Saint Kitts & Nevis, and Saint Lucia – possess world-class geothermal resources. Each country faces critical electricity supply challenges, with prices among the highest in the world (approaching US$ 0.30/kWh). Despite the would-be obvious project potential, no geothermal power development has succeeded in these countries. Among the barriers to such development is the lack of appropriate policies and regulations that establish the prerequisite conditions to attract competent commercial developers.

The objectives of the Geo-Caraïbes Project are to overcome the barriers to the development of geothermal power, and to implement a regional strategy that will create the conditions for successful development of one or more commercially viable geothermal power plants.

In addressing these matters, the project has developed partnerships among energy stakeholders – including the government, electricity utilities, energy consumers and commercial associations – to prepare legislative measures that will provide for the equitable treatment of project developers, ensuring that their investments are protected and that they are provided reliable and fair compensation for their risks. Likewise the measures will ensure the protection of the environment, preservation of the geothermal natural resources, and the appropriate compensation for host governments. It is expected that such policies and regulations will be adopted in each of the project dountries, by the time the resource assessment and financing tools are established, such that the sustainable development of locally sourced geothermal power will result.

Draft policies have been prepared for each participating country. Implementation of the comprehensive resource evaluation, establishment of the drilling risk fund, and adoption of policies and regulations is pending.

7. FRAMEWORKS

7.1. Regulation

Regulation considerations for mini-grid systems need to be approached differently from grid connection/extension. Key approaches are detailed below, and are largely based on the detailed ESMAP report on off-grid regulatory issues,[7] the ESMAP Best Practice Manual on the promotion of decentralized electrification investment[8] and the ESMAP report of promoting electrification.[9]

- Adopt light handed and simplified regulation – particularly procedures and processes for mini-grid systems/other off-grid electrification. Establish an enabling regulatory framework that has clear separation of responsibilities. A clear separation of responsibilities requires that separate departments have distinct responsibilities for *(a)* planning, monitoring, policy setting, licensing and permits, *(b)* establishing/promulgating regulations, *(c)* compliance ("regulator"), and *(d)* conflict resolution, arbitration, and adjudication in cases where an involved party wishes to appeal a finding of the regulator.
- The national or regional regulator should be allowed (or required) to temporarily or permanently "contract out" or delegate regulatory tasks to other government and non-government entities. One scenario would see a national or provincial regulator delegating regulatory tasks to a rural electrification agency/fund that inevitably is the de-facto regulator because they are often more knowledgeable about the operations of electrification providers and are better able to weigh the costs and benefits of imposing regulatory requirements.
- The regulator should be allowed to vary the nature of its regulation (i.e. concessions vs. licences vs. permits) depending on the entity that is being regulated (small vs. large, grid vs. off-grid, private vs. community based).
- Quality of service standards must be realistic, affordable, easily monitored and enforced. It is counterproductive to try to impose quality of service standards that cannot be met, although this does not imply that quality of service should be ignored. Unfortunately, although everyone talks about improving quality of service, in practice quality of service often gets very little attention.

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[7] Reducing the Cost of Grid Extension for Rural Electrification. (2000b) ESMAP Report 227/00. Energy Sector Management Assistance Program (ESMAP), Washington, DC: World Bank. 2000

[8] Best Practice Manual: Promoting Decentralized Electrification Investment, Joint UNDP/World Bank ESMAP, October 2001.

[9] Promoting Electrification: Regulatory Principles and a Model Law. Reiche, Kilian, Bernard Tenenbaum, and Clemencia Torres, Joint Publication of ESMAP and the Energy and Mining Sector Board. World Bank: Washington, D.C., Paper n.º18, July 2006

- Legal rights and a level playing field for private sector participation: government regulations should permit private sector participants to entry the market for supply of electricity and ensure fair competition for all suppliers with respect to the traditional utility in competing for new customers.

7.2. Tariffs and subsidies

The key costs for any system are the capital and installation costs and the running costs, often designated as operation and maintenance costs (O&M). Particularly for mini-grid systems, which may require considerable control and management, the extra cost consideration of management costs is included in the running costs, to yield O&M&M costs

In practice the cost of providing electricity in any rural situation is high and the recovery of all costs through tariffs may not be viable, especially given the limited resources of the community. However, tariffs should be designed to cover O&M&M costs as a minimum, and preferably some of the initial investment costs. There is, in general, a practice to provide subsidies for rural electrification, but this is best applied to connection/access costs, not to ongoing consumption costs.

It is not uncommon for projects to set an acceptable tariff level, based on these principles and the ability to pay of the community, and then to define the level of subsidy required. Although for renewable energy mini-grid, with high investment costs and low operating costs, tariffs set in this way may be more attractive than those, for instance, for diesel systems, and hence it may be possible to add a tariff component towards the recovery of (or least part of) the investment. The balance must be between ensuring that the system is commercially viable and that the consumers can pay for the energy provided.

To summarize, for renewable energy mini-grids, an adequate tariff structure should:

- Recover at least O&M&M costs;
- Reflect, ideally, the configuration of the real cost of the system – a fixed charge (usually higher than typical tariff structures applied in large grid systems) to reflect fixed O&M&M costs, a variable charge to reflect fuel costs, and a levelized capital cost charge partially reflect capital investment costs;
- Remain below consumers' ability to pay;
- In addition, community involvement is critical for renewable energy mini-grids. Communities sometimes can pay up to 10–20 per cent of the capital investment of renewable energy mini-grid systems upfront in the form of labour, material, and cash contributions.

For these reasons a tariff may be replaced by a fixed monthly fee. There are other pricing/payment schemes such as pre-payment systems as well as new solutions for intelligent metering. Such tariffs can be differentiated by customer segment and ability to pay. Collection of any tariff also needs careful consideration.

Box 7. **Mexico encourages renewables**

Based on findings that remote self-supply projects offer good possibilities for renewable energy development, the government has created a new contract template for self-supply projects. The new contract offers energy banking, favourable wheeling charges and capacity recognition of self-supply projects with intermittent generation from renewable sources.

Mexico's current electricity law presents barriers for renewable energy development. The National Utility CFE does not apply a least-cost approach for acquiring energy from third parties and a number of benefits derived from the use of renewables (social, economical, and environmental) are not taken into account by the current legislation. In December 2005 the Mexican House of Representatives passed a Law for the Use of Renewable Energy Sources (known by its Spanish acronym LAFRE). The measure has now been sent to the Mexican Senate for its review and approval. The bill seeks to support a wide array of energy stakeholders such as public and private electrical utilities, companies, municipalities, and individuals. The new legislation contemplates the use of photovoltaic, hydro, tidal, geothermal, and biomass, biofuel or organic wastes as renewable sources of energy.

The new law authorizes the creation of incentives to promote the use of renewables. It creates a national Trust Fund (fideicomiso), funded by a mix of federal and international resources to support several targeted funds. The trust fund will provide an incentive to foreign direct investment, augment national government borrowing power, contribute in keeping interest rates stable, and improve the availability of credit for clean energy investments and for consumers looking to purchase clean energy products. The Secretariat of Energy (Secretaría de Energía – SENER) will be in charge of establishing further incentives, thus allowing the legislation to keep up with new opportunities for the advancement of renewables. SENER will also coordinate with the Ministry of Economy on a package of incentives to encourage manufacturing of renewable energy equipment in Mexico.

Some incentives only will be given to Mexican utilities, such as CFE and Luz y Fuerza del Centro (LFC), and to Mexican electricity generators (defined as Mexican individuals or entities organized under Mexican law and domiciled in Mexico). The bill recognizes the significance of renewables and the benefits it brings to the country's electrification.

Any subsidies and proposed tariff structures must be clear to allow potential investors/operators to make decisions. For instance a government will usually decide on subsidies, but a regulator can nullify government granted subsidies with low tariffs.

Discussion question

What institutional and framework support is offered to rural electrification, and specifically to mini-grid systems in your country? Are there other support mechanisms not covered here? What measures might be added to provide further support?

8. CONCLUSION

There are basically three options or scenarios for the provision of electricity to rural areas: utility network grid-connection via grid extension, stand-alone systems and distributed-grid systems (often known as mini-grid systems).

Distributed-grid or mini-grid systems are decentralized power plants, effectively larger stand-alone systems, supplying power to isolated groups of households, communities or even larger groupings. They involve a local grid-network for the supply of power.

There is now sufficient experience in a number of developing countries, particularly in Asia, providing successful examples of a wide range of renewable energy-based mini-grid systems. Energy systems usually incorporated into mini-grid systems are: hydro, wind, PV, biomass and diesel systems. Diesel engines are frequently combined with wind turbines and/or PV to form a hybrid system.

When choosing a power supply system for a rural community there are several technical and non-technical factors that have to be considered including: distance from the utility grid, system power losses, load characteristics, demand-side management, base/peak load issues, economics and billing and ownership and management. Other considerations are institutional and framework issues.

LEARNING RESOURCES

Key points covered

This module covers the following key points:

- Outline and brief description of the different scenarios for power supply to rural areas.
- Basic overview of the technologies for renewable energy based mini-grid systems, including wind, hydro and PV, biomass systems and hybrid systems.
- Information on requirements for successful implementation of renewable energy mini-grid systems.
- Discussion regarding institutional and framework issues which are required to support the implementation of mini-grid systems.

Answers to review questions

Question: What are the three scenarios available for the supply of electricity to rural communities?

Answer: Grid-connection/extension, stand-alone systems and distributed or mini-grid systems

Question: What are the advantages and disadvantages of each approach?

Answer: See table 1 for the issues and considerations.

Question: What are the key system layouts for renewable energy based mini-grid systems?

Answer: Hydro powered, hybrid (incorporating a combination of wind and/or PV and/or diesel) powered and biomass powered systems.

Question: Why are hybrid-powered systems attractive?

Answer: Hybrid systems have been shown to: provide electricity more cheaply than grid extension, be as or even more reliable than grid power, operate more effectively than diesel-only systems, be modular and relatively easily assembled from standardised packages. Renewable energy systems, and specifically wind and PV, have complementary characteristics for mini-grid systems when compared with diesel powered mini-grid systems, especially concerning operating costs, logistics burden and maintenance requirements see table 2.

Question: What are the four main institutional issues that are important for rural energy development in general and mini-grid systems in particular?

Answer: Government policy, effective implementing agencies, attracting investment/reducing risk and local institutional structures.

Presentation/suggested discussion topics

Presentation:

RENEWABLE ENERGY – Module 11: Distributed generation – Options and approaches

Suggested discussion topic:

1. Consider the pros and cons of centralised and decentralised ownership and management of rural power supply. How might the difficulties be mitigated?

2. What institutional and framework support is offered to rural electrification, and specifically mini-grid systems in your country? Are their other support mechanisms not covered here? What measures might be added to provide further support?

Relevant case studies

1. Policies for Sustainable Energy Solutions – Geothermal Power Development in the Eastern Caribbean
2. Mexico Encourages Renewables
3. Huarci, Barkol, Xinjiang, China: A Wind Power Village System Project developed by Harnessing a Poverty Alleviation Loan

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*China Village Power Project Development Guidebook – Getting Power to the People Who Need it Most, A Practical Guidebook for the Development of Renewable Energy Systems for Village Power Project*s, SETC/UNDP/GEF, Project CPR/97/G31 Capacity Building for Rapid Commercialization of Renewable Energy in China, 2004

Rural Electrification in the developing world: A summary of lessons from successful programs, Douglas Barnes and Gerald Foley, Energy Sector Management Assistance Program (ESMAP), Washington, DC: World Bank, 2004

Prospects for Distributed Electricity Generation, www.cbo.gov

INTERNET RESOURCES

World Bank Group Energy Program: worldbank.org/energy

World Bank site specifically providing information on and links to Mini-grid design tools: web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTENERGY/EXTRETOOLKIT/0,,contentMDK:20758111~menuPK:2069968~pagePK:64168445~piPK:64168309~theSitePK:1040428,00.html

International Energy Agency: www.iea.org

IEA International database of small hydropower resources: www.small-hydro.com/index.cfm?fuseaction=welcome.home

NREL (National Renewable Energy Laboratory) DOE, USA site providing examples (database), resource information and analytical models: www.nrel.gov/villagepower/

GLOSSARY/DEFINITION OF KEY CONCEPTS

Biogas	Gaseous fuel produced from animal and crop residues. A mixture of methane, carbon dioxide and water vapour.
Biomass	Solid fuels from a wide range of sources.
Capital cost	Price for initial purchase.
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Distributed generation	Decentralized power plant, effectively larger stand-alone systems, that supply power to isolated groups of householders, communities or even larger groupings. They involve a local grid-network for the supply of power. Otherwise known as distributed-grid or mini-grid system.
Distributed-grid system	See distributed generation.
Distribution losses	Electricity lost in the process of distribution of electricity to consumers including losses due to pilferage.
Distribution network	The network (wiring system) allowing electricity to be distributed from the site at which it is produced to the customers.
Electricity grid	The distribution network providing electricity, unless otherwise specified this is usually on a national or regional basis, from central generating plant.
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth. The fluids are extracted by drilling and/or pumping.

Grid extension	Lengthening of the distribution network of the electricity grid, usually to connect more consumers, probably further afield.
Grid-connection	Link to the electricity network
Hybrid	A power plant, having two kinds of components that produce the same or similar results.
Independent power producers (IPPs)	Privately owned power companies that produce electricity and sell it for a profit to the national grid or to a distribution utility.
Legal and regulatory framework (LRF)	Combination of the laws, institutions, rules and regulations governing the operations of the electricity industry.
Levelized costs	The levelized cost approach is a commonly used index of long-run costs and is defined as the net present value of all direct costs (for capital, fuel, and O&M) over the expected lifetime of the system, divided by the system's total lifetime output of electricity. This approach is often used to compare distributed generation technologies with one another and with utility costs and residential prices.
Mini-grid system	See distributed generation
Operating cost	Price for running a system
Small hydro	Small-scale power generating systems that harness the power of falling water (<10MW).
Solar photovoltaic (PV) technologies	Devices that convert the sun’s energy into electricity for use in lighting, refrigeration, telecommunications, etc.
Stand-alone systems	A system not connected to the electricity grid, usually of small capacity.
System losses	The power that is lost during generation, transmission and distribution of electricity.
Transmission lines	The wiring system that makes up the distribution network.
Transmission losses	The electricity lost in the process of transmission.
Utility company	An entity partially or wholly involved in electricity generation, transmission, and/or distribution.

Utility network	The distribution network of a specific utility (company).
Wind turbines	Devices used to generate electricity using kinetic energy from wind.

Case study 1.

POLICIES FOR SUSTAINABLE ENERGY SOLUTIONS – GEOTHERMAL POWER DEVELOPMENT IN THE EASTERN CARIBBEAN

CONTENTS

1. BACKGROUND

A multi-year initiative – the Eastern Caribbean Geothermal Development Project (Geo-Caraïbes) – was recently launched to overcome the barriers to development of geothermal energy in the Eastern Caribbean. The Geo-Caraïbes Project Countries – Dominica, Saint Kitts and Nevis, and Saint Lucia – possess world-class geothermal resources. Each country also faces critical electricity supply challenges, with prices among the highest in the world (approaching US$0.30/kWh). Despite the would-be obvious project potential, no geothermal power development has succeeded in these countries. Among the barriers to such development, is the lack of appropriate policies and regulations that establish the prerequisite conditions to attract competent commercial developers.

The Project is primarily funded by the Global Environment Facility (GEF), and is implemented by the United Nations Environment Programme (UNEP), and is executed jointly by the Organization of American States (OAS) and the Agence Française de Développement (AfD).

2. THE PROJECT

2.1. Challenge

The lack of development of indigenous energy resources is a primary constraint on the economies of many small island-developing states (SIDS), including those of the Eastern Caribbean. In many of the islands, imported fossil fuel for electrical generation and transportation accounts for a startling one-third of GDP. Despite the abundance of renewable natural resources – including geothermal – the Eastern Caribbean island states have to date been unsuccessful in transforming these resources into commercial power sources

2.2. Solution

The objectives of the Geo-Caraïbes Project are to overcome the barriers to the development of geothermal power, and to implement a regional strategy that will create the conditions for successful development of one or more commercially viable geothermal power plants in the Eastern Caribbean. The resulting electricity from this generation will supply the country(ies) where the project(s) is/are located, and will offer the opportunity to supply power to the neighbouring French islands – Guadeloupe and Martinique – via submarine cables. The critical barriers to geothermal development in the participating countries addressed by the Project include:

- Lack of capacity/knowledge regarding Geothermal;
- Geological resource risk;
- Economies of scale;
- Need for private capital;
- Inadequate policy and regulatory frameworks.

3. POLICIES AND ACTIONS

Among the most significant barriers to the commercial development of geothermal energy has been the lack of transparent and enforceable policies and regulations. Such policies and regulations must address key issues including:

- Governance of the geothermal resource;
- Access to land;
- Rights for independent power producers in an otherwise monopolistic utility structure;
- Arrangements for long-term power purchase agreements (PPAs);
- Rights and responsibilities with regard to the environment, safety and labour.

In addressing these matters, the Project has developed partnerships among energy stakeholders – including the government, electric utilities, energy consumers and commercial associations – to prepare legislative measures that will provide for the equitable treatment of project developers, ensuring that their investments are protected and that they are provided reliable and fair compensation for their risks. Likewise, the measures will ensure the protection of the environment, preservation of the geothermal natural resources, and the appropriate compensation for host governments. It is expected that such policies and regulations will be adopted in each of the Project countries, by the time the resource assessment and financing tools are established, such that the sustainable development of locally sourced geothermal power will result.

4. PROJECT DATA

Where and When: Dominica, Saint Kitts and Nevis, Saint Lucia. 2003 to 2010.

Initiated by: Participating governments, United Nations Environment Programme (UNEP), and the Organization of American States (OAS)

Effectiveness: Draft policies have been prepared for each participating country. Implementation of the comprehensive resource evaluation, establishment of the Drilling Risk Fund, and adoption of policies and regulations is pending (GEF Full Project Phase).

More Information: www.thegef.org

Contact to learn more: mlambrides@oas.org

Case study 2.

MEXICO ENCOURAGES RENEWABLES

CONTENTS

1. BACKGROUND

Besides policies hostile to clean energy implementation, Latin American countries face a host of major macroeconomic barriers to clean energy development. These include unstable currencies, current account deficits, tight access to private credit and high inflation. Mexico is among the first countries of the region seeking to establish a more favorable energy and macroeconomic marketplace for clean energy by taking several steps toward providing incentives to use renewable energy. A comprehensive analysis of Mexico's long-term renewable energy planning is to be published by the Government in mid-2006.

Based on the Government's findings that remote self-supply projects offer good possibilities for renewable energy development, the Government has created a new contract template for self-supply projects. The new contract offers energy banking, favorable wheeling charges and capacity recognition of self-supply projects with intermittent generation from renewable sources. Projects with a combined capacity of no less than 1300MW have already been granted permits.

With the support of bilateral and multilateral donors, the Government is developing a renewable energy risk reduction valuation technique and a method to assess the contribution of intermittent sources to grid capacity. Instruments to enable small-scale self-supply are being developed and transmission models that incorporate wind power into the electricity sector are being designed.

2. PROJECTS DEVELOPING IN MEXICO

With support from the Global Environment Facility (GEF), the Government developed the Large-Scale Renewable Energy Development Project and the Action Plan for Removing Barriers to the Full-Scale Implementation of Wind Power. The Mexican utility Comisión Federal de Electricidad (CFE) is also implementing several wind and geothermal projects.

All these new measures are part of an overall scheme to diversify Mexico's energy matrix and augment the share of renewables in electricity generation. Furthermore, they are a necessary step toward meeting the country's growing energy demand, improving the people's quality of life, and responding to Mexico's international commitments regarding the reduction of greenhouse gas emissions.

3. LARGE-SCALE RENEWABLE ENERGY DEVELOPMENT PROJECT

With support form the GEF, the Mexican Government initiated the Large-Scale Renewable Energy Development Project. Through the implementation of this initiative, Mexico expects to stimulate the commercialization of renewable energy applications and markets, particularly at the grid-connected level, in order to reduce greenhouse gas (GHG) and other emissions while responding to increasing energy demand and energy diversification imperatives necessary for sustained economic growth. The project proposes a two-phase, single project approach to address key policy and tariff issues currently hindering renewable energy development, and facilitate initial investments with use of GEF support in a competitive financial mechanism to overcome initial investment barriers.

The project aims to reduce global carbon dioxide emissions by 4 million tonnes (Mt) per year by promoting the development of a commercial wind energy market in Mexico. The project will reduce identified barriers to wind energy development. As a result, institutional, legal and regulatory frameworks of the electricity sector are being revised so that they provide a more level playing field for wind energy.

4. LAW FOR THE USE OF RENEWABLE ENERGY SOURCES

Mexico's current electricity law presents barriers for renewable energy development. The national utility CFE, does not apply a least-cost approach for acquiring energy from third parties and a number of benefits derived from the use of renewables (social, economical, and environmental) are not taken into account by the current legislation. In December 2005 the Mexican House of Representatives passed a Law for the Use of Renewable Energy Sources[1] (known by its Spanish acronym LAFRE). The measure has now been sent to the Mexican Senate for its review and approval. The proposed legislation would lead to the removal of renewable energy barriers. The bill seeks to support a wide array of energy stakeholders such as public and private electrical utilities, companies, municipalities and individuals. The new legislation contemplates the use of photovoltaic, hydro, tidal, geothermal, and biomass, biofuel or organic wastes as renewable sources of energy.

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[1] Ley para el Aprovechamiento de Fuentes Renovables de Energía (LAFRE)

The new law authorizes the creation of incentives to promote the use of renewables. It creates a national Trust Fund (Fideicomiso), funded by a mix of federal and international resources to support several targeted funds. The trust fund will provide an incentive to foreign direct investment, augment national government borrowing power, contribute in keeping interest rates stable, and improve the availability of credit for clean energy investments and for consumers looking to purchase clean energy products. The Secretariat of Energy (Secretaría de Energía – SENER) will be in charge of establishing further incentives, thus allowing the legislation to keep up with new opportunities for advancement of renewables. SENER will also coordinate with the Ministry of Economy on a package of incentives to encourage manufacturing of renewable energy equipment in Mexico.

Some incentives will only be given to Mexican utilities, such as CFE and *Luz y Fuerza del Centro* (LFC), and to Mexican electricity generators (defined as Mexican individuals or entities organized under Mexican law and domiciled in Mexico). The bill recognizes the significance of renewables and the benefits it brings to the country's electrification system both in the short and the long term. It complements the current legal framework and is consistent with the Public Electric Utilities Law.[2]

5. CONCLUSION

By passing this bill, the Mexican Government expects to increase the quality and reduce the costs of renewable energy technologies (components, systems, and services) by expanding markets for the Mexican renewable energy industry; increase the use of clean energy sources to combat global climate change and protect the natural environment by limiting pollution; and increase the economic, social and health standards in rural, off-grid households and communities by utilizing renewable energy systems for productive applications.

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[2] Ley del Servicio Público de Energía Eléctrica (LSPEE)

Case study 3.

HUARCI, BARKOL, XINJIANG, CHINA: A WIND POWER VILLAGE SYSTEM PROJECT DEVELOPED BY HARNESSING A POVERTY ALLEVIATION LOAN

CONTENTS

1. BACKGROUND

Huaerci is a village located at an altitude of 1600 m in Barkol County, which has 90 households with 360 Kasac inhabitants. In this village, husbandry is the main economic activity and the monthly average income is below the national poverty line (circa of 400Yuans (approx. US$ 50) per capita in 2000). This village had no electricity and utilizes candles to provide light at night. The nearest electricity grid is situated 110 km away, and the distance and topographic conditions make it impossible for the grid to be extended in order to supply electricity to Huaerci village.

However, the annual wind speed of 8.3m/s and average insulation of 3100 hours per year present an opportunity for renewable energy resources to be utilized to solve the lack of electricity problem of the village.

2. SYSTEM CONFIGURATION

In 2000, a single wind power system (WPS) of 10kW with 55kWh battery bank and 7.5kW DC-AC inverter was installed in the village to supply electricity. This system provides power to the 90 households 24 hours a day. With electricity availability, ten colour TVs, more than 30 black/white TVs and one CD player have been purchased by the village residents. The total residential load is about 5kW, and monthly power consumption is about 300kWh, with 45kWh consumed additionally by the institutional loads.

3. FINANCING AND MANAGEMENT

A government-subsidized loan for the people, with a 3 per cent interest rate and five-year loan term, was arranged for the project by the county Poverty Alleviation Office (PAO).

Within this system a 1.2Yuans/kWh (US$ 0.16/kWh) tariff is charged to all consumers, and most of this revenue is used for maintenance costs. Also a village power management committee made up of village government officials, representatives of villagers and the deputy director of the border control station has been formed.

4. IMPACTS OF THE PROJECT AND POLICY AND LEGAL CONTEXT

To the complete satisfaction of the government and the village residents, the system has run very well. Furthermore, it has greatly improved the quality of life of village residents and allows children to study in the evenings. However due to the limited system capacity, no productive loads are served to date and education should be provided to the residents in order to make full use of their system, especially for productive uses.

As already mentioned, Huaerci is a neighborhood of Barkol County. Once RE systems have been seen as a way to achieve combined poverty alleviation actions with rural electrification programmes, the Barkol government became interested in developing stand-alone RE systems for other remote communities. Thus since 1999, six villages have been powered by WPS systems and another two villages are planned to be electrified, each with 30kW WPS.

5. LESSONS LEARNED

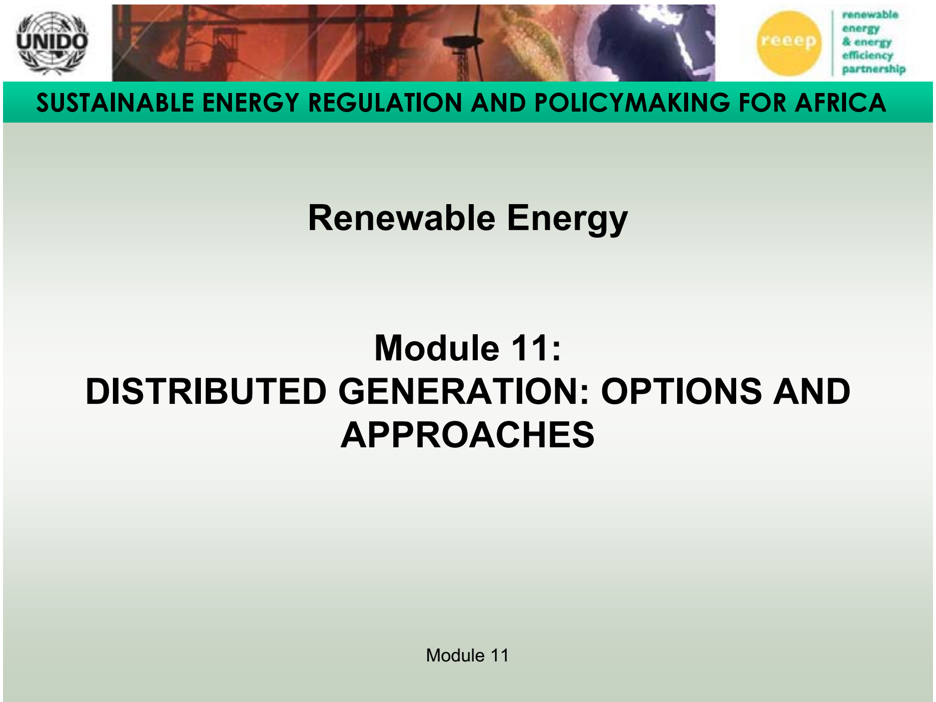
- Prediction and load analysis is important. A critical factor for cost recovery is proper system configuration to match the system load.
- The six village REVPSs provide a great opportunity to develop a multiple project management entity and to introduce a commercialized management model so as to ensure system sustainability.
- To place the system on a more commercial footing, productive load potential is needed.

6. SUSTAINABILITY AND REPLICABILITY

The initial investment costs of WPS systems are beyond local residents and local governments financing capacity and, sustainable operation is only possible if the system can be considered as a part of a utility extension programme, or financing is made available from upper levels of government or outside donors.

This type of system can be replicable elsewhere if:

- A good wind resource is available;
- The village is of reasonable size and preferably with opportunities for harnessing productive loads (the unit cost per installed capacity is indirectly proportional to the village size)
- The tariff structure is considered in order to maximize the system revenue;
- The technical operator not only runs the system but also provides some services to end-users and encourages wise electricity use.

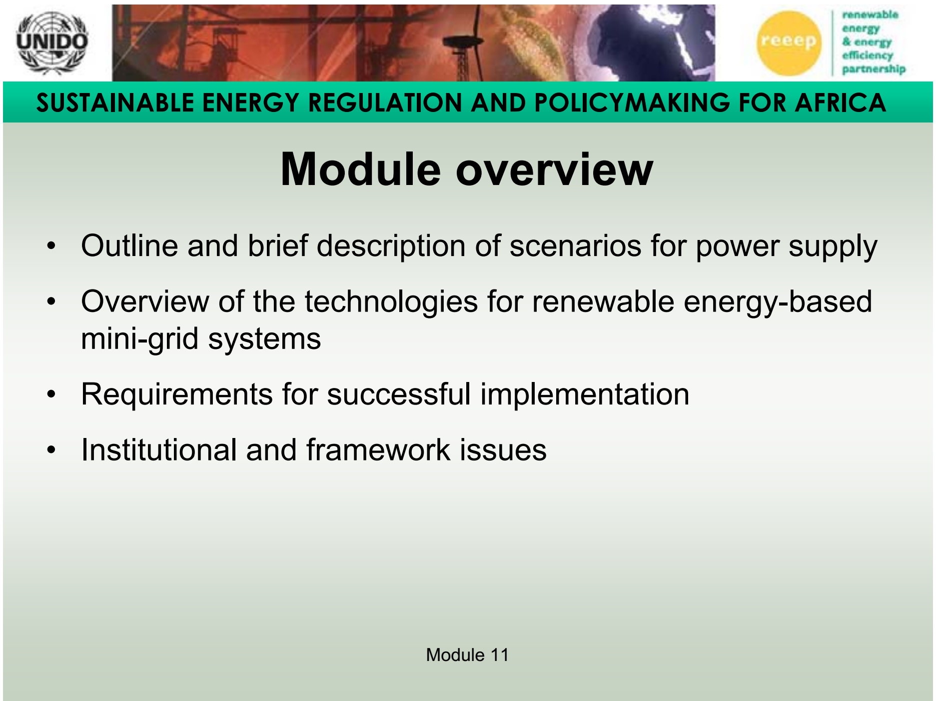


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Renewable Energy

Module 11:
DISTRIBUTED GENERATION: OPTIONS AND APPROACHES

Module 11

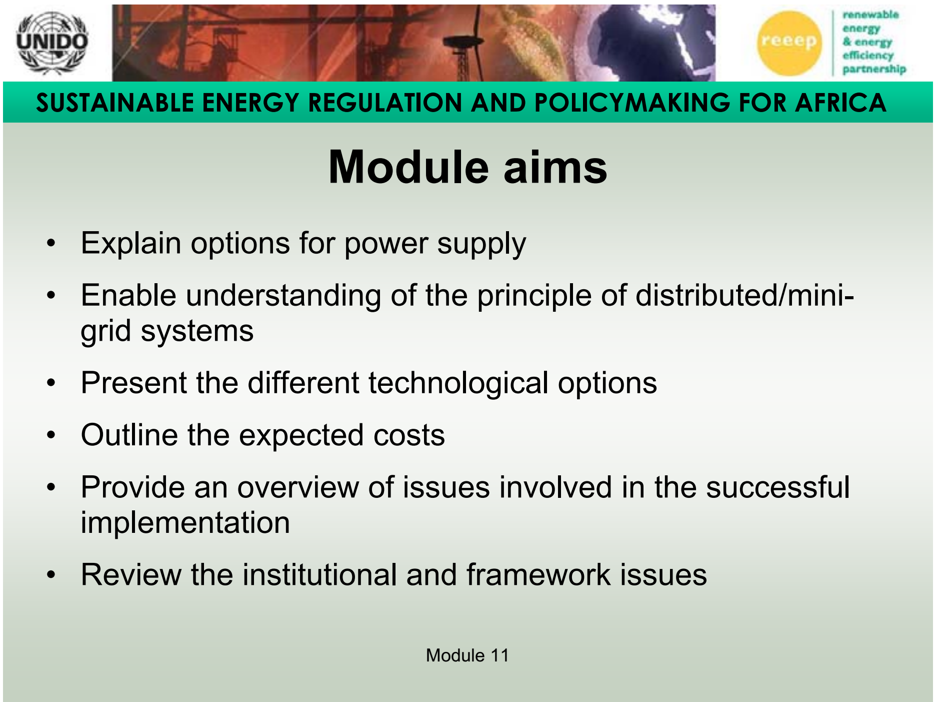


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Outline and brief description of scenarios for power supply
- Overview of the technologies for renewable energy-based mini-grid systems
- Requirements for successful implementation
- Institutional and framework issues

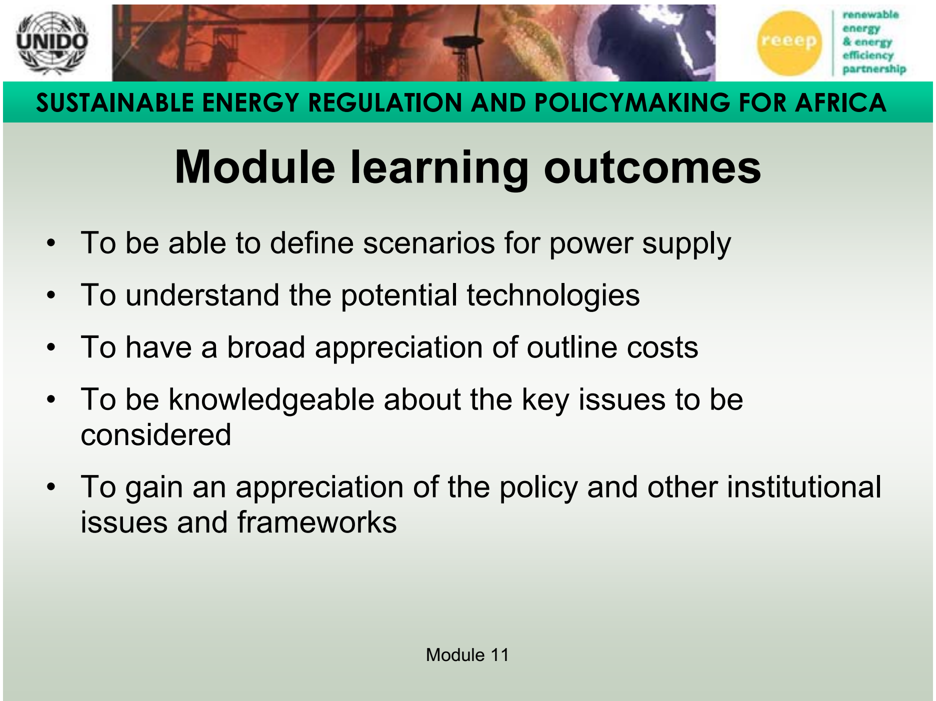
Module 11



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

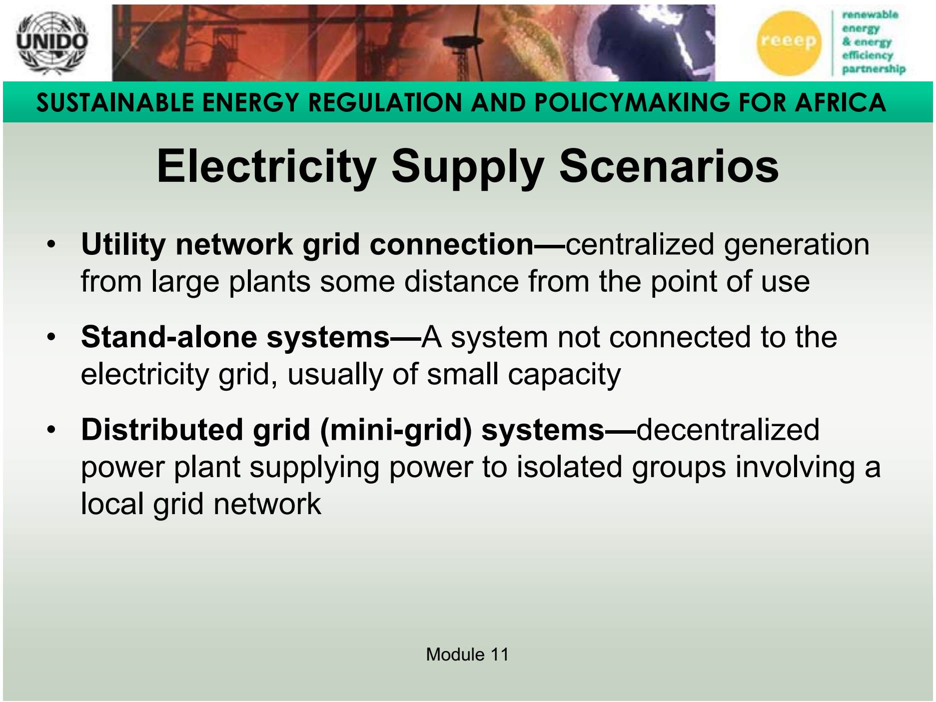
- Explain options for power supply
- Enable understanding of the principle of distributed/mini-grid systems
- Present the different technological options
- Outline the expected costs
- Provide an overview of issues involved in the successful implementation
- Review the institutional and framework issues



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define scenarios for power supply
- To understand the potential technologies
- To have a broad appreciation of outline costs
- To be knowledgeable about the key issues to be considered
- To gain an appreciation of the policy and other institutional issues and frameworks

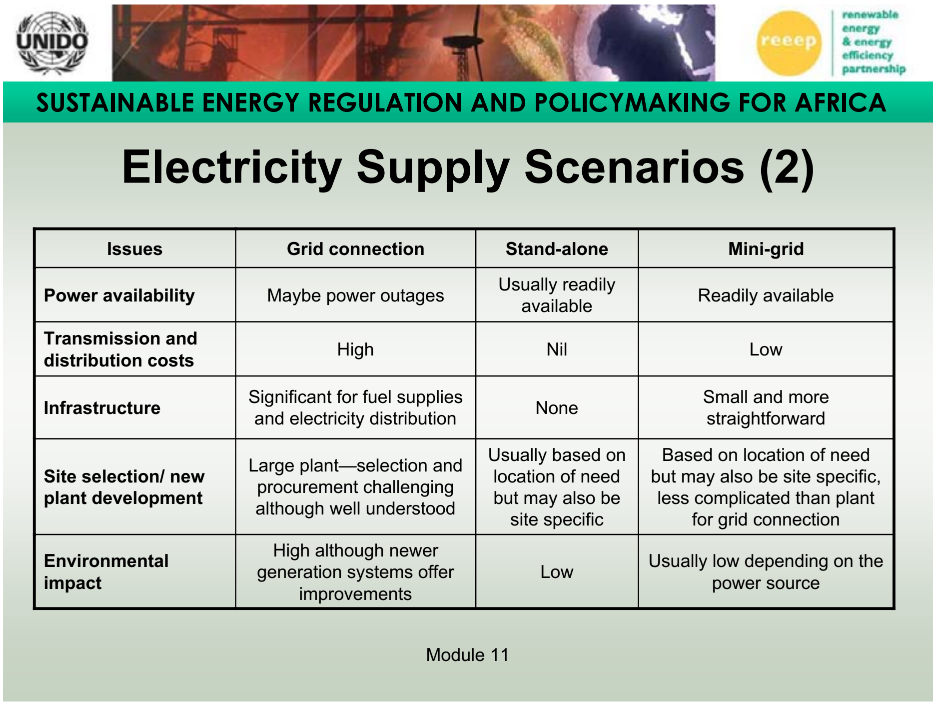


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Electricity Supply Scenarios

- **Utility network grid connection—**centralized generation from large plants some distance from the point of use
- **Stand-alone systems—**A system not connected to the electricity grid, usually of small capacity
- **Distributed grid (mini-grid) systems—**decentralized power plant supplying power to isolated groups involving a local grid network

Module 11

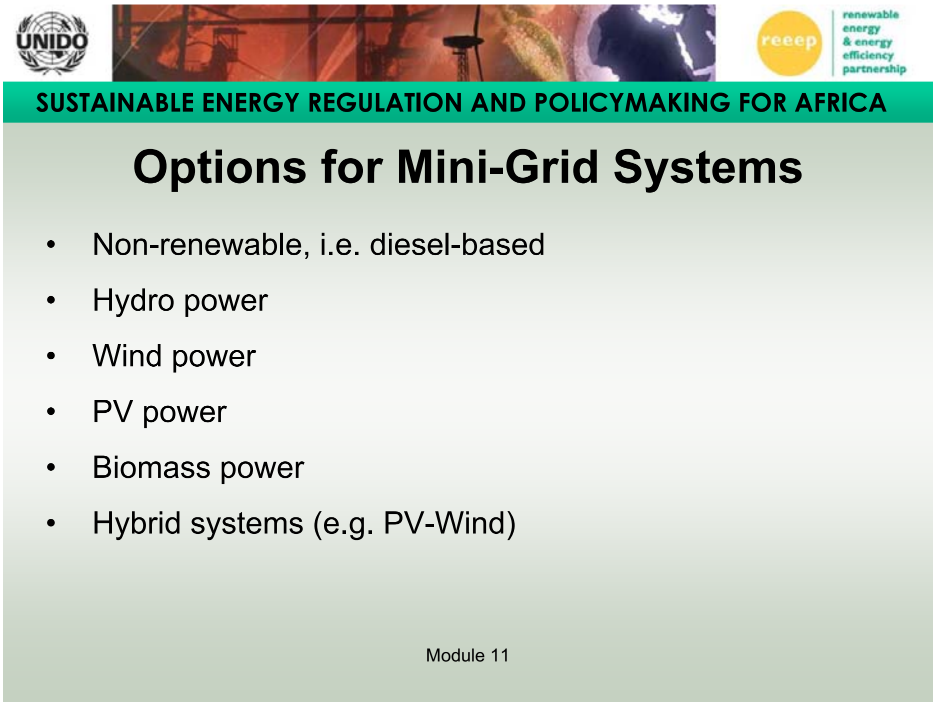


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Electricity Supply Scenarios (2)

Issues	Grid connection	Stand-alone	Mini-grid
Power availability	Maybe power outages	Usually readily available	Readily available
Transmission and distribution costs	High	Nil	Low
Infrastructure	Significant for fuel supplies and electricity distribution	None	Small and more straightforward
Site selection/ new plant development	Large plant—selection and procurement challenging although well understood	Usually based on location of need but may also be site specific	Based on location of need but may also be site specific, less complicated than plant for grid connection
Environmental impact	High although newer generation systems offer improvements	Low	Usually low depending on the power source

Module 11

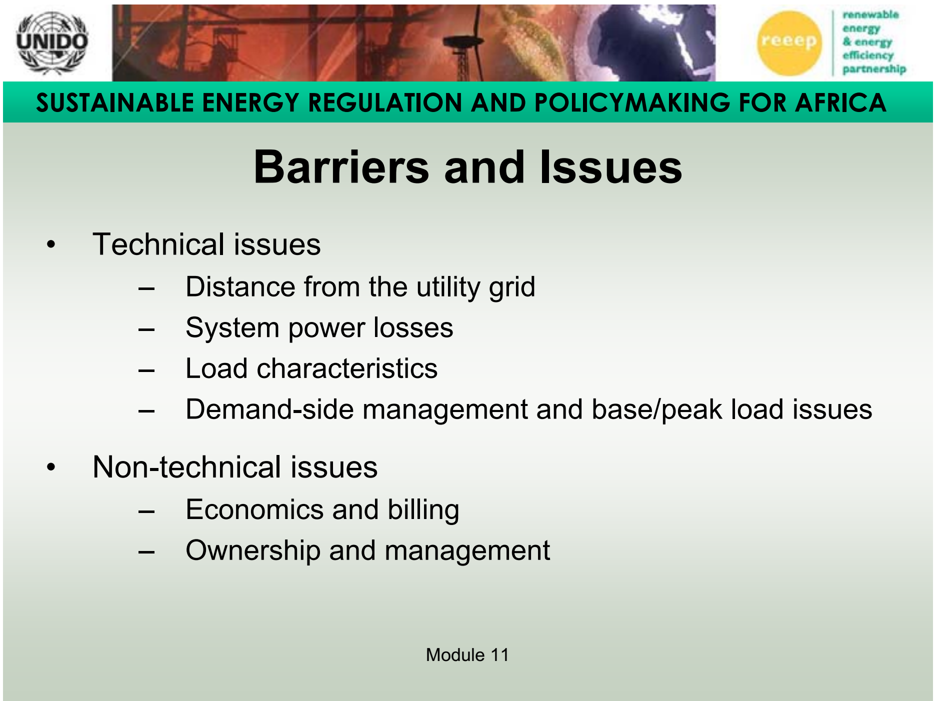


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Options for Mini-Grid Systems

- Non-renewable, i.e. diesel-based
- Hydro power
- Wind power
- PV power
- Biomass power
- Hybrid systems (e.g. PV-Wind)

Module 11



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Barriers and Issues

- Technical issues
  - Distance from the utility grid
  - System power losses
  - Load characteristics
  - Demand-side management and base/peak load issues
- Non-technical issues
  - Economics and billing
  - Ownership and management

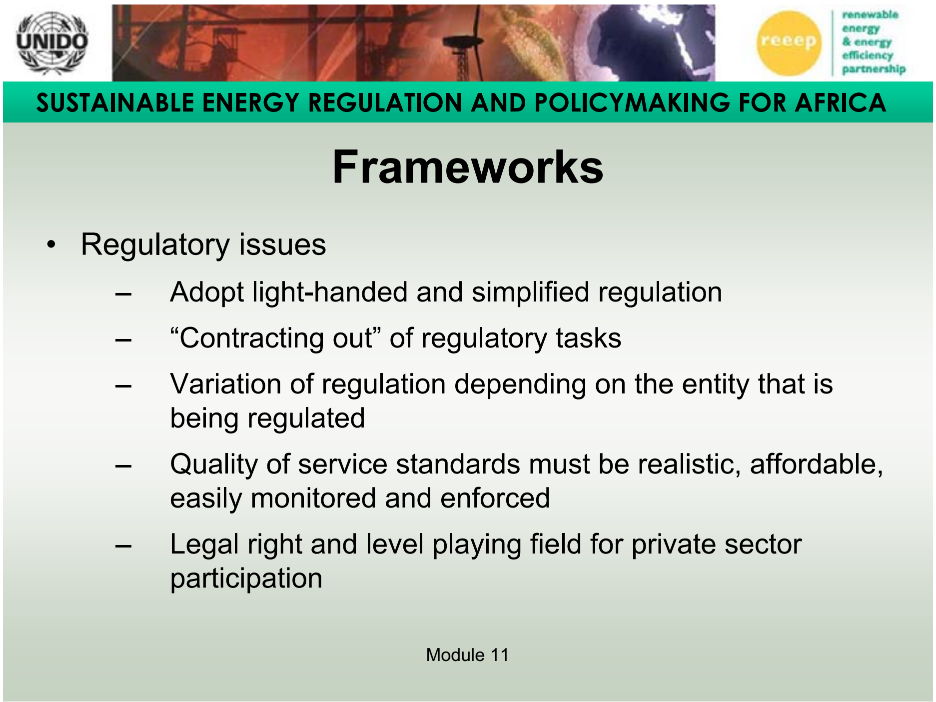
Module 11

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Institutional Issues

- Government policy
- Effective implementing agencies
- Attracting investment/reducing risk
- Local institutional structures

Module 11

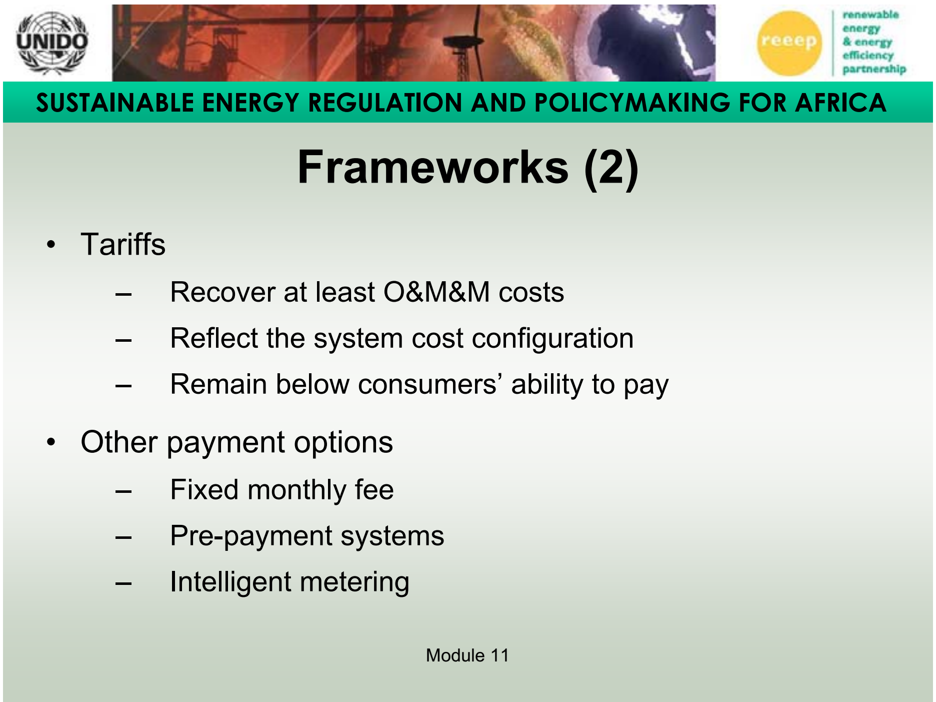


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Frameworks

- Regulatory issues
  - Adopt light-handed and simplified regulation
  - “Contracting out” of regulatory tasks
  - Variation of regulation depending on the entity that is being regulated
  - Quality of service standards must be realistic, affordable, easily monitored and enforced
  - Legal right and level playing field for private sector participation

Module 11

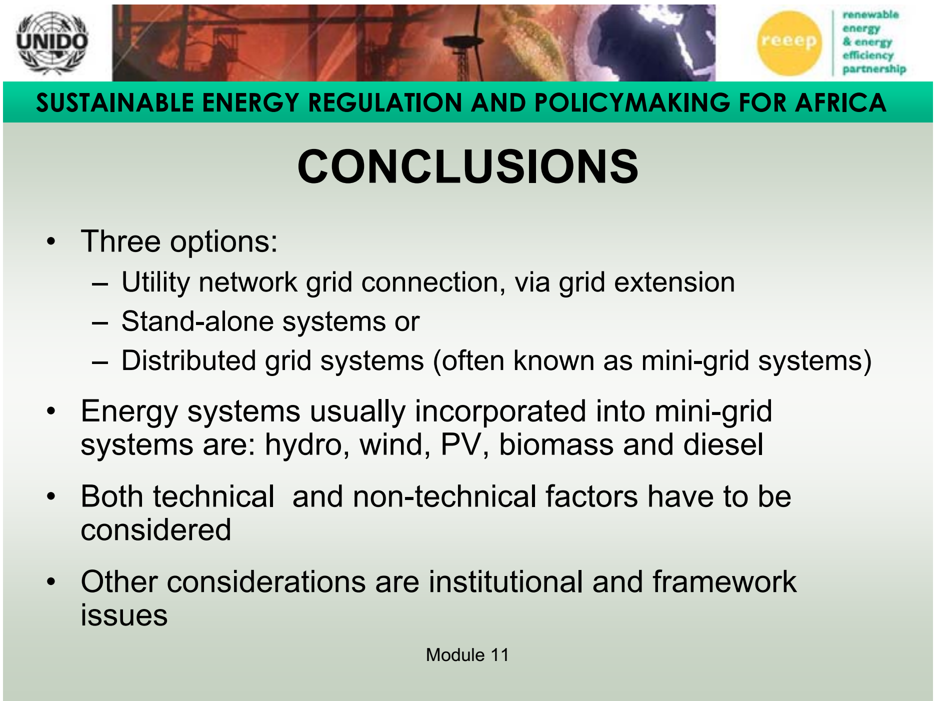


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Frameworks (2)

- Tariffs
  - Recover at least O&M&M costs
  - Reflect the system cost configuration
  - Remain below consumers' ability to pay
- Other payment options
  - Fixed monthly fee
  - Pre-payment systems
  - Intelligent metering

Module 11



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Three options:
  - Utility network grid connection, via grid extension
  - Stand-alone systems or
  - Distributed grid systems (often known as mini-grid systems)
- Energy systems usually incorporated into mini-grid systems are: hydro, wind, PV, biomass and diesel
- Both technical and non-technical factors have to be considered
- Other considerations are institutional and framework issues

Module 11

Module 12

Energy efficiency technologies and benefits

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This module introduces the concept of energy efficiency and some approaches—together with the associated technologies—to achieving higher energy efficiency for both energy supply and demand. It seeks to inform the reader about the real benefits which energy efficiency measures can unlock and aid the reader to understand why energy efficiency is a high priority in supporting greater sustainable energy supplies for development.

The module is particularly relevant to Africa, where levels of access to basic energy supplies are among the lowest in the world and where modest energy consumption can often have very high developmental benefits. By using energy more efficiently, African nations can maximize the effective use of available resources for the economic benefit of their populations.

1.2. Module aims

The aims of the present module are as follows:

- To introduce the concept of energy efficiency and how it may be applied for carrying out all types of energy-dependent activities, such as manufacturing products, heating/cooling buildings and transporting freight/passengers by rail;
- To indicate the benefits attainable by improving energy efficiency in both supply and demand;
- To outline a range of approaches to achieve increased levels of energy efficiency;
- To outline the typical barriers to enhanced energy efficiency.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

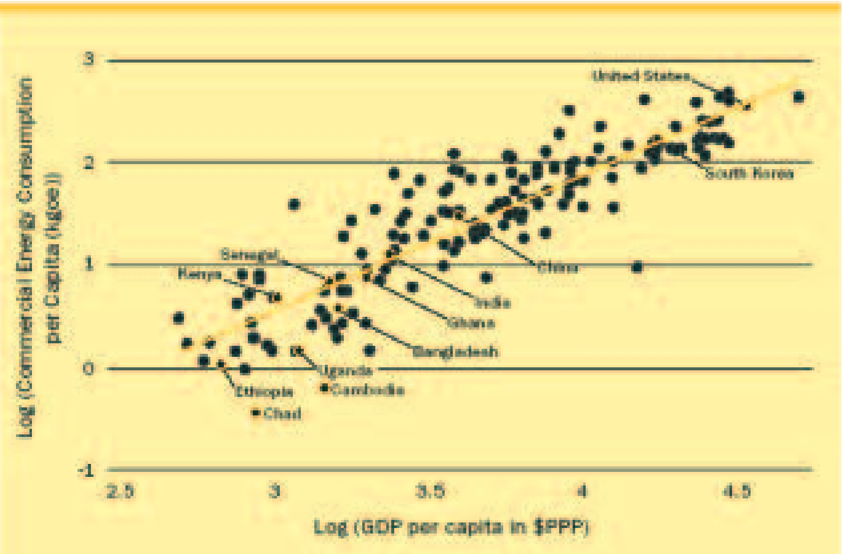
- To be able to define energy efficiency in all sectors of the economy;
- To understand the energy supply-demand chain;
- To appreciate the means of increasing energy efficiency throughout the supply chain and at the level of the energy consumer who is undertaking a specified activity;
- To appreciate the range of approaches and technologies available;
- To understand the typical barriers to achieving higher energy efficiency.

2. INTRODUCTION

2.1. Why is energy efficiency an issue?

Energy consumption is an essential element in development. This is illustrated in figure I below which is a plot of commercial energy consumption against GDP per capita and shows clearly higher energy consumption correlating with higher GDP per capita.

Figure I. **Commercial energy consumption and GDP, 2000**



Note: This is a log-log plot of per capita commercial energy consumption (kgoe) vs. GDP (in$PPP). In a log-log plot, the x- and y-axis numbers 0, 1, 2, 3, 4 ... correspond to 1, 10, 100, 1,000, 10,000...

Source: United Nations Common Database,2000.

While increased energy use clearly has many benefits, we are also becoming increasingly aware of the negative impacts of energy use. We experience these negative impacts globally and locally in the form of climate change (and the associated effects) and degradation of local environments in terms of—for example—poor air quality, degradation of soils (leading to desertification in extreme cases), resource depletion (e.g. water) and noise pollution.

However, more efficient use of energy at all stages of the supply/demand chain could reduce the negative impacts of energy consumption, while still allowing the same economic development. In addition, the inefficient use of energy generally implies higher than necessary operating costs to the customer (the energy end-user). At the company or enterprise level, higher energy efficiency will thus reduce operating costs and enhance profitability. At a national level, improved energy efficiency implies reduced energy imports, thus reducing foreign exchange pressures as well as increasing the availability of scarce energy resources for others to utilize, allowing increases in energy-dependent activities to contribute to the economic well-being of the population as a whole. Society as a whole also benefits from increased energy efficiency, principally through reduced adverse environmental impacts of energy usage.

Lastly, global primary energy resources (mainly fossil fuels) are finite and they will eventually be exhausted. They form part of the natural capital on which our lives—and economies—depend. However, their accelerated use in recent years has only brought the date that they will run out closer and reduced availability and higher costs have increased the pressure on countries that rely on fossil fuel imports. Sustainable future development depends on using these resources wisely and maximizing the benefit received for each unit of energy consumed.

2.2. What do we mean by energy efficiency?

Energy efficiency is understood to mean the utilization of energy in the most cost effective manner to carry out a manufacturing process or provide a service, whereby energy waste is minimized and the overall consumption of primary energy resources is reduced. In other words, energy efficient practices or systems will seek to use less energy while conducting any energy-dependent activity: at the same time, the corresponding (negative) environmental impacts of energy consumption are minimized.

Various ways of defining energy efficiency are discussed below in box 1. It can be appreciated that energy efficiency is a broad term and there are various ways of using it in the real world. The specific definition depends on the context and—in whatever way it is used—it represents a ratio of output to energy input (or of course the inverse, energy input per defined output).

Box 1. **Defining energy efficiency**

Energy efficiency is a term that is used in different ways, depending on the context and possibly on the person using the term. The strict technological usage relates an energy output to an energy input, and is used typically by engineers for machines and equipment. Thus, the energy efficiency of an electric motor is the ratio of mechanical output (that is, the work done using the motor) to the electrical input. Quantities must be expressed in the same units, e.g. kilowatt-hours per day, and the result—a dimensionless number—is conventionally expressed as a percentage. This approach is used extensively in industrial plants and buildings for a wide range of equipment including motors, pumps, compressors, furnaces and boilers. For boilers, for example, the efficiency might be say "85 per cent", meaning that 85 per cent of the energy value of the fuel has been converted into useful steam (and the sum of various losses is thus 15 per cent).

For many manufacturing processes and other energy-dependent activities such as the operation of passenger and freight vehicles, comparing input and output in the same units to derive a dimensionless number is not a practical approach. The "technical" definition is therefore little used for many types of energy efficiency analysis. In many real situations, energy efficiency is most often expressed as a surrogate, the ratio of energy input to the "output" from a specific activity. Thus in industry, the energy efficiency of a cement kiln can be expressed as X thousand litres of oil fuel fired per ton of clinker produced, and that of a rolling mill as Y tons of standard coal per ton of steel rebar manufactured. For the transport sector, the energy efficiency of a truck can be expressed as Z litres of diesel oil per ton-km of freight transported, and of a city bus as W litres of gasoline per thousand passenger-km achieved. Such indicators are often called "specific energy consumptions" and are widely used to compare energy efficiency across plants, buildings, transport vehicles and modes.

In practical situations therefore, to monitor energy efficiency over time, we need to relate energy consumption to a specific level of activity or output. The indicators used to express energy efficiency are not percentages but will have defined units, and changes observed from one time period to another will indicate if the activity is being carried out more or less efficiently—other factors remaining unchanged (e.g. no change in a manufacturing process, no fuel switching, similar weather conditions, etc.)

At national level, the term "energy efficiency" is not often used. Rather, "energy intensity" is typically adopted. Energy intensity is the ratio of energy consumption to some measure of the demand for energy-related activities, and it can be applied to an entire sector of the economy. An example is the energy intensity of say the industrial sector of a country, expressed as X joules per unit of GDP generated by that sector. Sometimes the energy intensity is expressed entirely in monetary terms, e.g. energy expenditure of Z dollars per dollar of GDP. Thus energy intensity—similar in many respects to the energy efficiency concept illustrated for processes or transport—will typically include structural and behavioural components. Changes in the sector—such as shifts in the types of product manufactured—will impact on the energy intensity, irrespective of changes in energy efficiency of the plants, processes and machines involved.

Other terms seen in reports worldwide include energy conservation and energy saving. These too are defined in a variety of ways and need to be used with care. Energy conservation tends to be associated—often wrongly—with "deprivation" of some sort, such as lower levels of comfort in buildings, lower industrial production levels. Energy saving generally means a lower consumption of energy and this may or may not be accompanied by changes in the quality or quantity of an output or activity.

Reference: A useful introductory discussion of energy efficiency definitions and terms is given in www.eia.doe.gov/emeu/efficiency/definition.htm

2.3. Who should be concerned with energy efficiency?

The impacts of energy use affect all of us and consequently, we should all be concerned about how to use energy more efficiently. However, the main bodies responsible for defining national approaches to energy efficiency are typically government agencies, whose responsibilities will usually include:

- Enacting legislation relating to energy efficiency if required, including defining an oversight role for energy regulators, when relevant.
- Deciding the state budget for promoting and conducting energy efficiency activities and programmes for the general public, including tax or other incentives when appropriate.
- Promoting energy awareness and disseminating useful information on energy efficiency measures and on recommended procedures for all sectors of the economy.
- Allocating the budget and carrying out energy efficiency programmes in relation to government-owned assets, e.g. government buildings, vehicle fleets. These actions will serve as examples of good practices for others to follow.

The government usually takes a lead role in promoting energy efficiency because of the diverse and essential role that energy plays in the national economy, and because government often has a major responsibility for long-term energy planning to meet the needs of society as a whole. The government is also in a special position to address many of the barriers to higher energy efficiency, including the key barrier formed by lack of reliable and timely information for all sectors.

In most countries, the main agency involved will be the Ministry of Energy, with other agencies and ministries also involved in specific areas of energy supply and consumption (e.g. agencies such as a Ministry of Energy and Mines, Ministry of Industry, Ministry of Public Works and Construction, Ministry of Public Utilities and Ministry of Finance, depending on the government structure in each country). In some countries, there are regulators to oversee the operations of oil, gas, electricity and water supply companies, in the private or public sector. These regulators may have responsibilities for observing the efficiency of supply activities and for taking efficiency into account in the setting of energy (and water) prices and tariffs.

Other organizations with a strong interest in improved energy efficiency are known as “stakeholders”. While this could cover the entire population, the main stakeholders are usually deemed to include industrial enterprises, industry associations, transport companies, owners of major commercial and other buildings (e.g. schools, hospitals), financial organizations, equipment manufacturers, gas and electric utility companies, and fuel supply companies. Many will themselves be energy consumers who have a direct incentive to improve energy efficiency and increase profits by cutting energy costs.

Thus while government has a role to play in establishing the right “environment” to promote energy efficiency, it is generally true that initiatives for carrying out energy efficiency actions will be taken by private firms and individuals. There may also be some government agencies responsible for energy-consuming activities, e.g. operating government buildings, running schools and universities, building and operating hospitals. These agencies should be required to carry out energy efficiency activities and investments themselves (possibly with the assistance of private-sector subcontractors). In the main, however, improved energy efficiency in most parts of the economy will often be achieved by the efforts of companies that have an interest in increasing their profits.

To some extent this applies to the domestic sector, where higher efficiency appliances will normally be promoted by manufacturers and their agents and importers. Nevertheless, individuals also have a responsibility for ensuring that they operate and maintain household equipment properly, and that they are aware of energy waste in the home caused by behavioural “deficiencies”, e.g. forgetting to switch off lights when not needed, and setting thermostats too low in air conditioned premises (or too high in heated buildings).

This module describes a range of energy efficiency approaches (including management actions and technologies) and the associated benefits to enable these major stakeholders to understand and implement more effective energy efficiency programmes within their own areas of responsibility.

3. THE BENEFITS OF INCREASED ENERGY EFFICIENCY

There are many benefits of increased energy efficiency. These can broadly be categorized into financial/economic, environmental and social benefits. The relative importance of each of these benefits depends on the actual situation in a given country or area, including for example the prices of different types of energy, the cost of energy efficiency measures and equipment, the tax regime and the current levels of energy efficiency already being achieved.

For private companies, the most important benefits of higher energy efficiency will be linked to the financial benefits of lower costs for running the business (see box 2). This applies to typical manufacturing companies as well as to energy suppliers such as electricity generating plants and oil refineries. Examples are:

- Energy efficient companies can gain a competitive advantage over less efficient companies, allowing them to increase their profits at current product prices, or lower their prices to gain market share, or a combination of these items.
- Utility regulators may require utility suppliers to reduce their prices to consumers, with the benefits of higher operating efficiency shared between energy producers and consumers for mutual benefit (and for the overall benefit of society).
- Reduced environmental impact can also serve as a significant marketing tool for efficient companies, as public perception of “green” companies takes an increasing role in purchasing decisions. Environmental benefits include many elements, such as reduced local pollution through burning less fuel, lower greenhouse gas emissions, less use of firewood and hence less destruction of forests.
- Even where company output is increased (e.g. through expanding manufacturing capacity) energy efficiency improvements can contribute significantly in most cases to reducing the negative impact of energy consumption per unit of output. Any increase in pollutant emissions will thus be minimized.

At a national level, these kinds of benefits could reduce the dependence of a country on imported energy, or could extend the life of energy reserves where present. These are worthwhile contributions to the national economy, often achievable at modest cost to the companies involved, and little or no cost to the government itself.

Box 2. **The business benefits of energy efficiency**

In most businesses, the initial stages of raising energy efficiency can be achieved through little or no capital investment. Correct and timely maintenance can have a substantial effect on improving energy efficiency (e.g. replacing broken or inadequate insulation on hot or cold piping). Boilers and furnaces can usually be operated more efficiently by ensuring the proper combustion conditions are maintained at all times. In some factories or buildings, the boiler/furnace operators might lack the necessary skills (and proper testing instruments) to know how this may be achieved. However, training programmes and the installation of a few simple low-cost devices could typically pay for themselves in a matter of a few weeks.

High efficiency light bulbs are another example of a modest investment that typically pays off in a very short time.

Of course, some major investments in energy efficiency improvements—e.g. new process equipment, totally new boilers—are well justified in financial terms and can often be undertaken by a business to produce big increases in profits. Large investments in new equipment will often be accompanied by increases in manufacturing capacity, and hence the benefits are not strictly limited to energy reduction. At the same time, new equipment may provide a safer and cleaner environment for the workers in addition to achieving higher energy efficiency.

Overall, higher energy efficiency brings lower operating costs to almost all businesses, allowing an “efficient” company to gain a competitive edge over more wasteful competitors.

In addition, as noted in the main text, a resource-efficient business demonstrates a responsibility towards the environment. This can be used to promote the business as an environmentally friendly business and this can be a strong marketing message.

Finally, we should note that businesses can be encouraged to undertake energy efficiency investments through various forms of tax incentives. Many of these are oriented to increasing the rate of depreciation for certain categories of efficient equipment or processes. In some countries, a lower consumption of energy can lead to a reduction in the company’s tax burden.

4. WHERE DOES ENERGY EFFICIENCY FIT IN TO THE OVERALL ENERGY MIX?

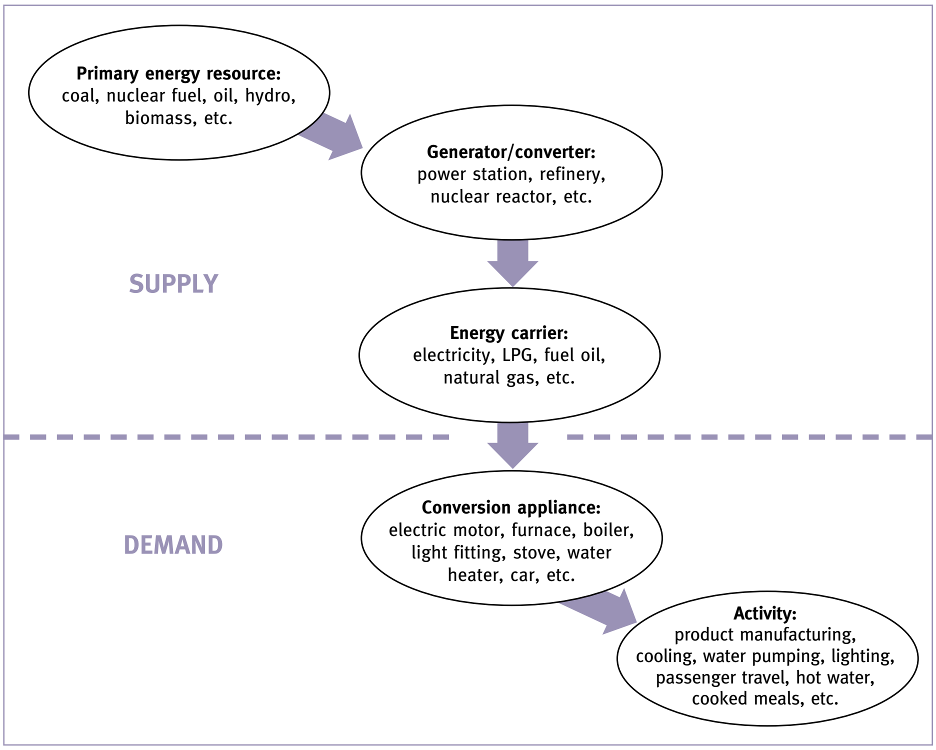
To appreciate the importance of energy efficiency, we must understand where energy efficiency fits into the overall energy picture and where the main energy losses occur.

4.1. Energy-dependent activities and the energy supply chain

All so-called end-users use energy to carry out an "activity", such as manufacturing a product, transporting goods or passengers, cooking a meal or providing light. Customers are generally not particularly interested in the details of how the energy is provided to them, rather they are interested in the utilization of energy within their own activities and how they may operate safely and efficiently to produce the required output, and for a low, or at least acceptable, cost. Of course, the energy supply companies themselves have relatively broad interests covering both supply and demand aspects of energy use.

It is useful to understand the overall supply/demand chain for providing the energy to an energy consumer and carrying out a specific activity (see below).

Figure II. **The energy supply-demand chain**



4.2. Energy losses

Inefficiencies can occur at any stage of the supply-demand chain. For example, the overall efficiency of a conventional electricity generating plant—even if well operated—can often be little more than 30 per cent, while a poorly operated coal fired boiler might struggle to reach 50 per cent efficiency. The energy losses can thus be significant throughout the chain. Losses can be divided into two main types:

- Intrinsic losses, i.e. unavoidable losses such as those that are a function of the activity and depend on thermodynamic and physical laws. For example, electricity distribution lines (and steam pipelines) will always have some associated losses, even if properly sized (or well insulated).
- Avoidable losses, i.e. losses resulting from sub-optimal/poor design, maintenance and operation of systems (steam leaks, non-insulated lines, inadequately sized electricity wiring, incorrectly adjusted combustion equipment, etc.).

The avoidable losses in the supply-demand chain will result in missed opportunities, requiring additional primary energy resources to be consumed in achieving the required output from a given activity. In addition to added costs, there will be a corresponding increase in environmental degradation.

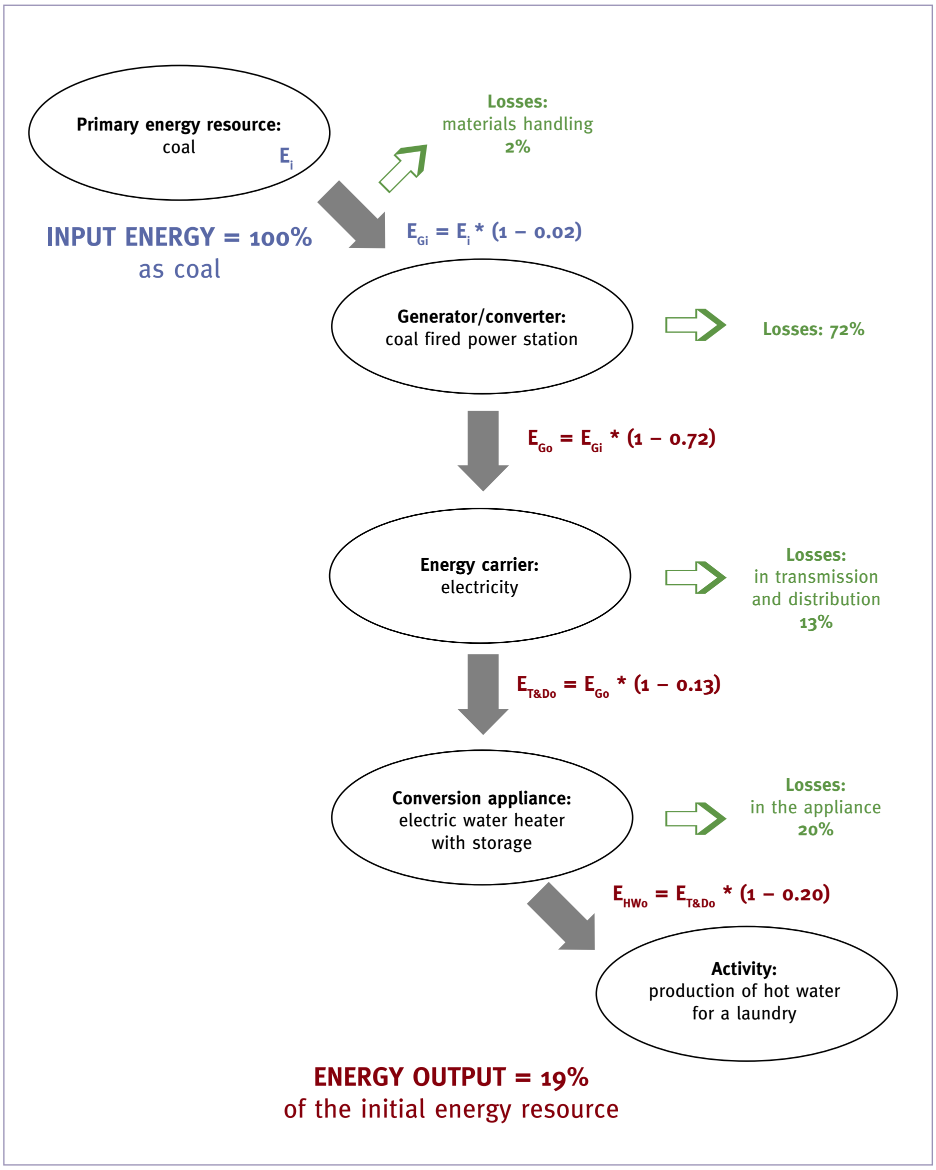
Raising the energy efficiency of all steps in the supply-demand chain is of course the means by which we can reduce energy losses. In the short term, improving energy efficiency addresses directly the so-called avoidable losses but, in the long term, we may be able to address the “unavoidable” losses to a degree. For example, we may be able to redesign a process or item of equipment to ensure the losses that are built-in for technical reasons are kept to the minimum.

Practical experience suggests that the avoidable losses are typically much more significant that the “technical” losses. Major losses occur in all sectors of the economy from the use of old and inefficient technologies or outdated processes. With very few exceptions, however, of even greater importance are the avoidable losses that result from poor management of plants, processes and equipment, and—in many cases—from inappropriate behaviour of energy consumers.

As an example of typical system losses, figure III below illustrates the provision of hot water for a laundry using coal-based electrical energy.

Figure III shows four key steps of hot water production and the various losses associated with each step. The numbers are illustrative and represent typical numbers found in practice, although there could be wide variations from plant to plant. Losses accumulate over the four steps because:

Figure III. **Example of energy losses in hot water production**



- Handling of the coal results in a loss of 2 per cent (lost to the area around the plant, lost in loading and unloading trucks, etc.);
- The power station is actually operated at about 28 per cent overall efficiency (losses of hot combustion gases from the stack, warm cooling water discharges, mechanical inefficiencies in turbines and generators, etc.);
- The transmission of electricity to the location of the hot water production and distribution within the generator plant itself is only 87 per cent efficient overall (mainly losses in lines and transformers);

- The efficiency of the water heater at the laundry is 80 per cent (heat losses are experienced from the boiler, storage tanks and pipe work).

The cumulative losses over the four stages thus amount to over 80 per cent of the original coal energy content. In terms of efficiency, the overall efficiency is:

$$0.98 \text{ x } 0.28 \text{ x } 0.87 \text{ x } 0.80 \quad = \quad 0.191 \quad \text{(or 19.1\%)}$$

The table below breaks down the results for each step:

Key steps	Energy input (energy units)	Step losses (per cent)	Energy output (energy units)	Corresponding efficiency (of the step per cent)
Step 1: primary energy resource	100	2	98	98
Step 2: power station	98	72	27.4	28
Step 3: electricity transmission and distribution	27.4	13	23.3	87
Step 4: water heater	23.9	20	19.1	80
Overall result	**100**	**80.9**	**19.1**	**19**

Efforts to improve energy efficiency can be undertaken in every step. For example:

- Material handling could perhaps be improved by better management of equipment to reduce losses to 1.8 per cent (efficiency 99.2 per cent);
- Power station efficiency could be raised through improved maintenance to 32 per cent (losses down to 68 per cent);
- Transformer upgrading could reduce transmission/distribution losses to 10 per cent (efficiency 90 per cent);
- An improved design and better insulation of the water heater, tanks and piping could reduce losses to 15 per cent (efficiency 85 per cent).

The figures are again illustrative and represent typical improvements achievable in many practical situations. The overall system efficiency would become:

$$0.992 \text{ x } 0.32 \text{ x } 0.90 \text{ x } 0.85 \quad = \quad 0.243 \quad \text{(or 24.3 per cent)}$$

Through the improved efficiency of the various step processes and equipment, the overall efficiency can reach 24 per cent. From a product output perspective, the same input energy can produce more than 24 units of output compared to previous 19—an increase of 26 per cent.

The cost-effectiveness of energy efficiency measures needed to achieve such gains will depend on many factors, including the cost of new and improved equipment, the cost of energy and the value of the energy saved. Changes in the use patterns of energy-dependent activities will also offer another opportunity to increase the overall efficiency (e.g. lower usage of hot water by lowering the amounts needed for washing laundry items, or lowering the wash temperature by blending hot water with some cold water).

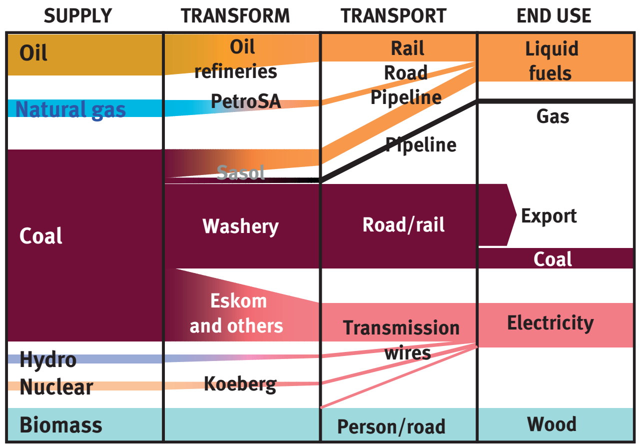
Thus energy efficiency has an important role to play in reducing the need for energy throughout the economy. The next sections outline both supply-side and demand-side energy efficiency approaches. More detailed information can be found in modules 13 and 14 respectively.

4.3. Energy flows in national economies

The energy transformations within the energy supply chain for different energy-dependent activities in national (and regional) economies can be summarized in a simplified diagram in terms of energy flows, such as the example for South Africa which is shown in figure IV below.

A diagram such as figure IV will show the relative amounts of energy supplied and consumed, and the amounts of primary energy allocated to each sector of the economy. The quantities suggested in the diagram are, of course, specific for South Africa. Diagrams for other countries will be different.

Figure IV. **National energy flows in South Africa (DME, 1997)**



Source: Andre Otto, Dept. of Minerals and Energy, South Africa

The energy flows, together with energy consumption data and an understanding of the relevant supply-demand chains for different sectors, can be used to suggest where energy efficiency improvements could have a major impact and indicate the types of energy that could be saved. With this information, some initial priorities could be developed for an energy efficiency programme at the national level.

An overall goal for such a national energy efficiency programme would be to reduce the energy intensity of the various sectors of the economy (see box 3), thereby decreasing the amount of primary energy per unit of economic activity (measured in GDP).

Box 3. **Energy intensity**

As already mentioned in box 1, energy intensity can be used as a rough measure of the energy efficiency of a nation's economy. For that purpose it is usually expressed as the ratio of national energy consumption to GDP and quoted in units of energy per unit of GDP (e.g. kilojoules per dollar of GDP). While it is true that a high energy intensity could possibly reflect an inefficient use of energy in an economy, a high figure may also simply reflect that the underlying structure of the economy is oriented strongly to basic industries—with relatively low value added and using large quantities of energy. These basic industries might well be quite efficient although this might not be appreciated at first sight from the quoted energy intensity.

While energy intensity is often used as a surrogate for energy efficiency, we can see that this may lead to misleading conclusions being drawn. Many factors influence the overall energy intensity for a national economy. The figure will—for example—reflect the overall standards of living for a nation, as well as its climate. It is not untypical for particularly cold or hot climates to require greater energy consumption in homes and workplaces for heating or cooling. As suggested above, energy intensity is most often strongly affected by the relative size of the industrial sector, and by the specific nature of industrial activities within that sector.

Indicators of energy intensity are thus useful provided underlying components are well understood and the data interpreted accordingly. Without a structural context, energy intensity figures can be misleading. A well-defined and quantified structural context allows government policymakers to decide where policy changes might be made and what the potential impacts might be. These will include the impact of energy efficiency improvement measures throughout the economy (e.g. changes in the efficiency of industrial furnaces and boilers, electric motor efficiencies, standards of construction for domestic and commercial buildings, the fuel economy of vehicles).

"Energy intensity" is discussed at www.eia.doe.gov

5. TARGET SECTORS

Energy efficiency interventions at a national level are generally developed and implemented in response to priorities identified within an integrated energy plan or an integrated resource plan. Sectoral interventions may also be developed and coordinated by government agencies or utility companies.

Energy intensity and energy consumption indicators are used to identify target priority areas—e.g. sectors, specific industries. In many countries, the share of energy consumed by industry is often large although the share of the domestic and commercial buildings sector will often be almost as large. Transport is a growing energy consumer in most countries. Energy efficiency activities are therefore increasingly important in many sectors, depending not only on the total amount of energy consumed but also on the potential for cost effective improvements (broadly reflected in the current level of energy efficiencies of different sectors).

In setting priorities, account has to be taken of the measures applicable in a given sector (including cost implications) and on the means of promoting energy efficiency action. The buildings and transport sectors may be complicated to address because the energy consumers are very widely dispersed and typically consume small amounts of energy individually. Industry—while perhaps also having many small consumers—will often include a relatively modest number of big consumers. It can therefore prove easier, at least administratively, to reach those consumers that represent a large proportion of sectoral energy use.

Examples of proven measures in demand-side sectors include:

Supply side segment	Examples of energy efficiency measures
Domestic and commercial buildings	• For heating and cooling services—use of efficient equipment, adjustments in use patterns (behavioural changes, temperature modifications, etc.) and good maintenance. • Lighting—using efficient light-bulbs, changing types of light sources, maximum use of natural lighting, behavioural changes (e.g. switching off when not needed, manually or automatically). • Office equipment and domestic appliances—installing energy efficient items, switching off when not used (e.g. reducing waste when on standby), and adopting good operating practices (e.g. running appliances only when full). • Construction materials—ensuring that appropriate materials and controls are utilized in new and retrofitted buildings (e.g. insulation, building orientation, double glazed windows).
Industry	• Operations in general—routine data collection and regular analysis of energy performance, improved maintenance, good energy management using skilled and experienced staff. • Boilers and furnaces—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained.

Supply side segment	Examples of energy efficiency measures
Industry	• Industrial processes—operated in accordance with design standards, heat losses minimized by good insulation, waste heat recovered for use elsewhere in the plant. • Industrial buildings—similar to the buildings sector, including attention to heating, cooling, lighting, etc. • Equipment—utilizing existing equipment well (e.g. electric motor speed and load controls) and replacing obsolete items with new higher efficiency equipment (motors, fans, boilers, pumps, etc.)
Transport	• Modal shifting—ensure freight and passenger transport is carried out in the most energy efficient mode (e.g. consider switching from road to rail, encouraging public transport over individual vehicles, etc., whenever possible). • Vehicles—encourage fleet replacement to modern higher efficiency equipment, improve maintenance, driver education. • Improved road maintenance.
Resources and resources preparation	• Clean coal technologies—they allow improving the efficiency of the extraction, preparation and use of coal. They offer various solutions for coal cleaning as well as reducing noxious emissions and improve the efficiency of power generation. • Fuel substitutions—also referred to as fuel switching, is simply the process of substituting one fuel for another. This could be either a fossil fuel that allows for using more efficient conversion technologies (i.e. natural gas) or renewables (i.e. wind. solar, biomass, hydro, etc.).
Power generation and energy conversion	• Plant operations in general—these include routine data collection and regular analysis of energy performance, improved maintenance, improved logistics, good energy management using skilled and experienced staff. • Improved boilers and furnaces control—proper combustion control with appropriate instrumentation, insulation and refractory brought up to good modern standards, burners well maintained. • Upgrading generating units—it includes installation of new and improved burners, extra flue gas heat recovery, additional heat recovery from hot blow-down water as well as modernization of instrumentation and combustion control systems. • Cogeneration—the combined production of electricity and heat can bring about major efficiency gains wherever a demand for heat exists next to a power plant (process heat for industrial factories, district heating, etc.).[1]
Transmission and distribution	• Transmission and distribution line upgrading—this includes replacement/upgrade of equipment (transformers, switchgear, insulators, system control and data acquisition systems, etc.) as well as substations. • Improved control and operations—this includes data and system monitoring, power factor improvement, voltage regulation, phase balancing, preventive maintenance and other measures to reduce technical losses while increasing reliability.

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[1] It has to be noted there are also cogeneration systems, usually part of big industrial factories, for which high temperature heat is the primary output of the generating plant, while electricity is the secondary product.

6. OVERVIEW OF ENERGY EFFICIENCY ACTIONS

Energy efficiency improvements particularly focus on available technology to make such improvements, with some technology options being well-known and proven over many years of application, and some of which may be relatively new and less well-known. Indeed, lack of information is a key barrier to energy efficiency improvements in many situations. However, experience in many countries of supply and demand-side activities shows that existing plants, buildings and equipment can often be improved substantially through simple low-cost/no-cost actions that have little bearing on technology.

Put simply, there are important opportunities for raising energy efficiency throughout the economy in every country, developed or developing, by adopting better "energy management" practices. It is certainly not true to claim that energy efficiency cannot be raised without investment in new technology, a claim made all too often by managers of companies who have failed to grasp the opportunities offered by good management.

At a national (or regional) level, energy efficiency interventions are best promoted in a strategic and integrated manner to use more efficient energy technologies and management practices within the context of an energy efficiency programme. For convenience, technologies and management programmes can be split into those applied to supply-side and those to demand-side activities. There are of course many similarities amongst the measures actually adopted for such activities.

Supply-side interventions are typically technical or management interventions, which are implemented by generators, grid operators and/or energy distributors, i.e. on the utility side of the meter or fuel pump. Demand-side interventions address aspects of energy efficiency, which can be implemented and achieved through changes in operating procedures and technologies by the customer/energy user, i.e. on the customer's side of the meter.

6.1. Technologies and practices

Energy efficiency technologies and energy management practices are discussed in more detail in module 13: supply-side energy management and module 14: demand-side energy management. Module 17 addresses the specific area of industrial energy systems efficiency and optimization. Module 18 addresses energy efficiency in buildings. In all situations, energy efficiency actions must be carefully costed and undertaken only when it is profitable to do so.

In brief, measures typically include:

On the supply side

- More efficient generation/conversion, including:
  - Minimizing waste heat generation and recovering waste heat to an economic maximum;
  - Improving maintenance practices;
  - Utilizing equipment that has been manufactured to the best modern standards of efficiency, e.g. electric motors, steam and gas turbines, transformers, boilers;
  - Applying modern process technologies including clean coal processes;
  - Cogeneration (particularly where this can be combined with biomass fuel from a renewable source, e.g. bagasse, or with the utilization of waste heat);
  - Better control systems and metering of key operating parameters.

- More efficient transmission and distribution systems, including:
  - Closer and improved control of existing systems, e.g. better balancing of phases, voltage regulation, power factor improvement, SCADA systems for better routine data acquisition and analysis;
  - Increased use of distributed generation;
  - Higher transmission voltages;
  - State-of-the-art technologies such as low-loss transformers, fibre optics for data acquisition, smart metering, etc.

On the demand side

- More efficient equipment and appliances in all sectors, e.g. motors, boilers, furnaces, industrial dryers, pumps, compressors, lighting, domestic appliances, air conditioning systems. This is particularly important for equipment that is operated over long periods or continuously.

- Improved maintenance of all equipment.

- Improved metering of fuel, electricity and steam flows and of key operating parameters such as temperatures. Such figures feed into routine monitoring and performance analysis, activities that can be applied in all sectors. Information on energy usage and related levels of “activity” such as production data allows energy consumers to appreciate better the quantities of energy consumed and the time and purpose of such consumption: this is an essential initial step to improving energy efficiency,

- Control and energy system optimization, often made practical by the improved metering mentioned above. This can include variable speed drives for electric motors, thermostats in buildings and industrial equipment, ripple control, smart appliances and power factor improvement.

- Behavioural change on the part of the energy user, such as:
  - Monitoring energy efficiencies in major energy-consuming industrial processes and equipment to ensure design operating parameters and performance are respected.
  - Reporting leaks and equipment failures systematically, e.g. in industrial plants, and checking the cost incurred through such deficiencies to ensure priority attention is given to repairs and replacement.
  - Changes in work practices such as working from home and/or flexitime.
  - Changes in equipment usage both at home and in the office, such as switching off appliances which are not needed and avoiding excessive use of “standby mode” for many types of equipment.
  - Electricity load shifting by industrial or commercial energy users is a demand-side intervention but it has implications for improving energy efficiency of the grid network that supplies the electricity (supply-side). This is because peak loads can be reduced if electricity demand is spread out over a longer time period or if it is moved to another time of day. Since many electricity systems are forced to operate their least efficient generators to meet peak demand, this allows them to reduce the use of lower efficiency generating equipment in favour of greater use of their more efficient equipment over a longer period of time.
  - Choosing different modes of transport, e.g. public transport versus cars for individuals, rail versus road for freight, where such alternatives are available.

An example of demand-side controls to save peak period electricity is given in box 4. The concept of ripple control is well established in some countries and is technically proven. However, it does not always meet with an entirely favourable customer response.

Box 4. **Ripple control of electrical storage water heaters in South Africa**

Ripple control has been used in South Africa to control electrical storage water heaters and street lighting. Ripple control is a technology that enables an electricity distributor to control appliances, for example in this case, an electrical storage water heater in a customer’s home.

It operates on the principle of sending control signals as a pulse, which is superimposed on the frequency of the grid supply. A relay on the appliance is programmed to operate the appliance in response to signals transmitted through the electricity distribution network. In South Africa, ripple control is used extensively to control domestic water heaters for demand-side management by switching off the electrical heaters at a large number of consumers for a short time during maximum demand periods.

Although ripple control appears to be a simple and effective means of demand-side management, it has not generally been very successful due to the negative perceptions of "big brother" control of the customer's life on the part of the utility. Consequently, customers are found to have by-passed the ripple control devices.

Source: Hot water load control in South Africa, N. Beute, J. Delport, Engineering Faculty, Cape Town 2006

6.2. Energy efficiency programmes

It is not possible to list all types of energy efficiency programmes here but the section will give some examples of situations where government action can be particularly effective. There is a very wide variety of possible actions and many of these are explored in the other energy efficiency modules (particularly modules, 13, 14 and 17). Typical programmes include:

- Development of energy efficiency policies and strategies.
- Energy awareness—raising awareness of energy consumption and related aspects of energy efficiency among consumers/users. This can cover many topics, from training of energy professionals to appliance labelling and consumer education for the domestic sector.
- Encouraging energy auditing and energy assessment both in the public and private sector. This is a logical next step after raising energy awareness.
- Development of, and publicity for, energy efficiency best practices, and information on norms and standards applicable to different sectors, such as good modern practice for electric motor efficiencies, comparisons of industrial process energy consumption per unit of output. This activity can be applied in various ways to all sectors.
- Development of the institutional capacity and human resources for implementation of energy efficiency interventions. This can range from teaching at schools and colleges, to requiring demonstrated competence at professional levels (e.g. air conditioning and heating engineers).

- Support for technology R&D, and especially for the demonstration of proven technologies to increase energy efficiency.
- Introduction of incentive/penalty mechanisms to support improved energy efficiency.
- Promotion and facilitation of international collaboration and cooperation.

While the above items are written in the context of government-led programmes, many of the concepts are also valid for energy efficiency programmes organized and implemented by the private sector. For example, staff energy awareness is important for all companies, industrial and commercial. Raising staff—and even customer—awareness can have valuable benefits to most firms. Manufacturing companies should be active in promoting good management and energy efficiency practices at all their sites and offices.

Demand-side management and energy efficiency

A distinction can be made between the terminology of demand-side management (DSM) and energy efficiency. In conventional usage, DSM is often applied to electricity load management, such as peak lopping or load shifting only, and not to the more general range of interventions included under the topic of demand-side energy efficiency, which is discussed in this module. This is particularly the case for DSM programmes implemented by utilities concerned with the management of load profile and peak-power demand. While it might seem desirable for a power utility to improve its load factor and postpone costly capacity expansion, in practice utilities companies tend to be unenthusiastic towards load shifting and DSM in general. This is because they foresee a reduction of electricity and power demand, and consequently a reduction in sales and revenues.

Review questions

1. Describe the difference between demand-side and supply-side interventions and name a technique of each.

7. COMMON BARRIERS TO IMPLEMENTATION OF ENERGY EFFICIENCY MEASURES

Despite the fact that energy efficiency appears to make good sense in many situations—both in terms of cost savings and reductions in environmental damage—it is often very difficult to get managers of companies (and individuals) to take action. It is even more difficult to achieve effective implementation over a long period. All stakeholders are inclined to accept the status quo, which is usually a less efficient scenario, and only respond in terms of energy efficiency once a crisis forces the issue, such as in the case of insufficient energy supplies. For private firms, other priorities are often quoted, such as capital investments to increase plant capacity and market share, leaving no funds for energy efficiency expenditures.

This inherent inertia against acting to improve energy efficiency is reinforced by numerous institutional, financial and technical barriers to energy efficiency programmes, either real or perceived. These include:

- Policy and regulatory barriers;
- Lack of information and awareness of the potential for energy efficiency;
- Lack of industry initiatives to emphasize energy management as an integral part of total management systems;
- Lack of technical capacity to identify, appraise, develop and implement energy efficiency projects;
- Financial and investment barriers;
- Technology barriers.

These barriers are reviewed below.

7.1. Policy and regulatory barriers

Policy and regulatory oversight systems can influence the priorities and manner in which energy efficiency measures are implemented. In the case of policies, these include both national and local government policies. In many countries, especially in Africa, there simply is no policy or, if there is, it can be indifferent (and thus perhaps counter-productive) to energy efficiency.

Regulations that support inappropriate tariffs can limit interest in energy efficiency. For example, it is common to see tariffs that provide for declining energy prices for incremental energy consumption by big consumers. This acts as a disincentive for such consumers to undertake energy efficiency actions.

Supportive policy and regulatory environments for energy efficiency include setting targets—mandatory or voluntary should be considered—from which strategies for encouraging increased levels of energy efficiency can be developed.

7.2. Lack of awareness and information

This barrier is the most common problem in almost all countries. Easy access to up-to-date and relevant information is typically lacking even in developed countries. Company managers are frequently observed stating that they have a particular problem that is adversely affecting their energy efficiency, yet the problem has already been solved—sometimes many times—in other countries and indeed in other locations in the same country.

In Africa especially, there may be a lack of awareness of proven energy efficiency measures and programmes. The information about these is often not well disseminated and the users are simply unaware of energy efficiency measures or their benefits to their company or the country.

End-users need to be informed of the availability of efficient equipment and the respective energy cost savings and their positive environmental impacts from proper adoption. In the United Republic of Tanzania, the existing market of energy efficient equipment is immature and is characterized by limited supplies from tradesmen and inadequate technical personnel.

Sometimes the information to end-users (energy customers) is incorrectly perceived as being an attempt by government to restrict their energy use or deny them the right to energy, or manipulation on the part of utilities to make higher profits. Industry trade associations could play a positive role in encouraging the sharing of relevant information.

7.3. Lack of initiatives to emphasize energy management

This barrier is particularly important for the industrial and commercial sectors. Since energy management is a continuing process, it is essential that it becomes part of total management system. Most industries have management systems that address production, accounting, maintenance, environment and safety, but many do not include energy management as part of their management systems. As energy management requires a knowledge and skills base, medium and small industries often claim to have no staff resources to undertake energy management tasks. While this must be true for many firms, it may be possible to cover some aspects of energy management by using part-time staff—a full-time person may not always be justified.

7.4. Lack of technical capacity to identify, evaluate and implement energy efficiency actions

There is a lack of qualified individuals and organizations to identify energy efficiency projects in many companies. Required skills include the ability to carry out energy audits, analyse performance data, from which opportunities to implement effective actions can be evaluated and properly justified in terms of the benefits achievable compared with the costs involved. This barrier is particularly relevant to most African countries.

In some countries, there are organizations that address this barrier by offering services to conduct energy audits or advising clients on energy efficiency measures. These service organizations need to:

- Have a knowledge and understanding of energy efficiency systems and opportunities, especially in the local context;
- Be aware of proper financial evaluation techniques and be experienced in analysing rates of return, life cycle costing, etc;
- Demonstrate the quality and comprehensiveness of their work;
- Have a knowledge of the production and safety constraints of the client plant/company.

A lack of technical capacity within such service organizations could result in an incorrect assessment and misdirected measures, which would be counterproductive. In many African countries there will be a need for training at a national level and for a technical certification scheme in order to improve technical capabilities and provide incentives for acquiring official qualifications.

7.5. Financial and investment barriers

The cost of implementing energy efficiency measures in industry, commercial or residential sectors is sometimes said to be a barrier to effective energy efficiency. Often however, a manager will have little or no ability to evaluate energy efficiency measures properly and may not appreciate that no-cost/low-cost measures are available that require very little capital to implement. All too often the lack of awareness of potential benefits from EE actions prevents management from doing the no-cost measures first and using the cost savings to build up capital for reinvestment later in energy efficiency.

In some cases of course, there are companies that really do not have funds to undertake even modest investments, even though the measures might have very short payback periods.

For example, energy suppliers may need to invest in upgrading to more efficient electricity generators or transmission lines, while energy users may need to upgrade to more efficient appliances or install capacitors to increase power factors (and hence reduce the power needed for induction motors). Unfortunately these investments may not be made because there is a genuine lack of capital and interest rates on loans may not be favourable enough in most African countries to justify borrowing. Financing considerations are addressed further in module 19.

7.6. Technology barriers

While great progress in achieving energy efficiency improvements is almost always made by improving energy management, there will be on occasions a real need for tackling deficiencies from a technology point of view. A barrier may be encountered because of a lack of availability of high efficiency equipment made to good modern standards in any particular country. There may also be insufficient cooperation amongst researchers or research organizations, making it difficult to build effective energy efficiency research, development and demonstration programmes, particularly in a local context in Africa. Thus even where research may have been effectively conducted there can be difficulty in transferring research prototypes into industrial scale working products.

Examples of technology barriers include the continuing use of obsolete and inefficient equipment in the industrial, commercial and residential sectors. At times this is due to unavailability of more energy efficient technologies. It is perhaps more likely that weak marketing strategies exhibited by equipment manufacturers or importers are contributing to the problem, especially where these do not address the inertia of customers who are reluctant to move away from obsolete and traditional products. Lack of confidence in local installers of new technologies can also be a barrier. Certainly inadequate marketing will do little to promote efficient energy use even though better technologies might actually be available in Africa.

Review questions

1. Name the common barriers to implementation of energy efficiency measures.

8. COMBINING RENEWABLES AND ENERGY EFFICIENCY TO IMPROVE SUSTAINABILITY OF ENERGY DEVELOPMENT

Renewable energy technologies tend to have a higher profile than energy efficiency actions. This is mainly for the obvious reason that they are more visible as new installations and perceived as more “cutting-edge” technologies. This occurs even though they often have higher initial capital costs than energy efficiency measures (and may have less favourable operating costs too). However, one of the benefits of adopting renewables is the ensuing increase in awareness of energy production and consumption in the owner of the installation and also often with the public who can see or might interact with the technology. For example, solar PV or solar water heating panels on a public building raises the awareness of renewable energy use in the building users and other members of the public.

This increased awareness of energy consumption may be used to stimulate awareness of energy efficiency by introducing energy efficiency measures simultaneously with a new renewable energy installation. As the renewable energy installation has a significant capital costs people can become more sensitive to the idea of “wasting” the energy from the system, especially if they feel a strong level of ownership of the renewable energy system.

In addition, a renewable energy system supplier/installer could make recommendations on how to use the energy produced in the most efficient manner, so output from the system could generate the most benefit in terms of services to the end-users. This is often a good opportunity to introduce demand-side energy savings measures.

From the supply-side perspective, a switch to renewables supports sustainable energy generation and contributes to reducing dependency on imported energy. For large scale operations, currently available renewable technologies are biomass-based cogeneration for electricity generation, on-shore and off-shore wind, geothermal energy and large-scale hydro. For small-scale side installations, the following types of technologies can offset the need for electricity or gas taken from a national grid:

- Solar water heaters for water heating;
- Small-scale wind generators and mini-hydro systems for electricity;
- Solar PV for electricity;
- Small-scale biomass technologies for heat and electricity.

Discussion questions/exercises

Are there, in your country, any barriers that may be constraining the implementation of energy efficiency measures? Consider, but don't be limited to, the existing practices as well as policy framework, availability of funds, technology level, energy management, levels of capability and awareness.

Discuss these and propose simple plans to overcome the barriers and enhance energy efficiency in your country.

9. CONCLUSION

The implementation of energy efficient measures at all stages of the supply/demand chain could reduce significantly the negative impacts of energy use on the environment and human well-being, and increase the availability of primary energy reserves while achieving maximum benefits in terms of outputs from the available energy. The cost to both suppliers and consumers can be reduced, while maintaining the same level of energy-dependent activities.

We have seen how the overall efficiency of an energy-dependent activity, from the primary energy resource to the final output, is a figure that represents the cumulative effect of all the inefficiencies along the supply-demand chain. Measures to improve energy efficiency of each step will contribute to increasing the final figure, so even small improvements can have significant impact.

While improving demand-side energy efficiency will clearly bring reduced energy costs directly to the energy end-users, improvement of generating, transmission and distribution efficiencies—supply-side actions carried out by utility companies—can also bring cost benefits to the end-users in the typical regulatory environment by ensuring energy prices are well controlled.

Indeed, the combined effect of supply and demand-side energy efficiency improvement means that the load on generating facilities is lowered, and this can help keep older systems and equipment in good condition. This is because lower overall loads often allow the equipment to run below maximum capacity or be shut down more frequently (or for longer periods) for preventive maintenance. Older equipment will usually need more maintenance: depending on system characteristics, forced shutdowns for repair can be reduced and system operating efficiency can be raised. Overall system reliability can be improved as a result.

Barriers to achieving a good level of energy efficiency improvement include the lack of policy or regulatory measures, the lack of information and awareness of potential benefits, a failure to emphasize good energy management, and a lack of technical capacity to identify, evaluate and implement energy efficiency measures. Technology and financing barriers are also seen in some situations. Of these barriers, the failure to practise good energy management is typically one of the most important factors for enterprises. Improving energy management is almost always a low-cost action that achieves valuable benefits in the short term. Maintaining good management ensures these benefits are continually contributing to enterprise profits (and the national economy) in the long term.

LEARNING RESOURCES

Key points covered

The following theme are covered in this module:

- Defining energy efficiency and appreciating the benefits of increased energy efficiency;
- The energy supply-demand chain and where the energy losses and inefficiencies occur;
- Target sectors for energy efficiency programmes and typical actions;
- The most common barriers to the implementation of energy efficiency measures;
- The importance of good energy management as a contribution to energy efficiency improvement.

Answers to review questions

Question: Describe the main difference between demand-side and supply-side interventions and name a technique of each.

Answer: Demand-side interventions address the aspects of energy efficiency, which can be implemented or achieved through changes in the technologies on the customer/user end of the supply chain, i.e. on the customer's side of the meter. The techniques include:

(a) Substituting more efficient appliances for less efficient ones
(b) Influencing/encouraging customers to change their usage patterns
(c) Adopting good energy management practices

Supply-side interventions are typically those that are implemented by generators, grid operators and/or energy distributors, i.e. on the supply-side of the meter (or fuel pump). These measures include also load shifting, aimed to reduce daily peak-power demand while improving the grid load factor and ultimately the overall electricity supply side efficiency.

Question: Name the common barriers to implementation of energy efficiency measures.

Answer: The barriers to achieving energy efficiency are lack of policy or regulatory measures, lack of information and awareness, lack of emphasis on good energy management, lack of technical capacity to identify, evaluate and implement EE opportunities, financial factors and technology barriers.

Exercises

Energy efficiency measures can be applied through the supply chain as well as at the end-user. Consider the different points in the supply chain where energy efficiency measures can be applied and the types of techniques that can be used to achieve energy efficiency.

Write a 2-page essay discussing these options and their techniques as well as the benefits to industrial, commercial and residential sectors.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 12: Energy efficiency technologies and benefits

Suggested discussion topic:

1. Discuss the DSM and SSM options in relation to the sectors of your country economy and situation

REFERENCES

Energy and Energy Efficiency, Tanzania Country Report, Lugano Wilson, Tanzania Industrial Research and Development Organization (TIRDO), March 2006

UNIDO, Capacity Building in Energy Efficiency and Renewable Energy Regulation and Policy-Making in Africa, Ghana—Energy Efficiency Country Profile, Alfred K. Ofosu Ahenkorah, Accra, January 2006.

Industrial Demand Side Management in South Africa, Tsholo Matlala, Eskom DSM, Paper presented at ICUE Conference 2004, Cape Town, South Africa.

UNIDO, Report on Capacity in Energy Efficiency and Renewable Energy Regulation and Policy, Project no: YA/FRA/05/016, Zambia Country Report on Energy Efficiency, March 2006, Prof F.D Yamba, National Expert in Energy and Energy Efficiency, Centre for Energy Environment and Engineering Zambia

INTERNET RESOURCES

General

www.reeep.org/index.cfm?articleid=1390

www.watergy.org/activities/countries/southafrica/southafrica.html

www.reegle.info—information gateway for renewable energies and energy efficiency

Building energy use

Commercial Buildings Energy Consumption Survey (CBECS). A service of the U.S. Department of Energy's Energy Information Administration. Provides regionally specific energy use data for different types of commercial buildings; **www.eia.doe.gov/emeu/cbecs**

Energy efficiency

Note that although some sites are country specific, the information they provide is relevant to individuals and businesses globally.

Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) Infostore. A searchable database of more than 1,500 renewable energy and energy efficiency projects and activities from all over the world. Several case studies highlight actions taken in the commercial sector that involve green buildings, cleaner transport fleets, and better lighting technologies. This service is maintained by the International Energy Agency; **www.caddet.org/infostore/index.php.**

Collaborative Labeling and Appliance Standards Program (CLASP). A clearing house for global information on efficiency standards and product labeling programs. CLASP provides information on which countries have mandatory or voluntary energy efficiency standards and which products are covered, as well as labeling programs to help consumers obtain energy-efficient products;
www.clasponline.org/main.php.

Emprove. A service of the New Zealand government, Emprove is an energy management and efficiency portal that provides information about the best energy management practices as well as incentives available to New Zealand businesses;
www.emprove.org.nz/index.aspx.

Energy Star Business Improvement. A programme jointly administered by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The site provides a wealth of information about energy-efficient products and services as well as tools, calculators, and online training sessions that facilitate cost-effective energy use reduction strategies; **www.energystar.gov.**

European Commission Joint Research Centre. Information about energy efficiency, renewable energy, and green building programmes throughout the EU; **energyefficiency.jrc.cec.eu.int**.

Greentie. An international searchable directory of suppliers whose products and services help reduce greenhouse gas emissions. The directory is maintained by the International Energy Agency and contains listings for countries in every region of the world;
www.greentie.org/index.php.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Energy Information Portal. Provides comprehensive information about various energy-efficient and renewable energy technologies as well as the best practices for implementing them;
www.eere.energy.gov.

Green buildings

Guidelines and resources for reducing the environmental impact of commercial buildings;
www.greenerbuildings.com.

UNEP Division of Technology, Industry and Economics (DTIE): Sustainable consumption product criteria database. Searchable database with links to ecolabeling and green procurement programmes around the world at every level of government;
www.uneptie.org/pc/sustain/design/green_find.asp.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program. Resources, tools, data, and case studies regarding green buildings.
www.eere.energy.gov/buildings.

U.S. Green Building Council. Dedicated to promoting environmentally responsible buildings; **www.usgbc.org.**

World Green Building Council. An umbrella group providing information about green building councils in Asia, Europe, and North and South America; **www.worldgbc.org.**

Industrial energy efficiency

The *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program* has a section on best practices for industrial energy efficiency that provides resources and tools to industrial energy users.
www1.eere.energy.gov/industry/bestpractices/bestpractices_resources.html

American Council for an Energy-Efficient Economy has an industry and agriculture programme where information can be found on energy efficiency for manufacturing, combined heat and power, agriculture and water and wastewater.
www.aceee.org/industry/index.htm

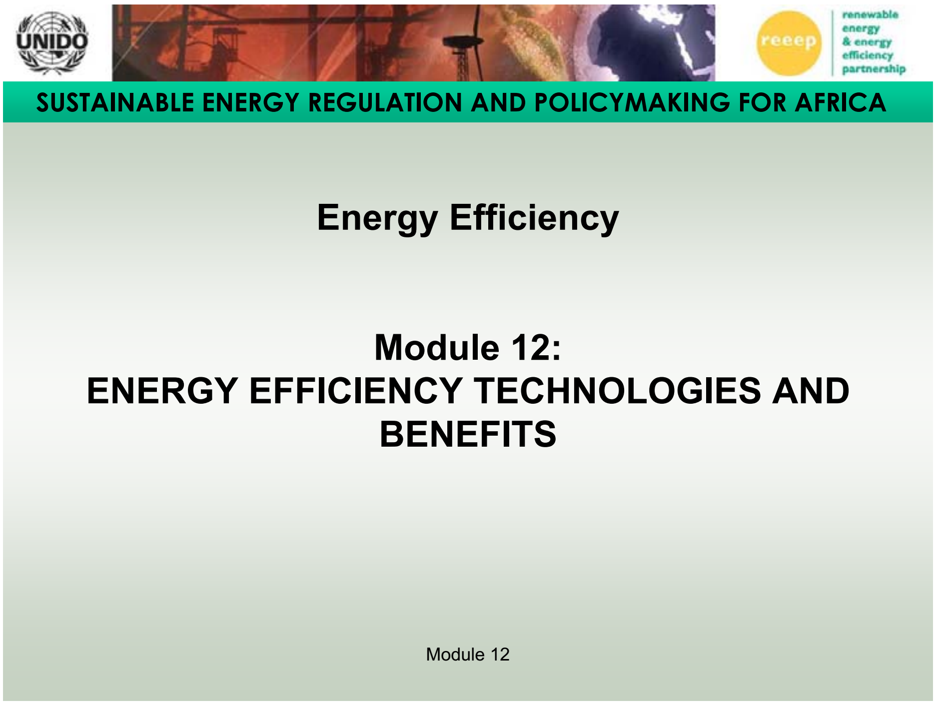
The *Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP)* was developed to remove barriers to efficient industrial energy use. This website provides a good example of a national industrial energy efficiency programme.
http://www.ptm.org.my/mieeip/indexabout.html

The *Iowa Energy Center* provides a number of industrial energy efficiency case studies and projects. **www.energy.iastate.edu/efficiency/industrial/cs-index.html**

GLOSSARY/DEFINITION OF KEY CONCEPTS

Activity	Used in this module in the context of “energy-dependent activity”, such as the production level in an industrial plant, heating or cooling of a building, lighting in any sector, number of cooked meals, etc.
Bagasse	The fibrous waste remaining from the extraction of sugar from sugar cane, typically around half being fibre and half moisture with minor amounts of unextracted sugar. Can be used to manufacture paper, or burnt to produce steam and electricity (usually for the sugar plant itself).
Biomass	Can be an important renewable energy resource when managed in a sustainable way, for example, wood from sustainably grown forests.

Demand-side management	DSM is typically used in the specific sense of actions to modify electricity loads to achieve higher system efficiency.
Energy audit	Evaluation of the energy-related performance of a manufacturing plant or building, used to identify energy efficiency opportunities.
Energy efficiency	The utilization of energy in a cost-effective way to carry out a manufacturing process or provide a service. Depending on the context, typically expressed as an amount of energy consumed per unit of output (e.g. tons of cement, square metres of heated building, cubic metres of water pumped).
Energy intensity	Often used as an indicator of the energy efficiency of a national economy (or sector) and expressed as the ratio of energy consumption to GDP e.g. tons of standard coal per dollar GDP.
Stakeholder	Organization or individual with a strong interest in achieving improved energy efficiency, e.g. industrial enterprises, trade associations, building owners and operators, equipment manufacturers, the general public.
Supply-side management	SSM is the efficient utilization of energy for the generation, transmission and distribution of energy. SSM applies in particular to electricity systems but can also apply to gas and liquid fuel systems.

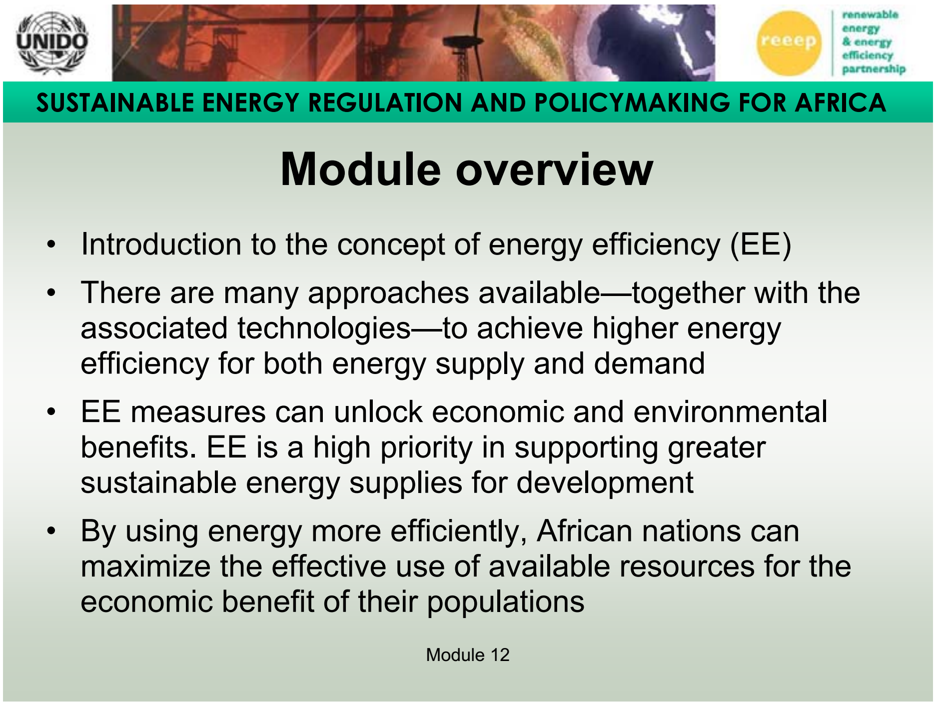


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 12:
ENERGY EFFICIENCY TECHNOLOGIES AND BENEFITS

Module 12

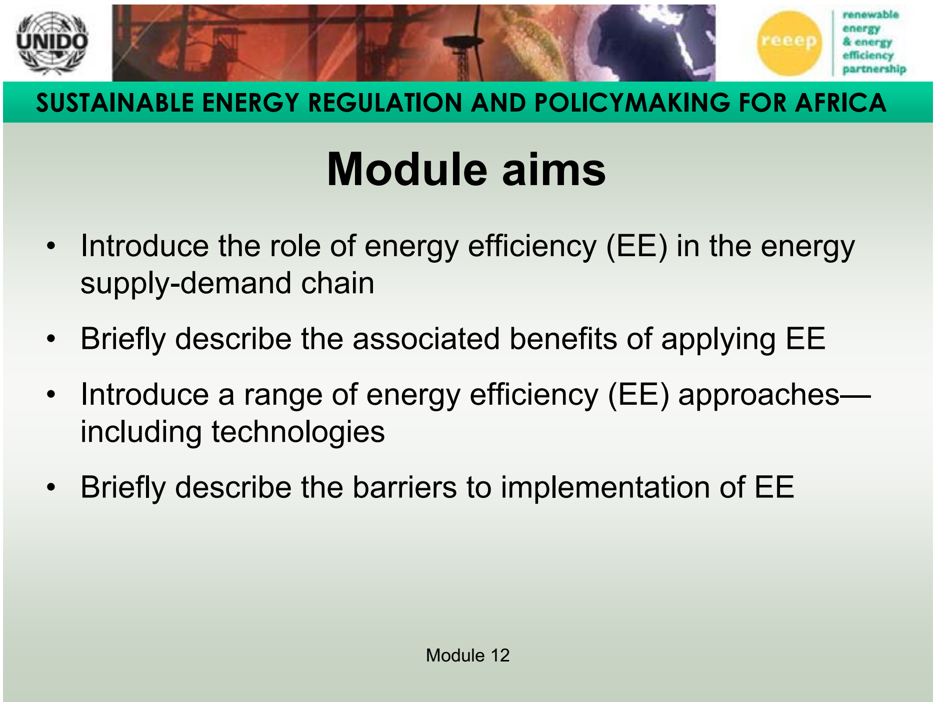


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Introduction to the concept of energy efficiency (EE)
- There are many approaches available—together with the associated technologies—to achieve higher energy efficiency for both energy supply and demand
- EE measures can unlock economic and environmental benefits. EE is a high priority in supporting greater sustainable energy supplies for development
- By using energy more efficiently, African nations can maximize the effective use of available resources for the economic benefit of their populations

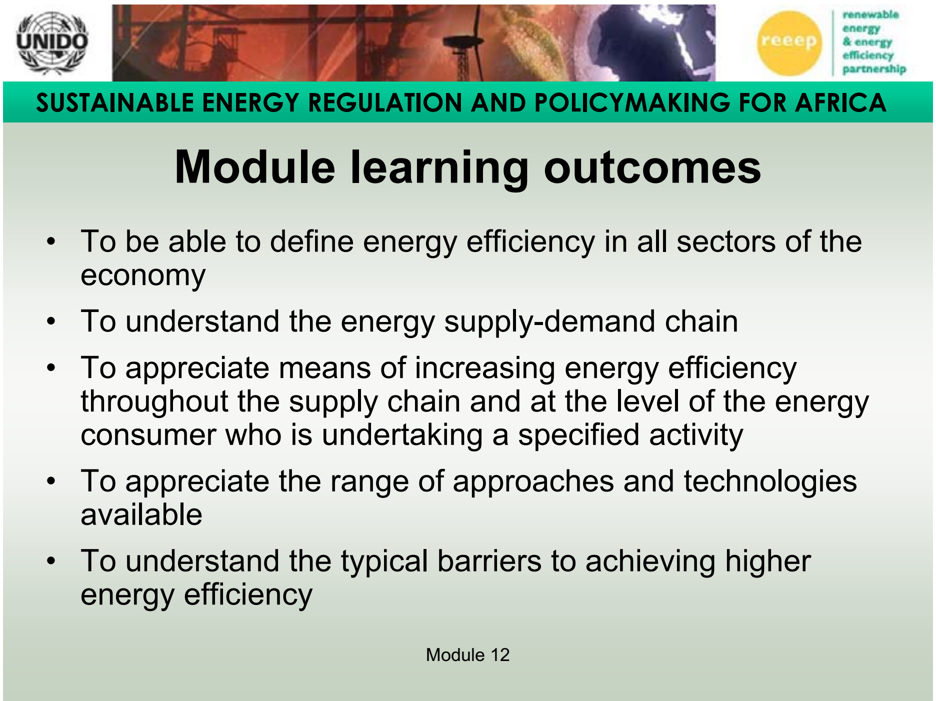
Module 12



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

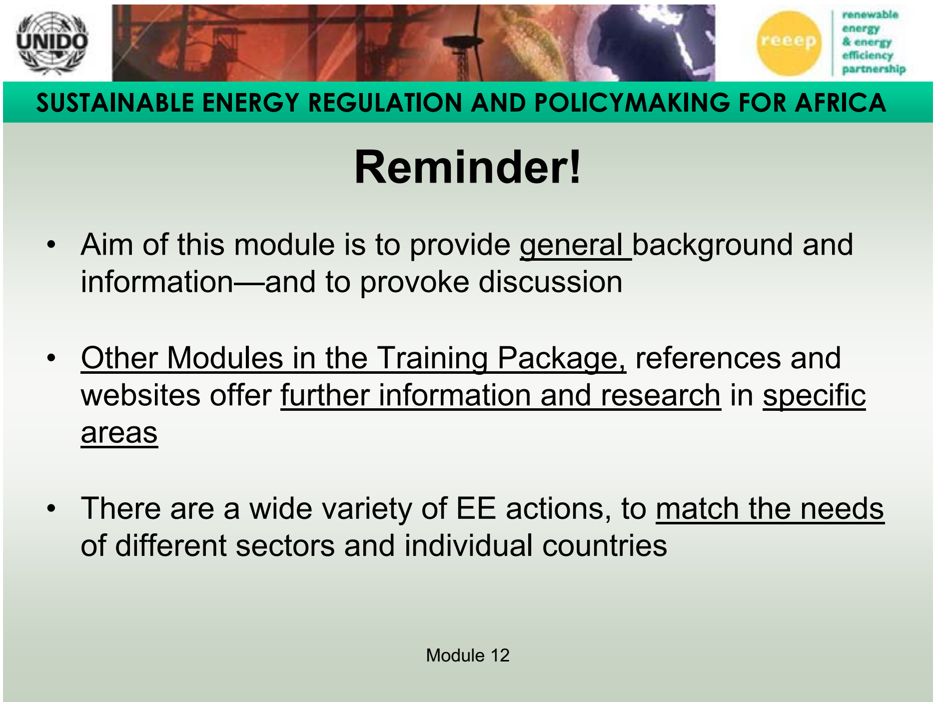
- Introduce the role of energy efficiency (EE) in the energy supply-demand chain
- Briefly describe the associated benefits of applying EE
- Introduce a range of energy efficiency (EE) approaches—including technologies
- Briefly describe the barriers to implementation of EE



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define energy efficiency in all sectors of the economy
- To understand the energy supply-demand chain
- To appreciate means of increasing energy efficiency throughout the supply chain and at the level of the energy consumer who is undertaking a specified activity
- To appreciate the range of approaches and technologies available
- To understand the typical barriers to achieving higher energy efficiency

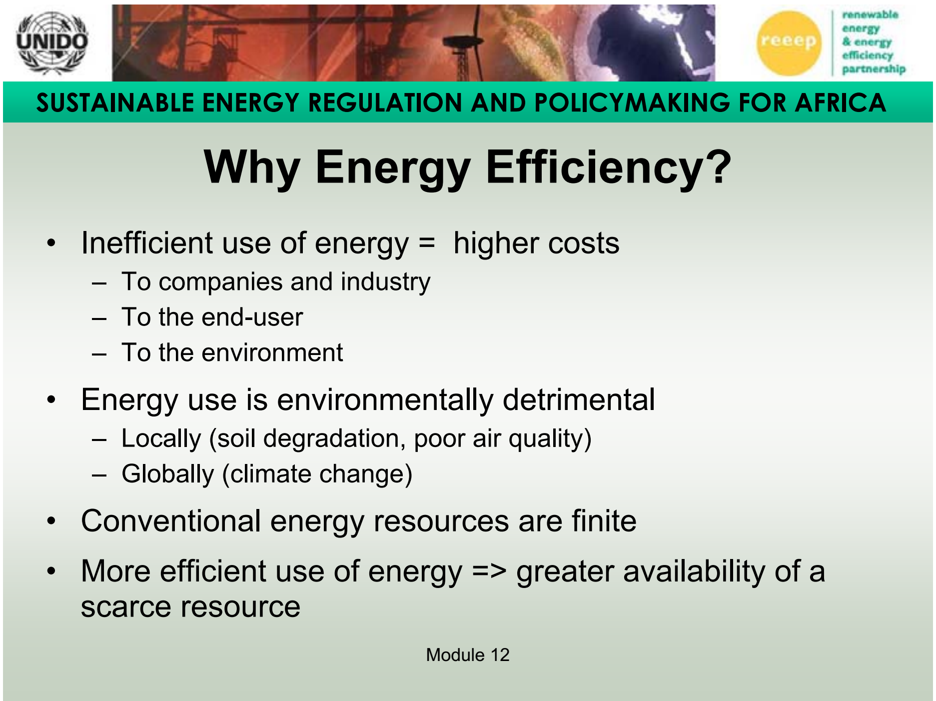


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reminder!

- Aim of this module is to provide general background and information—and to provoke discussion
- Other Modules in the Training Package, references and websites offer further information and research in specific areas
- There are a wide variety of EE actions, to match the needs of different sectors and individual countries

Module 12

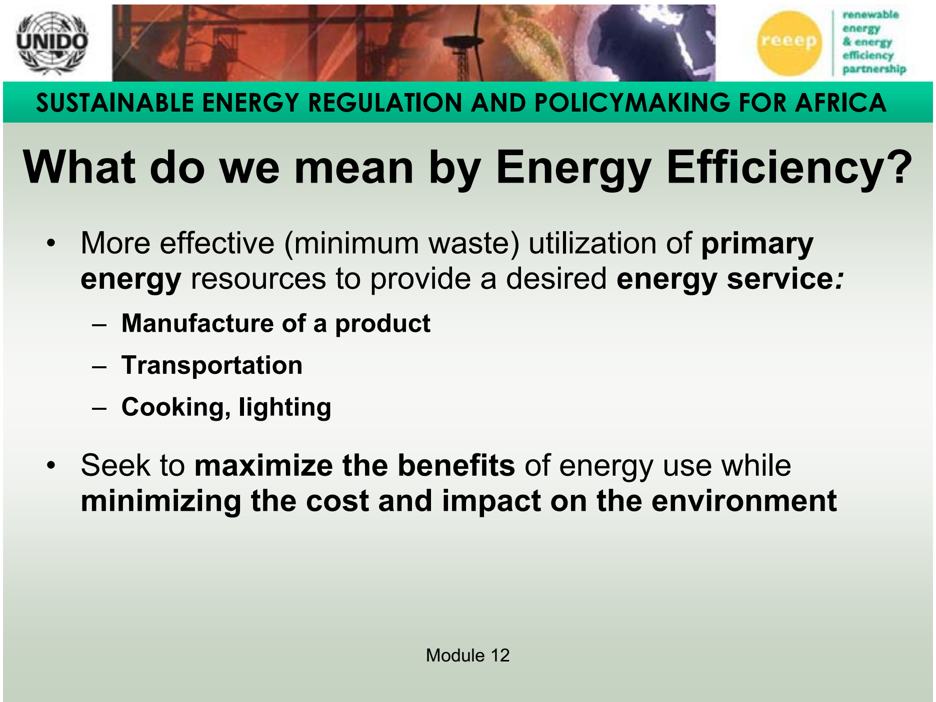


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Energy Efficiency?

- Inefficient use of energy = higher costs
    - To companies and industry
    - To the end-user
    - To the environment
- Energy use is environmentally detrimental
    - Locally (soil degradation, poor air quality)
    - Globally (climate change)
- Conventional energy resources are finite
- More efficient use of energy => greater availability of a scarce resource

Module 12



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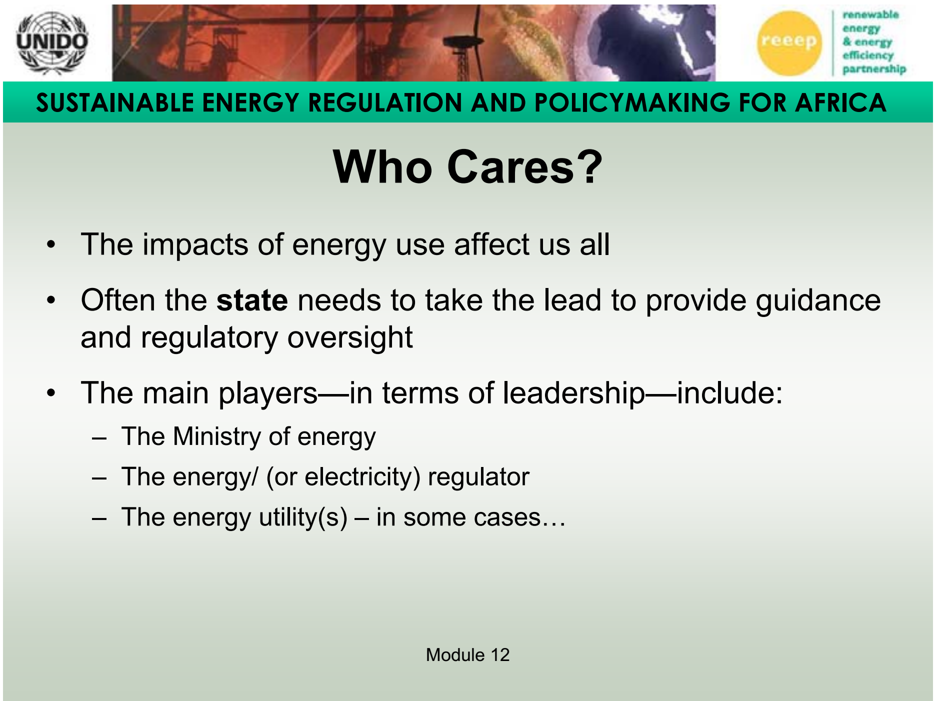
reeep renewable energy & energy efficiency partnership

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What do we mean by Energy Efficiency?

- More effective (minimum waste) utilization of **primary energy** resources to provide a desired **energy service***:*
  - **Manufacture of a product**
  - **Transportation**
  - **Cooking, lighting**
- Seek to **maximize the benefits** of energy use while **minimizing the cost and impact on the environment**

Module 12



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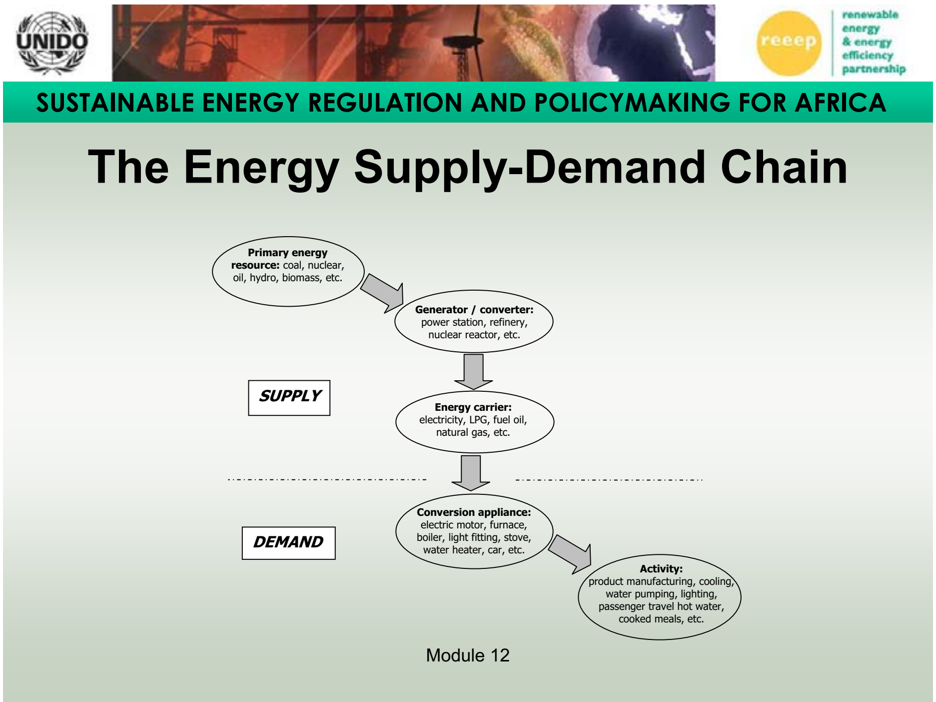
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Who Cares?

- The impacts of energy use affect us all
- Often the **state** needs to take the lead to provide guidance and regulatory oversight
- The main players—in terms of leadership—include:
  - The Ministry of energy
  - The energy/ (or electricity) regulator
  - The energy utility(s) – in some cases…

Module 12



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Energy Supply-Demand Chain

Primary energy resource: coal, nuclear, oil, hydro, biomass, etc.

Generator / converter: power station, refinery, nuclear reactor, etc.

SUPPLY

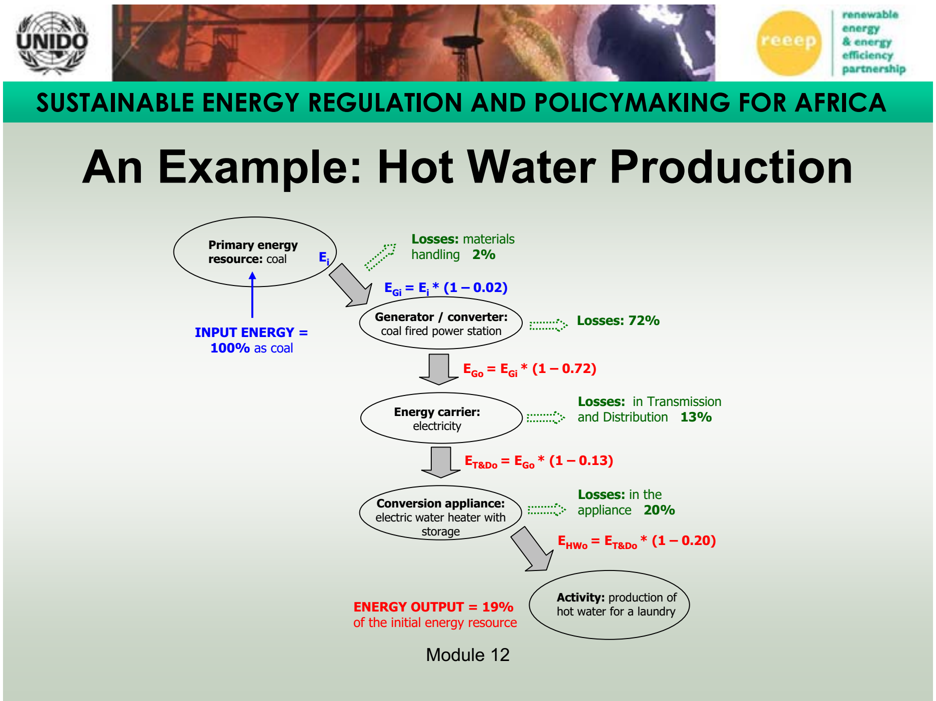
Energy carrier: electricity, LPG, fuel oil, natural gas, etc.

DEMAND

Conversion appliance: electric motor, furnace, boiler, light fitting, stove, water heater, car, etc.

Activity: product manufacturing, cooling, water pumping, lighting, passenger travel hot water, cooked meals, etc.

Module 12



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

An Example: Hot Water Production

Primary energy resource: coal E_i

INPUT ENERGY = 100% as coal

Losses: materials handling **2%**

$E_{Gi} = E_i * (1 – 0.02)$

Generator / converter: coal fired power station

Losses: 72%

$E_{Go} = E_{Gi} * (1 – 0.72)$

Energy carrier: electricity

Losses: in Transmission and Distribution **13%**

$E_{T\&Do} = E_{Go} * (1 – 0.13)$

Conversion appliance: electric water heater with storage

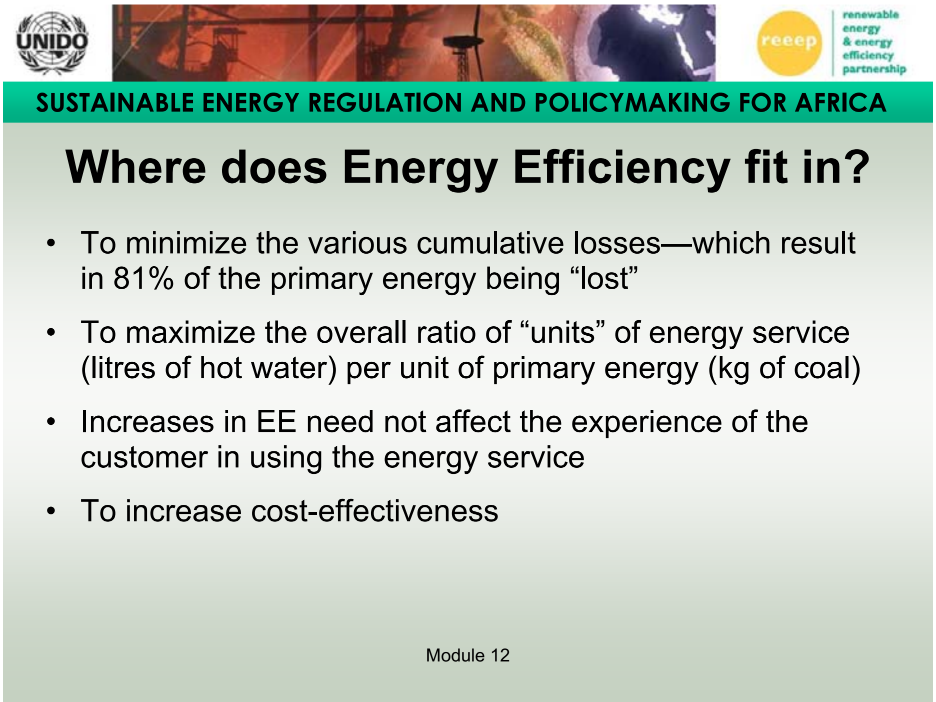
Losses: in the appliance **20%**

$E_{HWo} = E_{T\&Do} * (1 – 0.20)$

Activity: production of hot water for a laundry

ENERGY OUTPUT = 19% of the initial energy resource

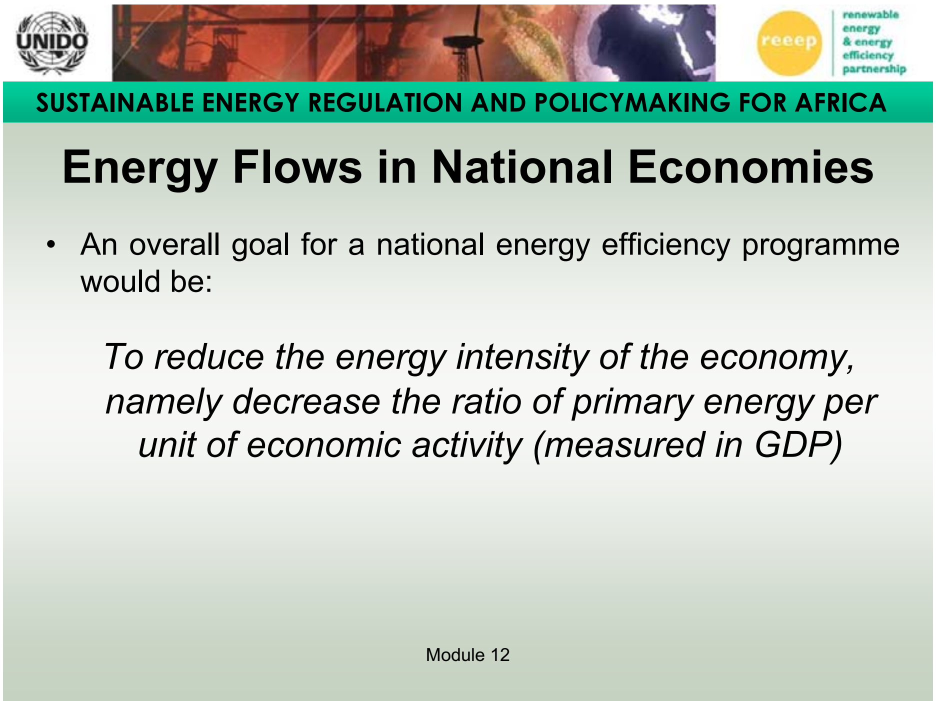
Module 12



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Where does Energy Efficiency fit in?

- To minimize the various cumulative losses—which result in 81% of the primary energy being “lost”
- To maximize the overall ratio of “units” of energy service (litres of hot water) per unit of primary energy (kg of coal)
- Increases in EE need not affect the experience of the customer in using the energy service
- To increase cost-effectiveness

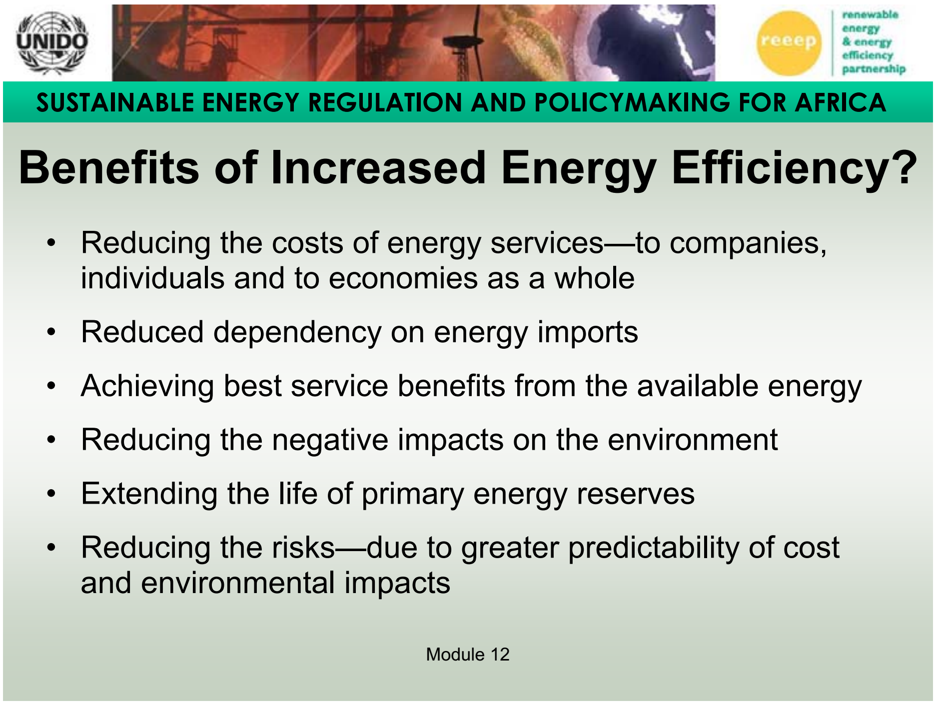


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Flows in National Economies

- An overall goal for a national energy efficiency programme would be:

To reduce the energy intensity of the economy, namely decrease the ratio of primary energy per unit of economic activity (measured in GDP)



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Benefits of Increased Energy Efficiency?

- Reducing the costs of energy services—to companies, individuals and to economies as a whole
- Reduced dependency on energy imports
- Achieving best service benefits from the available energy
- Reducing the negative impacts on the environment
- Extending the life of primary energy reserves
- Reducing the risks—due to greater predictability of cost and environmental impacts

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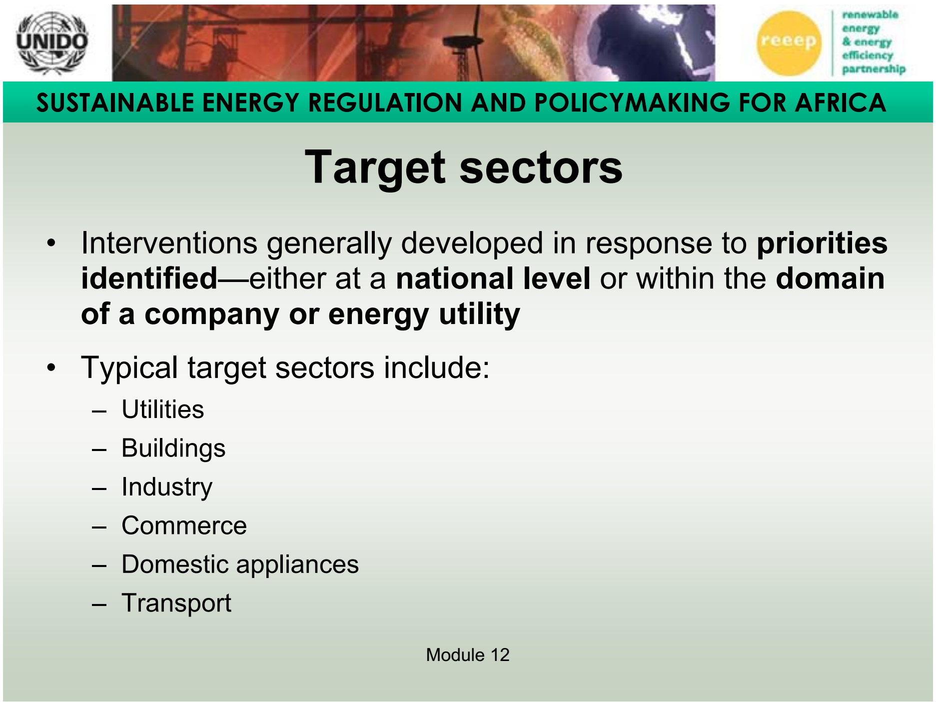

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Target sectors

- Interventions generally developed in response to **priorities identified**—either at a **national level** or within the **domain of a company or energy utility**
- Typical target sectors include:
  - Utilities
  - Buildings
  - Industry
  - Commerce
  - Domestic appliances
  - Transport

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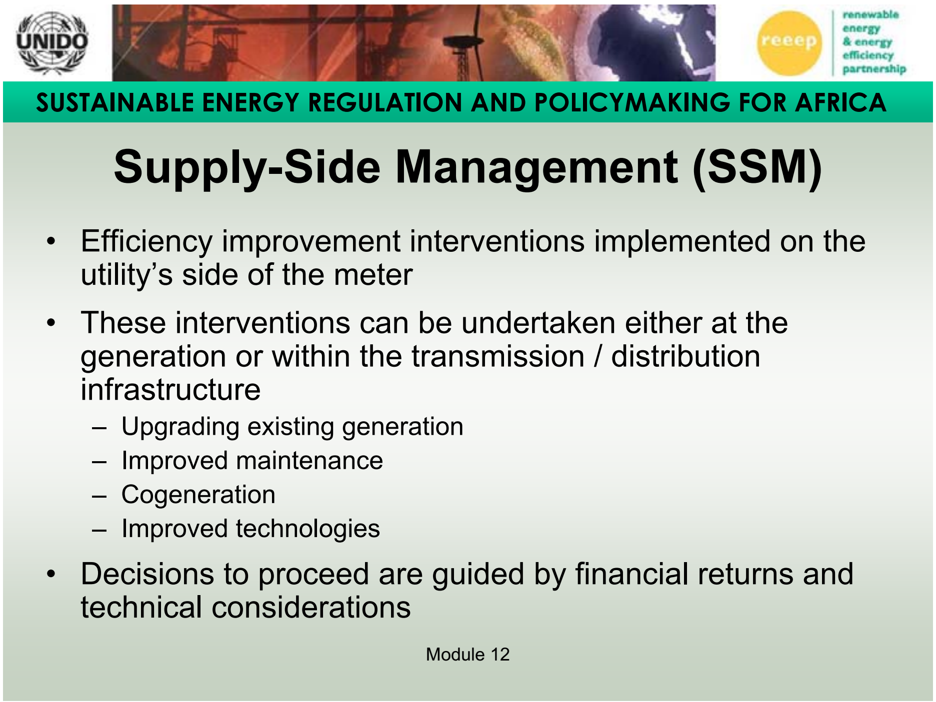

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Supply-Side Management (SSM)

- Efficiency improvement interventions implemented on the utility’s side of the meter
- These interventions can be undertaken either at the generation or within the transmission / distribution infrastructure
  - Upgrading existing generation
  - Improved maintenance
  - Cogeneration
  - Improved technologies
- Decisions to proceed are guided by financial returns and technical considerations

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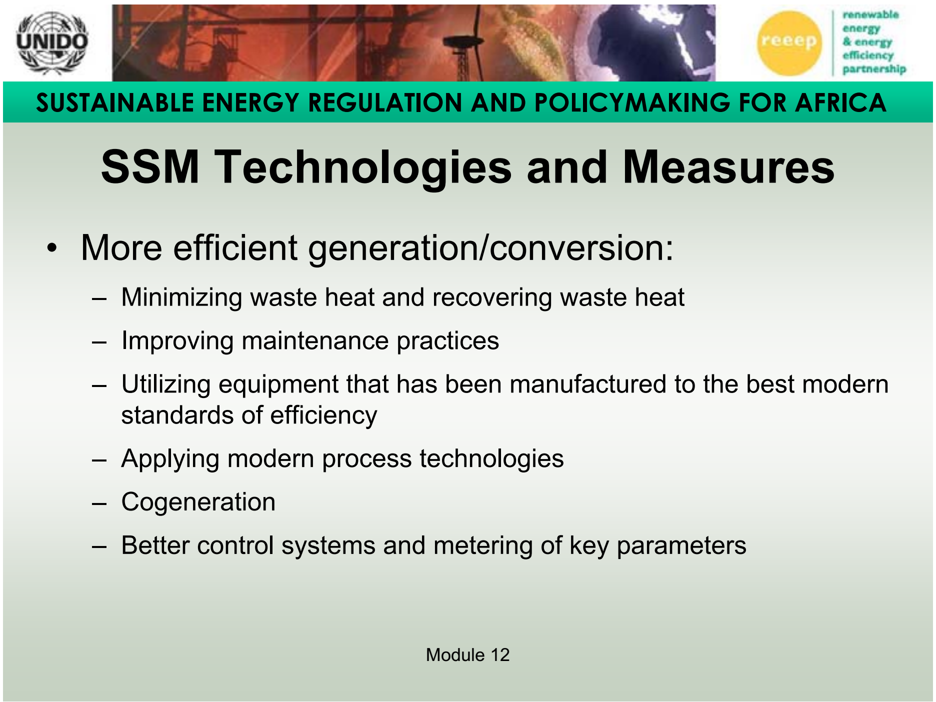

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

SSM Technologies and Measures

- More efficient generation/conversion:
  - Minimizing waste heat and recovering waste heat
  - Improving maintenance practices
  - Utilizing equipment that has been manufactured to the best modern standards of efficiency
  - Applying modern process technologies
  - Cogeneration
  - Better control systems and metering of key parameters

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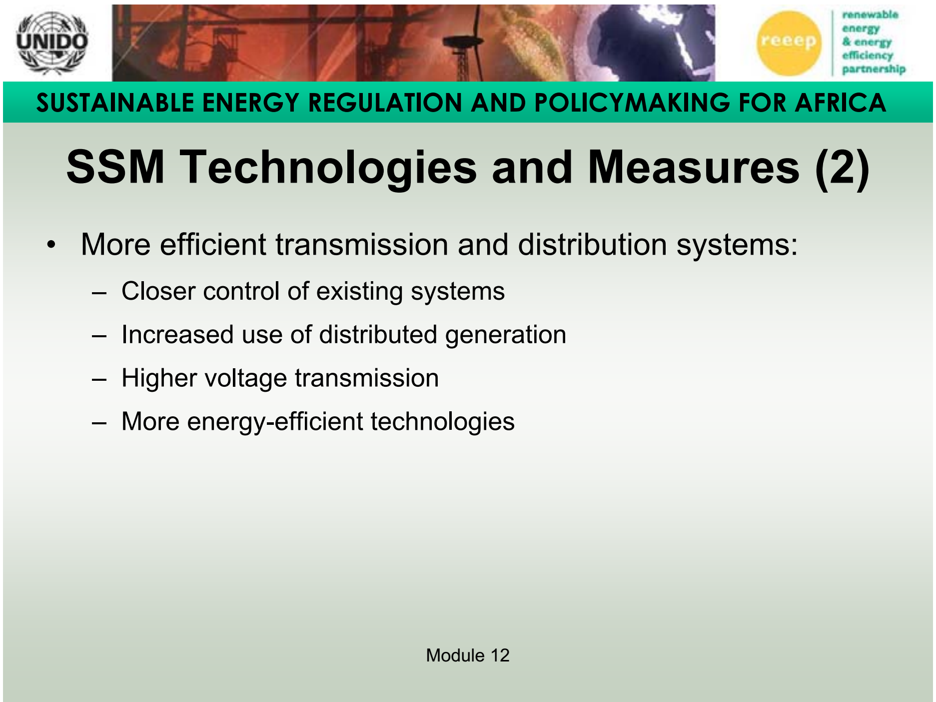
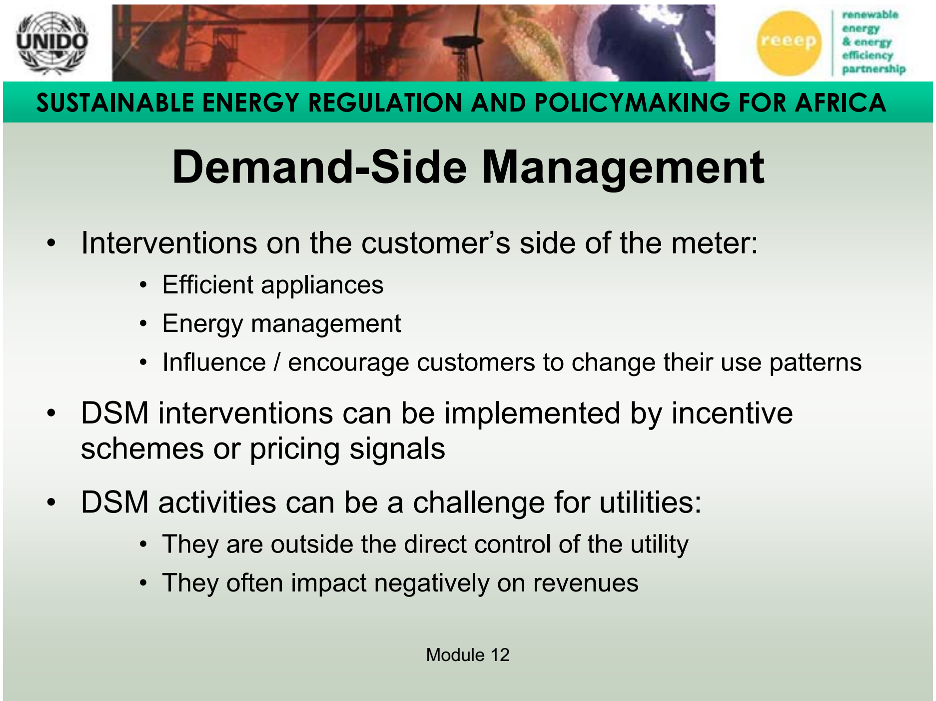


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

SSM Technologies and Measures (2)

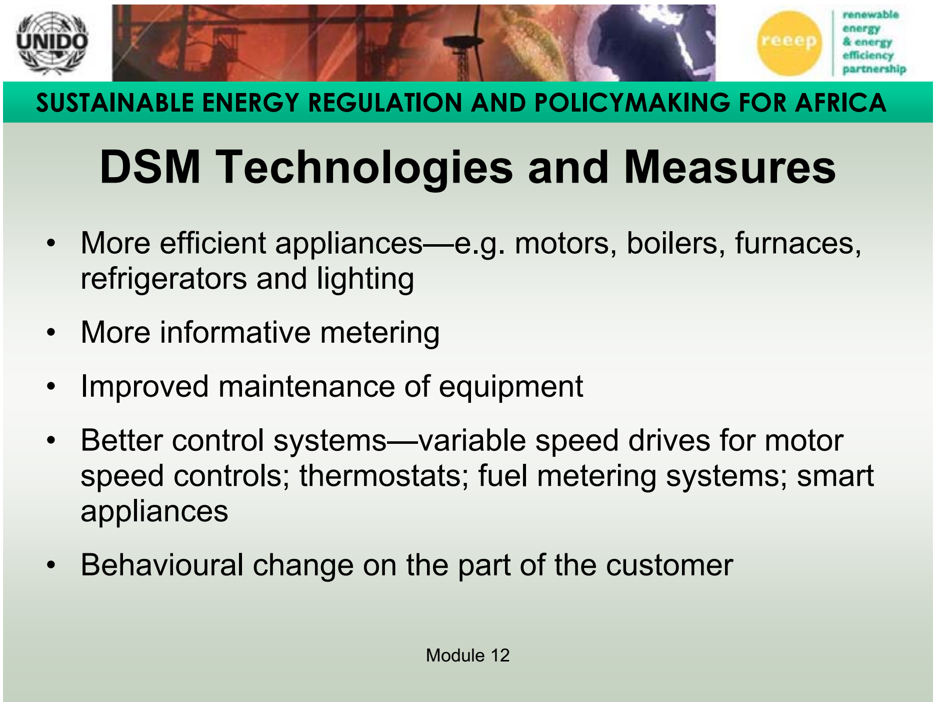
- More efficient transmission and distribution systems:
  - Closer control of existing systems
  - Increased use of distributed generation
  - Higher voltage transmission
  - More energy-efficient technologies



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Demand-Side Management

- Interventions on the customer’s side of the meter:
  - Efficient appliances
  - Energy management
  - Influence / encourage customers to change their use patterns
- DSM interventions can be implemented by incentive schemes or pricing signals
- DSM activities can be a challenge for utilities:
  - They are outside the direct control of the utility
  - They often impact negatively on revenues



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

DSM Technologies and Measures

- More efficient appliances—e.g. motors, boilers, furnaces, refrigerators and lighting
- More informative metering
- Improved maintenance of equipment
- Better control systems—variable speed drives for motor speed controls; thermostats; fuel metering systems; smart appliances
- Behavioural change on the part of the customer

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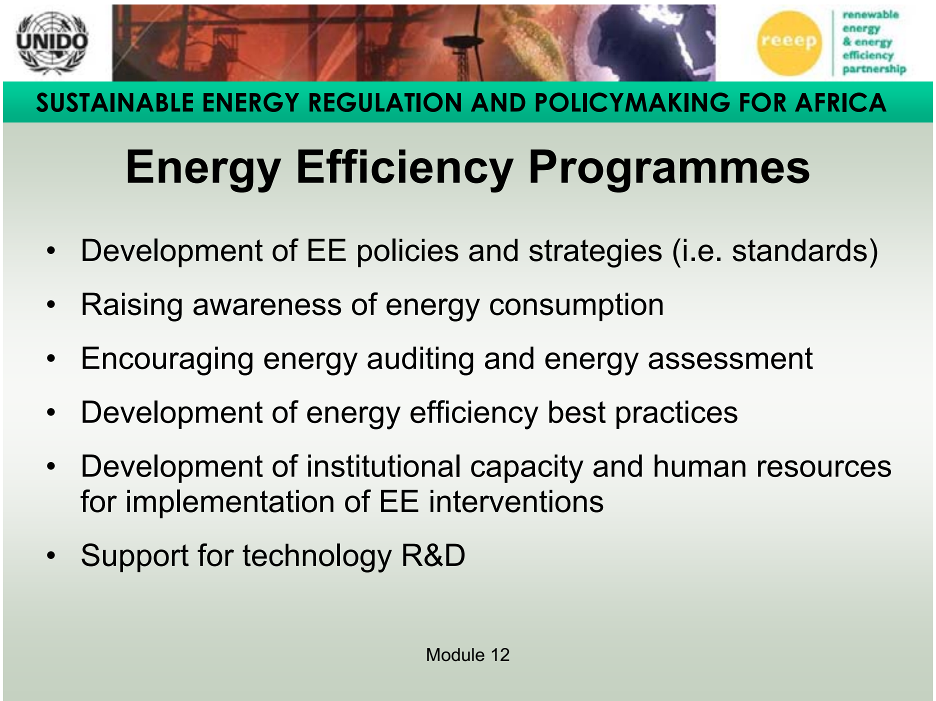

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency Programmes

- Development of EE policies and strategies (i.e. standards)
- Raising awareness of energy consumption
- Encouraging energy auditing and energy assessment
- Development of energy efficiency best practices
- Development of institutional capacity and human resources for implementation of EE interventions
- Support for technology R&D

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency Programmes (2)

- Introduction of incentive/penalty mechanisms to support improved EE
- Promotion and facilitation of international collaboration and cooperation

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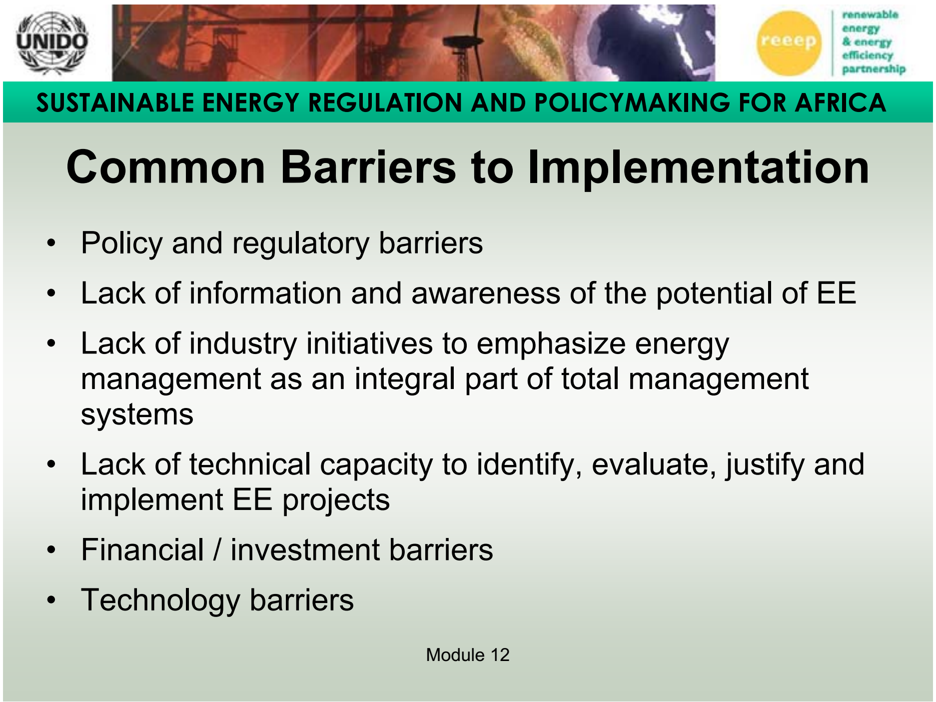

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Common Barriers to Implementation

- Policy and regulatory barriers
- Lack of information and awareness of the potential of EE
- Lack of industry initiatives to emphasize energy management as an integral part of total management systems
- Lack of technical capacity to identify, evaluate, justify and implement EE projects
- Financial / investment barriers
- Technology barriers

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Common Barriers to Implementation (2)

From a country undergoing
24h rolling load-shedding

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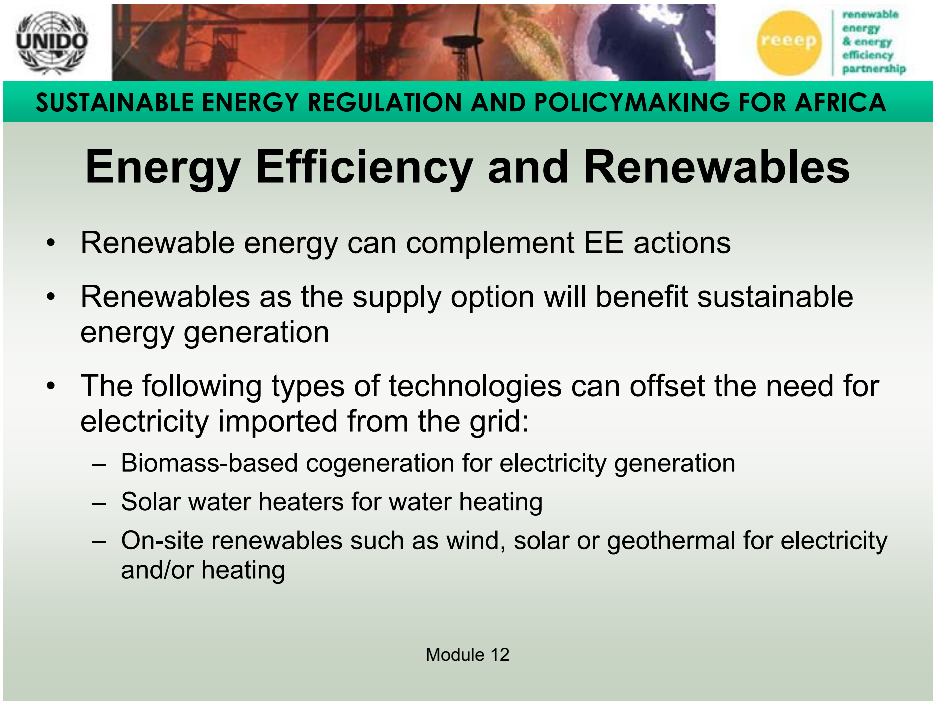

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency and Renewables

- Renewable energy can complement EE actions
- Renewables as the supply option will benefit sustainable energy generation
- The following types of technologies can offset the need for electricity imported from the grid:
  - Biomass-based cogeneration for electricity generation
  - Solar water heaters for water heating
  - On-site renewables such as wind, solar or geothermal for electricity and/or heating

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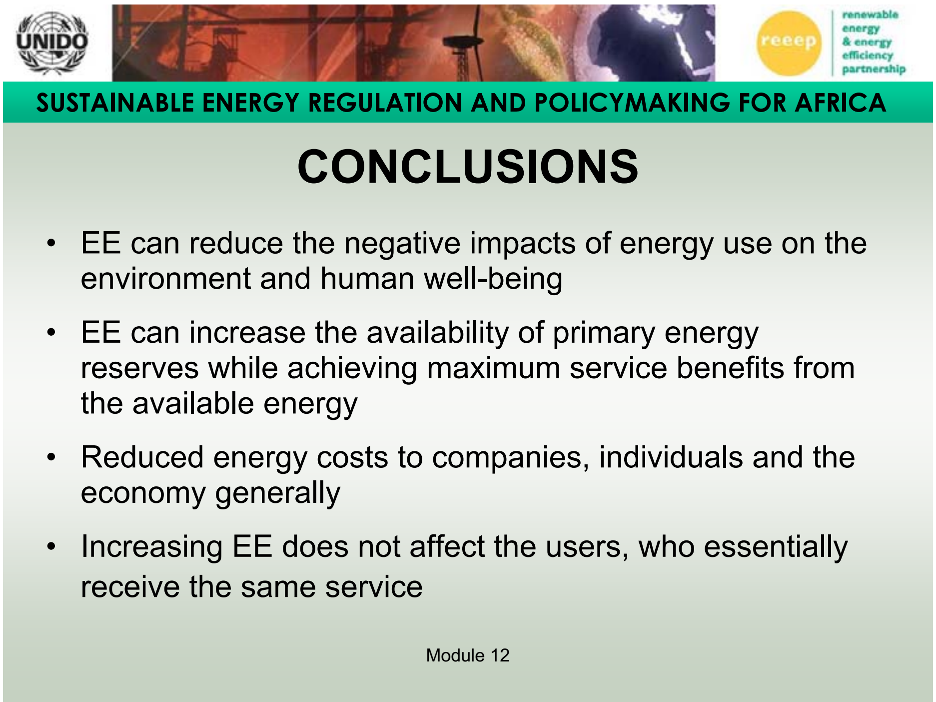


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- EE can reduce the negative impacts of energy use on the environment and human well-being
- EE can increase the availability of primary energy reserves while achieving maximum service benefits from the available energy
- Reduced energy costs to companies, individuals and the economy generally
- Increasing EE does not affect the users, who essentially receive the same service

Module 12

Module 13

Supply-side management

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Supply-side management (SSM) refers to actions taken to ensure the generation, transmission and distribution of energy are conducted efficiently. The term is used mainly with reference to electricity but it can also be applied to actions concerning the supply of other energy resources such as fossil fuels and renewables.

For the purpose of discussion in this module, the “supply-side” has been taken to include the following activities:

- Supply and utilization of energy resources—including clean coal technologies, fuel substitution and renewable energy use.
- Power generation and energy conversion—including operational improvements in existing plants, upgrading units and cogeneration.
- Transmission and distribution of electricity—including lines, substations and on-site generation.
- Transport of fuels—liquid, gaseous and solid fuels.

These topics—addressed primarily to electricity—are discussed in this module and various means of improving energy efficiency are mentioned. As the module is an introduction to the improvement of SSM, detailed technical topics have not been included but a number of references are provided to allow the reader to explore opportunities in greater depth.

As well as mentioning the benefits of SSM, a brief review is made of the constraints and challenges to cost-effective implementation.

1.2. Module aims

The aims of this module are:

- To introduce the concept of supply-side management, especially as it applies to electricity systems.
- To discuss options of supply-side management at each stage of the supply chain, e.g. energy resources used, generating plants, transmission systems, and distribution. This includes topics such as clean coal technologies, fuel substitution, cogeneration and decentralized (local) generation.

- To show how well known demand-side measures such as housekeeping and preventative maintenance can also apply in various parts of the supply side and how they have useful benefits in reducing energy waste.
- To give an overview of the constraints and the benefits of conducting supply-side management measures and programmes.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to define supply-side management and appreciate why it should be pursued.
- To understand the different types of supply-side management measures and programmes.
- To appreciate the constraints, challenges and benefits of supply-side management.

2. INTRODUCTION

2.1. What is supply-side management?

Supply-side management (SSM) refers to actions taken to ensure the generation, transmission and distribution of energy are conducted efficiently. This has become especially important with the deregulation of the electricity industry in many countries, where the efficient use of available energy sources becomes essential to remain competitive.

SSM is used primarily with reference to electricity but it can also be applied to actions concerning the supply of other energy resources such as fossil fuels and renewables. Utility companies may look at means of modifying their load profile to allow their least efficient generating equipment to be used as little as possible (compared with high efficiency equipment that should be used to the maximum). They may improve maintenance and control of existing equipment, or upgrade equipment with state-of-the-art technologies.

Energy users will normally focus their efforts on demand-side management methods (DSM) but some will consider the supply side too. For example, they may look at on-site generation alternatives—including cogeneration—or consider diversifying to alternative fuel sources (such as natural gas, solar, wind, biofuels).

2.2. Why pursue SSM?

For an electricity system, effective SSM will increase the efficiency with which the end-users are supplied, allowing the utility company to defer major capital expenditure, which might otherwise be required for increasing their capacity in growing markets (see box 1 below). SSM makes installed generating capacity able to provide electricity at lower cost (permitting lower prices to be offered to consumers) and reduces environmental emissions per unit of end-use electricity provided. SSM can also contribute to improving the reliability of a supply system. With the current trend of deregulating the supply industry, it is becoming more important to embark on supply-side management where the supplier, user and the environment all win.

In the case of SSM applied to biomass, the advantage of higher efficiency in the supply chain is the reduction in resources needed to meet a specific demand. This helps reduce the risk of deforestation and thus avoids not only a loss of energy supply but potential environmental damage.

In brief, an electrical utility may embark on SSM to:

- Ensure reliable availability of energy at the minimum economic cost ultimately increasing its profits;
- Provide maximum value to its customers by reducing energy prices;
- Meet increasing electricity demand without incurring in unnecessary major capital investments in new generating capacity;
- Minimize environmental impact.

Suppliers of other types of energy will have corresponding motives.

? Review question

Give at least three reasons why utilities undertake SSM programmes.

Box 1. **Electricity growth in the developing world**

Electricity consumption is growing rapidly worldwide. The highest rates of growth are in developing and transitional economies.

Examples of electricity consumption growth rates are as follows:

- Chile +53%
- China +19%
- India +20%
- Bangladesh +14%
- Senegal +8%

Source: World Commission on Dams, Project Output and Dissemination, Annex #3—Thematic Reviews (2001).

3. SSM OPTIONS AND OPPORTUNITIES

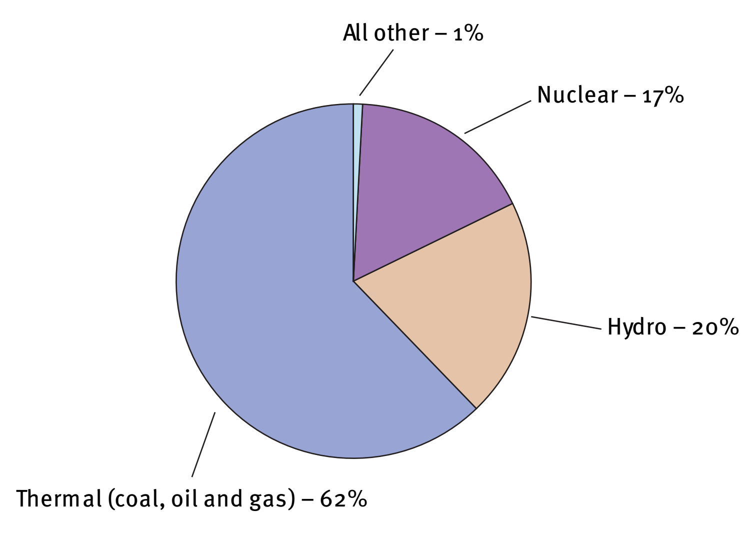
3.1. Introduction

As SSM is most often discussed in connection with electricity supplies, we will focus in this module on measures applying mostly to electric utilities. Electricity is of course a secondary source of energy and is derived from a wide range of primary energy sources, such as:

- Coal
- Natural gas
- Petroleum-based fuels.
- Nuclear energy
- Hydropower
- Geothermal energy
- Renewable energy such as solar, wing, tidal, biomass

To put the remainder of the module in context, figure I shows the breakdown of primary energy resources used worldwide for electricity generation.

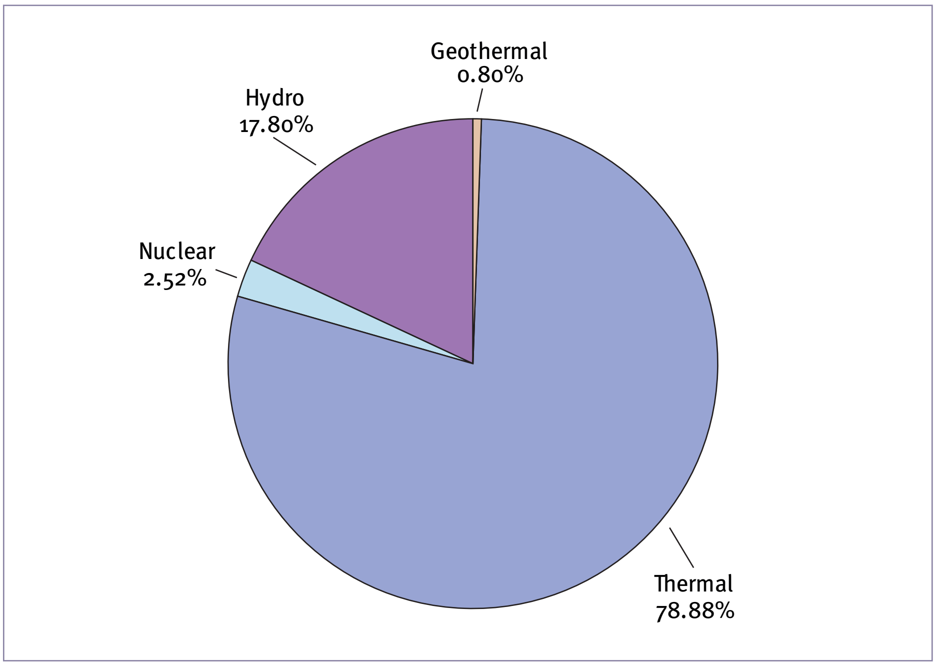
Figure I. Dominant electricity supply resources



Source: World Commission on Dams, 2001.

The contribution of renewables is small but growing. The bulk of the electricity generated in Africa is produced from conventional thermal power plants, with large coal plants in South Africa and oil-fired plants in Nigeria. In spite of very large exploitable hydropower capacity in Africa, its contribution remains relatively low at about 18 per cent, as shown in figure II below (see module 2 to know more about energy resources in Africa).

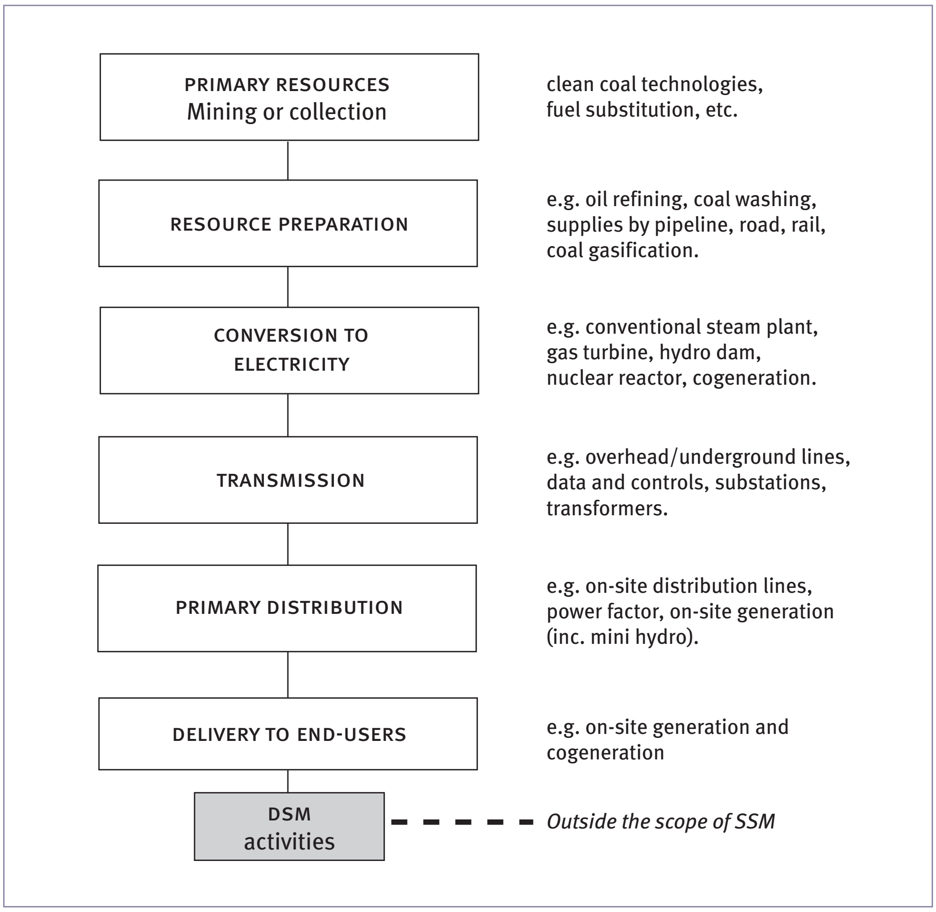
Figure II. Electricity production in Africa (2004)



Source: IEA, 2005.

For the rest of the discussion on SSM—most of which concerns electricity—the overall supply chain for electricity will be viewed according to the simplified structure shown in figure III.

Figure III. Simplified electricity supply chain



The indicated topics are dealt with in the order given above.

3.2. Resources and resource preparation

In this section, the various aspects of resource utilization for the production of electricity are addressed. The items presented all offer the potential for cost-effective efficiency improvements in elements of the supply chain and thus are classed as SSM options.

Clean coal technologies

Clean coal technologies (CCTs) are designed to improve the efficiency of the extraction, preparation and use of coal. Some of the technologies are well established and proven, others are relatively new and less well established, at least in developing countries. New technologies offer huge potential for using discarded coal. Improved efficiency in extracting energy from the coal delivers the same amount of electricity but with reduced gaseous emissions and solid waste. The importance of CCTs in general is that they offer more environmentally friendly means of exploiting a widely available and abundant resource—coal—that has traditionally been a difficult fuel to burn efficiently and is normally associated with environmental degradation.

There are many ways of using coal efficiently and cleanly, depending on different coal types, different environmental issues and different levels of economic development. Some CCTs require highly complex and expensive technology and infrastructure and therefore may not be relevant to all developing countries.

CCTs can include a broad range of items (Upgrading Transmission Capacity for Wholesale Electric Power Trade, John Makens) such as:

- Coal cleaning—processes used to increase the heating value and the quality of the coal, by lowering the level of sulphur and non-combustible mineral constituents. These simple methods—almost always used in developed countries—are suitable for developing countries.
- Emission reduction technologies—“bolt on” or “end of pipe” technologies including:
    - Activated carbon injection, to absorb pollutants.
    - Electrostatic precipitators, in which particulate/dust laden flue gases are passed between collecting plates where an electrical field creates a charge on the particles. The particles are attracted towards the collecting plates, where they accumulate and from which they are subsequently removed.
    - Fabric filters, to collect particulates by passing flue gas through tightly woven fabric.
    - Wet particle scrubbers, in which water is sprayed into the flue gas stream as a fine mist of droplets. The fly ash particles impact with the droplets forming a wet by-product, which is then removed for disposal.
    - Flue gas desulphurization (FGD), the process by which sulphur emissions are removed post-combustion by wet scrubbers, by dry scrubbers, by sorbent injection processes, by regenerable processes, or combined SO2/NOx removal processes.
    - Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR), in which steam is used as the reducing agent and is injected into the flue gas stream (passing over a catalyst in the SCR process).
- Efficient power generation processes, such as reducing emissions and improving efficiencies by the integrated gasification combined cycle (IGCC) process

in which the coal is gasified to produce a gaseous fuel for gas turbines to generate power. Fluidized bed combustion is another example—see the section on power generation and energy conversion.

- “Next generation” technologies, such as underground coal gasification (UCG) where coal is converted in-situ to combustible gas that can be used for power generation thus eliminating a large portion of the supply chain normally associated with coal fired generation. The gasified coal can be treated to remove sulphur derivatives and particulates to ensure combustion is clean.

Overall, CCTs improve the efficiency of coal-based electricity generation, with benefits such as:

- Increased electrical power output per unit of coal fired;
- Reduced environmental impact per unit of coal fired, possibly in conjunction with removal of CO_2 and SO_x emissions.

Fuel substitution

Fuel substitution (or fuel switching) is simply the process of substituting one fuel for another. Examples would be expanding the use of natural gas for industry, transport, domestic cooking and heating, and for electricity generation, rather than using liquid petroleum based fuel. Although such actions refer to energy supplies, most will in practice involve the energy user for implementation and thus could also be considered “demand-side management” measures in many cases.

As a general rule, the combustion of natural gas can be carried out much more efficiently than oil or coal, on a heating value basis. In industrial equipment, control of gas-fired equipment is usually much more precise and maintenance easier to carry out (partly because there will normally be much lower levels of corrosive components in the exhaust gases). A similar situation applies for commercial and domestic furnaces and boilers. The increased efficiencies that are achievable will often result in useful cost reductions even where the “new” fuel is somewhat more expensive than the “old” fuel. Thus fuel substitution can be regarded as a cost effective SSM measure.

An example of fuel substitution in energy supply in the transport sector is in Delhi, where 84,000 public vehicles converted from using gasoline and diesel as the fuel source to compressed natural gas (CNG) in a period of one year. In other sectors, the increased use of natural gas for electricity generation and public investment to develop the natural gas infrastructure for long distance and local distribution is also promoting fuel switching in Delhi. The share of gas in power generating capacity has risen from 2 per cent to 8 per cent over the past 10 years and LPG has largely replaced coal and kerosene in urban households (UNFCCC/SBI/2003/INF.14, 20 November 2003).

Renewable energy

Although the total contribution of renewable energy resources to energy demand in Africa is still very modest, the number of projects being implemented is growing. In 2003 developing countries that have no greenhouse gas emission reduction obligations under the Kyoto Protocol reported 141 supply-side improvement projects (UNFCCC/SBI/2003/INF.14, 20 November 2003). Of these, 82 projects involve renewable energy development:

- 31 with solar energy
- 23 with hydropower
- 14 with wind power
- 14 with various other renewable energies.

Renewable energy (RE) as a means of energy supply is covered in detail in the RE modules. However, due to its potential as part of supply-side management and on-site generation, it is briefly covered in this module too. Applications of on-site generation using RE are well suited for locations with no grid connection, where RE can offer a cost effective alternative to capital intensive extension of transmission and distribution lines and other highly priced fuels.

There are many examples of RE systems such as photovoltaic (PV) systems in remote rural areas of Africa powering schools, clinics or homes. Solar water heaters (SWH) are increasingly being recognized as a simple way to supply heat to homes or provide hot water in the industrial sector.

Utilization of biomass may offer important opportunities for providing energy supplies at moderate cost. Organic matter may be converted into energy in various ways. This organic matter is generally a renewable resource, which is either grown to replenish stocks (such as agricultural crops, trees or grasses) or collected as waste (e.g. animal or municipal waste).

The organic matter may be directly or indirectly:

- Used as a fuel—such as burning wood for cooking or burning bagasse to produce steam for electricity generation in a conventional steam turbine;
- Processed to liquid fuel (such as biodiesel from oil seed crops, or ethanol by fermentation of other crops) or a gas (such as methane from anaerobic digestion).

Box 2. **On-site wind generation**

"Wind Direct was formed in early 2004 to offer a service to intensive energy users by providing them with a cheap, direct energy supply from wind turbines. This demand has evolved from the present and future rise in electricity prices that industry has had to come to terms with. By utilizing on-site wind energy, the long term prospects of cheaper electricity allows for a more optimistic outlook and significant cost savings."

Source: www.wind-direct.co.uk

Sugar cane bagasse is an important example of biomass with significant potential for use as a fuel in the generation of electricity. Sugar cane has a high photosynthesis conversion efficiency, with yields of up to 130 tons per hectare. Generally only the stalk is used for sugar production leaving the fibrous bagasse consisting typically of around half fibre, half moisture and maybe around 2 per cent sugars. The bagasse can be burnt to produce steam and electricity (although it can also be processed into paper if economic conditions are favourable). Typically the full energy requirements of a sugar mill can be met by burning bagasse in special boilers and may often produce surplus power, which can be sold to the grid. The amount of electricity generated is around 55 to 85 kWh per ton of sugar cane processed, depending on the specific design of the system.

Sugar is produced in a number of Eastern and Southern African countries. It is a major agricultural export for Ethiopia, Madagascar, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe. The potential for electricity generation from bagasse is high, since cogeneration equipment is almost always an integral component of sugar factory design. However, despite this potential, at present only Mauritius and Réunion have succeeded in exploiting bagasse to a significant degree (Kassiap Deepchand, 2004) (see the case study in module 2 for more on the Mauritius experience).

Another application of fuel derived from biomass is methane produced by anaerobic digestion. Sewage, manure and organic waste can be used as the feedstock. The information provided in box 3 illustrates the potential of methane generation in Lusaka, Zambia, by anaerobic digestion of municipal sewage.

Box 3. **Methane generation in Lusaka**

Background

Lusaka Water and Sewerage company (LWSC) is involved in waste treatment and supply. It services Lusaka and surrounding areas. For pumping purposes LWSC has a total of 172 AC induction motors with a total demand of 10.4 MW.

Project objective

Investigation of the possibility of introducing an alternative energy supply through generation of electricity from methane from sewerage plant

Description

Conduct a feasibility study on the generation of electricity using methane derived from sewerage ponds at Manchinchi Sewer.

Electricity generation from methane

A detailed study was undertaken and, based on the results, it was found—and thus recommended—that electricity can be generated from waste material at Manchinchi sewerage plant through combustion of methane in a gas engine with a capacity of 1 MW. This will contribute to reducing the current LWSC power requirement of 10.4 MW, and save the corresponding amount from the electricity bill. A closed tank anaerobic digester is shown above.

Description of follow-up action

LWSC is in the process of sourcing funds for the methane production and combustion project through a CDM arrangement. Implementation of the project will result in a saving of 26,000 tonnes of CO_2 equivalent.

Finally, there are some locations where geothermal power could be exploited. The energy within hot rocks deep in the earth is "recovered" by pumping water into the rocks and collecting the resulting steam for the generation of electricity. Until now its potential—much of it in the Eastern African Rift Valley region—has remained largely untapped.

At a conference in Nairobi in April 2003—the Eastern African Geothermal Energy Week (UNEP)—a "challenging yet achievable target" for geothermal exploitation was set by the attending government energy experts, scientists, engineers and members of the private sector. This target was to develop 1,000 MW of geothermal energy recovery across Eastern Africa by 2020. This is equivalent to the electricity needs of several million people in the region. In total, Africa was said to have a potential of up to 7,000 MW of untapped geothermal energy resources.

At the time, Kenya, which has pioneered geothermal energy in the region, generated 45 MW of electricity from "hot rocks". The technology has proven very reliable, as Kenya has used geothermal energy for power generation for at least 22 years at greater than 97 per cent availability. Geothermal energy is clean energy and, unlike hydro-electricity, is not vulnerable to droughts. It also is not prone to unpredictable price fluctuations as can be the case with oil-fired power generation (UNEP).

Although not necessarily associated with geothermal resources, ground source heat pumps are another means of exploiting the heat that occurs naturally underground. Heat pumps can be used to convert the low temperature energy into high-grade heat, using electric or gas powered drivers. The higher temperature energy is then suitable for heating (or cooling) buildings.

3.3. Power generation and energy conversion

Power generation and energy conversion is almost certainly the activity where most energy losses occur and therefore where efforts to improve energy efficiency are most likely to prove most beneficial. Several topics relating to improving power plants are introduced and discussed below. Some apply mainly to existing facilities while others will represent opportunities for higher energy efficiency to be achieved through replacing old technologies and equipment with new and best modern practice designs.

Operation improvement in existing plants

The typical energy efficiency of a modern, well-maintained power plant is around 33 to 38 per cent (Frans van Aart, 2004). This is the amount of energy that is used in the plant as fuel and is converted into electricity for sale to customers. The main losses—the 62 to 67 per cent of energy that is not usefully converted—are in the hot exhaust gases from the boiler stack and in warm cooling water used in heat exchangers to condense low pressure exhaust steam. There are some technological limitations, deriving mainly from the laws of thermodynamics, that make it impossible to eliminate some of the lost energy but there are also many situations where equipment is not run at top efficiency and thus improvements could be made.

Housekeeping

Measures to reduce energy consumption and improve energy efficiency in enterprises and other organizations may be divided into three basic categories:

- No-cost and low-cost measures;
- Measures requiring moderate levels of investment;
- Measures requiring significant investment.

Each organization will have to make its own decision regarding what “moderate” and “significant” mean, as this depends on many factors, such as the size of facilities, levels and cost of energy consumption, and the financial situation of the organization.

The first category—the no and low-cost measures—covers items usually known as “good housekeeping” and these should be implemented by the organization to “tidy up” its operations. This applies to all the organizations involved with supply side activities but particularly to power plants (which are quite similar to industrial plants in terms of energy efficiency improvement activities). Organizations should always consider implementing housekeeping measures promptly because they can reduce energy demand in the short-term, usually for very small capital investments and low installation costs.

Some examples of good housekeeping are:

- Maintaining appropriate boiler and turbine control settings—optimizing the efficiency of the steam raising and electricity generating processes, thus reducing internal energy requirements.
- Checking boiler feed-water quality regularly to ensure water treatment is working properly and the appropriate blowdown of water is being carried out at all times.
- Repairing steam, water and compressed air leaks—improves system efficiency and reduces the energy needed to generate the equivalent of the leaked steam, to treat additional water to boiler feedwater purities, and to compress additional air using electricity for compressors.
- Removing redundant lighting fixtures—many sites undergo modifications and reorganization but lighting systems are often not correspondingly moved, with the result that lights may become redundant.
- Removing redundant pipework—often steam and water piping (and sometimes related equipment such as pumps) become redundant as a power plant is developed or changed over time. Unless properly insulated or removed, the redundant items may contribute to unnecessary heat losses and leaks of steam or other process fluids.
- Operating cooling towers efficiently—maintaining design parameters for water flows and temperatures in and out, and ensuring that scale is not allowed to accumulate on heat exchange surfaces.

Maintenance

Good maintenance has an essential part to play in achieving good levels of energy efficiency. For example, here are some typical deficiencies in industrial facilities and power plants:

- Meters are uncalibrated or out of service;
- Steam traps are defective—not working as traps, leaking etc;
- Valves are leaking at the spindle, losing steam, water, compressed air and process fluids;

- Insulation of steam distribution piping is inadequate.

Many power plants will be able to benefit from improved maintenance, increasing their energy efficiency performance and reducing emissions correspondingly. All too often maintenance is only performed when a breakdown occurs, whereas prevention of breakdowns can contribute greatly to long-term energy efficiency. Preventive maintenance can take various forms, some examples of which are:

- Developing and applying routine lubrication schedules;
- Replacing critical items on a regular schedule (e.g. steam traps);
- Monitoring lubricant composition to determine when excessive wear of metal parts is occurring (e.g. steam turbines, rotating generation equipment);
- Monitoring noise and vibration of bearings before failure actually occurs;
- Regular filter cleaning on air compressors, pumps, upstream of steam traps, in ventilation ducts, etc.;
- Continuous scale removal from heat exchangers;
- Monitoring hot spots on boilers to check for refractory failure.

Introducing a preventive maintenance system should include keeping good records of actual failure rates and an analysis of the reasons for breakdown of different types of equipment. Preventive maintenance thus contributes to machines running at optimum efficiency, as well as minimizing unscheduled downtime.

Data and performance monitoring

This section introduces the need for data to conduct regular performance monitoring of existing power plants, an essential management activity to keep conversion efficiency at its highest. Unfortunately many plants do not carry out rigorous analysis of performance on a regular basis. As this is an introduction, much detail has been omitted and only the main ideas and concepts are discussed here.

To ensure that existing plants and processes perform at their best—and this includes both industrial plants and electricity generating facilities—a routine monitoring system should be set up with three main activities:

- Checking selected material balances, to verify the efficient use of materials throughout the plant;
- Undertaking routine data analysis, to monitor energy performance and key consumptions (e.g. electricity, fuels, water) and the corresponding costs;
- Inspecting the physical condition of the plant to observe the general condition of process equipment and systems.

These activities are complementary and give senior management a regular review of energy (and other) performance. The well known phrase—"if you cannot measure it, you cannot manage it"—applies to most aspects of enterprise activities and therefore routine energy performance monitoring should be recognized as an important management tool in any type of plant.

The types of data needed for routine monitoring may be divided into three main categories:

- Consumption and production
- Cost
- Drivers

Consumption and production data—including fuels and materials consumed, and production (e.g. electricity output)—are the most basic data required for energy performance management, and are essential for environmental management too. The main data are meter readings although some items may be delivered in bulk and not measured on site (e.g. coal). In these cases, an alternative form of measurement is needed such as the weight of trucks or rail wagons. **Cost data** is important for any organization running an energy management programme to put costs into perspective and ensure savings are made. Cost also provides a common language across departments and disciplines. The principal sources of energy cost data are the energy or fuel suppliers, either from tariffs or actual invoices. A **driver** is any factor that influences energy consumption. For most industrial processes, the main driver is the production. For a power plant, it is the electricity output.

There are many sources of data in a typical power plant. Some examples are:

- Production statistics, e.g. steam produced by boilers, electricity produced;
- Material consumption reports, e.g. purchased fuels and other consumables;
- Purchasing reports for miscellaneous items such as refractory lining and chemicals;
- By-product and waste disposal reports, e.g. for wastes in liquid or solid form;
- Log sheets from individual departments and workshops, e.g. boiler operating data. These can include data on water treatment and water quality, and combustion gas analyses (to check combustion efficiency).

While measurement of oil or gas burned in a boiler is made in most plants, the measurement of coal burned in individual boilers is relatively rare. Again, plants tend to allocate coal consumption simply for accounting purposes and the figures appearing in reports are not the real data. Coal consumption is difficult to measure with any accuracy. Account should be taken of changes in inventory, for example, and it is difficult to estimate how much coal there is in a large pile on the ground. Also, coal quality is notoriously variable from one shipment to another, in terms of ash content and moisture for example. For proper energy analysis, an effort should be made to adjust the reported raw coal tonnages by the calorific value, deriving figures for the tons of “standard coal” consumed (usually defined as coal with a calorific value of 7000 kcal per kg). With coal quality taken into account, the quantity of coal burned in any individual boiler can then be compared to the steam production to give a figure that represents the combustion efficiency of that boiler.

Most industrial and electricity generating plants collect the main data on a monthly basis so this is a suitable time period on which to base analyses. The availability of reliable data varies from place to place but most power plants actually collect a great deal of information every month (although not all will analyse the data properly or treat data as a valuable management tool). Seasonal effects need to be checked and their impact removed from the consumption data: heating and cooling of buildings and offices should be analysed separately from the main boiler data.

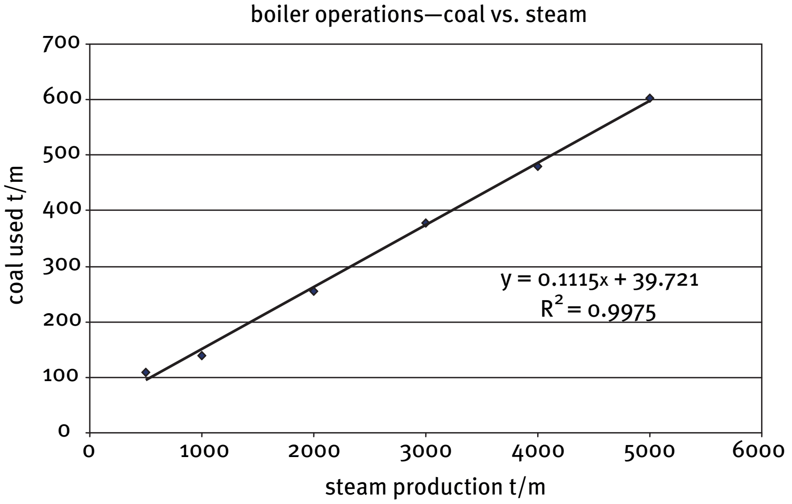
Above all, it is important that energy performance evaluations using monthly data be carried out promptly and preferably close to the end of each month. A monthly performance review should lead to a monthly report that is suitable for wide distribution within the power plant (both successes and failures can provide motivation for management and the workforce). If the analysis is left for later, it becomes much more difficult to account for any discrepancies that are observed, and of course it is always desirable that corrective measures be taken as soon as possible.

Regular monitoring of energy data forms the basis for continuous performance evaluation and control. The performance assessment will indicate if and where deficiencies in performance have occurred—such as a drop in boiler combustion efficiency—and indicate the necessary remedial action. It will also provide quantified evidence of exactly how successful any energy efficiency improvement (or supply-side management) measures have been.

The analysis of routine data is best presented graphically. A better appreciation of variations is almost always obtained from a visual presentation rather than from a table of numbers. For most power plants, a graph of “energy (fuel) used per month” against “monthly electricity production” can reveal a great deal about the energy efficiency of the process. Note that fuel use must be analyzed separately from internal electricity use (such as that used for auxiliary activities like cooling water pumping). Separate graphs should always be drawn. The efficiency improvement measures applicable to the different energy types are usually quite different and the efficiency of use of each energy type will also be different, and hence adding together the different energy forms using an assumed conversion factor to give a total energy consumption figure merely obscures what is actually happening.

From the separate graphs, we can develop equations that express in numerical terms, the “fuel consumption-electricity production” relationship (a proxy for boiler efficiency). For most typical power plants, the energy consumption plotted against electricity output, the energy-production graph will approach a straight line. The slope of the line is representative of the efficiency of the operation. We may also draw graphs against electricity production of compressed air consumption and of cooling water use.

Box 4. **Graph of coal consumption versus steam production for a boiler**



The equation for the best-fit line indicates efficiency of the boiler:

Efficiency based on best-fit line

Equation from graph: Coal (t) = 0.1115 Steam (t) + 39.7

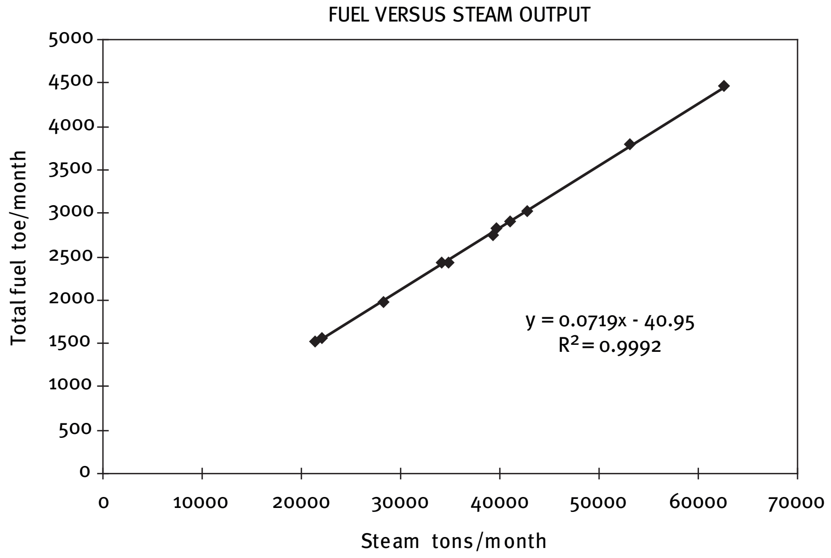
Steam Tons	Coal Tons	OUT heat Million KJ	IN fuel Million KJ	Efficiency %
500	95	1324	2673	49.5
1000	151	2648	4234	62.5
2000	263	5296	7356	72.0
3000	374	7944	10478	75.8
4000	486	10592	13600	77.9
5000	597	13240	16722	79.2

Based on 8 bar steam and coal calorific value of 28 MJ/kg

We may draw some conclusions by looking at various aspects of the graphs. For example, the degree of scatter of points in any graph is a general indication of the standard of energy management in the plant. If no significant changes in fuel type have occurred, widely scattered points usually mean that energy consumption is not properly controlled and operating practices are poorly defined and inadequately monitored by supervisors and managers. Points that follow a straight line quite closely suggest good process control.

Of course, it is quite common to find plants that falsify the steam-fuel data, or perhaps use design factors that remain constant for many years. In many cases therefore, the data points lie on a perfect straight line, a line that is too perfect to be a realistic picture of the actual situation. As an example, figure IV below shows data given by a large oil refinery in China: clearly the data are not real figures because the fit is perfect ($R^2 = 0.999$) and the line passes almost exactly through the origin. This implies a boiler efficiency that is identical every month and at every level of output, a situation that never occurs in the real world. Almost certainly, the steam production figures are correct and the fuel figures are calculated based on a fixed boiler efficiency of 90 per cent.

Figure IV. Example of unrealistic fuel-steam output data



Combustion control

For practical purposes, combustion refers to the burning of a fuel in air to release the energy in the fuel. In industrial plants, this energy might be used in many different ways. For example, to heat solids in a furnace (e.g. to heat steel ingots prior to rolling into steel sheets), to heat process fluids for a chemical reaction, or—most commonly—to heat water in a boiler in order to produce steam for heating or mechanical use (e.g. to power turbines).

With respect to power plants, minimum operating costs are achieved by running boilers at high thermal efficiency. Heat losses will include losses as hot flue gases (typically 15-30 per cent of fuel input energy), losses through the wall or structure of the boiler (typically 2-6 per cent of fuel input), and losses in blowdown (necessary to control boiler water quality, typically 2-5 per cent). In round figures, the losses thus add up typically to around 20 to 40 per cent of the fuel energy input, equivalent to a boiler efficiency of (100-20) or 80 per cent at best to (100-40) or 60 per cent at worst. It is possible to add various types of heat recovery devices to a boiler to improve on these figures. The figures quoted are of course only approximate, the actual figures for a boiler can vary greatly and depend on a large number of factors, including the skills of the operators, the maintenance levels, and the basic design of equipment (all of which are site-specific).

Most fuels contain differing amounts of carbon and hydrogen, both of which can be burned to release heat. The amount of oxygen needed to achieve complete combustion can be calculated accurately if the exact composition of the fuel is known—as it is in most cases. The amount of combustion air required can also be calculated since the composition of air is well known. However, while a certain amount of oxygen is needed from the air, any excess oxygen above the theoretical needs (also known as the stoichiometric amount of oxygen) is not needed, and all of the nitrogen introduced as part of the air is also unnecessary. Unfortunately the air will have been introduced at ambient temperature, say 15-20 °C, and will leave at the flue gas temperature, say 200-300 °C or maybe higher. Thus a lot of fuel will be used to heat up the unnecessary air, which becomes significant heat loss when it is discharged.

The key to keeping boiler efficiency high is to introduce just the right amount of air for combustion and as little as possible in excess of this amount. For this reason, the extra and unnecessary air is known as “excess air” and this should be kept—depending on the fuel used and the burner design—to say 5 to 10 per cent of the stoichiometric amount. This small amount of extra air is needed to ensure the combustion of the fuel is complete in the boiler. Too little air can lead to incomplete combustion and the formation of smoke in the stack (as well as significant amounts of carbon monoxide that should have been burned to carbon dioxide).

To maintain excess air at the lowest level possible, it is necessary to check the flue gas composition and keep the oxygen in flue gas to around 3-5 per cent in most cases. It is not enough to add air to the boiler until there is no smoke visible and then add a little more—the practice of some boiler operators. Accurate analyses of flue gas are essential. Analytical instruments are readily available to do this measurement, either as a fixed analyser mounted on the stack or as a portable analyser used regularly by plant operators. The cost of instruments can be quite modest: a simple hand held unit would cost say $US 1,000 while more comprehensive instruments will range up to perhaps $US 10,000. The more expensive instruments will include measurement of oxygen, carbon monoxide, nitrogen oxides and temperature: many such instruments compute and display excess air and combustion efficiency as percentages.

Where fixed gas analysers are installed, it is common to find that the instrument is used to adjust the air rate automatically, in line with the oxygen level actually found. Usually a signal is sent to an actuator that opens or closes a valve in the air supply line. Boiler controls can therefore be useful to maintain combustion efficiency at the highest level, even where loads fluctuate, fuel quality changes and ambient air temperature varies.

The fuel saved by ensuring the excess air is correctly set will of course depend on the situation at the boiler before corrective action is taken. Where no gas analysis has been done before, it is not uncommon to find excess air at 40-50 per cent on oil and gas fired boilers, and perhaps 100 per cent or more on coal fired units. Reducing these figures to levels around 5 to 10 per cent—closer to the minimum levels recommended—represents typically a saving in fuel costs of at least 5 per cent, or possibly 10 per cent in extreme cases. For a very modest investment in a gas analyser, the savings are often substantial and paybacks of 1-2 weeks are not unknown.

Fluid bed combustion

Fluidized beds are used to suspend solid fuels on upward-blowing jets of air during combustion. The result is a turbulent mixing of fuel and combustion air, like a bubbling fluid, and this ensures good contact between the fuel and the oxygen in the air. Combustion is improved and heat transfer between the hot bed and pipes within the bed is encouraged.

Fluidized bed combustion (FBC) evolved from efforts to develop a combustion process able to control pollutant emissions without external devices such as scrubbers. The technology burns fuels at temperatures of around 750 to 950 °C, well below the threshold at which nitrogen oxides form (typically about 1370 °C). The mixing action of the fluid bed also brings the flue gases into contact with a sulphur-absorbing chemical that can be introduced into the bed. Examples are limestone or dolomite particles. More than 95 per cent of sulphur pollutants in coal fuels can be removed in this way.

Pressurized fluid bed combustion (PFBC) was developed from the original FBC. The first generation systems use a bubbling bed technology in which a relatively stationary fluid bed is established in the boiler with low air velocities and a heat exchanger immersed in the bed. Cyclone separators remove particulate matter from the exhaust gases prior to their entry into a gas turbine, which operates as part of a combined cycle (see "Cogeneration" below). Second generation systems use a circulating fluid bed and other efficiency enhancement methods. These include integrating a coal gasifier to produce a fuel gas for burning in the PFBC.

Because of the vigorous mixing of fuel and air, FBC is suitable for many types of fuel that might otherwise be difficult to burn completely, such as coal, wood wastes, municipal solid waste, plastic and used tyres.

Upgrading generation units

Upgrading generating units can improve reliability, increase output and reduce environmental impacts from electricity generation. Typical improvements are the installation of new and improved burners, extra flue gas heat recovery, additional heat recovery from hot blowdown water, as well as modernization of instruments and combustion control systems. For very old power plants, it may be justified to replace the old equipment completely with a new generation plant designed and built to the best modern efficiency standards.

There are a large number of possible measures to adopt to raise the operating efficiency of an existing power plant. Implementation depends on the type of plant, the technology currently used, the level of maintenance, and many such factors that are site-specific. It is therefore impossible to estimate the potential improvements without a careful analysis of the actual plant and the costs involved. However, it is possible to make very rough estimates of the typical range of figures that might be encountered in practice.

In table 1, figures are quoted for the efficiency of various types of plant. They are based on the net calorific value of the fuel and are very approximate (Frans van Aart, 2004). Each plant is different and will achieve an efficiency dictated by site-specific conditions—the exact design adopted, the exact composition and quality of the fuel, the operating load, and maintenance. The figures suggest the approximate gains in efficiency that can be obtained by changing the technology used in a power plant. The economics of such a change are of course open to question and need to be assessed on a case-by-case basis.

Table 1. Best possible efficiencies for different types of generating plant

Fuel	Technology	Existing plants (percentage)	New plants (BAT) (percentage)
ELECTRICITY ONLY – figures for net electrical efficiency			
Bituminous coal	Pulverized coal, with conventional boiler and steam turbine	Typically 30 to 40	43-47
	Fluid bed combustion	30-40	>41
Lignite	Pulverized coal	30-40	39-45
	Fluid bed combustion	30-40	>40
Biomass	Grate firing Spreader stoker Fluid bed combustion	— — —	Approx. 20 >23 28-30 or more
Peat	Fluid bed combustion	—	28-30 or more
Gas firing	Gas turbine to power the generator	25-40	36-40
Gas firing	Conventional boiler and steam turbine	35-40	40-42
Gas firing	Combined cycle, with or without supplementary firing for electricity generation only	40-54	54-58
COGENERATION – fuel utilization			
All fuels	Boiler plus steam turbine with various configurations for heat production and heat recovery	75-80	75-80

BAT = best available technology

Cogeneration

Cogeneration is the production of heat as well as electricity from a single fuel source. This is also known as combined heat and power (CHP). Both power plants and industrial plants may use cogeneration to meet their needs for electricity and heat (in the form of steam or hot water, as required).

A typical large-scale cogeneration plant consists of a boiler to raise steam at high pressure and a steam turbine to drive an electricity generator. The steam turbine will often be a “back pressure” turbine in which the exhaust steam is discharged at a moderate pressure and distributed to various users such as industrial processes. Sometimes the steam is condensed at moderate pressure by heat exchange against cooling water. In such cases, the temperature of the resulting condensate is moderate to high, and can serve as a source of energy for space heating. Such an arrangement results in an energy output that is a combination of electricity and heat (hence “cogeneration”) and is often seen in a utility plant that exports electricity and is connected also to a municipal heating system.

The cogeneration system is in contrast to a conventional electricity generating plant in which the exhaust steam is discharged at the lowest possible pressure and condensed at low temperature by the cooling water. Such an arrangement results in the maximum amount of electricity being generated and no heat being produced for downstream energy users. We can compare typical systems as follows:

For cogeneration to be economically attractive to an industrial plant, the demands for electricity and steam need to be relatively stable all year round. Where this is so, the cogeneration option represents an important increase in energy efficiency compared with individual units to generate electricity and heat separately.

The benefits of cogeneration include (Cogeneration Technologies, 2006):

- Economic—improved operational efficiency to produce heat and electricity reduces overall energy costs;
- Environmental—improved efficiency reduces emissions per unit of output (heat plus electricity);
- Enhanced reliability of electricity supply—when industrial plants generate their own power demand, they either reduce or eliminate their need for electricity purchases from a utility company.

The choice to install a conventional power plant or to install a cogeneration plant will depend on the demands for electricity and heat. For a public utility company, the heat will probably be distributed as circulating hot water for space heating. Local heat exchangers can be used to generate domestic hot water too. The problem is of course the ratio of energy produced as electricity to that produced as heat. With a steam boiler/turbine arrangement, the ratio is not necessarily fixed but the flexibility to change the ratio to meet customer demands all year round may be limited.

There are basically two types of cogeneration system (Cogeneration Technologies, 2006), which differ depending on whether electricity or thermal energy is produced first:

Topping cycles, where electricity is produced first and the low grade thermal energy exhausted is captured for further use in a process. Supplementary fuel may be required to meet all the process heat demand. Topping cycle cogeneration systems are widely used in food, pulp and paper, petroleum refining and textile industries.

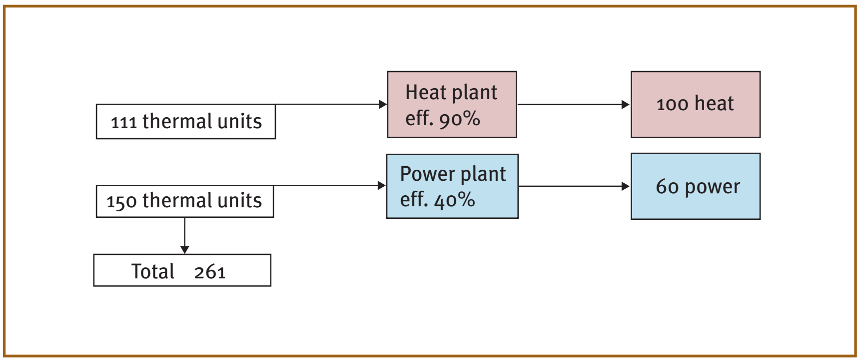
Bottoming cycles, where thermal energy is first used at high temperature in a process and excess thermal energy is then used to produce power, typically through a turbine driving a generator. Power is normally generated without the need for further fuel, and the turbine exhaust can be further used to provide lower grade heat to a process. Bottoming cycle cogeneration systems are used in processes that have large waste heat streams at relatively high temperatures, such as the steel industry, glass and chemical industries.

Box 5. Comparison of conventional and cogeneration systems

Assumptions

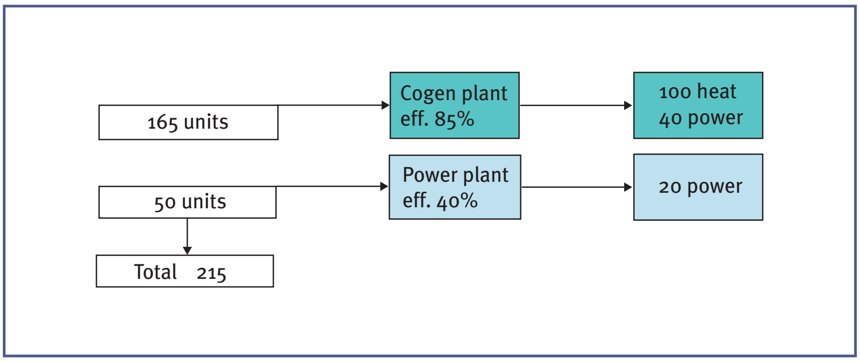
Heat demand = 100 thermal units
Electricity demand = 60 thermal units equivalent
Power only plant = 40 per cent efficiency
Heat only plant = 90 per cent efficiency
Cogen plant = 85 per cent efficiency

Without cogeneration



Total fuel consumption	261 units
Total output	160 units
Overall efficiency	160/261 = 61 per cent

With cogeneration



Total fuel consumption	215 units
Total output	160 units
Overall efficiency	160/215 = 74 per cent

Thus the cogeneration scheme is much more efficient (provided of course the simultaneous demands for heat and power are present consistently throughout the year).

Where a single cycle—as described above—provides a high grade heat output, this heat may be used in a waste heat boiler to generate more steam which in turn is fed in total or in part to a steam turbine to generate additional electricity. This system is known as a "combined cycle". It is most often applied to a basic gas turbine unit which produces a high grade heat output as an exhaust, which can be used to generate high pressure steam for powering a steam turbine (to make electricity) with the exhaust from that turbine still able to provide a site with low pressure steam or hot water for process use. Combined cycle systems such as this can achieve efficiencies approaching 60 per cent in converting the original fuel energy into electricity and—with supplementary firing available—will typically provide the most flexible cogeneration system for industrial plant use. Figure V shows the various possible cogeneration cycles.

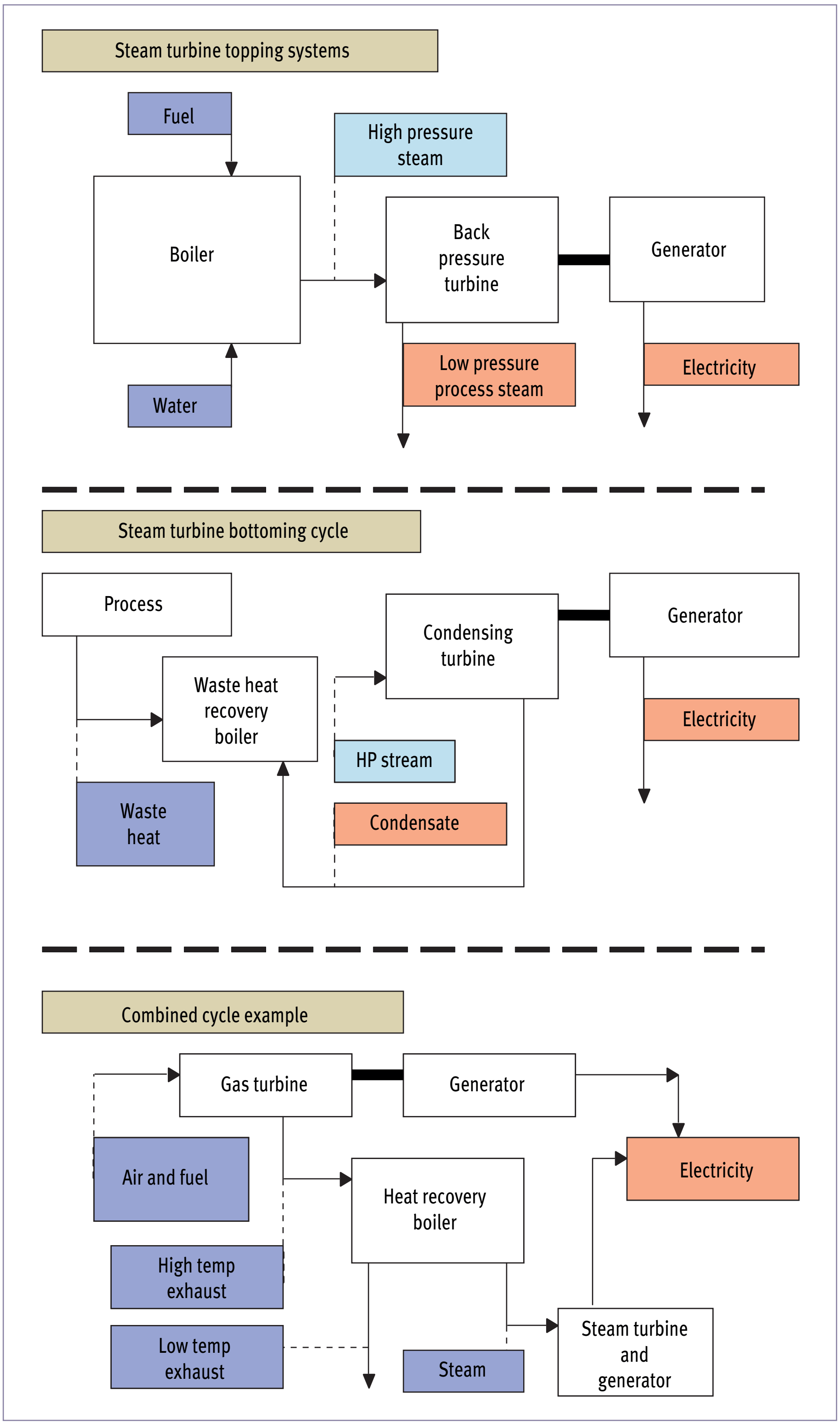
There are many variations on the basic cogeneration system based on different "prime movers"—the equipment that drives the electricity generator (Good Practice Guide 43, 1994). Table 2 shows some typical examples.

Table 2. Basic cogeneration systems base on prime movers

Type of equipment	Typical output	Typical fuels	Typical heat to electricity ratio	Grade of heat output required
Gas turbine	1 MWe upwards	Natural gas; gasoil; biogas; methane	1.5:1 to 3:1 Up to 5:1 with supplementary firing	High
Compression engine (diesel)	Up to 15 MWe	Natural gas with up to 5 per cent gasoil; heavy fuel oil	1:1 to 1.5:1 Up to 5:1 with supplementary firing	Low and high
Spark ignition engine	Up to 2 MWe	Natural gas; biogas; mine gas	1:1 to 2:1	Low and high
Steam turbine	0.5 MWe upwards	Any, converted to steam	3:1 to 10:1	Medium
Combined cycle	3.5 MWe upwards	Natural gas; gasoil; biogas; methane	Down to 1:1	Medium

It is important to note that different types of equipment permit the ratio of thermal to electrical energy to be designed into a system to match the anticipated demands. With supplementary firing as an option for some types of plant, flexibility can be built into the cogeneration plant to allow for seasonal changes in demands to be met. However, the flexibility may be limited and therefore it is particularly important to assess the likely heat and electricity demands carefully at the design stage, and to select the right type of system before the investment is finalized.

Figure V. Cogeneration cycles



The fuel used for cogeneration can be conventional fossil fuels or waste materials, such as crop residues. Box 6 illustrates the use of bagasse from sugar mills.

Finally, we may note that the heat produced by a cogeneration system may be utilized as heat for a process, and some may be used to power a refrigeration cycle. In this way, a cogeneration system can be designed to produce electricity, heat and "cold"—a trigeneration system. This type of configuration addresses the supply side for several items but remains relatively uncommon, mainly because of its complexity.

Box 6. **Benefits of bagasse cogeneration**

Economic benefits

Benefits and advantages of bagasse cogeneration include:

- Increasing the viability of sugar mills;
- Near-zero fuel costs, paid in local currency and valuation of bagasse as a waste product;
- Increasing diversity and security of electricity supply;
- Location at the point of energy demand, leading to minimal transmission and distribution (T&D) losses and costs.

Social benefits

The social benefits of on-site bagasse-fired cogeneration are:

- Greater employment for local populations;
- More widespread availability of electricity;
- More secure and reliable supply of electricity for existing consumers.

Environmental benefits

As a biomass fuel, bagasse supplies a raw material for the production of natural, clean and renewable energy, enabling its use to further government targets for renewable energy use. In brief, the environmental advantages of bagasse cogeneration are:

- Low emission of particulates, SO_2, NOx and CO_2 compared to coal and other fossil fuels;
- In GHG terms, bagasse combustion emits less than composting;
- Fuel efficiency.

Source: Bagasse Cogeneration – Global Review and Potential, June 2004, Aurelie Morand, Research Executive, World Alliance for Decentralised Energy:

www.localpower.org/documents_pub/report_bagasse_cogeneration.pdf#search=%22cogeneration%20constraints%22

Accessed on 2 September 2006.

Review question

What is the difference between bottoming cycles and topping cycles, and what type of SSM do they fall under?

3.4. Transmission

One area of supply-side management concerns transmission and distribution of electricity to customers. A reliable system depends on the reliability of the lines taking power from the generator to the end-users, and this includes other parts of the system such as transformers. Losses can occur throughout the system too, and these should be kept to an economic minimum to ensure no undue waste of primary resources to generate the electricity in the first place.

Transmission lines

Transmission lines carry electricity from one location to another, often over long distances. They can carry alternate current (AC) or direct current (DC) current, and may run over-ground or underground (U.S. Dept. of Energy, 2006). The majority of transmission systems operate with AC and are built over-ground. The main difference from distribution lines is that most transmission lines operate at relatively high voltage (typically from about 110 to 765 kilovolts). Overhead lines with polymer insulators are expected to last over 50 years.

Underground transmission lines are much less common than over-ground. Although expected to have a safe life of say 25 to 35 years, some underground lines may become unreliable after 15-20 years especially if water gets into the ducting or there is movement of the ground around the lines. The cost of typical underground lines is about 10 times more than overhead transmission lines.

Greater demands on most transmission systems require greater power transfer capacities. Even with adequate electricity generation, bottlenecks in transmission interfere with the reliable, efficient and affordable delivery of electric power. The amount of power on a transmission line is the product of the current, the voltage and the “power factor” (see Glossary). There are three types of constraints that limit the capability of a transmission line, cable or transformer to carry power—thermal/current constraints, voltage constraints and system operating constraints (John Makens, 2006).

Thermal limitations are relatively common. The flow of electricity through a line causes heat to be produced due to the resistance of the line. The actual temperatures occurring in the transmission system depend on any factors, such as the current and on ambient conditions (e.g. temperature, wind speed, wind direction) because the weather affects dissipation of heat to the air. Thermal ratings for transmission lines are thus expressed in terms of current rather than temperature, for ease of measurement. Thermal limits are imposed because overheating leads to two potential problems:

- The transmission line loses strength because of overheating which can reduce the expected life of the line;
- The transmission line expands and sags in the centre of each span between supporting towers. If the temperature is repeatedly too high, an overhead line may stretch permanently and its clearance from the ground may become less than required for safety reasons.

Because damage from overheating is a gradual process, higher current flows can be allowed for limited time periods, and the “normal” thermal rating for a line is the current flow it can support indefinitely. Underground lines and transformers also have thermal constraints. Overheating in both cases causes shortened lives primarily due to damage to insulation.

Voltage fluctuations can occur due to variations in electricity demand and to failures of transmission and distribution lines. Constraints on the maximum voltage levels are set by the design of the transmission system. If the maximum is exceeded, short circuits can occur and transformers and other equipment at substations and in customer facilities can be damaged or destroyed. Minimum voltages are also to be avoided as these cause improper operation of equipment at the customer end and motors can be damaged.

System operating constraints result from considerations of safety and reliability. For example, power flows in connected networks are affected by characteristics of the lines in the different networks, and by interconnecting systems at more than one point, electricity flows can become rather complex and limitations on the power transmission capacity of each network can be affected. Power system stability problems may also occur when networks are connected, causing fluctuations in AC frequency and possibly voltage instability.

Various options are available for reducing limitations on power transfers due to the thermal rating of overhead transmission lines (John Makens, 2006), although measures for underground cables and for transformers are more limited:

- With modern methods of calculating ratings, it may be possible to define higher ratings without any physical changes to the lines. For example, power flow limits based on reaching a maximum temperature can be calculated instantly using data on actual weather conditions and on the actual power flow. Some utilities measure the line temperatures with detectors in the lines. This data—calculated or actual—are transferred to the utility control centre for appropriate action.

- Since the thermal limit of a transmission line is based on the component that would be first to overheat, a substantial increase in overall rating can sometimes result from replacing an inexpensive element. For example, a switch or circuit breaker is much less expensive to replace than to replace a line (or indeed to build a new line).
- It may also be acceptable to increase allowable temperatures (and hence achieve higher power loads) and plan for a decrease in the life of the lines. However this approach can lead to sagging in the lines so that ground clearance is inadequate for safety reasons. In some cases, rebuilding selected towers can solve the problem.
- Finally, the most obvious (but most expensive) option is to replace lines with larger ones by re-stringing existing lines or adding cables. This action may require towers to be rebuilt in order to support the extra weight. Any such measure must be examined to take account of other changes in the system that might become necessary, such as upgrading substations for higher loads.

To address voltage constraints, various technical actions are possible. These include increasing the voltage at the generator during periods of light load, together with adjusting transformer settings (or replacing transformers) to achieve the correct operating voltage. Coordination with any interconnected network is of course essential. For this reason, this option may be difficult to apply in practice. Changing voltage levels permanently usually requires substantial reconstruction of power lines and is thus not considered further here.

Data monitoring

To ensure that generation, transmission and electricity use are all properly balanced and operated at highest efficiency, it is necessary to have comprehensive information on all elements of the system. There are many computerized systems available to do this. These are collectively known as “supervisory control and data acquisition” systems (SCADA). Such SCADA systems are able to switch selected equipment on or off, based on the current situation of the utility company supply system. SCADA systems can also be used to monitor and control buildings operations, operating heating, lights and cooling equipment as required. SCADA systems also are used to switch large loads on or off to ensure a customer does not exceed an agreed maximum demand and thus pay extra for the electricity consumed.

While this control of large loads normally remains with the owner and operator of the equipment, it is possible to set up systems in which control of major loads rests with the utility company, allowing it to delay loads from the highest peak time to another—a more convenient—time. In many such cases, the reduction in peak load represents a shift to more efficient generation by the utility, and is thus a useful supply-side management measure.

Load aggregation

Electric load aggregation is the process by which individual energy users band together in an alliance to secure more competitive prices that they might otherwise receive working independently (Pace Global Energy Services, 2006). Aggregation can be accomplished through a simple pooling arrangement or through individual contracts between suppliers and each member of an aggregate group. While natural gas purchasing alliances have been around for many years, the aggregation of electricity loads across multiple facilities is less well known.

Big industrial companies with large electricity loads have greater purchasing power and more leverage in negotiations with suppliers than smaller companies. For example, depending on the market conditions, a purchaser may be required to buy a 20-25 megawatt block of power in order to approximate wholesale pricing. Companies can look into forming purchasing alliances with other local businesses to purchase larger blocks of power.

Load factor is the ratio of the average load for electricity consumption to peak demand (expressed as a percentage) for each billing period. Energy suppliers usually impose a “demand charge” on each customer to reflect the power generation capacity needed to meet the peak demand for that customer. This demand charge is a fixed item that does not depend on the kilowatt hours consumed in a billing period. If the load factor of a customer is high, meaning their load runs consistently at or near the peak demand, the demand charge will represent a smaller percentage of the overall cost of electricity.

Through load aggregation, companies can enhance their purchasing power by taking advantage of load diversity among multiple facilities as a means of improving the overall load factor of the group. When the loads of several customers are aggregated, non-coincidental peaks and valleys in the load profiles of individual customers generally tend to offset each other. Of course, this needs careful data collection and analysis to monitor the loads at any time. The desired effect will result in a flatter overall load profile, a higher load factor, and ultimately, lower per unit energy costs for all members of an aggregate group. The challenge for consumers is to find suitable aggregation partners.

A smoother load profile can also have a beneficial impact on the supplier who can generate a certain load using the most efficient equipment and does not have to change the load up and down too frequently.

Substation improvements

A substation is used to switch generators, equipment, circuits or lines in and out of a system. It is also used to change AC voltages from one level to another, or to change AC to DC current (or vice versa). Some substations are small with only one transformer, others can be quite large with several transformers and switchgear.

Transformers are electrical equipment designed to convert one AC voltage to another. They are essential in electricity transmission and distribution systems (John L. Fetters, 2002) and are widely used to raise voltages for long distance transmission (say 4 to 35 kilovolts) and then reduce the voltage down to a level suitable for plant equipment (say 120 to 480 volts).

Dry-type distribution transformers are usually found in large commercial and industrial facilities. Liquid filled units are usually used in smaller facilities. Distribution transformers are generally very efficient with losses of less than 0.25 per cent in the largest units. However, when the overall losses of many transformer steps in a distribution system are taken into account, the losses can add up. In addition, the load on transformers decreases when facilities close for the day or at the weekend: the no-load losses in lightly loaded units increase as a percentage. Transformer losses in power distribution networks can exceed 3 per cent of the total electricity generated.

Reducing losses in transformers will increase their efficiency. There are two main types of loss. The first is “core” loss (also called no-load loss), which is the result of magnetizing and demagnetizing the core during normal operation. Core loss occurs whenever the transformer is energized and does not vary with load. Changing the material of construction of the core can reduce losses (e.g. amorphous iron instead of conventional carbon steel cores). The more efficient materials cost more than the standard core materials but losses could be reduced by up to 30 per cent.

The second loss is coil or load loss, so termed because the efficiency losses occur in the primary and secondary coils of the transformer. Coil loss is a function of the resistance of the winding materials and varies with load. The choice of winding material affects the coil loss. Copper is a better electrical conductor than any other material except silver. Electricity thus flows in copper more easily than in aluminium or steel wires of the same diameter. Copper wires result in lower losses, which appear as unwanted heat. Another way to reduce losses is to use larger diameter wires that allow current to flow more easily. Sizing distribution transformers to meet their expected load also affects efficiency. Oversized transformers can contribute to inefficiency.

The cost of installing higher efficiency transformers needs to be evaluated against the anticipated savings. Payback periods of two to five years are typical.

Other key equipment includes switchgear, alarms and controls. Old equipment may become unreliable and require replacement on these grounds. For reliability and safety, such equipment may need replacing, at which time best modern practices should be adopted in specifying the new equipment.

3.5. Distribution

Distribution networks consist mainly of overhead lines, underground cables, transformers, and switchgear. Most consumers are supplied at low voltage, defined typically as less than 1 kV, with domestic customer supplies usually at 230 volts or less. Some of the larger commercial and industrial consumers are typically supplied at high voltage, over 1 kV and some at extra high voltage (over 22 kV).

Electrical losses are an inevitable consequence of the transfer of energy across electricity distribution networks. In the UK, the losses amounted to around 7 per cent in 2000/2001. The level of losses varies from year to year, influenced by a number of factors, both technical and operational.

The International Energy Agency (IEA) publish figures regularly for losses in transmission and distribution. While the numbers vary from year to year, typical figures for 1998-2001 are around 7 to 8 per cent, with European Union figures averaging about 7 to 7.5 per cent (although the range is from under 4 per cent to over 10 per cent). According to various World Bank/ESMAP reports, some countries report distribution losses as high as 30 per cent of the energy supply. Much of these very high losses can often be attributed to theft with say half coming from technical losses. There are likely to be important opportunities for reducing losses by investigating the level of losses and where these occur in any distribution system.

Upgrading distribution systems

While there are many similarities in distribution networks, there can be important differences, such as:

- Geographical size;
- Number of customers connected;
- Quantity of electricity distributed;
- Degree of dispersion of customers across the network;
- Proportion of different types of customers;
- Amount of underground versus overhead lines.

There may also be wide differences in design, operating and investment principles, any of which can influence in detail the network configuration.

The level of losses in a network is driven by a number of factors. There are three main categories of losses; variable losses, fixed losses and non-technical losses:

- Variable losses, often referred to as copper losses, occur mainly in lines and cables, and also in the copper parts of transformers. They vary according to the amount of electricity transmitted through the equipment and are proportional to the square of the current. Losses are also proportional to the length of line, the resistivity of the material, and inversely proportional to cross-sectional area of conductors. Typically variable losses are about two-thirds to three-quarters of the total losses (UK Office of Gas and Electricity Markets, 2003);
- Fixed losses, or iron losses, occur mainly in transformer cores and do not vary according to current. These are typically a quarter to a third of total losses;
- Non-technical losses, unlike the two items above, refer to electricity delivered and consumed but not registered as sales. This includes theft as well as simply errors in recording and billing (e.g. meter errors, lack of calibration, no meters installed).

Measures to reduce variable losses include increasing the cross sectional area of lines. There is thus a trade off between the value of lower losses and the cost of replacing existing lines with larger ones. Use of higher voltage leads to lower currents to transmit the same amount of electricity and this will lead to lower losses. The configuration of a network will clearly affect the losses if distribution distances can be reduced (again, this necessitates investment in new lines and this may be expensive).

Demand management is another means of reducing variable losses because loads transmitted at peak time result in greater increases in losses than the same amount at off peak times. If distribution companies can encourage users to smooth out their demand, losses can be reduced.

Finally, variable losses can be reduced by balancing three-phase loads throughout the network on a regular basis.

Fixed losses do not vary according to current. They take the form of heat and noise and occur so long as a transformer is energized. The level of fixed losses can be reduced by upgrading the core material of transformers (e.g. special steels and amorphous iron). They can also be reduced by eliminating transformer levels (reducing the number of transformers involved), and by switching off transformers in periods of low demand.

Low power factors will also contribute to losses. Raising power factors by installing capacitors will lead to lower distribution losses, as can distributed on-site generation.

On-site generation

Strictly speaking, some might not consider on-site generation to be a true supply-side management measure. On-site generation at an electricity user might be a way of cutting the electricity supplied by the grid to zero of course, and this would no doubt have an effect on the electricity supplier (but this would be specific to the situation so general comments cannot be made).

However, we should consider on-site generation briefly in this module, as this might be encouraged by a utility company that is nearing the maximum level of demand that it can supply. The utility—in the absence of investment funds for increasing generating capacity—might wish to reduce the electricity it supplies to one customer to be able to supply others, provided the original customer is able to self-generate all or part of its power needs.

The benefits of on-site generation can therefore be:

- On-site “self-generation” reduces demand on the grid and may allow deferment of investment in additional capacity;
- The principal electricity supply can be at the end-user itself, reducing transmission losses incurred in getting supply from a distant power source.

The generating equipment can use a variety of energy sources—from conventional fossil fuels to renewables such as solar, wind, bio-energy. Systems may adopt conventional boiler-steam turbine technologies or can be installed as cogeneration plants (often worthwhile if an industrial plant has steady electricity and heat loads year-round, or has a low-cost source of energy available, such as waste heat from an industrial process). In some cases, the on-site generator can be connected to the grid, to import electricity if on site electricity production is inadequate (“stand-by electricity”) or to export to the grid if excess electricity is available. The cost of standby power from the grid to satisfy imports, and the value given to surplus electricity exported to the grid, are subjects of negotiation between the parties. Technical standards will also have to be met, such as voltage levels and AC frequency.

Power factor improvement

Power factor is the ratio between the useful load (in KW) and the apparent load (in KVA) for a system (L M Photonics Ltd., 2002). It is a measure of how effectively the current is being converted into useful work output, and is an indicator of the impact of the load on the efficiency of the supply system. A load with a power factor of one results in the most efficient loading of the supply, while a load with power factor say 0.5 will result in much higher losses.

Whenever loads are connected to an AC supply, there is a possibility that current and voltage will be out of phase. Loads such as induction motors draw current that lags the voltage, while capacitive loads (e.g. synchronous motors, battery chargers) draw current that leads the voltage. Loads that are predominantly resistive such as heaters and cookers draw current in phase with voltage. The angle between the current and voltage is known as the "phase angle φ"—this can be leading or lagging (or zero) depending on the load. The power factor is defined as cosine φ and is always less than one. It represents the ratio of active power (or useful power) to the total power supplied by the generating station.

Power factor correction is normally considered a key demand-side management option because it is usually implemented by the electricity customer and leads to a reduction in their electricity bills. However, it is a measure that reduces the power supplied by the utility and therefore it may also be considered a supply-side management option.

Indeed, utility companies often put in place incentives (or penalties) to encourage their customers to improve their power factor, in order to relieve load on their generators. When power factor is less than unity, the amount of useful power supplied by the generating plant at maximum output will be less than its full capacity (in other words, not all the power supplied is turned into useful work). This represents an inefficiency and therefore utility companies usually require customers to achieve a power factor of at least 0.9 (sometimes 0.95). Those who fail to meet the minimum will be charged a penalty on their bills to compensate for the various losses incurred by the generator (e.g. losses in distribution cables and transformers).

Operating at a high power factor allows energy to be used more efficiently (hence the setting of a limit such as 0.9 or 0.95). Since most loads are in practice inductive, and a low power factor can be increased ("corrected") by installing capacitors in the system. In most plants a practical solution is to install capacitor banks at the main point of power supply. Depending on the power factor, more or less capacitance can be connected at any time. Slightly more efficient but costlier is installing individual capacitors around a facility to correct the power factor in different parts of the network. In all cases, the utility company benefits because less power needs to be generated to meet the end use needs of customers with high power factors.

3.6. Transport of fossil fuels

Most of this module is concerned with the supply of electricity and supply-side management measures that might improve the efficiency of electricity delivery to a customer. There are also measures that can be taken to improve the supply of fossil fuels to customers, and these can be deemed supply-side management actions also. Since these actions are typically carried out by users of energy, we usually consider these "demand-side" management, and therefore only a few comments are added here.

With respect to pipelines for delivery of liquid and gas fuels, these will use pumps or compressors to transfer the fuels. Energy efficiency factors applicable to these types of equipment include:

- Oversized, inappropriate motors;
- Opportunity for using high efficiency motors;
- Excessive compressor or fan speed;
- Excessive system resistance (clogged filters, stuck dampers);
- Variable loads, and the inappropriate use of valves and dampers (inlet or outlet side) to control flow rates;
- Long periods of motor idling (running but not pumping or compressing fluids);
- Variable speed drives—energy efficient if adopted in the correct location although variable speed motors might be more cost effective sometimes;
- Leaks of process liquids and gases, including leaks from seals on equipment shafts;
- Steam leaks from steam turbine drivers;
- Gearboxes running hot, noisy;
- Worn or slack belts around pulleys, belts missing, use of ribbed belts
- Pulleys and couplings misaligned;
- Worn motor bearings;
- Low power factor, opportunity for installing capacitors.

With respect to road transport, a common means of supplying liquid fuels to consumers, there are a number of measures that can improve efficiency:

- Performance analysed by driver if vehicles are pooled or shared;
- Tyre pressures checked regularly;
- Planning of routes and loads;
- Vehicles left with engines idling;
- Vehicle aerodynamics;
- Driver motivation and education;
- Improved lubricating oils;
- Thermostatically controlled fans and radiator shutters on vehicle engines;
- Regular maintenance.

4. CONSTRAINTS AND CHALLENGES OF SSM

Supply-side management refers to actions taken to ensure the generation, transmission and distribution of energy—primarily but not exclusively electricity—are conducted efficiently.

Utility companies may change the load profile to allow their least efficient generating equipment to be used as little as possible. They may improve maintenance and control of existing equipment, or upgrade equipment with new items utilizing improved technologies. In brief, an electrical utility may embark on SSM to:

- Ensure reliable availability of energy at reduced generating cost;
- Reduce energy prices to some or all of their customers;
- Meet increasing electricity demand without necessarily incurring major capital investments until later;
- Minimize environmental damage.

Suppliers of other types of energy will have corresponding motives.

Energy users will normally focus their efforts on demand-side management methods (DSM) but some will consider the supply side too. For example, they may look at on-site generation alternatives—including cogeneration—or consider diversifying to alternative fuel sources (such as natural gas, solar, wind, biofuels).

One of the challenges in adopting SSM is the need for comprehensive information to be widely available to utility staff—including operating, technical and commercial departments—about measures that could be appropriate to their specific situation. In some cases (e.g. power factor correction) it will be the primary responsibility of customers to take the relevant measures and make the necessary investments, so that the efficiency of overall supply can benefit. Balancing the interests of the supplier and consumer may sometimes prove difficult, especially when capital investment gets involved. Investors will need incentives of some sort to be persuaded to take action, and these incentives will normally be in terms of improved profits and rarely in terms of environmental improvements.

Even where SSM can typically produce economic benefits to the utility or indeed the customer, there will often remain a problem of convincing company management to authorize expenditures. Sometimes a short-term approach is used and the evaluation of a project requiring a significant investment may fail to take into account long-term benefits and life cycle costing. All too often a “first cost” basis drives decisions: this frequently results from a lack of capital funds (Cogeneration Technologies, 2006).

With respect to clean coal technologies, many are well proven in developed countries but experience is lacking in developing nations. There will often be a lack of technical skills to participate in equipment design and to operate complex process plant, while management of such facilities may lack the necessary experience. Certainly a lack of management and technical training could prove difficult to overcome in the short term for organizations seeking to apply many of the aspects of SSM.

Exploitation of renewable energies is not believed to pose such a problem although large scale units may not have been proven in all countries in Africa. However, it is believed that sharing experiences and knowledge will have a role to play in helping those countries that might lack first-hand knowledge of the latest technologies. Other barriers to developing bagasse as a fuel for electricity generation exist, as described in box 9. These include the cost of power, problems with prompt payment to sugar mills for electricity sold, and sometimes the poor level of efficiency of many sugar mills themselves.

With respect to the efficient operation of existing facilities, it is often the lack of management that leads to poor energy performance, and not the lack of tried and tested equipment and processes. Senior managers all too often fail to appreciate the benefits achievable using simple low cost measures, and focus on expanding production rather than improving efficiency. Some will believe that no progress can be made without massive investments in new technology, and that—since the company lacks funds—nothing can be done.

Energy efficiency is usually highly cost effective and, at least at the beginning, is easy to apply with little or no funding needed. Better maintenance will almost certainly pay dividends immediately. As results are achieved and savings are made, most companies can accumulate funds to devote later to projects that need funding. A serious challenge is thus to educate managers that small and simple actions can make their contribution in the short term, and can pave the way for larger and costlier actions later.

Part of this education is of course to make clear that reliable operating data are important tools to raise plant and system efficiencies, and that collecting and reporting data are not simply tedious chores that are imposed on the operators. Indeed, good data and proper analysis contribute greatly to justifying new equipment in terms of economic benefit to the company. Good data can thus persuade banks or other financing institutions that SSM measures are worthwhile and deserving of loans at acceptable—low risk—interest rates.

Even where a plant has adequate funds for investment, managers should insist on adequate evaluation of all potential projects, especially those requiring large investments and those that have a long life expectancy. Here we may mention cogeneration plants. It is essential that reliable information is collected to define the load curves for heat and electricity supplies, including seasonal variations, so that the original design is correct and able to operate with the necessary flexibility. A large cogeneration plant might expect to operate for 30 to 40 years, or longer.

With respect to transmission and distribution of electricity, the challenge for many utility companies will probably be the funding of large investments to replace old equipment or to add significantly to capacity, as electricity demand grows quickly in developing countries. Technical solutions to problems are generally well known and expertise available from consulting engineers, if not from the utility companies themselves. Here again, good management of existing facilities has its role to play.

Load aggregation is interesting because the problems of several customers can often be solved at the same time. However, it is essential that comprehensive historical data on load profiles are available, and such data are readily available at any time in the future. Analysis of this data may have to be done by outside specialists if the expertise is not available in-house. Reliable and timely data are needed to ensure that the proper combined load profile is being maintained and that all parties—including the utility—are benefiting.

Finally we may mention power factor improvement again and stress that both parties—the electricity consumer (who will probably have to invest in the necessary equipment), and the supplier must see the benefits for themselves.

Box 7. **Barriers and constraints to development of bagasse cogeneration**

India:

- State Electricity Boards are still reluctant to buy power from biomass projects, despite the good example set by Maharashtra Electricity Regulatory Commission with its regulatory process and the provision of the Electricity Act. Many States and State Electricity Boards remain unaware of the opportunity for decentralized energy.
- In many States, there is neither the assurance that electricity can be sold to the grid nor, in fact, any guarantee of timely payment for electricity generated by non-utilities.
- Compensation for failure to supply or fluctuation in grid supply by State Electricity Boards is, more often than not, unavailable. This provides little incentive for forward planning of demand and production among non-utility electricity generators.

Eastern and Southern Africa:

- Bagasse cogeneration can be expensive compared to hydro electric power schemes already in place (6USc/kWh compared to 3USc/kWh) and compared to cheap electricity from the Southern African Power Pool. Therefore, electricity boards may be unwilling to set feed-in tariffs to the higher level required by sugar mills.
- Poor management of some sugar mills has caused the sugar industry to run into difficulties; some sugar mills—especially in Kenya and the United Republic of Tanzania—have been closed down as a result of this, limiting the scope for bagasse cogeneration in these countries.
- As in many other countries, sugar mills often require refurbishment and upgrading to ensure that they are energy efficient so that they can profit from electricity generation. Low sugar prices in world markets mean that sugar mills often have little money to invest in such schemes.

Source: Bagasse Cogeneration – Global Review and Potential, June 2004, Aurelie Morand, Research Executive, World Alliance for Decentralised Energy:

www.localpower.org/documents_pub/report_bagasse_cogeneration.pdf#search=%22cogeneration%20constraints%22

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Discussion question

What types of SSM options do you think have the most environmental benefits while still offering an affordable electricity supply to the consumers of your country? Consider the current infrastructure and capability of the supply industry and the possible cost savings, or increases, due to the SSM programme.

5. CONCLUSION

With increasing demand for energy worldwide and the resources being limited or becoming ever more expensive, it is important (and usually cost effective) to improve the efficiency of energy supply. In turn, this usually means a benefit to the energy consumer in terms of lower energy prices. Improved efficiency on the supply side will also make a valuable contribution to reducing the impact of energy use on the environment. While demand-side improvements are certainly important, supply-side options also need to be identified, evaluated and implemented where the economics justify.

LEARNING RESOURCES

Key points covered

These are the key points covered in this module:

- What SSM is and why it should be pursued.
- A review of the main options and opportunities for SSM, including better operation of existing power plants, transmission and distribution systems.
- Overview of the some constraints and challenges of implementing SSM measures or programmes.

Answers to review questions

Question: Give four reasons why a utility would embark on an SSM programme.

Answer:

An electrical utility may embark on SSM to:

- Ensure sustained availability of energy;
- Meet increasing electricity demand and expanding supply infrastructure due to economic and population growth;
- Cover electrification programmes or industrial investment;
- And mitigate environmental the impact of energy use.

Question: What is the difference between bottoming cycles and topping cycles, and what type of SSM do they fall under?

Answer:

A bottoming cycle uses the waste heat from a manufacturing process to produce steam and drive a turbine to produce electricity.

A topping cycle produces electricity or mechanical energy by burning or processing a fuel and the waste heat is used to drive a secondary electrical turbine (combine cycle) or provide process heat.

These are two main types of cogeneration technologies used by SSM programmes.

Exercises

1. Which type of SSM interventions could be implemented with the most ease/most rapidly in your country? Which interventions would be the most effective in your opinion and why?

   Write a one page answer.

2. Your government is faced with rising demand and approaching the limit of the reserve generating capacity. The cost of constructing new generating capacity is proving to be too high for the short term. While plans are being made for reducing the demand and raising funds for building additional capacity you have been asked to implement some key supply-side management strategies to increase the output of the existing capacity. You, in your country, have a few thermal generating stations with old transmission lines as well as an active sugar industry and an iron smelting plant. Some funds are available for SSM measures.

   Write a 2-3 page essay discussing the possible SSM options.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 13: Supply-side management

Suggested discussion topics:

1. Do you think clean coal technologies are merely a “gimmick” to promote coal use or do they offer sustainable solutions to energy supply? Discuss.
2. Renewables have an important role to play in future energy supply. Discuss.
3. Which type of SSM interventions could be implemented with the most ease/most rapidly in your country? Which interventions would be the most effective in your opinion and why?

Relevant case studies

1. EU-China partnership on climate change—clean coal technology.

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INTERNET RESOURCES

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World Coal Institute: www.worldcoal.org

U.K. Carbon Trust: www.carbontrust.co.uk/energy

Cogeneration Technologies: www.cogeneration.net

World Alliance for Decentralised Energy: www.localpower.org

U.S. Energy Information Agency, Dept. of Energy: www.eia.doe.gov

GLOSSARY/DEFINITION OF KEY CONCEPTS

Bagasse	Generally in sugar production only the stalk is used and the waste that is left is known as bagasse, which consists of 50 per cent fibre, 48 per cent moisture and 2 per cent sugars and can be burnt to produce steam and electricity.
BAT	Best available technology, used to refer to technology normally adopted in modern, newly built facilities. Not necessarily the lowest energy consuming technology but representative of proven commercial practice.
Boiler blowdown	Intermittent or continuous discharge of water from a boiler to maintain dissolved solids content below a specified level. The level is set by manufacturers to ensure boiler operation is efficient and there is minimum foaming and carry over of solids into the stem.
Biomass	Can be an important renewable energy resource when managed in a sustainable way, for example, wood from sustainably grown forests.
Bottoming cycle	The waste heat from the manufacturing process is used to produce steam and drive a turbine to produce electricity.
CCT	Clean coal technologies.
Conversion efficiency	As applied to a power plant, this is the ratio of electricity output to fuel (energy) input, calculated in consistent units and expressed as a percentage.
Demand charge	Fee charged to a customer on the electricity bill, corresponding to the agreed maximum load (in kW) that may be drawn in a specified period of time.
Excess air	Refers to boiler and furnace operation. Amount of combustion air above the theoretical amount needed for complete combustion, expressed as a percentage (see “stoichiometric”).
FBC	Fluidized bed combustion.
GTCC	Gas turbine combined cycle.

IGCC	Integrated coal gasification combined cycle.
Net efficiency, gross efficiency	Efficiency of a boiler or furnace, expressed as a percentage and referred to the net calorific value of the fuel (or gross, as relevant).
Power factor	The ratio of the real power (kilowatts) to apparent power (kilovoltampere).
Preventive maintenance	Procedures to monitor equipment performance and carry out maintenance on a regular basis and thus avoid—as far as possible—the equipment breaking down.
SCADA	Supervisory control and data acquisition.
Stoichiometric	The theoretical amount of air needed to achieve complete combustion in a boiler or furnace.
SWH	Solar water heater.
Topping cycle	Electricity or mechanical energy is produced by burning or processing a fuel and the waste heat is used to drive a secondary electrical turbine (combine cycle) or provide process heat.
UCG	Underground coal gasification.

Case study 1.

EU-CHINA PARTNERSHIP ON CLIMATE CHANGE—CLEAN COAL TECHNOLOGY

CONTENTS

1. BACKGROUND

Coal is simultaneously the fossil fuel with the highest carbon content per unit of energy and the fossil fuel with the most abundant resources in the world. Clean or more efficient use of coal is the subject of numerous international collaborative studies aimed at reducing local emissions and/or global CO_2 emissions from its use.

On 5 September 2005, the eighth China-EU Summit was held in Beijing, China. The Summit acknowledged 30 years of peaceful cooperation between the regions and believed that strengthening this relationship would add value to the long-term interests of both China and the EU. Looking to the future, the leaders proposed concrete actions in various strategic areas.

The Partnership on Climate Change (Partnership) was one of the major outcomes of the Summit. The Partnership will strengthen cooperation and dialogue on climate change and energy between the EU and China.

One major objective of this Partnership is the development and demonstration of advanced near “zero emissions” coal technology based on carbon dioxide capture and geological storage to address increasing greenhouse gas (GHG) emissions from the use of coal in China.

The Partnership on Climate Change (Partnership) was one of the major outcomes of the Summit. The Partnership will strengthen cooperation and dialogue on climate change and energy between the EU and China. A Joint Declaration on Climate change set out specific areas of cooperation including the following key areas for technical cooperation:

- Energy efficiency, energy conservation, and new and renewable energy;
- Clean coal;
- Methane recovery and use;
- Carbon capture and storage;
- Hydrogen and fuel cells;
- Power generation and transmission.

2. INTRODUCTION

China's primary commercial energy consumption increased at 5.4 per cent per annum from 1980 to 1996 to reach 1,388 million metric tons of coal equivalent (tce). Coal as the dominant source of energy, accounted for 74.8 per cent of total primary commercial energy production in 1996, followed by oil (17.1 per cent), hydropower (6.2 per cent), natural gas (1.7 per cent) and nuclear (0.2 per cent).

The industrial sector is the largest energy consumer, accounting for 64 per cent of final commercial energy consumption. Residential and commercial sectors have a share of 21 per cent. Transport and agriculture account for 10 per cent and 5 per cent, respectively.

From 1990 to 1996, the average annual growth rate of real gross domestic product (GDP) was 11.6 per cent, while primary energy consumption grew at 5.9 per cent. As a result, the overall energy intensity of the economy declined by almost 30 per cent from 1990 to 1996. This decline reflects changes in economic structure and sources of industrial value added (75-85 per cent), as well as energy efficiency improvements (15-25 per cent). However, the energy intensity figure is still high, more than double the average for industrialized countries.

China is the second largest electricity producer in the world. Between 1980 and 1997, both installed capacity and annual electricity generation grew at an average annual rate of about 8.9 per cent, reaching 250 GW and 1132 TWh. Every year since 1988, 11 to 15 GW of generating capacity has been added.

As of the end of 1997, the total installed capacity was 250 GW from which 75.8 per cent uses fossil fuels, 23.4 per cent hydropower and 0.8 per cent nuclear. Coal-fired power plants provided 81.9 per cent of the total electricity generation of 1132 TWh in 1997.

The annual electricity consumption per capita in 1997 was 897 kilowatt hours (kWh), placing China at the mid-level among the developing countries. Most of the electricity has been consumed by industries. Heavy industry had a share of 58.2 per cent in 1997, followed by light industry (14.6 per cent), residential consumers (11.4 per cent), public and commercial consumers (7.7 per cent), agriculture (6.2 per cent), and transportation and telecommunications (1.9 per cent). (World Bank, undated).

3. MAIN DESCRIPTION

3.1. Aims and objectives

One major objective of this Partnership is the development and demonstration of advanced near “zero emissions” coal technology based on carbon dioxide capture and geological storage to address the challenge of tackling increasing greenhouse gas (GHG) emissions from the use of coal in China. This is in recognition that carbon dioxide emissions from China’s increasing coal use are set to double to more than 5000 Mt CO_2/year by 2030.

The Partnership contains two concrete cooperation goals, to be achieved by 2020. The first is to develop and demonstrate, in China and the EU, advanced near “zero-emissions” coal technology. This technology will allow for the capture of CO_2 emissions from coal-fired power plants and its subsequent storage underground, for example in exploited oil or gas fields or in sealed geological strata, thereby avoiding CO_2 emissions into the atmosphere.

The second cooperation goal is to significantly reduce the cost of key energy technologies and to promote their distribution and operation.

3.2. Planning and strategy

The first phase will be a three-year feasibility study, examining the viability of different technology options for the capture of carbon dioxide emissions from power generation and the potential for geological storage in China, and leading towards a possible demonstration project starting up between 2010 and 2015.

The Partnership supports the EU and Chinese efforts to reduce the energy intensity of their economies. China has set the goal of halving the energy intensity of its economy by 2020. In the recently adopted Green Paper on energy efficiency, the Commission has proposed to reduce the EU’s energy consumption by 20 per cent over the same period by increasing energy efficiency.

3.3. Institutional issues

The Partnership will also reinforce EU-China cooperation on the Kyoto Protocol’s Clean Development Mechanism (CDM). It foresees a dialogue on the further development of this mechanism “post 2012” in combination with an exchange of information and experience on the use of market-based mechanisms such as the EU emissions trading scheme. It furthermore foresees a number of joint research activities on the impacts of climate change.

These efforts will be strengthened through the involvement of the private sector, bilateral and multilateral financing instruments and export credit agencies, and the promotion of joint ventures and public-private partnerships.

4. IMPACT

Most Chinese cities exceed national air quality standards. Air pollution levels in many large cities are among the worst in the world. The central government has set its sight on controlling the total emissions of major pollutants, including total suspended particulates (TSP) and SO_2. The current goal for SO_2 emission control is to cap total emissions in 2010 at 2000 level. Emission standards for coal-fired plants to regulate particulates and SO_2 were first introduced in 1991. They were revised in December 1996 (World Bank, undated).

It is envisaged that carbon capture and storage offers the opportunity to reduce CO_2 emissions per unit of electricity by 85-90 per cent.

5. KEY SUCCESSES

The EU-China Partnership complements the Dialogue on Climate Change, Clean Energy and Sustainable Development, as well as other outcomes of the G8 Summit at Gleneagles in July 2005.

Although not directly linked to the EU-China Partnership, China has had an SO_2 emissions fee system in place since 1992. Beginning January 1998, a 200 yuan/ton SO_2 emission fee for all SO_2 emitting sources has been in effect in the designated acid rain-control and SO_2 pollution-control regions (World Bank, undated).

6. LESSONS LEARNED

While the EU-China Partnership has not been fully implemented and thus does not realize lessons learnt from the process, the following lessons can be drawn from successes and failures of various international collaborative efforts on clean coal technology transfer in China:

- Technology transfer is about more than equipment transfer. The various successes of bilateral efforts and the Global Environment Facility (GEF) to bring clean technologies to China suggest that technology transfer is more widespread when manufacturing technology is also transferred to the host country. Beyond the transfer of clean coal equipment, this implies transferring the technical ability to replicate and manufacture such equipment locally. Enhancing the knowledge of and providing training to manufacturers and users is also critical. More generally, it appears that technology transfer would benefit from policy reform. With a few notable exceptions, transfer of clean coal technology has been witnessed in the context of "one-off" demonstration projects with limited dissemination. Domestic policy that fosters technology diffusion is likely to be a key factor for successful technology transfer.
- Intellectual Property Rights (IPR) protection matters for transferers and transferees. The conventional understanding of the wisdom is that the weak IPR protection in developing countries deters foreign companies from transferring their technology as they see a risk that it may be stolen, once transferred. While this is true, companies in countries that are willing to acquire the technology (via licences) may also be deterred by inadequate IPR protection: host companies may be reluctant to acquire technology that competitors in their own markets could copy while not having to pay. IPR protection addresses both concerns.

An interesting, paradoxical finding from this case study is that strong growth in power demand is not necessarily conducive to the introduction of advanced technologies. While economic growth provides opportunities to introduce new, more efficient technologies, in the particular case of power generation in China, it creates concerns about power shortages. Generators are therefore discouraged from discarding outdated, inefficient and dirty infrastructure. This suggests that technology transfer on the generation side may benefit from efforts to limit too rapid a growth in electricity demand, and may be crucial for the success of an international effort to encourage the transfer of clean coal technologies (Philibert and Podkanski, 2004).

Although not part of the Partnership, joint studies carried out by the World Bank and China in the late 1990s suggest that the total amount of SO_2 reduction potential from non-power sector options is limited. Additional reduction would require measures taken by the power sector. In most cases, coal cleaning and flue gas desulphurization (FGD) were deemed to be the most cost-effective options (World Bank).

7. THE WAY FORWARD

In addition to electrostatic precipitators (ESP) upgrading, coal washing and FGD, China has developed a strategy to acquire clean coal technologies including supercritical pulverized coal, circulating fluidized bed combustion (CBC), pressurized fluidized bed combustion (PFBC) and integrated gasification combined cycle (IGCC) (World Bank, undated).

The Partnership provides for a robust follow-up process, which will include a regular review of progress in the context of the annual EU-China Summits.

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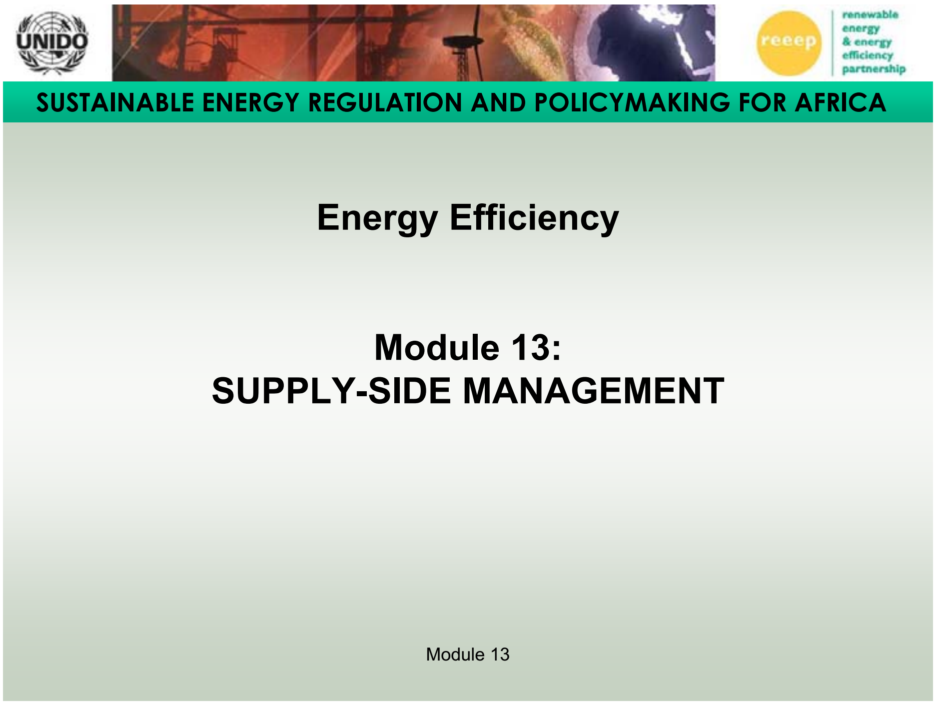
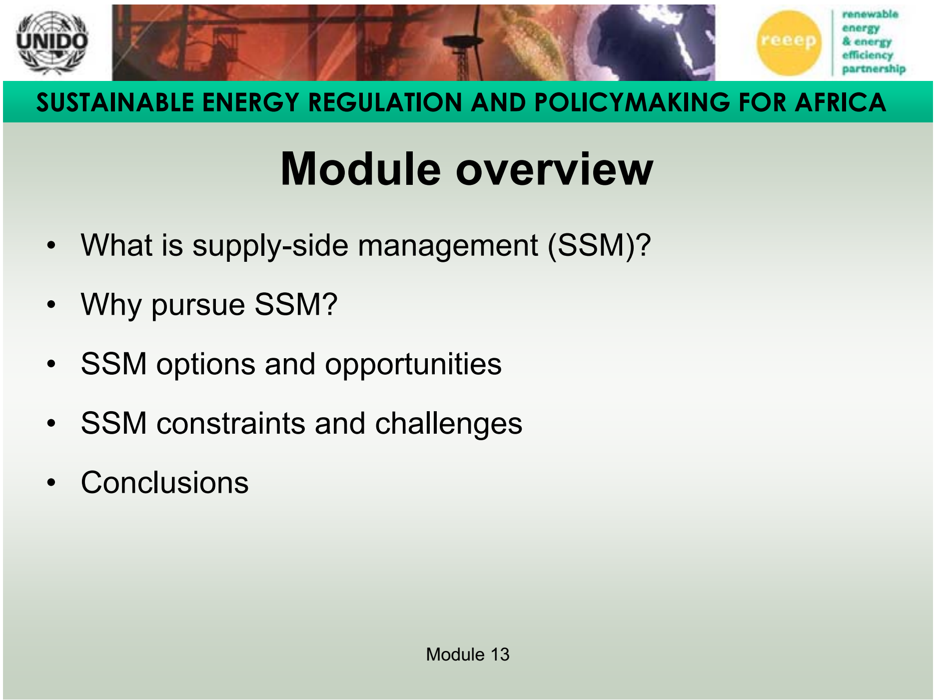


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

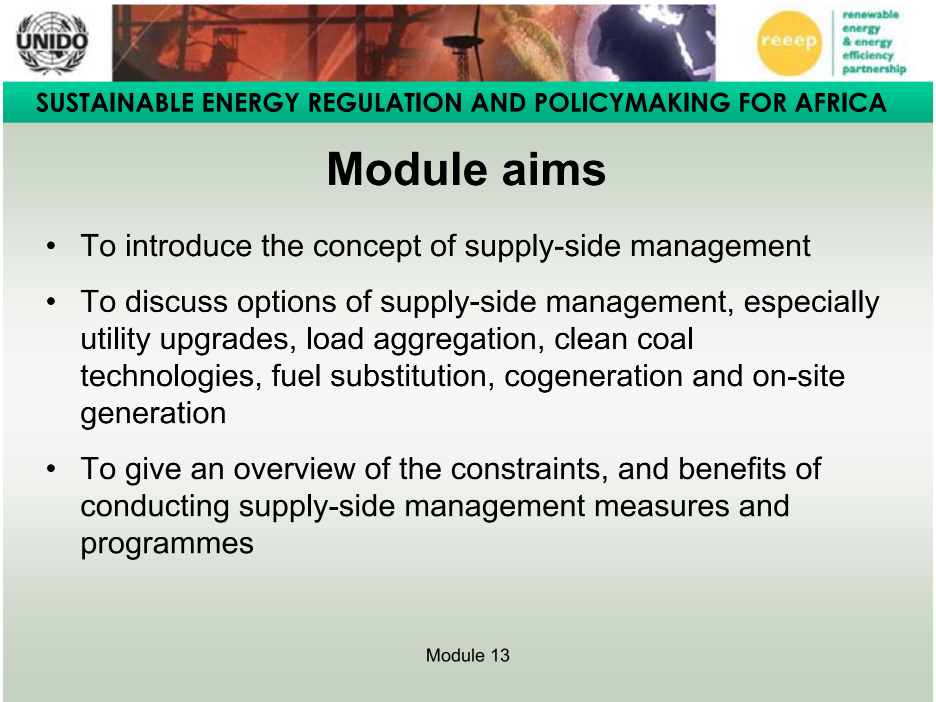
Module 13:
SUPPLY-SIDE MANAGEMENT



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

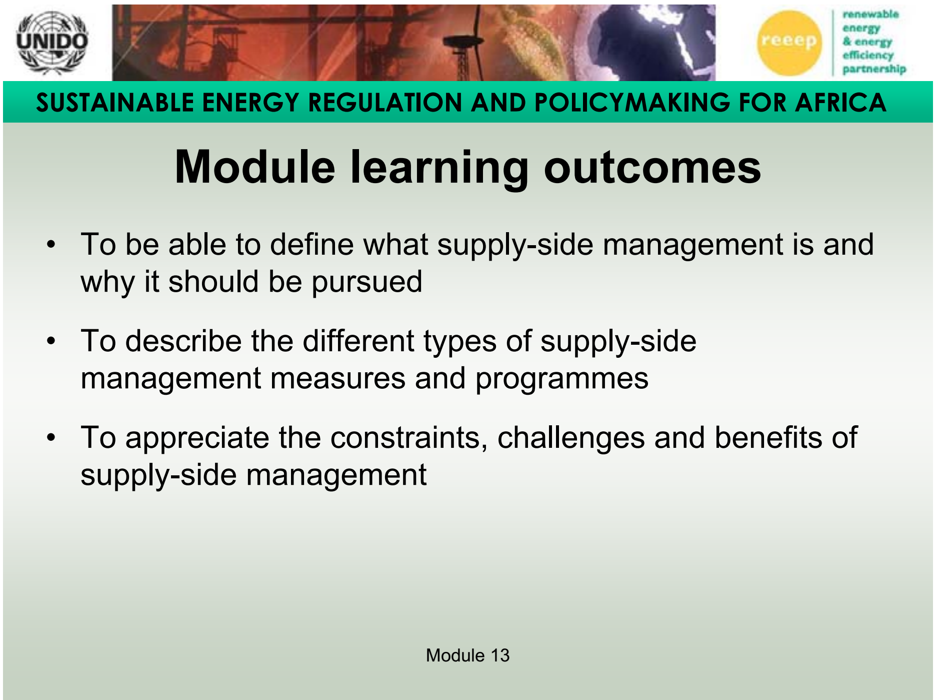
Module overview

- What is supply-side management (SSM)?
- Why pursue SSM?
- SSM options and opportunities
- SSM constraints and challenges
- Conclusions



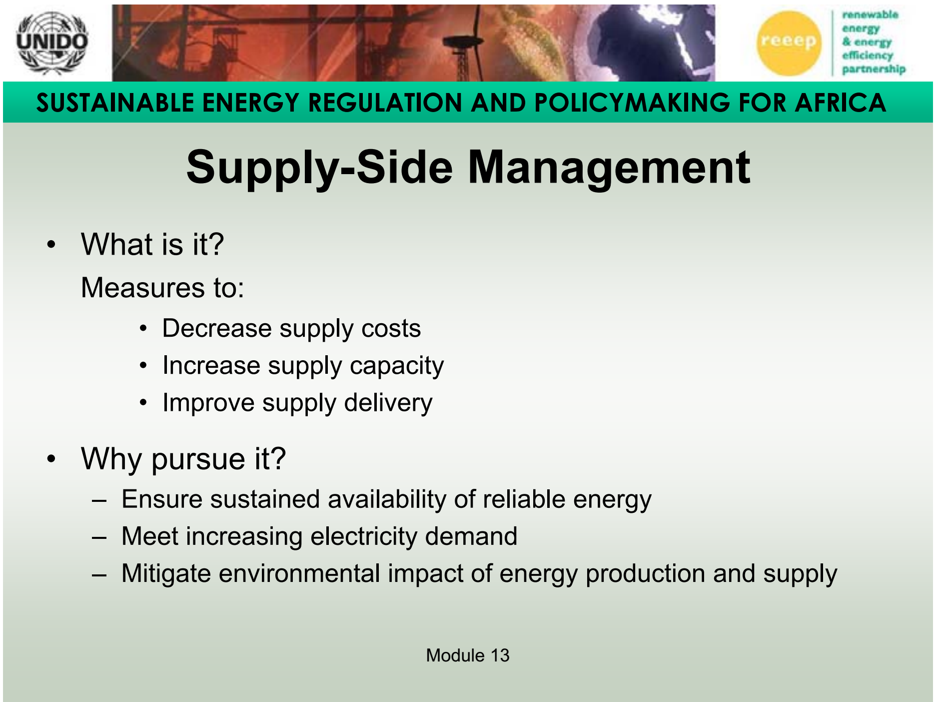
Module aims

- To introduce the concept of supply-side management
- To discuss options of supply-side management, especially utility upgrades, load aggregation, clean coal technologies, fuel substitution, cogeneration and on-site generation
- To give an overview of the constraints, and benefits of conducting supply-side management measures and programmes



Module learning outcomes

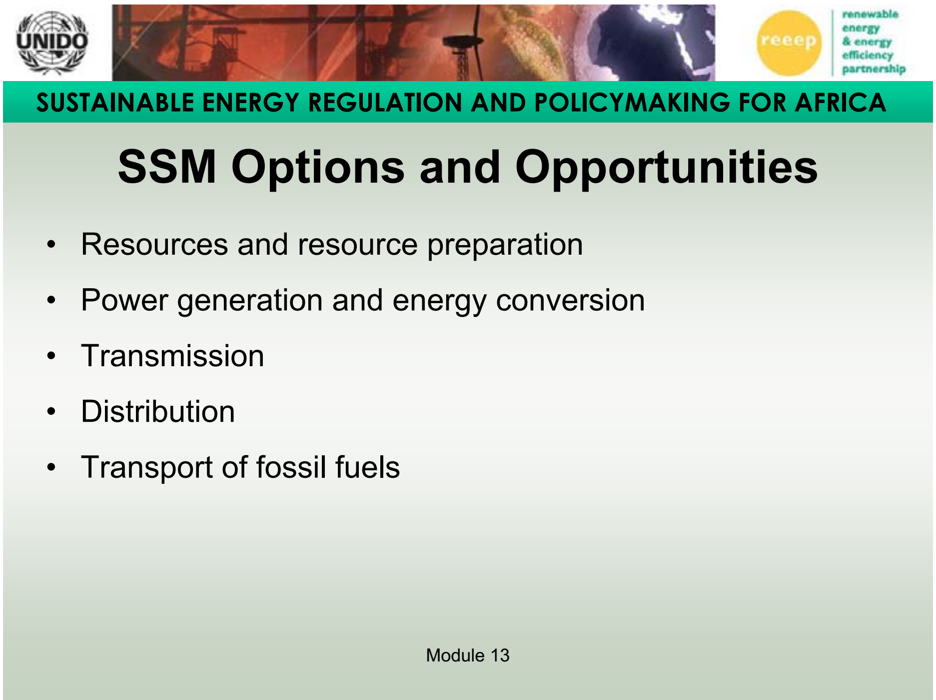
- To be able to define what supply-side management is and why it should be pursued
- To describe the different types of supply-side management measures and programmes
- To appreciate the constraints, challenges and benefits of supply-side management



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Supply-Side Management

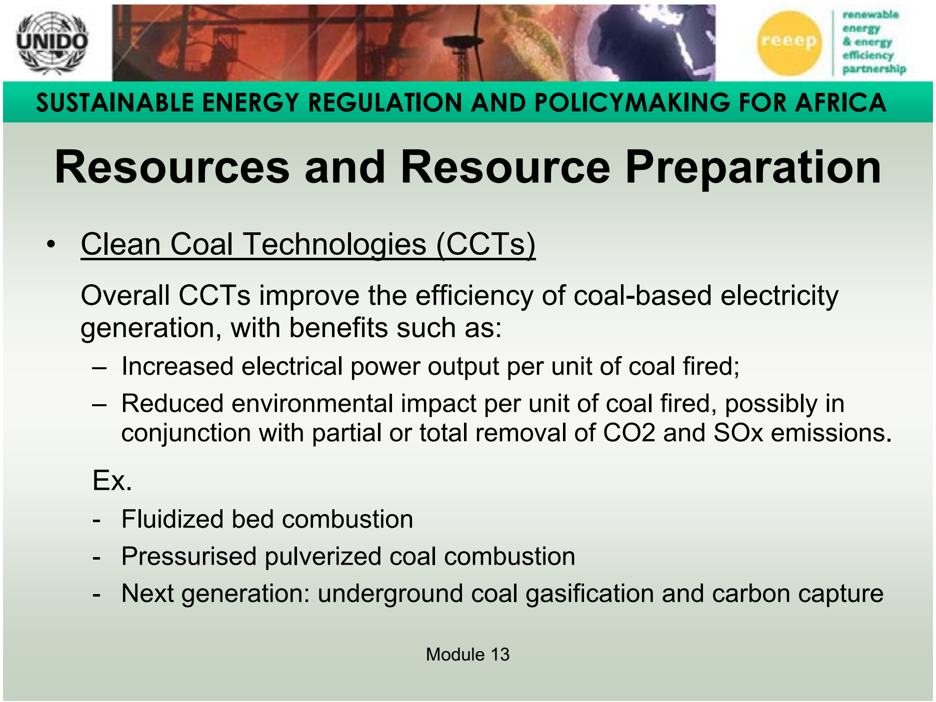
- What is it?
  Measures to:
    - Decrease supply costs
    - Increase supply capacity
    - Improve supply delivery
- Why pursue it?
  - Ensure sustained availability of reliable energy
  - Meet increasing electricity demand
  - Mitigate environmental impact of energy production and supply



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

SSM Options and Opportunities

- Resources and resource preparation
- Power generation and energy conversion
- Transmission
- Distribution
- Transport of fossil fuels



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Resources and Resource Preparation

- Clean Coal Technologies (CCTs)

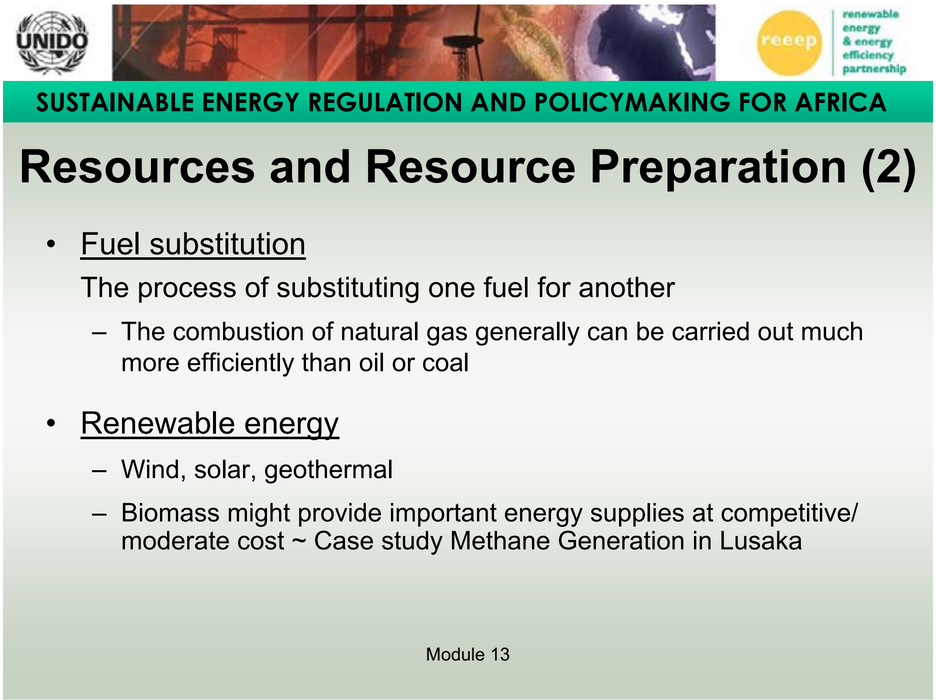
  Overall CCTs improve the efficiency of coal-based electricity generation, with benefits such as:

  – Increased electrical power output per unit of coal fired;

  – Reduced environmental impact per unit of coal fired, possibly in conjunction with partial or total removal of CO2 and SOx emissions.

  Ex.

  - Fluidized bed combustion
  - Pressurised pulverized coal combustion
  - Next generation: underground coal gasification and carbon capture



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Resources and Resource Preparation (2)

- Fuel substitution

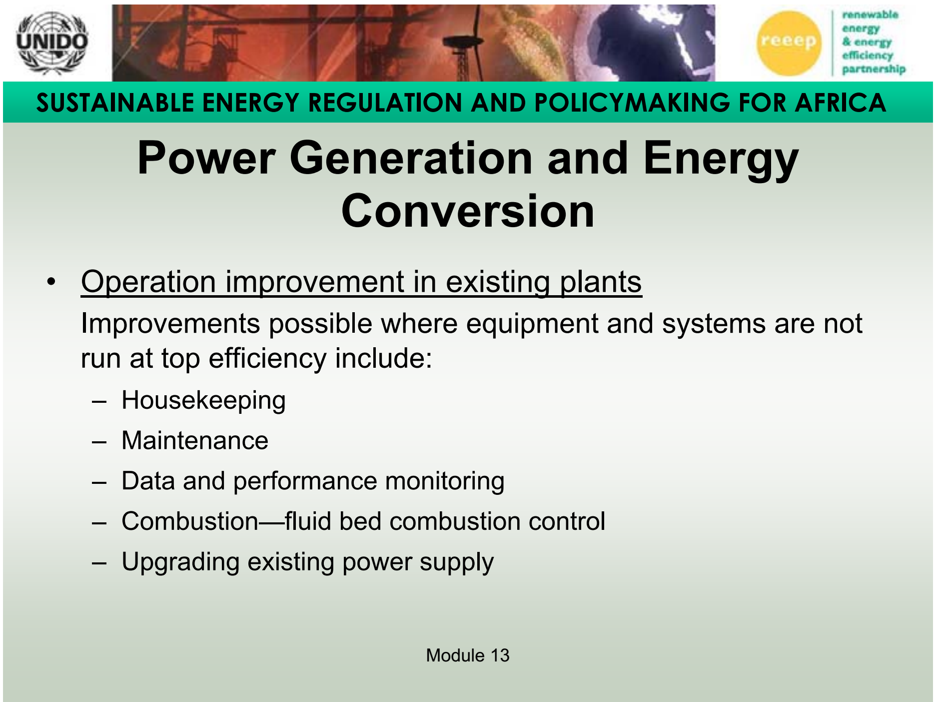
  The process of substituting one fuel for another

  – The combustion of natural gas generally can be carried out much more efficiently than oil or coal

- Renewable energy

  – Wind, solar, geothermal

  – Biomass might provide important energy supplies at competitive/ moderate cost ~ Case study Methane Generation in Lusaka



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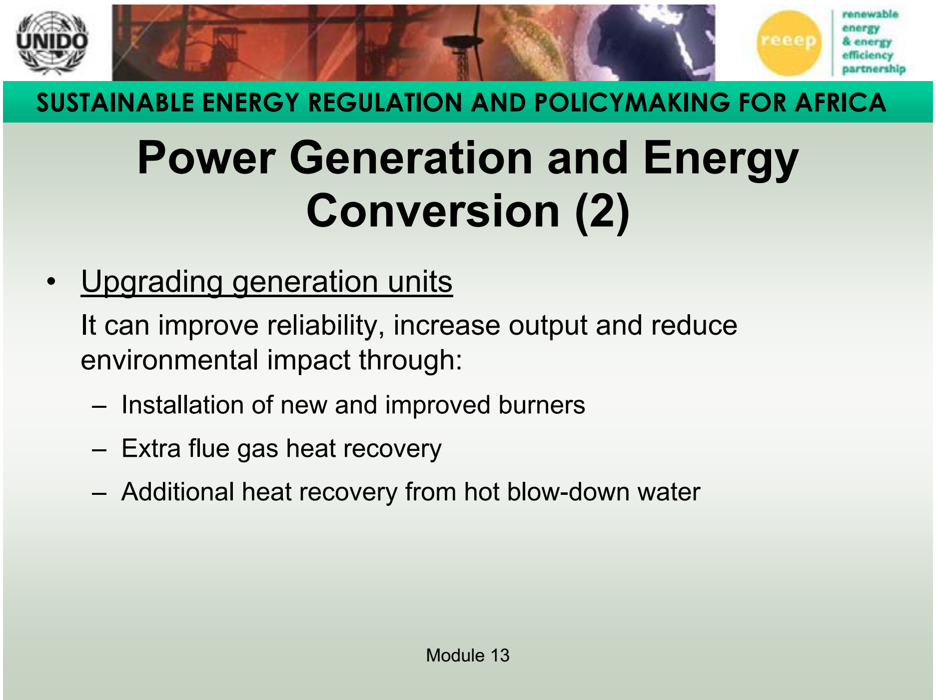
Power Generation and Energy Conversion

- Operation improvement in existing plants

  Improvements possible where equipment and systems are not run at top efficiency include:
  - Housekeeping
  - Maintenance
  - Data and performance monitoring
  - Combustion—fluid bed combustion control
  - Upgrading existing power supply

Module 13



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Power Generation and Energy Conversion (2)

- Upgrading generation units

  It can improve reliability, increase output and reduce environmental impact through:
  - Installation of new and improved burners
  - Extra flue gas heat recovery
  - Additional heat recovery from hot blow-down water

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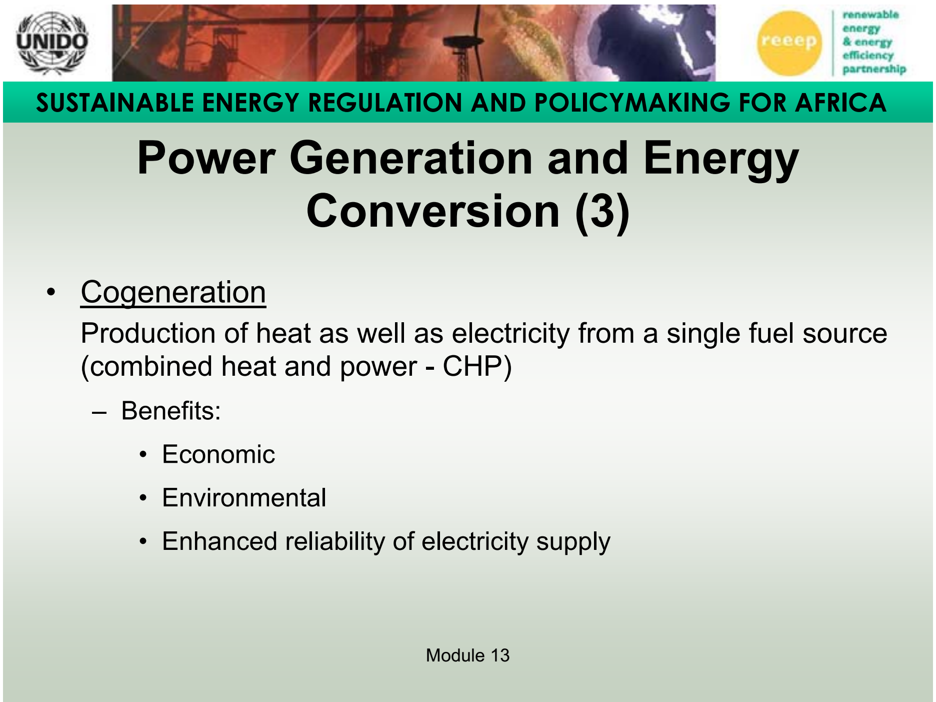

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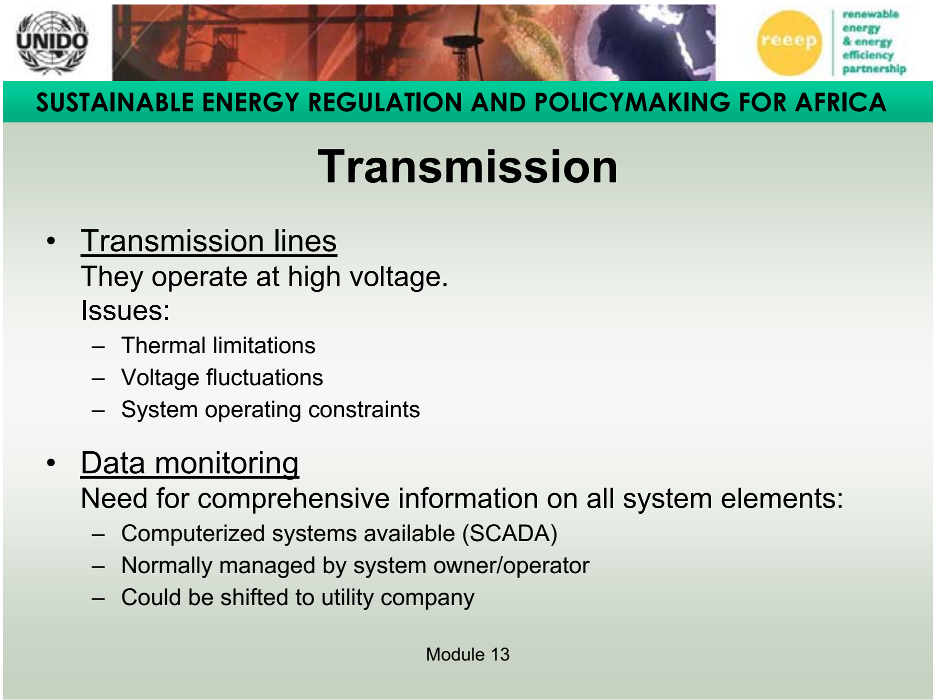
Power Generation and Energy Conversion (3)

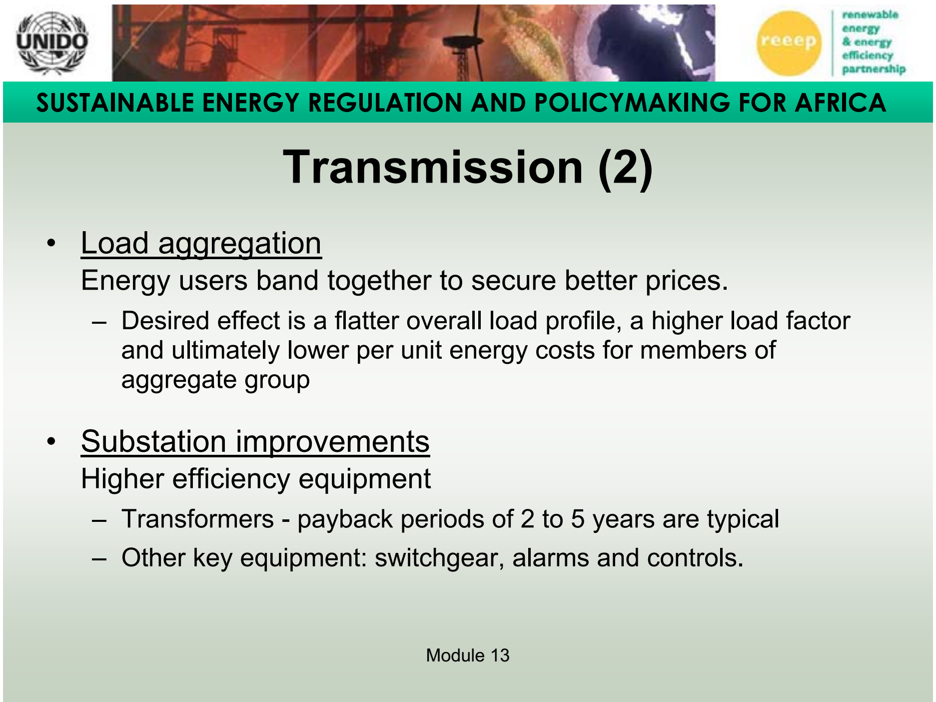
- Cogeneration
  Production of heat as well as electricity from a single fuel source (combined heat and power - CHP)
  - Benefits:
    - Economic
    - Environmental
    - Enhanced reliability of electricity supply



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Transmission

- Transmission lines
  They operate at high voltage.
  Issues:
  - Thermal limitations
  - Voltage fluctuations
  - System operating constraints
- Data monitoring
  Need for comprehensive information on all system elements:
  - Computerized systems available (SCADA)
  - Normally managed by system owner/operator
  - Could be shifted to utility company



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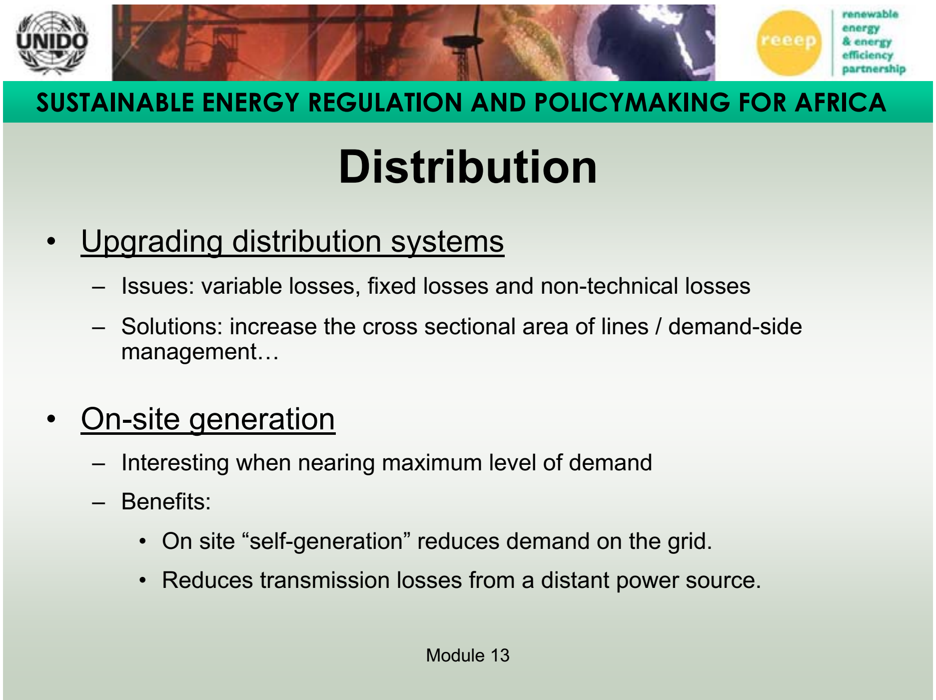
Transmission (2)

- Load aggregation
  Energy users band together to secure better prices.
  - Desired effect is a flatter overall load profile, a higher load factor and ultimately lower per unit energy costs for members of aggregate group
- Substation improvements
  Higher efficiency equipment
  - Transformers - payback periods of 2 to 5 years are typical
  - Other key equipment: switchgear, alarms and controls.



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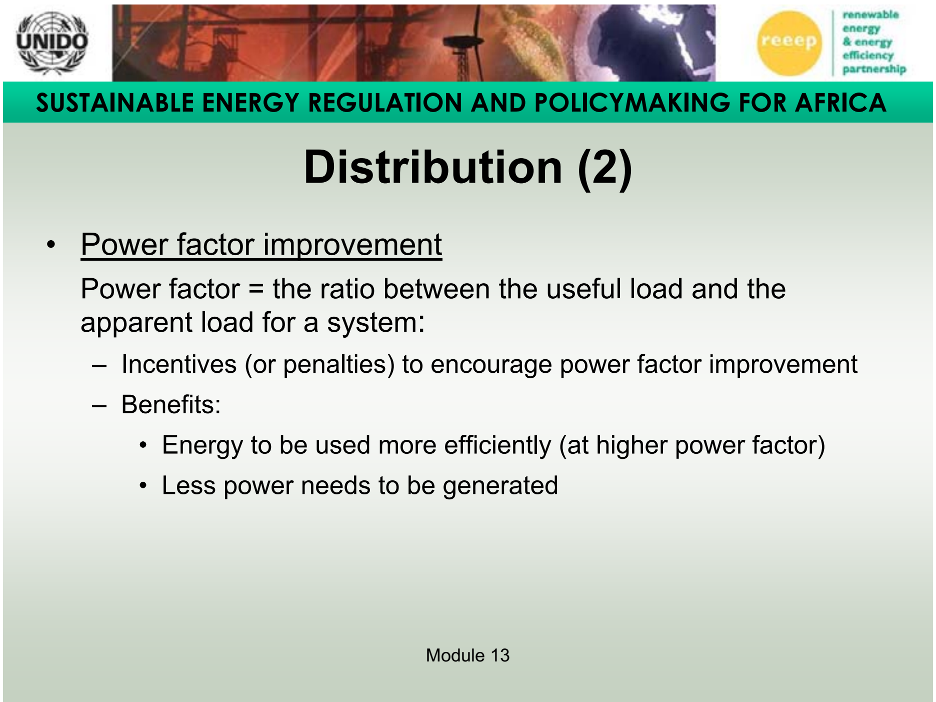
Distribution

- Upgrading distribution systems
  - Issues: variable losses, fixed losses and non-technical losses
  - Solutions: increase the cross sectional area of lines / demand-side management…
- On-site generation
  - Interesting when nearing maximum level of demand
  - Benefits:
    - On site “self-generation” reduces demand on the grid.
    - Reduces transmission losses from a distant power source.



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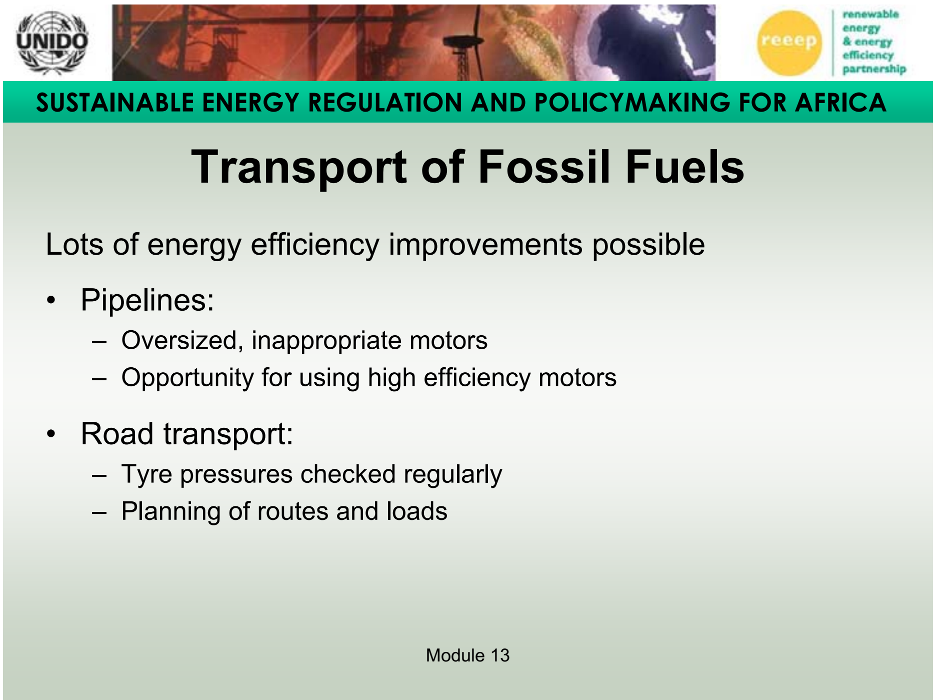
Distribution (2)

- Power factor improvement

  Power factor = the ratio between the useful load and the apparent load for a system:
  - Incentives (or penalties) to encourage power factor improvement
  - Benefits:
    - Energy to be used more efficiently (at higher power factor)
    - Less power needs to be generated



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Transport of Fossil Fuels

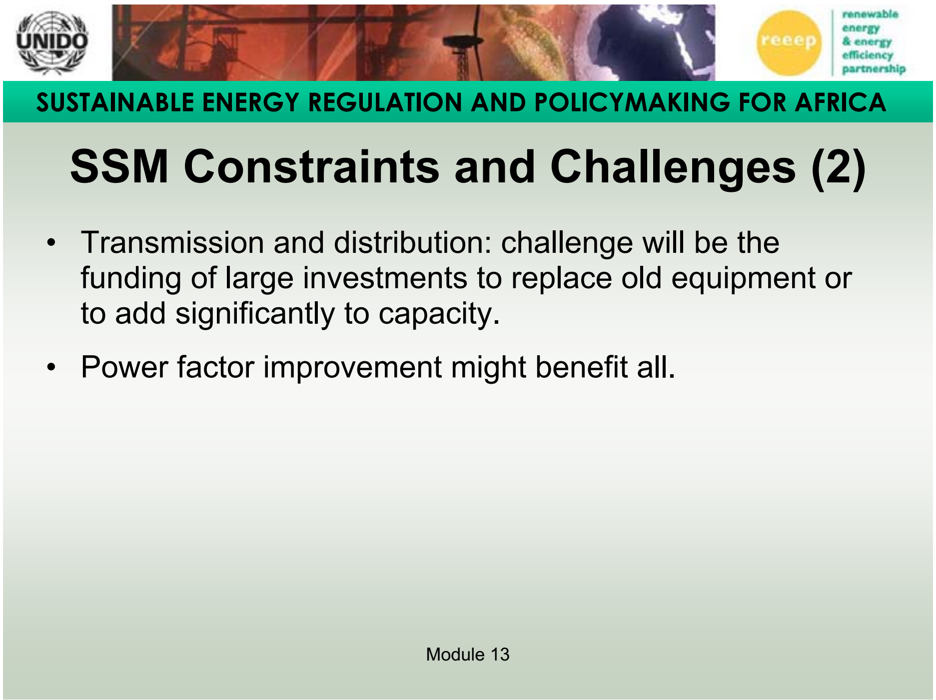
Lots of energy efficiency improvements possible

- Pipelines:
  - Oversized, inappropriate motors
  - Opportunity for using high efficiency motors
- Road transport:
  - Tyre pressures checked regularly
  - Planning of routes and loads

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

SSM Constraints and Challenges

- Availability of comprehensive information
- “First cost” basis drives decisions
- Experience in new technologies lacking in developing countries
- Case studies on bagasse for India and Eastern and Southern Africa
- When funds for investment available: evaluate all potential projects, especially those requiring large investments and those having a long life expectancy (cogeneration plants)



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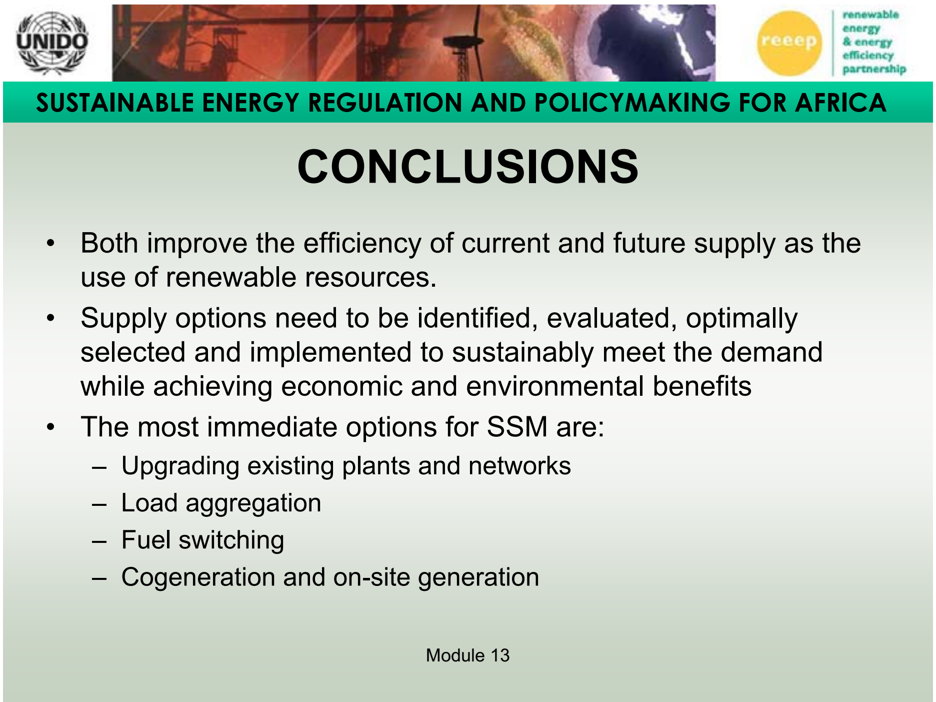
SSM Constraints and Challenges (2)

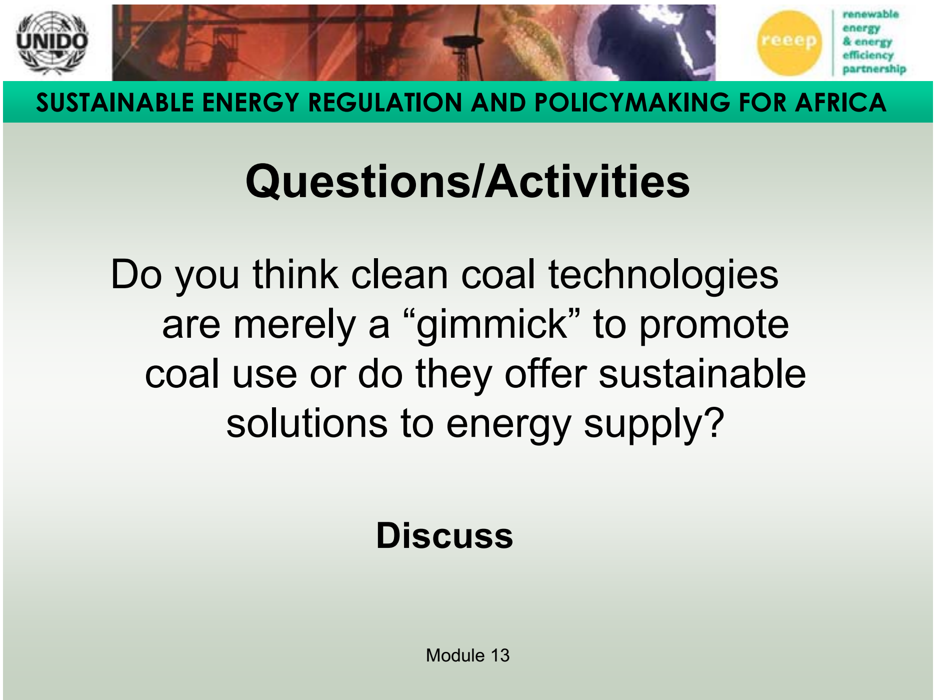
- Transmission and distribution: challenge will be the funding of large investments to replace old equipment or to add significantly to capacity.
- Power factor improvement might benefit all.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Both improve the efficiency of current and future supply as the use of renewable resources.
- Supply options need to be identified, evaluated, optimally selected and implemented to sustainably meet the demand while achieving economic and environmental benefits
- The most immediate options for SSM are:
  - Upgrading existing plants and networks
  - Load aggregation
  - Fuel switching
  - Cogeneration and on-site generation



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

Do you think clean coal technologies are merely a “gimmick” to promote coal use or do they offer sustainable solutions to energy supply?

Discuss

Module 14

Demand-side management

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Demand-side management (DSM) has been traditionally seen as a means of reducing peak electricity demand so that utilities can delay building further capacity. In fact, by reducing the overall load on an electricity network, DSM has various beneficial effects, including mitigating electrical system emergencies, reducing the number of blackouts and increasing system reliability. Possible benefits can also include reducing dependency on expensive imports of fuel, reducing energy prices, and reducing harmful emissions to the environment. Finally, DSM has a major role to play in deferring high investments in generation, transmission and distribution networks. Thus DSM applied to electricity systems provides significant economic, reliability and environmental benefits.

When DSM is applied to the consumption of energy in general—not just electricity but fuels of all types—it can also bring significant cost benefits to energy users (and corresponding reductions in emissions). Opportunities for reducing energy demand are numerous in all sectors and many are low-cost, or even no-cost, items that most enterprises or individuals could adopt in the short term, if good energy management is practised.

This module examines the types of DSM measures that can reduce energy demand for the end-user, that can manage and control loads from the utility side, and that can convert unsustainable energy practices into more efficient and sustainable energy use. The module includes a review of housekeeping and preventative maintenance, two of the simplest and most effective ways of reducing demand, and discusses marketing of DSM programmes. Some of the challenges that face the implementation of DSM programmes are also examined.

1.2. Module aims

The aims of the module are:

- To introduce the concept of demand-side management for residential, commercial and industrial energy users.
- To give an overview of the different types of demand-side measures.
- To show how housekeeping and preventative maintenance in commerce and industry can be used to reduce energy demand.

- To describe energy auditing and routine data collection and monitoring, and to indicate their benefits.
- To outline information dissemination on demand-side management.
- To provide an overview of the major implementation challenges for DSM programmes.

1.3. Module learning outcomes

The module attempts to achieve the following learning outcomes:

- To be able to define demand-side management.
- To understand the different types of demand-side management measures and their suitability to various energy users.
- To be aware of the benefits of good reliable data collection for regular performance analysis, and as an essential part of energy auditing.
- To appreciate the need for effective information dissemination.
- To understand the challenges facing the implementation of demand-side management.

2. INTRODUCTION

This module covers “demand-side management” or DSM, as applied to energy efficiency measures that modify or reduce end-users’ energy demand. This has traditionally been applied to electricity loads but is also used for changes that can be made to demands for all types of energy. The benefits for the energy user are reduced energy costs for a given output (production level or other measure of activity). For the energy provider, the benefit is a better use of its supply capacity.

From a utility point of view it would seem that a sensible business approach would be the promotion of consumption thereby increasing sales. This would be true if there were an excess of capacity and revenues were the only important factor in an energy supply system. However, increased revenues does not translate necessarily in higher profits and in some situations a least-cost planning approach would/could prove the implementation of DSM measures to be more profitable than investing in new generating capacity. Utilities might therefore be better advised to promote DSM and energy saving. From an environmental perspective, a decrease in energy demand due to improved efficiency reduces the environmental impact of energy consumption associated with a particular level of production or other activity. In this respect, promoting DSM can thus enhance the public image of a utility company.

Most of the literature and case studies relating to DSM are linked to electrical demand as a result of programmes set up by utilities and governments and thus this module concentrates on electrical DSM programmes. However, in Africa, where a modest percentage of the population have access to utility generated electricity, it is also necessary to consider DSM in relation to other energy resources—on perhaps a local level. Here an important resource is biomass in the form of wood for space heating and cooking. In this scenario, the supply and demand is often met by the same person and hence self-regulating—the one bearing the load of wood searching and collection will certainly manage the demand and use the supply of wood efficiently as far as their energy use methods/technologies allow e.g. stove types.

There are technologies that assist with the efficiency of wood fuel cooking, such as improved cook stoves. However, in the United Republic of Tanzania, as in many other sub-Saharan countries, the majority of rural people are poor and since they can collect firewood for free, they cannot be easily motivated to purchase improved stoves. Improved stoves for rural applications must therefore utilize cheap and innovative clay stove technologies to keep costs as low as possible

(Lugano Wilson, 2006) and information needs to be made available to end-users to explain how using an improved cook stove can save them time (collecting firewood) and/or money (if they buy their wood).

Having said this, this module focuses principally on the opportunities for applying DSM principles to industrial and commercial enterprises. Improved energy management can reduce fuel consumption for little or no investment in many cases, and this may contribute to lower imports of fuels that are costly and in short supply, therefore increasing the cost-effectiveness and competitiveness of industries and businesses.

Box 1. **DSM facts in the United States**

- In 1999 in the United States, 459 large electricity utilities had DSM programmes. These programmes saved the large utilities 50.6 billion kilowatt hours (kWh) of energy generation. This represented 1.5 per cent of the annual electricity sales of that year.
- New York has the potential to reduce demand by 1,300 MW (2002) through DSM—enough to supply power to 1.3 million homes.

Source: www.cogeneration.net/Demand_Side_Management.htm (accessed 06July06)

3. WHY PROMOTE DSM?

Various reasons are put forward for promoting or undertaking DSM. For example, DSM may be aimed at addressing the following issues (University of Warwick, REEEP, 2005):

- Cost reduction—many DSM and energy efficiency efforts have been introduced in the context of integrated resource planning and aimed at reducing total costs of meeting energy demand;
- Environmental and social improvement—energy efficiency and DSM may be pursued to achieve environmental and/or social goals by reducing energy use, leading to reduced greenhouse gas emissions;
- Reliability and network issues—ameliorating and/or averting problems in the electricity network through reducing demand in ways which maintain system reliability in the immediate term and over the longer term defer the need for network augmentation;
- Improved markets—short-term responses to electricity market conditions ("demand response"), particularly by reducing load during periods of high market prices caused by reduced generation or network capacity.

An energy customer may have many reasons for selecting a certain DSM activity. Generally these would be economic, environmental, marketing or regulatory. The above points are expressed in a slightly different way (Satish Saini, 2004), where it is argued that the benefits of DSM to consumers, enterprises, utilities and society can be realized through:

- Reductions in customer energy bills;
- Reductions in the need for new power plant, transmission and distribution networks;
- Stimulation of economic development;
- Creation of long-term jobs due to new innovations and technologies;
- Increases in the competitiveness of local enterprises;
- Reduction in air pollution;
- Reduced dependency on foreign energy sources;
- Reductions in peak power prices for electricity.

An additional aspect (Satish Saini, 2004) is that of enhanced energy security through a diminished dependency on foreign energy sources. While the vulnerability to the volatility of international energy markets may not be the concern of an individual utility, industry or commercial company, at the national level, decreased dependency on energy imports can have important security of energy supply implications. For example, the dependency of many countries on oil, which as a primary resource is concentrated in only a relatively few countries, is creating geo-political tensions.

In a survey conducted by the International Energy Agency (IEA) between governments and utilities of 14 OECD countries[1] (*INDEEP Analysis Report*, 2004), the top four reasons given for implementing DSM programme were:

- Wanting reductions in global warming-related emissions of GHGs (environmental);
- Public image (marketing);
- Quality of service (marketing);
- Regulatory incentives (regulatory).

Where economic reasons were quoted for programme implementation—such as reducing cost of services—actual implementations were relatively few. However, this survey focused on the motivation of government and utilities; industrial plants, commercial companies and individuals are likely to have different priorities.

Box 2. **Environmental benefits of DSM**

As part of the City of Cape Town's initiative to improve energy efficiency in government buildings, an energy audit was carried out to determine potential energy saving opportunities. As a result of the audit, certain measures were implemented to reduce energy consumption including timers on electric geysers so that water is only heated when needed, replacement of inefficient urns with insulated electric water heating systems, installation of energy efficient lighting and installation of solar water heaters. Resulting from these measures, 20 per cent savings in electricity were achieved per month (equal to 24 476 kWh/month) equivalent to a reduction in greenhouse gas emissions of about 323 tons of CO_2 per year. The next step will be to introduce measures to influence behavioural changes in staff energy use to reduce consumption further.

Source: Energy Management News, Vol 10, number 4, Dec 2004. www.erc.uct.ac.za

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[1] Austria, Brazil, Canada, Denmark, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom and United States.

4. WHAT DRIVES DSM?

The motivation behind the implementation of DSM is obviously different for the various parties involved. Thus for utility companies, the reduction or shift of a customer's energy demand could mean avoiding or delaying building additional generating capacity. In some situations, this would avoid or defer energy price increases that would otherwise be imposed on customers to help finance new investments in system capacity. For customers, DSM offers the opportunity to reduce their energy bill through efficiency and conservation measures. In the case of industrial customers, this would translate to lower production costs and a more competitive product. For domestic customers it means that they would save money that could be spent on other household commodities.

Utilities (and thus governments, where utilities are nationalized enterprises) can therefore be one of the key driving forces behind DSM implementation but energy customers should also be motivated in using energy more efficiently, subsequently reducing their energy demand and thus their energy costs. Consumers may also be able to take advantage of any special incentives offered by utility companies, and may participate in programmes offered by the utilities (and possibly supported by government).

Organizations with energy-dependent activities such as industrial manufacturers and owners/operators of buildings are often strongly interested in DSM, primarily to reduce their own energy consumption and costs, and partly perhaps to assist their local utility to maintain a reliable energy supply. The latter is of course directly in the interests of the energy user.

Industrial plants are often able to reduce overall demand by adopting various kinds of energy efficiency measures. Depending on the processes used, many have the flexibility to reschedule their periods of highest demand to cut peak loads and to even out their demand over a longer or different time period, thus helping the utility itself to run at higher efficiency.

The investment needed for these actions may be quite low if a simple retiming of operations proves possible. Other measures, such as replacing electric motors with high efficiency versions or installing variable speed drives, will require investments. A financial evaluation of any proposed measure is needed to see where and when the benefits of DSM can be accrued to the industrial enterprise. Provided a reasonable return on investment can be assured, the enterprise management should take prompt action, in some cases with the technical advice of the utility company experts.

For building owners or operators, there may be a variety of cost effective measures available. For example, light fixtures can be modified, and heating and cooling systems can be altered from constant-volume to variable-volume drive applications (or indeed replaced entirely by new equipment). Equipment changes and new controls and other instruments, e.g. meters or timers, should also be considered.

In conclusion, based on the discussion above on “Why promote DSM?” and taking into account the driving forces for DSM, it is possible to trace the rationale of the various DMS efforts back to two main categories:

- Cost reduction and environmental motives;
- Reliability and network motives.

4.1. Cost reduction and environmental motives

DSM was started with the focus strongly on electricity systems. There was a first wave of DSM activity in California in the late 1970s as part of the response to rising oil prices (cost motivation) and increasing public hostility to new power stations (environmental motivation). However, the initiative began to develop in earnest in the United States in the early 1980s, in the context of integrated resource planning where the emphasis was on reducing total costs (financial and environmental) of meeting energy demand (University of Warwick, REEEP, 2005).

California set up the California Energy Commission (CEC) which worked with the California Public Utilities Commission (CPUC) to set spending targets for energy conservation and load management for the state's four investor-owned utilities. During the 1980s and early 1990s, cost reduction and environmentally-driven DSM programmes were implemented in many United States states, Canada and a number of European countries. Essentially, DSM was made attractive for utilities, through changes to the incentives set by regulators.

Before these changes were made, the utilities would lose income if they sold fewer kWh and DSM programmes offered risk but no reward for shareholders, as such investment would not be added to the asset base on which the regulators calculated the allowed rate of return. The solution was to make utility profits less dependent upon the numbers of units sold and to enable the utilities to earn profits on DSM activities. DSM became a major activity in the United States with utilities spending $US 2.8 billion on it by 1993 (Hadley & Hirst, 1995). The main activity undertaken under DSM programmes was energy efficiency for customers. Typically, utilities would subsidize the cost of energy saving measures such as efficient heating systems, appliances, lighting and insulation.

DSM as operated in the 1980s and early 1990s worked in the context of vertically integrated monopoly electricity utilities. It is more complicated to use it where companies are not vertically integrated and/or where competition has been introduced. As electricity market reform was introduced in the United States from the mid-1990s, spending on DSM fell by 50 per cent from 1994 to 1997 (Crossley, 2005). Nevertheless it is possible to use it where electricity reforms have taken place, particularly in the natural monopoly distribution side (see case study of New South Wales below) where network-driven DSM can be particularly useful.

The fate of DSM programmes in the face of power sector reform has varied widely across the globe. In some jurisdictions, DSM programmes are now coordinated by governmental or other agencies, rather than utilities, and funded with taxes or general revenues, rather than by ratepayers. However, in most countries where DSM is used it is funded through electricity bills and the electric utilities are actively involved in programme design and delivery. Policies that support the continuation of DSM programmes include the following, often in combination:

- An agreed-upon or mandated quantified target for energy savings;
- A funding mechanism that strengthens, or does not harm, the competitive position of the energy companies practicing DSM;
- A standardized and mandatory scheme for cost-benefit evaluation of the DSM activities;
- Price regulation of the remaining monopoly segments (transmission and distribution network and retail supply to non-eligible customers) in a manner that removes artificial incentives to increase sales and disincentives to save energy (e.g. Denmark, Italy, NSW in Australia, Norway and the United Kingdom).

DSM measures can certainly reduce consumer energy costs. Many measures require little or no implementation costs, as suggested in “Energy Saving Tips” later in this module. The implementation of different DSM mechanisms would incur different costs that need to be carried by government, utilities or consumers. Often any implementation cost is passed on to the consumer, for example, by the utility in the form of higher tariffs or by the manufacturer of an energy efficient appliance in the price tag of that appliance. However, government in the form of subsidies or loan assistance may often share these costs.

The advent of competitive electricity wholesale (generation) markets in which prices can be highly volatile is encouraging the development of market-driven DSM, particularly to provide short-term responses to energy market conditions (“demand response”). Market-driven DSM is a growth area in the United States and this is likely to be replicated in other developed countries that have competitive electricity markets. Such market-driven DSM will be primarily motivated to achieve cost savings. It may also reduce energy demand although it may mainly shift demand to times when prices are lower. Market-driven DSM may have positive or negative environmental impacts. This will depend upon the nature of the marginal generating plants that may be displaced (e.g. coal or gas) and the demand-side response (e.g. energy efficiency measures or different forms of distributed generation such as solar or diesel).

A study conducted by the Government of New Zealand estimated in about 22 per cent of current consumption, the economically efficient savings that New Zealand could achieve through electricity DSM over a five-year period (Treasury, New Zealand, 2005). More realistic estimates have set between 6.5 per cent and 11 per cent the amount of savings that could be practically achieved.

DSM effectiveness needs to be quantified and this can be achieved using measurement and verification (M&V). M&V has the advantage of being an impartial, credible and transparent process that can be used to quantify and assess the impacts and sustainability of DSM and energy efficiency projects (Eskom, 2006). It provides customers and utilities with information on the impact of the DSM programme so that future planning can take into account the results. In South Africa the following DSM results were quantified by M&V and published by Eskom *(Eskom—Energy Audits, Quarterly Report,* Period: April to June 2006*)*:

- 2004 calendar year — 42.71 MW saved, of which 31.09 MW was saved by two separate lighting projects applying compact fluorescent lamps (CFL);
- January 2005 to March 2005 — 44.57 MW saved (CFL lighting projects);
- 2005/6 Eskom financial year — 81.80 MW saved (of this, 9.78 MW was saved by three separate CFL lighting projects);
- 2006/7 Eskom financial year — pro-rata first quarter savings are 38 MW.

Whilst there will be environmental benefits from not constructing new infrastructure, these need to be considered alongside actions taken to avoid infrastructure development. Most (e.g. energy efficiency, distributed co-generation using gas, solar power) will bring environmental benefits but some (e.g. some forms of stand-by generators) may create some environmental problems such as localized noise and pollution from diesel generators and risk of pollution from careless disposal of batteries or other equipment.

4.2. Reliability and network motives

Network constraints are becoming a problem in both developed and developing countries where electricity demand is increasing and network infrastructure is becoming inadequate. For example, air conditioning is a major growth area in many countries. In many situations, network-driven DSM can delay the need for network expansion and augmentation. Sometimes network-driven DSM may even be able to eliminate cost-effectively the requirement to build a large-scale distribution network: this may be particularly useful in many developing countries where extensive distribution networks do not exist. Although experience to date with this type of DSM is limited, network-driven DSM may offer the scope for significant savings in costs in the future (University of Warwick, REEEP, 2005).

Box 3. **Katoomba demand management project, New South Wales, Australia**

In late 1990s, the electricity network infrastructure in the Katoomba area of the Blue Mountains west of Sydney had limited capacity and, due to load growth, required a new transmission substation at Katoomba North, which was constructed in 1996/97. In 1998, Integral Energy launched a demand management programme, focusing on energy efficiency in the residential sector in an attempt to defer further augmentation of the network.

The programme used one full-time advocate of energy efficiency measures to provide advice to homebuilders and developers. It created a register of energy efficiency service providers that could sell and/or install items such as insulation, double glazed windows, alternative fuel appliances, high efficiency light fittings and heat pumps. Integral Energy also ensured that the registered vendors offered their products and services at reasonable prices. However, Integral Energy did not arrange for the installation of energy efficiency measures or provide subsidies for the installation cost. The programme ran from 1998 for about five years. It was successful in achieving reductions in winter peak period loads, particularly space heating loads. However, the summer load continued to grow. The programme successfully deferred additional capital works in the area—including the construction of a second feeder and second transformer—until 2006/07. The programme cost $AUS 70,000 per annum (administrative costs).

5. TYPES OF DSM MEASURES

Most DSM measures are put in place by utilities or by the energy end-users themselves—typically industrial enterprises. Utilities try to encourage energy users to alter their demand profile, and this is generally accomplished through positive tariff incentives allowing customers to schedule demand activities at a time that will reduce their energy costs. This in turn helps the utilities by moving the demand away from the peak period. In some cases, negative incentives (penalties) are charged for the continued operation of inefficient equipment with unnecessarily high loads: this is intended to encourage customers to upgrade equipment and thereby reduce electrical demand.

Industrial enterprises will normally consider a wide range of possible actions to reduce the consumption of all types of energy. A straightforward reduction in energy consumption will normally reduce costs, and a shift of demand to a different time might reduce costs if an appropriate tariff is available.

The main types of DSM activities may be classified in three categories:

- Energy reduction programmes—reducing demand through more efficient processes, buildings or equipment;
- Load management programmes—changing the load pattern and encouraging less demand at peak times and peak rates;
- Load growth and conservation programmes.

5.1. Energy reduction programmes

This category covers a large number of measures in all sectors. As examples of typical energy reduction measures, a series of “energy saving tips” are presented below. Many are so-called housekeeping items that can be implemented for little or no investment, while others may require significant capital investment. A discussion of widely applicable measures follows, as well as examples of particular relevance to industrial and commercial enterprises.

Energy saving tips

Industrial and commercial sectors

Boilers

Production of steam and hot water is a major activity for most enterprises and uses well known technology. However, poor boiler operation represents a significant source of energy losses. Therefore, boiler performance improvement is often a practical and low cost option. The actions that can be taken to improve performance include:

- Monitoring combustion conditions routinely and keeping efficiency as high as possible at all times;
- Ensuring there are adequate controls to adjust the quantity of combustion air;
- Ensuring insulation (on the outside of the boiler) and refractory (inside) are in good condition and that thicknesses are appropriate for good modern practice;
- The water treatment system should be in good working order at all times, and boiler feed water quality should be monitored regularly;
- Equipment should be checked frequently for steam and water leaks;
- Capacity utilization should be checked—one boiler operating at high load is much more efficient that two boilers each at low load.

Steam systems

These represent an important operating cost for many companies and good performance can be achieved by good management. Substantial losses are incurred through poor maintenance as well as poor original design. The following actions should be considered:

- Insulate steam and condensate return lines, vessels and fittings;
- Repair steam leaks and maintain steam traps;
- Use condensate return systems to the maximum;
- Consider heat recovery from contaminated condensate that cannot be returned;
- Consider using flash steam in the plant;
- Fit automatic temperature controls to equipment wherever possible, to minimize waste of steam to overheat equipment or processes.

Lighting

Often consuming 10 per cent or more of industrial plant electricity and 50 per cent or more in commercial buildings, lighting normally offers good opportunities for savings. Some of the items listed below will also apply to a greater or lesser extent to the domestic sector.

- Use energy efficient fluorescent tubes, CFLs and other low energy light sources;
- Consider using energy efficient electronic ballasts;
- Clean luminaries regularly;
- Use appropriate lighting levels for different parts of the work area;
- Install lights at working level where possible, not necessarily on a high ceiling;
- Use natural light where possible, e.g. fit translucent roof panels or skylights;
- Paint walls and ceilings white or bright colours (also floors if possible) to improve light reflection.

Motors and drive systems

In all sectors, motors are significant energy consumers. In many industrial plants, motors and drive systems may consume over 50 per cent of the total electricity used. Poor motor performance is typically a major source of energy losses. The following actions should be considered to improve motor performance:

- Use properly sized motors and only run when needed;
- Use high efficiency motors;
- Use electronic variable speed controls where motor loads are variable in normal operation;
- Use cogged belts or improved gears: smooth belts often slip and are not efficient;
- Install improved bearings and lubricate regularly;
- Check power factor regularly and improve with capacitor banks, preferably installed close to the running equipment;
- Maintain all equipment regularly.

Compressed air systems

Often a significant user of electricity in an industrial plant, compressed air systems frequently lack meters and suffer poor maintenance. Operating practices may be poor too. The following actions should be considered:

- Eliminate inappropriate use of compressed air (e.g. do not use for clearing away dust or metal shreds from lathes and similar machines);
- Listen for leaks during shift changes or lunch breaks, when workshops are typically quiet and not supposed to be using air;
- Regular maintenance of all parts of the system, including valves and joints, which are often subject to leaks. Check air filters as these may be blocked by dust or grease;
- Reduce air intake temperature e.g. consider relocating the intake;
- Improve overall system efficiency by checking compressor running times e.g. running when there is little or no demand;
- Optimize system pressure: do not generate at high pressure for tools etc. that do not need this;
- Install heat recovery systems.

Household

No-cost or low-cost measures

If no action has previously been taken on simple energy savings measures, there may be large savings opportunities available for very low cost. Although the items below are classed as “household”, most of them apply just as well to buildings of any kind.

- Sealing and insulation—look for air infiltration or hot air escapes, and inadequate or failed insulation in:
    - Floors, walls, ceilings;
    - Doors and windows;
    - Fans and vents;
    - Heating, cooling and ventilating ducts, and fireplaces;
    - Electric outlets;
    - Plumbing penetrations through walls.
- Hot water cylinders—set the thermostat to 50°C, use insulating blankets, and insulate pipes;
- Washing machines, dryers and dish washers—only run with a full load;
- Space heating/cooling temperatures—use curtains to insulate at night and as a sun blind: to cool if hot, or open to let sun in if cold;
- Replace incandescent lighting with CFLs.

Measures needing investment

- Replace old outdated appliances (washing machines, refrigerators, air conditioners, etc.) with new more efficient ones;
- Install a solar water heater (but check payback period for the investment needed);
- Install double glazing windows (but check payback period).

Widely applicable measures

Efficient lighting

Energy consumed for industrial, commercial and domestic lighting is a significant component of energy demand for many electricity supply systems, particularly at times of peak demand. Measures to save electricity in lighting will normally require some investment but this need not be excessive and will typically allow paybacks under a year or so to be attained. Measures include changes in light bulbs, fittings and switches. In some cases, increased use of natural light can be achieved but may involve expensive building modifications. Other measures are suggested in the “tips” above.

Regarding light bulbs, traditional incandescent bulbs lose a large proportion of their energy to heat and only 3-6 per cent of the input energy results in light. Depending on the colour acceptable in the specific situation, different lights may be used. For example, fluorescent lamps can allow big reductions to be made in lamp wattage for the same intensity of illumination. Standard fluorescent tubes may be adopted but energy saving tubes operate at even lower wattages (saving around 12 per cent) for almost the same light output. Fluorescent lamps controlled by electronic ballast operating at high frequency (20 kHz) are typically 10 per cent more efficient than those with conventional ballasts. Note too that ballasts of flickering fluorescent tubes continue to consume 15 per cent of the lamp wattage even if the contribution to lighting is zero. Also, although up to 25 times more expensive than conventional starters, electronic starters last longer and start lamps without flicker, thus extending lamp life.

Compact fluorescent lamps (CFL) are now available from various manufacturers as direct replacements for incandescent lamps up to 100W. The lamp, complete with electronic ballast can be fitted in the lamp holder of the incandescent lamp to be replaced with no modifications required. Although more expensive (up to 20 times the cost of the equivalent incandescent bulbs) they consume less than 25 per cent of the energy for the same light output and last up to 10 times as long.

Table 1 below gives a summary of different light source characteristics. For industrial plants or large commercial warehouses and yards where colour rendering is not critical, sodium and mercury-based lamps can offer substantial savings in electricity.

Table 1. Comparison of typical light source characteristics

	LAMP TYPE					
		Low pressure discharge		High pressure discharge		
CHARACTERISTIC	**Incandescent (tungsten-halogen)**	**Fluorescent**	**LP sodium**	**Mercury vapour**	**Metal halogen**	**HP sodium**
Efficacy in terms of initial lumens watt	20 (23)	70	140	50	80	120
Typical rated life in hours	1,000 (2,000)	12,000 to 20,000	18,000	16,000 to 24,000	7,500 to 15,000	20,000 to 24,000
Ballast required	NO (YES)	YES	YES	YES	YES	YES
Colour of light	Warm	Cool/warm	Yellow	Cool/warm	Cool	Warm
Lamp cost	Low	Low	Low	Medium	High	High
Operating cost (comparative)	1.0	0.25	0.15	0.36	0.22	0.2

In summary, the main opportunities for reducing the electricity used for lighting are:

- Lighting retrofitting—the replacement of existing lamps with more efficient light sources, sometimes in conjunction with new lighting fixtures (possibly high initial costs but long-term benefits);

- Fixture delamping—removing selected lamps from existing light fixtures in a uniform pattern throughout specific areas to reduce overall lighting, or to remove selected lights entirely where they do not contribute to task or safety lighting;

- Modifying switches, e.g. to allow selected areas of lighting to be switched off while adjacent areas remain on. Additional switches can be installed in large areas where selected parts are switched on or off by the workers in different parts, rather than keeping the whole area illuminated when few people are present.

Box 4. **Efficient lighting initiative in South Africa**

In South Africa 69 per cent (2001 Census) of households that have access to electricity use electricity for lighting. Vast potential exists for reducing load demand relatively quickly and cheaply. The Global Environment Facility (GEF) has provided $US 225 000 in funding to assist with an Efficient Lighting Initiative (ELI). The aim of ELI is to penetrate the South African Market with 18 million compact fluorescent lamps (CFLs) over the next 15 years.

With coal-fired power stations accounting for 90 per cent of South Africa's generation capacity, any reduction in electricity demand due to demand-side measures benefits the environment by reducing associated emissions and water use. If the target of 18 million lamps is met, then on an annual basis, it could reduce power consumption in South Africa by over 4,000 GWh compared with the power consumed by standard incandescent lamps.

Source: Future Planning (Eskom CER 1999), Corporate Environmental Affairs, Eskom
www.eskom.co.za/enviroreport99/future.htm Accessed 06July06

Energy efficient motors

Electric motors are extensively used in all sectors. In many industrial plants, they may represent over 50 per cent of the total electrical load. In manufacturing plants and the mining industry, there can be large ventilation requirements to dilute dust and gases, and to remove heat in buildings or deep mines. In buildings—commercial, institutional and domestic—a major source of power usage is in air conditioning for air circulation and compressor motors.

An opportunity therefore exists in many situations to reduce electrical loads by the types of measure listed above in the “energy saving tips”. In particular, for locations where motors are run continuously for long periods of time, it can often be cost effective to replace conventional motors by high efficiency types. This may be carried out at any time—provided it is cost effective to do so—but companies may typically find that the shortest paybacks are obtained when replacing a conventional motor that has failed in service. Rather than replacing it with an identical motor, serious consideration should be given to installing a high efficiency motor instead.

For the ventilation of mines, for example, the use of energy efficient motors and high power impellers can allow demand to be reduced without changing the main equipment frames. The payback time is often quite short and reliability can be improved (C.D. Pitis, 2004).

In Ghana in 1999, feasibility studies were conducted for the establishment of one-stop motor repair and sales centres, which could serve as outlets for energy efficient motors and drives in various parts of the country. The study established that repeated motor rewinding and refurbishment (common practice in Ghana and many other countries) leads to significant efficiency losses.

The study found that it was feasible to establish private motor centres that would sell energy efficient motors to industry and provide motor advisory and repair services.

The study also recommended the development and implementation of motor testing procedures, minimum efficiency standards and labels as well as the establishment of a facility in Ghana to manufacture small electric fan and pump motors (Alfred K. Ofosu Ahenkorah, 2006).

Box 5. **Assessment of energy utilization at the University of Zambia**

1. Background

Since energy costs have risen in the past few years and since energy is essential for operating a big learning institution, the University of Zambia (UZ) undertook an energy audit to identify ways of reducing energy expenses. At the beginning of the study, UZ owed the supply company about $US 1.0 million in unpaid electricity bills. Electricity consumption had to be reduced to sustainable levels. The advantages of energy efficiency to UZ are very significant as the financial savings can be channelled to more needy sections in the university.

2. Audit objectives

The objectives were to identify ways of reducing energy costs, and evaluate possibilities for energy substitution to reduce electricity bills.

3. Description of the project

The key tasks of the audit were identifying the main energy using units, estimating energy consumed by each, and identifying energy saving opportunities. Specifically the study undertook the following:

- Energy consumption estimates were made for student hostels and water pumping systems by measuring currents and voltages with a clamp-on-meter because these units are fed by sub-stations with faulty energy meters. There are 52 hostels and about 124 students live in each. Students do not pay for electricity since this is paid in bulk by the University authorities. There are five borehole pumping systems to supplement water supply from municipal sources.

- Power factor measurements were carried out from a sample of about 14 hostels for a continuous period of three months.
- A questionnaire was also administered to study energy consumption patterns.

4. Results

	Location	Typical load (kW)	Average power factor
1	Hostels	650	0.72
2	Water pumps	105	0.72›

Results of the questionnaire responses showed the following:

- Over 90 per cent of respondents cook for less than 8 hrs per day, about 30 per cent play radios for 18-24 hours per day, and 90 per cent use fluorescent lamps for lighting systems.
- About 70 per cent of respondents leave lights on 16-24 hours per day; about 79 per cent realize the need to use natural daylight while 21 per cent do not see the need for using daylight to conserve energy.
- About 68 per cent of respondents suggested that the institution should set up measures to ensure that the number of electrical appliances purchased is regulated. They also suggested that students be made aware of the need to save energy.
- There is no use of low power consuming appliances or automatic switching systems.
- About 11 per cent of respondents suggested that the Government should raise meal allowances to enable them to purchase meals from cafeterias since this would minimize cooking in rooms.

5. Description of recommended actions

- For lighting, replace 54 watt fluorescent tubes with more efficient 18 watt tubes; replace incandescent lights with more efficient CFLs and reduce usage by 10 per cent; use automatic switches on lighting systems; increase awareness on the use of natural daylight.
- Install capacitor banks to raise power factor from 0.72 to 0.95 as required by the utility to save on money being paid on penalties for low power factors.
- Regulate the types and number of electrical appliances used.
- Set up an energy management centre for training and conducting awareness programmes, and study implementation of energy saving measures.

6. Lessons learnt

The study identified various energy saving opportunities and overall substantial savings in energy that can be realized. It was recommended that feasibility studies be undertaken to determine the savings from reduced energy consumption from specific actions and the cost of implementation. The next step would then be to implement items with payback periods under two years. A two-year payback period is generally regarded as a good guideline for implementation of DSM actions.

Industrial and commercial DSM practices

Energy management

The aim of energy management is to lower energy costs and bring immediate benefits to an organization or enterprise. Energy management is the structured application of a range of management techniques that enables an organization to identify and implement measures for reducing energy consumption and costs.

Energy management activities typically cover:

- Energy purchasing;
- Metering and billing;
- Performance measurement;
- Energy policy development;
- Energy surveying and auditing;
- Awareness-raising, training and education;
- Capital investment management (including equipment procurement).

The specific tasks of an energy management department will depend on the nature of the organization and the budget and staff skills available. Energy management is a continuous process, with continuous monitoring of energy performance and always seeks to maintain and improve the efficient use of energy.

Once top management has given its approval to undertake energy management in the organization, and appropriate resources have been authorized, the next step is the appointment of an energy manager. The role of an energy manager will vary from organization to organization but they will normally be concerned with the following tasks:

- Collecting and analysing energy-related data on a regular basis;

- Monitoring energy purchases and equipment procurement;
- Identifying energy saving opportunities;
- Developing projects to save energy, including technical and financial evaluations;
- Implementing projects and checking post-implementation performance;
- Maintaining employee communications and public relations.

An important part of this job is the collection and analysis of data. Thus the energy manager must be aware of load profiles or time of use for all forms of energy consumption. Reliable quantitative information on load profiles is needed to analyse the opportunities for load shifting and load levelling. To obtain the data, automated measurement and recording equipment is available to record load profiles, and indeed to control and manage the use of electricity, gas, liquid fuels, steam and water.

As an example, advanced software programs are available to organize data on energy use (and other key operating parameters) and provide a series of utility cost management applications, such as (C. Martel Chen, 2004):

- Load profiling of individual and multiple facilities to ease energy decisions;
- External and internal benchmarking of energy performance;
- Utility bill verification and budget tracking;
- Energy accounting, baselining and savings analysis;
- Measurement and verification of energy conservation measures;
- Internal cost allocation by cost centres, product lines, etc.;
- Tenant billing for multiple occupancy buildings;
- Facility management reporting to senior management.

Housekeeping

Measures to reduce energy consumption and improve energy efficiency in enterprises and other organizations may be divided into three basic categories (as discussed below for “energy audits”):

- No-cost and low-cost measures;
- Measures requiring moderate levels of investment;
- Measures requiring significant investment.

Each organization will have to make its own decision regarding what “moderate” and “significant” mean, as this depends on many factors, such as the size of facilities, levels and cost of energy consumption, and the financial situation of the organization.

The first category—the no and low-cost measures—covers items usually known as “good housekeeping” and these should be implemented by the organization to “tidy up” its operations. Organizations should always consider implementing housekeeping measures promptly because they can reduce energy demand in the short term, usually for very small capital investments and low installation costs.

Some examples of good housekeeping are:

- Removing redundant lighting fixtures—many plants undergo modifications and reorganization but lighting systems are often not correspondingly moved, with the result that lights may become redundant;
- Removing redundant pipework—as for lighting, process changes or increases in production capacity often result in piping (and sometimes equipment) being redundant. Unless properly insulated or removed, the redundant items may contribute to unnecessary heat losses and leaks of steam etc;
- Switching off unnecessary loads, such as:
  - Lights—in unoccupied areas, and in areas where daylight provides adequate lighting (manually—light switches at strategic points can facilitate manual switching; or by automatic controls—motion detectors, time controls and photo sensors);
  - Computers and monitors—when not in use, switching off reduces the load and also reduces heat and therefore the demand on space cooling;
- Improving distribution systems for electricity, steam and other utilities e.g. better insulation of hot and cold services, replacing electricity lines to cut line losses;
- Repairing steam leaks—improves the system efficiency and reduces energy needed to compensate for energy losses in the leaked steam;
- Maintaining appropriate process control settings—optimizing the efficiency of the processes and other energy-dependent activities, thus reducing energy needs.

Review question

What are three housekeeping practices that would improve efficiency and reduce energy demand?

Preventive maintenance

Good maintenance has an essential part to play in achieving good levels of energy efficiency. For example, some typical deficiencies in industrial plants are:

- Meters are uncalibrated or out of service;
- Steam traps are defective;
- Valves are leaking at the spindle, losing steam, water, compressed air and process fluids;
- Insulation of steam and refrigeration distribution piping is inadequate.

Most plants and many commercial buildings will benefit from improved maintenance, increasing their energy efficiency performance and reducing emissions correspondingly. All too often maintenance is only performed when a breakdown occurs, whereas prevention of breakdowns can contribute greatly to long-term energy efficiency. Preventive maintenance can take various forms, some examples of which are:

- Developing and applying routine lubrication schedules;
- Replacing critical items on a regular schedule (e.g. steam traps);
- Monitoring lubricant composition to determine when excessive wear of metal parts is occurring;
- Monitoring noise and vibration of bearings before failure actually occurs;
- Regular filter cleaning on air compressors, pumps, upstream of steam traps, in ventilation ducts, etc;
- Continuous scale removal from water heating equipment or appliances;
- Monitoring hot spots on boilers and furnaces, to check for refractory failure;
- Monitoring transformer temperatures for abnormalities.

Introducing a preventive maintenance system should include good records of actual failure rates and an analysis of the reasons for breakdown of different types of equipment. Preventative maintenance thus contributes to machines and processes running at optimum efficiency, as well as minimizing unscheduled downtime.

Buildings regulations

The design and construction of buildings is regulated in most countries by "buildings regulations" which set minimum standards for various items that impact on the energy consumed to operate a building (as well as on items affecting safety). The detail contained in regulations can be quite comprehensive and designed to require architects, designers and constructors to adopt good energy efficiency practices and thus reduce energy consumed in the built environment. Typically regulations will cover, for example:

- Improved materials of construction of buildings—to reduce heat losses though walls and floors;
- Insulation of roof spaces—to reduce heat losses;
- Window design and construction—to minimize heat losses/gains;
- Standards for the performance and control of air conditioning systems;
- Efficiency standards for lighting, and use of passive lighting;
- Minimum efficiency standards for central heating boilers and hot water heaters;
- Timers and temperature controls on electric hot water cylinders;
- Application of solar water heaters and passive space heating.

Appliance labelling

Labelling appliances, selected equipment and even buildings to indicate their expected energy consumption is a well-known and tested tool for raising customer awareness. Educating energy consumers can contribute to reducing energy consumption by making them aware of the consumption levels of, for example, household appliances, cars and buildings and thus encouraging the choice of items with the highest energy efficiency.

Domestic appliances represent an important source of energy consumption in households, especially refrigerators and water heaters. Appliance labelling allows the consumer to compare appliances from various manufacturers and make an informed judgement when buying a new appliance. Generally the label contains a simple means of rating consumption, for example a letter from A to G (where A is the most efficient). The label may also contain the consumption of the appliance in kWh per year, or expressed as an estimated cost of operating the appliance for say one year.

Energy labelling needs to be in place for at least a couple of years before the effect can be observed on consumption levels. This is because consumers need to become familiar with the content of the label and will then make their choice for energy efficiency only when they need to replace a particular appliance.

Energy auditing

Introduction

For many enterprises, energy consumption data is limited to a few utility bills, e.g. for electricity, gas, coal, fuel oil, and these apply to the whole organization. Separate consumptions for different workshops, processes or buildings are rarely known. For such enterprises, there may be only one meter for the energy supplied to the factory fence, and sub-metering to different parts of the site may not exist. In other organizations, sub-meters may well exist but readings are not always taken at the same time every month, and records may be unreliable. Data on production and other key parameters maybe available but are not related to the corresponding energy consumptions. In this situation, it is impossible to determine with any certainty the energy performance of different departments.

When setting up an energy management programme, it is necessary for an organization to undertake a complete review of energy consumptions and corresponding activities, e.g. quantities manufactured, buildings heated or cooled. An "energy audit" is done to gather together all the relevant data and to analyse performance throughout the organization, from which deficiencies can be identified and recommendations for improvement made.

There are various types of audit and levels of complexity that can be applied for an organization, as well as various objectives of an audit in specific circumstances. Audits may be applied, for example, to industrial operations, commercial buildings, transport companies, and domestic premises. A typical audit for an industrial company might carry out some or all of the following:

- Obtain information on the processes employed, on plant equipment and physical facilities, design data, machinery characteristics and production capacities;
- Determine from historical records the emissions, energy consumptions and production levels for the plant and key departments (over a period of say 2-3 years);
- Determine—if necessary from on-site measurements using portable instruments—the actual operating parameters and performance of equipment and processes;
- Observe the nature and extent of energy management procedures and reporting, and the corresponding management structure in the organization;

- Analyse the data obtained and the observations made, establishing the efficiency of energy utilization by key equipment;
- Identify and characterize the constraints to improving performance, including organizational, technical and financial constraints;
- Identify potential measures for improvement and carry out financial evaluations where investment is needed;
- Develop a logical action plan to address the constraints, including specific recommendations and priorities for the different measures.

For buildings or transport activities, corresponding information will be collected and similar analyses carried out.

For convenience, audits may be divided into “preliminary” and “detailed” audits. In practice of course, many audits will be “between” the two. Practical audit work requires a flexible approach, in which procedures are adapted to meet the needs of the specific organization. Various types of audit are discussed below.

Preliminary audits

A preliminary audit (PA) is an initial data-gathering exercise and may be known by many names, such as walk-through audit, short audit or initial survey. Typically the PA can be completed without sophisticated instruments and uses only data that are already available in the organization. The work is carried out in cooperation with plant personnel. Data from plant records are collected and supplemented by a “walk through” of the plant (or building) during which the audit team observes the general condition of equipment, the standard of maintenance, the level of operations control exercised by management, and the reporting procedures in effect.

Few measurements are made during a PA, other than perhaps making some limited stack gas analyses on boilers and furnaces. This is because combustion gas compositions are relatively simple to determine and easily used to estimate the excess air applied and the stack losses. Excess air should be set at levels that depend on the fuel type and composition, and on the design and condition of the equipment.

The PA can be completed in a short time. The energy auditors rely on their experience to gather information for a rapid diagnosis of the energy performance of the organization. The typical output of the PA will include a report with a series of low-cost improvement measures, the housekeeping measures discussed earlier in this module. The report will also include recommendations for the scope of a detailed audit, if this is justified.

Detailed audits

A detailed audit (DA) is a more comprehensive study of the plant (or building). Portable instruments are usually used to check parameters on equipment and processes, followed by a detailed analysis of the different systems. Although instruments are needed, this does not mean that auditing is an exact science. The auditors must always use their experience and judgement in collecting and interpreting data. Plant personnel will also be involved and should participate closely at all stages with the audit team.

The specific measurements required vary according to the type of plant and its condition. In general terms, about half of the effort on a DA will be spent for data collection on-site and the other half on analysing data and preparing the report. Measures that require investment should include financial analyses with estimates of likely returns on the capital invested. An example of a typical report is given in box 6.

While some audits allow a good understanding to be gained of the performance of equipment and workshops, they do often have limitations. An audit will typically require a significant amount of effort to complete, and many tend to be "static", giving a comprehensive picture of performance at one particular time. An audit should therefore be considered as a start to a continuing activity of data collection and performance analysis, in which the results from one time period to the next are compared and trends in energy efficiency—better or worse—are identified. A good energy management programme will include the initial auditing and also a longer-term activity of performance monitoring.

Finally, we may note that an advantage of having an energy audit conducted at an organization is the raising of awareness of the staff members who may well take this knowledge back to their own home and apply the same principles and carry out their own energy efficiency measures.

Box 6. **An energy audit report template and guidelines**

1. Title page

- Report title
- Client name (company for which facility has been audited)
- Location of the facility, date of report
- Audit contractor name

2. Table of contents

3. Executive summary

All information in the executive summary should be drawn from the more detailed information in the full report. The executive summary should contain a brief description of the audit including:

- Name, plant(s), location(s) and industry of the company audited
- Scope of the audit
- Date the audit took place
- Summary of energy consumption data
- Results:
  - Assessment of energy-consuming systems
  - Identification of energy management options (EMOs) and estimates of energy, greenhouse gas (GHG), and cost savings associated with each option, with the relevant implementation cost and the expected payback period (and return on investment). In the event that an audit covers more than one facility, the statistics for each facility should be reported on an individual basis to the extent possible. Results are conveniently expressed in concise tables.
- Recommendations summarized in table form.

4. Introduction

The introduction should include:

- Audit objectives: a statement that defines the scope of the energy audit in clear and measurable terms—example, space(s), systems and/or process(es) to be audited
- Background information: a description of the facility where the audit will be conducted, as well as information regarding facility layout, products/services produced/distributed, operating hours including seasonal variations, number of employees and relevant results of previous energy initiatives.

5. Audit activity and results

This section should make reference to:

- Description of the audit methodology (techniques, e.g. inspection, measurements, calculations, analyses and assumptions)
- Observations on the general condition of the facility and equipment
- Identification/verification of an energy consumption baseline in terms of energy types, units, costs and greenhouse gas (GHG) emissions for the facility/system being assessed

- Results of the audit including identification of EMOs and the estimated energy, GHG, and cost savings associated with each measure as well as the required investment and payback period associated with each of the EMOs identified.

6. Recommendations

This section should list and describe the recommendations based on the identification of EMOs and may include details concerning implementation. An explanation should be provided for recommending or not recommending each EMO identified in the results.

7. Appendices

Appendices include background material that is essential for understanding the calculations and recommendations and may include:

- Facility layout diagrams
- Process diagrams
- Reference graphs used in calculations, such as motor efficiency curves
- Data sets that are large enough to clutter the text of the report

5.2. Load management programmes

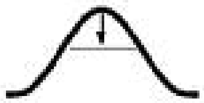
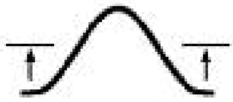
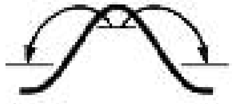
Electricity suppliers can influence the redistribution of the demand and time of electricity usage by load management by their customers. Similar activities can be encouraged by gas utilities. Load management of any kind will generally be conducted so that the energy user will be able to continue production while the utility achieves a modified load curve. The types of load management techniques are (www.cogeneration.net, 2006):

- Load levelling;
- Load control;
- Tariff incentives and penalties.

Load levelling

Load levelling helps to optimize the current generating base-load without the need for reserve capacity to meet the periods of high demand. Classic forms of load levelling are presented in table 2 below.

Table 2. Classic forms of load levelling

Peak clipping—where the demand peaks (high demand periods) are "clipped" and the load is reduced at peak times. This form of load management has little overall effect of the demand but focuses on reducing peak demand.	
Valley filling—where the demand valleys (low demand periods) are "filled" by building off-peak capacities. This form of load management can be achieved by thermal energy storage (water heating or space heating) that displaces fossil fuel loads.	
Load shifting—where loads are "shifted" from peak to valley times (achieving clipping and filling). Examples of applications include storage water heating, storage space heating, coolness storage, and customer load shifting. Shifting is different to clipping in that the load is present in the overall demand whereas in clipping it is removed.	

Source: engineering.purdue.edu, 2006

Load control

Load control is where loads (e.g. heating, cooling, ventilation and lighting) can be switched on or off, often remotely, by the utility. In this case, the customers may have back-up generators or energy storage capability and generally have an interruptible agreement with the utility in return for a special rate. Utilities may even call on on-site generators to meet peak demand on the grid.

The energy distribution industry may use rolling blackouts to reduce demand when the demand surpasses the capacity. Rolling blackouts are the systematic switching off of supply to areas within a supplied region such that each area takes turns to "lose" supply. Utilities or municipalities in these cases would try to publish or announce a schedule so that businesses and homes can plan their use of energy for that period. Recently, in Western Cape of South Africa, consumers were subject to a fairly long period of rolling blackouts. This was due to demand surpassing capacity at one unit of Koeberg Power Station under unplanned maintenance. These cuts were not always well communicated to the customers or did not run according to the published schedule causing much confusion, lost production and even lost goods such as refrigerated products. However, the winter demand was largely met due to customer participation in energy efficiency and DSM initiatives.

Tariff incentives and penalties

Utilities encourage a certain pattern of use by tariff incentives where customers use energy at certain times to achieve a better-priced rate for their energy use. These include:

- Time-of-use rates—where utilities have different charges for power use during different periods. Higher peak time charges would encourage a user to run high load activities in an off-peak period when rates are lower.
- Power factor charges, where users are penalized for having power factors below a fixed threshold, usually 0.90 or 0.95 (see box 7).
- Real-time pricing, where the rate varies based on the utilities load (continuously or by the hour).

Box 7. **Power factor correction: the Posta House case**

Background

Whenever loads are connected to an alternate current (AC) supply, there is a possibility that current and voltage will be out of phase. Loads such as induction motors draw current that lags behind voltage, while capacitive loads (e.g. synchronous motors, battery chargers) draw current that leads the voltage. Loads that are predominantly resistive such as heaters and cookers draw current in phase with voltage. The angle between the current and voltage is known as the “phase angle φ”—this can be leading or lagging (or zero) depending on the load. The power factor (PF) is defined as cosine φ and is always less than 1. It represents the ratio of active power (or useful power) to the total power supplied by the generating station.

When power factor is less than unity, the amount of useful power supplied by the generating plant at maximum output will be less than its full capacity (in other words, when the PF is less than one not all the power supplied is turned into useful work). This represents an inefficiency and therefore utility companies usually require customers to achieve a power factor of at least 0.9 (sometimes 0.95). Those who fail to meet the minimum required value will be charged a penalty on their bills to compensate for the various losses incurred by the generator (e.g. losses in distribution cables and transformers).

Power factor correction

Operating at a high power factor allows energy to be used more efficiently. In most cases, a low power factor can be increased (“corrected”) by installing capacitors in the system. In most plants, a practical solution is to install capacitor banks at the main point of power supply. Depending on the power factor, more or less capacitance can be connected at any time.

Power factor correction: the Posta House case

The head office of Tanzania Posts Corporation experienced substantial monthly bills and it was found the power factor averaged 0.75. Based on meter readings for electricity consumption in the existing situation, the active power (useful power) was 225 kW while reactive power (not useful) was 198 kVAr, for a total chargeable power demand of 300 kVA.

Improving the PF to 0.98 would reduce the reactive power to 45.7 kVAr and the total chargeable power demand to 230 kVA. To achieve a PF of 0.98, the required capacitor bank investment would amount to Tanzanian Shillings (T Sh) 9,850,000 while the annual energy saving accrued through the lower power demand would be T Sh 6,472,000. The PF improvement would therefore result in having a payback of 1.52 years or just over 18 months. Power factor correction by installing capacitor banks was therefore recommended to the management as a means of reducing the monthly costs in the electricity bill.

Review question

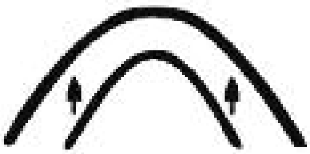
Describe briefly the main load management programmes.

5.3. Load growth and conservation programmes

Load growth programmes are implemented with the intention of improving customer productivity and environmental compliance while increasing the sale of kW for the utilities. This increases the market share of the utility and enables an ability to fill valleys and increase peaks. These programmes can often divert unsustainable energy practices to better and more efficient practices such as the reduction of the use of fossil fuels and raw materials.

Strategic load growth is the load shape change that refers to a general increase in sales beyond the valley filling described previously. This is represented schematically in figure I.

Figure I. Strategic load growth



Source: engineering.purdue.edu, 2006

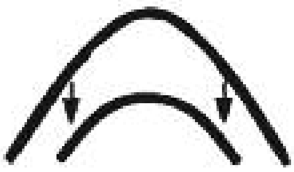
Load growth may involve increased market share of loads that are, or can be served by competing fuels, as well as area development. In the future, load growth may include electrification. Electrification is the term currently being employed to describe the new emerging electric technologies surrounding electric vehicles, industrial process heating and automation.

An example is the promotion of electro-infrared technologies to heat, dry or cure a variety of products such as wood, paper and textiles. Electro infrared technology replaces the use of fossil fuel furnaces or other energy hungry and environmentally problematic technologies (www.epri.com, 2006). Other examples are the promotion of electric space heating in residential areas, electric vehicles and automation.

Load conservation programmes are generally utility-stimulated and directed at end-use consumption involving a reduction in sales as well as a change in the pattern of use. Examples include weatherization (insulation, sealing, double glaze windows, etc., for homes) and appliance efficiency improvement (engineering.purdue.edu, 2006).

Strategic conservation is the load shape change that results from utility-stimulated programmes directed at end use consumption. This is represented schematically in figure II.

Figure II. Strategic load conservation



Source: engineering.purdue.edu, 2006

Not normally considered load management, the change reflects a modification of the load shape involving a reduction in sales as well as a change in the pattern of use. In employing energy conservation, the utility planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended utility programmes to accelerate or stimulate those actions. An example is appliance efficiency improvement.

6. INFORMATION DISSEMINATION ON DSM

Energy savings and energy efficiency improvement depend on the combined efforts of many individuals. Well-motivated personnel are best able to develop and implement energy efficiency policies that are crucial for continued energy efficiency improvement in their organizations. It is therefore necessary to raise awareness by campaigns informing the staff of energy-consuming organizations about energy efficiency options and specific DSM techniques (Lugano Wilson, 2006).

These campaigns may be marketed by personal contact and visual media (such as posters, fliers, leaflets, brochures and video clips), as well as carrying out energy audits, which also have benefits with respect to energy awareness. An IEA survey (INDEEP Analysis Report, 2004) showed that most DSM programmes in industrialized countries used "personal contact" as the means of marketing. This was closely followed by "direct mail" or "advertising" and lagging a bit further behind was marketing by conducting "energy audits".

Box 8. **DSM promotion**

DSM programmes and policies can be promoted and implemented at different levels of society, such as:

- Government policies and regulations;
- Utilities programmes;
- Energy consumer participation.

Each of these categories has its own significant role to play. But the optimum results can be obtained by coordinating all three. Government agencies can make various policies and regulations, and provide subsidies for these programmes. Utilities can implement these effectively through various programmes, preferably with customized programmes developed and operated in coordination with the end-users i.e. the energy consumers (Satish Saini, 2004).

7. CHALLENGES OF IMPLEMENTING DSM PROGRAMMES

In developing countries there is generally a low awareness of energy efficiency and DSM programmes, and therefore marketing is necessary to promote these. In the service area of a utility company, the sectors and end-users that can benefit from DSM need to be identified, customized programmes developed (and their cost effectiveness evaluated) and then a plan to market and implement the programmes needs to be prepared.

Many industrial and commercial companies still have not carried out energy audits to collect reliable information on their current operations. While this may be due to a failure by management to appreciate the potential benefits of energy efficiency, some companies will lack skilled personnel able to perform audits. Consideration should be given to using outside experts, as the cost will normally be well justified. Organizations conducting energy audits or advising on DSM measures need to: (Eskom DSM, 2004).

- Have a knowledge and understanding of DSM systems and opportunities;
- Demonstrate the competence and comprehensiveness of their assessment;
- Consider the accuracy of their assumptions;
- Be aware of the production and safety constraints of involved plants/ companies.

Often as a result of completing an audit, a variety of DSM measures may be identified. Load management programmes to increase energy efficiency need to consider the following factors (Satish Saini, 2004):

- The cost to the customer;
- Variations in the prices of electricity and other fuels;
- The value of avoided losses resulting from improved electricity system reliability;
- Any potential losses in production when implementing DSM programmes.

It is essential that a proper financial analysis of the benefits of energy efficiency improvement be carried out when considering setting up DSM activities. For example, too much emphasis may be placed on the initial cost of equipment used by DSM programmes rather than on life cycle costs. Also there is often a perception that electrical energy is a small component of overall cost and therefore there is little motivation to pay for DSM measures to modify load profiles. Where fuels are involved, proper sensitivity analyses may not be performed to take account of potential energy cost variations or inaccuracies in capital investment estimates.

All investments need to be justified as part of the procedure of finding funds for DSM projects. This applies both to funds from company internal resources and to funds from banks or other funding institutes such as international cooperation agencies and the World Bank. Without a competent evaluation of a project, it will be difficult to get funds approved, internally or externally. The failure to get funds is one of the most important challenges of implementing DSM projects (see modules 17, 18 and 19 to know more on financing for energy efficiency and DSM measures).

Discussion/research question

What do you think are the main challenges to implementing DSM in your country? Consider the level of awareness and the technical capabilities of industry and commerce staff with reference to DSM implementation and any suspicion towards the utilities or regulators on the part of the energy user.

8. CONCLUSION

DSM in its various forms is an important tool for enabling a more efficient use of the energy resources available to a country. For example, DSM applied to electricity systems can mitigate electrical system emergencies, minimize blackouts and increase system reliability, reduce dependency on expensive imports (in some countries), reduce energy prices, provide relief to the power grid and generation plants, defer investments in generation, transmission and distribution networks and contribute to lower environmental emissions. Similar benefits can be achieved from DSM when applied to the use of other types of energy. Thus DSM can offer significant economic and environmental benefits.

Housekeeping and preventive maintenance are simple and cost-effective ways to reduce demand and have other benefits like process improvement. Opportunities may exist to take advantage of special tariff rates by changing load profiles or entering into contractual agreements with the utilities. It is therefore important to market DSM programmes to show potential customers their life cycle benefits and the techniques—often quite simple—for reducing demand.

LEARNING RESOURCES

Key points covered

These are the key points covered in the module:

- The reasons for promoting DSM measures in an energy sector and market;
- The main drivers of DSM measures motivated by economics, environment and regulation;
- The main types of DSM measures including energy reduction programmes and load management;
- DSM practices such as housekeeping and preventative maintenance in industry and commerce;
- The marketing and promotion of DSM;
- Challenges of implementing DSM programmes.

Answers to review questions

Question: Describe in short the main load management programmes.

Answer: Load levelling—the extremes of the peaks and valleys of the load profile can be flattened by peak clipping (high demand periods are reduced), valley filling (low demand periods are built up) or load shifting (where loads are “shifted” from peak to valley times).

Load control—utilities have interruptible agreements with customers (at special rates) and can switch off loads, e.g. heating, cooling, ventilation, and lighting when capacity is needed.

Tariff incentives or penalties—customers can choose lower rates at off-peak times to run loads (time-of-use), customers can raise the power factor of electric motors using capacitors to avoid penalties (power factor charges), customers can choose real time pricing where the rate varies based on the utilities load.

Question: What are three housekeeping practices that reduce demand?

Answer:

1. Switching off unnecessary load (like lights in unoccupied areas or in areas where daylight provides adequate lighting, and computers while not in use). This not only reduces direct load but may also reduce cooling loads due to the reduction of heat production.
2. Repairing steam leaks improves the system efficiency and reduces energy needed to compensate for lost heat through the leak, and possibly that needed to cool the area where the leak is.
3. Proper process control settings—optimizing the efficiency of the process thus reducing energy needs.

Exercises

1. Which type of DSM interventions could be implemented with the most ease/most rapidly in your country? Which interventions would be the most effective in your opinion and why?

Write a one page answer.

2. What do you think are the main challenges to implementing DSM in your country? Consider the level of awareness and the technical capabilities of industry and commerce with reference to DSM implementation and any political suspicion towards the utilities or regulators on the part of the user.

Write a 1-2 page answer.

3. Imagine a typical manufacturing industry housed in an old building with many old electric motors and large and numerous light fixtures. Imagine too that the main electrical load is currently, and mainly due to tradition, run from 6am to 9pm. Imagine lastly that the company does not follow (or even know of) any DSM programmes and yet has high energy costs.

Describe the possible DSM programmes that the industry could implement and how they would get to know of them, giving consideration to initial costs and long-term savings. Take into account the minimum that can be done that will result in the greatest demand reductions.

Write a two-page essay discussing these options.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 14: Demand-side management

Suggested discussion topic:

1. "DSM programmes can be win-win measures for suppliers and customers". Discuss, considering the benefits and drawbacks
2. "Energy efficiency (both supply and demand-side) should take priority over development of renewables." Do you agree with this statement? Why? Why not?

Relevant case studies

1. Lighting retrofitting in the United Republic of Tanzania
2. United Republic of Tanzania: power factor correction
3. Zambia: automatic load control and alternative energy supply at Lusaka water and sewerage company
4. Zambia: university energy assessment
5. Why DSM initially failed in Ghana

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INTERNET RESOURCES

1. International Energy Agency
dsm.iea.org

The **IEA Demand-Side Management Programme** (started in 1993) is an international collaboration with 17 IEA Member countries and the European Commission, to promote opportunities for demand-side management (DSM). For the purposes of this programme, DSM is defined to include a variety of purposes such as load management, energy efficiency, strategic conservation and related activities. The programme undertakes work suited to different regulatory regimes and market structures and has a website with detailed reports of specific projects. A key resource on the website is the International Database on Energy Efficiency Programmes (INDEEP), where the IEA has brought together and analysed information on DSM from a large number of IEA countries. There are also other databases with useful information on the site and it is a good source of information on who are the experts in this field.

2. Energy Futures Australia
www.efa.com.au

DEFA is run by David Crossley who has led much of the IEA's work on demand-side management. He has undertaken considerable work for governments in Australia and elsewhere on energy efficiency policy development. The EFA web site contains many publications written by Crossley and also has links to other useful publications on DSM in Australia and elsewhere.

GLOSSARY/DEFINITION OF KEY CONCEPTS

Activity	Used in this module in the context of “energy-dependent activity”, such as the production level in an industrial plant, or heating and cooling of buildings.
CFL	Compact fluorescent light bulbs
DSM	“Demand-side management”, typically used in the specific sense of actions to modify electricity loads to achieve higher system efficiency. Also used (including in this module) to refer to efforts to modify demands for any type of energy—e.g. fuel oil, gas, coal—so as to improve energy efficiency and reduce energy consumption for a given output.

Energy audit	Evaluation of the energy-related performance of a manufacturing plant or building, used to identify energy efficiency opportunities.
EE	Energy efficiency, the utilization of energy in a cost effective way to carry out a manufacturing process or provide a service. Depending on the context, typically expressed as an amount of energy consumed per unit of output (e.g. kilocalories per ton of cement).
EMO	Energy management opportunity or option, often identified through an energy audit of a plant or building.
Interruptible load	DSM programme activities that, in accordance with contractual arrangements, can interrupt consumer load at times of peak load by direct control of the utility system operator or by action of the consumer at the direct request of the system operator. This type of control usually involves commercial and industrial consumers. In some instances, load reduction may be effected by direct action of the system operator (remote tripping) after notice to the consumer in accordance with contractual provisions (Satish Saini, 2004).
Load shape	A method of describing peak load demand and the relationship of power supplied to the time of occurrence (Satish Saini, 2004).
Load shifting	Loads are “shifted” from peak to valley times (achieving clipping and filling).
Lumens	A measure of the illumination provided by a lighting source (e.g. incandescent bulb, fluorescent tube).
Luminaires	Fittings to hold a light source (light bulb, fluorescent tube, etc.)
Peak clipping	Demand peaks (high demand periods) are “clipped” and the load is reduced at peak times.
Preventive maintenance	Maintenance efforts that are designed to prevent or avoid a breakdown before it happens. This should reduce unexpected breakdowns.
Real-time pricing	The electricity rate varies based on the utilities load (continuously or by the hour).
SSM	“Supply side management” refers to efforts made to improve the energy efficiency of the supply of energy to customers. Commonly refers to the generation, transmission and distribution of electricity.
Time-of-use	Utilities have different charges for power use during different periods.

Case study 1.

LIGHTING RETROFITTING IN THE UNITED REPUBLIC OF TANZANIA

CONTENTS

1. INTRODUCTION

1.1. Background

Lighting is essential in industrial plants, commercial centres and at the household level. For aesthetic and for occupational and health reasons, different activities require specific illumination levels. For instance, stairways require illumination of only 160 lux, library reading tables and hand tailoring will require 500 lux and 1,000 lux respectively.

The cost of lighting an industrial plant can be substantial with electricity representing the major proportion of operational costs. Good effective lighting can have a major impact on workers' productivity and safety. Effective industrial lighting depends not only on providing the right lighting levels for a task but also on selecting the best suited light source and equipment, optimizing lighting controls and utilizing daylight.

1.2. Light sources

There exist a variety of light sources. These sources convert electrical energy into light energy and the efficiency to do so (efficacy) is measured in lumens per watt. Consequently, the higher the efficacy, the lower the cost of lighting. Table 1 summarizes the characteristics of common light sources.

Incandescent lamp

Figure I. Incandesent light bulb

In the incandescent lamp, light is produced by passing an electric current through a tungsten filament contained in an evacuated glass bulb partially filled with an inert gas. The current heats the filament to incandescence. The pressure of the inert gas slows down the evaporation of the filament. Only 3-6 per cent of the input energy results in light production, the rest is dissipated as heat. As shown in table 1, this type of light is very inefficient. The Tungsten-halogen, also called quartz or quartz-iodine lamp is an incandescent filament lamp that operates at very high temperature.

Halogen gas prevents rapid depreciation of the lamp filament and darkening of the lamp bulb. The lamp bulb is made of quartz glass to withstand the high operating temperatures.

Table 1. Light sources characteristics

	LAMP TYPE					
CHARACTERISTIC	**Incandescent (tungsten-halogen)**	**Low pressure discharge**		**High pressure discharge**		
		Fluorescent	**LPS**	**MV**	**MH**	**HPS**
Efficacy initial lumens/watt	20 (23)	70	140	50	80	120
Rated life hours	1,000 (2,000)	12,000 - 20,000	18,000	16,000 - 24,000	7,500 - 15,000	20,000 - 24,000
Ballast required	NO (YES)	YES	YES	YES	YES	YES
Colour of light	Warm	Cool/warm	Yellow	Cool/warm	Cool	Warm
Lamp cost	Low	Low	Low	Medium	High	High
Lamp lumen depreciation factor (LLD) %	90 (99)	85	103	75	70	90
Operating cost (comparative only)	1.0	0.25	0.15	0.36	0.22	0.2
Warmup/restrike time (minutes)	Instant	Immediate	12/0.5	7/7	5/10	3/1

Fluorescent lamp

The fluorescent lamp is a tubular, low-pressure discharge lamp containing small amounts of mercury with argon as the fill gas. The lamp tube is coated on the inside with phosphor. In operation, ultraviolet radiation resulting from the luminescence of the mercury vapour due to an electrically induced gas discharge is converted to visible light by the phosphor. As with all gas discharge lamps, a ballast is needed to aid in starting and sustaining the operation of the lamp. Being a linear lamp with a large surface area, its brightness is comparatively low and its potential for discomfort and glare is also low. Principal applications are for the office and industrial interiors and utility areas in the home.

Figure II. Compact fluorescent light

Energy saving fluorescent lamps are available in most sizes and colours. Rapid start versions are also available. They are lower wattage, in the order of 12 per cent, than the equivalent standard lamp but are nearly equal in light output. Energy saving ballasts are also available—with high efficiency and electronic rapid and instant start capability. Savings in energy, using electronic ballasts can be as much as 25 per cent. Fluorescent lamps controlled by electronic ballast operating at high frequency, 20 kHz, are 10 per cent more efficient. Electronic control starters are also available for preheat starting. Although up to 25 times more expensive, electronic starters last longer and start lamps without flicker, thus extending lamp life.

Compact fluorescent lamps are now available from various manufacturers as replacement for incandescent lamps up to 100W. The lamp, complete with electronic ballast can be fitted in the lamp holder of the incandescent lamp to be replaced with no modifications required. Although more expensive (up to 20 times), they consume less than 25 per cent energy for the same light output and last up to 10 times as long.

Low pressure sodium (LPS) lamp

The LPS lamp is among the most efficient light source presently available. The LPS is a discharge lamp where the arc is carried through vaporized sodium, producing the characteristic yellow sodium light colour. Unlike other light sources, LPS lamp wattage rises with use to approximately 3 per cent above the initial value by the end of the rated life expectancy of the lamp. This is coupled with an increase in light output of approximately 5 per cent above initial rating. As a result, the LPS lamp is able to maintain fairly uniform output during its life. The monochromatic yellow characteristic of LPS makes all colours appear yellow or as shades of brown. It is most suitable for outdoor areas and security lighting. The high pressure sodium (HPS) lamp counterpart utilizes a ceramic arc tube containing sodium, mercury and xenon gas. The xenon gas acts as a starting gas and as the arc tube heats up, the mercury and sodium vaporize to produce the golden-white discharge. Principle applications are in roadways, area and industrial lighting. HPS can also be used in non-colour sensitive areas, such as warehouses and gymnasiums.

Metal halide (MH) lamp

The MH lamp is an improved version of the mercury vapour (MV) lamp where iodine compounds are added in the arc tube to produce a whiter coloured light at a higher efficacy than in MV lamps. The “white” light produced by metal halide lamps make them the choice for sports fields and architectural lighting, and for colour sensitive industrial processes.

2. ENERGY MANAGEMENT OPPORTUNITIES

2.1. Switch off unnecessary lights

Switching off lights in unoccupied areas, and in areas where daylight provides adequate lighting levels is an opportunity for energy saving. Switching can be done manually or by automatic controls. Providing light switches at strategic points can facilitate manual switching.

2.2. Remove redundant fixtures

Many plants undergo modifications and reorganization. Areas are redesignated and equipment moved but the lighting system is not correspondingly updated, with the result that lights may become redundant. On removing redundant fixtures, energy and lamp costs are reduced, and the removed fixtures can be reused.

2.3. Fixture delamping

This measure simply entails removing selected lamps from existing light fixtures. Either lamps are removed in a uniform pattern throughout specific areas to reduce overall lighting or selected lights that do not contribute to a task or safety lighting are removed. Flickering fluorescent tubes should be removed from the fixture as the ballast will continue to consume power, at approximately 15 per cent of the lamp wattage.

2.4. Lighting retrofitting

Lighting retrofitting is the replacement of an existing lamp with a new more efficient light source. The retrofitting will involve more initial cost than delamping but has a long-term benefit from low energy consuming new fixtures.

2.5. Application of energy management systems

Lighting can be switched on or off automatically by using a varied scheme of automatic controls. The principal devices employ occupancy sensors (motion detectors shut off light in unoccupied space), time controls (through programmed schedules), and photo sensors (by detecting daylight illumination levels). Energy savings from the application of these controls are highly sensitive to baseline assumptions, especially hours of use and occupancy patterns. However, it has been shown that programmable timers are capable of saving 10-30 per cent of lighting energy where as occupancy sensors and photo sensors are capable of saving 30-60 per cent and 10-35 per cent respectively.

3. LIGHTING RETROFITTING; THE CASE OF THE UNIVERSITY OF DAR ES SALAAM

The University of Dar es Salaam has been paying monthly electricity bills amounting to T. Shs. 80 million ($US 78,640).[1] The electricity consumption and monthly bill has been on the increase, a fact attributable to various factors including the increased population of students and increased installed facilities coupled with energy inefficiencies. The university management therefore commissioned a study to search for options to reduce its energy costs.

The study findings were submitted to the university management in early 2006, and among other things, revealed that the university's lighting had a varied mixture of inefficient fixtures including fluorescent tubes in ranges of 120-150 cm bulbs, mercury vapour and incandescent bulbs. About 47 per cent of lighting fixtures in the hostels and halls of residence were inefficient incandescent bulbs and 4 per cent of lighting fixtures in the university offices, laboratories and lecture rooms were also using inefficient incandescent light bulbs. In total, 3,653 incandescent bulbs were being used.

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[1] Exchange Rate: 1 $US = 1,017.720 TZS (Tanzanian Shillings)

As shown in table 2, when all the incandescent bulbs are replaced with efficient compact fluorescent bulbs, an annual energy saving of about 421,000 kWh is achievable giving annual cost savings of about T. Shs 49 million ($US 48,167). The cost of implementation of this measure is about T. Shs 11 million ($US 10,813), which results in a simple payback period of 0.24 years (3 months). It should be noted that the retrofitting is done without impairing the illumination level.

Upon receiving this recommendation, the university management acted promptly by drawing up an implementation plan for the energy study's findings. However, the implementation was subject to allocation of financial resources, which are budgeted annually. In order to maintain and keep on improving energy efficiency at the university, the management went further by deciding to put in place an “Energy Policy”. The policy will put down an institutional framework for energy conservation and management through awareness-raising and by providing standards and guidelines for new equipment installation and maintenance practices.

Table 2. Replacement of inefficient incandescent lights with efficient compact fluorescent lights

Location:	University of Dar es Salaam - offices, hostels and halls of residence
Identification:	General lighting

Data Required:

	Existing	Proposed	Symbol
Watts of light (and choke), watts	100	20	WL
Annual operating hrs of lighting	1,440	1,440	h
Unit cost of lights, THS	250 (0.245)	6,500 (6.39)	CL
Life of lights, Hrs	750	10,000	LL
Number of lights	3,653	3,653	N
Lumens per watt	15.7	60	LW
Cost of electricity, THS/kWh (USD/kWh)	116.25 (0.114)	116.25 (0.114)	CE

Calculations:

Existing total lumens	5,735,210	TLe = LWe*WLe*Ne
Suggested total lumens	4,383,600	TLp = LWp*WLp*Np
Existing energy consumption, kWh	526,032	ECe = Ne*WLe*he÷1,000
Proposed energy consumption, kWh	105,206	ECp = Np*WLp*hp÷1,000
Annual energy savings, kWh	420,826	ES = ECe - ECp
Annual cost savings, TSH	48,920,976	CS = ES*CE
Cost of implementation, TSH	11,567,833	CI = (CLp*Np) - (Ne*Cle*LLp÷Lle)
Simple payback, years	0.24	SP = CI÷CS

Note: In above calculations, “e” stands for existing and “p” for proposed values.

Annual energy savings, kWh	420,826
Annual cost savings, TSH	48,920,976 (48,089)
Cost of implementation, TSH	11,567,833 (11,371)
Simple payback, Yrs	0.24

4. CONCLUSIONS

Lighting plays an essential role for human activities in industrial and commercial centres and in households. However, the cost of lighting can occupy a substantial portion of total operational costs. Consequently, it is desirable to have good, effective and efficient lighting. Good efficient industrial lighting depends not only on providing the right lighting levels for the task but also on selecting the best suited light source and equipment, optimizing the lighting controls as well as utilizing daylight.

In the case of existing inefficient light sources, retrofitting them with efficient ones offers an opportunity for energy conservation and cost saving. Feasibility studies of lighting retrofitting have shown that, on top of the high energy and cost savings, they have instant payback periods of less than half a year, making them an attractive investment.

Case study 2.

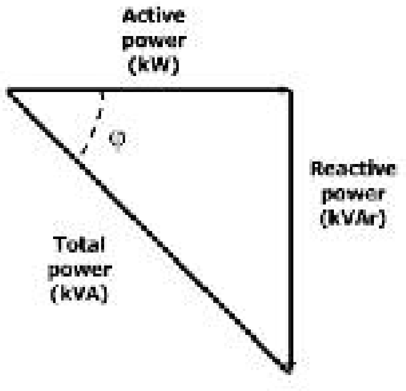
UNITED REPUBLIC OF TANZANIA: POWER FACTOR CORRECTION

CONTENTS

1. BACKGROUND

Whenever inductive loads such as air-conditioners and all other equipment that make use of an inductive motor are connected to an electrical installation there is a tendency for these loads to draw current that is lagging the supply voltage, i.e. the current phaser will be trailing by a certain angle φ with respect to the voltage phaser. Similarly, whenever there are capacitive loads such as battery chargers and equipment that comprise dominantly of capacitors or synchronous machines, the load will draw current that is leading the supply voltage, i.e. the current phaser will be ahead by a certain angle φ with respect to the voltage phaser. However, for loads that consist of dominantly resistive loads such as heaters and cookers, the supply voltage and current will be in phase.

Figure I. Power triangle



Power factor (PF) is defined as the cosine of the phase angle φ between the supply voltage and current. Therefore inductive loads will have a lagging power factor, and capacitive loads will have leading power factor, in other words leading or lagging power factors indicate whether the current is leading or lagging the supply voltage respectively. Figure I, known as the power triangle, shows the relationship between total power, active power, reactive power and power factor.

$$PF = \frac{Active\ Power}{Total\ Power} = Cos\ \varphi \qquad \text{---------------------------------} (1)$$

2. EFFECTS OF LOW POWER FACTOR

With a power factor less than unity, the amount of useful power that can be supplied by the supply system's generating plant will be less than its full total power capacity. In other words, although the generators may be delivering their full current capacity, not all of this current results in useful power. Consequently, the electricity supply authorities generally require consumers to restrict their reactive power demand such that their power factor level is maintained above 0.9. Defaulters are subject to significant cost penalties, some of which are reflected in the tariffs customers pay.

2.1. Effects to the electricity supplier

Reactive power actually costs something to produce at the generating station since low power factor causes a large drop of voltage in the generators, hence requiring larger exciters. It also increases transmission and distribution losses. The losses in the cables or conductors are proportional to the square of the current, and consequently they are inversely proportional to the square of the power factor. Thus, for example, the losses in the cable conductors at a power factor of 0.8 are 1.57 times the losses at unity power factor, and the losses at a power factor of 0.4 will be 6.25 times that at a unity power factor.

The ratings of transformers, cables and protective switchgears are proportional to the current and therefore inversely proportional to the power factor. Therefore higher ratings of transformers and cables are required for loads that operate at low power factor.

2.2. Effects to the consumer

When there is extensive application of inductive motors and associated devices, consumers will have a low system power factor, which causes a significant voltage drop across the cables. Low voltage results in inefficient operation of equipment such as motors and lighting. Consequently, extra voltage regulating/ stabilizing equipment needs be installed.

When demand charges are based on the total power demand (kVA), electricity costs are inversely proportional to the power factor level and therefore a low power factor results in higher costs. The cost of electricity to consumers whose demand charges are based on their kW or active demand is unaffected by the level of the plant's power factor, unless there is a low power factor penalty provision in the tariff agreement.

3. POWER FACTOR CORRECTION

Operating at a power factor above 0.9 (most electricity suppliers set the threshold value at this level) is a way of conserving and utilizing energy efficiently and it is beneficial to both the electricity supplier and the consumer.

A low electrical system power factor can be corrected by installing capacitors locally to the load. A power factor of unity is the optimum level, but this is not always feasible. Economics dictates that individual compensation is generally only feasible with larger motors, say in excess of 30 kW. In most plants, the more practical solution is to install capacitor banks with a control unit at the main service entrance board. The control unit senses the power factor level, which changes with the load, and automatically switches the required capacitors in and out of service to maintain the power factor level within prescribed limits.

3.1. Power factor correction: the Posta House case

Tanzania Posts Corporation is a Government-owned organization charged with the provision of postal services. A twelve-storey building (Posta House) located along Ohio Street accommodates the headquarters of the Posts Corporation. The Posta House was experiencing increased monthly electricity bills, which in 2003 amounted to over T. Shs. 5.5 million per month ($US 5,406)[1] . The money paid for the monthly electricity bill increased the operational costs of the Posts Corporation. Consequently, the management contacted a consultant to conduct an energy study whose purpose was to identify energy losses and provide advice to the management on how to reduce the monthly electricity bill.

The existence of a low power factor profile, averaged at 0.75, was one of the main findings of the study. As shown in fig. II, the demand profile at the Posta House increased from 160 kVA in 2000 to almost 300 kVA in 2003. In this period, energy consumption increased marginally. This was an indication of a deteriorating power factor.

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[1] Exchange Rate: 1$US = 1,017.720 TZS (Tanzanian Shillings)

Figure II. Demand and energy consumption profiles at the Posta House

Monthly Maximum Demand (kVA)

Demand (kVA)	January	February	March	April	May	June	July	August	September	October	November	December
2000			157	150	138	136	122	157	163	155	196	211
2001	211	199	214	218	225	205	170	149	163	178	210	220
2	228	224	228	228	210	213	197	204	200	204	235	285

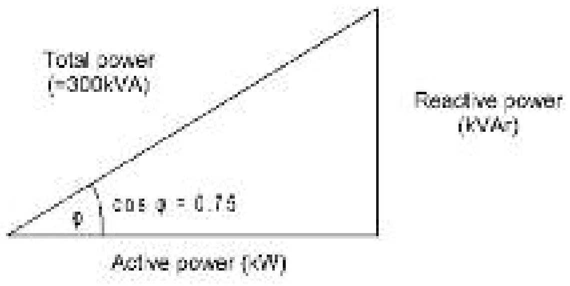
Monthly kWh Consumption

Energy (kWh)	January	February	March	April	May	June	July	August	September	October	November	December
2001	26.000	37.100	35.800		36.100	39.500	34.800	33.000	35.200	36.700	42.200	45.000
2002	37.500	41.580	41.580	41.580	39.500	42.400	37.850	41.500	38.400	40.900	48.000	49.300

Power factor correction by installing capacitor banks was therefore recommended to the management as a means of reducing monthly electricity bills.

The power triangle as reproduced in figure III is utilized to estimate the capacitor bank size (reactive load in kVAr to be supplied by the capacitors) for the power factor correction. This is indicated in the following calculations:

Figure III. Power triangle with Posta House data



Active and reactive power is calculated using equations (2) and (3) respectively

$$KW = KVA * Cos\ \varphi \text{---} (2)$$

$$(KVA)^2 = (kW)^2 + (kVAr)^2 \text{------- ---------------------------------} (3)$$

Consequently, in the existing situation, active power is found to be 225kW where—as the reactive power is 198.4kVAr.

Similarly, after the power factor has been improved to 0.98, the maximum demand becomes 229.59 (=225/0.98) kVA and the reactive power is lowered to 45.69kVAr. The size of the capacitor bank is defined by the difference between the initial and corrected reactive power, which is 152.74 kVAr. On enquiring from suppliers, the cost of supplying and installing the capacitor banks was T. Shs. 9,850,000 ($US 9,682). Monthly kVA reduction is therefore 70.41 (300—229.59) kVA. From the tariff, the cost of 1kVA is T. Shs. 7,660 ($US 7.53). Therefore, reducing the maximum demand by 70.41 kVA gives monthly demand cost savings of T. Shs 539,326 ($US 530) and yearly cost savings of T. Shs. 6,471,912 (6,360 $US).

The simple payback period (in years) is defined as the ratio of cost of implementation to the respective annual cost savings. For this measure it was found to be 1.52 years.

Payback period = (cost of implementation) / annual cost savings --------------- (4)

3.2. Follow-up to the Posta House

A recent follow-up visit to the Posta House revealed that the management had not implemented power factor correction. It was evident that the main reason for not implementing the measure was the scarcity of financial resources for the purchase of capacitor banks.

4. CONCLUSION

Power factor correction offers an opportunity for energy cost reductions at facilities by reducing losses from their distribution systems. Since power factor correction reduces the apparent demand, the saved demand is therefore made available for other needy consumers.

However, facility and commercial centre owners find it difficult to implement power factor correction due to the up-front capital required to purchase the necessary equipment. The scarce financial resources available to managers and owners are usually allocated to the most pressing issues at hand and power factor correction is often neglected. Awareness-raising on the long-term benefits of power factor correction needs be carried out, followed up by innovative policies that create incentives and make resources available for power factor correction implementation.

Case study 3.

ZAMBIA: AUTOMATIC LOAD CONTROL AND ALTERNATIVE ENERGY SUPPLY AT LUSAKA WATER AND SEWERAGE COMPANY

CONTENTS

1. BACKGROUND

The Lusaka Water and Sewerage company (LWSC) is involved in waste treatment and supply. It services Lusaka and surrounding areas. For pumping purposes LWSC has a total of 172 AC induction motors with a total demand of 10.4MW. In view of the high poverty levels of its customers, LWSC is unable to charge economic tariffs to a large part of the population of the city. As a result LWSC is unable to fully pay its high electricity bill to the power utility, ZESCO. Despite the huge electricity bill, it also ironic that LWSC operates its electric motors not at full load, thereby losing energy since the motors are always drawing energy regardless of its load. In addition, the power factor is low, at around 0.58.

2. MAIN ACTORS

The main actors in the study were Chavuma Water Falls Ventures, an ESCO involved in the installation of automatic load control devices, and LWSC. The automatic load control is based on the Powerboss design concept. Powerboss is a motor power controller, manufactured by SOMER International of the U.K. Since electric motors have no way of intelligently matching the power they consume in relation to the load, most energy is lost during partial running load conditions. The Powerboss on the other hand, is a device that will control the current being consumed in relation to the load, thereby saving energy in the process.

3. PROJECT OBJECTIVES

The project had two objectives:

- To investigate the operational, financial and environmental benefits of the use of a Powerboss motor power controller.
- To Investigate the possibility of introducing an alternative energy supply through the generation of electricity from methane from the sewerage plant.

4. DESCRIPTION OF THE PROJECT

The project attempted to undertake:

- A feasibility study on the installation of automatic load control (Powerboss) to all the electric motors amounting to 10.4 MW.
- A feasibility study on the generation of electricity from methane combustion from sewerage ponds at Manchinchi Sewer.
- Studies initially needed to ascertain the amount of electricity consumed by all electric motors.

5. RESULTS

5.1. Electricity consumed

Under baseline conditions and project conditions, savings made and amount of CO_2 savings for LWSC are given in table 1.

Table 1. Energy and CO_2 savings

Company	Total motor capacity (kW)	Average operating hours per year	Annual energy consumpt. ('000' kWh)	Average energy efficiency gain.	Annual energy saved ('000' kWh)	Annual CO_2 saved (tons)
Lusaka Water & Sewerage	10,400	6,570	68,328	15%	10,249	10,249

The savings are made as a result of the installation of a Powerboss motor controller, which leads to electric motors working efficiently in relation to the actual load being delivered at a particular time.

Table 2 shows the investment costs, O+M costs, IRR and NPV.

Table 2. Investment costs, O +M costs, IRR and NPV

Company	Total motor capacity (kW)	Investment (US $)	O+M (US $)	Annual CO2 saved (t)	IRR (%)	NPV ($'000')	Payback period
Lusaka Water	10,400	354,000	153,649	10,249	24.95	229,07	14 months

In conclusion, installations of automatic load control devices will lead to an annual saving of $US 310,000 per annum in electricity consumption and the investment of $US 364,000 will yield an IRR of 25 per cent with a positive NPV and a payback period of about 14 months.

5.2. Electricity generation from methane combustion generated from sewerage system

A detailed study was undertaken for the production of energy from municipal sewerage waste. Based on the results, it was found and recommended that electricity can be generated from waste material at Manchinchi sewerage plant through the combustion of methane in a gas engine with a capacity of 1.0 MW. 1.0 MW will go a long way to reducing LWSC power requirement of 10.4 MW, and save substantial amount of money from electricity billing.

6. DESCRIPTION OF FOLLOW-UP ACTION

LWSC is in the process of sourcing funds for the Powerboss project, and for the biomethenation project through CDM arrangements. Implementation of the methane combustion project will result in savings of 26,000 tonnes of CO_2 equivalent.

Case study 4.

ZAMBIA: UNIVERSITY ENERGY ASSESSMENT

CONTENTS

1. BACKGROUND

Since the cost of energy has risen sharply in the past few years throughout the world, and as energy is an essential service in the running of big learning institution, the University of Zambia decided to undertake an energy audit to reduce and/or optimize the use of energy, and recommend means of reducing energy costs.

At the time of the commencement of the study, the University of Zambia owed ZESCO close to $US 1.0 million in unpaid electricity bills. This is a colossal sum of money, which the university in its current financial state cannot sustain. Therefore, the consumption of electricity had to be reduced to levels that are sustainable to the university. The advantages of energy efficiency to the university were indeed very significant as the financial savings can be channelled to more needy sections in the university.

2. MAIN ACTORS

The main actors in the study were the Centre for Energy, Environment and Engineering and the Department of Mechanical Engineering, School of Engineering, and the University of Zambia who worked closely with university administration on the audit.

3. PROJECT OBJECTIVES

The objectives of the audit were formulated as follows:

- To undertake an energy audit for the University of Zambia and make recommendations on how energy costs could be reduced.
- To evaluate the possibility of the use of an energy substitution system aimed at reducing electricity bills and thus reducing dependence on ZESCO power.

4. DESCRIPTION OF THE PROJECT

The key tasks of the audit comprised of the following:

- To identify the energy consuming units;
- To estimate the quantity of energy consumed by each unit;
- To identify energy saving opportunities;
- To recommend conservation measures;

Specifically the study undertook the following:

- Energy consumption estimation was undertaken for the student hostels and water pumping systems through measurements of the currents and voltages by clamp-on meters because these units are fed by sub-stations with faulty energy meters. There are all together 52 hostels and about 124 students live in each hostel. Students do not pay for electricity since this is paid in bulk by the university authorities. There are three substations to cover the 52 hostels and currently five borehole-pumping systems to supplement water supply from the municipal source.
- Power factor measurements were carried out from a sample of about 14 hostels for a continuous period of three months.
- A questionnaire was also administered to study the energy consumption pattern.

5. RESULTS

Table 1 shows the power consumption and average power factor at the hostels and the water pumps as found by the assessment.

Table 1. Power consumption results

	Location	Power consumption (kW)	Average power factor
1	Hostels	650	0.72
2	Water pumps	105	0.72

The questionnaire responses revealed the following:

- More than 90 per cent of the respondents use their cookers for not more than eight hours per day, about 30 per cent, play their radio sets for 18-24 hours per day, 90 per cent use fluorescent lamps for lighting systems.
- About 70 per cent of the respondents leave their lights on for 16-24 hours per day; about 79 per cent realize the need to use natural daylight while 21 per cent do not see the need to use natural daylight and thereby conserve energy.
- About 68 per cent of the respondents suggested that the institution should set up measures to ensure that the number of electrical appliances that are bought into the university should be regulated. They also suggested that students be sensitized.
- There was no use of low power consuming appliances and automatic switching systems.
- About 11 per cent of the respondents suggested that Government should increase their meal allowances so that they are able to afford to eat at cafeterias since this would stop them cooking in their rooms.

6. DESCRIPTION OF FOLLOW-UP ACTIONS RECOMMENDED

These follow-up actions are recommended:

- Replacement of fluorescent tubes for lighting with a power rating of 0.054 kW with more efficient ones with a power rating of 0.018kW thereby saving on what is currently being paid.
- Replacement of incandescent lights with more efficient compact lights to reduce their use by 10 per cent.
- Increase awareness of the use of natural daylight.
- Use of automatic switching lighting systems.
- Regulation of types and number of electrical appliances used.
- Setting up an energy management centre for training and conducting awareness programmes, and to undertake feasibility studies for implementation.
- Installation of capacity banks to improve the power factor from its current average figure of 0.72 to 0.95 as required by the utility to save money being paid in penalties for low power factors.

7. LESSONS LEARNT

The study identified the electricity-consuming units, the amount of power/energy consumed, and identified a number of energy saving opportunities. It is clear from the results that with an energy management system put in place as part of total management system of the university, substantial savings in energy can be realized.

It is being recommended that feasibility studies be undertaken to first determine the amount of savings both by reduced energy consumption and the value to be realized through implementation of the suggested options. To undertake such implementation requires calculation of the payback period of each option, and for this to be determined, it is important to ascertain the amount of positive savings and the investment cost of implementing the suggested options. If the payback period is found to be less than 2 years, the options are viable and should be implemented.

Case study 5.

WHY DSM INITIALLY FAILED IN GHANA

CONTENTS

1. BACKGROUND

From 2000 to 2003, the residential sector of the Ghanaian economy accounted, on average, for about 50 per cent of the country's total energy consumption. This highlights the importance of domestic energy consumption in Ghana, while at the same time pointing out the small share of energy consumption for productive (income-generating) purposes.

Table I. Energy use by sectors 2000-2003

	2000	2001	2002	2003
Residential	49,8	50,2	50,5	51,7
Agriculture & fisheries	1,3	1,2	1,2	1,2
Industry	23,6	23,9	23,6	21,6
Transport	22,4	21,4	21,3	22
Commercial & services	2,9	3,3	3,4	3,6

Energy utilized between 2000 and 2003 in the other main sectors was as follows:

- Transport used between 21 per cent and 22 per cent.
- Industry including indigenous (informal) industry such as textiles (tie and dye and batik) accounted for 21 per cent to 24 per cent.
- Commercial and services consumed between 3 per cent and 4 per cent.
- Agriculture and fisheries accounted for just about 1.5 per cent of total energy used.

In addition, the residential sector (mainly households) accounted for approximately 72 per cent of all wood fuels consumed in Ghana, whilst about 25 per cent was used by the informal manufacturing category of the industrial sector.

About 81 per cent of petroleum fuels were consumed by transportation, whilst about 7 per cent and 5 per cent were accounted for by the industrial and the residential sectors respectively. About 35 per cent of the electricity produced in Ghana was consumed in the aluminium smelter operations at VALCO, whilst the residential sector and other industries accounted for about 32 per cent and 25 per cent respectively.

2. THE CASE FOR ENERGY EFFICIENCY

The economic, social and environmental advantages of energy efficiency have been proven worldwide and have become an integral component of the energy policies of governments in both developing and developed countries since 1975. Modern energy efficient technologies such as energy efficient lighting systems, more productive industrial processes and energy efficient industrial equipment are increasingly being exploited to reduce the energy intensities of world economies.

By exploiting the benefits of energy efficiency, countries that belong to the Organization for Economic Cooperation and Development (OECD), led by Japan, Germany and the United States, managed to increase industrial output by over 40 per cent from 1975 to 1995 with only a 6 per cent increase in energy consumption.

It is on record that the State of California, in the USA, during the power crisis in 1999-2000 spent $US 20 billion in new power supply contracts and was only able to increase electricity supply by 2 per cent. An expenditure of $US 1 billion on energy efficiency promotion and retrofits resulted in a 10 per cent reduction in electricity demand emphasizing the effectiveness of energy efficiency as a tool for sustainable development even in advanced and sophisticated economies.

In Ghana, it has been established that 30 per cent of electricity supplied is wasted in homes, industrial and commercial premises. Unless efforts are made to reverse this trend, government efforts aimed at expanding energy supply will yield few dividends.

Energy consumers tend to blame government for high energy costs whilst in reality the consumers have the ability to reduce their energy costs through end-use energy efficiency practices and technologies.

The government energy policy framework identifies energy as a necessary engine for the economic development of the country and mentions the efficient and productive use of energy as a way forward to sustainable development.

3. WHY INITIAL UTILITY-BASED DEMAND-SIDE MANAGEMENT FAILED

The use of demand-side management (DSM) as a tool by the supply utilities to defer investments in energy supply facility expansion through efficient end-use was introduced by the Volta River Authority (VRA)[1] in the early 1990s following the earlier introductory programme in 1988 by the then National Energy Board.[2] Though these initiatives were made with the best of intentions, they were not well received by consumers and were in some cases rejected outright for political and other logistical reasons.

The Ministry of Energy's programme in particular was wrongly perceived by the public as a politically motivated attempt by government to shift blame for supply-side inefficiencies from state-owned utilities to the consumer. This was mainly because the activities were initiated and implemented from and by officials of the Ministry of Energy, which was at the same time responsible for tariff setting, energy policy formulation, rural electrification and energy efficiency project implementation.

Some industrial and commercial consumers called on the government to reduce tariffs, if it was interested in assisting industry to reduce costs and promote competitiveness. In addition, some government-owned utilities viewed the promotion of energy efficiency and conservation by the Ministry with scepticism and adopted a “wait and see” attitude.

The situation was aggravated by the fact that VRA traditionally sells power to consumers through distributor utilities who are in fact “middlemen” and therefore regard DSM as a threat to their existence since consumer savings lead to lower revenues for distributing utilities. As expected, the interests of the two utilities with regards to efficiency promotion did not always coincide. Whilst VRA was interested in reducing investments in power plant development by initiating efforts to reduce demand, the Electricity Company of Ghana (ECG) found network expansion and increased power sales more attractive. In fact, ECG occasionally did ask its customers to reduce demand but this occurred only when local constraints, such as transformer and cable overloads, were encountered.

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[1] The VRA introduced compact fluorescent lamps and sold them at reduced prices in 1994. This initiative failed because of poor quality of the lamps and inadequate marketing by the ECG, which sold the lamps on behalf of the VRA at its customer service points.

[2] The activities of the National Energy Board were taken over by the Ministry of Energy in 1991 when the Board was dissolved and its staff were integrated into the Ministry as the technical wing.

One other factor that aggravated the diversity in the interests of the utilities towards DSM is the issue of capacity or demand charges. VRA sells electricity to ECG on the basis of energy (kWh) only and does not charge ECG for demand. Investments in additional capacity by VRA therefore do not directly reflect in the finances of ECG and this further eroded any interest ECG might have had in DSM.

The inapplicability of utility-based DSM has also been compounded by the fact that a lot of electrical appliances or “white goods” that are imported into Ghana are “used” appliances, imported from Europe, often based on old technologies which are inherently technically inefficient in terms of energy consumption. Until their continuous importation is curtailed, utility-based DSM, which in most cases involves subsidies on appliances and energy services, cannot not achieve the desired results.

Electricity tariffs in Ghana, which have been generally low over the years due to subsidies, also contributed to the failure of initial energy efficiency programmes. However, in line with the Government of Ghana's Energy Sector Reform Process initiated in 1995, which has the aim of introducing and encouraging private sector participation in the power sector, the price and cross-subsidies are gradually being removed. The removal of subsidies, the separation of functions and assignment of regulatory responsibilities to institutions other than the Ministry of Energy through the reforms, since 1997, have prompted a change in consumer attitude towards energy efficiency.

4. CONCLUSION

Energy management has generally been accepted as an effective tool for reducing operational costs in industry and commerce, and the utilities have come to accept the concept as a “win-win” measure, both for the consumer and the utilities. However, the prospect that utility-based demand-side management will succeed in Ghana given the structure of the power generation and distribution industry as well as the financial positions of the utilities is very gloomy.

Under the existing utility-consumer relationship, and with the memories of occasional power shortages since 1983 (the most recent was in 1998) still in the minds of consumers, it will be extremely difficult to build consumer confidence to enable the acceptance and patronage of purely utility-based demand-side management (DSM) programmes. This is especially so, since consumers would now want compensation for utility inefficiencies, some of which are due to transformer overloading leading to brownouts, voltage fluctuations and reduced reliability.

The utilities on the other hand, are going through difficult times as low tariffs and high levels of commercial and technical losses as well as poor consumer behaviour are affecting their cash flow. The Electricity Company of Ghana (ECG), which is responsible for the distribution of power in the southern part of Ghana, in particular, has a backlog of meters to install to measure consumption accurately and would rather invest in this area than in DSM. With a technical and commercial loss rate of over 25 per cent, utility-based DSM would only compound the cash flow difficulties of the utilities.

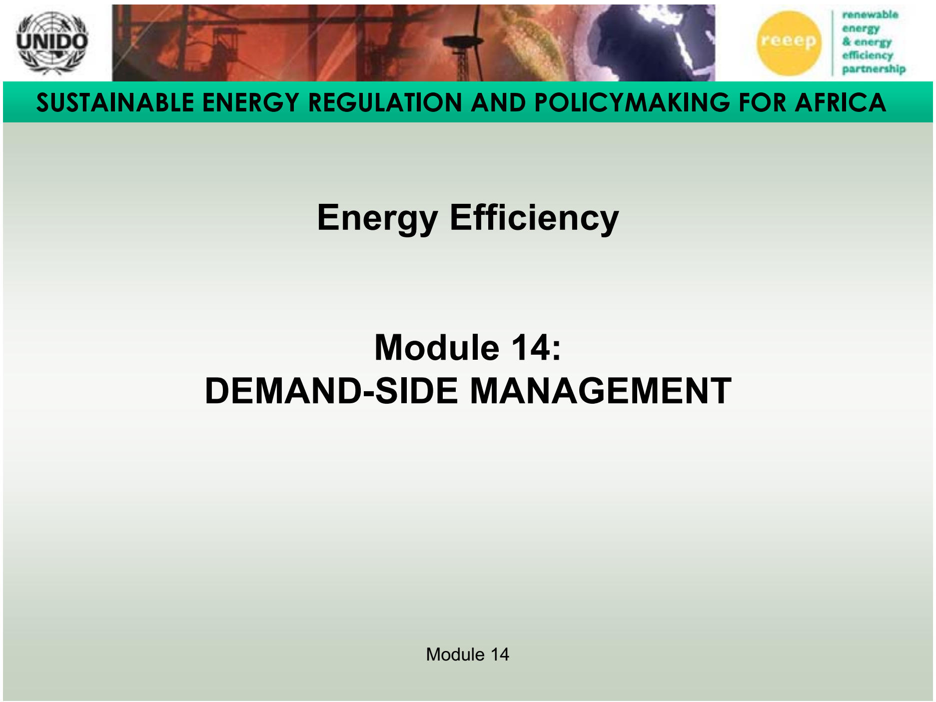
In the ensuing vicious circle, it has become clear that only a politically neutral institution with the required technical expertise could play the efficiency promotion and advocacy role.

5. THE WAY FORWARD: FORMATION OF THE ENERGY FOUNDATION

The Private Enterprise Foundation (PEF), which brings together the major energy consumer groups, such as the Association of Ghana Industries (AGI), the Ghana Chamber of Mines (GCM), the Ghana National Chamber of Commerce and Industry (GNCCI), the Ghana Employers Association (GEA), the Federation of Associations of Ghanaian Exporters (FAGE), the Association of Ghanaian Banks and others collaborated with the Ministry of Energy to establish the Energy Foundation, whose activities cover: the promotion of energy efficiency and conservation, sustainable development of energy and protection of the consumer from the inefficiencies of the utilities.

The Foundation has created a more direct channel of communication between the key players in the area of energy supply and consumption. A public-private cooperation for energy efficiency improvement has been adopted because of the effectiveness of the “win-win” nature of energy efficiency to both government and the private sector. This structure, the first in Africa, has been used very successfully in Brazil, Thailand, the United Kingdom and United States.

Since 1998, the government has transferred the entire government Energy Efficiency & Conservation Programme to the Energy Foundation, which is the current implementing agency. The government finances the activities of the Energy Foundation. Since the Energy Foundation has taken up the promotion of energy efficiency measures, the success rate in communicating the energy efficiency message to the public and improving public perception of DSM measures has increased significantly.

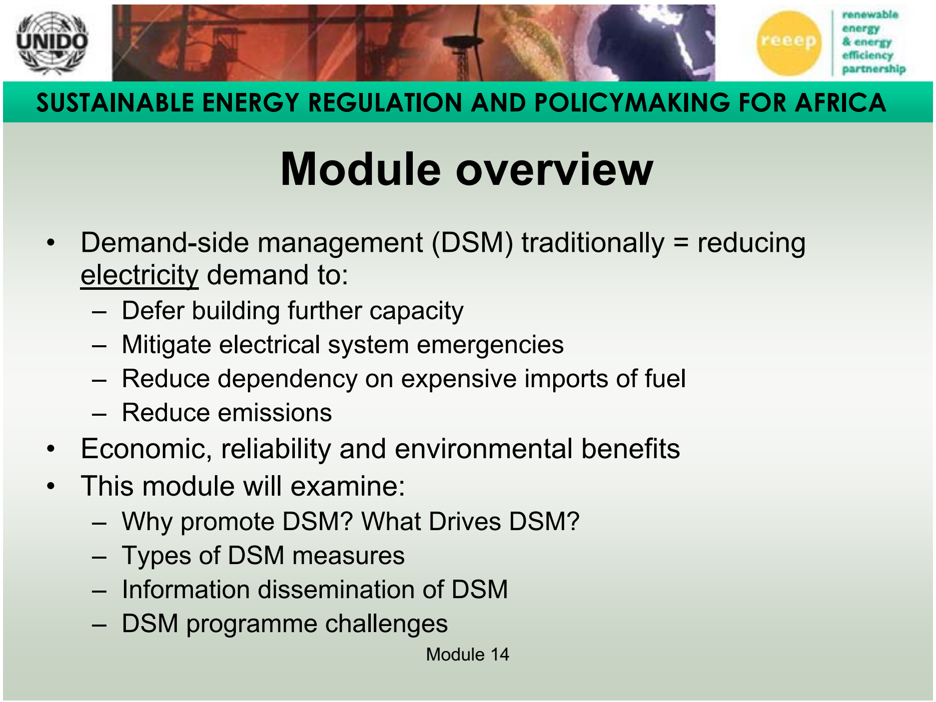


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 14:
DEMAND-SIDE MANAGEMENT

Module 14

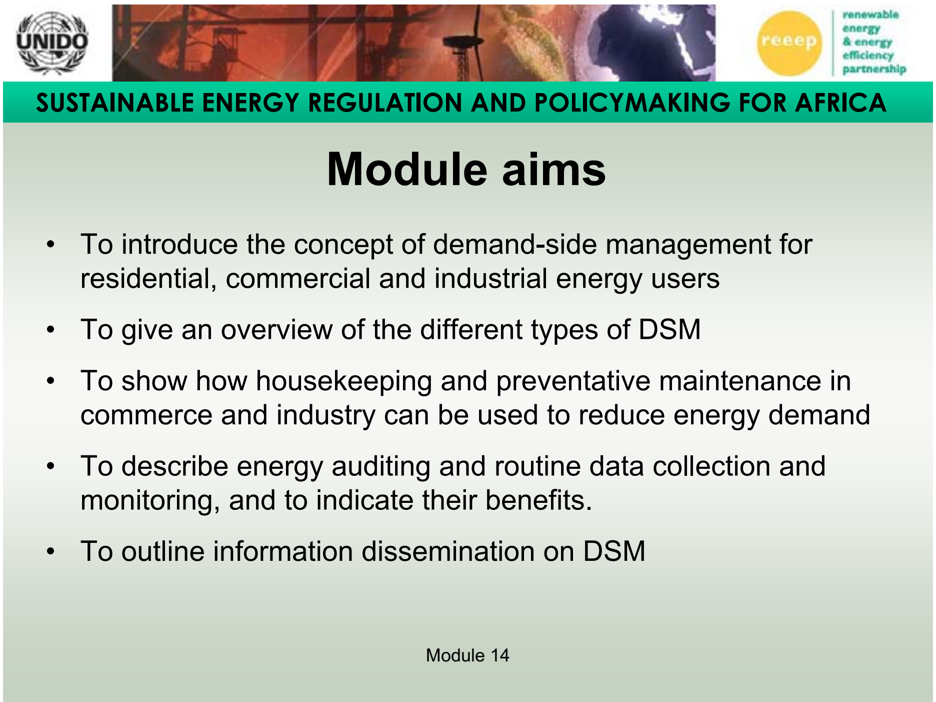


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Demand-side management (DSM) traditionally = reducing electricity demand to:
  - Defer building further capacity
  - Mitigate electrical system emergencies
  - Reduce dependency on expensive imports of fuel
  - Reduce emissions
- Economic, reliability and environmental benefits
- This module will examine:
  - Why promote DSM? What Drives DSM?
  - Types of DSM measures
  - Information dissemination of DSM
  - DSM programme challenges

Module 14

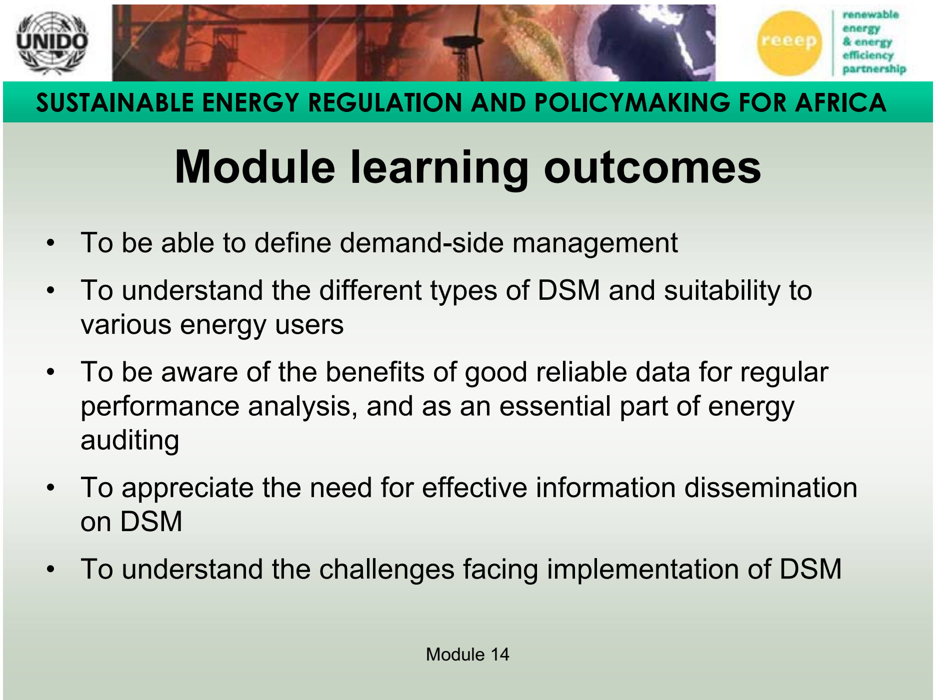


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To introduce the concept of demand-side management for residential, commercial and industrial energy users
- To give an overview of the different types of DSM
- To show how housekeeping and preventative maintenance in commerce and industry can be used to reduce energy demand
- To describe energy auditing and routine data collection and monitoring, and to indicate their benefits.
- To outline information dissemination on DSM

Module 14

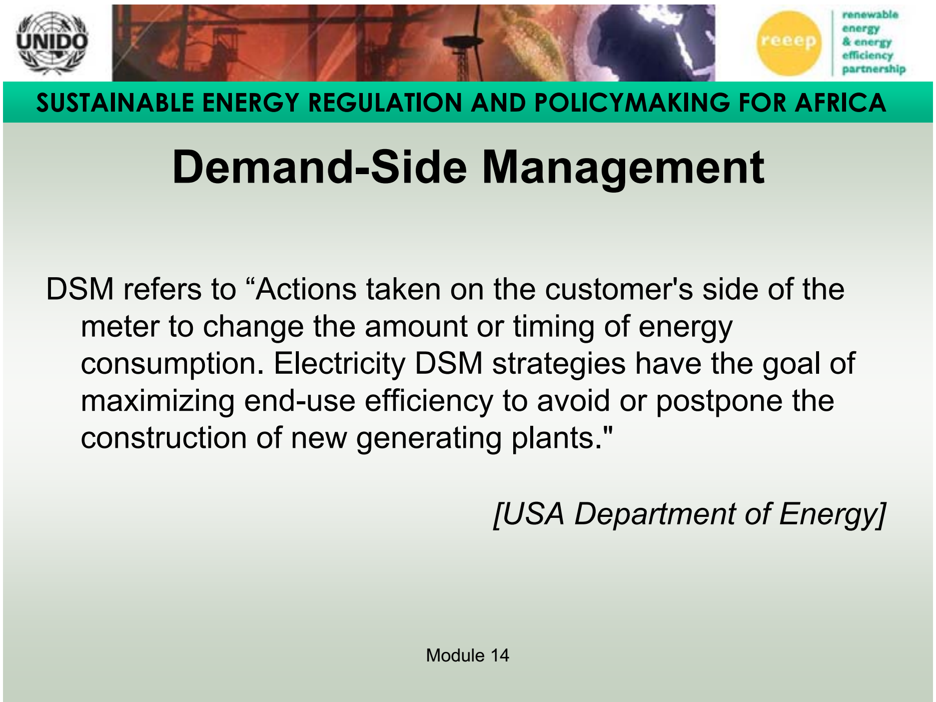


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define demand-side management
- To understand the different types of DSM and suitability to various energy users
- To be aware of the benefits of good reliable data for regular performance analysis, and as an essential part of energy auditing
- To appreciate the need for effective information dissemination on DSM
- To understand the challenges facing implementation of DSM

Module 14

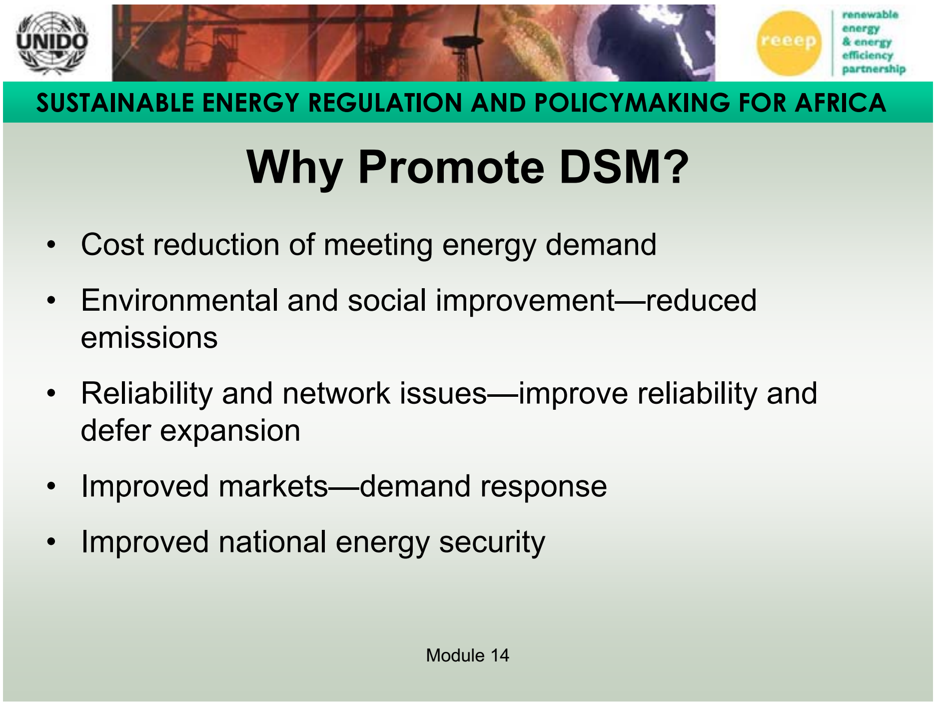


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Demand-Side Management

DSM refers to “Actions taken on the customer's side of the meter to change the amount or timing of energy consumption. Electricity DSM strategies have the goal of maximizing end-use efficiency to avoid or postpone the construction of new generating plants."

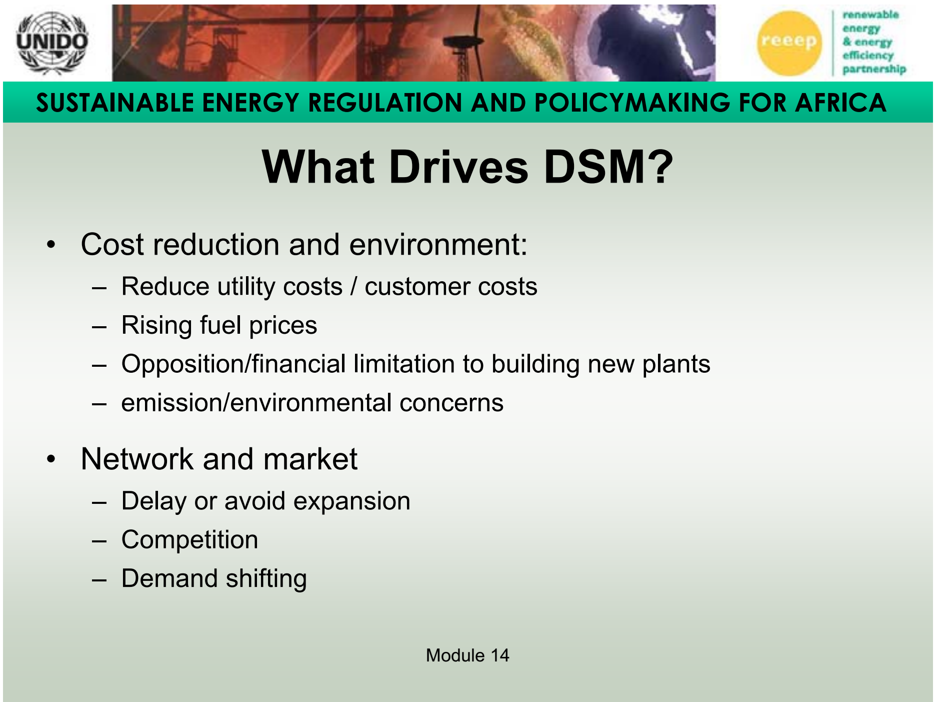
[USA Department of Energy]



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

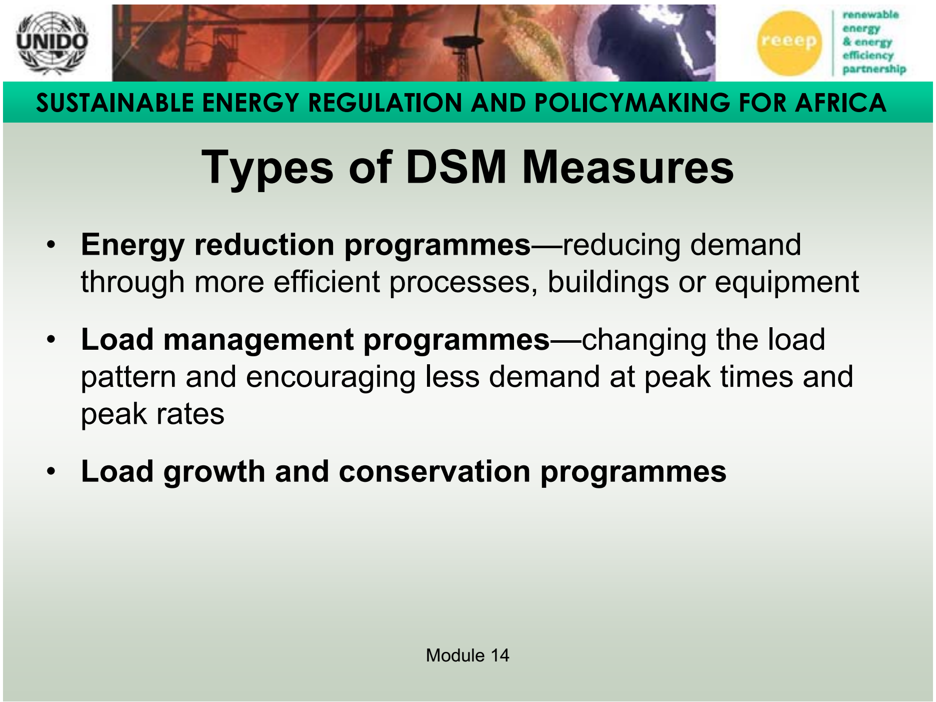
Why Promote DSM?

- Cost reduction of meeting energy demand
- Environmental and social improvement—reduced emissions
- Reliability and network issues—improve reliability and defer expansion
- Improved markets—demand response
- Improved national energy security



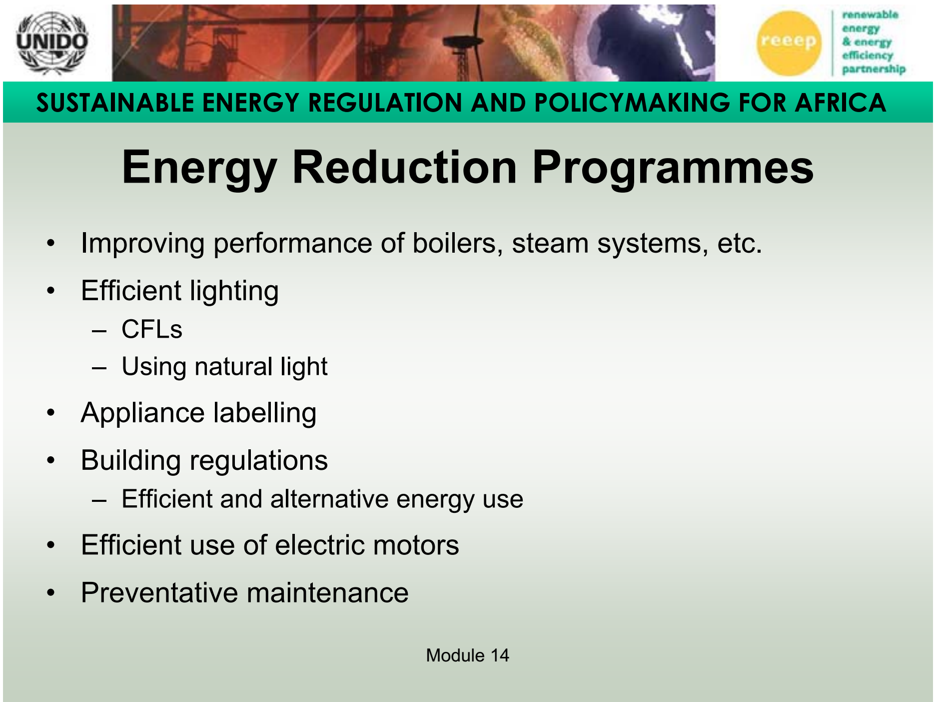
What Drives DSM?

- Cost reduction and environment:
  - Reduce utility costs / customer costs
  - Rising fuel prices
  - Opposition/financial limitation to building new plants
  - emission/environmental concerns
- Network and market
  - Delay or avoid expansion
  - Competition
  - Demand shifting



Types of DSM Measures

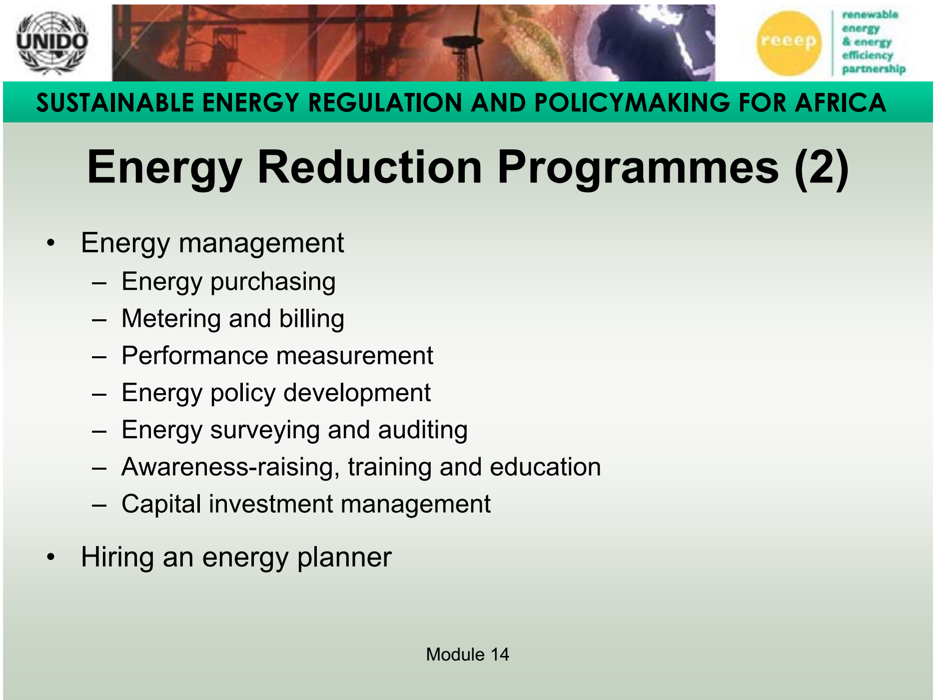
- **Energy reduction programmes**—reducing demand through more efficient processes, buildings or equipment
- **Load management programmes**—changing the load pattern and encouraging less demand at peak times and peak rates
- **Load growth and conservation programmes**



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Reduction Programmes

- Improving performance of boilers, steam systems, etc.
- Efficient lighting
  - CFLs
  - Using natural light
- Appliance labelling
- Building regulations
  - Efficient and alternative energy use
- Efficient use of electric motors
- Preventative maintenance



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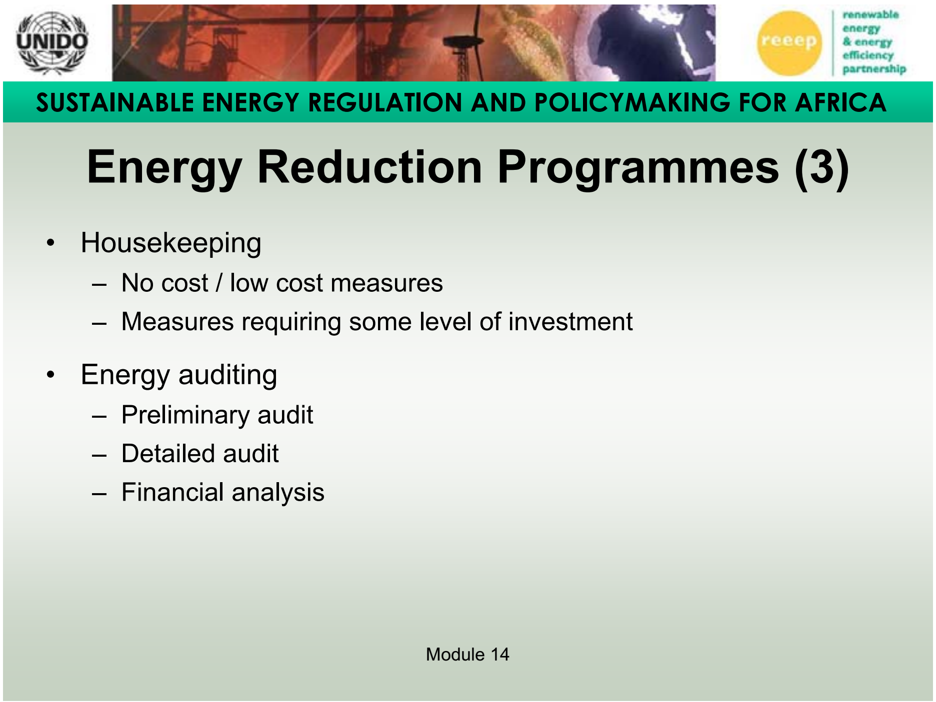
Energy Reduction Programmes (2)

- Energy management
  - Energy purchasing
  - Metering and billing
  - Performance measurement
  - Energy policy development
  - Energy surveying and auditing
  - Awareness-raising, training and education
  - Capital investment management
- Hiring an energy planner

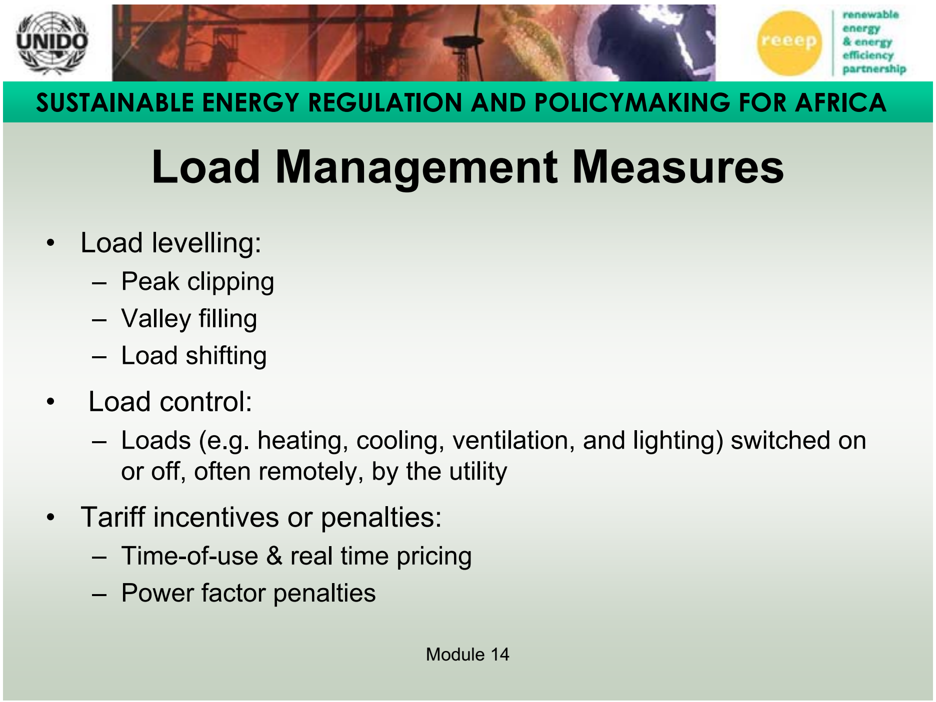


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Reduction Programmes (3)

- Housekeeping
  - No cost / low cost measures
  - Measures requiring some level of investment
- Energy auditing
  - Preliminary audit
  - Detailed audit
  - Financial analysis

Module 14

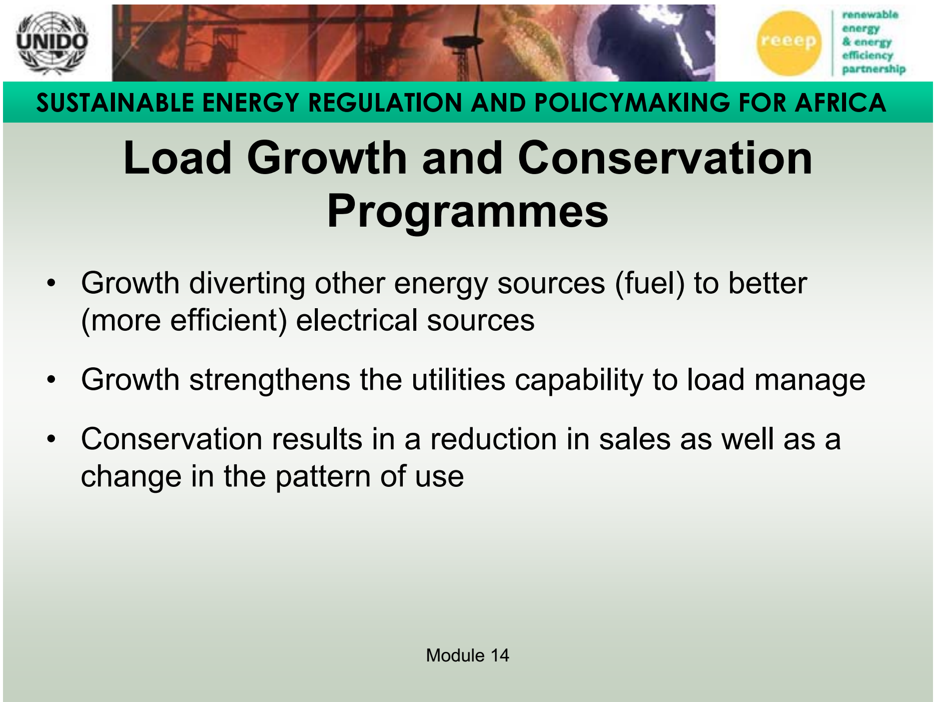


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Load Management Measures

- Load levelling:
  - Peak clipping
  - Valley filling
  - Load shifting
- Load control:
  - Loads (e.g. heating, cooling, ventilation, and lighting) switched on or off, often remotely, by the utility
- Tariff incentives or penalties:
  - Time-of-use & real time pricing
  - Power factor penalties

Module 14

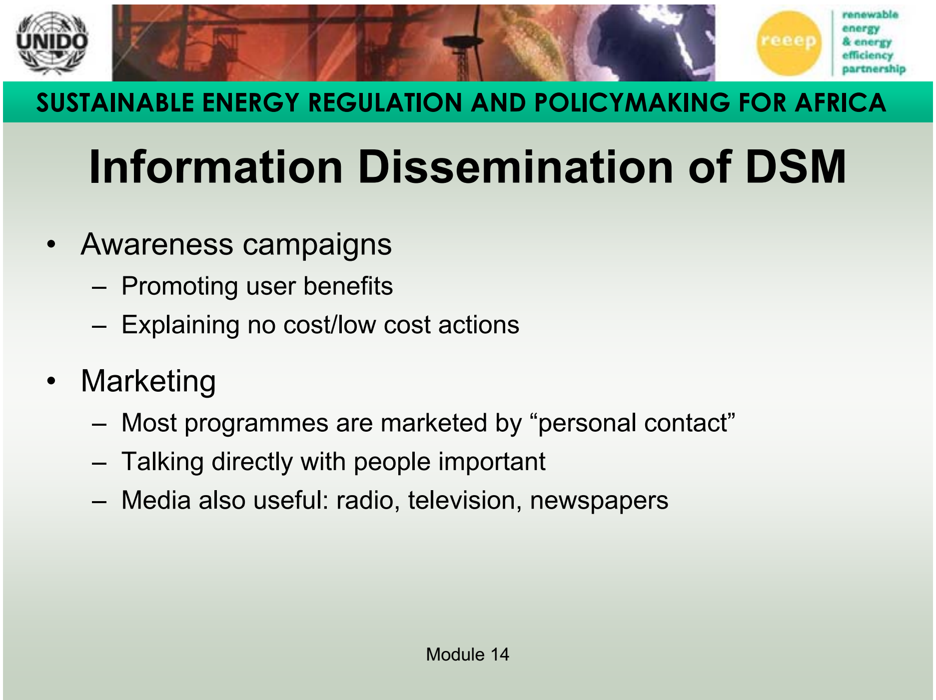


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Load Growth and Conservation Programmes

- Growth diverting other energy sources (fuel) to better (more efficient) electrical sources
- Growth strengthens the utilities capability to load manage
- Conservation results in a reduction in sales as well as a change in the pattern of use

Module 14



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Information Dissemination of DSM

- Awareness campaigns
  - Promoting user benefits
  - Explaining no cost/low cost actions
- Marketing
  - Most programmes are marketed by “personal contact”
  - Talking directly with people important
  - Media also useful: radio, television, newspapers

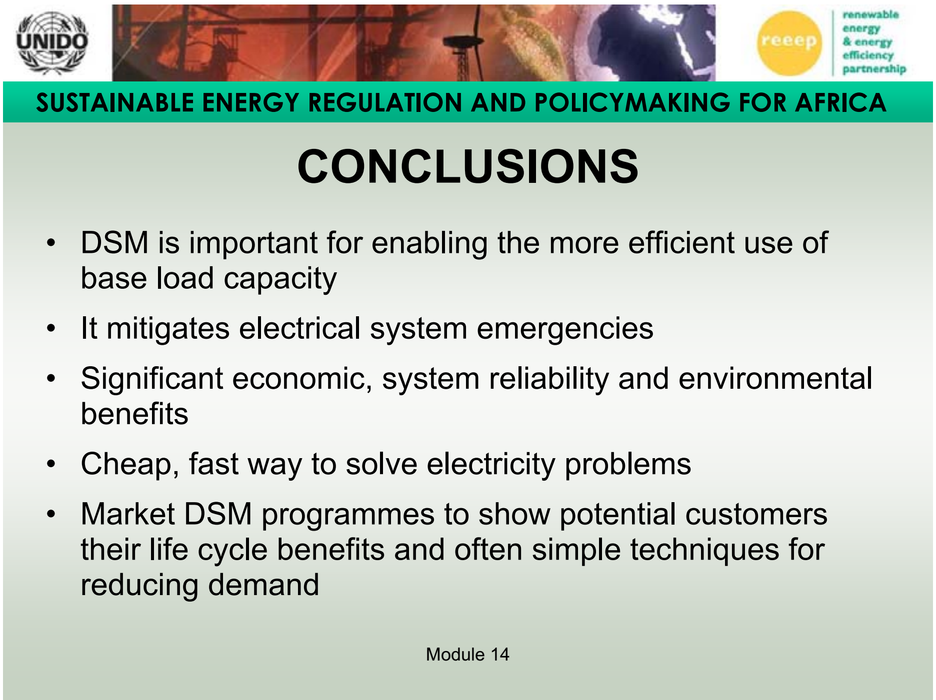
Module 14

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

DSM Programme Challenges

- Developing countries
  - Awareness
  - Technical capabilities
- Production and safety constraints
- Cost to customer
- Financing constraints

Module 14

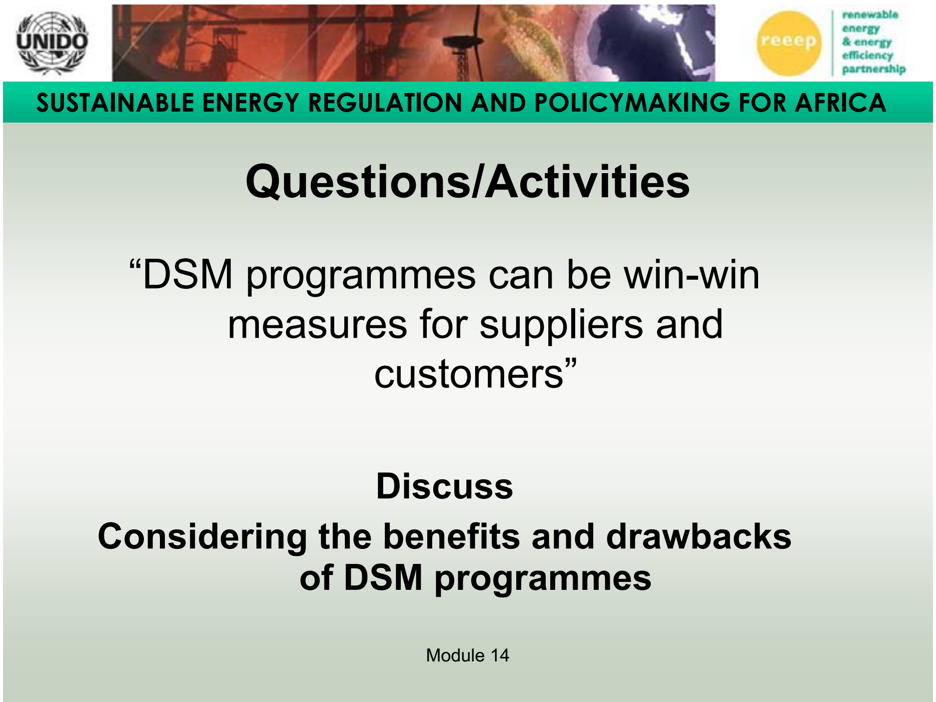


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- DSM is important for enabling the more efficient use of base load capacity
- It mitigates electrical system emergencies
- Significant economic, system reliability and environmental benefits
- Cheap, fast way to solve electricity problems
- Market DSM programmes to show potential customers their life cycle benefits and often simple techniques for reducing demand

Module 14



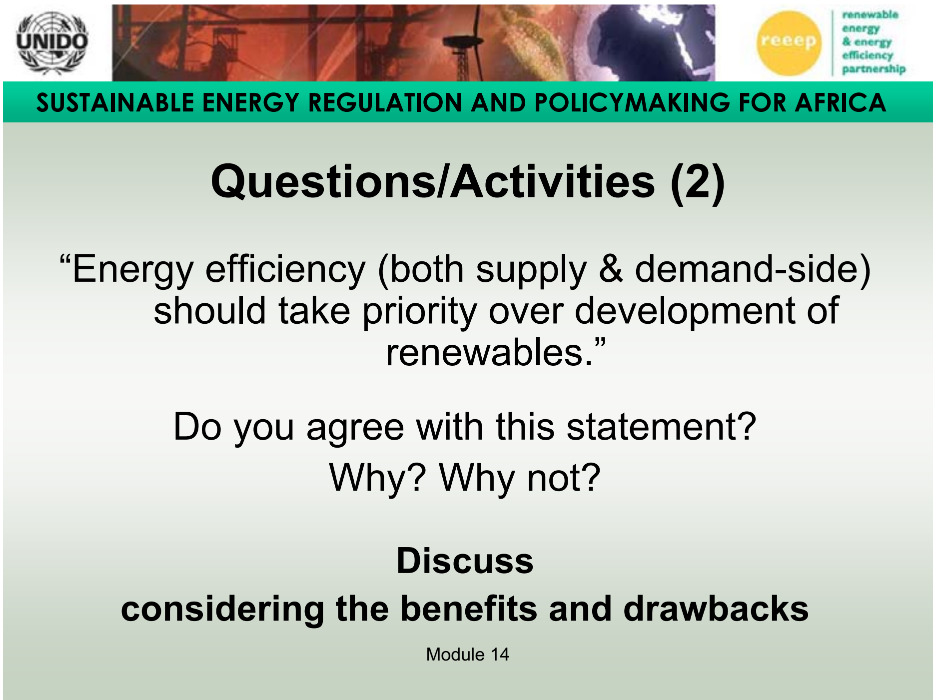
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

“DSM programmes can be win-win measures for suppliers and customers”

Discuss
Considering the benefits and drawbacks of DSM programmes

Module 14



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (2)

“Energy efficiency (both supply & demand-side) should take priority over development of renewables.”

Do you agree with this statement?
Why? Why not?

Discuss
considering the benefits and drawbacks

Module 14

Module 15

Impact of different power sector reform options on energy efficiency in Africa

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Past studies on power sector reform in Africa reveal that power sector reforms were largely designed to increase the electricity generation capacity and to ensure profitability of the power sector and not to promote its efficiency per se. It is therefore, not surprising that energy efficiency is yet to gain significant foothold in the area of energy generation, transmission, distribution, and usage in Africa. This is in spite of the increased call by the international community for energy conservation and demand-side management.

The overall objective of this module is to provide a broad overview of the impact of power sector reforms on energy efficiency in Africa. In particular, the module discusses the impact of reform options on energy efficiency by focusing on five key options, which include: unbundling (also referred to as restructuring); management contracts, corporatization/commercialization; independent power producers (IPPs); and amendment of the Electricity Law.

The impact of these five reform options on energy efficiency in Africa has been elaborated under each option. It is important to note that the impact for each of the reform options is different from country to country depending on the manner, pace and the timing of reforms and, as a result, the module provides specific country examples under each of the options.

The final section of the module presents key overall conclusions on the impact of the power sector reform on energy efficiency, the key terminologies and references/websites used.

1.2. Module aims

The aims of the present module are:

- To highlight the positive and negative impacts of the five different power sector reform options on energy efficiency in Africa to date;
- To provide examples, where relevant, of countries that have implemented the above reform options and the results achieved.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To appreciate the potential benefits and drawbacks of the various power sector reform options with regard to the promotion of energy efficiency;
- To draw lessons from the case studies provided.

2. INTRODUCTION

Currently efficiency programmes are largely absent in most countries. With the exception of a few countries in sub-Saharan Africa, energy efficient systems development is often undertaken within an energy planning and policy vacuum. As a result, the development of energy efficiency systems often follows an ad hoc path with no reference to a coherent vision and plan. For example, in Malawi, the policy vacuum has meant that the majority of energy efficient system dissemination efforts have not only been ad hoc in nature, but operated largely as an informal activity outside the formal Government planning and budgeting cycle, thus failing to attract significant support from the national treasury and/or donor agencies (Kafumba, 1994).

Policies that are supportive of energy efficiency should therefore explicitly set the stage for the implementation of innovative institutional structures in the form of energy agencies which can help to promote energy efficiency in the region (Praetorius, B. and Bleyl, W., 2006). In Kenya, for, example, it is estimated that between 10-30 per cent of the primary energy input is wasted (IEEN, 2002).

In general, power reform options were not primarily designed to promote energy efficiency. The main objective of reforms was to increase electricity generation capacity and to enhance the financial health of the utilities.

Very few countries have included provisions in reforms to secure and enhance activities and resources for energy efficiency. In Africa, most reforms measures are generally seen to hinder the wider use of energy efficiency options. For example, requiring utilities to reduce consumer demand for electricity through energy efficiency is, in an ideal setting, expected to promote competition. However, in the majority of African countries where the monopoly of national utilities prevails with a static customer base, reduction in consumer demand might appear to affect profitability of the utility due to a reduction in sales. On the other hand, energy efficiency regulations may enable a utility to have more electricity available for distribution thereby encouraging it to seek more new customers to absorb the excess energy. However in practice, most national utilities consider promotion of energy efficiency to reduce consumer demand only during periods in which there is a shortfall in generation capacity. As soon as the generation capacity resumes to normal, promotion of energy efficiency peters out.

Other reform options however, appear to present opportunities and/or barriers to the promotion of energy efficiency.

This module discusses how various reform options impact on the promotion of energy efficiency and it provides examples from African countries to illustrate these impacts.

3. IMPACT OF UNBUNDLING ON ENERGY EFFICIENCY

The key objective of unbundling—separation of the core business units of generation, transmission and distribution into legally and operationally distinct and independent entities—is to enhance overall operational efficiency of the power sector. There are two types of unbundling: vertical unbundling and horizontal unbundling. Since the implementation of horizontal unbundling in sub-Saharan Africa is limited, this section will focus on the impacts of vertical unbundling.

Perhaps the most important positive impact of vertical unbundling is exposing the inefficient sections in the power system. Prior to unbundling, utilities facing high system losses—an indicator of an inefficient energy system—would cover for the losses by using part of the reserve generation capacity to dispatch higher amounts of electricity into the system. However, unbundling implies that the generation, transmission and distribution segments have to minimize electricity and financial losses to meet committed generation, transmission and distribution levels as well as economic performance. In each of these cases, the regulatory framework and tariff setting mechanisms can play an important role in driving utilities towards increased energy efficiency in all three segments.

Besides the aforementioned potential and desirable positive impact of vertical unbundling on energy efficiency, there are also some negative impacts to be considered. One of these is linked to the fact that the separation of generation and distribution segments means that the distribution utility is at liberty to obtain electricity from different sources. The general response by the distribution utilities to increases in electricity demand appears to be seeking additional suppliers of electricity rather than embarking on demand-side energy efficiency programmes.[1]

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[1] In this regard appropriate regulation could reconcile the objective of distribution utilities to increase sales with that of improved energy/power efficiency. A major cause of the failure of the first DSM programme in Ghana was the fact that the distribution company was charged by the generation and transmission company only for energy supplied (kWh) and not for power demanded (kW). Under such arrangement the distribution company did not have any reason or incentive to care about power efficiency aspects such as consumers' power factor and harmonics. Besides charging distribution companies for power demanded, a possible way to address low efficiency could be that of allocating distribution utilities a "fixed" portion of available power generating capacity, for a certain period of time (e.g. 1-2 years). It would be then in the interest of the distribution utilities to attain for such power capacity the best possible load factor in order to maximize energy sales. It would also serve as an important incentive for improved efficiency if a parameter linked to the efficiency of the distribution was incorporated into tariff calculation formulae.

The need for additional electricity generation appears to have in turn encouraged a focus on large-scale thermal IPPs. As a result, opportunities for both energy efficiency through DSM and distributed generation (offered by renewables such as small hydro, cogeneration and geothermal) have not been fully exploited.

Another negative impact that power sector reforms seem to have had on energy efficiency is the fact that integrated resource planning has become less useful or relevant (IEA, 2000). Prior to unbundling, integrated resource planning was an important tool in the hands of the one utility, usually state-owned, mandated to manage and develop all sector-related activities: generation, transmission and distribution. Within a vertically unbundled power sector, various established autonomous entities would likely tend to carry out resource planning largely independently unless appropriate institutional and coordination mechanisms are put in place to ensure that integrated resource planning is to be used effectively.

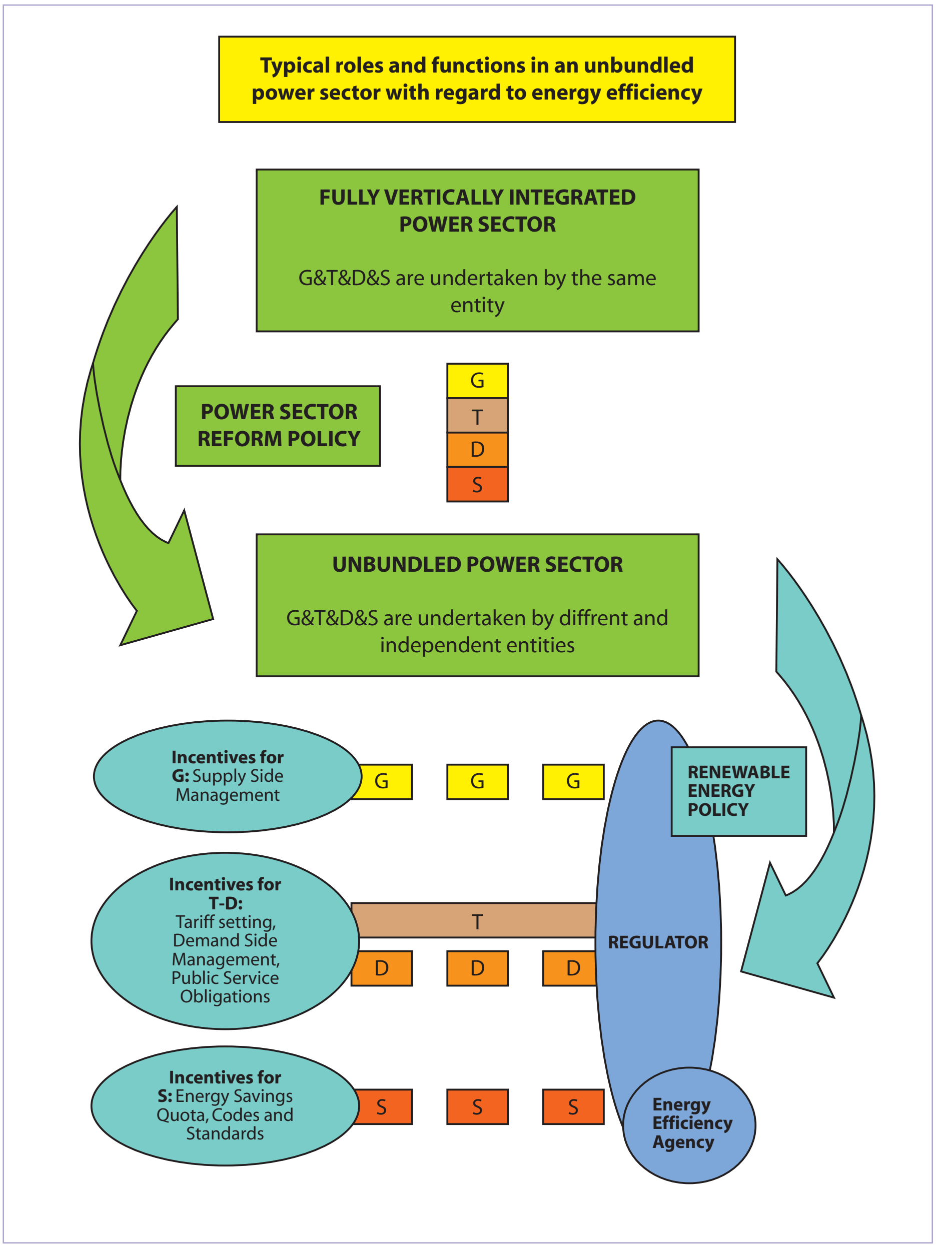
This includes any supply-side management (SSM) and demand-side management (DSM) programme would need to be initiated and monitored from outside the utility, i.e. by the independent regulator and/or supported by an Energy Efficiency Agency or Government ministries.

In most European countries the integrated approach including resource planning and security of supply tend to become responsibilities of regulators and governments, rather than of (national) utilities. This approach makes it easier to integrate the priorities of the national energy policy in the future development of the energy sector, as well as to make social and environmental corrections in the market. On the other hand it remains a difficult task as regulators often do not have all the information about resources and market player's strategies, and in addition the advice from regulators is not necessarily followed by the national government and parliament.

Figure 1 presents the organization and different roles with regard to energy efficiency in an unbundled power sector. SSM and DSM are further elaborated in modules 13 and 14, as well as in examples of how energy efficiency measures are implemented, e.g. in Denmark and Flanders.

Dedicated energy efficiency agencies are quite rare in both Africa and industrialised countries. Tunisia with its National Agency for Energy Efficiency (ANME) over the last two decades has been on the forefront of energy efficiency measures in the Mediterranean region. The background and roles of ANME are further explained in the Case study "National Agency for Energy Efficiency (ANME) in Tunisia" at the end of this module.

Figure I. **Power sector reform and energy efficiency: possible way forward for Africa**



(G: Generation; T: Transmission; D: Distribution; S: Supply)
Source: Source: IT Power

4. IMPACT OF ELECTRICITY LAW AMENDMENT ON ENERGY EFFICIENCY

One important contribution of the amended Electricity Acts is that they stipulate the formation of the regulatory authority. However, with the exception of South Africa, few other regulators have made the preparation of integrated resource plans (IRPs) which include energy efficient systems—an important pre-requisite for licensing. In most countries of the region there are at the moment, no explicit and effective incentives or requirements in place for the promotion of energy efficiency or demand-side management.

A textual assessment of the newly amended Electricity Acts of most countries in East and Southern Africa reveals that the Acts do not explicitly promote energy efficiency i.e. they do not stipulate support for energy efficiency technologies nor do they provide for energy efficiency programmes or any targets. Consequently, the promotion of energy efficiency is left to the discretion of the Ministries of Energy and the respective energy/electricity regulatory agencies.

Mauritius is one of the few cases where the newly amended Electricity Act clearly supports the use of energy efficient technologies for electricity generation especially through bagasse-based cogeneration. The Act guarantees attractive tariffs for investors in energy efficient technologies as provided for in section 5 (3) of the Schedule to the Electricity Act 2005 (GoM, 2005):

> “Where the Authority imposes a requirement in terms of paragraph (2), the Authority shall ensure that the reasonable costs incurred by the licensee as a result of the requirement are recovered by the licensee.”

Generally, where some mention of energy efficiency in the Electricity Act is made, it is not highlighted as a priority. For example, in several national Electricity Acts, energy efficiency is one of the many factors that might be considered in determining a tariff. In some cases, implementation of energy efficiency measures is provided by the Electricity Act as an elective and to the discretion of the Minister. For instance, this is the case of the Namibian Electricity Act 2000 whose excerpt from section 32 (2) is provided below:

> “…the Minister may, if the Minister considers it to be in the national interest… accordingly make arrangements or issue directives to the local authority for the promotion of the efficient utilization of electricity.”

In order to ensure the substantial support of energy efficiency, a thorough revision of the Electricity Acts—the pillar of power sector reforms—is necessary.

Box 1 provides an example of what the institutional organization could look like under a legislation framework that has energy efficiency as one of its declared objectives.

Box 1. Energy savings obligation on distribution network operators in Flanders

The Electricity Law which sets out the liberalization process of the Flemish energy sector also contains provisions with regard to energy efficiency. Based on the Electricity Law further legislation was approved clarifying the obligations imposed on both electricity suppliers and distribution network operators (DNO) as part of their public service obligation.

Electricity suppliers only need to comply with the obligation to carry out a set of informative actions, such as including the source of the energy used to produce the electricity on every energy bill, as well as the evolution of the energy use of the consumer over the last three years in order to make people better aware of their (changing) energy consumption.

DNO are subject to obligations both in terms of informative actions as in terms of achieving effective energy savings results; the DNO need to save 1 per cent of primary energy of its distributed energy. For every kWh not being saved a penalty of 10 c€ has to be paid. In order to trigger the significant energy savings potential at household level the target for low voltage customers was increased to 2 per cent in 2004, and gradually increased to 2.3 per cent in 2007.

The DNO can choose which measures it deems most appropriate to achieve its target, and a plan—the Energy Savings Action Plan—describing the set of supportive measures needs to be submitted and approved by the Energy Agency. The extra costs for carrying out these actions and measures are allowed to be integrated in the distribution tariffs; the penalties are not. This is checked by the Energy Regulator.

Source: Flemish Energy Agency, 2008, www.energiesparen.be

For some further examples of Electricity Law Amendments which laid the basis for the energy efficiency measures (which are then described in full detail) reference is made to module 16 “Policy and Regulatory Options to increase Energy Efficiency”, notably for Japan, Korea and Flanders.

5. IMPACT OF CORPORATIZATION ON ENERGY EFFICIENCY

The rationale for corporatization is to ensure that the utility is profitable. The profit-making motive of corporatized utilities has contributed to this reform option having some negative impacts on the promotion of energy efficiency in Africa. There is no motivation for the utility to enhance demand-side energy efficiency as it requires an additional investment and could potentially lead to lower revenue levels that can negatively impact profitability. This is particularly true in the case where utilities have not increased their consumer base for a long time. As it is the case now, most of the utilities in the region have made very little progress in connecting new customers.

However, corporatization can also have positive impacts on energy efficiency. Two examples of these positive impacts[2] are discussed below:

- Corporatization of state-owned utilities leads to enhancing the utilities' competitiveness by driving them to reduce their cost of production in order to maximize profitability. This development encourages utilities to implement energy efficiency measures that minimize system losses, which in turn reduces the cost of power production.
- Peak load "shaving" in the power system thereby minimizing the need for huge investments to meet peak demand, which lasts for only a few hours in a day. For example, the peak load experienced in the mornings is often associated with water heating. Therefore, using energy efficient water heating technologies such as solar water heaters can "shave off" a significant amount of the peak load and also provide attractive returns to the end-user (see box 1).

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[2] The potential for the stated positive impacts to materialize could be influenced significantly by the type of regulatory framework/electricity sector legislation that are in place. For example, it is legitimate to expect that a utility would pursue efficiency improvements and costs reduction under a price-cap regulatory system. On the contrary, under a rate-of-return (ROR) regulatory mechanism, a utility might not have any financial and economic interest in pursuing efficiency improvements unless an efficiency factor is accounted for in the ROR setting calculating formula.

Box 2. Case of solar water heaters in Ethiopia

Based on its storage capacity and who its producer is, the price of a locally manufactured solar water heater ranges from $US 400 to $US 625, while the price of imported ones range from $US 680 to $US 910. Studies undertaken by the Faculty of Technology, Addis Ababa University, indicate that with the current electricity tariffs, the investment cost of a solar water heater can be paid back within six months (source: Gashie, W., 2005). Given the plan to further increase the electricity tariffs (as required by the World Bank and other financial institutions) the installation of solar water heaters will become even more economically attractive in the future. A cost comparison study carried out by the Ethiopian Rural Energy Development and Promotion Center between solar water heaters and electric boilers indicates that the former has more advantages over the latter, especially for commercial purposes. Another comparative study made for a small hotel indicates the possibility of saving a minimum of $US 2,600, which translates to a payback period of about eight years.

Solar water heaters appear to be economically attractive in Ethiopia due to the escalation of the price of petroleum and electricity in the last past few years. This has been caused mainly due to price rise of petroleum price at global level and the removal of government subsidy from the end use supply of the two commodities. As the subsidy is removed, the price of oil and electricity will continue to rise, making solar water heaters more attractive.

This example is relevant in highlighting how the removal of subsidies for traditional energy sources (as a form of corporatisation) can facilitate the deployment of new and economically viable sustainable energy technologies. More information is available in the case study on Solar Water Heating in Ethiopia, which can be found as an annex to this module.

Source: Workineh, G. 2006

6. IMPACT OF INDEPENDENT POWER PRODUCERS ON ENERGY EFFICIENCY

The advent of independent power producers (IPPs) has had a positive impact on the promotion of energy efficiency in several ways. For example, IPPs have enabled utilities to retire old and inefficient generation power plants. Some of the inefficient power plants were kept in service longer than their useful lifetime due to inadequate electricity generation capacity and, at the same time, lack of capital to build new power plants.

The perceived profitability of IPPs appears to have convinced some industries whose core business is not electricity sales to implement energy efficiency measures to enable them become net electricity exporting entities in two ways. Firstly, some entities with embedded generation have embarked on “in-house” energy efficiency measures thereby consuming less energy. The resultant excess generation capacity leads to higher electricity sales to the grid. This is the case of the sugar industry in Mauritius, which currently contributes to 40 per cent of the electricity production in the country.

Secondly, industrial entities located near attractive small hydropower sites are developing the sites for captive power as well as for exporting the excess electricity to the grid. This is the case of the tea industry in Eastern and Southern Africa.

Another positive impact of IPPs on energy efficiency is that some utilities appear to encourage privately owned distributed generation in order to enhance energy efficiency and stability within the grid. A case example is in Zimbabwe where the national utility entered into an IPP agreement with a sugar mill in the Chiredzi area to foster energy efficiency and enhance stability of the grid in that part of the country.

The advent of IPPs has also had some negative impacts on energy efficiency. By definition, an IPP implies a certain amount of vertical unbundling, which complicates attempts to implement integrated resource planning (IRP) a key platform for promoting demand-side management (DSM).

Box 3 offers an example of how investments in more energy efficient equipment leading to both environmental and economic benefits. The IPP in this case is a public district heating company. In addition this example highlights the institutional set up of the utility as well as regulatory aspects like tariff structures and demand side management. Box 4 offers an example in Czech Republic where a combined heat and power (CHP) plant increases efficiency, and the use of sewage gas replacing natural gas.

Box 3. Modernization of the district heating system in Zhytomyr, Ukraine

The proposed project involves the rehabilitation and modernization of the existing district heating infrastructure, including modernization of the boiler houses and the replacement of pipes. In addition new residential apartment buildings in the City will be equipped with meters, and small co-generation plants will be installed. The Municipal District Heating Company "ZhytomyrTeploKomunEnergo" is a municipal enterprise wholly owned by the City of Zhytomyr in Ukraine.

The efficient institutional set up of the municipal utility will be supported by the following regulatory aspects:

- Tariff setting methodology: the project will include the implementation of a market-based tariff structure which aims at full cost recovery thus ensuring long term financial sustainability of the district heating sector in the city;
- Demand-side management: consumers will be billed according to actual consumption, motivating end-users to economize natural resources;

The change towards a demand-driven business strategy, the adoption of a least cost district heating strategy, shift to alternative fuels, recovery of waste heat and the introduction of heat pumps are expected to further increase efficiency and reduce emissions.

Economic and environmental benefits: The decreased heat consumption and a rational prioritization of further upgrades and renovations of the district heating system will reduce fuel consumption (economic benefit) and emissions (environmental benefit) from the heat production plants.

The project is not yet realized; at this stage it has passed the concept review for obtaining a loan from EBRD for 10 million euros. The total project cost is estimated at 12.6 million euros.

Source: Bank for Reconstruction and Development (EBRD), February 2008

Box 4. CHP plant using biogas in Otrokovice, Czech Republic

The sewage disposal plant is operated by private company Toma Inc. and takes care of both the industrial sewage from the local leather industry and the municipal sewage of the local town of Otrokovice.

When the sewage plant was enlarged two CHP units were installed in 1994 and 1996, and a third one was commissioned in 2005. Especially this third CHP unit was aiming to make more efficient use of the energy sources provided by the sewage system, i.e. to transform the sewage waste into biogas and use the heat for the operation of the plant, and secondly to generate electricity from the biogas production.

The project makes sense from a financial point of view; the excess electricity generation is fed into the grid, creating an important additional revenue stream as a fixed price is set by the Energy Regulatory Office. Secondly savings are generated at both heat and electricity level; instead of having to purchase about 86 MWh electricity per year, as much as 1,400 MWh is resold to the grid, in addition to covering the plant's own electricity needs. Similarly the CHP unit provides the heat requirements of the plant (about 1,700 MWh per year) thus avoiding the purchase of 180,000 m3 of natural gas.

In addition there are environmental gains; without using the biogas in the CHP the methane—which acts as a powerful greenhouse gas—would be lost into the atmosphere. Finally emission reduction in terms of SO_2, NO_x and CO_2 are realised through the avoided use of natural gas.

Source: CHP Projects in Czech Republic, Austrian Energy Agency, 2006, www.energyagency.at

7. IMPACT OF MANAGEMENT CONTRACT ON ENERGY EFFICIENCY

Management contracting has been adopted in different economic sectors, and therefore has different meanings. In the energy sector, it refers to outsourcing of the managerial functions of a utility to a private entity, with the Government remaining the owner of the assets. It transfers responsibility for the operation and maintenance of Government-owned businesses to a private entity.

If properly implemented, management contracting enables the following:

- It helps in determining, early in the process, what tasks the contractor should accomplish. The management contract provides specific statements of work that contain clearly stated, results-oriented performance criteria and measures.
- It engages the contractor expeditiously so as to meet demanding schedules. Where practical, contracts can be issued in advance so that contractors are available when needed.
- It minimizes cost while maintaining quality by:
    - Maximizing competition.
    - Using past performance information as a factor in awarding future work.
    - Using incentives to motivate superior contractor performance.

To a limited extent, management contract also impacts on the promotion of energy efficiency in the same way as corporatization because of the following reasons:

- Consultants usually hired to manage the utility have the key task of making the utility profitable—the same objective as corporatization—and enhancing operational efficiency.
- Usually management contracts, which last for a relatively short period of about 2 years,[3] manage existing utility assets and any assets procured during their tenure. Therefore, management contractors have limited decision-making powers especially pertaining to investments in new generation and new energy efficiency investments.

If, however, management contracts incorporate energy efficiency improvement targets, it can have a positive impact on the promotion of energy efficiency. For example, peak “shaving” can avoid large-scale investments in generation, which increase liabilities and reduce profitability.

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[3] An exception is the case of Côte d’Ivoire whereby management contracts of 15 years have been issued.

8. CONCLUSION

Energy efficiency in Africa is generally given a low priority, both at the industrial and domestic level. The power sector reforms have not adequately supported the promotion of energy efficiency in the power sector. However different reform options appear to have different impacts on energy efficiency i.e. some have neutral impacts while others have positive and/or negative impacts.

Involvement of IPPs and the unbundling of the power sector generally appears to have significant benefits on energy efficiency. While some positive impacts of power sector reforms on energy efficiency have been registered, in overall terms, the impacts of reforms have largely been negative.

LEARNING RESOURCES

Key points covered

- In general, power reform options were not primarily designed to promote energy efficiency. The main objective of reforms was to increase electricity generation capacity and to enhance the financial health of the utilities.
- Very few countries have included provisions to secure and enhance activities and resources in energy efficiency. In Africa, reforms have created new challenges and are generally seen to contradict/hinder efficiency through regulations especially in cases where distribution utilities still enjoy a monopoly. For example, requiring a single distribution utility in a country to reduce consumer demand for electricity through energy efficiency is inconsistent with introducing competition as it might appear to affect profitability of the utility due to the reduction in electricity sales. Consequently, this may be viewed as a potential trade-off before enhancing energy efficiency and competition.
- Reforms have not adequately supported the promotion of energy efficiency in the power sector. However different reform options appear to have different impacts on energy efficiency i.e. some have neutral impacts while others have positive and/or negative impacts.

Exercises

1. According to you, have power sector reforms had any impact on enhancing energy efficiency? Using relevant documents, provide 2-3 page essay of your reaction.
2. Different power sector reform options appear to have had different impacts on energy efficiency. Using examples from the region, discuss their impacts.

Presentation/suggested discussion topics

Presentation:

ENERGY EFFICIENCY – Module 15: Impact of power sector reform on energy efficiency in Africa

ENERGY EFFICIENCY – Module 15: Case study 1 – Solar water heaters in Ethiopia.

ENERGY EFFICIENCY – Module 15: Case study 2 – Institutional framework and power sector reform working for Tunisia Energy Efficiency.

Suggested discussion topic:

Question: Discuss the impact of corporatization/commercialization on energy efficiency in your country.

Question: Discuss the impact of management contracts on energy efficiency in your country.

Question: Discuss the impact of unbundling on energy efficiency in your country.

Question: Discuss the impact of independent power producers on energy efficiency in your country.

Question: Discuss the impact of electricity law amendment on energy efficiency in your country.

Question: What role do you see that renewables can play in enhancing energy efficiency in the electricity sector?

NB: The questions provided above are all discussion questions and the answers are therefore country specific. Trainees are encouraged to answer the relevant questions on the basis of their respective countries and/or countries whose reform process they are more conversant with.

Relevant case studies

1. Solar water heaters in Ethiopia
2. National Agency for Energy Efficiency (ANME) in Tunisia

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INTERNET RESOURCES

Renewable Energy and Energy Efficiency Programme: www.reeep.org

International Energy Agency Demand-Side Management Programme: www.dsm.iea.org

Rocky Mountain Institute: www.rmi.org

Energy Foundation: www.ef.org

American Council for an Energy Efficient Economy: www.amceee.org

Lawrence Berkeley National Laboratory: www.lbl.gov

“Cogen for Africa” Project: cogen.unep.org

Greening the Tea Industry in East Africa Project: greeningtea.unep.org

AFREPREN/FWD: www.afrepren.org

African Forum for Utility Regulation: www.afurnet.org

Regional Electricity Regulators Association of Southern Africa: www.rerasadc.com

International Energy Initiative: www.ieiglobal.org

World Resources Institute: www.wri.org

GLOSSARY/DEFINITION OF KEY CONCEPTS

Boiler	A device for generating steam for power, for heating purposes; or for generating hot water for heating purposes or hot water supply.
Cogeneration	Simultaneous production of electricity and heat energy.
Complete horizontal unbundling (provincial utilities which are vertically integrated)	When each province owns a utility that undertakes electricity generation, transmission and distribution in vertically integrated operations.
Complete vertical unbundling	When the generation, transmission and distribution entities are independent companies.
Corporatization	This is the act of transforming a state owned utility into a limited liability corporate body often with the government as the main shareholder.
Distribution	Delivery of electricity to the customer's home or business through low voltage distribution lines.
Electricity/power sector reforms	Deliberate changes in the structure and ownership of the electricity sector aimed at improving performance, efficiency and investment.
Electricity regulator	The agency in charge of monitoring the electricity sector.
Emissions	Flows of gas, liquid droplets or solid particles released into the atmosphere.
Energy reserves	Estimated quantities of energy sources that have been demonstrated to exist with reasonable certainty on the basis of geologic and engineering data (proven reserves) or that can reasonably be expected to exist on the basis of geologic evidence that supports projections from proven reserves (probable or indicated reserves).
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Fossil fuel	An energy source formed in the earth's crust from decayed organic material e.g. petroleum, coal, and natural gas.
Global warming	An increase in the near surface temperature of the Earth due to increased anthropogenic emissions of greenhouse gases.

Interconnected system	An integrated electricity generation, transmission and distribution network.
Licensing	The act of issuing licences allowing investors to operate legitimately within the electricity sector, usually as IPPs.
Management contract	The outsourcing of managerial functions of the utility to a private entity, with the Government after remaining the owner of the assets.
Modern energy	Refers to high quality energy sources e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biomass fuels.
Primary energy	Energy sources in their crude or raw state before processing into a form suitable for use by consumers.
Sub-Saharan Africa	All African countries north of the Republic of South Africa and south of the north African countries (Algeria, Egypt, Libyan Arab Jamahiriya, Morocco, Tunisia).
Unbundling	The process of breaking-up a vertically integrated public utility into either different entities of generation, transmission and distribution, or into regional companies within the country.

Case study 1.

SOLAR WATER HEATERS IN ETHIOPIA

CONTENTS

1. BACKGROUND TO SOLAR WATER HEATING TECHNOLOGY

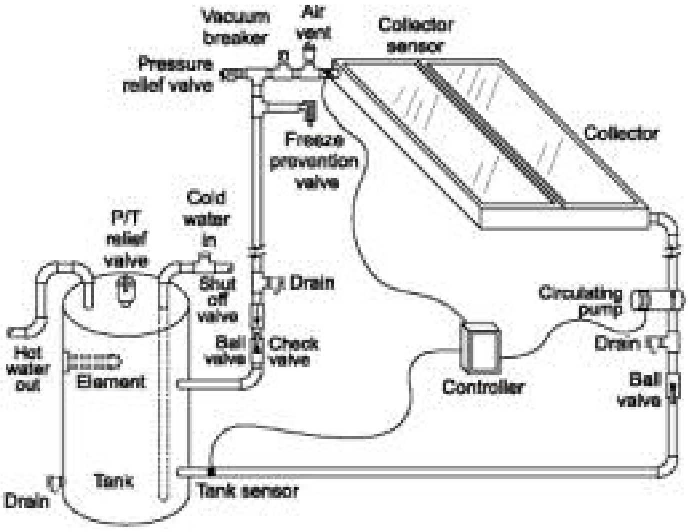
1.1. Introduction

Solar water heaters are an example of solar thermal technologies that have been disseminated in Africa. Other examples of solar thermal technologies include solar cookers (Kammen 1991; 1992), solar stills and solar dryers. This section concentrates on solar water heating, as it seems to be the most developed technology among the other possible solar thermal technologies currently being used or researched. Solar water heating has also found greater use than the other technologies in most countries with reasonable solar radiation. Solar water heaters (SWHs) for domestic purposes can be used either as stand-alone systems or as hybrid systems with electrical geysers. The fundamentals of the SWH technology are presented together with an assessment of the factors affecting dissemination of the technology.

1.2. Fundamentals of the technology

Solar water heaters, sometimes called solar domestic hot water systems, use the sun to heat either water or a heat-transfer fluid, such as a water-glycol antifreeze mixture, in collectors generally mounted on a roof. The heated water is then stored in a tank similar to a conventional electric water tank (see figure I). Some systems use an electric pump to circulate the fluid through the collectors.

Figure I. **A solar water heating system**



Source: www.kenital.com

Solar water heaters are made up of collectors, storage tanks, and depending on the system, electric pumps. There are three basic types of collectors namely: flat-plate, evacuated-tube and concentrating. Most commercially available solar water heaters require a well-insulated storage tank. Many systems use converted electric water heater tanks or plumb the solar storage tank in series with the conventional water heater. In this arrangement, the solar water heater preheats water before it enters the conventional water heater. Some solar water heaters use pumps to re-circulate warm water from storage tanks through collectors and exposed piping. This is generally to protect the pipes from freezing when outside temperatures drop to freezing point or below.

Solar water heaters can either be active or passive. An active system uses an electric pump to circulate the heat-transfer fluid, while a passive system has no pump. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation and the tilt angle and orientation of the collectors.

Solar water heaters are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (potable) water through the collector. A closed-loop system uses a heat-transfer fluid (for example water or diluted antifreeze) to collect heat and a heat exchanger to transfer the heat to the water to be used.

Sizing a solar water heater involves determining the total collector area and the storage volume required to provide 100 per cent of a household’s hot water during the summer. Solar-equipment experts use worksheets or special computer programs to assist in determining the size of a system. A small 100-litre system is sufficient for one to two people, a medium 150-litre system is adequate for a three or four person household, while a large 250-litre system is appropriate for four to six people.

A rule of thumb for sizing collectors allows about 1.5 square metres of collector area for each of the first two family members. The next size is 0.6 square metres for each additional family member in areas like central Zimbabwe with a daily average radiation of 5kWh/m2. A ratio of at least eight litres of storage capacity to 0.1 square metres of collector area prevents the system from overheating when the demand for hot water is low. In very warm, sunny climates, experts suggest that the ratio should be at least ten litres of storage to 0.1 square metres of collector area.

1.3. Benefits of solar water heaters

There are many benefits to owning a solar water heater. In terms of economics, solar water heaters compare favourably with those of electric water heaters.

However, its economics are not quite as attractive when compared to those of gas water heaters. Solar water heaters offer the largest potential savings, with owners saving as much as 50 per cent to 85 per cent annually on their utility bills over the cost of electric water heating. However, at low (subsidized) prices of electricity and other fuels, solar water heaters cannot compete favorably in some countries.

Payback periods vary widely, but one can expect a simple payback[1] of 3 to 5 years on a well-designed and properly installed solar water heater. Shorter payback periods are expected in areas with higher energy costs. After the payback period, one continues to accrue the savings over the life of the system, which ranges from 15 to 20 years depending on the system and how well it is maintained.

There is amble evidence to show that SWHs play a very crucial role in demand-side management (DSM) in many countries. SWHs can be used to flatten out the maximum demand curve for any utility. The technology can also be used to cut down the actual demand, and this can have various implications for a country. Depending on the circumstances, this can mean delayed investment in power generation or reduction of the import bill for those countries that import power or fuel.

The solar heating of water can also yield significant long-term benefits such as helping to cushion a country from energy prices shocks and shortages by reducing dependence on imported petroleum products/electricity/big hydro water resources. Solar water heating can also present significant environmental benefits.

When a 200-litre solar water heater replaces an electric water heater, the electricity displaced over 20 years represents more than 50 tons of the avoided carbon dioxide emissions alone (this figure is derived assuming the electricity supplied by the grid is generated from oil-based generation.[2]

1.4. Regional dissemination of solar water heaters

Solar water heater dissemination levels in selected African countries are shown in table 1. These capacities have been achieved in most cases due to national policies, which were deliberately supporting the use of SWH technology. Policies came either as laws, which stipulated that all buildings of a particular type must be fitted with SWHs or incentives to the suppliers.

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[1] Simple payback is the length of time required to recover an investment through reduced or avoided energy costs.

[2] Estimates obtained from Powerhouse and Eco Business Links

Table 1. Estimated installations of domestic solar water heater (1991-2002)

Country	Installed capacity (1000 m^2)
South Africa	500,000
Egypt	400,000
Botswana	50,000
Mauritius	40,000
Kenya	40,000
Namibia	24,000
Zimbabwe	10,000
Malawi	4,800
Seychelles	2,400

Source: Karekezi, S., and Kithyoma, W. 2005

2. CASE OF SOLAR WATER HEATERS IN ETHIOPIA

2.1. Objective of the case study

The main objective of this case study is to assess the status and the contribution of solar water heaters to the power and rural energy sector in Ethiopia

2.2. Development of the solar water heaters in Ethiopia

In Ethiopia, after several years of total neglect, solar water heaters have recently begun being more widely disseminated. In the recent past, only two charity organizations, the Ethiopian Evangelical Mekane Yesus and Selam Technical Vocational Centers, were producing and disseminating solar water heaters. Since the year 2000, more than 10 private companies have entered the market as local producers and also as importers, mainly from China and India. Currently, it is estimated that more than 880 units of solar water heaters have been installed by these organizations. The potential users of the technology are limited mainly to higher income groups of people living in major towns particularly in Addis Ababa.

With rising electricity tariffs, increased incomes in urban areas and rapid technical capacity-building of local producers of the technology, the demand for the solar home heaters is expected to rise. Based on its storage capacity and who its producer is, the price of a locally manufactured solar water heater ranges from $US 400 to $US 625, while the price of imported ones range from $US 680 to $US 910. Studies undertaken by the Faculty of Technology, Addis Ababa University indicate that with the current electricity tariffs, the investment cost of a solar water heater can be paid back within 2.3 years (Gashie, W., 2005). Given the plan to further increase electricity tariffs (as required by the World Bank and other financial institutions), the installation of solar water heaters will become even more economically attractive in the future. A cost comparison study carried out by the Ethiopian Rural Energy Development and Promotion Centre between solar water heaters and electric boilers indicates that the former has more advantages over the latter, especially for commercial purposes. Another comparative study made for a small hotel indicates the possibility of saving a minimum of $US 2,600, which translates to a payback period of about eight years. A higher economic benefit is also noted for the manufacturers, i.e. with the current price, a net benefit of about $US 230 can be obtained on a single solar heater, which may take a single worker not more than three days to manufacture.

2.3. Impact of solar water heaters in Ethiopia

Solar water heaters appear to be economically attractive in Ethiopia due to the escalation of the price of petroleum and electricity in the past few years. This has been caused mainly by the rise in the price of petroleum at the global level and the removal of government subsidies from the end use supply of the two commodities. As the subsidy is further removed, the prices of the petroleum products and electricity will continue rise and will in turn make solar water heaters more attractive. As a result, the production and marketing of solar water heaters is expected to grow at a faster rate. Box 1 gives a simple demonstration of the cost-effectiveness of domestic SWHs.

Box 1. The cost-effectiveness of domestic solar water heaters

Mr Boja Galalcha is a dweller of Addis Ababa city and has six family members. He installed a 100-litre SWH in 2000. Before installing the SWH, Mr. Galalcha used a standard electric boiler system. When using the electric boiler, his average monthly electricity bill was about $US 23.30. However, since he started using the solar water heater, his electricity dropped to about $US 8.20 per month—a monthly saving of approximately $US 15.

Source: Gashie W., 2005

In addition to the economic benefits obtained by the users and producers, the introduction of solar water heaters has other advantages, which include (Gashie, W., 2006):

- Increasing the diversity of energy utilization;
- Avoiding risks associated with peak loads;
- Creating local employment opportunities for manufacturers and maintenance workers;
- Reducing deforestation and increasing agricultural productivity through reducing biomass fuel utilizations for water heating in the process of food cooking which in turn reduces women's and children's physical strain and time spent caused by fuel wood collection activities.

2.4. Financing

The production of solar water heaters in Ethiopia was initially begun by EECMY and STVC in early 1990s mainly for demonstration purposes. But with the increase in demand for hot water on the one hand and the rise in electric tariffs on the other hand, solar water heaters have gradually made inroads in markets as a commercial commodity. At present, more than five private companies are involved in the production of the technology, particularly in Addis Ababa. The production of solar water heaters needs at least three different skilled persons; machine technologists, welders and plumbers. A group of these skilled persons with two daily labourers can produce two solar water heaters in a day. For the production of the technology, the materials needed and their respective costs are depicted in tables 2 and 3.

Table 2. Fixed costs for establishing/equipping a SWH production line

No	Item	Unity	Qty	Unit price ($US)	Total price ($US)	Life time (year)	Cost per year ($US)
1	Shed construction	No	1	1,704.55	1,704.55	9	189.39
2	Sheet metal bending machine	pcs	1	909.09	909.09	8	113.64
3	Sheet metal rolling machine	pcs	1	198.86	198.86	8	24.86
4	Hand drill machine	pcs	1	1,022.73	1,022.73	2	511.36
5	Hand girding machine	pcs	2	200.57	401.14	2	200.57
6	Welding machine	set	2	409.09	818.18	5	163.64
7	Circular saw machine	pcs	1	363.64	363.64	4	90.91
8	Bench vice	pcs	1	397.73	397.73	4	99.43
9	Hand clamp	pcs	5	16.48	82.39	1	82.39
10	Different hand tools	set	6	26.14	156.82	2	78.41
11	Workers salary (5)	month	12	56.82	3,409.2	1	3,409.20
	Total						**4,963.79**

Source: Bereket, producer of solar water heaters, 2005

Table 3. Variable costs to produce a solar water heater with a capacity of 200 litres

No	Item	Unity	Qty	Unit Price ($US)	Total Price ($US)
1	Galvanized sheet metal	m	15	28.41	426.14
2	Black sheet metal 4mm thick	pcs	1.5	64.20	96.31
3	Galvanized pipe 1 inch	m	1	21.02	21.02
4	Galvanized pipe ½ inch	m	18	1.61	28.96
5	Pipe fittings	pcs	8	1.36	10.91
6	Insulation material	kg	5	1.93	9.66
7	Bolt and nut M10	pcs	22	0.06	1.25
8	Electrode diameter 2.5	pkt	0.5	2.73	1.36
9	Grinding and cutting disc dim.180mm	pcs	2	1.14	2.27
10	Two different paints	kg	2	2.84	5.68
	Total				**603.56**

Source: Bereket, producer of solar water heaters, 2005

At the present, the average price of a locally manufactured solar water heater with a capacity of 200 litres of water is about $US 740.00. A producer that has only one group of skilled personnel can produce about 600 solar water heaters per year. With these two estimations and from tables 1 and 2 one can easily determine the following simple calculation on an annual basis:

- Total variable cost = 600 x $US 603.56 = $US 362,136.00
- Total fixed cost = $US 4,963.79
- Total cost (sum of variable and fixed costs) = $US 367,099.79
- Total income = 600 x $US 740 = $US 444,000.00
- Benefit = 444,000-367,100 = $US 76,900.00
- Benefit per heater = $US 76,900÷600 = $US 128.20

2.5 Progress with implementation

There have been rapid technical advances in solar water heaters (SWHs) globally for the last 50 years due to benefits accruing to domestic, commercial, public services and for light industries. Following this worldwide trend, research activities have been carried out in Ethiopia for the last two decades to identify and then propose cost-effective locally manufactured solar water technologies. Nevertheless, the number of organizations involved in the process of production and dissemination of these technologies was very low until recent years. Prior to 2000, only two charity organizations; the Ethiopian Evangelical Mekane Yesus and Selam Technical Vocational Center were involved in the production and dissemination of SWHs, mainly for demonstration purposes. The two organizations disseminated only 67 SWHs. However, more than 10 private companies have entered into the market as local producers and also as importers mainly from China and India since the year 2000 (Workeneh, 2006). It is estimated that more than 1,562 SWHs units have been disseminated by these organizations at the present time. A comparison of the disseminated quantity in the year 2005 to any given year between 2000 and 2004 shows an increment of more than 177 per cent (see annex 1). This is a promising trend, and coupled with rising electricity tariffs, it can be expected that more private companies will enter the business. Due to increasing incomes in urban areas and rapid technical capacity-building of local producers of the technology, the demand for the solar water heaters is expected to rise.

Generally, the target groups of solar water heaters in Ethiopia can be categorized into four major groups. These target groups are urban domestic, urban commercial (hotels, restaurants, hostels, beauty salons, etc.), health institutions (clinics and health centres) and light industries. Among these target groups urban domestic and urban commercial are the largest users of the technology and hence this study has focused only on these two target groups. In the case of domestic users, even though SWHs have been widely introduced into larger cities of the country, Addis Ababa accounts for about 90 per cent of the total demand. Empirical analysis carried out by Getnet and Wogayehu (2004) to assess domestic market potential for SWHs in Addis Ababa, based on income levels, indicated that from the total number of households in the city, only 10 per cent can afford the initial cost of the technology. From this target potential of the technology 50 per cent already had electric boilers. Thus, the domestic market potential of SWHs is about 5 per cent of of the city dwellers, which is estimated to be about 27,500[3] households. This target group needs the technology mainly for bathing purposes. In addition to this, due to the continuous increase in electric tariffs through time, 10 per cent of those households with electric boilers (2,750) are expected to shift from electric boiler to SWHs, which in turn will increase the domestic market potential for solar water heaters by a further 10 per cent of to a total potential of 30,250 households (Getnet and Wogayehu, 2004).

2.6. Recommendations

Experiences indicate that NGOs have been instrumental in reaching grassroots communities with renewable energy technology dissemination programmes because of their flexibility and innovativeness. They have been instrumental in training and providing public education on renewable energy technologies through

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[3] The current number of household in the city is estimated to be about 0.55 million.

workshops, training courses, newsletters, posters and calendars. In Ethiopia, NGOs such as ELVIA, GTZ, EECMY, SVTC and Menschen für Menschen, have been instrumental in the development of the solar water heaters. Therefore, NGOs should be widely involved in solar water heater development and promotion.

Advocacy is extremely important to provide Government authorities, potential producers, distributors and users with information on small and medium-scale renewable technologies and to develop interest in the respective areas of concern. Therefore, it is necessary to engage civil societies, community-based organizations, Government organizations, NGOs, etc., in coordinated advocacy efforts using existing multi-media. These advocacy efforts need to be a continuous initiative and reach all groups of the population.

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Case study 2.

INSTITUTIONAL FRAMEWORK AND POWER SECTOR REFORM WORKING FOR TUNISIA ENERGY EFFICIENCY

CONTENTS

1. CONTEXT

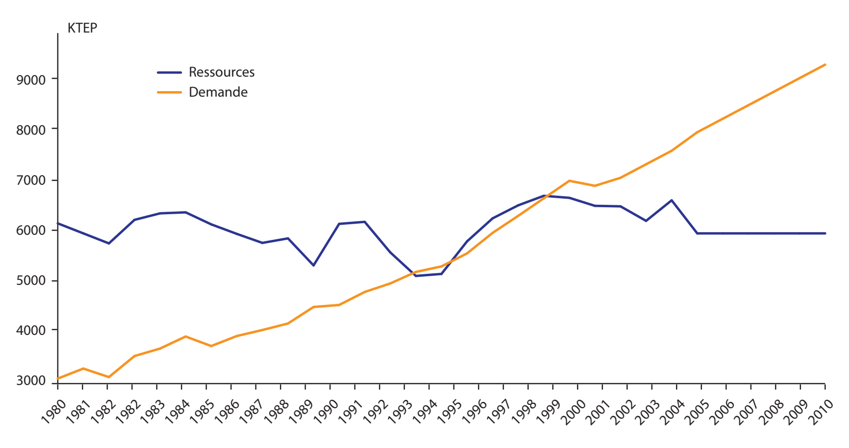
Due to its national oil and gas resources Tunisia historically enjoyed a favourable energy situation. The energy sector accordingly played an important role in the economic growth, representing 13 per cent of the national gross domestic product and 16 per cent of the national export in 1980.

However, as of the end of the 1980s, Tunisian authorities realized this favourable situation was about to change drastically. This shift was the result of two main factors:

- The stagnation of the national oil and gas resources; and
- The rapid increase of energy demand through economic and social growth.

This has led to a deficit on the energy balance as of the year 2000, and unsurprisingly, to a decreasing contribution of the energy sector in the economic growth of the country since 1986.

Figure I. **Evolution of primary energy demand (in red) against national energy resources (in blue) in Tunisia**



Source: ANME

This forecasted energy deficit urged the Tunisian government to develop a comprehensive sustainable energy policy, and Tunisia can be considered as being at the forefront of energy efficiency policies in the Mediterranean region since the 1980s.

This policy is further described in the following sections.

2. POLICY PRIORITIES AND TARGETS

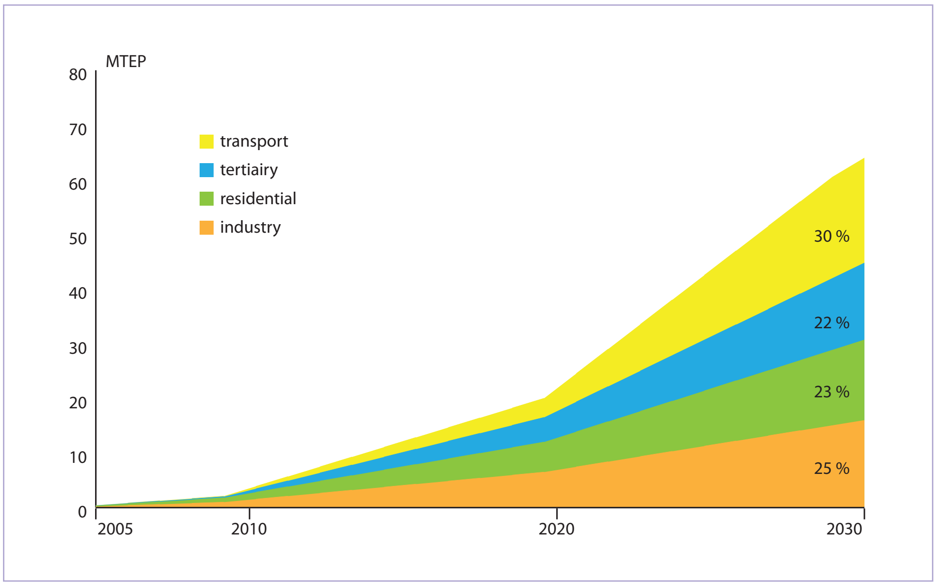
Since the beginning the energy conservation policy has been built around three pillars:

- Putting in place an institutional framework, with a dedicated national energy savings agency (ANME) in charge of policy implementation;
- The elaboration of a complete set of regulatory measures to promote energy efficient practices and techniques;
- The adoption of financial incentives, including subsidies for energy audits and investments as well as fiscal measures.

Recently an overall savings target of 640,000 toe[1] was set by 2010 and a decrease in energy intensity of 2 per cent per year. The objective is to save 940,000 toe and cut down state subsidies by about 155 million TND.[2]

The long-term opportunities and potential for energy efficiency were demonstrated in the strategic outlook towards 2030, and are shown in figure 2.

Figure II. **Energy savings potential per sector by 2030**



Source: ANME

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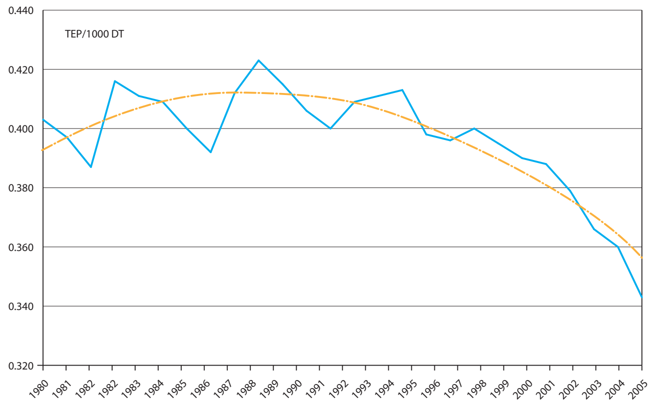
[1] Ton oil equivalent

[2] The Tunisian dinar (TND) is the national currency in Tunisia; 1 USD = 1.16510 TND (23 May 2008).

3. RESULTS

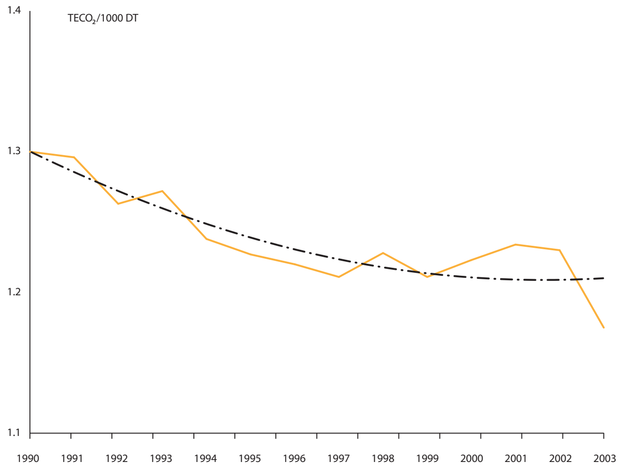
The series of policy measures related to energy conservation have led in 2006 to reducing energy intensity from 0.344 toe/1000TND (in 2005) to 0.332 toe/1000TND (in 2006), as shown in figure 3. This has helped achieve an aggregate reduction of energy consumption of 270,000 toe, of which 180,000 toe resulting from actions of rationalization of energy consumption and actions of renewable energy promotion.

Figure III. **Evolution of energy intensity (average in orange) in Tunisia**



Source: ANME

Figure IV. **Evolution of carbon intensity (average in red) in Tunisia**



Source: ANME

The simultaneous improvement of the energy and carbon intensity is remarkable, and is explained by the combined effect of four aspects:

- The impact of energy efficiency programmes especially in manufacturing industry;
- The improvement of energy consumption in electricity production plants, notably the introduction of combined heat and power (CHP);
- The modernization of the industrial complex;
- A shift to proportionally more tertiary services in the Tunisian economy.

In addition state subsidies in 2006 could be reduced by about 87 million TND, with 22 million TND due to actions of rationalization of energy consumption and of renewable energy promotion and 65 million TND due to actions of energy substitution in the industrial and residential sectors.

Finally the measures and support with regard to the use of solar thermal energy have led to the installation of 57,000 m^2 until 2006, with a target of reaching 620,000m^2 by 2010 (including a reduction of state aid of 2.5 million TND per year).

4. ELECTRICITY LAW AMENDMENTS

For the past two decades, public interventions via financial support from the State budget and the mobilisation of international financial resources have been decisive in the development of energy conservation in Tunisia.

The basis for the regulatory framework which had to be put in place in order to reach the formulated policy goals was laid down in a range of presidential decisions and national laws.

On 3rd May 2001 twenty presidential decisions were announced which would help to put in place the national energy efficiency strategy. These decisions included general updates of outdated legislation, the improvement of financial incentive regulations, and the introduction of a national energy efficiency day. In addition new frameworks were established with regard to the promotion of new sectors and technologies, e.g. the use of cogeneration, the mandatory use of solar water heating in new public buildings, the deployment of wind energy and the launch of energy services.

Recently, law N° 2005-82, dated 15 August 2005, instating a “energy conservation system”, has been a major asset ensuring support to effective implementation and sustainability of the actions aimed at rationalizing energy consumption, the promotion of renewable energies and energy substitution.

This system has developed into a “National Fund for Energy Conservation” (FNME), subject of law N° 2005-106, dated 19 December 2005, thus representing a quantum leap towards the choice of an extra-budgetary resource for financing the public support to energy conservation investments in Tunisia, and this based on the granting of allowances.

The rates and amounts of the allowances related to the actions concerned by this Fund, as well as the terms and methods of their granting are established by decree N° 2005-2234, dated 22 August 2005:

The sources of the fund are supplied by tax measures, including:

- A duty levied on the first registration of private cars in a Tunisian series, at a rate set by this Law at 250 to 1000 TND, for petrol-powered cars, and 500 to 2000 TND, for diesel-powered cars, with a certain number of exemptions stipulated by the Law;
- An import duty or local production duty, excluding export of air-conditioning equipments relevant to numbers set by the Law, at customs duties rates of 10 TND for each 1,000 thermal units.

5. ROLE OF THE ENERGY SAVINGS AGENCY

The actions and modalities of the National Fund are managed and implemented by the National Agency for Energy Conservation (ANME), which acts as the core component in the institutional set up of the Tunisian energy efficiency policy. ANME’s mission is defined as the improvement of the energy balance and the reduction of gas emissions form energy use. Particular tasks include:

- The development and implementation of national energy efficiency programmes; e.g. support the actions of mandatory and periodical energy audits, and signing of performance contracts with high energy consuming entities and the promotion of the use of energy-saving techniques and equipments for various activities such as:

  - Cogeneration;
  - Certification of household electrical appliances;
  - Thermal and energy regulation of buildings;
  - Rationalization of street lighting power consumption; and
  - Car engine check-ups;

- Setting out the legal and regulatory framework related to energy efficiency;
- The launch of awareness-raising campaigns, and organization of educational and training actions;
- Support research and development through innovative demonstration projects;
- The encouragement of private sector investment;
- Conducting prospective and strategic studies, e.g. the "Energy Efficiency in Tunisia towards 2030" as mentioned above;
- The design and administering of tax and financial incentives; these are described in detail in box 1 below.

Box 1. Financial incentives for energy conservation measures in Tunisia

- Subsidy for an energy audit: 50 per cent of the cost, up to a maximum of 20,000 TND;
- Subsidy for a demonstration project: 50 per cent of the cost; up to a maximum of 100,000 TND;
- Subsidy for energy conservation investments: 20 per cent, up to maximums which go up with the average yearly energy consumption of the organization in question;
- Solar water heaters for households: 20 per cent subsidy up to 100 TND per m^2;
- Energy substitution: Shift to gas in the residential (140 TND for a house and 20 TND for a flat) and industrial sector (20 per cent up to 400,000 TND);
- The installation of checkpoints for car engines: 20 per cent subsidy up to 6,000 TND;

In addition fiscal measures are put in place to complement the investment subsidies as described above.

Source: Energy Efficiency in Tunisia towards 2030, ANME, 2006

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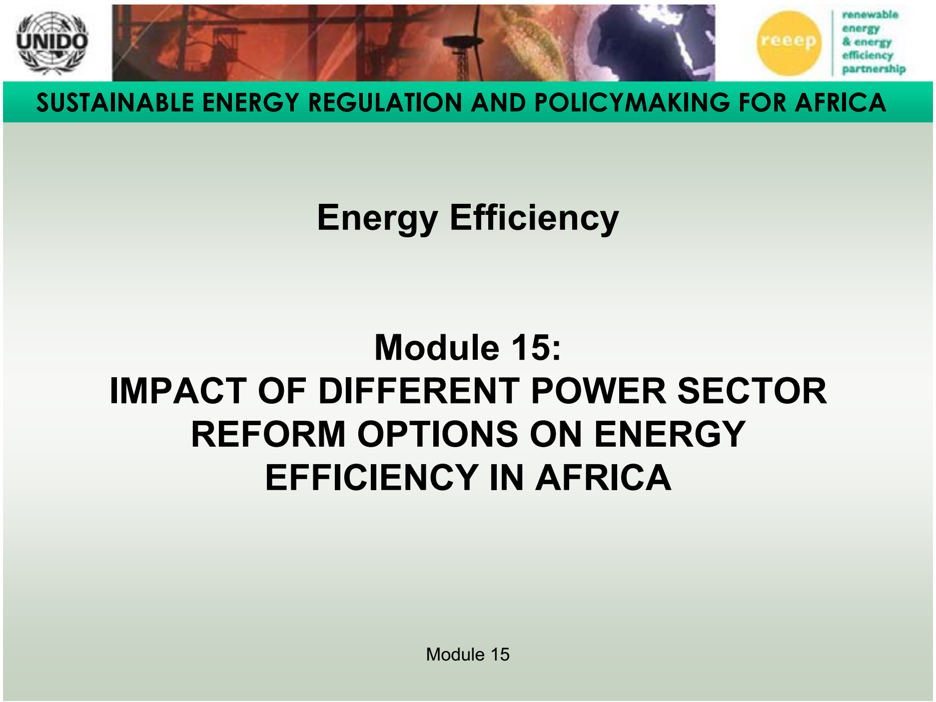
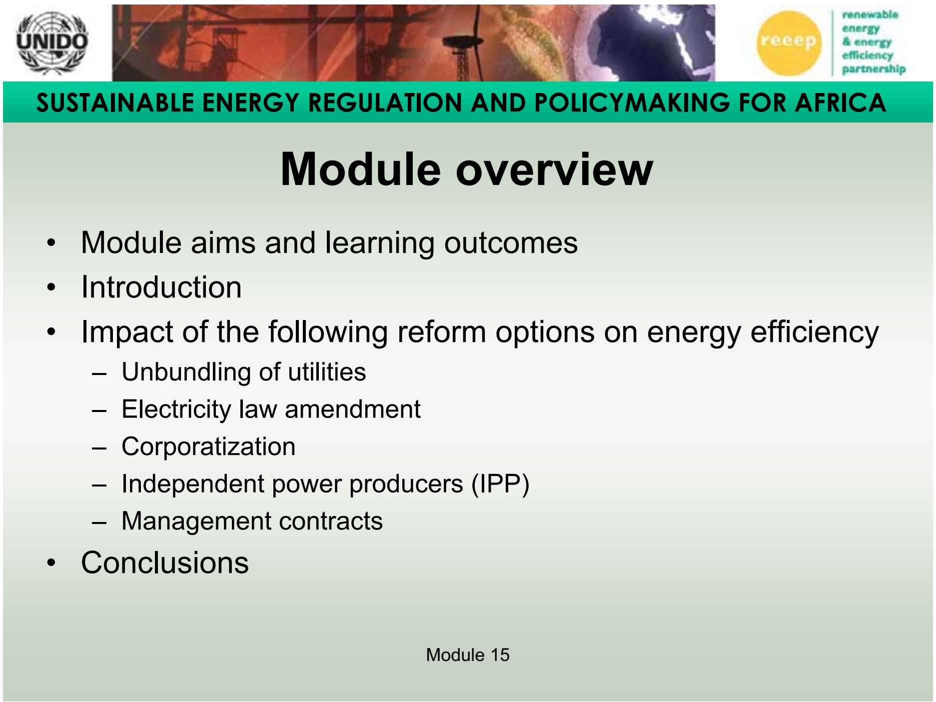


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

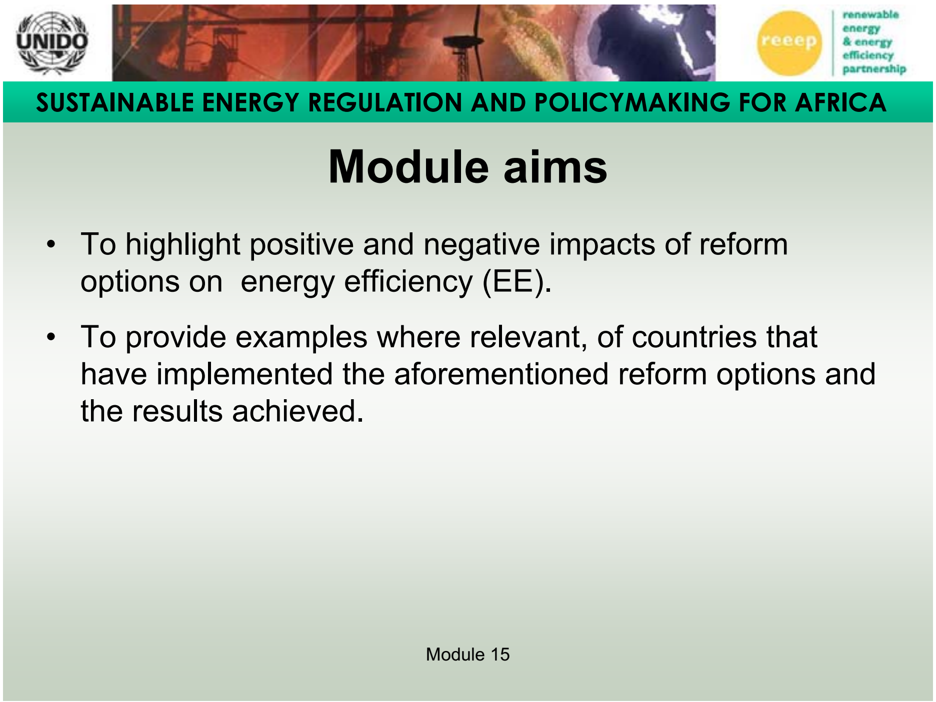
Module 15:
IMPACT OF DIFFERENT POWER SECTOR REFORM OPTIONS ON ENERGY EFFICIENCY IN AFRICA



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Module aims and learning outcomes
- Introduction
- Impact of the following reform options on energy efficiency
  - Unbundling of utilities
  - Electricity law amendment
  - Corporatization
  - Independent power producers (IPP)
  - Management contracts
- Conclusions

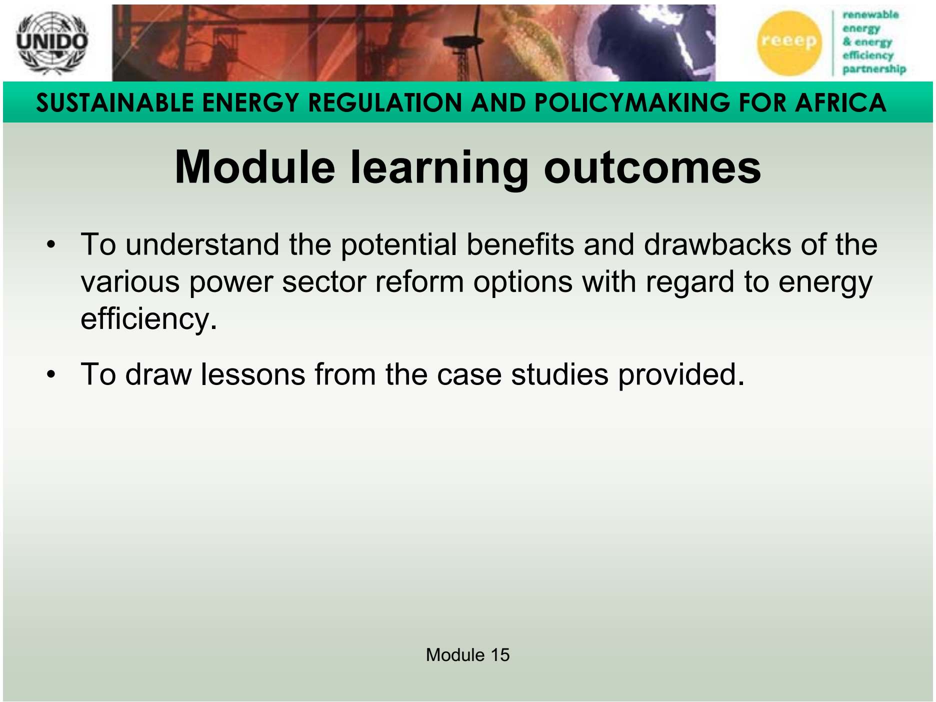


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- To highlight positive and negative impacts of reform options on energy efficiency (EE).
- To provide examples where relevant, of countries that have implemented the aforementioned reform options and the results achieved.

Module 15

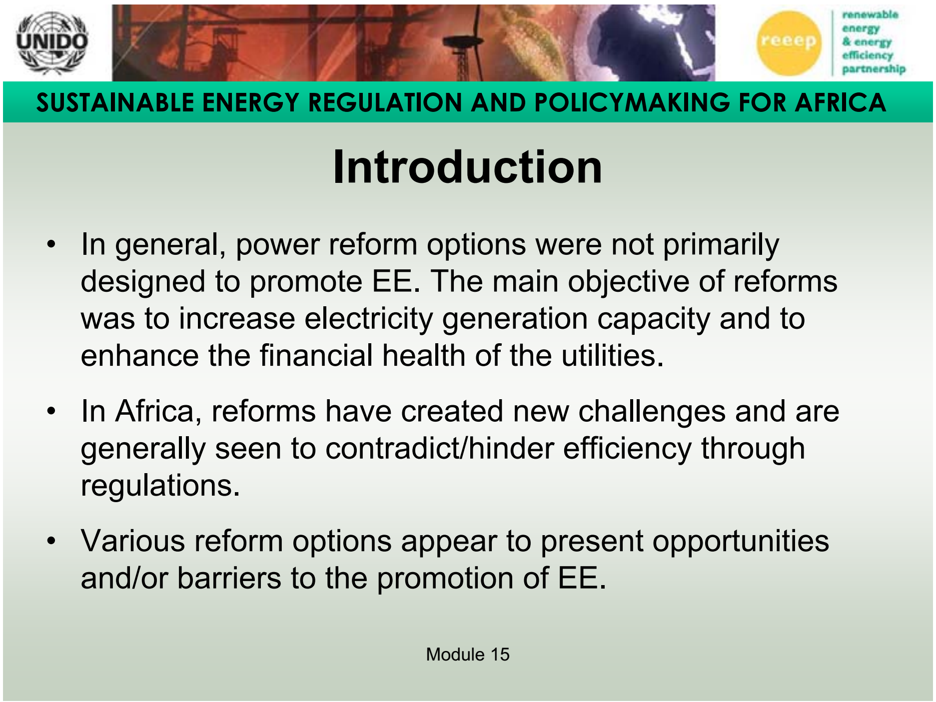


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To understand the potential benefits and drawbacks of the various power sector reform options with regard to energy efficiency.
- To draw lessons from the case studies provided.

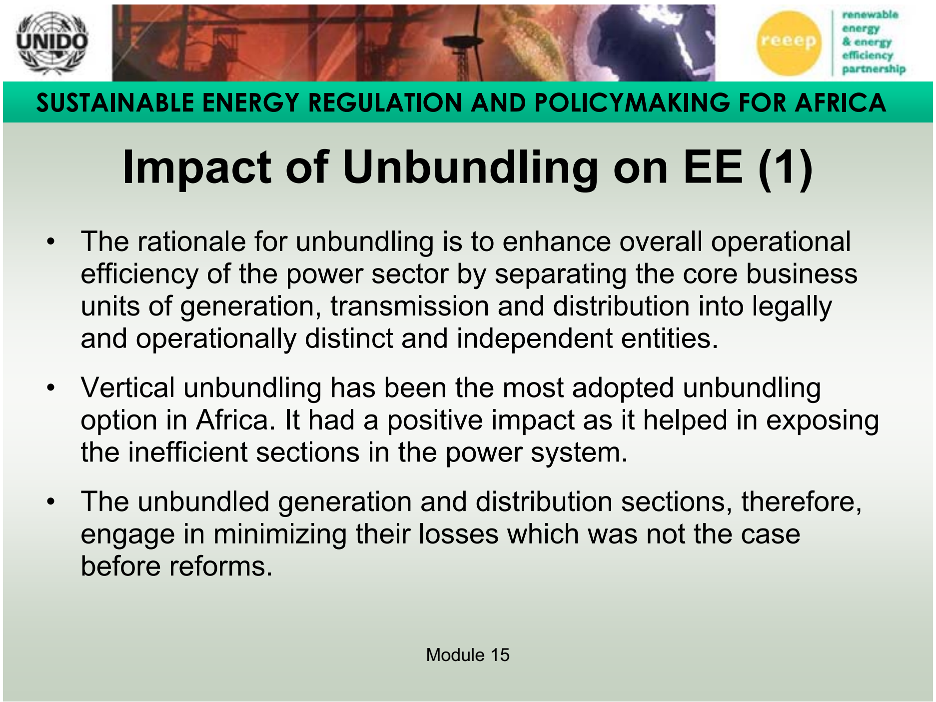
Module 15



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

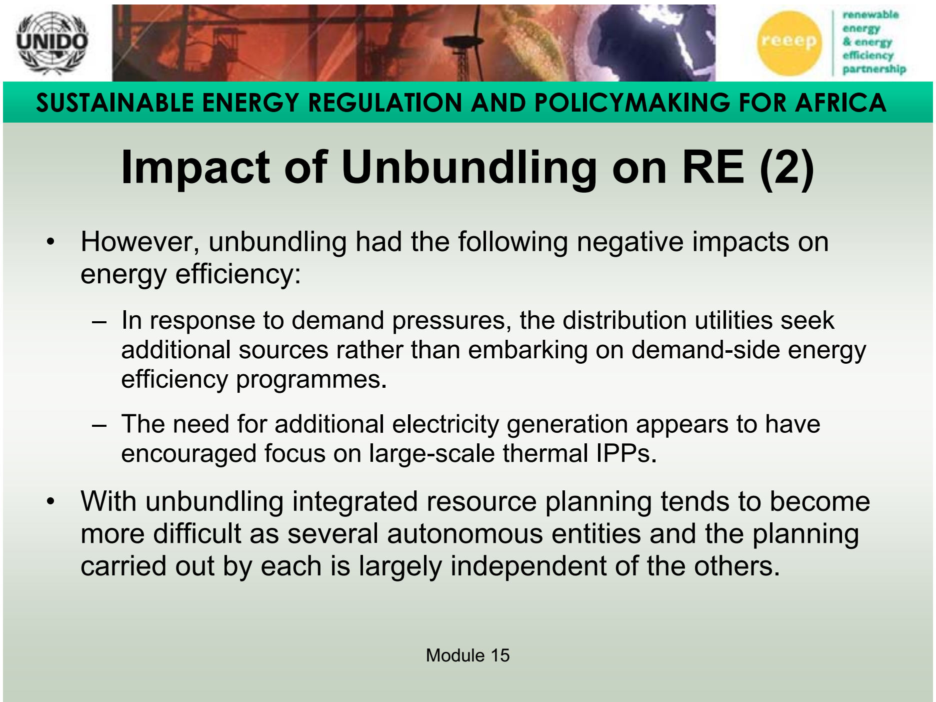
- In general, power reform options were not primarily designed to promote EE. The main objective of reforms was to increase electricity generation capacity and to enhance the financial health of the utilities.
- In Africa, reforms have created new challenges and are generally seen to contradict/hinder efficiency through regulations.
- Various reform options appear to present opportunities and/or barriers to the promotion of EE.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on EE (1)

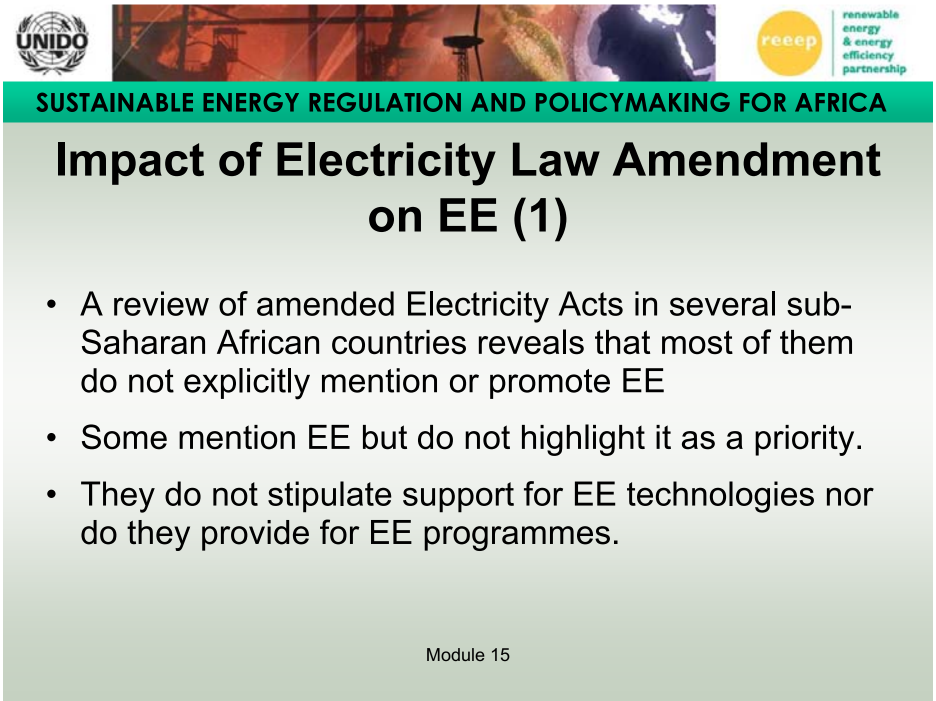
- The rationale for unbundling is to enhance overall operational efficiency of the power sector by separating the core business units of generation, transmission and distribution into legally and operationally distinct and independent entities.
- Vertical unbundling has been the most adopted unbundling option in Africa. It had a positive impact as it helped in exposing the inefficient sections in the power system.
- The unbundled generation and distribution sections, therefore, engage in minimizing their losses which was not the case before reforms.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Unbundling on RE (2)

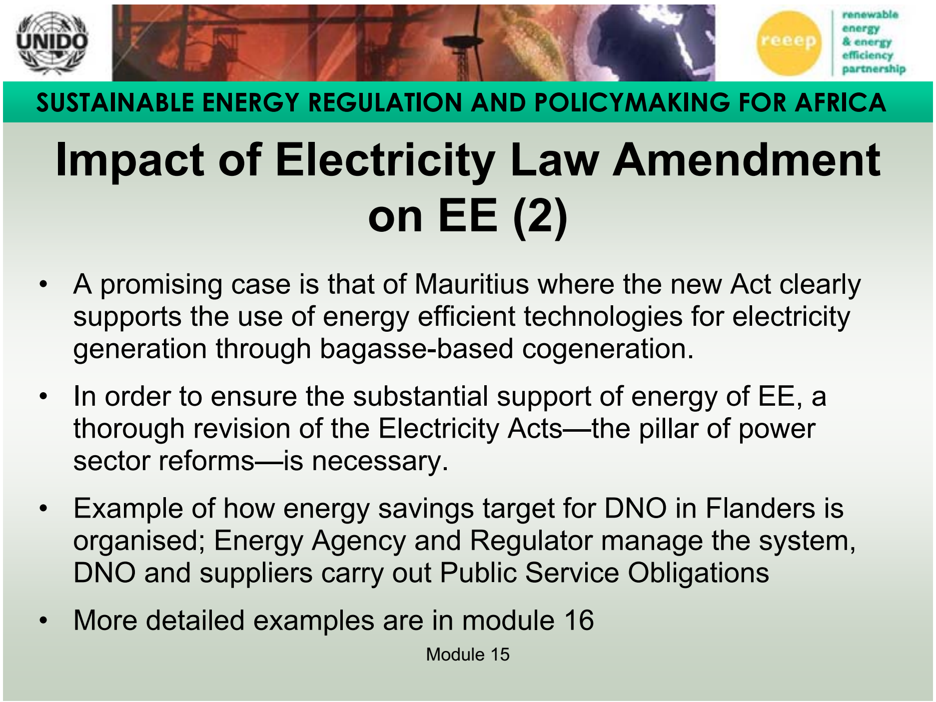
- However, unbundling had the following negative impacts on energy efficiency:
  - In response to demand pressures, the distribution utilities seek additional sources rather than embarking on demand-side energy efficiency programmes.
  - The need for additional electricity generation appears to have encouraged focus on large-scale thermal IPPs.
- With unbundling integrated resource planning tends to become more difficult as several autonomous entities and the planning carried out by each is largely independent of the others.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on EE (1)

- A review of amended Electricity Acts in several sub-Saharan African countries reveals that most of them do not explicitly mention or promote EE
- Some mention EE but do not highlight it as a priority.
- They do not stipulate support for EE technologies nor do they provide for EE programmes.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Electricity Law Amendment on EE (2)

- A promising case is that of Mauritius where the new Act clearly supports the use of energy efficient technologies for electricity generation through bagasse-based cogeneration.
- In order to ensure the substantial support of energy of EE, a thorough revision of the Electricity Acts—the pillar of power sector reforms—is necessary.
- Example of how energy savings target for DNO in Flanders is organised; Energy Agency and Regulator manage the system, DNO and suppliers carry out Public Service Obligations
- More detailed examples are in module 16

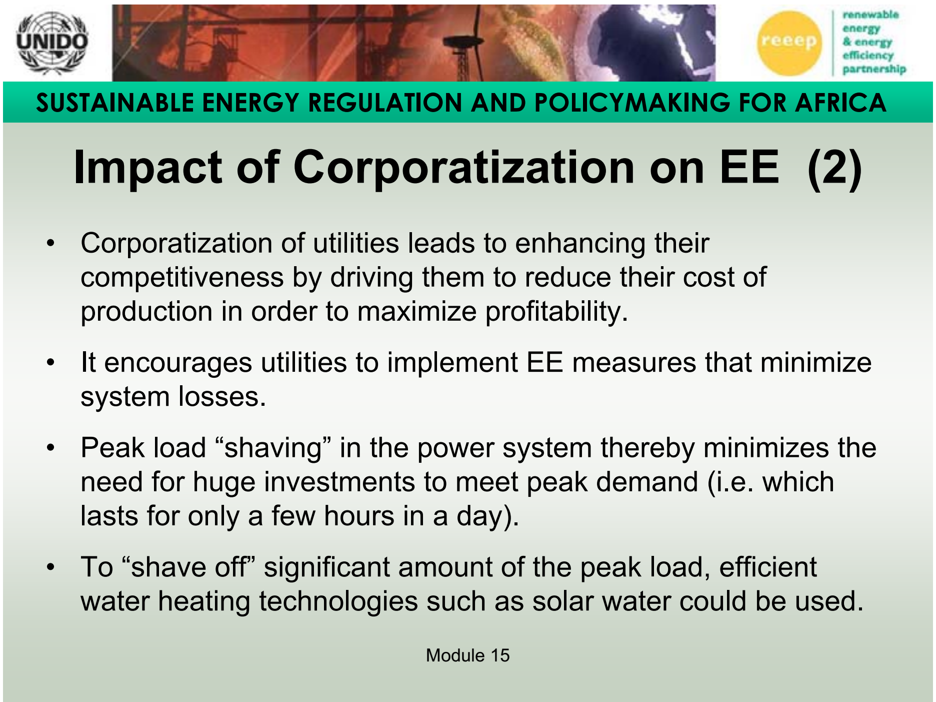
Module 15

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Corporatization on EE

- Generally the rationale for corporatization is to ensure that the utility is profitable.
- Corporatization in Africa has generally had a negative impact on EE due to its profit motive which:
  - Implies that utilities tend to avoid investments involving relatively high upfront cost.
  - Contributes to utilities in minimizing their operational costs.
- There is no motivation for the utility to enhance demand-side EE as it could lead to lower revenue levels.

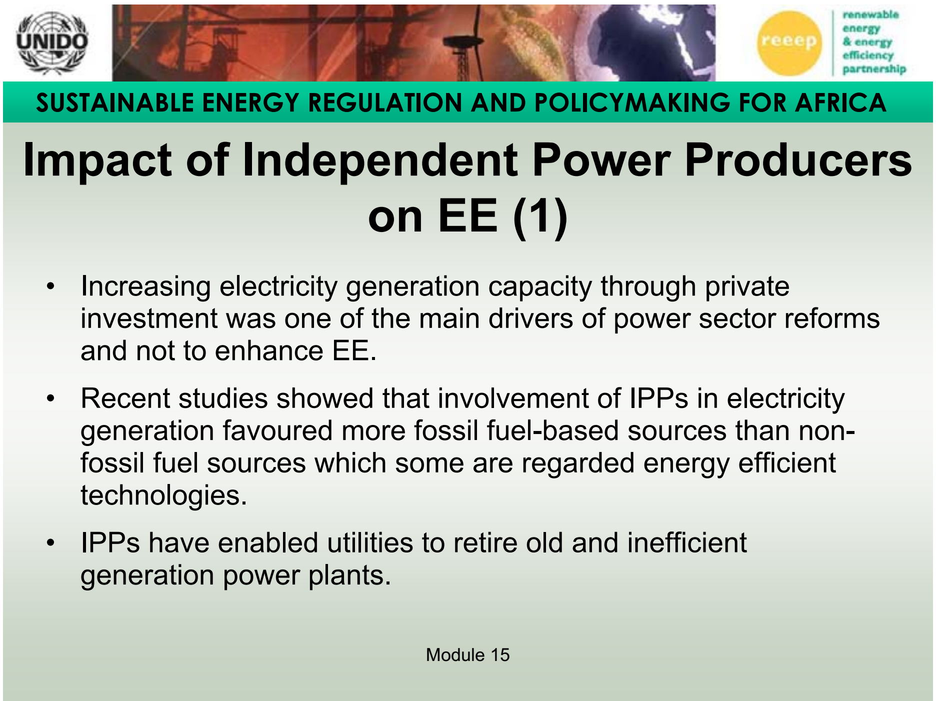
Module 15



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Corporatization on EE (2)

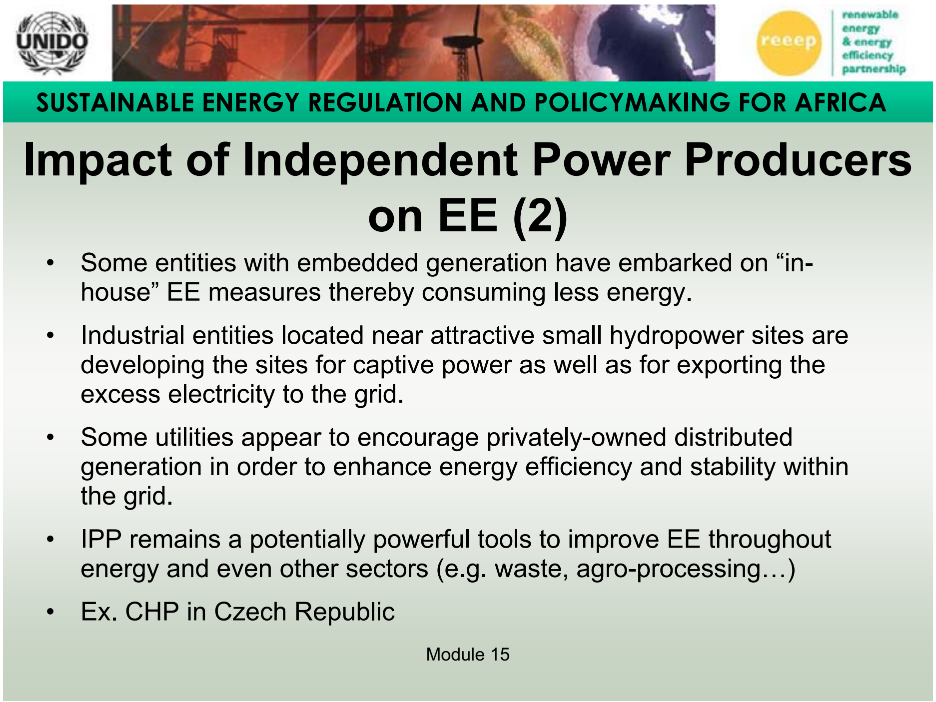
- Corporatization of utilities leads to enhancing their competitiveness by driving them to reduce their cost of production in order to maximize profitability.
- It encourages utilities to implement EE measures that minimize system losses.
- Peak load “shaving” in the power system thereby minimizes the need for huge investments to meet peak demand (i.e. which lasts for only a few hours in a day).
- To “shave off” significant amount of the peak load, efficient water heating technologies such as solar water could be used.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Independent Power Producers on EE (1)

- Increasing electricity generation capacity through private investment was one of the main drivers of power sector reforms and not to enhance EE.
- Recent studies showed that involvement of IPPs in electricity generation favoured more fossil fuel-based sources than non-fossil fuel sources which some are regarded energy efficient technologies.
- IPPs have enabled utilities to retire old and inefficient generation power plants.

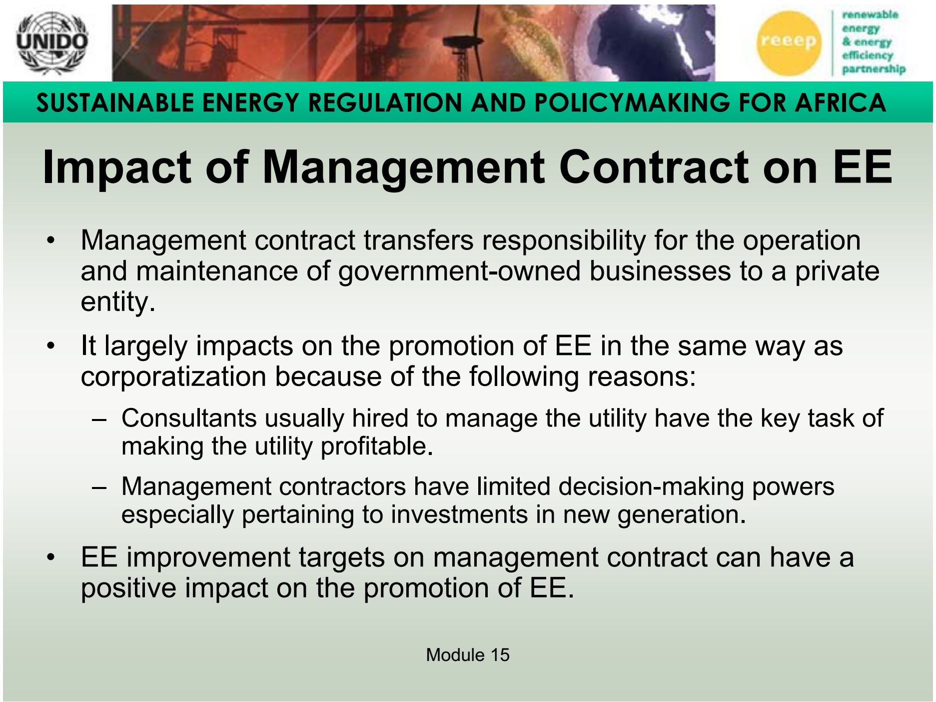


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Independent Power Producers on EE (2)

- Some entities with embedded generation have embarked on “in-house” EE measures thereby consuming less energy.
- Industrial entities located near attractive small hydropower sites are developing the sites for captive power as well as for exporting the excess electricity to the grid.
- Some utilities appear to encourage privately-owned distributed generation in order to enhance energy efficiency and stability within the grid.
- IPP remains a potentially powerful tools to improve EE throughout energy and even other sectors (e.g. waste, agro-processing…)
- Ex. CHP in Czech Republic

Module 15

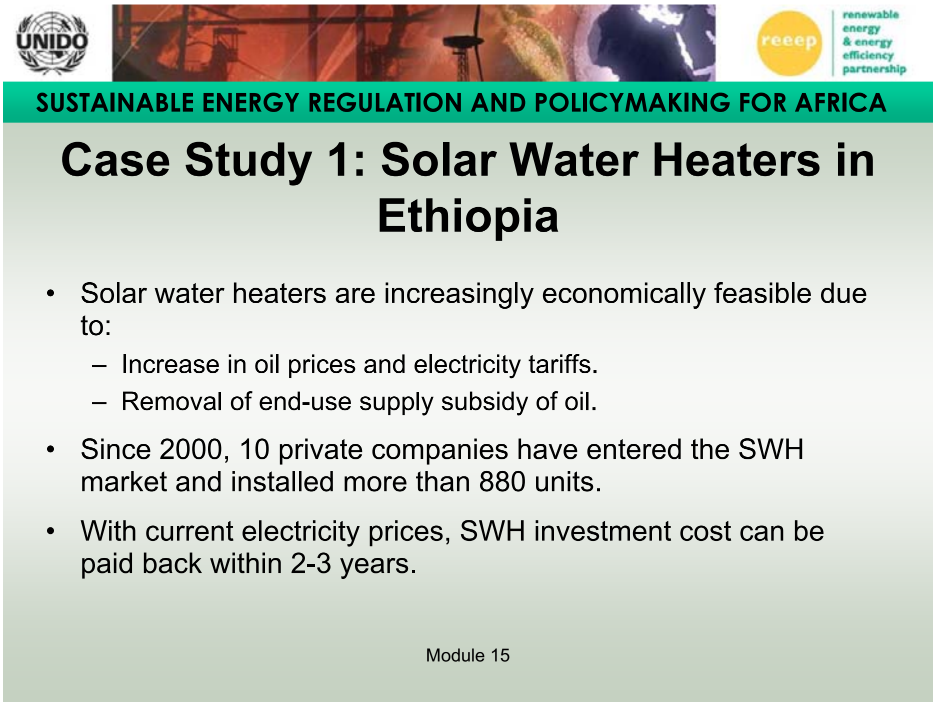


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Impact of Management Contract on EE

- Management contract transfers responsibility for the operation and maintenance of government-owned businesses to a private entity.
- It largely impacts on the promotion of EE in the same way as corporatization because of the following reasons:
  - Consultants usually hired to manage the utility have the key task of making the utility profitable.
  - Management contractors have limited decision-making powers especially pertaining to investments in new generation.
- EE improvement targets on management contract can have a positive impact on the promotion of EE.

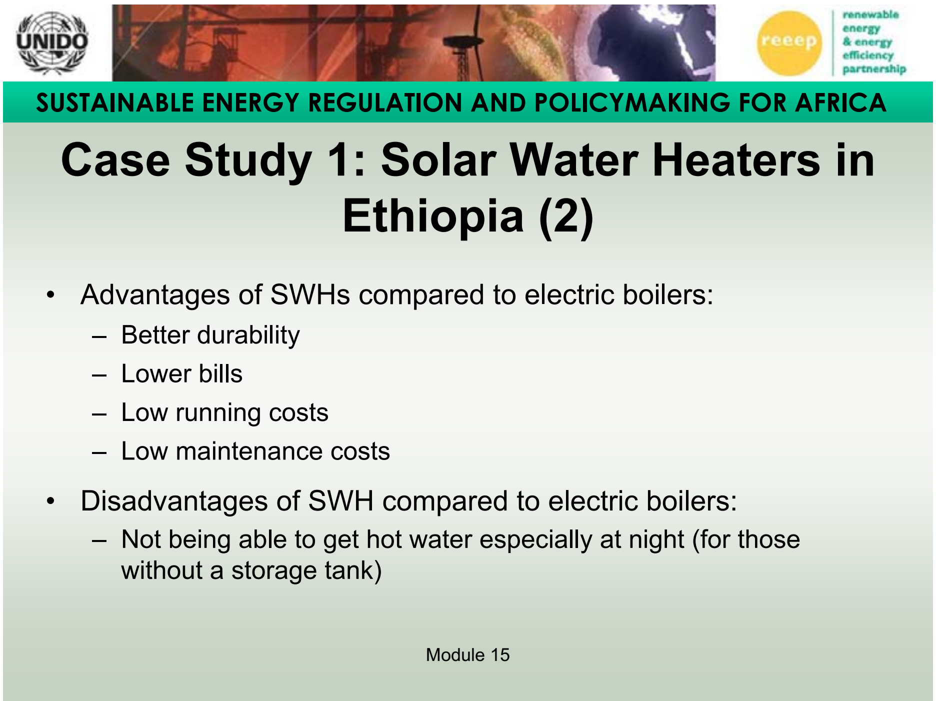
Module 15



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Solar Water Heaters in Ethiopia

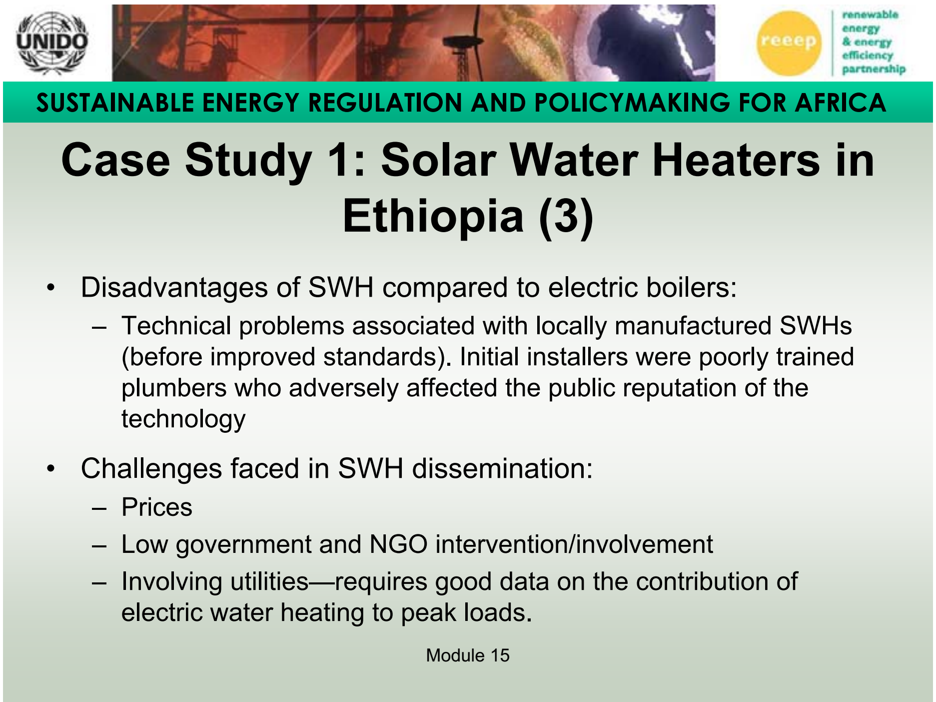
- Solar water heaters are increasingly economically feasible due to:
  - Increase in oil prices and electricity tariffs.
  - Removal of end-use supply subsidy of oil.
- Since 2000, 10 private companies have entered the SWH market and installed more than 880 units.
- With current electricity prices, SWH investment cost can be paid back within 2-3 years.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Solar Water Heaters in Ethiopia (2)

- Advantages of SWHs compared to electric boilers:
  - Better durability
  - Lower bills
  - Low running costs
  - Low maintenance costs
- Disadvantages of SWH compared to electric boilers:
  - Not being able to get hot water especially at night (for those without a storage tank)

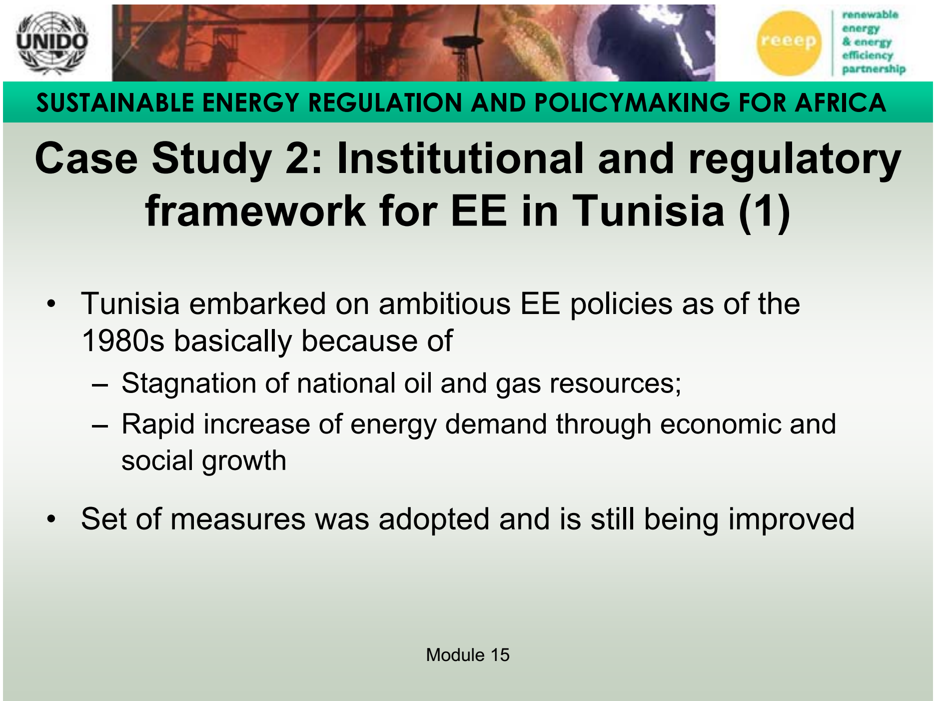


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 1: Solar Water Heaters in Ethiopia (3)

- Disadvantages of SWH compared to electric boilers:
  - Technical problems associated with locally manufactured SWHs (before improved standards). Initial installers were poorly trained plumbers who adversely affected the public reputation of the technology
- Challenges faced in SWH dissemination:
  - Prices
  - Low government and NGO intervention/involvement
  - Involving utilities—requires good data on the contribution of electric water heating to peak loads.

Module 15

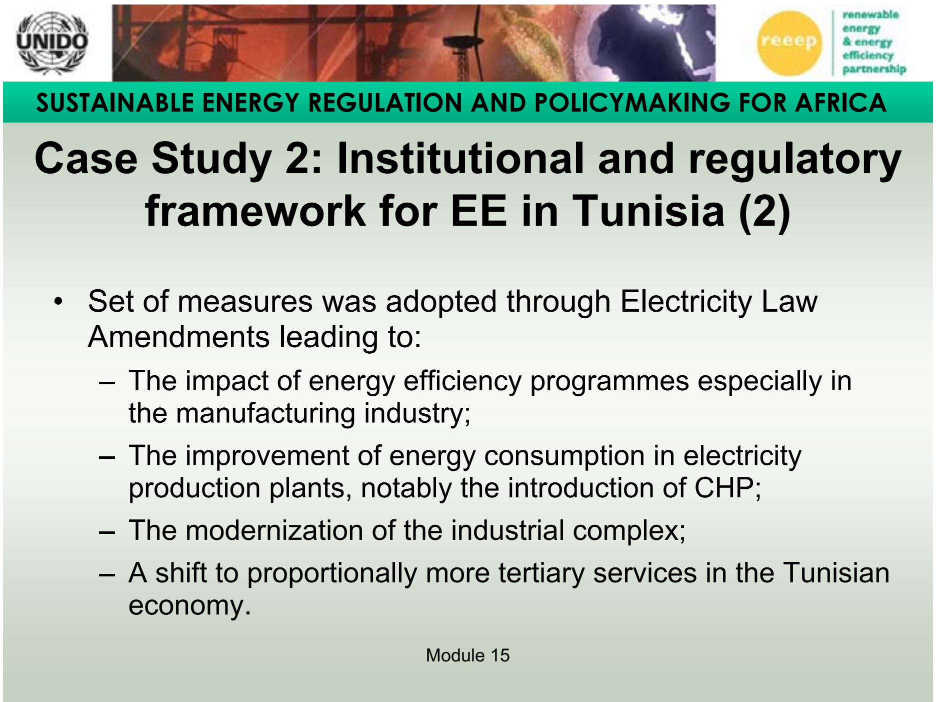


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Institutional and regulatory framework for EE in Tunisia (1)

- Tunisia embarked on ambitious EE policies as of the 1980s basically because of
  - Stagnation of national oil and gas resources;
  - Rapid increase of energy demand through economic and social growth
- Set of measures was adopted and is still being improved

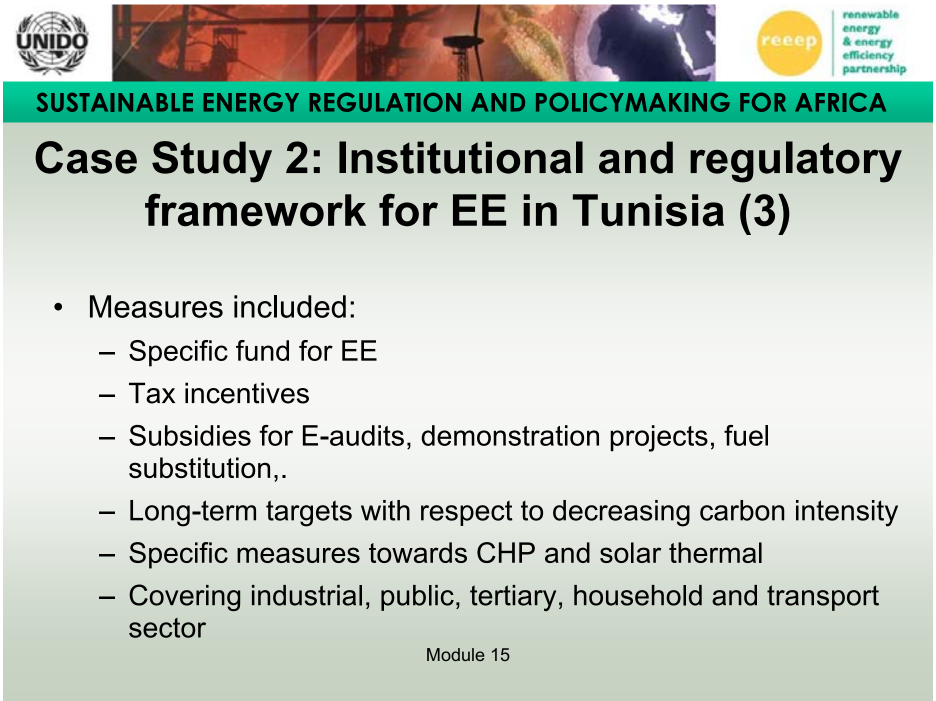
Module 15



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Institutional and regulatory framework for EE in Tunisia (2)

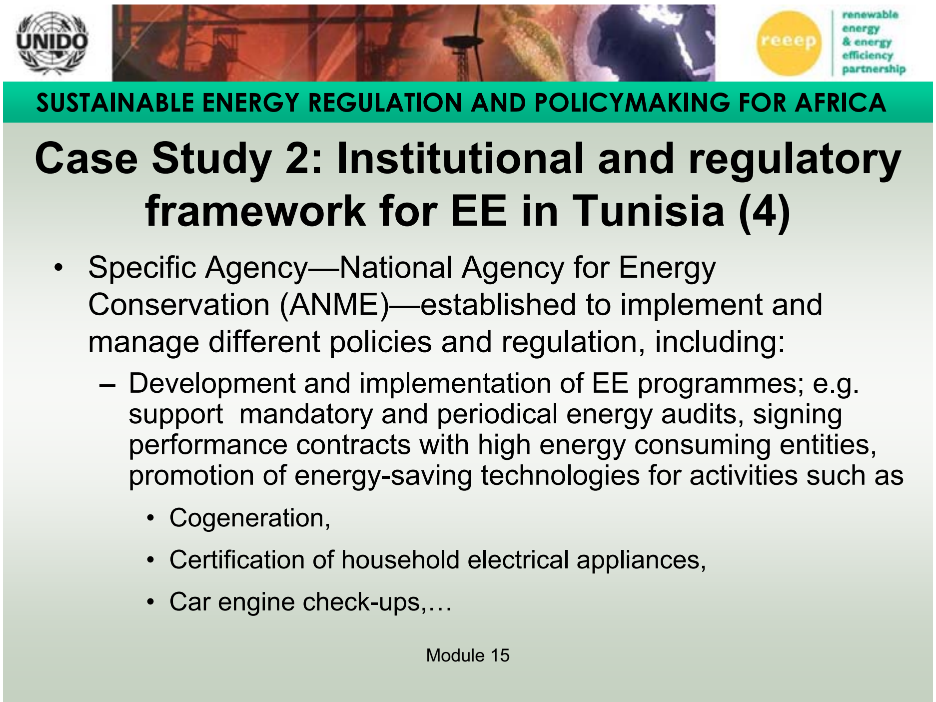
- Set of measures was adopted through Electricity Law Amendments leading to:
  - The impact of energy efficiency programmes especially in the manufacturing industry;
  - The improvement of energy consumption in electricity production plants, notably the introduction of CHP;
  - The modernization of the industrial complex;
  - A shift to proportionally more tertiary services in the Tunisian economy.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Institutional and regulatory framework for EE in Tunisia (3)

- Measures included:
  - Specific fund for EE
  - Tax incentives
  - Subsidies for E-audits, demonstration projects, fuel substitution,.
  - Long-term targets with respect to decreasing carbon intensity
  - Specific measures towards CHP and solar thermal
  - Covering industrial, public, tertiary, household and transport sector

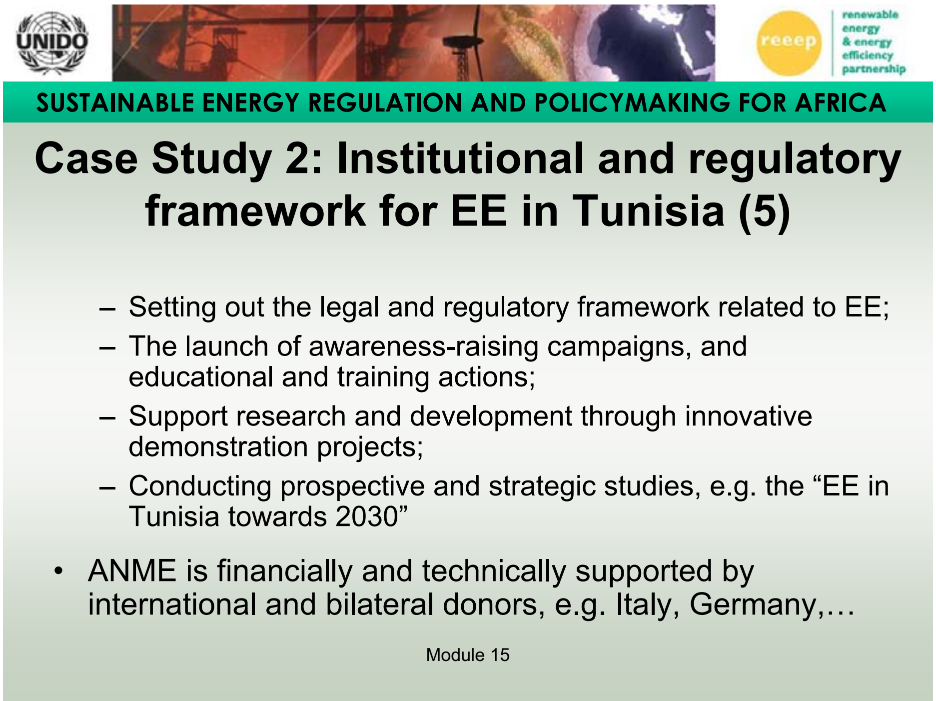


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Institutional and regulatory framework for EE in Tunisia (4)

- Specific Agency—National Agency for Energy Conservation (ANME)—established to implement and manage different policies and regulation, including:
  - Development and implementation of EE programmes; e.g. support mandatory and periodical energy audits, signing performance contracts with high energy consuming entities, promotion of energy-saving technologies for activities such as
    - Cogeneration,
    - Certification of household electrical appliances,
    - Car engine check-ups,…

Module 15

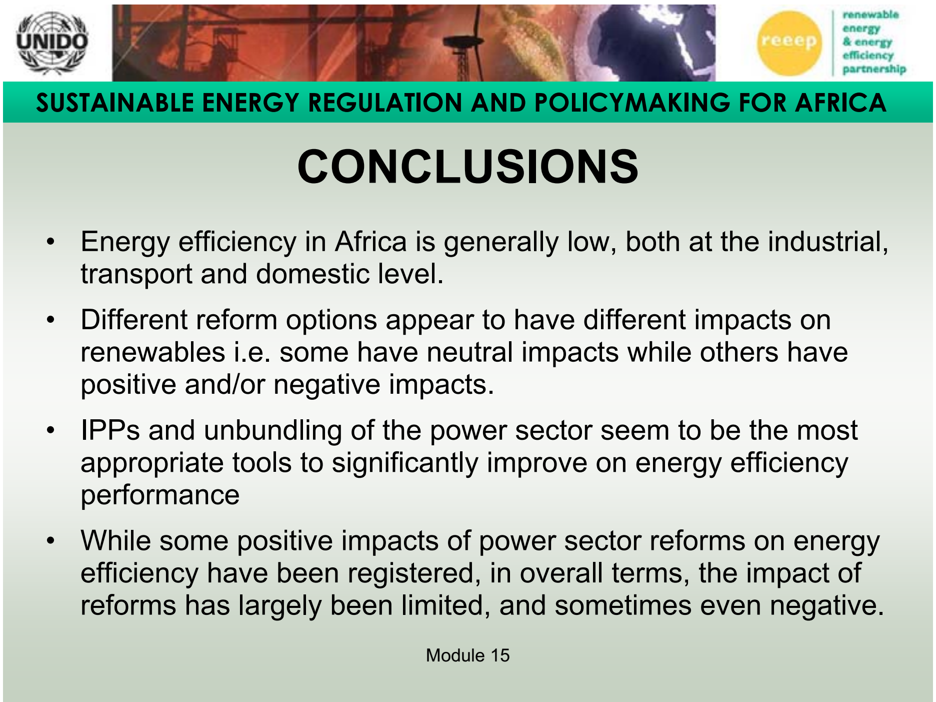


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Case Study 2: Institutional and regulatory framework for EE in Tunisia (5)

  - Setting out the legal and regulatory framework related to EE;
  - The launch of awareness-raising campaigns, and educational and training actions;
  - Support research and development through innovative demonstration projects;
  - Conducting prospective and strategic studies, e.g. the “EE in Tunisia towards 2030”
- ANME is financially and technically supported by international and bilateral donors, e.g. Italy, Germany,…

Module 15

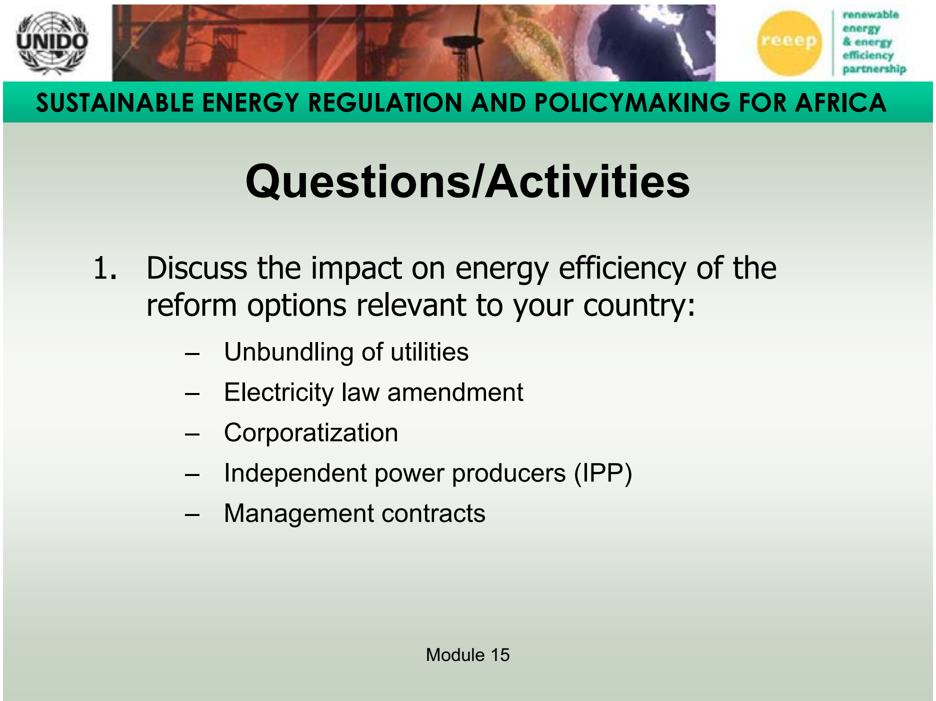


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Energy efficiency in Africa is generally low, both at the industrial, transport and domestic level.
- Different reform options appear to have different impacts on renewables i.e. some have neutral impacts while others have positive and/or negative impacts.
- IPPs and unbundling of the power sector seem to be the most appropriate tools to significantly improve on energy efficiency performance
- While some positive impacts of power sector reforms on energy efficiency have been registered, in overall terms, the impact of reforms has largely been limited, and sometimes even negative.

Module 15



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

1. Discuss the impact on energy efficiency of the reform options relevant to your country:
    - Unbundling of utilities
    - Electricity law amendment
    - Corporatization
    - Independent power producers (IPP)
    - Management contracts

Module 15

Module 16

Regulatory and policy options to encourage energy efficiency

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This module seeks to provide an understanding of the regulatory approaches and policy measures that could encourage higher levels of energy efficiency in the energy system. Some of the suggested approaches and measures would have immediate short-term impacts whereas others would have to be part of a long-term energy efficiency strategy.

1.2. Module aims

This module aims:

- To introduce the concept of regulation—or regulatory oversight—in terms of its impacts on energy efficiency.
- To show how regulation and policy measures can be used to encourage increased levels of energy efficiency in the energy system.
- To outline the steps in introducing a more conducive regulatory and institutional environment for energy efficiency interventions and management.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to define what is meant by regulation in relation to energy efficiency.
- To understand how regulatory systems operate and how they can be used to encourage higher levels of energy efficiency in the energy system.
- To understand how policy measures can be used to encourage higher levels of energy efficiency.
- To describe an approach to introducing and applying a more progressive regulatory environment for energy efficiency.
- To understand energy regulation and the regulatory and policy mechanisms for encouraging improved levels of energy efficiency.

2. INTRODUCTION

This module intends to provide information and understanding of what energy regulation is, how it operates and how it can impact on energy efficiency in the energy system. The module will also cover some of the policy measures that could encourage higher levels of energy efficiency. The module will start with an introduction to the concept of regulation (or regulatory oversight) in terms of its possible impacts on energy efficiency.

2.1. Why regulation?

The energy sector requires significant long-term investment to develop the supply and distribution infrastructure required to provide the energy services expected by customers—both large and small. This investment is motivated on the basis of social and economic goals—usually at a national level—and consequently some degree of risk management is required to ensure the long-term security of the investment.

This is particularly the case when public funds are used for investment or for under-writing the investment. Similarly, customers seek assurance that the energy services, which they desire, will be available in an orderly and consistently priced manner. Consequently, it is important that the operation and management of the energy sector is conducted in a stable and predictable manner. Regulatory oversight of the energy sector has evolved over time to protect and manage the interests of all stakeholders in the sector—primarily those of the investors (including governments) and customers.

Energy regulation is also closely linked to energy policy, planning and strategies for implementation. It is also linked to the financial and economic status of the environment in which the energy services are provided.

2.2. Who regulates for energy efficiency?

Energy regulation is primarily provided by one (or more) statutory and independent organization(s)—usually called a national energy regulator—which is established by national law and which is accountable to parliament.

It is often the case that there may be multiple regulators, one per sector, such as an Electricity Regulator and, in addition, a Liquid Fuels (and Gas) Regulator. Clearly, this implies a need for good communication and cooperation between these separate regulators to achieve consistency and efficiency in regulation. In addition, energy regulation is also affected by local government by-laws and guidelines. Finally, typical key players are the transmission system operator (TSO) and the distribution system operators (DSO).

Regulatory oversight for energy efficiency often straddles these different domains of regulation and it is often overlooked as a priority by the different regulators (electricity, fuels, and gas). Ideally, energy efficiency should be dealt with through a coordinated approach between the different sectors. In reality this is often hard to achieve.

In different countries, regulation is provided in different forms and with different levels of regulation depending on the state of development (and needs) of the energy sector.

In the early stages of market development, the levels of regulation are generally fairly minimal and loosely administered. The national energy regulator is usually answerable to the parliament or to the Ministry of Energy.

Overall, in Africa the establishment of regulatory oversight is still relatively poorly developed. This is also true in the energy sector. The African Forum for Utility Regulation (AFUR) is an organization aiming to build capacity in African regulators, including energy and electricity regulators, and assists in information dissemination and training amongst other activities.

2.3. How is regulation funded?

There are usually three main avenues for funding energy regulation. These are either through a direct budgetary line from the central government to the regulatory agency, through licensing fees from the organizations being regulated (supply, distribution and transmission licences) or through means of a levy charged at the point of consumption. Often, a combination of these approaches is used to fund the regulatory institution.

A fixed annual budget direct from central government has the advantage of a guaranteed level of funding for the regulator but the disadvantage of possible political pressure on the regulator. Licensing fees from the regulated organizations can supplement the government budget. More often than not, the costs of administration and regulation are provided for by means of a levy—or surcharge—which is charged at the point of consumption in the energy service supply chain, i.e. the meter or pump. This cost is finally borne by the customers.

In the case of developing countries, a regulator is often established with financial assistance from a multilateral or bilateral donor. This external financing is used to set up the physical infrastructure of the regulator (offices, equipment) and to hire the core team of staff. Once the regulator has been set up with external assistance, funding for its on-going operation is usually derived from one or a combination of the sources mentioned above. Sometimes international financial assistance is also provided for capacity building and training activities for the regulator staff.

2.4. How can regulation and policy affect energy efficiency?

It is generally accepted that there is a huge potential to improve energy efficiency in a cost-effective way. Yet different sectors such as households and industry frequently do not implement these measures. The main reasons for not making the financial and energy savings are a lack of technical capacity, a lack of capital and lack of an appropriate regulatory framework.

As the possible benefits are often not clearly visible on a single household, company or sector level, it is the role and responsibility of regulations and policies to provide the necessary framework and the required incentives to increase energy efficiency in the different economic sectors.

3. INSTITUTIONAL CONSIDERATIONS

For regulation and policy to be effective the necessary institutions to implement actions in a country must be in place. Usually this means a regulatory agency or body must be established often assisted at the national level by ancillary organizations such as Energy Advice Centres (as in the United Kingdom) or Energy Efficiency Centres (such as the Energy Foundation in Ghana).

3.1. International and regional bodies

As introduced above, regulatory oversight is usually provided by a national institution or a number of different institutions (or regulatory agencies) and will cover all the energy sectors (power, fuel, gas, etc.). These institutions can be assisted at the regional and international level by umbrella organizations or associations that provide other valuable services that can enhance the skills and capabilities of national regulators. The matrix below gives some typical international and regional institutions and their main activities.

Table 1. International and regional institutions related to regulation and energy efficiency

Level	Examples of institutions	Types of services provided
International	Centre for Analysis and Dissemination of Demonstrated Energy Technologies (IEA/OECD) www.caddet.org International Energy Agency Demand Side Management Programme http://dsm.iea.org	• Exchange of information on new, cost-effective technologies that have been demonstrated in applications such as industry, buildings, transport, utilities and agriculture • Provide case studies • Access information on best practice • Facilitate countries working together to promote energy efficiency measures
Regional	African Forum for Utility Regulation (AFUR)[a] www1.worldbank.org/afur/ Regional Electricity Regulators Association of Southern Africa (RERA)[b] www.rerasadc.com	• Provide advice on regulatory issues • Provide case studies • Access information on best practice • Capacity building services • Organize regional forums • Work towards harmonization of regional standards

[a] The African Forum for Utility Regulation (AFUR) was established by African Utility Regulators—with support from the World Bank and PPIAF—to promote the development of effective utility regulation within Africa. AFUR seeks to do this by facilitating the exchange of information and lessons of experience between regulators.

[b] The Regional Electricity Regulators Association of Southern Africa (RERA) is a formal association of independent electricity regulators which provides a platform for effective cooperation between independent electricity regulators within the Southern African Development Community region.

3.2. Energy Advice Centres

Energy Advice Centres operate usually on a local level and their principal role is to raise awareness and provide advice on energy efficiency towards different sectors and the public. This mainly consists of organizing information campaigns (through media campaigns, street posters, flyers, etc.) and providing independent and personalized advice to the public (via a call centre, a website, an email account, appointment with advisor, etc.).

Energy Advice Centres are often (governmental) energy agencies, or non-profit organizations funded by the government and/or the private sector. Wherever more appropriate, this task can be carried out by the energy regulator or the transmission/distribution company.

For example in Ghana, the Energy Foundation Ghana is a non-profit, public-private partnership institution, devoted to the promotion of energy efficiency and renewable energy, as a key strategy to managing Ghana's growing energy needs in a sustainable manner.[1] The Energy Foundation provides consumers with relevant information on the energy efficiency of common household appliances. In order to increase awareness on energy efficiency and the cost reduction potential, an online tool is offered to calculate the electricity bill both for a residential and a non-residential customer.

In the United Kingdom, Energy Advice Centres raise awareness on energy efficiency and offer a range of services for households and schools, including general energy saving tips, financial advice on how to fund energy efficiency improvements, free posters and energy education packages, and energy audit information.[2] Specifically aimed at low-income households, an "Affordable Warmth Action Plan" was introduced to fight fuel poverty and achieve affordable warmth, helping people to look into which grant aid may be available to upgrade existing systems and reduce their fuel bill.[3] The Housing Energy Efficiency Best Practice programme offers advice, training and publications in best practice technologies and methods in house building and refurbishment to house builders, designers and architects on the range of energy efficiency options in home.

As outlined in the examples above, Energy Advice Centres are able to target different sectors, design according actions as well as address cross-cutting issues. They ideally promote local initiatives and work with key local partners to raise the profile of energy efficiency in their area, having a close relationship with the local authorities.

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[1] www.ghanaef.org, see box 1. for more information

[2] www.energy-advice.co.uk

[3] National Energy Action, www.nea.org.uk

3.3. Energy regulators

Most countries in a liberalized or in the process towards liberalized energy markets, introduce a regulatory authority, further called the regulator. The overall mission of the regulator is:

- To guarantee the non-discriminatory, competitive and efficient functioning of the market;
- To bring transparency to the energy market in terms of grid access, tariff setting and the procurement of balancing power;
- To provide appropriate and efficient mechanisms for regulation, control and transparency in order to avoid misuse of a dominant position, which could undermine the proper functioning of the market and harm the interests of the end consumer.

The concrete tasks following from these principles include:

- The assessment of the short, mid- and long-term future infrastructure and network needs for both electricity and gas;
- The calculation of tariffs for transmission and distribution grid operators;
- The elaboration of the conditions and the procedure for submission, examination and approval of supply licences;
- The organization of stakeholder consultations;
- The conducting of surveys to compare the price and quality of offered energy services;
- The formulation of recommendations for national government to adopt new or improve existing policy instruments.

In terms of renewable energy and energy efficiency, the regulator usually operates the support system (management of the green certificate or feed-in database), controls the fulfilment of public service obligations (e.g. for instance a specified energy savings target or the provision of minimal energy services) and collects fines when obligations or targets have not been met.

In order to be able to set up an energy savings target, minimum requirements include:

- The availability of energy consumption data per targeted sector: e.g. households, non-households, consumers connected directly to the transmission grid, consumers connected to the distribution grid, energy-intensive industry and small and medium enterprises. This type of information is required in order to be able to define realistic, possibly differentiated per sector or gradually increasing, energy savings targets.

- A team of experts (per sector) capable of evaluating the proposed actions, calculating the energy savings per action and improving the instrument over time.

As was pointed out in module 2, the electricity sector in most African countries is generally only partly liberalized, if at all, and typical regulatory authority do not generally exist. On the other hand most of the roles as described above could be carried out by other organizations, depending on the existing authorities and expertise in a given country. For instance, the national government could impose an energy savings target on grid operators and authorize one of its ministries (Ministry of Energy, Industry or Environment) to manage the system. Environmental regulators could be handed the authority to control certain actions and non-governmental organizations could be included to carry out stakeholder consultations and surveys.

3.4. Main target sectors for energy efficiency policy and regulation

Which appropriate policy or regulatory mechanisms to apply depends significantly on the sector or target groups at which it is aimed. Roughly four sectors could be distinguished, as these are usually the top four energy consumers in any given country:

- Industry
- Households
- Transport
- Offices and buildings

The following section will describe, on a per sector basis, how policies in general are designed, and where this might be relevant or offer opportunities for sub-Saharan countries.

4. POLICY OPTIONS FOR INCREASING ENERGY EFFICIENCY IN TARGETED SECTORS

4.1. Industry

Fiscal incentives

Fiscal incentives are an effective means to stimulate companies to realize energy conservation projects in their organization.

In China these fiscal policies included loan payment before tax, three-year product tax and value-added tax exemption for new energy conservation products, import duty reduction and exemption for energy conservation technology and equipment introduction. The state budget made special allocation for an energy conservation infrastructure construction fund and energy conservation technical renovation fund. These special funds enjoyed the preferential policy of reduced interest loans and loan payment before taxation. See case study 3: China's Energy Conservation Policy for more detail.

In Japan the "Energy Conservation Assistance Law" sets out financial incentives for energy conservation in the form of tax exemptions, low-interest financing and industrial improvement bonds to support approved voluntary efforts by business operators and building owners for energy conservation. See case study 1: Japan—Overview of Energy Efficiency Measures for further details.

In Flanders part of the investment to improve energy efficiency in industrial processes is allowed to be deducted from the taxable income of the company (13.5 per cent).

Energy efficiency targets

Energy efficiency targets can be imposed on or agreed with the energy intensive industry.

For instance in Flanders, the so called benchmarking covenant was agreed between the government and industry, with the aim of benchmarking the energy performance of a given site with the best performing similar site in the world. As such, the companies committed themselves to work towards the best international standard by 2012, taking into account that the best standard will improve in the meantime. The government from its part guaranteed not to impose other measures to these companies, as for instance an energy or CO_2 levy.

Experienced consultants perform the benchmark study of a specific site. Therefore it is often necessary to split up the site into its different process installations, being as such different units to be benchmarked separately.

The participant proposes an Energy Plan, which contains all the necessary measures to tend towards, and maintain the best international standard. The terms to realize these measures are defined by the covenant, based on economic efficiency. Once approved and started, the industry will annually draw up a monitoring and progress report. The covenant currently has a working period up to 2012.

In Japan, a similar approach was used for product standards; under the Top-Runner Scheme, the best performing items in their category in the market set the minimum standard for a target year.

The programme originally covered 11 items, and has since been extended to 18 items including cars, refrigerators, air conditioners, televisions, copy machines, etc. If a company cannot achieve the target by a target year, then its name and the product name are made public, and a fine has to be paid. However, compliance is evaluated not based on each product, but on products in the same category.[4]

The Top-Runner Scheme has significantly contributed to energy conservation of machinery and equipment in Japan. It worked especially well for gasoline passenger cars. See case study 1: Japan—Overview of Energy Efficiency Measures for further details.

EU emissions trading scheme

Following the EU ETS Directive[5] the major energy intensive industries in Europe were obliged to decrease their CO_2 emissions. The system is designed as a so-called cap and trade system: the amount of CO_2 to be emitted is capped (per sector, plant or installation), and the CO_2 emission reductions are tradable, meaning that plant owners can decide to either reduce their CO_2 emissions, or buy CO_2 emission reductions, whichever is cheaper.

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[4] Current Japanese climate policy from the perspective of using the Kyoto mechanisms, www.iges.or.jp

[5] Directive 2003/87/EC of the European Parliament and of the council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, commonly called EU ETS Directive (ETS = European Trading Scheme), eur-lex.europa.eu

Financial sanctions for non-compliance are imposed (40 €/ton CO_2 in 2005-2007/ 100 €/ton CO_2 from 2008). The obvious/cheapest way to decrease CO_2 emissions is to increase the energy efficiency of the plant/installation.

The EU ETS essentially is a means to internalize the cost of CO_2 emissions into the electricity price so as address the failure of economical markets in reaching the social optimum, and could in essence even be called a taxation instrument. The EU ETS system is designed to achieve this reduction in the most cost-effective way, by allowing trade of emission reductions so the reductions are achieved where they are cheapest. As such, this system implies a correction of the market but remains a "market-based" instrument, compatible with the existing market.

Naturally in Africa, the reduction of CO_2 emissions does not have the same priority as in Europe. On the other hand, were it not for the CO_2, a similar system could still be introduced in order to stimulate or oblige market players to carry out investments they would not carry out in an uncorrected market. It basically comes down to giving the CO_2 or the saved energy a price or value (through a fine when the target is not achieved), and then allowing the market players to achieve the target as they wish.[6]

Essentially the same principle of creating a financial value for a thus far unvalued good (e.g. CO_2 or energy savings) is applicable in Africa. This might especially be worth considering for energy savings, as a means to stimulate industries in carrying out the investments, which will save them money over time. When considering the adoption of such a scheme, in parallel the issue of upfront costs will need to be addressed, by means of soft loans, additional funds or investment money, as the one without the other would not be effective in an environment short of money in the first place.

Link with the Clean Development Mechanism

An immediate opportunity of the EU ETS system for developing countries lies in the possibility for industrialized countries to invest (money and technology) in energy efficiency measures in developing countries, claiming the CO_2 emission reductions. This system is called the Clean Development Mechanism (CDM) and is one of the flexible mechanisms within the Kyoto Protocol—the EU ETS is linked to CDM through the Linking Directive.[7]

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[6] This is the cap and trade principle, as used in the EU ETS, but also in green certificate quota systems (where it is not a cap but a target) and potentially in policies imposing energy savings targets, although the "trade" aspect is usually not operational (yet), but could be in the future in the form of white certificates.

[7] Directive 2004/101/EC of the European Parliament and of the council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, eur-lex.europa.eu

As is currently shown in Brazil, China and India, CDM can actually facilitate investments in more efficient energy infrastructure by creating an extra value through the selling of CO_2 emission reductions to industrialized countries.

When carefully designed, CDM project/programmes could trigger and support other policies in a developing country, e.g. local employment, poverty reduction, gender policies etc. While the actual potential for CDM projects in a given country highly depends on a range of criteria (e.g. type of existing electricity generation infrastructure, economic and political situation), the possibility deserves consideration.

Small and medium sized companies

Where the described EU ETS scheme includes only the major industry sectors, comparable policy schemes are likely to be adopted in the future for medium and small companies to comply with.

A possible means is a public agreement between given sectors and the government, where the sector commits itself to reduce CO_2 emissions (by a certain percentage in an agreed time frame), and where on the other hand the government commits itself to providing favourable investment conditions and/or the promise not to impose other policy obligations (e.g. a CO_2 tax) in the future. Examples are the Climate Change Agreement[8] in the United Kingdom and the Benchmark Covenant[9] in Flanders (Belgium).

4.2. Households

A number of policies is available to increase energy efficiency on household level, either directly or indirectly.

Direct policy measures

Energy efficiency technologies generally require higher initial investment costs, while the financial benefit (through lower energy bills) only comes in later. Even when the paid back period is just a few years, the higher initial investment might make people choose the cheaper (less efficient) technology.

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[8] www.defra.gov.uk/environment/ccl/index.htm

[9] www.energiesparen.be

In order to decrease the barrier of higher initial investment, the government can foresee specific tax incentives, investment subsidies or soft loans. A tax incentive includes that (a percentage of) the investment can be deducted from the tax bill. An investment subsidy implies that a certain percentage of the investment cost of the given technology is provided—usually by a direct capital grant for a percentage of the cost. This percentage should equal the extra cost of the more efficient technology compared to the classic technology. The eligible amount to deduct/subsidise can be differentiated according to the technology.

Indirect policy measures

Actions aiming directly towards households are often complemented by regulations, on a level surmounting the individual household level. This happens when the government defines an energy savings target for the distribution system operator (DSO) to comply with, as part of its public service obligations. For instance if a government sets a target for DSOs to save 1 per cent of their yearly supplied energy, this means a DSO supplying 5000 GWh per year to end-consumers needs to save 50 GWh (1 per cent of 5000 GWh) for the coming year.

It is then up to the DSO to decide which specific actions and regulations towards different target groups are most appropriate to get to the target. Usually the actions are put together in an action plan that is discussed between the DSO and the government. The DSO claims its expenses by an increase of the distribution tariff, to be agreed by the Energy Regulator.

Over the past decades this system has been quite successful in Denmark, keeping Danish energy consumption static since 1980, despite economic growth of around 3 per cent during the last decade. A similar system was introduced in 2003 in Flanders (Belgium) and can be generally evaluated as successful as all network managers reached their target in 2003 and in 2004 (except one grid operator), and the target was reached with less budget than initially planned. As from 2008, the targets will be increased to 2 per cent for households, and 1.5 per cent for non-households. These policies are usually managed by the Energy Agency. In the case of Flanders the roles of the regulator apply to the start of the legal procedure for the collecting of the fines if the targets are not achieved, and to check whether the costs of the Public Service Obligation are incorporated correctly in the electricity tariffs.

These policies are described in detail in the case studies 4 and 5 for Denmark and Flanders respectively.

It is arguable whether this kind of policy should be called a supply or a demand-side measure. The DSO is acting on the supply-side, but as the actions are targeting end-consumers, it also involves demand-side management. The matter is therefore mentioned in the section on supply-side management options, specifically when explaining a market mechanism with which to reach a given target, i.e. white certificates.

Another policy measure is the setting of energy efficiency targets for domestic electric appliances such as refrigerators and air-conditioning systems. The corresponding regulations are usually standards and labels (see also under Regulatory Options: Demand-Side Management—Standards and Labels). An example of standards and labels in a sub-Saharan Africa setting is described in box 1.

Box 1. Industrial energy efficiency standards and labelling regulations in Ghana

In collaboration with the Ghana Standards Board and with financial support from the United Nations Department for Economic and Social Affairs (UNDESA), the Energy Foundation has developed energy efficiency standards and labelling regulations for non-ducted air conditioners or self-ballasted fluorescent lamps, being manufactured in or imported to Ghana. The initiative aims to impose minimum performance requirements, to provide consumers with relevant information on the energy efficiency of common household appliances, and to avoid Ghana becoming a dumping ground for inefficient appliances.

It is stated that only air conditioners that meet a minimum energy efficiency ratio (EER) of 2.8 watts of cooling per watt of electricity input, and compact fluorescent lamps that have a minimum service life of 6,000 hours and minimum efficacy of 33 lumens per watt will be allowed into the country.

This initiative began in 1998 and was formalized by the Minister responsible for energy on 2nd June 2005. The energy efficiency standards and labelling regulations were approved by Parliament in February 2006 and can be downloaded from the website of the Ghana Energy Foundation.

Source: Energy Efficiency Standards and Labelling Regulations—the Energy Foundation Ghana, www.ghanaef.org

For most countries in sub-Saharan Africa, cooking is a major use of energy, most often by means of wood (or charcoal where affordable). The use of low-cost appropriate technologies of heat retention cookers (hay baskets/boxes) and fuel-efficient mud stoves can help people use less wood for cooking.[10] Another example is the use of biogas from manure in homemade stoves in Manicaland

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[10] Heat retention cookers in Tanzania—Sunseed Tanzania Trust, www.sunseedtanzania.org

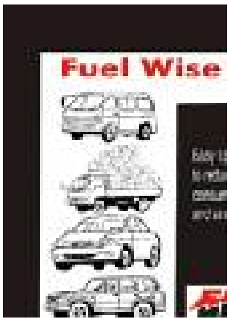
in Zimbabwe. Apart from increased energy efficiency, additional advantages may include a decrease in terms of deforestation and health damage from exposure to smoke.

Finally it is possible that in the future, small (including household level) low carbon projects will be eligible for so called programmatic CDM, and as such could create an income by selling the CO_2 emission reductions. Programmatic CDM is a specific instrument under development within CDM that could address the specific barriers for CDM projects in some African countries and other Least Developed Countries (LDCs). The Meeting of Parties (MOP) to the Kyoto Protocol (COP/MOP2) and the 12th Conference of the Parties to the Climate Change Convention (COP 12) in November 2006 in Nairobi made some progress on agreeing support for capacity-building for African countries and consideration of programmatic CDM, but the definitions and modalities on how programmatic CDM could actually work are not fully clarified at this stage.

4.3. Transport

The use of more efficient car and truck engines could substantially lower the fuel cost and the environmental impact of road transport. Once again, policies could address the barrier of the higher initial investment cost by providing tax incentives, investment subsidies or soft loans. Another policy measure that could address transport efficiency issues is the encouragement of public transport and schemes to encourage the development of good public transport infrastructure. Where applicable using (locally produced) bio-fuel, new transport methods potentially could trigger local employment and provide a new market opportunity.

Box 2. Improving fuel efficiency in Ghana



The Energy Foundation in Ghana printed and distributed 100,000 copies of the “Fuel Wise” brochure, which was launched by the Minister of State for Economic Planning in April 2004.

The brochure provides motorists with graphic representations and easy to follow information on the steps they could take to improve fuel efficiency during transportation and save money on their fuel costs. The brochures were distributed free of charge to motorists across the country, through a collaborative effort with the Ghana Oil Company (Goil), a major oil marketing company in Ghana. The entire brochure was published in the national papers for wider coverage.

Box 2. *(continued)*

Radio interviews were also conducted on FM stations on the Fuel Wise brochure in a number of cities including Accra, Kumasi, Sunyani, Takoradi, Konongo, Techiman, Tamale, Goaso and Bolgatanga. The interviews, which were conducted in the various local languages, highlighted the educational information in the Fuel Wise brochure. Questions on energy efficiency, posed by listeners through phone calls were also answered.

The "Fuel Wise" brochure can be downloaded from the website of the Ghana Energy Foundation.

Source: Energy Efficiency Standards and Labelling Regulations—The Energy Foundation Ghana, www.ghanaef.org

4.4. Offices and buildings

Finally (public) offices and buildings offering a significant energy reduction potential, need to be mentioned as a fourth, cross-cutting category potentially covering all sectors, especially industry and households.

For the construction of new buildings, it is particularly important to consider during the planning phase the use of energy efficient construction methods, lighting and electric appliances.

When considering the renovation of existing buildings, an energy audit is recommended to point out where the main energy reduction potentials are possible and at which costs. Often relighting is worth considering. Changes in lighting systems can often pay back the cost of their installation within a year or less due to savings on the electricity bill.

Building regulations and energy performance standards can be imposed by the government, for instance for any new office with floor surface over 1000 m^2. In Europe, the European Union has just introduced the "EU directive on the energy performance of buildings" which aims to improve energy efficiency in the building sector. More details on this are given in box 3.

A common policy is to demonstrate and communicate how energy efficiency in buildings can be improved, followed by imposing building regulations and standards on all new office buildings (over a certain floor surface). Wherever more relevant, renovation projects may be included in the regulation.

Box 3. The EU directive on the energy performance of buildings

Introduction

In 2001 there were about 178 million buildings within the 25 member States of the European Union (EU) accounting for around 41 per cent of all energy consumed within the EU. Of this, around two-thirds was consumed within homes and one-third within commercial buildings.

The biggest single requirement for this energy is for heating (and increasingly cooling) and hot water, representing around 70 per cent of domestic energy consumption and 50 per cent of commercial energy consumption.

There are two main drivers to reduce the level of energy consumed within European buildings:

1. Environmental concerns deriving from energy consumption, particularly climate change.
2. Energy security, in terms of the increasing need to import energy to meet EU demand.

The EU recognizes that energy efficiency is the single most cost-effective and publicly acceptable way of meeting its Kyoto commitments.

The European Climate Change Programme states that the EU Directive on the Energy Performance of Buildings should be able to deliver reductions of 35 to 45 million tonnes of carbon dioxide per year within the EU by 2010. This compares to the requirement under the Kyoto Protocol that the EU reduce its greenhouse gas emissions by eight per cent on 1990 levels, or by 336 million tonnes carbon dioxide per year, by 2010.

In its Green Paper “Towards a European Strategy for Energy Supply”, published in June 2002, the European Commission (EC) goes further and states that if its indicative target of reductions in final energy consumption in buildings is realized, then savings of around 100 million tonnes carbon dioxide per year, which equates to a reduction of around 22 per cent can be achieved.

Aims and objectives

The objective of the Directive is to “promote the improvement of the energy performance of buildings within the European Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.” This is to be achieved through five main actions:

1. The creation of a general methodology following a framework provided by the Directive that can be used to calculate the energy performance of buildings. This will encompass aspects of building design, construction and services. It

Box 3. *(continued)*

will allow building designers and managers to meet energy reduction standards in a flexible and cost-effective manner, as well as incorporating simple energy indicators.

2. The application of minimum requirements, as measured by the methodology above, to all new residential and tertiary (generally public and commercial) buildings and to the major refurbishment of existing buildings with floor areas greater than 1,000 square metres.
3. The introduction of an energy performance certificate to be available whenever a building is constructed, rented out, or sold. This should include legal standards and benchmarks, as well as recommendations for cost-effective improvement of energy performance. The certificate should be displayed prominently when applied to public buildings or buildings serving large numbers of the public.
4. Regular inspection of boilers with outputs of more than 20 kW and inspection every two years for boilers of more than 100 kW. Where the boiler is more than 15 years old a one-off inspection should be carried out that covers the entire heating system.
5. Regular inspection of air conditioning systems with outputs of more than 12 kW.

Source: www.est.org.uk

An example of how energy efficiency policy and regulations can address different sectors is given for India in box 4. Other examples of energy efficiency policies are described in full detail in the case studies for Denmark, Flanders (Belgium), China, Republic of Korea and Japan.

Review questions

1. Which different sectors can be distinguished for improved energy efficiency?
2. What are different policy measures that can be applied to encourage energy efficiency in these sectors?

Box 4. Energy efficiency policies in India

Energy efficiency is an area that did not receive due attention from policy makers in India until fairly recently. Energy Efficiency had traditionally been a subject of the Ministry of Power (MoP) and did cover electrical and industrial energy efficiency promotion. An organization to encourage and promote energy efficiency, namely the Energy Management Centre (EMC) had existed since the late 1980s but its efforts were directed towards information dissemination and awareness creation, rather than policy and regulation.

However, the central government, recognizing the importance of energy efficiency, passed the Energy Conservation Act of 2001, which came into effect from March 2002. The key provisions of the Energy Conservation Act, 2001 are the:

- Establishment of a Bureau of Energy Efficiency (BEE) to provide the policy framework and direction to the national energy conservation activities;
- Conferred power on the central Government to facilitate and enforce the efficient use of energy and its conservation;
- Conferred powers to the state governments to enforce certain provisions for efficient use of energy and conservation;
- Established financing mechanisms such as Central Energy Conservation Fund (CECF) and authorized states to set up State Energy Conservation Funds (SECF) for meeting the provisions of the Act;
- Established procedures for adjudication of non-compliance, penalties and mechanism for appeals under the Act.

The BEE is currently in the process of creating the framework for implementation of the Act and has already been carrying out the following activities:

- Currently developing regulations for a standards and labelling programme for equipment and appliances;
- Designated 14 agencies at the state level to regulate and enforce the provisions of the energy conservation Act;
- Development and implementation of a national energy conservation award scheme for industries;
- Currently developing codes for energy efficiency in buildings and establishments.

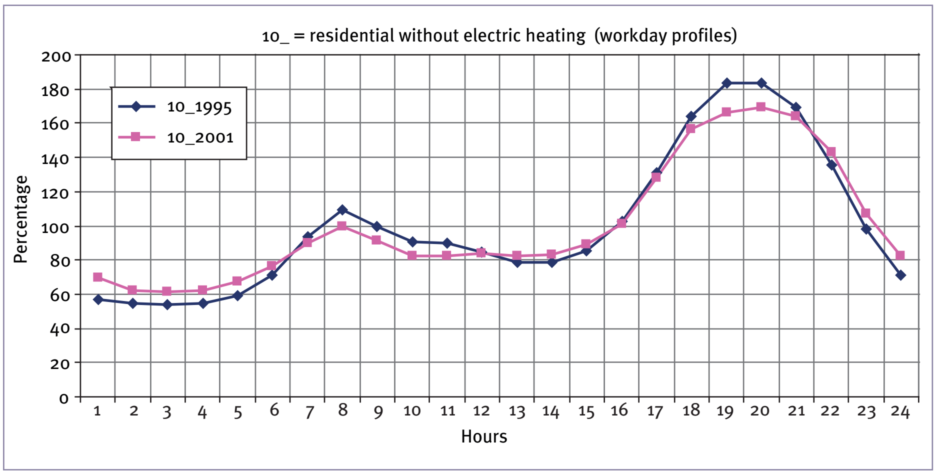
Professional accreditation and certification efforts have been made to organize the first national level examination for energy managers (all designated energy intensive industries are required to appoint an energy manager to comply with the Act).

The policy framework is expected to develop steadily as a result of the continued efforts by BEE as well as the central and state governments under the provisions of the Energy Conservation Act. It is expected that in the short to medium-term, these policies will start to show significant impact on energy efficiency and conservation.

5. REGULATORY OPTIONS: DEMAND-SIDE MANAGEMENT

Energy demand fluctuates throughout the day, with morning and evening periods of high usage. The figure below shows the typical load profile of a European household over 24 hours.

Figure I. Typical load profile of a household over 24 hours[a]



[a] "The load curves displayed are based on a large number of hourly measurements, taken in 1995 and 2001, of individual residential customers. "10_" is the identifier of the residential customer group without electric heating in Finland. These customers have a normal flat tariff, i.e. constant price. The load curves are relative values so that 100 per cent corresponds to the average hourly consumption of the day: sum of 24 hourly kWh values divided by 24." From communication with the Author on date 2 April 2007.

Source: Small customer dynamic pricing pilots in Denmark and Norway (EFFLOCOM-project) vs. demand response of electric heating in Finland, Seppo Kärkkäinen, VTT, DR workshop in Helsinki, April 19, 2005

Demand-side management (DSM) measures aim to increase the efficiency of energy service delivery by using opportunities, which are not being fully taken advantage of in the market. Using DSM measures electricity suppliers try to mobilize cost-effective savings in electricity and peak demand by aiming to influence the time and level of electricity used by customers. DSM essentially aims to decrease the amounts of electricity used during peak times by shifting enough demand from peak morning and evening periods into the mid-day and night-time hours, thus resulting in a constant, efficient use of electricity.

Regulators can encourage electricity suppliers to influence the time and quantity of electricity used by consumers by offering incentives. For example, the regulator can influence the tariffs that can be charged by the supplier at different times of the day, perhaps allowing the supplier to charge higher tariffs during peak hours and lower tariffs during off-peak.

Regulators can also work directly with larger consumers by offering financial assistance on investments to improve consumption patterns and reduce overall consumption through efficiency measures.

A successful DSM strategy will ultimately result in a more efficient electricity system, and therefore in significant cost savings for the provider and the consumer. The household sector is a prime target for DSM measures, as energy consumption in this sector is always rising.

Box 5. **DSM in South Africa**

In South Africa, the South African national utility (ESKOM), is running a DSM policy where entities improving electricity efficiency are entitled to get financial assistance, following an assessment on whether the implementation criteria are met. An energy services company (ESCO) then assists the DSM implementation.

Both upgrades to existing buildings and the incorporation of efficient systems in new buildings are targeted.

Source: Eskom, the major South African electricity supply company, www.eskom.co.za

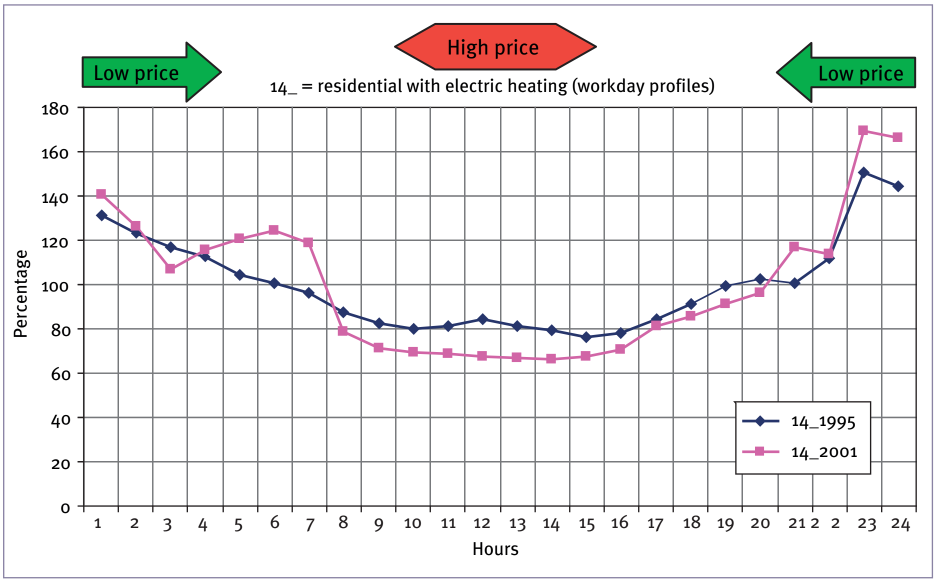
5.1. Design of tariffs and prices to encourage lower consumption

Time of use tariffs

Electricity tariffs varying according to the time of use is an effective means to shift demand from peak times, by setting lower electric rates for off-peak energy use, and higher rates for peak consumption.

Electricity consumers can lower their energy bill and are as such actively encouraged to run certain appliances (e.g. washing and drying machines) off-peak (at night and on weekends) at a lower price per kWh, rather than place those demands on the utility during periods of peak energy consumption. Time of use tariffs can change the load profiles of households from that in figure 1 to that shown in figure 2.

Figure II. Household load profile over 24 hours influenced by time of use tariffs[a]



[a] "14_ is the identifier of the residential customer group with electric heating in Finland. These have higher annual consumption, typically 20000 kWh, and have time-of-use tariff The load curves are in relative values as in figure 1." From communication with the author on date 2 April 2007.

Source: Small customer dynamic pricing pilots in Denmark and Norway (EFFLOCOM-project) vs. demand response of electric heating in Finland, Seppo Kärkkäinen, VTT, DR workshop in Helsinki, April 19, 2005

China for instance was able to influence energy conservation behaviour by varying the energy price. Under the planed economy, China practised an energy quota system and energy prices were seriously distorted. Under this energy price system, enterprises and individuals lacked the motivation to save energy. From the mid 1980s, the government began to relax the energy price gradually and adopted the dual pricing system. By the mid 1990s, China's energy price had been brought close to international levels. Reform in energy price generated the motivation among enterprises and individuals to save energy and greatly stimulated energy conservation in China.

Metering

Easy and regular access to reliable energy consumption data is an essential prerequisite for good energy management for every type of consumer. The analysis of existing metering data and consumption profiles can show where the highest and/or easiest to realize energy savings potential lies in order to direct the focus of energy efficiency measures towards certain appliances, certain periods and certain target groups.

Metering provides an effective means to raise awareness on energy efficiency, as metering data offer insight into the increase/decrease of actual energy consumption over the months/years. It is generally recognized that for instance in the household sector, there is the potential to deliver energy savings of 5-10 per cent for many customers through the use of improved feedback on energy consumption.[11]

A possible, although somewhat extreme measure is the use of budget meters, where customers get a card by which they charge their electricity meter (cf. a pay-and-go mobile phone card), according/restricted to their budget. This measure is usually imposed on customers having difficulties to manage their budget and pay their bills. Prepayment meters are offered by private electricity companies and run on the same principle. The disadvantage of these is that the price for the electricity is usually higher.[12]

As the availability of energy consumption data is a major issue for most sub-Saharan African utilities, a first set of data could be collected by distributing a questionnaire to and interviewing a representative sample of a selected target group. As this data will often not be very accurate, rules of thumb could be applied initially in order to estimate energy consumption. The questionnaire and interviews should then be repeated yearly in order to improve the quality of the data (collection) and start building historical data, which in time will enable utilities to discover trends and patterns in energy consumption.

5.2. Standards and labels

Policies aiming to increase energy efficient products and encourage product innovation are usually backed by the setting of standards and the establishment of labels. Standards can be applied to products and appliances in household and non-household sectors. The use of voluntary and/or mandatory standards and labels aim to remove the poorest performing appliances from the market.

An example of such a label is the EU Energy Star regulation, a voluntary energy labelling of office equipment.[13] Other appliances to consider setting efficiency requirements for are lighting ballasts, domestic hot water boilers, domestic refrigeration appliances and air conditioning systems. An example of standards setting in Sub-Saharan Africa was given in box 1 “Energy efficiency standards and labelling regulations in Ghana”.

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[11] Energy Efficiency, the UK Government Plan for Action, April 2004, www.defra.gov.uk

[12] www.energywatch.org.uk

[13] http://energyefficiency.jrc.cec.eu.int/energystar/index.htm

6. REGULATORY OPTIONS: SUPPLY-SIDE MANAGEMENT

6.1. Energy efficiency obligations

As was pointed out in the paragraph on indirect policy measures, the government can impose energy efficiency obligations on the distribution system operator. Denmark and Flanders (Belgium) offer good examples of how electricity distribution companies can play a key role in energy efficiency obligation schemes. These schemes are described in detail in the case studies on Denmark and Flanders.

In principle the same policy is thinkable for transmission system operators (TSO), although in practice this is not very common. The main difference would be the target group, as usually only large companies and organizations with significant electricity consumption are directly connected to the transmission grid.

6.2. White certificates

Following the experience gathered with systems using green certificates,[14] the introduction of “white certificates” (or energy saving certificates) is currently being investigated. Some European countries such as Italy and United Kingdom recently adopted a similar system, while France is preparing to do so. New South Wales (Australia) was one of the first regions to introduce a white certificate scheme as part of a Greenhouse Gas Abatement scheme.[15]

A white certificate system is a market-based policy instrument and essentially includes a target (in order to create demand), a clear definition of what the white certificate contains, and a set of certificate trading rules. Whereas demand creation and trading rules can be similar to a green certificate system, the definition of what the white certificate actually stands for needs additional clarification.

A green certificate is commonly defined as an amount (usually 1000 kWh) of electricity produced from renewable energy sources. Defining a white certificate

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[14] Tradable green certificates are the means for electricity suppliers or producers to comply with the green electricity quota set by the government. The financial trigger is the fine set when not meeting the target. See module 9: “Regulatory and Policy options to encourage development of renewable energy” for a detailed description of Quota systems.

[15] For more info on the policy scheme in New South Wales, see www.greenhousesgas.nsw.gov.au/default.asp

as an amount of energy saved requires a reference point to compare with (e.g. energy consumption in a given year). The amount of energy saved can be either expressed as primary energy savings (Italy), or as saved kWh (United Kingdom).

The use of white certificates could prove a useful means to trigger more and cost effective energy savings measures in different sectors. Ultimately (cross border) trade of white certificates between grid operators could be possible. As the experience with green certificates has shown though, the establishment of cross border certificate trade faces substantial market and institutional barriers. It is therefore too early at this stage to make assumptions on how successful white certificate systems can be on national and regional level.

7. CONCLUSION

Increasing energy efficiency may not be as visible as renewable energy technologies, but it offers a significant energy and cost savings potential in different sectors of society.

As the possible advantages of a successful energy efficiency policy become clear to governments all over the world, a wide range of policies and regulations are currently being operated, and will continue to be updated and improved.

Any policy or regulation needs careful design taking into account the nature of the national electricity sector, the regulatory authorities involved and the targeted sector. The most important sectors to focus on are industry, households, transport and buildings.

LEARNING RESOURCES

Key points covered

This module covers the following key points:

- A general outline of the regulatory institutions in the electricity sector.
- The role and possible advantages of energy efficiency policies.
- The main sectors to address when designing policy and regulatory instruments to increase energy efficiency.
- The existing energy efficiency policies—experiences from Europe, Africa and Asia.

Answers to review questions

Question 1: Which different sectors for improved energy efficiency can be distinguished?

Answer:

Industry, households and transport

Offices and buildings can be mentioned as a fourth sector, as they generally offer a high-energy savings potential.

Question 2: What are different policy measures that can be applied to encourage energy efficiency in these sectors?

Answer: Some examples are:

Industry: Obligation to reduce CO_2 emissions by a fixed amount, enforced by financial penalties.

Households: Direct capital grants to enable consumers to buy higher efficiency household appliances.

Transport: Encouraging public transport and improving public transport services such as buses.

Offices and buildings: Setting energy performance standards for newly-built offices over a certain size (m^2)

Presentation/selected discussion

Presentation: ENERGY EFFICIENCY—Module 16 Regulation and policy options to encourage energy efficiency.ppt

Discussion question:

Given the particular situation in your country, analyse which of the mentioned sectors (industry, households, transport, offices and buildings) offers the highest energy savings potential. Apart from the potential itself, consider which sector is most suitable for policy and regulations.

Relevant case studies

1. Japan: Overview of energy efficiency measures
2. Rational Energy Utilization Act of Korea
3. China's energy conservation policy
4. Denmark: Electricity distribution companies as key actors in energy efficiency policy
5. Flanders' (Belgium) energy savings obligations on electricity grid operators

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Energy Efficiency Standards and Labelling Regulations in Ghana—The Energy Foundation Ghana, www.ghanaef.org

DSM in South Africa, www.eskom.co.za

Doing more with less, Green Paper on Energy Efficiency, DG TREN, European Commission, ec.europa.eu/dgs/energy_transport/index_en.html

Energy Efficiency Advice Centres in the UK, www.energy-advice.co.uk

National Energy Action, www.nea.org.uk

Energy Efficiency, the UK Government's Plan for Action, April 2004, www.defra.gov.uk

INTERNET RESOURCES

African Forum for Utility Regulation (AFUR): www1.worldbank.org/afur/about-e.html

Regional Electricity Regulators Association of Southern Africa (RERA): www.rerasadc.com

Independent Pricing and Regulatory Tribunal of New South Wales—Australia: www.ipart.nsw.gov.au

International Energy Agency Demand-Side Management Programme—Strategic Plan 2004-2009: dsm.iea.org

Energy Savings Trust, United Kingdom: www.est.org

Sunseed Tanzania Trust: www.sunseedtanzania.org

Tanzania traditional energy development and environment organization (TaTEDO)—for information on improved cookstoves: www.tatedo.org

GLOSSARY/DEFINITION OF KEY CONCEPTS

Clean development mechanism	The clean development mechanism (CDM), being one of the flexible mechanisms within the Kyoto Protocol, is designed to possibly meet the needs of both developing and industrialized countries, by helping to solve non-Annex I countries, needs for capital to finance the technology transfer of clean, energy efficient technologies for economic development and for addressing environmental issues such as loss of biodiversity, while also providing a lower cost, more flexible alternative for annex I countries to meet emissions reduction targets.
Energy savings obligations	Systems where electricity suppliers or distributors are obliged to undertake energy efficiency measures for final users.
Distribution system operator	The authority in charge of the operation of the electricity distribution grid within a given region/area. The distribution of electricity is to serve end consumers and normally takes place at lower voltage (under 110 kV).
Energy savings obligations	Systems where electricity suppliers or distributors are obliged to undertake energy-efficiency measures for final users.
Metering	The process and methods of utilizing devices to measure the amount (and direction) of electrical energy flow, particularly for end-use.

MOP	MOP is the Supreme Body of the UNFCCC's Kyoto Protocol and an acronym for Meeting of Parties. The first Meeting of Parties to the Kyoto Protocol was held during the 11th Conference of Parties (COP) in Montreal in December 2005 since the Protocol's entry into force in February 2005.
Transmission system operator	The authority in charge of the operation of the electricity transmission grid within a given country/region. The transmission of electricity normally takes place at high voltage (110 kV or above).
White certificates	Tradable certificates containing a defined amount of energy saved.

Case study 1.

JAPAN: OVERVIEW OF ENERGY EFFICIENCY MEASURES

CONTENTS

1. BACKGROUND

Through the energy efficiency efforts of the government and the public, Japan has achieved the highest level of energy efficiency anywhere in the world since the oil crises of the 1970s. However, the weakness of Japan's energy supply structure remains unchanged, and the level of dependency on Middle East crude oil is higher now than at the time of the oil crises. With the tendency of increased of energy consumption in the commercial, residential and transportation sectors in recent years, the promotion of effective and consistent energy efficiency measures in the future remains essential.[1]

2. LEGAL FRAMEWORK FOR ENERGY EFFICIENCY

2.1. The Energy Conservation Law

Japan's Law Concerning the Rational Use of Energy (Law No. 49), which was enacted 1979, and amended in 1999 and 2005, (also referred to as the "Energy Conservation Law") and the underlying Enforcement Ordinance, Enforcement Regulations, and Evaluation Criteria, establish mechanisms to promote the efficient use of energy in "energy-using" equipment, buildings, factories, and machinery.

Among other things, the Law and related implementing measures establish energy efficiency targets for covered items powered by electricity and combustible fuel. These targets are calculated using a complex formula. This formula essentially measures, for each category of covered items, the average energy consumption efficiency weighted according to the shipped number of the covered items in the category.

In addition, the Law Concerning the Rational Use of Energy specifies energy efficiency labeling for certain manufactured and imported products.

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[1] Agency for Natural Resources and Energy, Japan, www.enecho.meti.go.jp

2.2. The Energy Conservation Assistance Law

The Law Concerning the Rational Use of Energy and Recycled Resources Utilization, enacted in 1993 and also known as the "Energy Conservation Assistance Law", sets out financial incentives for energy conservation in the form of:

- Low-interest financing;
- Industrial improvement bonds;
- Tax exemptions

This is to support approved voluntary efforts by business operators and building owners for energy conservation (this law has since been surpassed by the Law Concerning the Rational Use of Energy, mentioned above). These incentives facilitate the realization of the energy efficiency initiatives described under the Law Concerning the Rational Use of Energy.[2]

The latest revision of the Energy Conservation Assistance Law was in 2002. The main measures for each sector are summarized below:

Factories (of a given energy consumption—as designated by the government):

- Obligatory energy manager for each factory;
- Medium to long-term plans for rational utilization of energy;
- Regular (annual) reporting to the Government on energy consumption;
- Energy consumption targets;
- Training courses and examinations for energy managers.

Buildings

- All owners of new buildings are responsible for energy efficiency measures to reduce heat loss and are to ensure efficient use of air conditioning equipment;
- Energy standards for buildings.

Machinery and Equipment

- Call for efforts by manufacturers to improve equipment energy performance;
- Standards for machinery (manufactured and imported);
- Product labelling—energy consumption efficiency.

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[2] Energy Efficiency in Japan, www.eiatrack.com

More general measures called for in the law are:

- Budgetary, financial, tax measures to promote the rational use of energy;
- Promotion of science and technology helpful to rational use of energy, supporting research and development;
- Measures for increasing public awareness;
- Penalties for non-conformance with standards or limits on energy consumption.

This law also assigned some responsibilities in the area of energy efficiency and conservation to the New Energy and Industrial Technology Development Organization (NEDO) including development of technology for the rational use of energy to be used in industry in particular, provision of subsidies for the introduction and diffusion of new technologies and provision of guidance on the collection, and distribution of information regarding the rational use of energy.

Box 1. The Top-Runner Scheme

The Top-Runner Scheme was introduced in the Amended Law Concerning the Rational Use of Energy, which was passed in the Diet and went into force in April 1999. When the law was amended in 1999, the Top-Runner programme was introduced to replace the existing energy-efficiency standards.

While the energy-efficiency standards were set at a level slightly above the average of the energy efficiency of each product, under the top-runner programme the best performing items in their category in the market set the minimum standard for a target year.

The programme originally covered 11 items, and has since been extended to 18 items including cars, refrigerators, air conditioners, televisions, copy machines, etc. If a company cannot achieve the target by a target year, then its name and the product name are made public, and a fine has to be paid. However, compliance is evaluated not based on each product, but on products in the same category.[a]

The Top-Runner Scheme has significantly contributed to energy conservation of machinery and equipment in Japan. It worked especially well for gasoline passenger cars. The reasons for success include the following:

- A market mechanism is the driver for the scheme;
- Not too harsh penalties made it possible to set very high targets;
- Works best when combined with tax incentives (as in the case of green taxes for passenger cars)

In the future, there is a need to create better awareness among consumers of the scheme and the products contained within it so as to make it more effective.

[a] Current Japanese Climate Policy from the Perspective of Using the Kyoto Mechanisms, www.iges.or.jp

3. MAIN POLICIES FOR ENERGY EFFICIENCY

3.1. Fundamental policies for rational use of energy (1993)

These fundamental policies were adopted by the cabinet meeting of the Ministry of International Trade and Industry. These policies were aimed at the promotion of the rational use of energy in factories, workshops, buildings and for machines, etc. Apart from specific measures relating to these areas the policies also covered:

- Measures to be adopted by the central and local governments themselves as energy users, etc.;
- Support to capital investment, etc.;
- Support to energy management;
- Support to technical development;
- Support to the introduction and diffusion of optimum energy supply-demand systems in areas;
- Promotion of research and development, etc.;
- Education, public relations, etc. to people.

3.2. Establishment of NEDO

The New Energy and Industrial Technology Development Organization (NEDO) was established by the Japanese Government in 1980 to develop new oil-alternative energy technologies. Eight years later, in 1988, NEDO’s activities were expanded to include industrial technology research and development, and in 1990, environmental technology research and development. Activities to promote new energy and energy conservation technology were subsequently added in 1993. Following its reorganization as an incorporated administrative agency in October 2003, NEDO is now also responsible for R&D project planning and formation, project management and post-project technology evaluation functions.

4. REFERENCES

Agency for Natural Resources and Energy, Japan, www.enecho.meti.go.jp

IEA, Policies and Measures, www.iea.org

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IGES, Current Japanese Climate Policy from the Perspective of Using the Kyoto Mechanisms (2005), www.iges.or.jp

Impact of Top Runner Scheme on Improvement of Fuel Economy, Shinsuke Ito, Automobile Division, Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry, 22 October 2005.

Case study 2.

RATIONAL ENERGY UTILIZATION ACT OF KOREA

CONTENTS

1. BACKGROUND

The Republic of Korea has a thriving public sector energy conservation programme that encompasses not only its national government, but also city and state governments and public corporations. Its various initiatives are carried out both by government agencies (e.g. the Ministry of Commerce, Industry, and Energy) as well as by the government-chartered Korean Energy Management Corporation (KEMCO). A big boast to Korea's effort was the 1995 revision of the Rational Energy Utilization Act (originally promulgated in 1979.) While some of Korea's initiatives predate the revision, it both created new programmes and strengthened existing ones.[1]

2. RATIONAL ENERGY UTILIZATION ACT OF KOREA

The Rational Energy Utilization Act, passed in 1995, stated the responsibilities of central government, local government, end-users and suppliers, manufacturers and citizens.

2.1. Setting out a national energy plan

The Act stated that there would be a five-year basic national energy plan with a period of 10 or more years. The plan would include the following matters:

- Possible transitions and prospects of the domestic and foreign situation on the demand and supply of energy;
- Measures for a stable security and supply of required energy;
- Measures for the utilization of the energy with environmental affinity;
- Measures for the rationalization of energy utilization and carbon dioxide emissions reduction through the rationalization of energy utilization;
- Measures for promoting the development and dissemination of energy related technology;

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[1] www.pepsonline.org/index.html—Accessed 29 September 2006.

- Measures for international harmony and cooperation energy and energy related environmental policy;
- Other matters which are deemed necessary by the Minister of Commerce, Industry and Energy for attaining the goal of the national energy policy.

2.2. Creation of KEMCO

The Act also created the Korea Energy Management Corporation (KEMCO) with responsibility for carrying out the following projects:

- Driving forward of the projects for rationalization of the energy utilization;
- Development, introduction, guidance and dissemination of energy technology;
- Loan and support funds for the rationalization of the energy utilization, development and dissemination of substitute energy and mass energy supply projects;
- Energy audits and guidance on energy management;
- Promotion of substitute energy development projects;
- Investigation, research, education and public information for energy management;
- Acquisition, installation, operation, lease, and transfer of land, buildings and facilities, etc. for projects focusing on the rationalization of energy utilization;
- Mass energy projects;
- Efficiency management of energy using machinery and materials, and safety control of heat using machinery and materials.

2.3. Other measures for energy efficiency

Other measures provided for in this act included:

- Demand-side management investment plan for energy suppliers;
- Management and publication of energy statistics;
- Measurement of energy consumed;
- Public awareness and education;
- Finance, taxation, subsidies to promote the rational use of energy;
- Energy management standards;
- Energy technology development plan;
- Penalty measures.

3. ENERGY EFFICIENCY PROGRAMMES

Three programmes that emerged from the 1995 Act are particularly notable. These will be examined below one by one.

3.1. Prior Consultation on Energy Utilization Planning Programme

The Prior Consultation on the Energy Utilization Planning Programme, begun in 1993, aims to affect energy-related projects such as the construction of new public buildings or the extension of railway systems. The goal is to influence these projects while they are still in the planning stages. By the end of 2001, the programme had impacted 245 projects, promoting the installation of energy-efficient equipment and systems, as well as larger-scale (e.g., cogeneration) and renewable energy installations. Currently, the six-member staff is trying to broaden the programme's reach through the use of financial incentives and "on-the-spot" assistance to promote highly energy-efficient designs.

3.2. Energy Conservation Guideline for Public Institutions

The Energy Conservation Guideline for Public Institutions, started in 1997, directs the creation of annual energy conservation plans, including reduction targets, by public organizations. One element is an efficient public building code requiring the installation of energy-efficient systems and equipment in new public buildings. Transportation energy is addressed by a "Voluntary 10 per cent Reduction Programme," as well as the purchase of higher-efficiency government cars. Also urged is the use of ESCOs to address existing buildings. Among the sites affected were the 2002 World Cup stadiums in Seoul, where energy-efficient motors, transformers, and lighting were installed, and heat was supplied through landfill gas. Another success is the Gwachun Government Complex, where an investment of $US 180,000 in efficient fluorescent lighting is saving $US 100,000 annually.

3.3. Energy-Saving Product List

In the purchasing arena, Korea maintains an "Energy-Saving Product List" that includes both products that fall under Korea's national energy information labeling programme, like clothes washers and cars, as well as energy-using products that hold the Korean endorsement label for being more efficient than others of the same type. In all, 55 product types are covered. Public sector purchasers are required to buy models with the endorsement label, which covers 43 classes of products.

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Promoting an energy-efficient Public Sector (PePS) is a collaborative effort funded by multiple sources to promote and assist energy conservation programs in governments around the world. www.pepsonline.org/index.html

Case study 3.

CHINA'S ENERGY CONSERVATION POLICY

CONTENTS

1. BACKGROUND

1.1. Strategic importance of energy conservation in China

Population control, efficient utilization of limited resources and environmental protection have been taken as fundamental policies by the Chinese government to safeguard sustainable social economic development. From 1980 to 1998, the annual GDP growth rate in China reached 9.9 per cent, while consumption of primary energy only grew by 4.9 per cent annually.

The strategic importance of energy conservation in China can be summarized as follows:

Effectively relieve future energy demand and supply pressure

Stimulated by population growth and rapid economic development, future energy demand in China is expected to increase greatly leading to increasing energy supply pressure. Without effective energy efficiency measures, energy shortages will become a severe constraint for future economic development. If by 2020 China's energy efficiency level can be raised to the present advanced international level, energy demand could be reduced by 8-9 per cent by 2020 and 13-15 per cent by 2050. This will significantly reduce future energy supply pressure and facilitate sustainable economic growth.

Relieve regional and global environmental pressure

In 1995, China's CO_2 emissions were 800 million tons ranking second in the world. Under business as usual, CO_2 emissions will surpass the United States in the next 20 years, with China becoming the largest emitter in the world. China will, thus, inevitably become a focal point for world CO_2 emission reductions.

On the other hand, China also faces serious environmental pressure from within. Environmental degradation from SO_2 resulting in acid rain, soil acidification and forest destruction has become a serious concern. Currently, one third of China's land area has been affected by acid rain to various degrees. Without effective SO_2 emission control measures, SO_2 emissions will increase from the present 17 Mt to 60 Mt by 2020. This will lead to even more severe acid rain and soil acidification problems further increasing agricultural and forest destruction. Research proves that energy efficiency improvement is the most practical and cost effective means to reduce CO_2 and SO_2 emissions. It is, therefore, concluded that energy efficiency strengthening and improvement can effectively reduce future energy demand, directly reduce SO_2 and CO_2 emissions and relieve domestic and international environmental pressures as well as promote future economic growth in an environmental sustainable manner.

Increase economic competitiveness

It has been calculated that overall energy efficiency level in China was 32 per cent in 1997 being 10 percentage points lower compared to advanced international levels. In 1997, the share of total energy cost to GDP was 12 per cent being 5 and 9 percentage points higher than the US and Japan respectively. Energy consumption in China is dominated by industry accounting for more than 70 per cent of the total. Of the total industrial energy consumption, energy intensive subsectors such as mining, power generation and heating supply, iron and steel, non-ferrous metals, building materials, chemicals, oil refinery and coke making account for more than 70 per cent of the total. Currently, energy cost accounted for >25 per cent, 40-50 per cent, 70-75 per cent, and 40 per cent of the total production cost for the iron and steel, building materials, fertilizer, and petrochemicals industries respectively.

For the short-term, energy conservation and cost reduction will facilitate the smooth reform of large state-owned enterprises. From a long-term point of view, energy conservation can also increase overall national economic efficiency and competitiveness in China in the context of increasing globalization.

Reducing dependence on international energy market

For a considerably long period of time, China has been relying on domestic energy resources in order to maintain energy security. Globalization provides China with the opportunity to utilize both domestic and international markets as well as resources. However, in seeking additional energy resources from the international market, China has to face the uncertainties of the international energy market. Experts estimated that by 2020, oil imports in China could reach 140 Mt and as much as 400 Mt by 2050. Energy efficiency improvement can reduce energy demand and lead to lower dependency on the international energy market.

2. ENERGY CONSERVATION EXPERIENCES AND EVOLUTION OF ENERGY CONSERVATION POLICY REGULATION

2.1. Evolution of energy conservation policies

China began to pay great attention to energy conservation in the late 1970s in the context of domestic energy shortages and international oil crises. Under a centrally planned economy at that time, the government mainly adopted a top-down approach through administrative measures to promote energy conservation. The main characteristics of energy conservation management by the government were through a fixed energy supply and energy quota management system.

In 1981, the then State Economic Commission, State Planning Commission and the State Energy Commission jointly promulgated the Regulations on Energy Conservation for Enterprises and Cities which laid the foundation for energy conservation during this period. The regulation for the first time standardized energy conservation work making requirements for the establishment and strengthening of energy conservation management institutions. Specific requirements were also made for enterprises to install energy-measuring instruments, conduct thermal balance measurements and to conduct energy conservation propaganda and training. The regulation also stipulated an energy bonus system and put forward energy efficiency targets for industrial boilers, kilns and other general electric appliances and in particular made higher requirements for reducing direct oil burning.

An important milestone was the promulgation and implementation of the Provisional Regulations for Energy Conservation Management by the State Council in 1986. The Regulation made specific provisions on energy conservation management systems, energy supply and utilization, energy conservation technological advance, energy consumption and penalties and award measures. Under the centrally planed economic system, the regulation was implemented fully by various sectoral and regional authorities. These authorities also formulated detailed rules following the promulgation of the Provisional Regulation. The regulation played significant roles in energy conservation in the following decade and beyond.

In order to improve energy conservation management standards, energy utilization efficiency and reduce product energy consumption in enterprises, energy conservation management upgrade (grading) activities were conducted in enterprises. The state authority in charge of energy conservation formulated the Regulation for Enterprises Energy Conservation Management Upgrading (Grading). Many sectors also formulated their respective Enterprise Energy Conservation Management Upgrading (Grading) Methods putting forward specific energy consumption targets for enterprises of different grades. These upgrading (grading) activities were conducted in almost all enterprises. Enterprise upgrading activities had a significant impact in enterprise energy conservation work.

From 1986 to the early 1990s, enterprises in China generally practised the energy conservation bonus system. Enterprises could allocate certain amount of funds in proportion to an energy conservation volume and award energy conservation operating and management staff. This practice greatly motivated the initiatives of the enterprises and employees increasing their awareness and strengthening energy conservation management.

In the 1990s, deepening economic reform, and the transformation of the function and operation of government within enterprises, resulted in enterprises becoming the main business operating entities. It is no longer practical to carry out energy conservation administration using the previous practices. In view of the new changes in the national economy, the Government began to adopt market mechanisms, implement market-based energy conservation projects, explore market-based incentive policies for energy conservation as well as strengthening energy conservation information dissemination and international cooperation.

In November 1997, the Chinese government promulgated the Energy Conservation Law and it into effectiveness on the 1 January 1998. The Energy Conservation Law made provisions for energy conservation administration, the rational use of energy and the promotion of energy conservation technology advances. Currently, the central government and the local and sector authorities are formulating supporting regulations for the implementation of the Energy Conservation Law. In November 1998, the China Energy Saving Product Certification Administration Committee and the China Energy Saving Product Certification Administration Centre were established and formulated the China Energy Saving Product Certification Administration Method. In March 1999, the government issued the Administration Method for Key Energy Consuming Units. This resulted in the List of Key Energy Consuming Units, which was published in August of the same year. To date, Shanghai, Zhejiang, Shandong, Beijing and Shanxi have formulated their respective Energy Conservation Regulation and Implementation Methods.

In addition, in order to standardize the management system and energy consumption behaviour, the State has promulgated a range of policies and regulations. Other laws and regulations relevant to energy conservation include the Electricity Law, Coal Law, Law of Mineral Resources and the Law on Atmosphere Pollution Prevention etc.

By the end of 1998, at the central government level alone, a total of 25 energy conservation regulations and provisions, 27 energy conservation design codes, nearly 100 national standards on energy conservation had been issued. Over the years, the government has also made announcements to popularize 18 batches with a total of 1068 energy saving products as well as to eliminate 17 batches with a total of 610 energy inefficient products.

In view of the new changes in the national economy emerged in recent years, government intervention in the national economic activities is gradually shifting from past control and command to relying on market-based measures. More attention is being focused on strengthening macro control, structural adjustment and upgrading and improving economic operating quality and benefits. The objective of formulating energy conservation plans has also shifted away from meeting short-term energy supply shortages. Instead, formulation of the energy conservation plan is to meet the requirement of medium to long-term socio-economic development for energy through energy structure optimization, control of energy efficiency for newly increased production capacity and the technical renovation of existing facilities.

2.2. Energy management systems

In the 1980s, China established one of the most extensive energy conservation management systems. At the central government level, the State Council established the working meeting system to study and decide on key national energy conservation issues. Energy conservation management organizations were also established by the SETC, SPC, local and sectoral authorities to organize and implement various energy conservation management work. Key energy consuming enterprises also established energy conservation units and allocated specific personnel to monitor and manage energy use within the enterprises. In addition, more than 200 energy conservation technical service centers were also established nationally to provide technical services, energy auditing and information services to enterprises.

2.3. Formulating preferential economic policy and providing special fund for energy conservation

In the 1980s, the State practised various preferential economic policies to promote energy conservation. These policies included low interest rate loans, loan payment before tax, three-year product tax and value-added tax exemption for new energy conservation products, import duty reduction and exemption for energy conservation technology and equipment introduction. The state budget made special allocation for an energy conservation infrastructure construction fund and an energy conservation technical renovation fund. These special funds enjoyed the preferential policy of reduced interest loans and loan payments before taxation.

1. The Energy Conservation Infrastructure Construction Fund: The fund was allocated from the state budget and the state established the national-level Energy Conservation Investment Corporation to manage the energy conservation infrastructure fund. The fund was undertaken by the China Construction Bank, the Commercial and Industry Bank of China and China Agricultural Bank. In the 1980s, the fund was provided through preferential interest rate and a differential interest rate in 1991-1993 before being cancelled in 1994.

2. The Energy Conservation Technical Renovation Fund: This fund was raised by the government through a 30 per cent depreciation collected from enterprises. Before 1988, the fund was provided to enterprises in the form of grants and was subsequently changed to low-interest rate loans afterwards. The energy conservation technical renovation fund was undertaken by the Industrial and Commercial Bank of China and was administrated by the State Economic and Trade Commission. In 1998, the fund was merged into the general technical renovation fund.

3. In addition, local authorities also established similar funds to support important energy conservation infrastructure construction and technical renovation projects in their respective regions.

Overall, from 1981-1998, total energy conservation investment reached 136.3 billion Yuan ($US 17.6 billion), of which 27 per cent was from the central Government.

Table 1. Energy conservation investment from 1981-1998

	Total investment (**10^8 Yuan**/10^8 USD)	Of state grant and loans	Local and enterprise fund	EC Capacity formed (10^4tce*)
State ECIC* Fund	615/79	265/34.21	350/45.19	4580
State ECTR* Fund	194.75/25.14	106.39/13.73	88.36/11.41	4462
Societal ECTR* investment	(748.01/96.57)		(64.62/82.83)	
Total	809.75/104.54 (163.01/175.96)	371.39/47.95	438.36/56.59 (991.62/128.02)	9042

Note: EC stands for Energy Conservation, ECIC for Energy Conservation Infrastructure Construction, ECTR for Energy Conservation Technical Renovation. Estimated in US Dollar is based on the exchange rate dd. 26 February 2007, Chinese yuan to US Dollar = 0.1291.

*1 ton coal equivalent (tce)

2.4. Using energy price to influence energy conservation

Under the planned economy, China practised an energy quota system and the energy price was seriously distorted. Under this energy price system, enterprises and individuals lacked the motivation to save energy. From the mid 1980s, the Government began to relax the energy price gradually and adopted the dual pricing system. By the mid 1990s, China's energy price had been brought close to international levels. Reform in energy prices generated the motivation among enterprises and individuals to save energy and greatly stimulated energy conservation in China.

2.5. Promoting industrial technological structure advance

These measures included:

- Closing down outdated factories and eliminating highly energy consuming techniques;
- Technical renovation of existing factories;
- Developing, introducing and disseminating advanced production and energy saving technologies;
- Energy conservation propaganda and training;
- Phasing out outdated mechanical and electrical products and disseminating advanced products;
- Fostering the development of an energy conservation technical and service market;
- Organizing and promoting important energy conservation system engineering projects.

Some of the important energy conservation projects are:

China Green Lights Programme

In 1996, the Chinese government initiated the China Green Lights Programme with the aims of promoting efficient lighting products, reducing lighting electricity consumption, facilitating the development of a Chinese lighting equipment manufacturing industry, increasing enterprise competitiveness and protecting the environment.

China Energy Conservation Project

China Energy Conservation Project is a cooperative project between the World Bank/GEF and the Chinese government to support China adopting, demonstrating and disseminating market-based performance contracting mechanisms for energy conservation. The China Energy Conservation Project includes the following three major components:

- Energy management company (EMC) demonstration;
- Energy conservation information dissemination;
- Project management.

In order to further disseminate the performance contracting mechanism in China, the Chinese government and the World Bank are discussing to initiate the second phase for the project. In the second phase, the performance contracting is to be disseminated widely in China and more new EMCs will be established. In addition, the project will also seek the participation of the domestic financing sector to provide financing for the EMCs to implement energy conservation projects.

Developing combined heat and power (CHP)

In order to promote the development of combined power and heat, the State Planning Commission issued the directive “Notice to Prepare Urban Combined Heat and Power Plan” in 1997 requesting local authorities to develop CHP plans. In 1998, the State Planning Commission, State Economic and Trade Commission, the Ministry of Electric Power and the Ministry of Construction jointly issued Regulations to Promote Combined Heat and Power Development. The regulation stipulates technical guidelines for newly built and expanding CHP. All newly built and expanding CHP facilities meeting the technical requirement enjoy the preferential policy of free grid connection.

In addition, China is also actively implementing DSM[1] and IRP[2] demonstration projects and has made experimented in the power grid of Shenzhen, Shanghai, Beijing, Liaoning, Fujian and Shengli Oilfield. A DSM Centre has also been established by the State Power Corporation.

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[1] Demand-side management (DSM) measures aim to increase the efficiency of energy service delivery by using opportunities which are not being fully taken advantage of in the market; using DSM measures requires special programs that try to mobilize cost-effective savings in energy usage and peak electricity demand.

[2] Integrated resource planning (IRP) is a planning process for electric utilities that evaluates many different options for meeting future electricity demands and selects the optimal mix of resources that minimizes the cost of electricity supply while meeting reliability needs and other objectives.

3. ENERGY CONSERVATION ACHIEVEMENTS

From 1981 to 1998, a total of 2300 energy conservation infrastructure construction projects were implemented forming a combined annual energy saving capacity of 45.8 Mtce (371 GWh).[3] These projects include:

- Important energy conservation projects;
- Energy conservation demonstration projects;
- Energy efficient fans and pumps leasing;
- Comprehensive utilization and environmental protection projects;
- Energy conservation industry development projects;

Examples include: the reconstruction of the national economic structure (i.e. industry, sector and product adjustments) and the enhancement of energy management, the construction of new large-scale power generation units, cogeneration for district heating and the retrofitting of power grids in urban and rural areas.[4]

The state invested 19.5 billion yuan ($US 2.52 billion) in the energy conservation technical renovation special fund between 1981 and 1998 and formed a combined annual energy saving capacity of 44.6 Mtce (361 GWh). These include:

Technical renovation projects

Key projects in this category mainly included waste heat utilization and power generation, industrial boiler and heat supply system renovation, kiln renovation, renovation and transformation of old and low efficiency equipment, clean combustion technology, green lighting etc.

Material conservation

This has formed a conservation capacity of 400,000 tons of steel and 20,000 tons of non-ferrous metal per year, with a total investment of 1.14 billion yuan equivalent to an energy saving capacity of 1.40 Mtce/year (11 GWh).

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[3] One ton of coal equivalent (tce) = 0.7×107kcal = approximately 8100 kWh (1 kWh = 3.6 MJ = 859.8 kcal)

[4] Economic Development and Energy Issues in China, Wei Zhihong, March 2004

Comprehensive utilization

This mainly includes the utilization of power station fly ash, coal gangue, waste plastics and glass etc. Total investment for these projects amounted to 2.245 billion yuan ($US 0.29 billion) resulting in an annual energy saving capacity of 4.30 Mtce or 33.8 GWh.

The achievements of energy conservation in China can be summarized as follows:

Safeguarding rapid economic growth

China's GDP grew at an annual rate of 9.87 per cent between 1980 and 1998 whereas increase in primary energy consumption only increased by 4.87 per cent per year. Energy elasticity for the same period was only 0.48 indicating that nearly half of the energy required to support economic development was from energy conservation.

Greatly increased energy productivity

From 1981-1998, per GDP energy consumption decreased from 7.98 tce/104 yuan to 3.24 tce/104 yuan[5] decreasing by 59 per cent. In the same period, unit energy productivity increase by 144 per cent from 750 yuan/tce to 1828 yuan/tce.

Reducing the unit product energy consumption gap between China and International level

From 1980-1997, the gap in specific energy consumption for thermal power supply decreased from +32.5 per cent to +25.8 per cent and for steel production it reduced from +70 per cent to +49 per cent.

Achieving great economic benefit

From 1980 to 1998, China achieved a cumulative energy saving volume of 834 million tce. Based on the 1997 end-use energy price of 945 yuan/tce, energy saving

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[5] For a better understanding, these figures were converted in Wh/USD, using estimates. The sentence then reads: "From 1981-1998, per GDP energy consumption decreased from 0.07Wh/USD to 0.03Wh/USD, decreasing by 59 per cent." The following conversions were used: 1 ton of coal equivalent (tce) = 0.7×107kcal = approximately 8100 kWh (1 kWh = 3.6 MJ = 859.8 kcal). Estimate in US Dollar (USD) is based on the exchange rate dd. 26 February 2007, Chinese yuan to USD = 0.1291. 13.43 USD.

generated an economic benefit of 788.4 billion yuan. Average annual energy conservation volume in China reached 46.3 Mtce from 1981-1998. In 1997, investment required for new supply capacity was 5702 yuan/tce. Based on this, reduction in energy supply investment amounted to 264.2 billion yuan ($US 34 billion).

Environmental benefit

Based on the cumulative energy saving volume and the emissions factors for 1995, energy efficiency improvement and energy conservation led to reductions of 526 Mt of CO_2 emissions and 15.1 Mt of SO_2 emissions.

4. FUTURE DEVELOPMENT TREND

Overall, in order to meet the requirements of the future, the Chinese energy conservation policy will have the following characteristics:

- Reliance on market mechanisms and strengthen the macro control and adjustment of the government;
- In terms of the overall socio-economic development plan, the policy is to guide the establishment of rational end-use demand structures to enable the development of industrial structures in a energy efficient and environment friendly direction;
- Creation a level playing field between energy development and energy conservation and provide energy conservation incentive policies to overcome market barriers for energy efficiency investments—in order to fully implement the policy of energy conservation, this being the priority;
- Formulation guiding and compulsory regulations and rules which can be easily implemented and monitored to internalize energy conservation benefits;
- Formulation and implementation energy conservation and environmental protection through comprehensive technical, informational and energy efficient engineering projects to promote technical advance and optimal resource allocation;
- Promotion of the development of an energy conservation investment market.

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Case study 4.

DENMARK: ELECTRICITY DISTRIBUTION COMPANIES AS KEY FACTORS IN ENERGY EFFICIENCY POLICY

CONTENTS

1. BACKGROUND

Denmark has a long history when it comes to proactive government energy policies. The leading role Denmark has played in renewable energy, especially during the eighties and the nineties, has been an example for the rest of the world and was extensively documented. Besides its pioneering role in renewable energy, Denmark has been running an ambitious policy on energy efficiency.

Policies on energy efficiency include stringent building codes, the public sector setting an efficiency example, an extensive combined heat and power and district heating network, high taxes on energy and negotiated agreements with industry.

The following will focus on the current government-induced energy efficiency programme through the electricity distribution companies.

2. KEY ROLE FOR ELECTRICITY DISTRIBUTION COMPANIES

The Danish Government recently introduced legislation by which electricity distribution companies are to play a key role in reaching the energy efficiency target.

Since 1994 legislation has been in place that sets Danish electricity distribution companies (EDC), to be the companies responsible for maintaining the low voltage distribution grid, and to promote energy efficiency as part of their public service obligation. So far this initiative has brought measurable savings in consumption of 0.5 per cent per year, keeping Danish energy consumption static since 1980, despite economic growth of around 3 per cent over the last decade.

In June 2005 the Danish Government agreed to increase the goal for energy savings to 1 per cent per year from energy efficiency activities, representing a saving target of 7.5 Peta Joules (PJ) per year during the period 2006-2013.

The programme allocates a certain amount of demand reduction to each EDC, whereby the way to achieve the actual reduction is up to the EDC to decide. As the money provided to the EDC remains the same as before, but the target increases, there is a strong incentive to reduce costs and achieve the goals in the most cost effective way.

3. WHITE CERTIFICATES

The use of tradable energy efficiency certificates (white certificates) might offer an additional way to increase cost efficiency. Similar to green certificate systems, the government puts in place a quota and a fine in order to create a demand for certificates, but leaves it upto the market players to choose where (location and target group) and how (type of technologies and appliances) to develop projects, assuming the most cost effective projects will be realized. As the white certificates would be tradable, an EDC could decide to realize its own projects, or to buy white certificates on the market, depending on which option is expected to be cheaper.

4. ANALYSIS

The major possible obstacle to an energy target imposed on EDCs is the possible complexity of the system and the methodology and standards to be determined to measure the savings (as well as the associated monitoring and evaluation aspects) of each proposed action. A calculation methodology, which is as clear and simple as possible, will be a prerequisite for a well-functioning system.

Moreover, when considering the cross border trade of white certificates, methodologies will need to be mutually recognized by both importing and exporting countries. As well as other aspects of White Certificates, the Euro WhiteCert project is looking into this issue.

The expected evolution for Denmark in the near future is a sort of exchange facility for energy savings to emerge in some form. In the short-term, it is rather unlikely a white certificate system as described would be implemented.

5. CONCLUSIONS

Energy savings policies are generally cheaper than renewable energy policies when it comes to reducing CO_2 emissions. On the other hand, energy savings projects are usually small-scale (household or building level) projects, and therefore ECDs can play a key role as an intermediary between different target groups.

As savings calculations and evaluation methodologies tend to become complex, it will be crucial for governments to keep these as clear and simple as possible. Finally the introduction of white certificates might offer an effective means to further develop energy reduction potential through the most cost-effective measures.

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Case study 5.

FLANDERS' (BELGIUM) ENERGY SAVINGS OBLIGATIONS ON ELECTRICITY GRID OPERATORS

CONTENTS

1. BACKGROUND: LEGAL FRAMEWORK

The Flemish Parliament Act of 17 July 2000 and the Decree of 29 March 2002 imposes Rational Use of Energy (RUE) public service obligations on the electricity grid operators. A primary energy saving target for end users every year was defined as follows:

- Low voltage clients (< = 1000V)
  - 1 per cent of the electricity supplied for the year 2003
  - 2 per cent and 2.1 per cent for the years 2004 and 2005
  - 2.2 per cent for the calendars years 2006 and 2007
- High voltage clients (> 1000V)
  - Target of 1 per cent each year

2. THE RUE ACTION PLAN

Each grid operator needs to put together and submit a plan with RUE actions for the next year each year before 1 June. These actions must contain the following information:

- The proposed financial support (e.g. premium);
- Proposal for the calculation of energy savings;
- How awareness-raising and information campaigns are included.

The Flemish Energy Agency then evaluates and (dis)approves the method for the calculation of the energy savings. Not only actions for electricity savings, but for all kind of fuels are considered. The primary energy saving is equaled as the electricity saving multiplied by 2.5 (being the average conversion factor for primary energy into electricity).

2.1 Examples

Action	Premium	Saving/year
Energy saving bulb	free	168 kWh
Energy saving shower	free	1311 kWh
Condensing boiler	125 Euro	7800 kWh
Solar boiler	625 Euro	2410 kWh
Roof insulation	1,25 Euro/m^2	158 kWh/m^2

2.2. Control and evaluation

The grid operator must draw up an evaluation report every year before 1 May on the execution of the actions during the previous year. The Flemish Energy Agency then presents a report to the Flemish regulator (VREG).

When grid operators do not meet their target, a fine is imposed (10 euro cents for every kWh of primary energy that is not saved). The cost of the fine cannot be calculated in the (electricity distribution) tariff, whereas the costs for the energy savings action plans can be, as part of the public service obligation. The VREG then starts the legal procedure for the collection of fines if targets are not achieved

It is clear that this mechanism provides a strong incentive for the grid operator to comply with the target.

2.3. Some figures for 2003

Domestic clients

Premiums	13.629
Amount	2,86 million Euro
Primary energy	
Savings	76,72 GWhp*
Cost effectiveness	av. 3,7 €cent/kWhp (between 0,5 and 113 €cent/kWhp)

*The “p” stands for “primary”, as the target for grid operators is formulated as a primary energy savings target. This means that fuel savings are calculated directly whereas electricity savings are multiplied with a factor 2.5.

Best domestic actions

TOP +6 premiums	TOP +6 energy saving	TOP +6 cost effectiveness
Energy saving light bulbs	Energy saving showerhead	Energy saving showerhead
Energy saving showerhead	Energy saving light bulbs	Tube insulation
Condensing boilers	Condensing boilers	Radiator foil
High efficient boilers	High efficient boilers	Roof insulation
Super insulating glazing	Roof insulation	Energy saving light bulbs
Roof insulation	Super insulating glazing	High efficient boilers

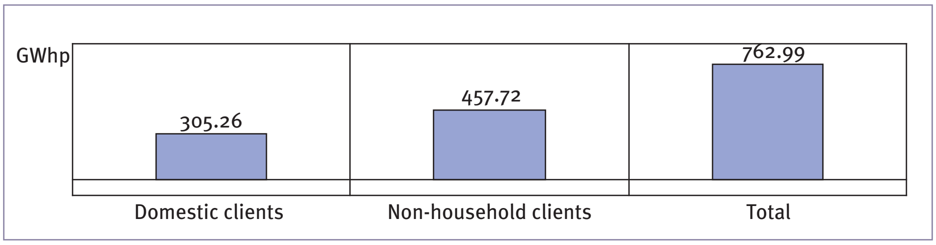
Non-household clients

PremiumsPremiums	2.828
Amount	4,73 million Euro
Primary energy Savings	457,718 GWhp
Cost effectiveness	av. 1,03 €cent/kWhp (between 0,25 en 152 €cent/kWhp)

Best non-household actions

TOP +5 premiums	TOP +5 energy saving	TOP +5 cost effectiveness
Frequency converters	Frequency converters	Thorough audit
Energy bookkeeping	Thorough audit	Quick scan
Condensing technology	Relighting	Frequency converters
Heat pumps	Condensing technology	Roof insulation
Relighting	Roof insulation	High efficiency motors
Roof insulation	Super insulating glazing	

Figure I. **Energy consumption per sector for 2003**



3. EVALUATION AND CONCLUSIONS

The main advantages of the system are:

- A clear and quantitative energy saving target;
- The incentive for grid operators to take cost-effective actions
- The financing of these actions is clear and transparent;
- Thorough control and evaluation of actions is possible.

The main disadvantages of the system are:

- The actions are not uniform throughout Flanders (as grid operators define their own actions);
- The conditions to get the premium for the same measure can therefore differ between one town and another;
- There is an overlap with other energy efficiency instruments such as the benchmarking covenant and tax deduction.

The policy instrument can be generally evaluated as successful as all network managers reached their targets in 2003 and in 2004 (except one grid operator), and the target was reached with a lower budget than initially planned.

As of 2008, the targets will be increased to 2 per cent for households, and 1.5 per cent for non-households. Moreover the Energy Agency will have to approve not only the savings calculations but also the level and conditions of the premiums. This will allow the Energy Agency to impose uniformity on the currently different premium schemes run by the grid operators.

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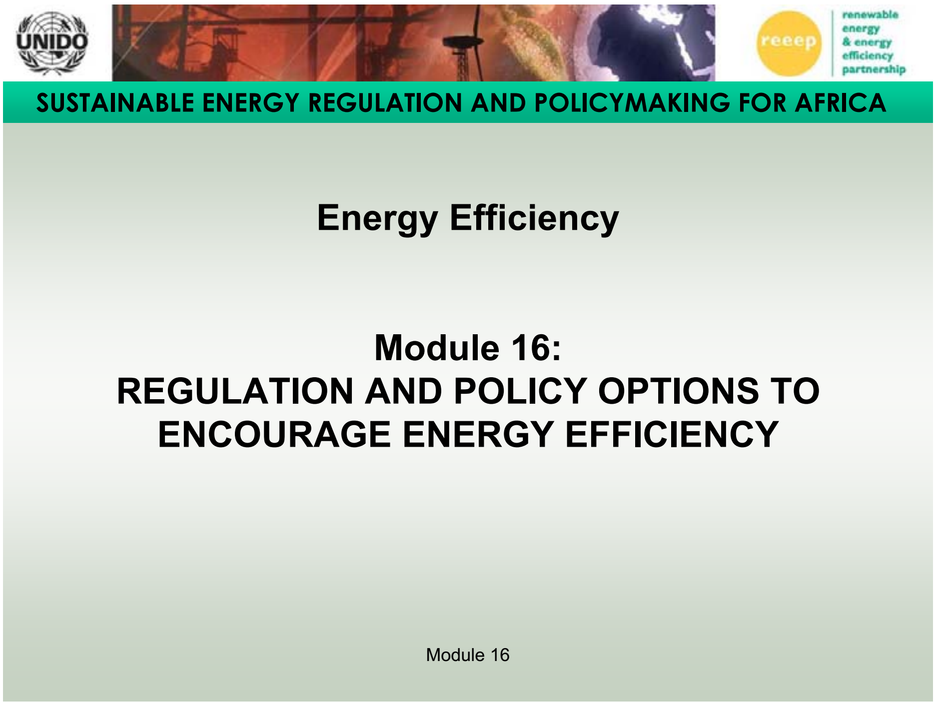
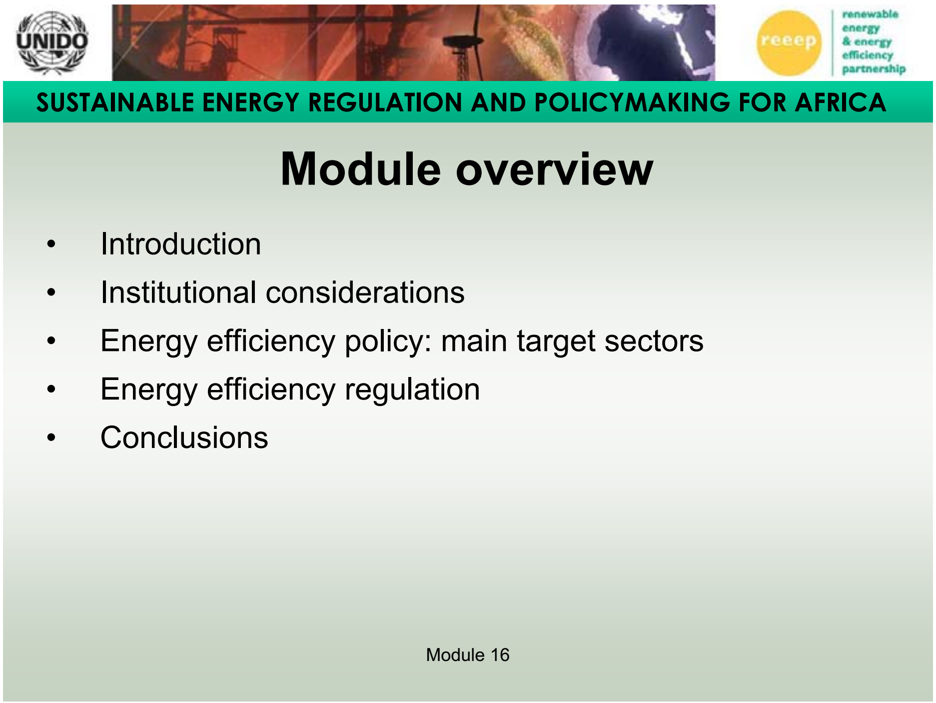


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

Module 16:
REGULATION AND POLICY OPTIONS TO ENCOURAGE ENERGY EFFICIENCY

Module 16

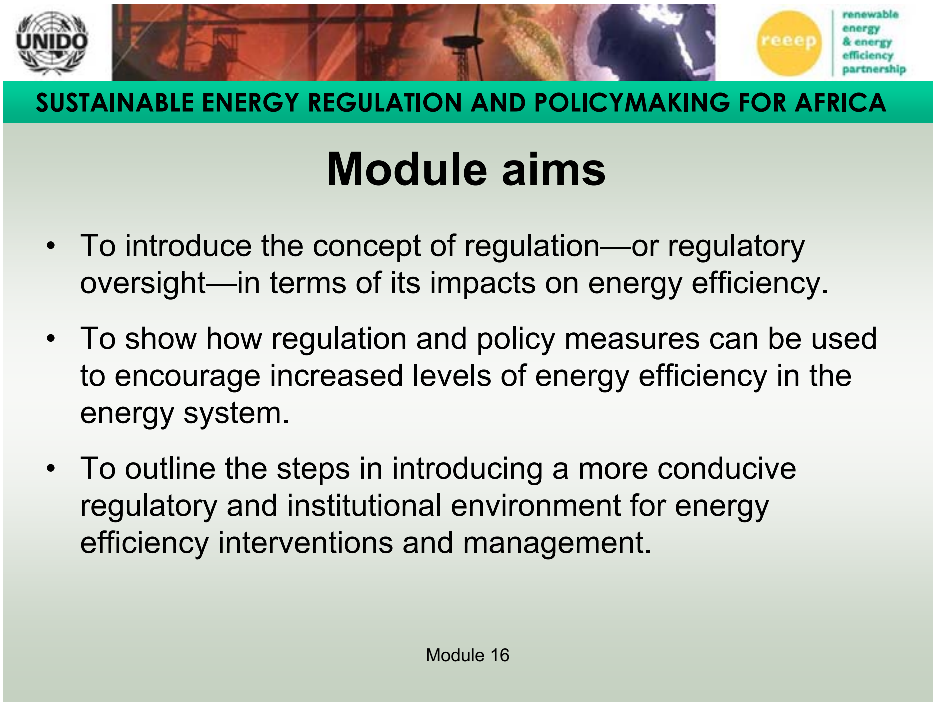


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Introduction
- Institutional considerations
- Energy efficiency policy: main target sectors
- Energy efficiency regulation
- Conclusions

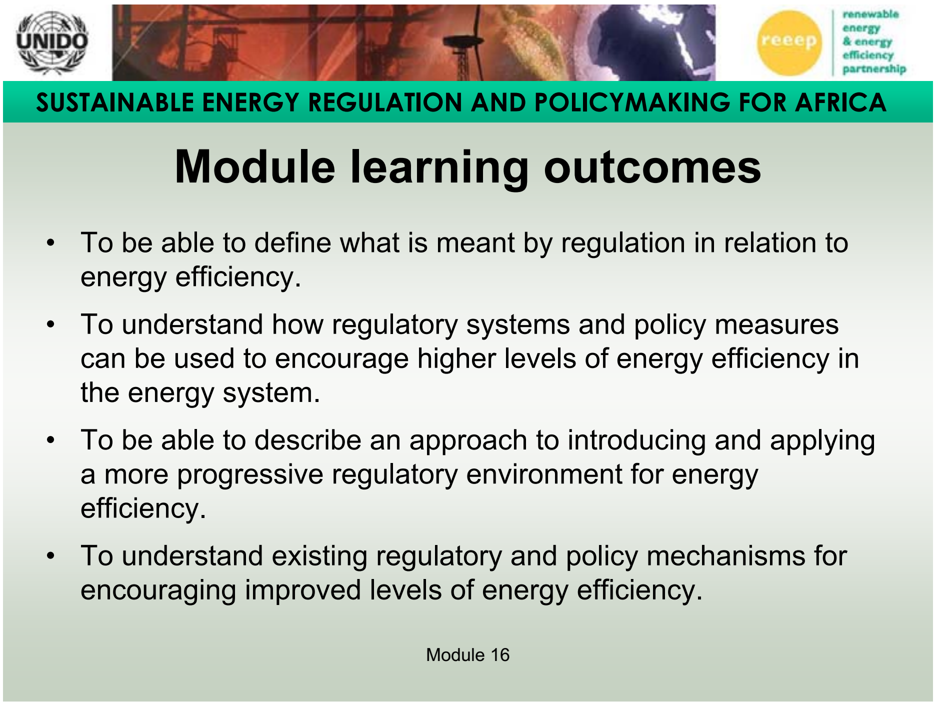
Module 16



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

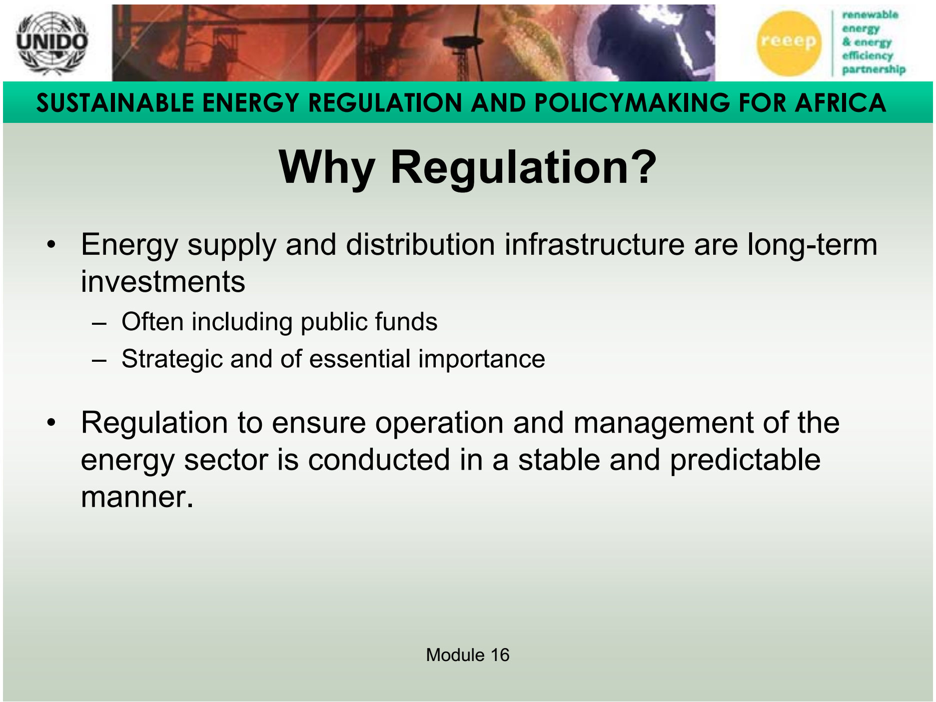
- To introduce the concept of regulation—or regulatory oversight—in terms of its impacts on energy efficiency.
- To show how regulation and policy measures can be used to encourage increased levels of energy efficiency in the energy system.
- To outline the steps in introducing a more conducive regulatory and institutional environment for energy efficiency interventions and management.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To be able to define what is meant by regulation in relation to energy efficiency.
- To understand how regulatory systems and policy measures can be used to encourage higher levels of energy efficiency in the energy system.
- To be able to describe an approach to introducing and applying a more progressive regulatory environment for energy efficiency.
- To understand existing regulatory and policy mechanisms for encouraging improved levels of energy efficiency.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Regulation?

- Energy supply and distribution infrastructure are long-term investments
  - Often including public funds
  - Strategic and of essential importance
- Regulation to ensure operation and management of the energy sector is conducted in a stable and predictable manner.

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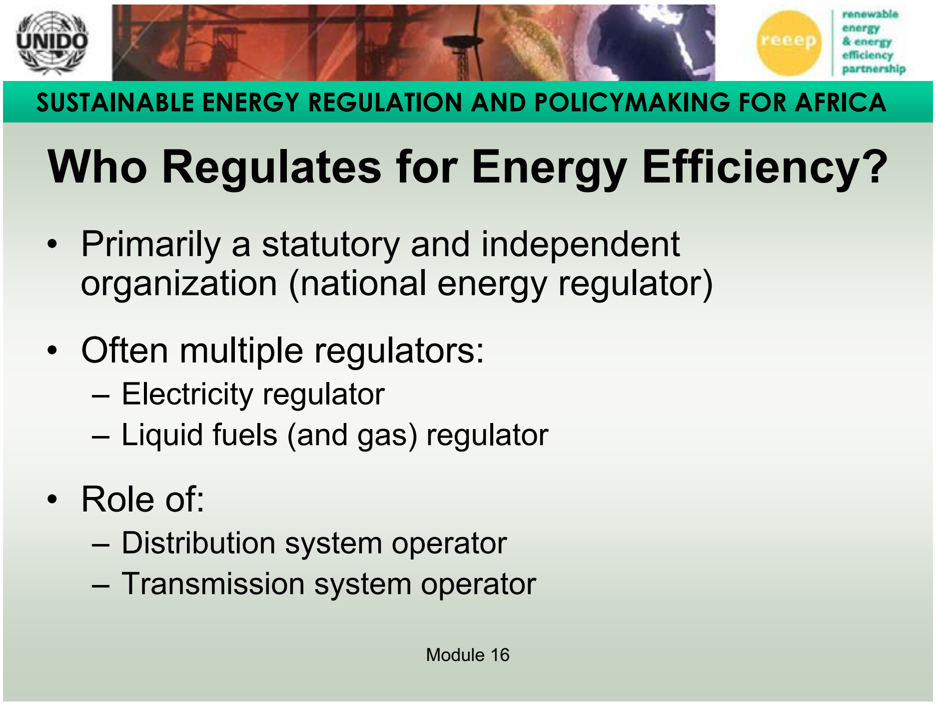

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Who Regulates for Energy Efficiency?

- Primarily a statutory and independent organization (national energy regulator)
- Often multiple regulators:
  - Electricity regulator
  - Liquid fuels (and gas) regulator
- Role of:
  - Distribution system operator
  - Transmission system operator

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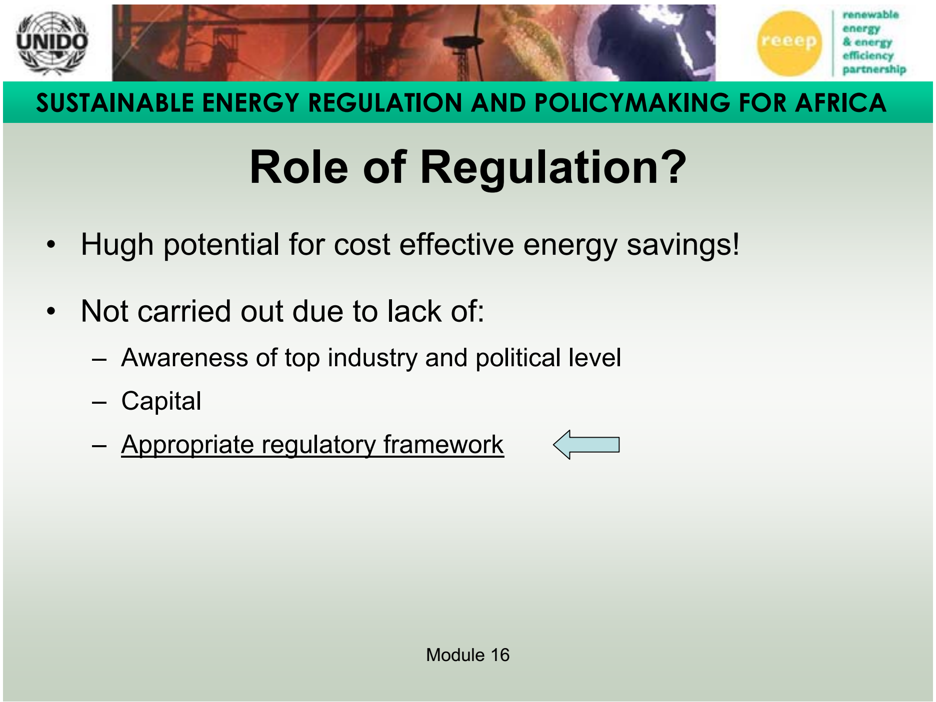

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Role of Regulation?

- Hugh potential for cost effective energy savings!
- Not carried out due to lack of:
  - Awareness of top industry and political level
  - Capital
  - Appropriate regulatory framework

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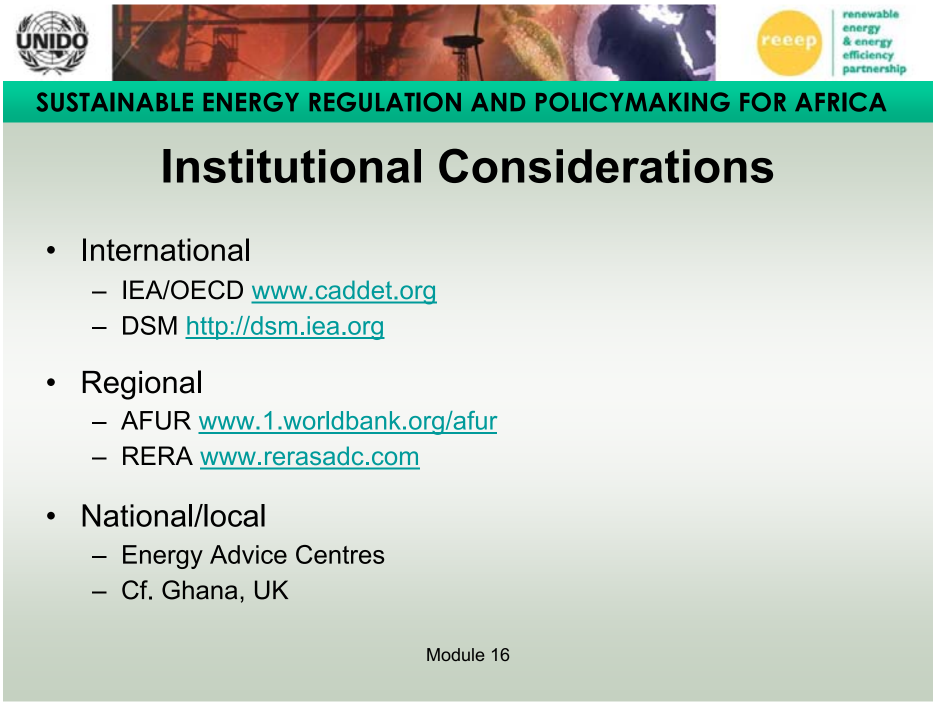

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Institutional Considerations

- International
  - IEA/OECD www.caddet.org
  - DSM http://dsm.iea.org
- Regional
  - AFUR www.1.worldbank.org/afur
  - RERA www.rerasadc.com
- National/local
  - Energy Advice Centres
  - Cf. Ghana, UK

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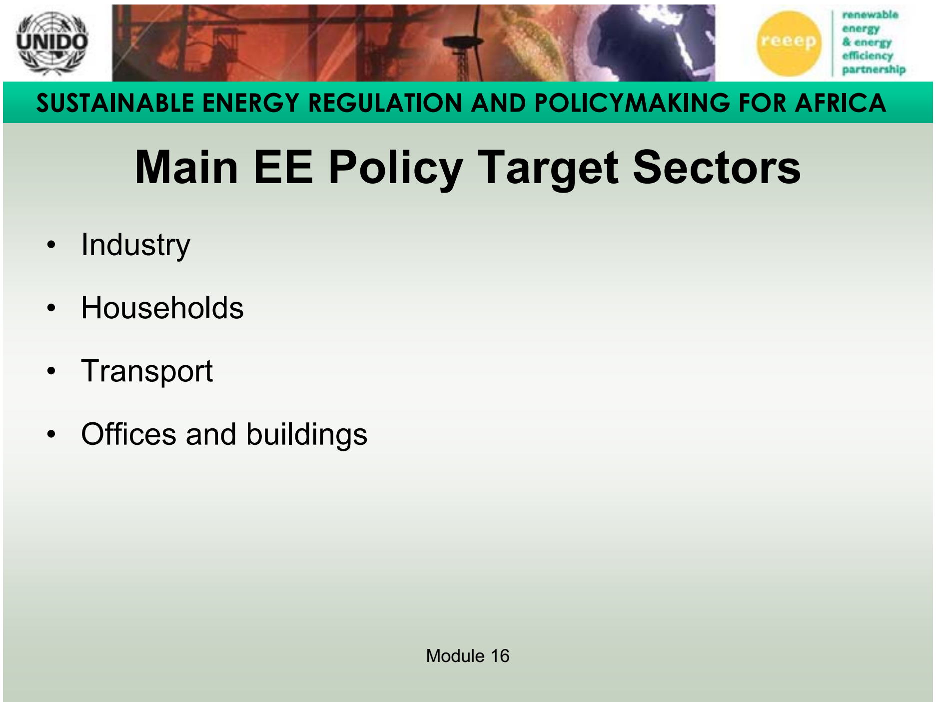

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Main EE Policy Target Sectors

- Industry
- Households
- Transport
- Offices and buildings

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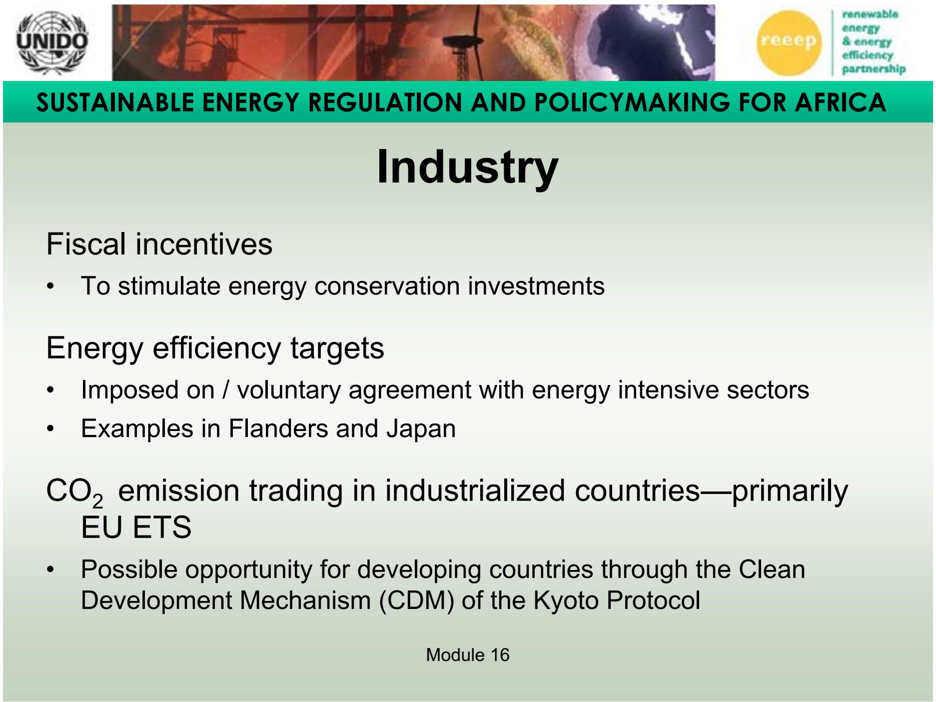

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industry

Fiscal incentives

- To stimulate energy conservation investments

Energy efficiency targets

- Imposed on / voluntary agreement with energy intensive sectors
- Examples in Flanders and Japan

CO_2 emission trading in industrialized countries—primarily EU ETS

- Possible opportunity for developing countries through the Clean Development Mechanism (CDM) of the Kyoto Protocol

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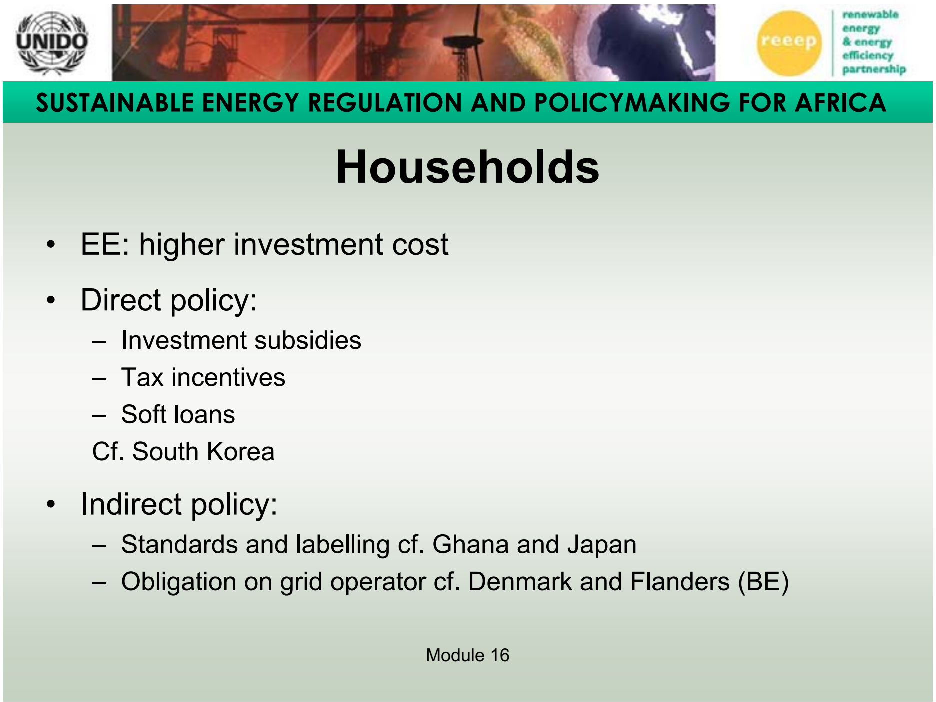
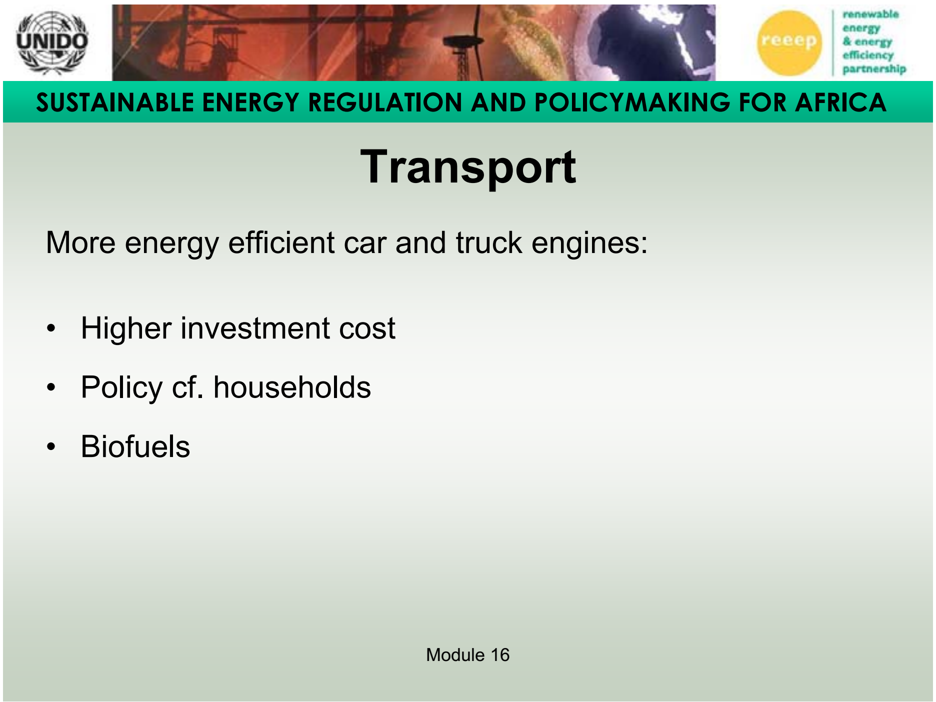


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Households

- EE: higher investment cost
- Direct policy:
  - Investment subsidies
  - Tax incentives
  - Soft loans

  Cf. South Korea
- Indirect policy:
  - Standards and labelling cf. Ghana and Japan
  - Obligation on grid operator cf. Denmark and Flanders (BE)

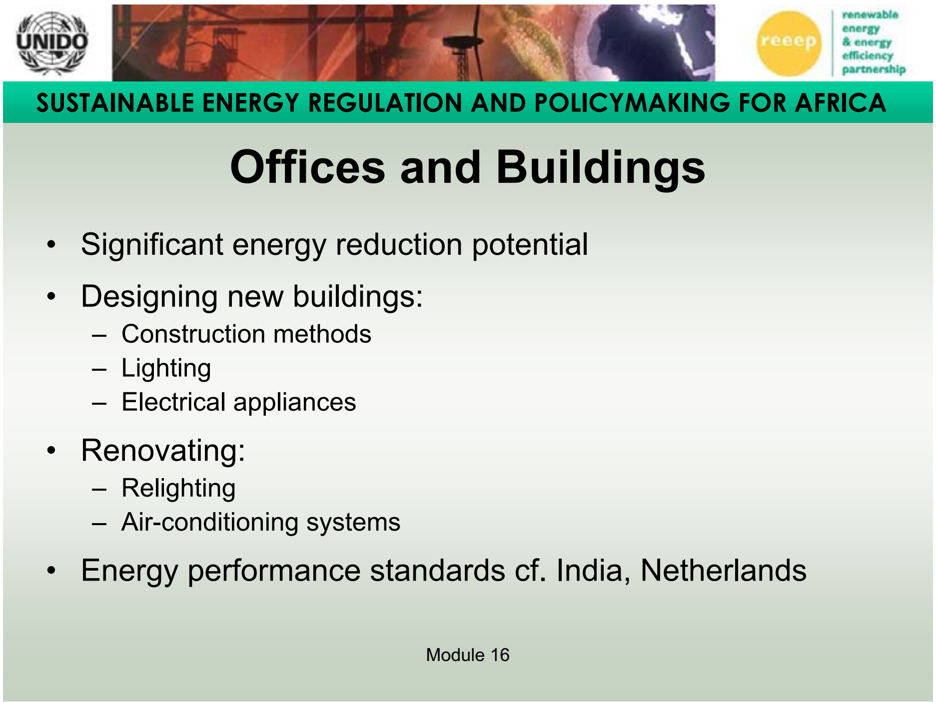


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Transport

More energy efficient car and truck engines:

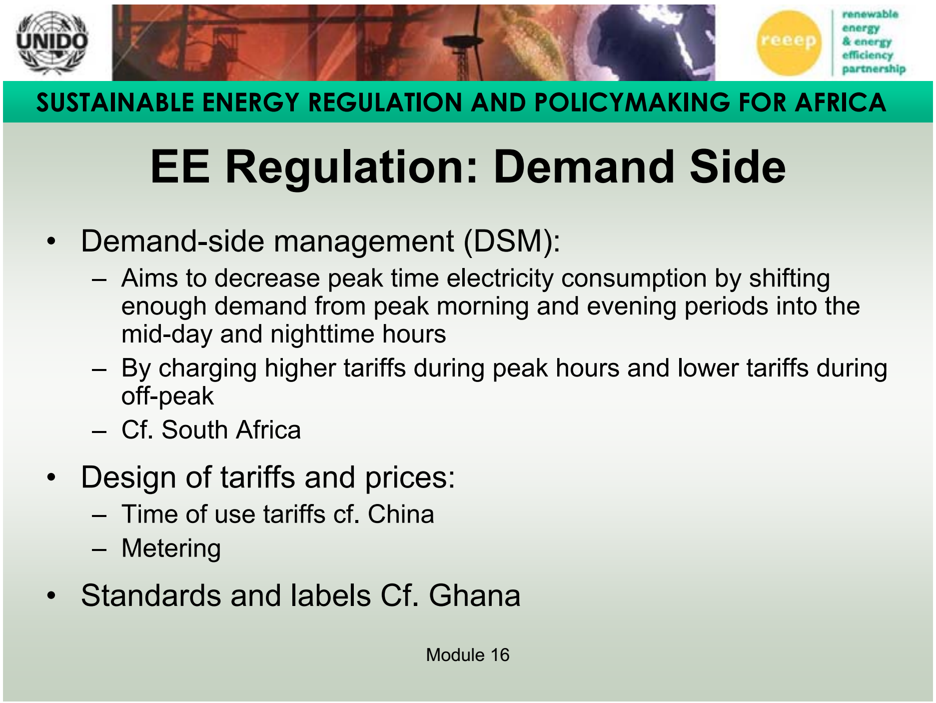
- Higher investment cost
- Policy cf. households
- Biofuels



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Offices and Buildings

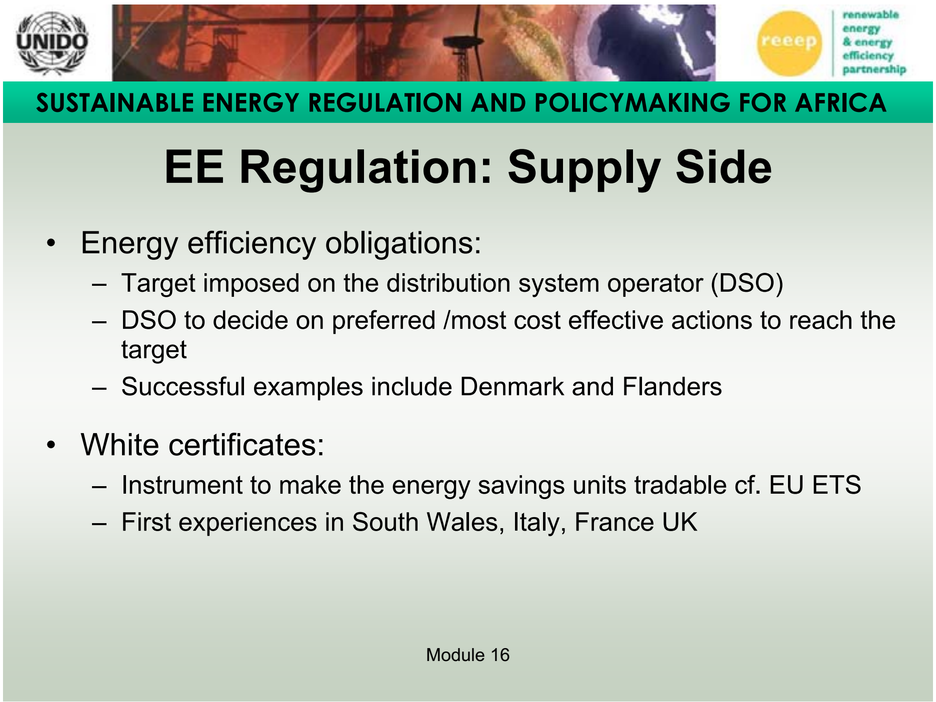
- Significant energy reduction potential
- Designing new buildings:
  - Construction methods
  - Lighting
  - Electrical appliances
- Renovating:
  - Relighting
  - Air-conditioning systems
- Energy performance standards cf. India, Netherlands



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

EE Regulation: Demand Side

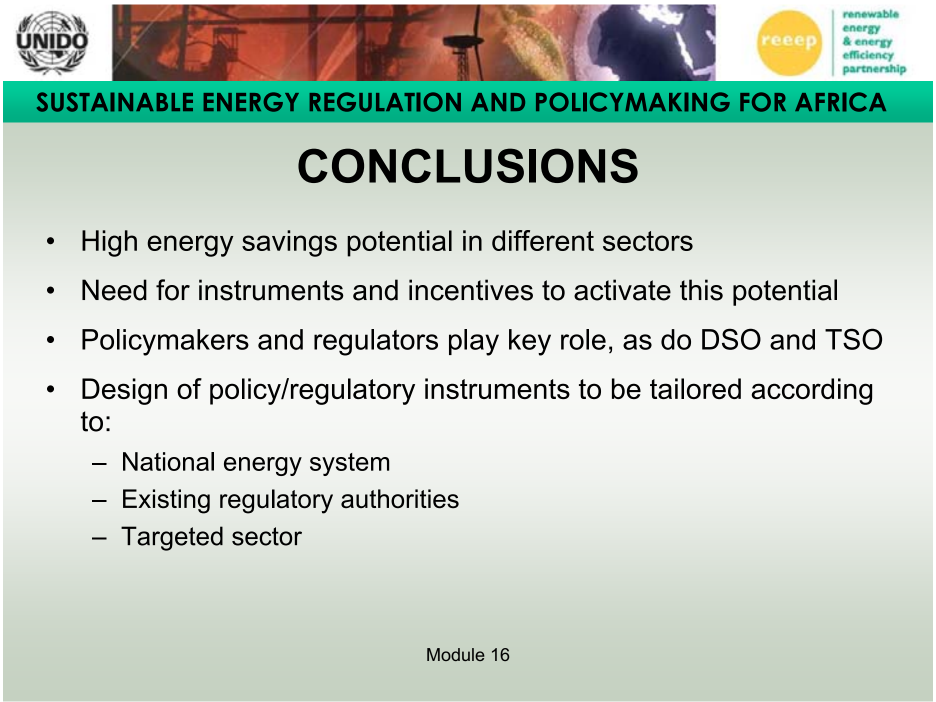
- Demand-side management (DSM):
  - Aims to decrease peak time electricity consumption by shifting enough demand from peak morning and evening periods into the mid-day and nighttime hours
  - By charging higher tariffs during peak hours and lower tariffs during off-peak
  - Cf. South Africa
- Design of tariffs and prices:
  - Time of use tariffs cf. China
  - Metering
- Standards and labels Cf. Ghana



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

EE Regulation: Supply Side

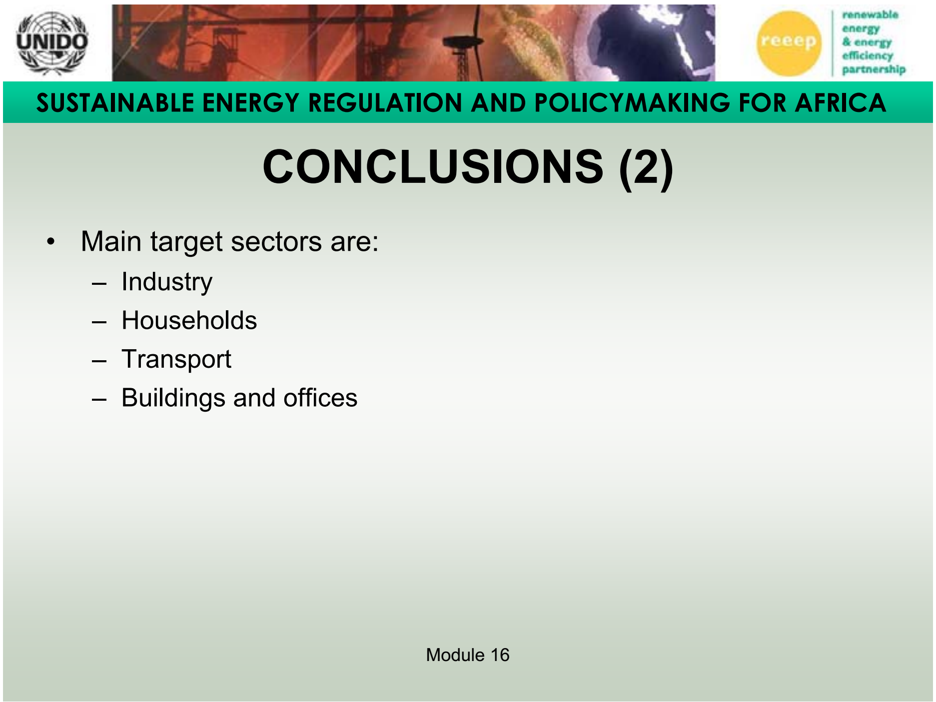
- Energy efficiency obligations:
  - Target imposed on the distribution system operator (DSO)
  - DSO to decide on preferred /most cost effective actions to reach the target
  - Successful examples include Denmark and Flanders
- White certificates:
  - Instrument to make the energy savings units tradable cf. EU ETS
  - First experiences in South Wales, Italy, France UK



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- High energy savings potential in different sectors
- Need for instruments and incentives to activate this potential
- Policymakers and regulators play key role, as do DSO and TSO
- Design of policy/regulatory instruments to be tailored according to:
  - National energy system
  - Existing regulatory authorities
  - Targeted sector



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS (2)

- Main target sectors are:
    - Industry
    - Households
    - Transport
    - Buildings and offices

Module 17

Industrial energy efficiency and systems optimization

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1 Module overview

This module builds on the information contained in the previous module concerning industrial energy efficiency. The module contains a brief recap of selected concepts and presents them in terms of firstly creating policies and regulations that will foster sustainable industrial energy efficiency programmes that will be widely supported by industry and hence will have a greater degree of sustainability and success. Secondly, the module will introduce the process of industrial systems optimization and the very significant financial benefits that can be realized by industries and national economies as a whole through the process of optimizing industrial systems.

The opportunities for improving the efficiency of industrial facilities are substantial, even in markets with mature industries that are relatively open to competition. The barriers that prevent industrial facilities from becoming more energy efficient will be described in greater detail later in this module.

Industrial energy use globally accounts for 40 per cent of electricity use, 77 per cent of coal and coal products use, and 37 per cent of natural gas use and is a major contributor to CO_2 emissions.[1] In developing countries, the portion of the energy supply (excluding transport) required for industry is frequently in excess of 50 per cent and can create tension between economic development goals and a constrained energy supply. Further, developing countries with emerging and expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy efficient best practices from the outset in new industrial facilities, rather than following the slower path to implementation that occurs in existing industrial facilities in more developed countries.

According to estimates using the Intergovernmental Panel on Climate Change (IPCC) baseline greenhouse gas (GHG) emissions scenarios published in 2000, the projected average annual growth rate for primary energy consumption in sub-Saharan African industry for 2000-2030 is 7.3 per cent under the A1 scenario and 5.1 per cent under the B2 scenario.[2] The corresponding projected growth in CO_2 emissions is 7.2 per cent and 4.2 per cent, respectively. Average annual growth rates for Middle East/N. Africa are just slightly lower.[3]

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[1] International Energy Agency (IEA) Statistics Division and IEA 7 July 2006 Industrial motor system energy efficiency: Toward a plan of action.

[2] Special Report on Emissions Scenarios: Report of Working Group III of the Intergovernmental Panel on Climate Change, 2000, Nakicenovic, N., Alcamo, J., et.al.

[3] Lawrence Berkeley National Laboratory, 24 July 2006, Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions, Lynn Price, Stephane de la Rue du Can, et al.

This module presents a practical approach to building effective industrial energy efficiency policy through a focus on energy management, industrial system optimization, and measurement and documentation to support continuous improvement. Examples will be provided from Nigeria, the United States, Europe, and China to illustrate the benefits of industrial energy efficiency. This approach is not targeted to the use of energy efficient technologies in any specific sector; instead, it addresses the opportunities for improving energy efficiency that are common across all industrial sectors.

This module will also address issues concerning programme design, developing enabling partnerships, and building a national and regional market for energy efficiency services. An overview will be provided of a range of financing mechanisms that can be employed to encourage investment in energy efficient projects.

Finally, an introduction will also be given to the Industrial Standards Framework, an integrated approach to industrial energy efficiency under development globally, including a description of additional policy mechanisms such as voluntary agreements and recognition programmes. This approach, while compatible with new technologies, does not depend on them. Rather, it relies on the application of proven management and engineering practices and existing technology to attain greater energy efficiency. Additional references will be provided from the peer-reviewed literature and from public websites to provide greater depth for interested policy makers.

1.2. Module aims

The aims of the present module are to:

- Introduce the concept and benefits of industrial energy efficiency to government officials, policy makers and regulators;
- Provide an overview of policy measures that promote industrial energy efficiency;
- Describe how to develop an industrial energy efficiency programme based on these policy measures that is sustainable and has market support;
- Introduce a broader international framework for industrial energy efficiency.

1.3 Module learning outcomes

This module attemps to achieve the following learning outcomes:

- To be able to describe the benefits and barriers of industrial energy efficiency;

- To be able to describe the policy mechanisms that can contribute to industrial energy efficiency;
- To understand the fundamental goals of energy management and industrial system optimization;
- To be able to describe the process of designing an effective industrial energy efficiency programme;
- To be aware of the international context for undertaking an industrial energy efficiency programme.

2. INTRODUCTION

This module covers industrial energy efficiency as it applies to any industrial sector, including industries that are very energy intensive (i.e. petroleum refining, chemicals), as well as those that are less intensive (i.e. textiles, general manufacturing), or seasonal (i.e. food and beverage processing). Industrial energy use globally is extremely important, accounting for 40 per cent of global electrical usage, 77 per cent of coal and coal products use, and 37 per cent of natural gas use and is a substantial contributor to CO_2 emissions that contribute to global warming. Industrial motor systems alone are responsible for 7 per cent of global electrical usage.[4]

Energy use in industry differs from energy use in the commercial and residential sectors in several important ways. First, there is the scale of use—industrial facilities are very large individual users of energy relative to commercial or residential customers. These facilities are typically among an energy provider's largest customers and use their purchasing power to get the lowest available price for delivered energy supply. Second, industrial facilities may have onsite waste (i.e. bagasse, wood scraps or fibre) that can be used for onsite generation to replace some or most of purchased energy. The high level of use tends to reinforce attention to price and availability of supply; with only so much staff time available for non-production issues, there may be little time to attend to energy efficiency.

Third, energy use in industry is much more related to operational practices than in the commercial and residential sectors. If energy efficient lighting or appliances are installed in a commercial or residential building, those devices supply the same level of service at a reduced energy use without any further intervention from the user. If a building is well insulated and favourably oriented to benefit from solar exposure, then those benefits will accrue for the life of the building unless extraordinary measures are taken to negate them.

By way of contrast, an industrial facility may change production volumes or schedules and/or the type of product manufactured many times during the useful life of the factory. The energy-using systems designed to support these production practices may be relatively energy efficient under an initial production scenario but are typically significantly less so under other production scenarios. The presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. In fact, the misapplication

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[4] Communication with Stephane de la Rue du Can, Lawrence Berkeley National Laboratory, and IEA 7 July 2006 Industrial motor systems energy efficiency: Toward a plan of action.

of energy-efficient equipment in industrial systems is common. The disappointing results from these misapplications can provide a serious disincentive for any subsequent effort toward system optimization.

The principal business of an industrial facility is production, not energy efficiency. Traditional approaches to industrial system design and operation emphasize reliability rather than energy efficiency. As long as these systems continue to support production, however inefficiently, there is little awareness of the benefits of a more energy efficient approach.

The key to industrial energy efficiency is to establish broad policy goals, such as energy management standards, build awareness of how energy efficiency can benefit industry without increasing risk, and then work with both users and suppliers of industrial systems to develop the technical skills and tools required to transform the industrial market toward more energy efficient practices. While this will take time to fully implement, immediate benefits can be realized within less than two years and the long-term effects will contribute substantially to economic growth and sustainability.

Box 1. Industrial energy efficiency in the United States

- In the United States, industry is the largest energy-using sector, accounting for 37 per cent of national natural gas demand, 29 per cent of electricity demand, and 30 per cent of greenhouse gas emissions. The U.S. Department of Energy (USDOE) estimates that a potential energy savings of 7 per cent of industrial energy consumption remains to be achieved through the application of best available practices alone.
- From 1993-2004, the industrial energy savings identified by US DOE's BestPractices programme from the application of industrial energy management best practices totalled 255 trillion Btu per year, or $US 1.4 billion in annual energy cost savings, equivalent to the energy used in 1.55 million homes

Source: United States Department of Energy presentation to the International Energy Agency, May 2006.

3. WHY INDUSTRIAL ENERGY EFFICIENCY?

As previously discussed, industries use a great deal of energy, often inefficiently, and are major contributors to CO_2 emissions. Industries are also a major contributor to economic growth. There is no inherent conflict between industrial energy efficiency and economic growth—indeed, industrial facilities that are well managed for energy efficiency are typically well managed generally, more sustainable, and therefore more competitive in global markets. In addition, the optimization of industrial systems frequently results in greater reliability and higher productivity.

Managers of industrial facilities always seek pathways to more cost-effective and reliable production. Materials utilization, labour costs, production quality and waste reduction are all subject to regular management scrutiny to increase efficiency and streamline practice. The purchase of energy from outside sources at the lowest possible price that preserves reliability of service has also become a central concern in this era of high prices and constrained supply. However, energy efficiency, particularly as it pertains to systems, is typically not a factor in this decision-making equation.

Equipment manufacturers have improved the performance of individual system components (such as motors, steam boilers, pumps and compressors) to a high degree but these components only provide a service to the users' production process when operating as part of a system. Industrial electric motor and steam systems consume huge amounts of energy and can be very inefficient.

Electric motor and steam systems offer one of the largest opportunities for energy savings, a potential that has remained largely unrealized worldwide. Both markets and policy makers tend to focus exclusively on individual system components, with an improvement potential of 2-5 per cent per component versus 20-50 per cent for complete systems, as documented by programme experiences in China, the United Kingdom and the United States.

Improved energy systems' efficiency can contribute to an industrial facility's bottom line at the same time when improving the reliability and control of these systems. Increased production through better utilization of equipment assets is frequently a collateral benefit. Maintenance costs may decline because better matching of equipment to demand needs results in less cycling of equipment operation, thus reducing wear. Optimizing the efficiency of steam systems may result in excess steam capacity that can be used for cogeneration applications. Payback periods for system optimization projects are typically short—from a few months to three years—and involve commercially available products and accepted engineering practices.

With all of these benefits, one would expect system optimization to be standard operating procedure for most industrial facilities. However, most industrial managers are unaware of both the existing inefficiency of these systems or the benefits that could be derived from optimising them for efficient operation. Inefficient energy use does not leave a toxic spill on the floor or a pile of waste material on the back lot—it is invisible. Even when it is audible, as is the case with a leaking compressed air system, plant personnel frequently accept this situation as “normal” because they have no other point of reference.

Box 2. Nigerian petroleum jelly plant doubles production with additional steam traps

In 1998, additional steam traps were installed on the drum oven at a petroleum jelly production facility at an Exxon Mobile plant in Apapa, Nigeria. The steam traps improved heat transfer and reduced the amount of time required to adequately heat the drum oven. As a result, the plant was able to double production of petroleum jelly, which led to a $US 52,500 increase in annual revenue. Total project costs were $US 6,000.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/nigeria.pdf

Box 3. Soda-ash facility recovers cost from improved coal boiler controls in six weeks

In 2002, FMC Chemicals Corporation improved the efficiency of two large coal-fired boilers at its soda ash mine in Green River, Wyoming by upgrading the burner management system (BMS). Before the upgrade, a continuous supply of natural gas was required to maintain the appropriate flame conditions required by the flame detection system of the BMS. After performing a system-level evaluation, plant personnel realized that upgrading the BMS would allow them to discontinue the natural gas supply without compromising boiler operation. The BMS upgrade project is yielding annual energy savings of $US 899,000 and 250,000 MMBtu. In addition, the components within the improved BMS require less servicing, saving $US 12,000 per year in maintenance costs. Also, a smaller inventory of spare parts is needed, and boiler reliability and plant safety are better. With total annual project savings of $US 911,000 and total project costs of $US 110,000, the simple payback was just over six weeks.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/bp_cs_fmc_chemicals.pdf

4. WHAT MOTIVATES INDUSTRY TO BECOME MORE ENERGY EFFICIENT?

Industry is motivated to become more energy efficient for a variety of reasons, including, but not limited to:

- Cost reduction;
- Improved operational reliability and control;
- Ability to increase production without requiring additional, and possibly constrained, energy supply;
- Avoidance of capital expenditures through greater utilization of existing equipment assets;
- Recognition as a “green company”;
- Access to investor capital through demonstration of effective management practices.

Box 4. In their own words—why Frito-Lay, a United States food processor, manages energy

“Frito-Lay spends about $US 110 million a year for its energy needs. This includes natural gas (everything we operate is natural-gas fueled), electricity, water and waste water. While this is well under 5 per cent of our manufacturing cost, it is a substantial outlay. Saving any fraction of that cost is worthwhile, and energy-cost improvement projects turn out to be fairly reliable investments compared to other investments. For example, we spend a lot of money developing new products and concepts. Some products do very well while others don’t do well at all”.

“Product investments are unreliable in the sense that we can’t be sure what return we will get—or if we will get any return at all. But our resource conservation portfolio consistently returns 30 per cent on investment. For example, if we spend $US 100,000 on improving, say, a steam system, and we expect to get $US 30,000 in savings per year out of it, we can rely on getting those $US 30,000 savings year in and year out. There is a community-relations aspect as well. In the communities where we operate, we are one of the larger energy consumers. When a curtailment happens, such as fuel shortages in cold winters or electricity curtailments

Box 4. *(continued)*

in hot summers, it is critical for us to be able to show that we are making significant strides to reduce our consumption. We need to be seen as doing our best to alleviate the situation rather than exacerbating it".

Source: "Energy Management Path-finding: Understanding Manufacturers' Ability and Desire to Implement Energy Efficiency," by C. Russell; presented during "National Manufacturing Week" in Chicago, Illinois, March 2005.

However, unless an industrial facility is made aware of the potential for energy efficiency, none of these factors have significance. Often facility managers have no knowledge of these opportunities.

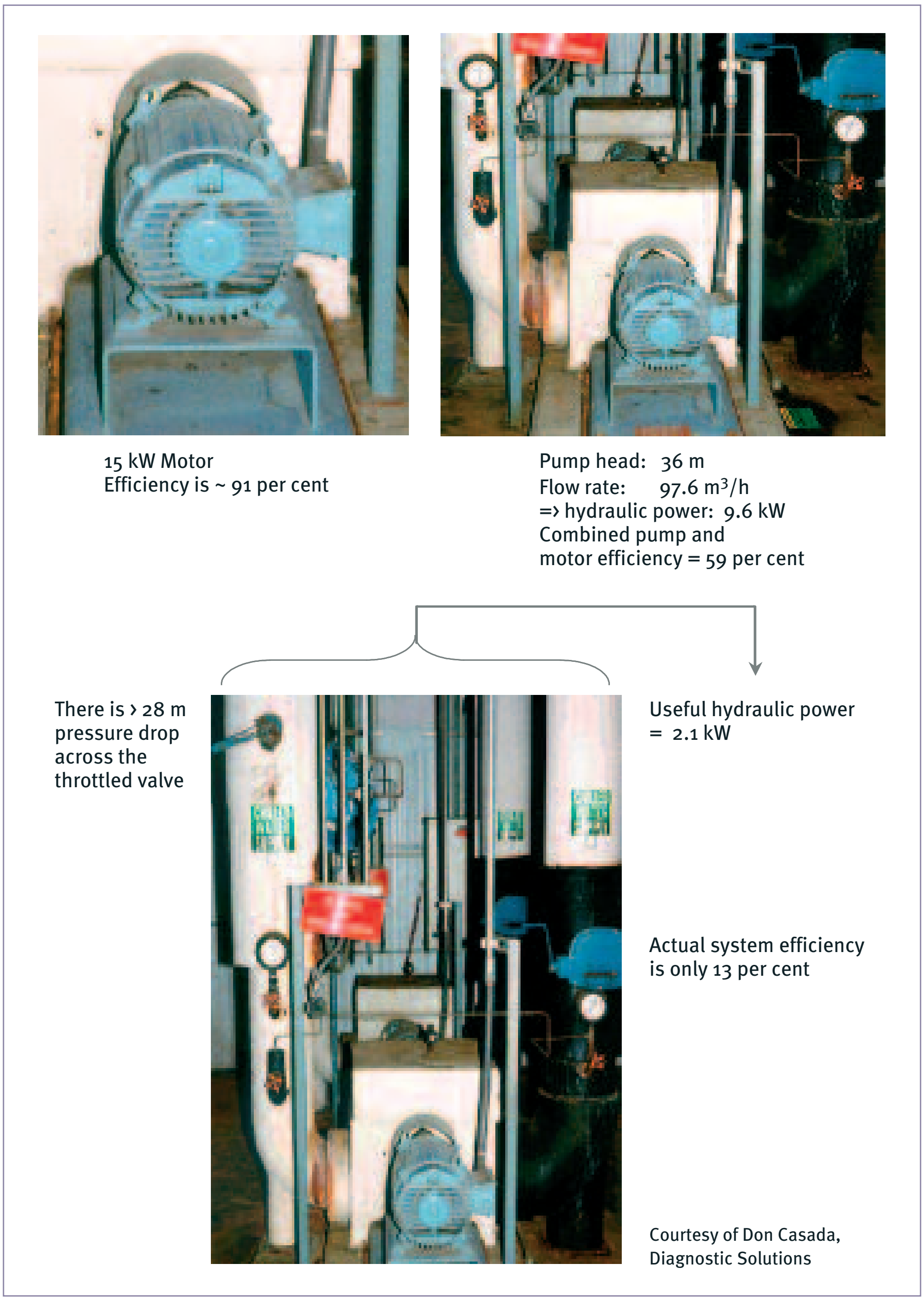
4.1. Opportunities and barriers

If system optimization is so beneficial, why isn't industry already doing it? There are several factors that contribute to a widespread failure to recognize the opportunity that systems optimization presents. This lack of awareness is a global phenomenon—including the EU, the United States, Canada, China, and Australia. Contributing factors include the complexity of these systems and the institutional structures within which they operate. Industrial systems (motor-driven and steam systems) are ubiquitous in the manufacturing environment, but their applications are highly varied. They are supporting systems, so facility engineers are typically responsible for their operation, but production practices on the plant floor (over which the facility engineer has little influence) can have a significant impact on their operational efficiency.

System optimization cannot be achieved through simplistic "one size fits all" approaches. Both industrial markets and policy makers tend to focus on equipment components (motors and drives, compressors, pumps, boilers), which can be seen, touched, and rated rather than systems, which require engineering and measurement. As previously stated, the presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. Misapplication of energy-efficient equipment (such as variable speed drives) in these systems is common. System optimization requires taking a step back to determine what work (process temperature maintained, production task performed, etc) needs to be performed. Only when these objectives have been identified can analysis be conducted to determine how best to achieve them in the most energy-efficient and cost-effective manner

An illustration of how energy efficient components can fail to result in an energy efficient *system* in shown in figure 1.

Figure I. Optimizing a motor system



15 kW Motor
Efficiency is ~ 91 per cent

Pump head: 36 m
Flow rate: 97.6 m^3/h
=> hydraulic power: 9.6 kW
Combined pump and
motor efficiency = 59 per cent

There is > 28 m
pressure drop
across the
throttled valve

Useful hydraulic power
= 2.1 kW

Actual system efficiency
is only 13 per cent

Courtesy of Don Casada,
Diagnostic Solutions

Since the efficiency of the system (motor + pump + throttle valve) is only 13 per cent, replacing the existing motor in this system with a more energy efficient one would accomplish little.

A typical example may help to illustrate the opportunities that can be derived from the application of system optimization techniques using commercially available technology, see box 5 below.

Box 5. Textile mill lowers costs and increases production after compressed air system improvement

In 1997, a compressed air system improvement project was implemented at the Peerless Division of Thomaston Mills in Thomaston, Georgia, United States. The compressed air system project was undertaken in conjunction with an effort aimed at modernizing some of the mill's production equipment. Once they were both completed, the mill was able to increase production by 2 per cent per year while reducing annual compressed air energy costs by 4 per cent ($US109,000) and maintenance costs by 35 per cent ($US 76,000). The project also improved the compressed air system's performance, resulting in a 90 per cent reduction in compressor downtime and better product quality. The project's total cost was $US 528,000 and the annual savings are $US185,000 per year, the simple payback is 2.9 years. The mill also avoided $US 55,000 in costs by installing a more optimal arrangement of compressors.

Source: www1.eere.energy.gov/industry/bestpractices/pdfs/thomastonmill.pdf

The goal to increase production and lower production costs for the mill at the same time as production changed to a new type of loom requiring more, and better controlled, compressed air triggered an opportunity to conduct an assessment of the mill's compressed air system. During the system assessment, a problem with *unstable* air pressure was identified (note that this is commonly misdiagnosed as *inadequate* pressure). Instead of increasing the pressure to compensate, thus using more energy, the plant installed storage and controls, properly configured the compressors, and reduced the amount of leakage from piping and drains. As a result, pressure was stabilized, fewer compressors were required to serve increased production, production suffered many fewer work stoppages, and energy use declined.

Without the application of system optimization techniques, the typical outcome would be treatment of the *symptom* (problems maintaining the pressure required for production equipment) rather than the *root cause* (the compressed air supply could not respond adequately to variations in the plant's compressed air requirements). Understanding how such practices occur and how they can be addressed through effective public policy and programmes is a major focus of this module.

First, existing systems were typically not designed with operational efficiency in mind. Optimizing systems for energy efficiency is not taught to engineers and designers at university—it is learned through experience. Systems are often designed to maintain reliability at the lowest first cost investment. As a result, basic design factors such as pipe size may be too small to optimize performance, and too expensive to retrofit—requiring a work-around approach to do the best optimization project possible. Unless the load to be served is constant and unlikely to change, the preferred approach to new systems is to design for efficient operation in response to variations in load

Second, once the importance of optimizing a system and identifying system optimization projects is understood, plant engineering and operations staff frequently experience difficulty in achieving management support. The reasons for this are many, but central among them are two: *(a)* a management focus on production as the core activity, not energy efficiency and *(b)* lack of management understanding of operational costs and equipment life cycle cost (which are often 80 per cent or more of the life cycle cost of the equipment). This situation is further exacerbated by the existence of a budgetary disconnect in industrial facility management between capital projects (incl. equipment purchases) and operating expenses.

Third, as a further complication, experience has shown that most optimized systems lose their initial efficiency gains over time due to personnel and production changes. Since system optimization knowledge typically resides with an individual who has received training, detailed operating instructions are not integrated with quality control and production management systems.

Since production is the core function of most industrial facilities, it follows that the most sophisticated management strategies would be applied to these highly complex processes. Successful production processes are consistent, adaptable, resource efficient, and continually improving the very qualities that would support industrial system optimization. Because production processes have the attention of upper management, the budgetary disconnect between capital and operating budgets is less evident. Unfortunately, efficient use of energy is typically not addressed in these management systems in the same way as other resources such as labour and materials. An answer lies in fully integrating energy efficiency into these existing management systems through the application of energy management standards.

5. PROMOTING INDUSTRIAL ENERGY EFFICIENCY

Returning to the question, “What motivates industry to become more energy efficient?”, one needs to look below the surface to the organizational culture. Simply defined, companies can either become energy efficient because they have to, or bad things will happen or because they want to, because there is a competitive advantage to be gained. In the first instance, companies are concerned with negative factors such as taxes, fines, damage to the company’s public image and loss of revenue and/or market share. Companies with this operating mode will typically only meet the minimum requirements; there is no integration of efficient practices. By way of contrast, companies seeking a competitive advantage are looking to energy efficiency as a strategy to achieve market distinction, low-cost positive publicity, lower operating costs, less waste, and access to financing or rebates. Companies with this operating mode tend to treat energy efficiency as continuously improving.

Effective public policy for industrial energy efficiency leverages a company’s desire to improve and to become more competitive and attractive to customers and investors alike. While judicious use of mandatory requirements (such as appliance standards) may help push some markets rapidly forward by removing the worst performing equipment or “bottom feeders”, industrial markets require a different policy/programme mix.

Recalling that the application of industrial energy efficiency best practices is largely operational, it follows that industrial energy efficiency policy and programmes must seek to change traditional operational practices and to integrate these practices into the institutional culture of the company. This is the underlying challenge of industrial energy efficiency—it requires a new way of looking at systems and corresponding changes in the behaviour of those that supply and manage them. If well-structured and delivered, an industrial energy efficiency programme can have a substantial and lasting positive impact on a country or region’s energy use that far exceeds many other opportunities. Without an effective structure and supportive delivery mechanism, policies and programmes can fall well short of this potential. The most effective tool available in developing industrial programmes and policies is the participation by industry (both manufacturing facilities and the companies that supply them) early and consistently during the planning process, while carefully avoiding the dual and unforgivable offences of wasting their time or giving the appearance of product bias.

The section that follows will present the elements of effective industrial policy making: energy management standards, enabling policies, training in energy management and system optimization and tools.

5.1. Energy management

If, as previously stated, the answer to industrial energy efficiency lies in fully integrating it into existing management systems—how is this accomplished? If, as previously discussed, plant engineers with an awareness of the benefits of system optimization still face significant barriers to achieving it, how is this overcome? If, as experience has shown, most optimized systems lose their initial efficiency gains over time, how is this avoided? Energy management standards, system optimization training, and tools to assist companies in documenting and sustaining their improvements are essential elements of an effective programme response. Other enabling policies can include recognition programmes, favourable tax policies and sectoral targets.

Since production is the core function of most industrial facilities, it follows that the most sophisticated management strategies would be applied to these highly complex processes. With the advent of quality control and production management systems such as International Organization for Standardization (ISO) 9000/14000, Total Quality Management, and Six Sigma, companies have instituted well-documented programmes to contain the cost of production and reduce waste. To date, most companies have not integrated energy use and efficiency into these management systems, even though there are obvious links to reducing operating costs and waste.

The objective is a permanent change in corporate culture using the structure, language and accountability of the existing ISO management system. The operation of industrial steam and motor systems can have a significant environmental impact on an organization. Inefficient systems not only use up to twice the energy required of optimized systems, but are also responsible for off-quality products, waste and scrap. Organizations do not normally recognize this impact. When they do, they usually think only of the initial energy impact, which is significant. The rework of off-quality products resulting from improperly operating systems can double the energy input of a product and produce additional waste. Products that cannot be reworked result in increases in the amount of scrap requiring disposal. Properly operating systems not only have reduced energy input requirements, but in many cases, reduce other energy inputs in the tools and equipment being operated by the system.

Most energy audits of such systems result in recommendations that apply to the current factory production levels. In cases where future expansion is anticipated at the time of the audit, the expansion is commonly included in the recommendations. After the recommendations have been implemented and the auditor is gone, there is no procedure in place to ensure continued proper operation of the system. Often, improvements in systems are made but changes to production levels and/or personnel negate the improvements over time. In other cases, operating personnel simply go back to doing things the way they were doing them, again negating the improvements.

Linkage to ISO

Of the management systems currently used by industrial facilities across most sectors to maintain and improve production quality, ISO is recommended as the management system of choice because it has been widely adopted in many countries, is used internationally as a trade facilitation mechanism, is already accepted as a principal source for standards related to the performance of energy-consuming industrial equipment, and has a well established system of independent auditors to assure compliance and maintain certification. For the purpose of this discussion, ISO includes both the quality management programme (ISO 9001:2000) and the environmental management programme (ISO 14001:2004), which can share a single auditing system.

A link is proposed between ISO 9000/14000 quality and environmental management systems and industrial system optimization, which has at its core an energy management standard. Since ISO currently has no explicit programme for energy efficiency, use of an ISO-compatible energy management standard, especially in combination with ISO-friendly documentation (see Documentation for Sustainability), will effectively build energy efficiency into the ISO continuous improvement programme. The objective is a permanent change in corporate culture using the structure, language, and accountability of the existing ISO management structure.

Formal integration of energy efficiency into the ISO programme certification structure (most likely as part of the ISO 14000 series), while desirable for the explicit recognition of energy efficiency as an integral part of continuous improvement, would be a resource- and time-intensive undertaking. Since the current ISO programme structure creates no specific barriers to the inclusion of energy efficiency projects, immediate programme integration is not a high priority, but could occur over time as the user community for the standard grows.

Energy management standards

The American National Standards Institute (ANSI) has adopted the Management System for Energy (MSE) developed by Georgia Institute of Technology as ANSI/MSE 2000:2005. This standard was developed by individuals with extensive experience with ISO certification and is suited for future consideration as an ISO standard. It is also compatible with Energy Star Guidelines for Energy

Management and is easily added to an ISO 14001 Environmental Management System:

> ANSI/MSE 2000:2005 . . . is a documented standard that establishes the order and consistency necessary for organizations to proactively manage their energy resources. [In this standard] personnel evaluate the processes and procedures they use to manage energy issues and incorporate strong operational controls and energy roles and responsibilities into existing job descriptions and work instructions . . . MSE 2000:2005 integrates energy into everyday business operations, and energy management becomes part of the daily responsibility for employees across the entire organization (Georgia Tech, 2005).

Figure II. ANSI/MSE 2000:2005

Source: Georgia Institute of Technology 2006.

In addition to ANSI/MSE 2000:2005, several European countries have developed energy management standards, including: Denmark, Ireland and Sweden. Additional work is underway by UNIDO to facilitate international cooperation on the development of energy management standards. Typical features of an energy management standard include:

- A strategic plan that requires measurement, management and documentation for continuous improvement for energy efficiency;
- A cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- Policies and procedures to address all aspects of energy purchase, use and disposal;
- Projects to demonstrate continuous improvement in energy efficiency;
- Creation of an energy manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- Identification of key performance indicators, unique to the company, that are tracked to measure progress;
- Periodic reporting of progress to management based on these measurements.

Additional information concerning energy management standards is included in the reference section of this chapter.

5.2. System optimization

What do we mean by system optimization? System optimization seeks to design and operate industrial systems (i.e. motor/drive, pumping, compressed air, fan and steam systems) to provide excellent support to production processes using the least amount of energy that can be cost-effectively achieved. The process of optimizing existing systems includes:

- Evaluating work requirements;
- Matching system supply to these requirements;
- Eliminating or reconfiguring inefficient uses and practices (throttling, open blowing, etc);
- Changing out or supplementing existing equipment (motors, fans, pumps, compressors) to better match work requirements and increase operating efficiency;

- Applying sophisticated control strategies and variable speed drives that allow greater flexibility to match supply with demand;
- Identifying and correcting maintenance problems;
- Upgrading ongoing maintenance practices.

Please note that a system that is optimized to both energy efficiency and cost effectiveness may not use the absolute least amount of energy that is technically possible. The focus is on achieving a balance between cost and use that applies energy resources as efficiently as possible.

Figure III. What is a system

Courtesy of Don Casada, Diagnostic Solutions and United States Department of Energy.

An industrial system encompasses everything from the supply of energy into the system to the production end uses. A pump house, compressor room, or boiler room is not an industrial system because it only covers the supply side, not the distribution and end use. The mismatch between supply and end use is the most fertile ground for improving energy efficiency.

Opportunities overview

The skills required to optimize systems are readily transferable to any individual with existing knowledge of basic engineering principles and industrial operations. Training and educational programmes in the United States and the United Kingdom have successfully transferred system optimization skills since the early-1990s.

Examples of system optimization benefits:

- After system optimization training, a Chinese engineer connects two compressed air lines in a polyester fibre plant, saving 1 million RMB annually (about $US 127,000);[5]
- A United States system optimization expert conducts a plant assessment and directs operations staff to close a valve serving an abandoned steam line, saving nearly $US 1 million annually;
- A United Kingdom facility experiencing difficulty with excess delivery pressure, pump cavitation and water hammer identifies an opportunity to reduce the system head. After trimming the pump impeller for a cost of £377, the plant realizes energy savings of £12,905 and maintenance savings of £4,350 for a simple project payback of eight days.

While these examples have been selected for their impact, it is important to understand that the inefficient situations that produced these opportunities occur frequently. The primary cause is quite simple—the employees at industrial facilities rarely have either the training or the time to recognize the opportunities, to take the “step back” to see the big picture.

Building technical capacity

Since system optimization is not taught in universities or technical colleges, UNIDO has worked with a team of international experts to develop and pilot in China a training curriculum specifically designed to build the necessary technical capacity.

A carefully organized training programme can have a significant impact. As a result of the United Nations Industrial Development (UNIDO) China Motor System Energy Conservation Programme, 22 engineers were trained in system optimization techniques in Jiangsu and Shanghai provinces. The trainees were a mix of plant and consulting engineers. Within two years after completing training, these experts conducted 38 industrial plant assessments and identified nearly 40 million kWh in energy savings.

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[5] 1 RMB = $0.127146, Exchange Rate 10 November 2006.

Table 1. Energy savings from system improvements (China pilot programme)

System/facility	Total cost ($US)	Energy savings (kWh/year)	Payback period
Compressed air/forge plant	18,600	150,000	1.5 years
Compressed air/machinery plant	32,400	310,800	1.3 years
Compressed air/tobacco industry	23,900	150,000	2 years
Pump system/hospital	18,600	77,000	2 years
Pump system/pharmaceuticals	150,000	1.05 million	1.8 years
Motor systems/petrochemicals (an extremely large facility)	393,000	14.1 million	0.5 years

UNIDO 2005

The goal of capacity-building training is to create a cadre of highly skilled system optimization experts. Careful selection is needed of individuals with prior training in mechanical or electrical engineering, who have an interest and the opportunity to apply their training to develop projects. This training is intensive and system-specific. Experts may come from a variety of backgrounds, including, but not limited to: government sponsored energy centres, factories, consulting companies, equipment manufacturers and engineering services companies. Experts in pumping systems, compressed air systems, ventilating systems, motors and steam systems should be used to develop local experts through an extensive training programme. Training should include both classroom and hands-on measurement and system assessment instruction and include at least a year of access to follow-up technical assistance from the instructors to assist the trainees in developing their first few projects. The resulting system experts are prepared to evaluate and optimize one or more industrial motor-driven systems or steam systems

Ideally, the completion of the intensive training programme is coupled with recognition for the competency of the trained local experts through a certificate. Testing of skills through the successful completion of at least one system optimization assessment and preparation of a written report with recommendations that demonstrates the ability to apply system optimization skills should be a prerequisite for any recognition.

The trained local experts should also be prepared to offer awareness level training to factory operating personnel on how to recognize system optimization opportunities. This awareness training can be used to build interest in and a market for the local experts' system optimization services. In addition, awareness training can provide a basic understanding of system optimization for factory operating personnel to apply in identifying energy efficiency project opportunities.

Documenting for sustainability

In order to ensure persistence for energy efficiency savings from system optimization projects, a method of verifying the on-going energy savings under a variety of operating conditions is required. ISO 9000/14000 Series Standards would require continuously monitoring an organization's adherence to the new energy system-operating paradigm.

The purpose of ISO 14001 is to provide a framework for organizations to achieve and demonstrate their commitment to an environmental management system that minimizes the impact of their activities on the environment (a similar framework for ISO 9001:2000 pertains to quality). The framework does not include any specific requirements, only a means of achieving goals set by the organization. This ISO standard also provides for an audit procedure to verify that established policies of the organization are being followed. To maintain certification, participating companies must maintain a Quality Environmental Management (QEM) Manual.

The environmental management system model for this standard is composed of six elements: *(a)* the establishment of an environmental policy by the organization; *(b)* planning; *(c)* implementation and operation; *(d)* checking and corrective action; *(e)* management review; and, *(f)* continual improvement.

Once top management has defined the organization's environmental policy, the next step is planning. In the ISO 14001-1996 Environmental management systems—Specification with guidance for use, Section 4.3.1 states:

> "The organization shall establish and maintain (a) procedure(s) to identify the environmental aspects of its activities, products or services that it can control and over which it can be expected to have an influence, in order to determine those which have or can have significant impacts on the environment. The organization shall ensure that the aspects related to these significant impacts are considered in setting its environmental objectives".

There are two approaches to establishing and maintaining efficient operation of energy systems. Both approaches involve the "Planning" phase and the "Implementation and operation" phase of ISO 14001. As an alternative for operations that are ISO 9000 certified, but not ISO 14000, these same steps can be incorporated into the ISO 9000 Quality Standards.

First, a set of standards can be developed in the ISO format that can be incorporated in the "Planning" portion of ISO 14001.[6] From those standards, work instructions can be written for the "Implementation and operation" portion. By making these "best practices" standards part of ISO certification, an organization ensures that these best practices will become part of the organization culture through the continuing audit procedure required by ISO. By making these best practices ISO-friendly, organizations can easily incorporate them into existing ISO systems. The number of standards incorporated can be determined by the individual organization. As more goals are reached, new standards can be included, further improving the energy efficiency of the steam and motor systems' operation and making efficiency part of the culture. Second, for organizations that are involved in carbon financing, ISO standards can be developed that are specific to that organization's on-going commitment to energy efficiency and pollution reduction.

A procedure refers to a general description of a process and is incorporated into a company's QEM Manual. The first step is for a company to develop a policy of efficient operation of energy systems within their facility, then develop and implement system procedures that are consistent with that policy.

The company must develop procedures for energy systems. The company must document those procedures and keep the documentation up to date. Each procedure should:

- Specify its purpose and intended scope;
- Describe how an activity is to be performed;
- Describe who is responsible for carrying out the activity;
- Explain why the activity is important to the efficient operation of the system;
- Identify a timetable for the activity;
- Explain what equipment is required to complete the activity;
- Detail the documents and records that need to be kept.

Procedures may also refer to detailed work instructions that explain exactly how the work should be performed.

A project refers to a specific activity designed to contribute to meeting the ISO requirement for continuous improvement. Examples of projects include: initiating a leak management programme or replacing a throttle valve on a pumping sys-

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[6] The use of the term "standard" in this context broadly refers to a company-specific operational standard as part of the company's ISO plan, not an energy efficiency standard per se. The inclusion of energy-efficient best practices as part of these operational standards is what is discussed here.

tem with a speed control device. Work instructions are step-by-step information (text, diagrams, photos, specifications, etc) to assist operations staff in maintaining the improvements realized through implementation of a project. Examples include: instructions on how and when to check leaks and repair them or maintenance information to ensure that the pump system speed control device continues to function efficiently. Work instructions are typically posted for or easily accessible to operations staff.

The regular external audit process assures that proper and efficient operation of industrial energy systems is maintained and becomes part of each firm's operating culture, while transferring much of the burden and cost associated with regulatory compliance enforcement to these independent auditors. Linkage to ISO will also provide verification of results for financial backers (including future CDM carbon traders), and provide a clear methodology for recognizing "investment grade" projects, which will help stimulate a significantly higher level of industrial energy efficiency.

To enable firms to comply with the energy management standards and to more easily include energy efficiency projects as part of a company's continuous improvement plan (whether ISO or not), UNIDO and its partners are creating a System Optimization Library. The System Optimization Library consists of an electronic reference document that organizes energy efficiency opportunities by system and includes a series of procedures, projects, and work instructions written in an ISO-compatible format that are designed to facilitate integration of energy efficiency system improvements into ISO 9000/14000 operational and compliance materials.

Other enabling policies

In addition to energy management standards, system optimization training, and tools to assist industrial facilities in documenting and sustaining energy efficiency, other enabling policies that have been effective include: recognition programmes, favourable tax policies and sectoral targets in the form of energy efficiency agreements. This section will provide a brief introduction to energy efficiency agreements. For a more complete discussion of international experience with these policies, see Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience (Price, Lynn et al, 2006).

Energy efficiency agreements

Energy efficiency agreements, otherwise known as voluntary agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within a specific industrial sector. The Netherlands has the most extensive experience with these types of agreements, but they have also been implemented in a number of other countries, including: Australia, China, Denmark, and the United Kingdom.

An energy efficiency agreement is a written agreement between an industrial company and government (this can be accomplished through an industrial association) that establishes a mutually agreed upon target for energy savings over a long-term period given specified supporting policies. The features of an effective energy efficient agreement include:

- Signed, negotiated agreement with specific targets tied to units of production;
- Long-term outlook (typically 5-10 years);
- Includes an implementation plan for reaching the targets;
- Includes annual monitoring of progress toward the targets;
- Require supporting programmes- technical assistance, recognition to succeed;
- Most effective programmes;
- Are legally binding;
- Set realistic targets;
- Include sufficient government support;
- Include real threat of increased government regulation or energy/GHG taxes if targets are not achieved.

The inclusion of energy efficiency agreements is a useful addition to an industrial energy efficiency policy. This policy instrument is entirely compatible with the promulgation of energy management standards, system optimization training, and documenting for sustainability. An energy efficiency agreement provides a broad, but measurable target while an energy management standard provides an industrial facility with a methodology for meeting the target and system optimization techniques identify projects that help the facility meet both the goals of the standard and the efficiency targets of agreement.

6. GETTING STARTED

6.1. Building a market for industrial energy efficiency services

Role of government

The primary role of government is to develop and issue energy efficiency standards and to support the provision to industry, consultants and suppliers of training and tools to aid in compliance. A further role is to recognize outstanding efforts that exceed compliance requirements.

Standards for corporate energy management provide a framework for companies to integrate an energy efficiency ethic into their management practices. Government-sponsored training would prepare plant engineers and emerging energy service companies with:

- The skills to recognize energy efficiency opportunities, including on-site power generation, via training on system techniques;
- An understanding of standards requirements;
- Knowledge and access to the software tools for use in developing and implementing projects;
- Government-sponsored recognition based on verified energy savings provides industrial plants with the incentive to document and report project savings.

Engineers (plant-based and consulting) will need to be trained in the systems approach. These experts will provide awareness training to encourage plants to undertake system optimization improvements, conduct plant assessments to identify system optimization opportunities, work with plants to finance and develop projects based on these findings, and prepare case studies of successful projects. This cadre of experts will also form the nucleus for future training of additional experts.

Role of industry

Industrial plants are responsible for compliance with national standards for corporate energy management, which typically require:

- An energy management team led by an energy coordinator with strong management support;
- Policies and procedures to promote energy efficiency;

- Projects to demonstrate continuous improvement in energy efficiency;
- Monitoring and measurement to document achievement of annual energy efficiency goals.

These requirements can be achieved through the application of system optimization techniques (with their own staff or outside experts), to identify energy efficiency opportunities. If the industrial plant is ISO-certified, work instructions, projects and procedures should be integrated into current ISO 9000/14000 programmes. The periodic ISO audit provides independent verification of compliance with written procedures and policies, and energy-efficient operation becomes part of the factory culture.

Role of suppliers

Industrial facilities typically develop very close relationships with their supply chain, including the suppliers of the equipment used in motor-driven and steam systems. Suppliers can have an important role in introducing system optimization concepts through their interactions with customers. Conversely, if suppliers do not identify any benefit or value from an industrial energy efficiency programme or policy, they can have a significant negative impact. Plant personnel are well aware that if they experience an equipment failure or system problem that affects production, they must obtain emergency service from their supplier, and quickly. A government programme that seeks to influence the system supplier/user relationship to promote more energy efficient practices needs to recognize the importance of the relationship to both parties, or expect that the supplier may discourage the plant from adopting any new practices.

Role of energy service companies

Energy Service Companies, or ESCOs, typically provide customers with a range of services to develop energy efficiency projects. These services can include: technical assessments, bid specification development, project development and implementation, and financing arrangements in which the cost of the project is paid from the resulting energy savings. A principal benefit to an industrial facility from using an ESCO is the opportunity to develop capital projects “off-budget”—without any investment of capital funds.

In general, energy service companies (ESCOs) are under-represented in industrial markets worldwide. With a few exceptions, ESCOs have had little impact on the development of energy efficiency projects that involve industrial systems. ESCOs typically enter industrial markets with experience from the commercial sector and tend to concentrate on measures such as lighting and district heating that are found in commercial buildings. Alternatively, ESCOs concentrate on a very narrow portfolio of measures in which they build a specific expertise.

Properly prepared, however, ESCOs can be an important element of an effective industrial energy efficiency programme. For example, several projects developed by experts who participated in the UNIDO system optimization training programme in China have had shared savings arrangements. Please note that before undertaking these projects, the experts completed their training and understood the optimization potential of the systems that they assessed. Please also note that all such work in industry requires close attention to contract details, as changes in production can have a significant impact on anticipated energy savings.

Finally, one relatively recent market development should also be considered. Equipment suppliers well trained in system optimization techniques are becoming increasingly engaged in offering ESCO-type services for their system of specialty, especially compressed air and pumping systems. These services generally include a commitment to manage for energy efficiency and are usually offered by suppliers to industrial customers with whom they hope to continue a long-term relationship. As such, they offer more promise for sustaining energy efficiency than the narrow range of measures from other specialized ESCOs.

6.2. Programme design

The key to an effective industrial energy efficiency policy is to find a balance between consistency and flexibility. Consistency in programme message, goals, target industries and basic programme offerings is critical. When announcing an industrial programme, a policy maker should assume that industry will require at least a year to accept it and another year or more to respond. Most industries require at least 12-18 months for completion of an energy efficiency project after an assessment is done and opportunities have been identified. This is because any planned capital improvements must wait to be included in the following year’s budget cycle. Changing organizational behaviour takes time and permanent market change takes even longer. Assume that an industrial energy efficiency programme will take at least five years to fully mature. Small improvements to the programme or “tweaking” during this period can be helpful—especially in response to industry input; but re-branding and major meddling with the programme design are counterproductive and to be avoided. If funds are too limited to consider a full-scale launch, a graduated programme could begin with system optimization training (expert and awareness), followed later by energy management standards and documentation for sustainability.

Training experts and suppliers

A comprehensive training programme would include the following components:

Experts training

The purpose of this training is to prepare a group of experts who will be expected to: *(a)* provide awareness training to encourage plants to undertake system optimization improvements; *(b)* conduct plant assessments to identify system optimization opportunities; *(c)* work with plants to finance and develop projects based on these findings; and, *(d)* prepare case studies of successful projects. A one-to-one, one-to-many, training and implementation scheme has been tested and proven effective. In this approach, international experts are engaged in the initial capacity-building to create a core of highly skilled experts who will become a resource to their country and the region for years to come. To ensure success of the training, selection of the individuals to be trained must be rigorous and based on technical and training capabilities. Successfully negotiating this selection process will require the international team and the country coordinators to develop a shared vision of the project goals, which will vary somewhat from country to country in response to cultural, organizational, and social requirements. This cadre of experts will also form the nucleus for future training of additional experts.

A three-step training programme on optimization of each industrial energy system is recommended, based on UNIDO's execution of similar training in China. According to this model, an international team of experts initiates the training of system optimization experts in close cooperation with country coordinators. The international team is drawn from a pool of the leading experts who either participated in the UNIDO China Motor System Program experts training or otherwise come highly recommended as trainers and system optimization experts. The international team should include at least two experts for each system type (see figure IV):

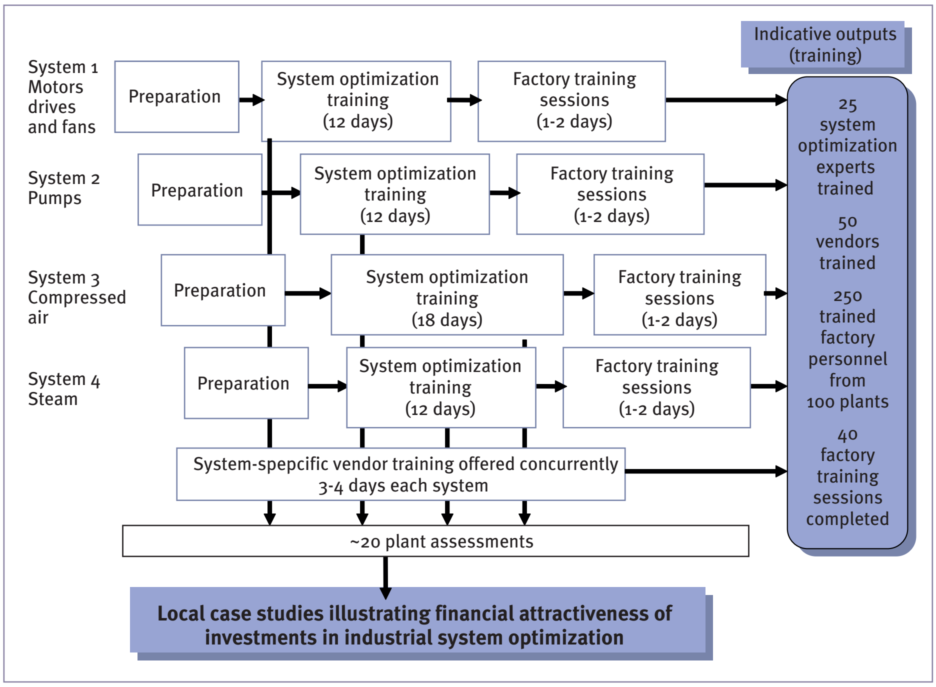
- Preparatory activities are completed over periods of two to three months in advance of each system optimization training session. This involves the compilation of training materials by the international team, the identification of appropriate factories for the in-plant training by the country coordinator with requisite pump/fan/drive/compressor/steam systems, securing approval of site visits, purchase of measurement equipment to perform the in-plant training, acquisition of technical data from host plants pertaining to the systems and components to be evaluated by the teams, identification of classroom facilities, provision of accommodation for trainees, etc.
- During system optimization training, international teams train local energy experts in classroom and plant settings. At each plant the local experts are

trained "on-the-job" in the use of measuring instrumentation, data collection and analysis and the preparation of investment proposals for energy systems improvements, which are subsequently submitted to management of the plants hosting the training. Training covers system design, operation and installation, measurement of fluid flows, pressures, energy consumption, and application of analytical software.

Case studies are developed illustrating financially attractive investments in efficiency improvements. The national experts then employ the case studies in the subsequent factory training.

- Following completion of each system optimization training module, each international team returns to work with their trainees on plant assessment and project development skills. In addition, the international teams prepare and observe trained national experts conducting training of local personnel in "factory training sessions". These factory-training sessions continue to be undertaken by the national experts to build awareness of system optimization services.

Figure IV. System optimization training—expert and vendor



UNIDO 2005.

Vendor training

Concurrent with experts training, it is an excellent idea to conduct training to introduce equipment vendors, manufacturers' representatives, and suppliers to system optimization techniques. Each training session should focus a specific system type and be offering a mix of theory and practical considerations. The purpose of this training is to prepare manufacturers, vendors and suppliers to: *(a)* participate in reinforcing the system optimization message with their customers; and *(b)* assist them in identifying what will be required to reshape their market offerings to reflect a system services approach. Combining the expert training and vendor training is not recommended, as their needs are different and the dynamics of the supplier/customer relationship could distract from the overall learning experience.

Building industrial awareness

A core element of any industrial energy efficiency programme is an information campaign. This campaign should introduce industry to the basic concepts of energy management and industrial system optimization. The message needs to be appropriate to plant managers and needs to make a direct link, through brief examples no more than a couple of sentences long, between industrial energy efficiency and cost savings, improved reliability and greater productivity. If international corporations have already established or plan to establish industrial facilities in the country, they may be important allies in this campaign—see Developing enabling partnerships. Please note that while reference to the environmental benefits of industrial energy efficiency can be helpful, this is an additional benefit for most managers, after the economic benefit.

Once the in-country system optimization experts have been trained, additional awareness messages will be needed to help them build the market for system optimization services. It is important for the government to be active during this early stage of market transformation, for instance, hosting factory awareness training sessions as part of the programme response to the announcement of the energy management standard. A list of the trained experts should be kept and made available to companies seeking system optimization services.

Establishing an energy management standard

The appropriate government agency will be charged with developing and issuing an energy management standard. Even if the agency decides to adopt an existing energy management standard, an advisory committee should be formed to participate in the process. The advisory committee should include representatives from companies with medium and large industrial facilities and from several of the industrial sectors most important to the country's economic growth. The advisory committee should also include respected members of the consulting engineering and supplier community who have extensive experience in industry. To be effective, this group should number no more than 15 persons. The purpose of the advisory committee is to ensure that the standard, as adopted, can be practically applied to the country's industries and to build ownership in use of the standard prior to its announcement. Work is now underway at UNIDO on guidance documents on energy management standards.

In addition to the advisory committee, a public comment period should be held. The length of this period and the number of informational workshops will be determined by the requirements of the implementing country and the effort required to provide access to information about the proposed standard. Again, this public comment period can be used to build ownership of the energy management standard prior to its formal announcement. Industrial companies do not like sudden changes in governance, so providing information well in advance can improve the chances for success of the standard.

An energy management standard should be issued initially as a voluntary standard coupled with a recognition programme for companies who demonstrate that they are applying the standard. The decision to make the standard mandatory is best made well in advance, for instance, the government might announce a voluntary standard with a three to five-year phase-in period to a mandatory energy management standard. Some time will be required for industrial firms to develop the organizational infrastructure needed to effectively implement the standard. This transition period is needed to avoid unnecessary disruptions in industrial operations.

Standards training

Training will be needed to prepare industrial firms to comply with energy management and standards. What is envisioned is a "train the trainer" approach that engages interested system optimization experts and representatives from large companies in understanding and learning how to apply these standards. The programme would recognize experts and representatives from large firms as qualified to offer their services to industrial firms who are developing their compliance programmes. Government representatives and their designees would receive specialized training in standards oversight and enforcement.

6.3. Developing enabling partnerships

For an industrial energy efficiency policy to become effective, government officials will need to form partnerships. These enabling partnerships are needed to:

- Build ownership in the proposed efforts to change existing practices and behaviours for greater energy efficiency;

- Reach many industrial firms with the system optimization message through existing business relationships (such as with suppliers, trade associations, etc);
- Develop credibility within specialized industrial sectors;
- Ensure that proposed policies are practical given the current situation of industry in the country;
- Engage the financial community and assist them in understanding the financial benefits of industrial energy efficiency;
- Recruit the best talent to become trained in system optimization techniques;
- Successfully launch an industrial energy efficiency programme.

The specific organizations that make effective partners will vary from country to country, but generally include: industrial trade associations, professional engineering societies or associations, equipment manufacturers and suppliers and their associations, leading and/or growing industrial companies, power companies, technical universities and commercial lenders.

If well-established multi-national corporations have already, or plan to have, industrial operations in the country, they may be interested in becoming identified with an industrial energy efficiency programme as a way to demonstrate that they are a good corporate citizen in the host country. Most multi-national corporations have sophisticated business management systems in place, such as ISO or Six Sigma, however, they may not yet have an energy management system in place. Plants operated by these companies offer the potential for either case studies on the ongoing benefits of energy management (if such a system is already in place), or as “early adopters” through integration of a new energy management standard into their existing business practices.

6.4. Financing considerations

Although systems optimization projects are typically small ($US 10,000-250,000) and do not require off-balance sheet financing, partnerships with financial institutions or other sophisticated financing measures, the availability of capital varies widely from country to country. An effective industrial energy efficiency programme will need to establish mechanisms designed to enable local banks and financing institutions to support the energy efficiency (systems optimization) efforts of their industrial clients.

As experts have noted, a common barrier to financing of energy efficiency projects is caused by the introduction of a cash-flow based financing model required by third party financing rather than the typical model of asset-based lending directly to an institution. This section does not propose major structural changes in financing practices, but rather to identify meaningful short-term mechanisms that will create incentives for the industrial organizations to initiate and accelerate the process of integrating energy efficiency into their management programmes for continuous improvement.

A comprehensive programme should consider a mix of financing mechanisms developed in consultation with plant personnel, energy efficiency organizations, vendors, utilities, and financial institutions that are identified as needed to accelerate this integration process. All incentives should be carefully evaluated to select only those that do not interfere with developing market support for energy efficiency that continues after the incentive is phased out. These mechanisms could include, but are not limited to:

- Loans—an intermediary loan fund can be used to reduce the cost of capital made available to commercial banks for loans to industrial organizations that undertake improvement projects developed using recognized system optimization methods. The lending product can be either a guaranteed loan or a subsidized interest rate loan; typically backed up by a revolving fund initiated through non-commercial sources. Thailand has experience with a revolving fund for energy conservation.

- Financial incentives—these are typically rebates, dealer incentives, or other mechanisms offered through a utility as part of a peak load management or demand reduction initiative. These incentives need to be very carefully structured to avoid distorting the true market value of energy efficiency improvements—which needs to be recognized in order to persist after the financial incentive is withdrawn.

- Leasing arrangements—sometimes described as leaseback arrangements, which allow an industrial plant to make a monthly payment for energy efficiency improvements from their operating and maintenance budget rather than seeking approval and financing for capital improvements. Some vendors are already offering these arrangements, which could be expanded and strengthened through capacity building to focus on system improvements rather than components. Established vendors have access to commercial credit and are frequently further supported by equipment manufacturers.

- Vendor provision of the desired service rather than equipment. In this arrangement, the vendor retains ownership of the system and contracts with the plant to provide the desired service—pumped fluid, compressed air, etc. This arrangement is also known as “over the fence”, since the system owner is outside of the factory.

- Third party financing—energy service performance contract in which, via shared savings or other mechanisms, a third party finances the improvement. This arrangement differs from a vendor arrangement because the ESCO typically obtains payment from the savings achieved.

7. PULLING IT TOGETHER

7.1. Industrial standards framework

The Industrial Standards Framework proposes a link between ISO 9000/14000 quality and environmental management systems and industrial system. This Industrial Standards Framework includes energy management standards, policies, training and tools that have the net effect of making system optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The objective is a permanent change in corporate culture using the structure, language and accountability of the existing ISO management structure. The proposed Industrial Standards Framework is equally applicable in industrialized or industrializing countries. See table 2: Industrial standards framework.

The purpose of the framework is to standardize, measure and recognize industrial system optimization efforts, including waste heat recovery and the installation of on-site power generation. The framework builds on existing knowledge of "best practices" using commercially available technologies and well tested engineering principles. The framework seeks to engineer industrial systems for reliability and productivity, as well as energy efficiency. Factories can use the framework to approach system optimization incrementally in a way that maximizes positive results and minimizes risk and downtime.

A key element of the framework is a corporate energy management programme. Since ISO currently has no explicit programme for energy efficiency, the framework builds energy efficiency into an ISO continuous improvement programme (9001:2000 or 14001) through an ISO-compatible energy management programme.

Table 2. Industrial Standards Framework

Element	Category	Purpose	Current status	Importance	Compatibility
Corporate energy management standard	Standard, voluntary or mandatory	Provides organizational guidance for “hardwiring” energy managementinto company management practices	ANSI/MSE 2000 (US); existing standards also in Denmark, Ireland, Sweden; planned for China	Essential for management support; compliance with standard can be met through other elements	Written as possible ISO standard with ISO-friendly documentation and continuous improvement requirements
	Training	Prepares management to implement standard	Existing training through Georgia Tech (US).		
System optimization library	Tool-electronic reference document	Provides factory personnel and experts with guidance on system optimization within the ISO context of procedures, projects, and work instructions	Library samples developed and reviewed; demonstration project planned	Essential—provides an incremental path to continuously improve and maintain system efficiency	Written in ISO language for use in ISO 9000 or 14000 programme; supports corporate energy management goals
	Training	Prepares factory personnel and system optimization experts to use library (Follows system optimization awareness training)	Training to be developed as art of demonstration project		
System optimization training	Training	Expert training prepares a cadre of engineers to conduct factory assessments, train factory personnel, and assist in project development Awareness training alerts factory personnel to system optimization opportunities	Expert and awareness training developed as part of UNIDO Motor System Programme (China)	Essential—provides the technical skills for small group of experts and prepares them to train others	Consistent with the approach used for Motor System Standard, system optimization library

ISO 9001:2000 and/or 14001 certification	Independent certification	Determines whether a factory is meeting ISO objectives for continuous improvement via procedures, projects and work instructions	Global programme with over 770,000 participating companies	Essential for sustaining and improving energy efficiency	Other elements provide path for maintaining certification
Energy efficiency targets by industrial sector	Policy	Provides plant-specific energy efficiency targets based on continuous improvement that is non-prescriptive and developed in cooperation with the industrial sector	Pilot programme developed and demonstrated in Chinese steel industry; based on European experience	Very helpful—engages management in efficiency objectives, leading to other elements	Compatible with all elements
Government recognition of outstanding energy management	Policy	Provides meaningful recognition programme for factories who initiate and sustain continuous improvement for energy efficiency	Proposed	Very helpful for motivating companies to become energy efficient	Recognition based on measurable results from other elements

Source: Aimee McKane, Lawrence Berkeley National Laboratory 2005.

8. CONCLUSION

Industrial energy efficiency is frequently overlooked by policy-makers concerned about energy supply and use. Although designing an industrial energy efficiency programme takes time and must be undertaken with some care, the opportunities for improving the efficiency of industrial facilities are substantial, even in markets with mature industries that are relatively open to competition. Developing countries with emerging and expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy efficient best practices from the outset in new industrial facilities, rather than following the slower path to implementation that occurs in existing industrial facilities in more developed countries.

For a company to achieve a high level of energy-efficiency, maintain it and continuously improve it:

- The company needs an organizational culture that supports continuous improvement;
- The company's management must develop methods to "hardwire" energy-efficiency into existing management practices;
- Energy efficiency needs to become a "key performance indicator" for managers and workers.

The business-as-usual scenario would likely include the continuation of oversized and poorly controlled systems that inadequately match system supply to production demand. The reason is that this is "generally accepted engineering practice" which can only be overcome through a concentrated educational effort.

This missed energy efficiency opportunity from the business-as-usual scenario would apply to both existing systems and new systems. For existing systems, conservative engineering practices would dictate replacing failing or ageing equipment with equipment of similar or larger capacity without first conducting a thorough assessment of actual system needs. For new systems or systems undergoing a major retrofit, this missed opportunity could be even greater, since these systems, once oversized or mismatched to load requirements, are likely to remain so for the life of the equipment, which could be 10-20 years or more.

In the growing economies of the African region, the loss from omitting industry from a country's energy efficiency portfolio would be large and virtually non-recoverable in terms of wasted energy and excessive GHG emissions. While it could be argued that global market pressures will eventually push industries in the region toward greater energy-efficiency, this is a very blunt and long-term instrument that will be overshadowed in the short-term by other production cost advantages, such as labour.

LEARNING RESOURCES

Key points covered

These are the key points covered in the module:

- The concept of industrial energy efficiency has been described along with the economic and developmental reasons why industrial energy efficiency represents an important goal for industries and governments to pursue and how this applies to both developed and developing countries.
- The proven opportunities and the existing barriers to industrial energy efficiency have been detailed and explained.
- The process of industrial systems optimization has been presented and the very significant benefits that can be realized by industries have been demonstrated.
- The available policy and market-based instruments to promote industrial energy efficiency as integral part of industrial corporate management and operation have been presented and described.
- The process for establishing a policy framework and a suitably enabling market environment for industrial energy efficiency services has been described along with the roles of the various relevant parties/stakeholders. The key steps and tools/actions needed for developing and implementing sustainable IEE programmes have been explained and described.

Review questions

1. An equipment supplier has been selling pumps for 20 years. What benefit could the system optimization approach have for his/her business? What are the perceived threats to his/her business? What might you do to encourage his/her participation in system optimization training?
2. A company has factories that are fewer than five years old. What possible benefit could this company gain from *(a)* implementing energy management standards or *(b)* system optimization training?

Exercises

How would you begin to develop an industrial energy efficiency programme in your country? Sketch a diagram of what your programme implementation scheme might look like. Think about each element of the programme (standards development, capacity building, training, documentation and reporting, other enabling policies), what would be required to complete each, who would participate, what you could accomplish.

Presentation/suggested discussion topics

Presentation: ENERGY EFFICIENCY—Module 17: Industrial energy efficiency and systems optimization

Suggested discussion topics:

What do you think are the main challenges to implementing industrial energy efficiency in your country? Consider the types of industries and the industrial growth, the typical size of industries, the growth of management systems such as ISO, the technical capabilities of industry and suppliers, and the current status of interactions between industrial companies and government.

1. Make a list of the greatest challenges.
2. Make a list of organizations that are potential partners and what would motivate them to become involved.

Answers to review questions

Question: An equipment supplier has been selling pumps for 20 years. What benefit could the system optimization approach have for his/her business? What are the perceived threats to his/her business? What might you do to encourage his/her participation in system optimization training?

Answer:

A supplier will typically have experience in equipment components, not systems. In this example, it is likely that the supplier is quite familiar with pumps, seals, valves and other equipment which are selected from the perspective of providing the customer with reliable service. The supplier is much less likely to have experience with the operation of the pumping system from an energy efficiency perspective.

Potential business benefit: expand the market for selling pumping system services and related products, especially for existing systems. Provide market distinction for energy efficient performance. Bring greater technical value to the customer relationship.

Perceived threats: government has an unknown (and potentially negative) influence on customer interest in supplier and supplier's products; providing system services requires an investment of time and money in training that takes away from resources available for today's business with no guarantee of a positive return.

To encourage participation:

Involve major suppliers in developing and offering the vendor training programme. *Note: you must invite all major suppliers to participate in this process to ensure that the resulting training is well balanced and not biased toward any one-product line or business practice.* Explain to participating suppliers that the vendor training is being offered to them to familiarize them with the training that their customers will be receiving. Invite them to develop ways to effectively "sell into" the systems message.

Question: A company has factories that are fewer than five years old. What possible benefit could this company gain from *(a)* implementing energy management standards or *(b)* system optimization training?

As discussed earlier, many new systems are not designed for energy efficiency and could benefit from further optimization. Moreover, a company that does not have a system in place to measure and document system performance over time will not be able to sustain the initial energy efficiency level of those systems. An energy management system addresses all aspects of energy in the facility, from procurement through use to proper disposal. Any plant, however new, would benefit from such an approach.

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INTERNET RESOURCES

www1.eere.energy.gov/industry/bestpractices/

> BestPractices, under the United States Department of Energy (USDOE) Industrial Technologies Program, works with U.S. industry to implement energy management practices in industrial plants. To meet the diverse needs of U.S. industry, BestPractices provides a wide variety of downloadable publications, case studies, technical reports, and software for corporate executives, plant managers, technical staff, and the general public.

industrial-energy.lbl.gov/

> Lawrence Berkeley National Laboratory, a multi-disciplinary scientific laboratory managed by the University of California at Berkeley and USDOE, has a website dedicated to industrial energy analysis and programme design, both in the US and internationally. The website includes a range of publications and technical information from LBNL researchers as well as links to other researchers and websites of interest.

www.energystar.gov/index.cfm?c=guidelines.guidelines_index

> The US Environmental Protection Agency (USEPA) offers a energy management tools and resources such as guidelines for energy management, sector-based technical guides, and a self-benchmarking index for selected industrial sectors.

www.ase.org/section/topic/industry/clearinghouse/ieeenergymanagement

> The Alliance to Save Energy, a not-for-profit organization in the US, has a section of their website dedicated to industrial energy management, including case studies.

energyefficiency.jrc.cec.eu.int/Motorchallenge/

> The Motor Challenge Programme is a European Commission voluntary programme through which industrial companies are aided in improving the energy efficiency of their Motor Driven Systems. The website includes useful technical information on motor system efficiency as well as links to other European organizations with programme activities in industrial energy efficiency.

GLOSSARY/DEFINITION OF KEY CONCEPTS

Capacity building	Providing the technical and policy training required to prepare individuals and organizations to carry out a new function within a country or region. In the case of industrial energy efficiency, capacity building refers to training designed to develop a cadre of system optimization experts and skilled vendors. The goal is to prepare these individuals to train others and demonstrate system optimization techniques through plant assessments and resulting projects.
Continuous improvement	A term widely used in industry to describe a method of management applied to the manufacturing and supporting processes in a company that requires regular examination of these processes to identify ways to improve efficiency, quality, cost, materials utilization, or other factors. Continuous improvement is not a destination, it is a *process* and is a core concept of the ISO 9000/14000 management series.
Documentation for sustainability	Refers to the process of developing written policies, procedures, and work instructions to document changes in system operations. This documentation is used by a management system such as ISO to ensure that the new, more energy efficient operating practices are sustained over time, despite changes in personnel and production.
Energy management standards	A comprehensive standard, initially voluntary, that establishes the order and consistency necessary for organizations to proactively manage their energy resources. A key feature requires personnel to evaluate the processes and procedures they use to manage energy issues and incorporate strong operational controls and energy roles and responsibilities into existing job descriptions and work instructions.
Industrial standards framework	Industrial standards framework includes energy management standards, policies, training and tools that have the net effect of making system optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The objective is a permanent change in corporate culture using the structure, language, and accountability of the existing ISO management structure.
Industrial system	Industrial systems include motor-driven (compressed air, fan, pumping, conveyors, other motor/drive configurations) and steam systems. These are supporting systems, rather than industrial processes. They are ubiquitous in the manufacturing environment,

	but their applications are highly varied. Facility engineers are typically responsible for their operation. An industrial system encompasses everything from the supply of energy into the system to the production end uses. A pump house, compressor room, or boiler room is *not* an industrial system because it only covers the supply side, not the distribution and end use. The mismatch between supply and end use is the most fertile ground for improving energy efficiency.
ISO	International Organization for Standardization or ISO is the world's largest developer of voluntary international standards for business, government and society. Of these, ISO 9001:2000 and ISO 14001:2004, which give the requirements for, respectively, quality management and environmental management systems, are among ISO's most well-known and widely implemented. They are used worldwide by businesses and organizations large and small, in public and private sectors, by manufacturers and service providers, in all sectors of activity.
Market transformation	Refers to a permanent change or "transformation" in the way that a market functions. In the case of industrial system energy efficiency, we seek to shift buyers and sellers of industrial energy-using equipment from a market based on the sale of equipment components to a market based on the sale of system energy efficiency services, including system assessments, controls, proper piping and storage, and quality maintenance practices in addition to equipment sized for efficient operation. While financial incentives may be required to begin shifting market behaviour, no incentives should be necessary once this transformation has occurred.
System optimization	The process through which an industrial system achieves the most energy efficient operating configuration that is cost-effective for the industrial facility. System optimization requires analysis and measurement to determine the current state of operation and to make recommendations concerning energy efficiency alternatives.

Case study 1.

COMPANIES FORGE INDIVIDUAL PATHS TO ENERGY MANAGEMENT

CONTENTS

1. INTRODUCTION

Scrambling for relief from today's high energy costs, many industrial manufacturers are focusing on their energy consumption and finding ways to manage it. Although there is no "one size fits all" programme, companies are finding positive ways to integrate energy management practices into their daily operations.

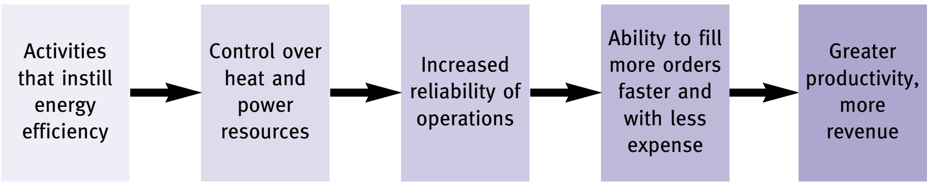
2. BENEFITS AND IMPACTS

As an organizational process, *energy management* improves a company's business performance, while *energy efficiency* describes the practices and standards that are specified by an energy management plan.

Unchecked energy expenditures are like cumulative tax burdens on each stage of production. Thus, effective energy use can directly improve productivity. Aside from lower energy bills, other benefits include greater capacity utilization, reduced scrap rates, compliance with emissions and safety regulations, and enhanced risk management.

The best industrial energy management programmes engage human, technical, and financial resources. Energy performance criteria usually reflect input from engineering, maintenance, finance, and utility staff, and all staff are accountable for outcomes. Coordinated energy decision-making improves a company's competitiveness and ultimately contributes to its wealth, as illustrated in the diagram.

Figure I. **Cumulative benefits of energy management in industry**



3. TEN PATHFINDERS

To better understand effective energy management programmes, the U.S. Department of Energy's (DOE) Industrial Technologies Programme (ITP) supported a sample study conducted by the Alliance to Save Energy. Ten companies were studied: 3M, C&A Floorcoverings, Continental Tire North America, DuPont, Frito-Lay, Kimberly-Clark Corporation, Merck & Co., Mercury Marine, Shaw Industries, and Unilever HPC. Many of them used ITP information resources and software tools in creating their energy management programmes.

They cited these reasons for establishing their programmes:

- Energy expense control and management of energy price volatility;
- Control of other expenses, such as capital expenditures;
- Increased revenue potential through identification and replication of capacity improvements;
- Improved product marketing through visible resource stewardship;
- Risk mitigation related to environmental liabilities and operational reliability.

Though some common threads run through the programmes, they are all different. Each has noteworthy features and results. Here are some examples:

- Both ***3M*** and the manufacturers that purchase its many products know that their markets require goods and materials with low environmental impacts; 3M has reduced its own energy consumption per pound of product at least 20 per cent since 2000. Managers believe that resource stewardship simply makes good business sense.
- ***Georgia-based C&A Floorcoverings*** matches its energy-efficiency initiatives with its business goals. In two years, C&A reduced its annual costs for natural gas, which topped $US 800,000 annually, by 10 per cent by adopting an ANSI-certified standard, “Management System for Energy 2005,” as a template for its programme.
- Energy consultants and in-house management worked together to help a ***Continental Tire North America*** plant in Illinois reduce its energy consumption per tire produced by 31 per cent. Continental also partnered with an energy services company (ESCO) to incorporate self-sustaining energy management procedures into its operations.
- With more than 100 plants in 70 countries, ***DuPont*** has made energy efficiency a high priority, applying a “Six Sigma” methodology to energy management. Through 2002, more than 75 energy improvement projects had been implemented, with average annual savings of more than $US 250,000 per project.
- ***Frito-Lay’s*** energy management focuses on results and requires extensive monitoring, measurement, and communications. The company’s efficiency initiatives have yielded a return of more than 30 per cent on efficiency investments.

- ***Kimberly-Clark Corporation*** employs best practices to reduce air emissions, upgrade waste water treatment, minimize process water use and packaging, and eliminate landfills and toxic chemicals at more than 165 plants worldwide. The company has reduced energy use per ton of product by about 12 per cent.
- The corporate energy programme at ***Merck & Co.*** holds site managers accountable for reaching performance targets. The company's goal is to cut site energy costs by 22 per cent in four years and avoid 250,000 tons of carbon emissions. Energy efficiency was used as a strategy to increase production from existing assets, offsetting the need to make capital investments in new capacity.
- ***Mercury Marine,*** a marine propulsion systems manufacturer, gives a single manager the authority to make energy improvements, assigns cost control responsibility to production units, and uses information technologies to monitor energy flows and to bill production units for their energy use. A centralized compressed air system has reduced the company's $US 7 million annual electricity bill by nearly $US 500,000.
- Using DOE plant assessment methods and ITP BestPractices materials, a demand-side engineer at ***Shaw Industries*** documented potential energy savings of $US 1 million per month in the first six months of his tenure. In-house staff use DOE resources in energy assessment and remediation activities.
- ***Unilever's Health and Personal Care Division's*** energy management programme features a simple budget-to-actual spreadsheet comparing the energy performance of 14 facilities. The spreadsheet information has inspired facility managers to save $US 4 million in energy costs and another $US 4 million in avoided costs. This activity has caught the attention of Unilever's Board of Directors.

4. CONCLUSION

Market conditions, asset management strategies, corporate involvement, a structure of authorities, and linking energy performance to business goals all seem to be major factors in effective corporate energy management programmes.

More and more companies are tailoring programmes to their own particular characteristics and needs. Their approach to energy management reflects their organizational profiles and abilities, and their commitment to improving productivity and profits through more efficient energy use.

5. REFERENCES

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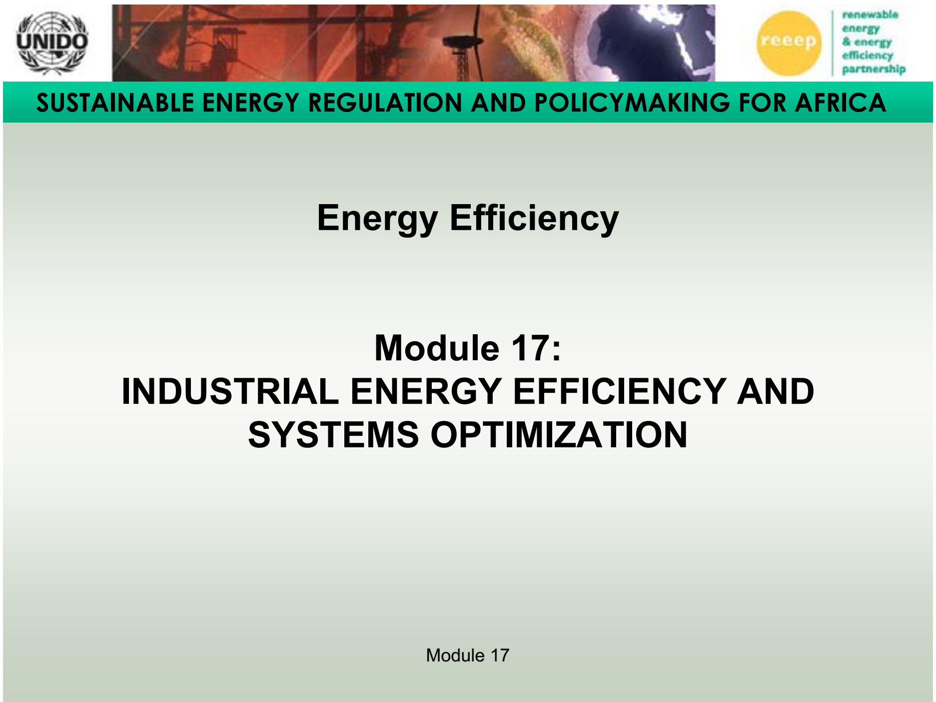
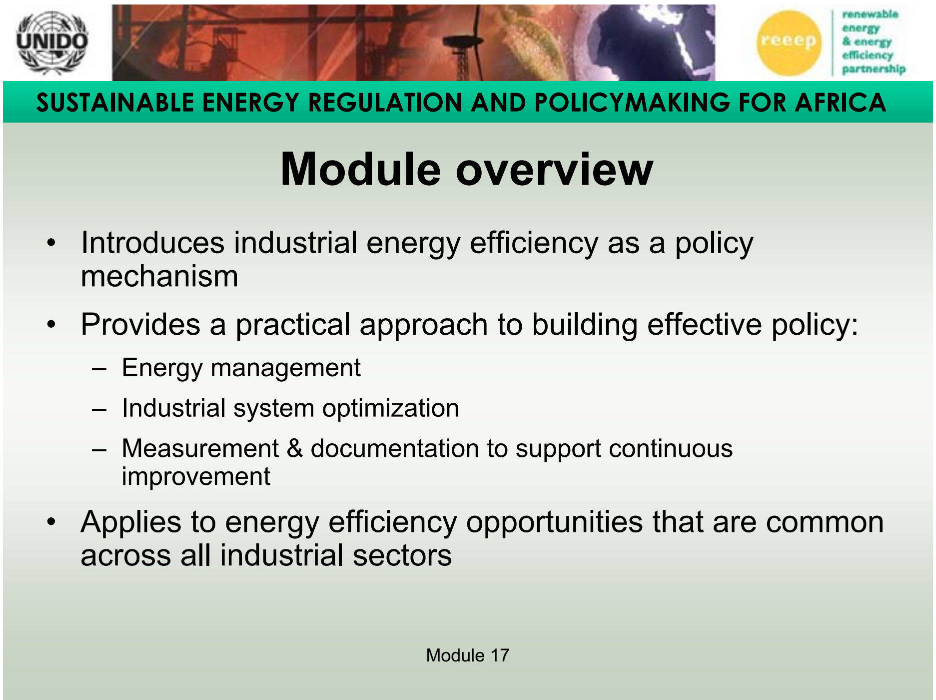


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

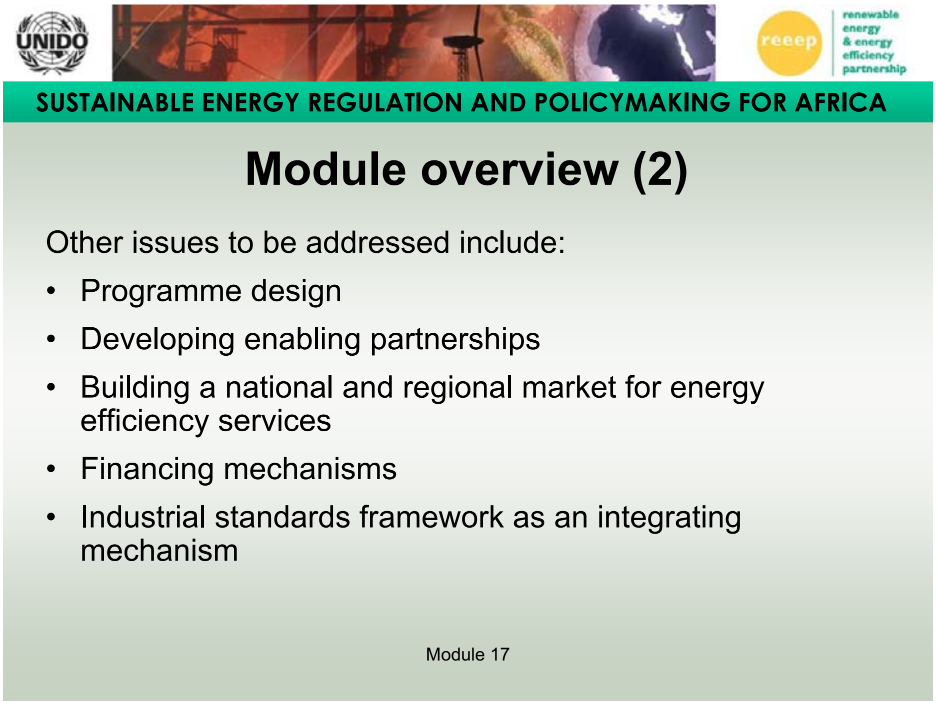
Module 17:
INDUSTRIAL ENERGY EFFICIENCY AND SYSTEMS OPTIMIZATION



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Introduces industrial energy efficiency as a policy mechanism
- Provides a practical approach to building effective policy:
  - Energy management
  - Industrial system optimization
  - Measurement & documentation to support continuous improvement
- Applies to energy efficiency opportunities that are common across all industrial sectors



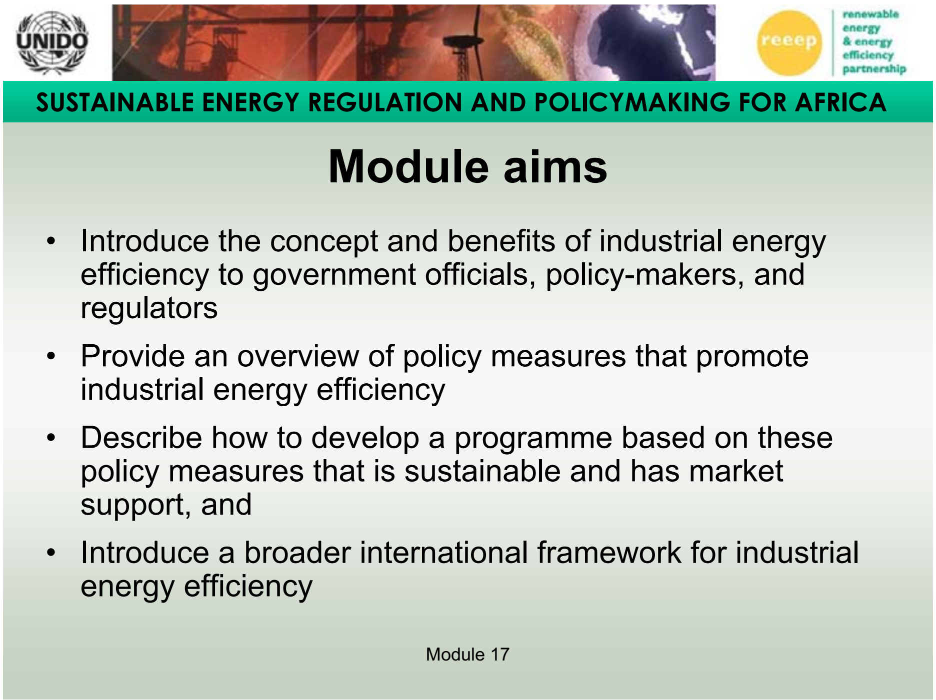
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview (2)

Other issues to be addressed include:

- Programme design
- Developing enabling partnerships
- Building a national and regional market for energy efficiency services
- Financing mechanisms
- Industrial standards framework as an integrating mechanism

Module 17

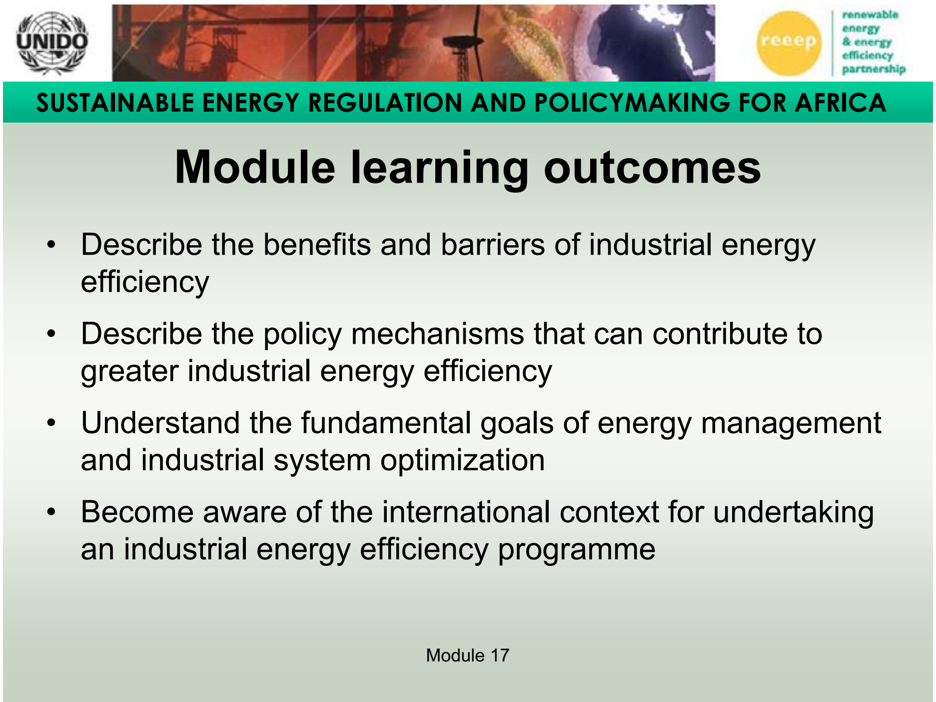


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Introduce the concept and benefits of industrial energy efficiency to government officials, policy-makers, and regulators
- Provide an overview of policy measures that promote industrial energy efficiency
- Describe how to develop a programme based on these policy measures that is sustainable and has market support, and
- Introduce a broader international framework for industrial energy efficiency

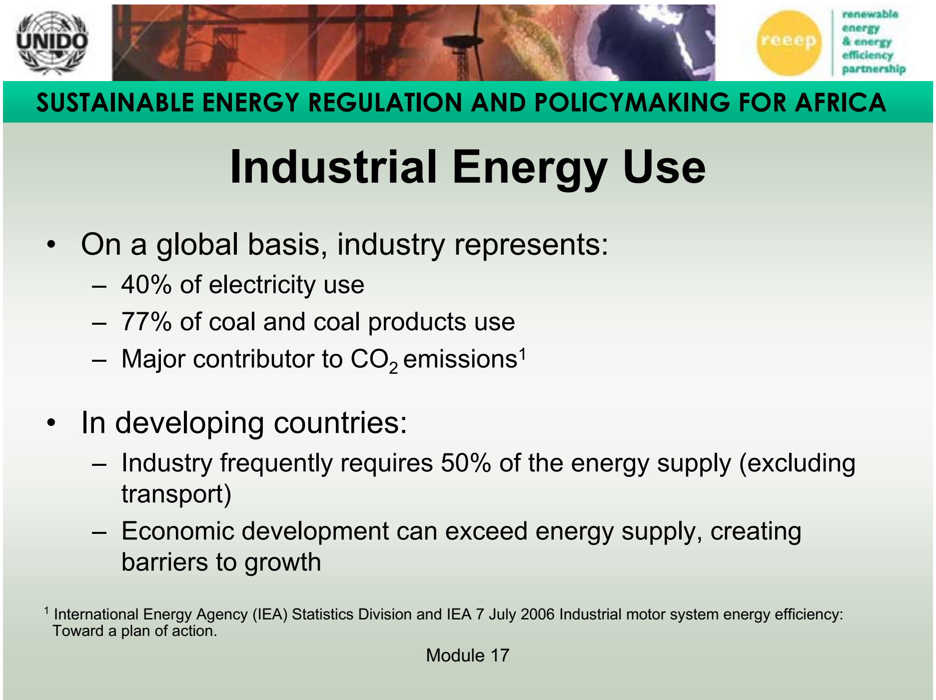
Module 17



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- Describe the benefits and barriers of industrial energy efficiency
- Describe the policy mechanisms that can contribute to greater industrial energy efficiency
- Understand the fundamental goals of energy management and industrial system optimization
- Become aware of the international context for undertaking an industrial energy efficiency programme

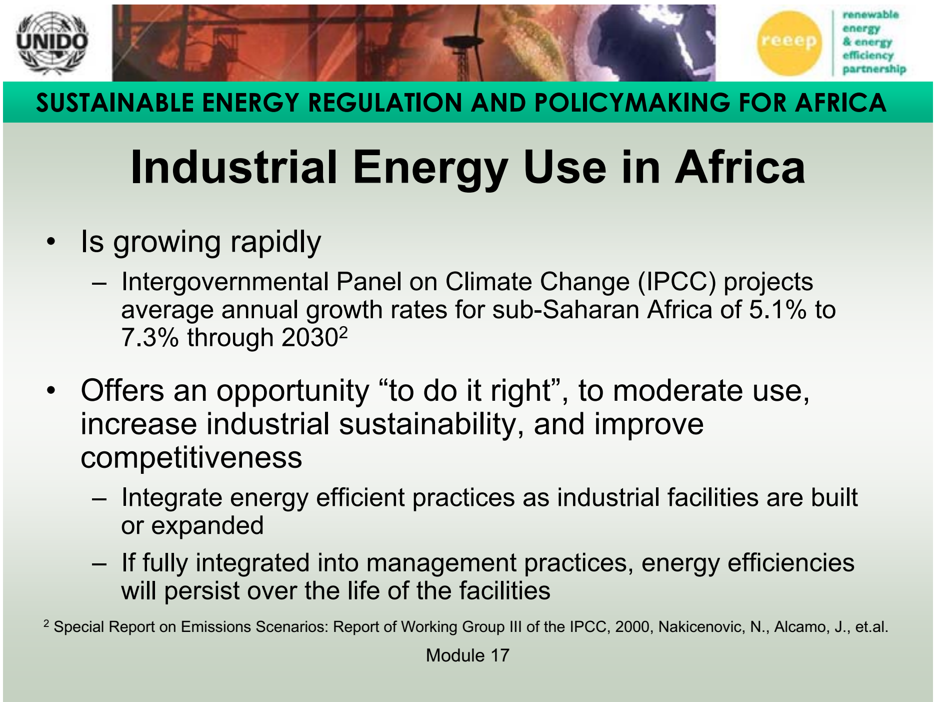


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Energy Use

- On a global basis, industry represents:
  - 40% of electricity use
  - 77% of coal and coal products use
  - Major contributor to CO_2 emissions[1]
- In developing countries:
  - Industry frequently requires 50% of the energy supply (excluding transport)
  - Economic development can exceed energy supply, creating barriers to growth

[1] International Energy Agency (IEA) Statistics Division and IEA 7 July 2006 Industrial motor system energy efficiency: Toward a plan of action.



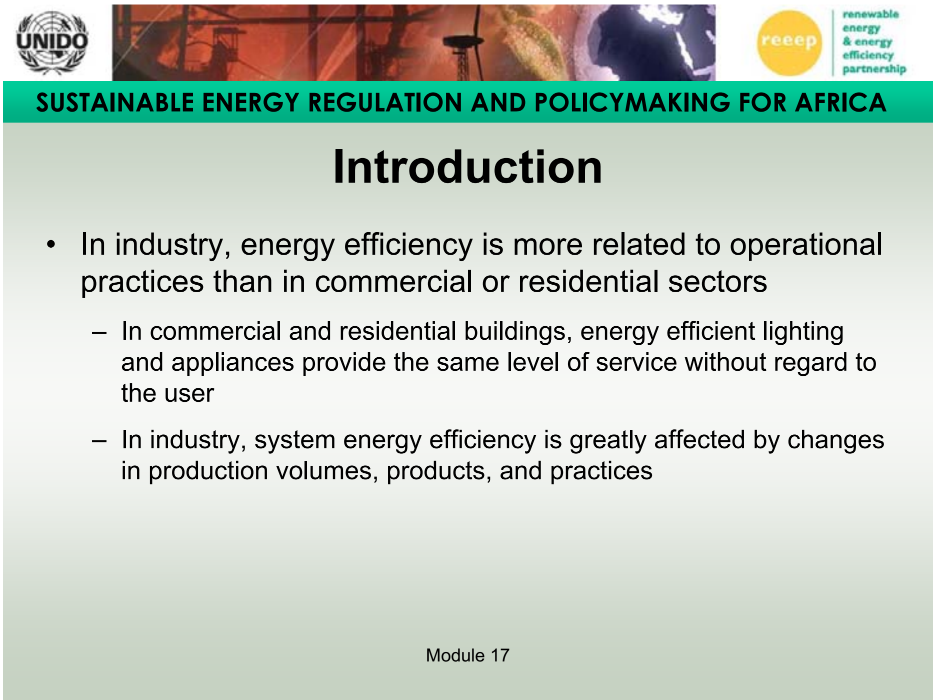
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Energy Use in Africa

- Is growing rapidly
  - Intergovernmental Panel on Climate Change (IPCC) projects average annual growth rates for sub-Saharan Africa of 5.1% to 7.3% through 2030[2]
- Offers an opportunity “to do it right”, to moderate use, increase industrial sustainability, and improve competitiveness
  - Integrate energy efficient practices as industrial facilities are built or expanded
  - If fully integrated into management practices, energy efficiencies will persist over the life of the facilities

[2] Special Report on Emissions Scenarios: Report of Working Group III of the IPCC, 2000, Nakicenovic, N., Alcamo, J., et.al.

Module 17



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

- In industry, energy efficiency is more related to operational practices than in commercial or residential sectors
  - In commercial and residential buildings, energy efficient lighting and appliances provide the same level of service without regard to the user
  - In industry, system energy efficiency is greatly affected by changes in production volumes, products, and practices

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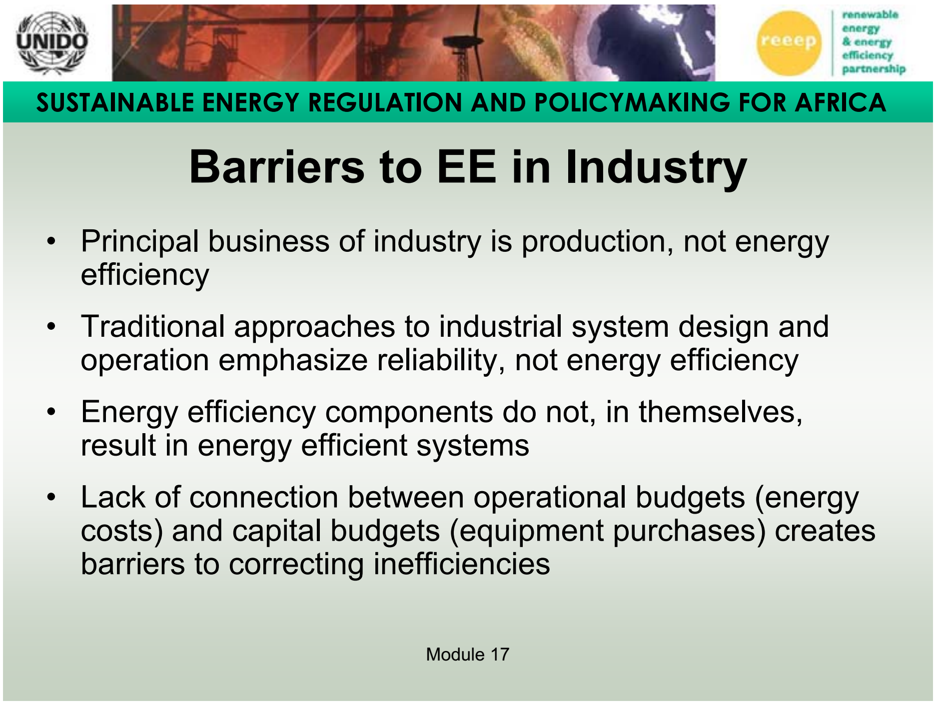

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Barriers to EE in Industry

- Principal business of industry is production, not energy efficiency
- Traditional approaches to industrial system design and operation emphasize reliability, not energy efficiency
- Energy efficiency components do not, in themselves, result in energy efficient systems
- Lack of connection between operational budgets (energy costs) and capital budgets (equipment purchases) creates barriers to correcting inefficiencies

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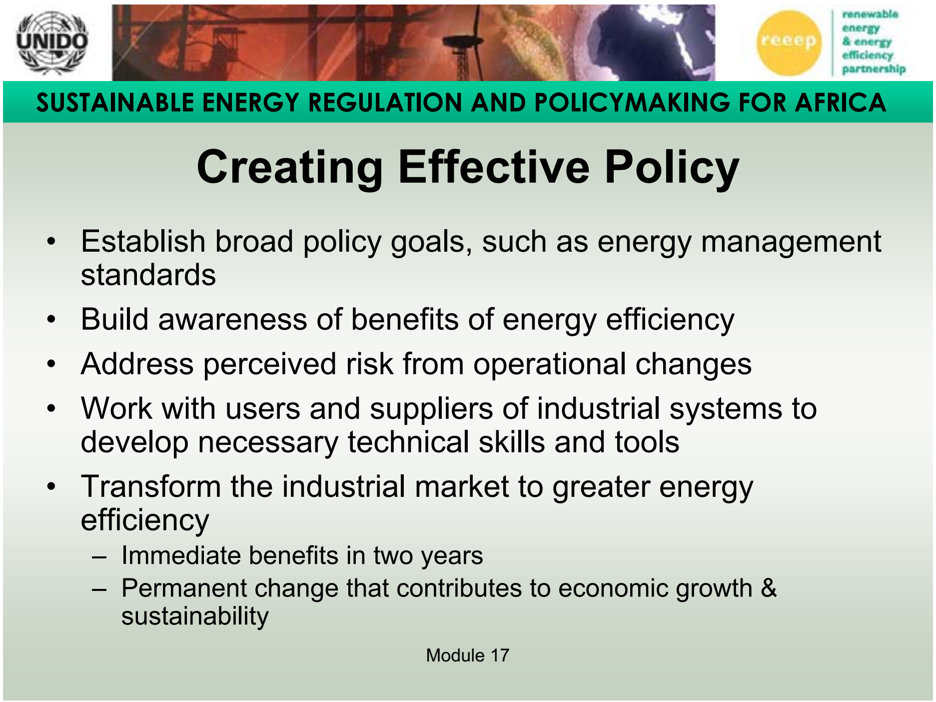

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Creating Effective Policy

- Establish broad policy goals, such as energy management standards
- Build awareness of benefits of energy efficiency
- Address perceived risk from operational changes
- Work with users and suppliers of industrial systems to develop necessary technical skills and tools
- Transform the industrial market to greater energy efficiency
  - Immediate benefits in two years
  - Permanent change that contributes to economic growth & sustainability

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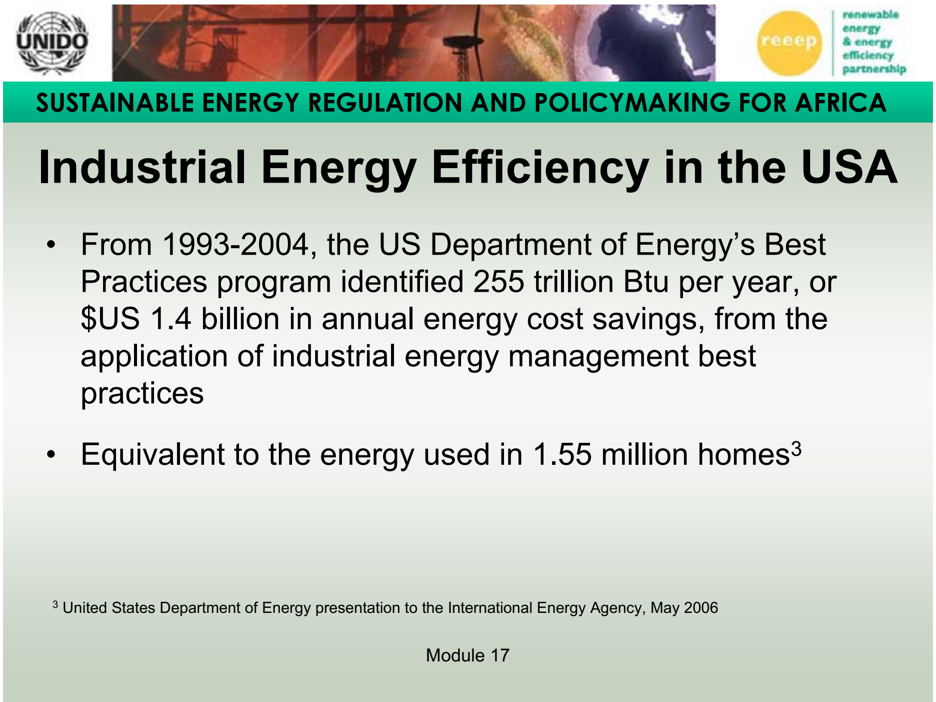

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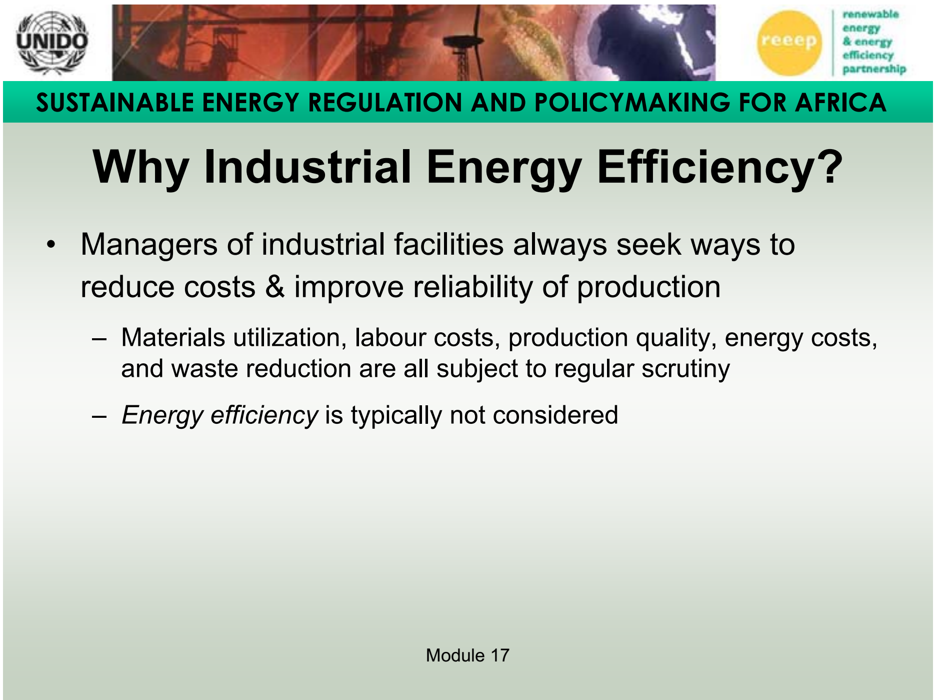
Industrial Energy Efficiency in the USA

- From 1993-2004, the US Department of Energy's Best Practices program identified 255 trillion Btu per year, or $US 1.4 billion in annual energy cost savings, from the application of industrial energy management best practices
- Equivalent to the energy used in 1.55 million homes[3]

[3] United States Department of Energy presentation to the International Energy Agency, May 2006



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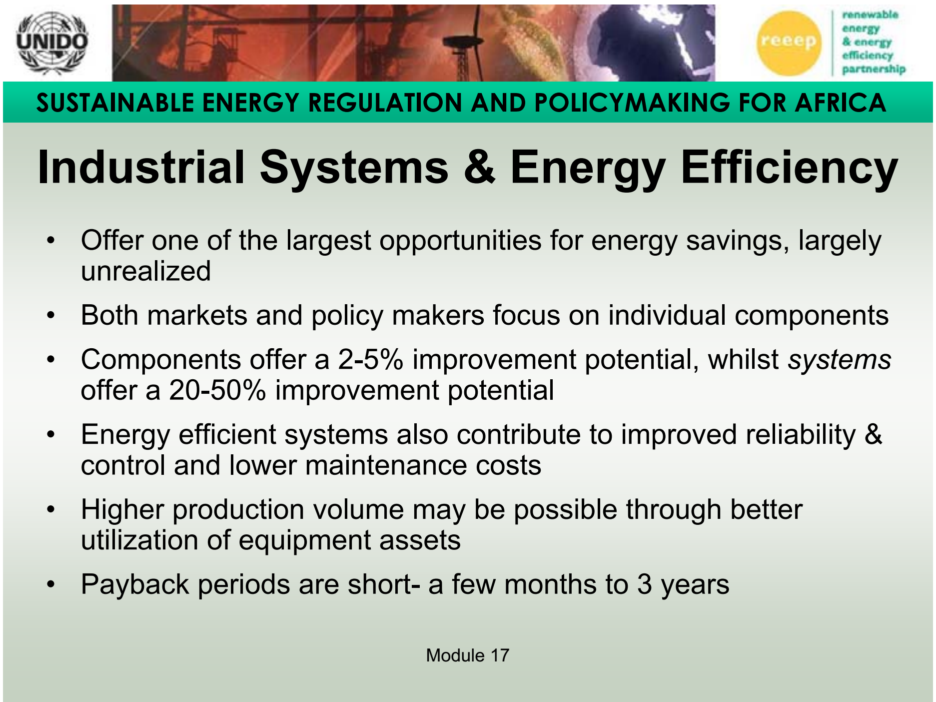
Why Industrial Energy Efficiency?

- Managers of industrial facilities always seek ways to reduce costs & improve reliability of production
  - Materials utilization, labour costs, production quality, energy costs, and waste reduction are all subject to regular scrutiny
  - *Energy efficiency* is typically not considered



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Industrial Systems & Energy Efficiency

- Offer one of the largest opportunities for energy savings, largely unrealized
- Both markets and policy makers focus on individual components
- Components offer a 2-5% improvement potential, whilst *systems* offer a 20-50% improvement potential
- Energy efficient systems also contribute to improved reliability & control and lower maintenance costs
- Higher production volume may be possible through better utilization of equipment assets
- Payback periods are short- a few months to 3 years

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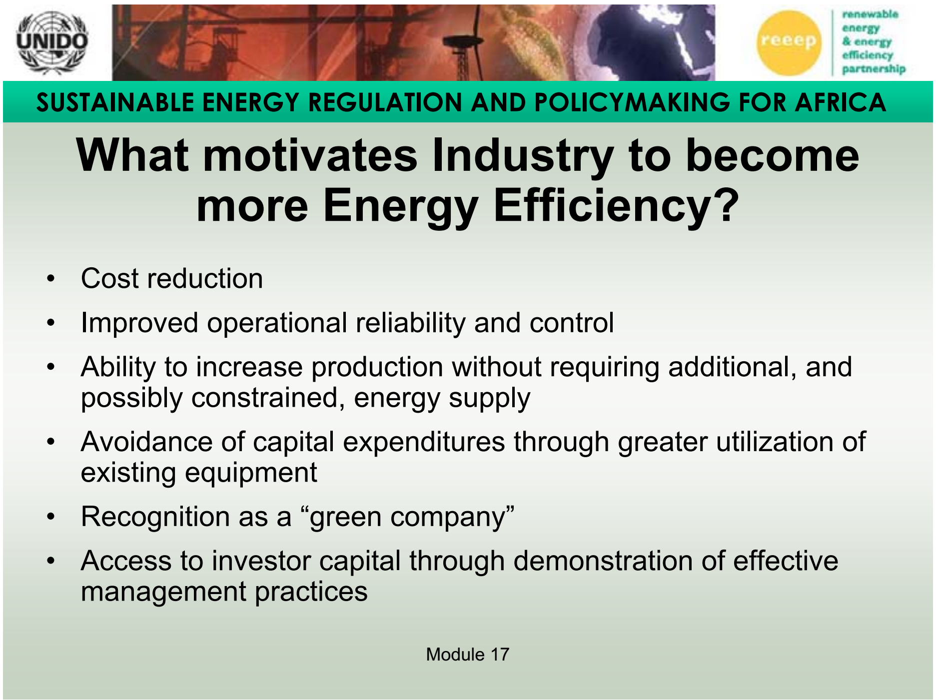

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What motivates Industry to become more Energy Efficiency?

- Cost reduction
- Improved operational reliability and control
- Ability to increase production without requiring additional, and possibly constrained, energy supply
- Avoidance of capital expenditures through greater utilization of existing equipment
- Recognition as a “green company”
- Access to investor capital through demonstration of effective management practices

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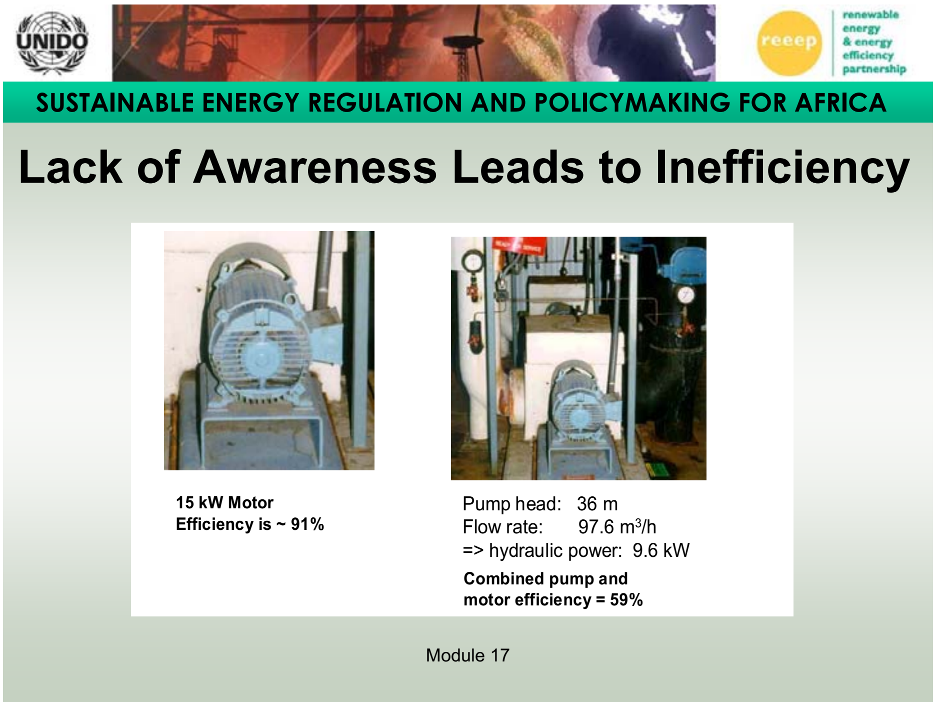

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Lack of Awareness Leads to Inefficiency

15 kW Motor
Efficiency is ~ 91%

Pump head: 36 m
Flow rate: 97.6 m^3/h
=> hydraulic power: 9.6 kW

Combined pump and
motor efficiency = 59%

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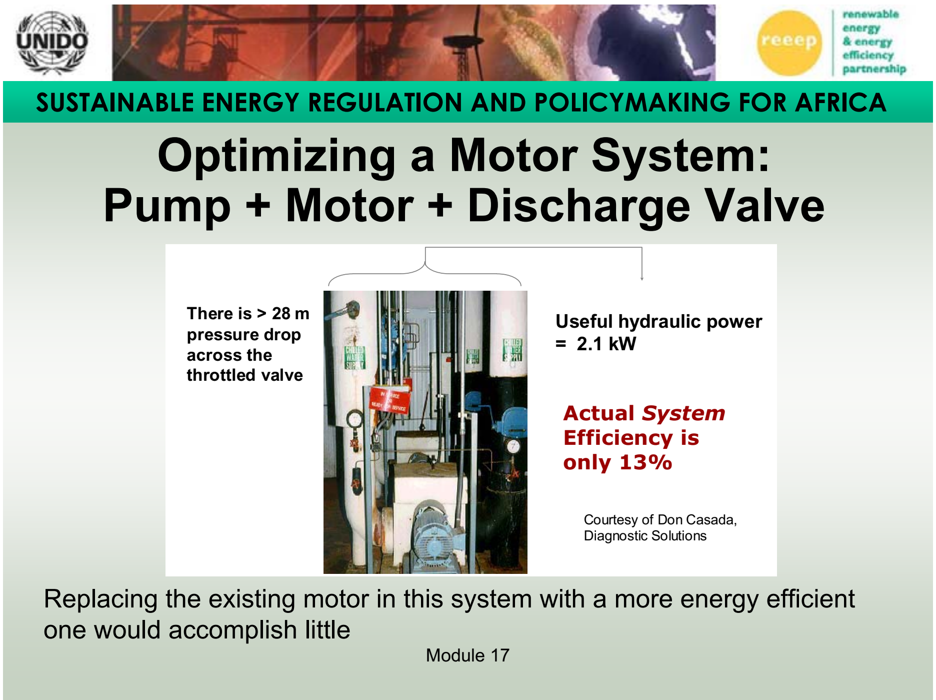

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Optimizing a Motor System:
Pump + Motor + Discharge Valve

There is > 28 m pressure drop across the throttled valve

Useful hydraulic power = 2.1 kW

Actual *System* Efficiency is only 13%

Courtesy of Don Casada, Diagnostic Solutions

Replacing the existing motor in this system with a more energy efficient one would accomplish little

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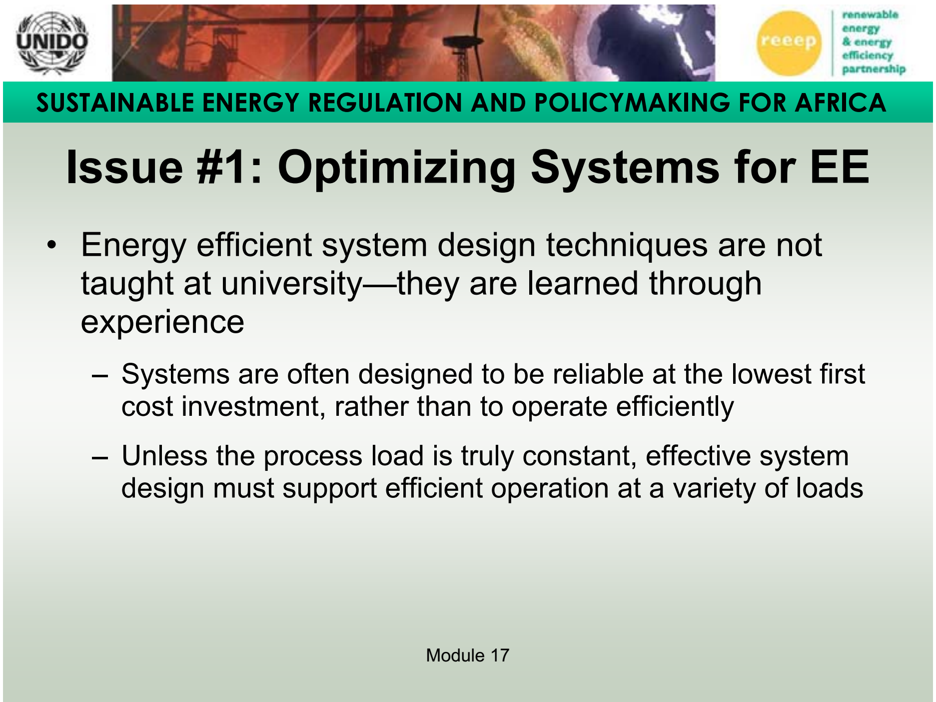

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Issue #1: Optimizing Systems for EE

- Energy efficient system design techniques are not taught at university—they are learned through experience
  - Systems are often designed to be reliable at the lowest first cost investment, rather than to operate efficiently
  - Unless the process load is truly constant, effective system design must support efficient operation at a variety of loads

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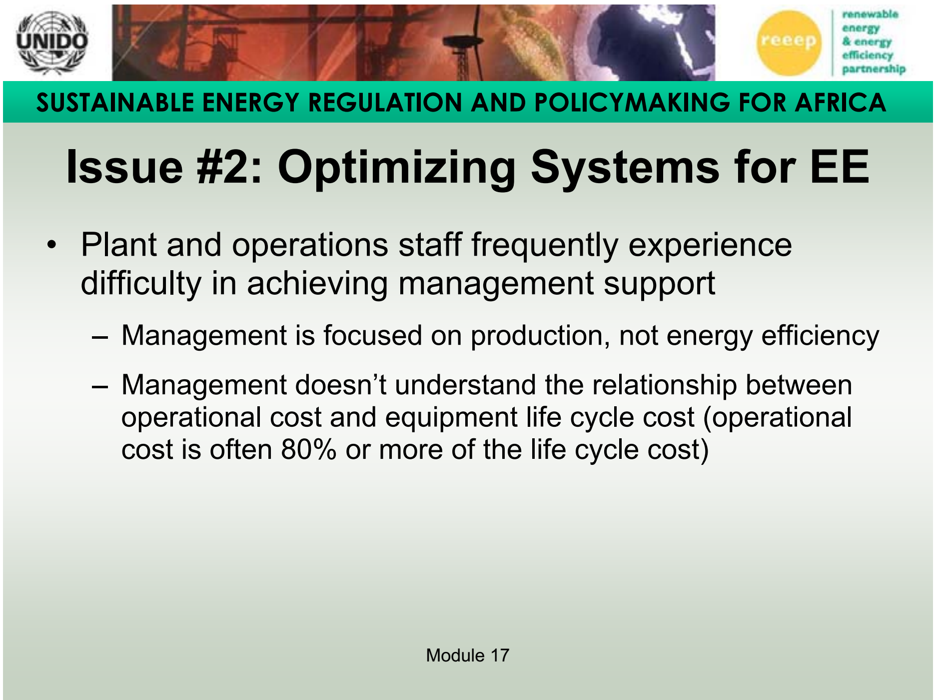

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Issue #2: Optimizing Systems for EE

- Plant and operations staff frequently experience difficulty in achieving management support
  - Management is focused on production, not energy efficiency
  - Management doesn’t understand the relationship between operational cost and equipment life cycle cost (operational cost is often 80% or more of the life cycle cost)

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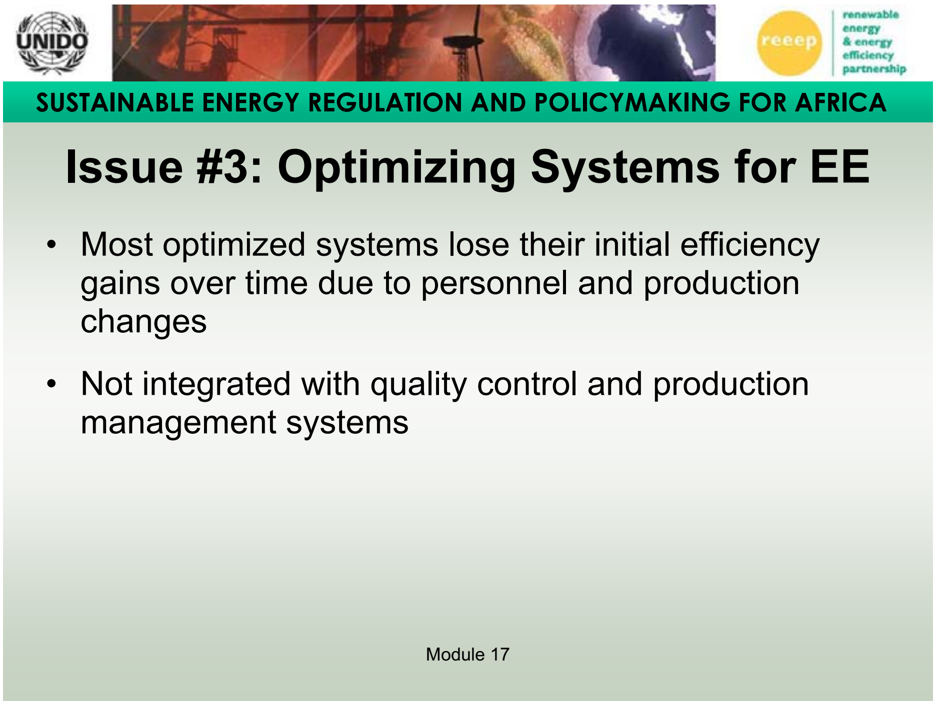

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Issue #3: Optimizing Systems for EE

- Most optimized systems lose their initial efficiency gains over time due to personnel and production changes
- Not integrated with quality control and production management systems

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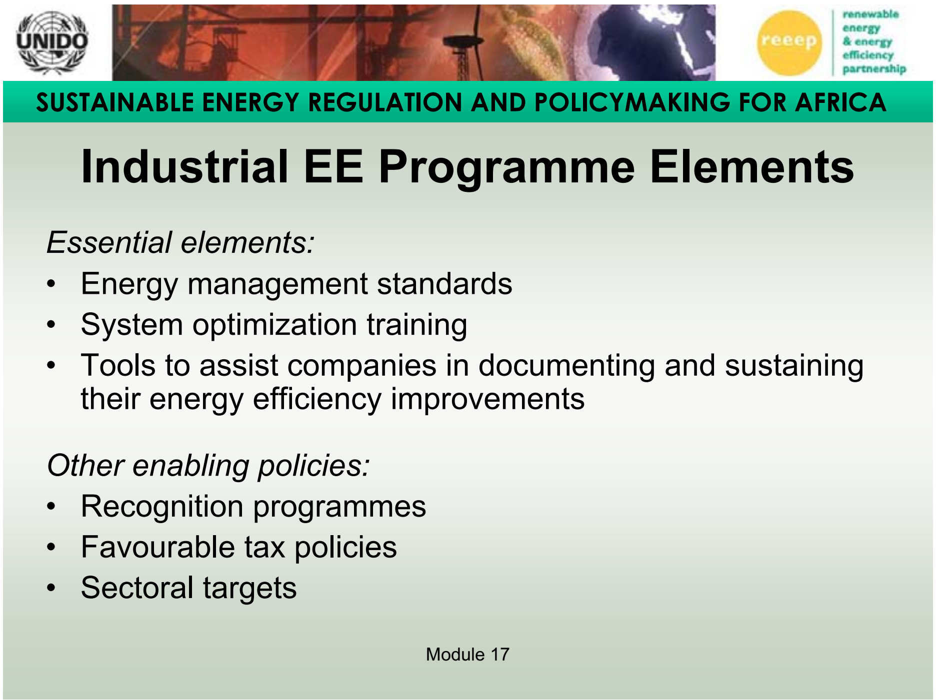

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Industrial EE Programme Elements

Essential elements:

- Energy management standards
- System optimization training
- Tools to assist companies in documenting and sustaining their energy efficiency improvements

Other enabling policies:

- Recognition programmes
- Favourable tax policies
- Sectoral targets

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Tips for Success

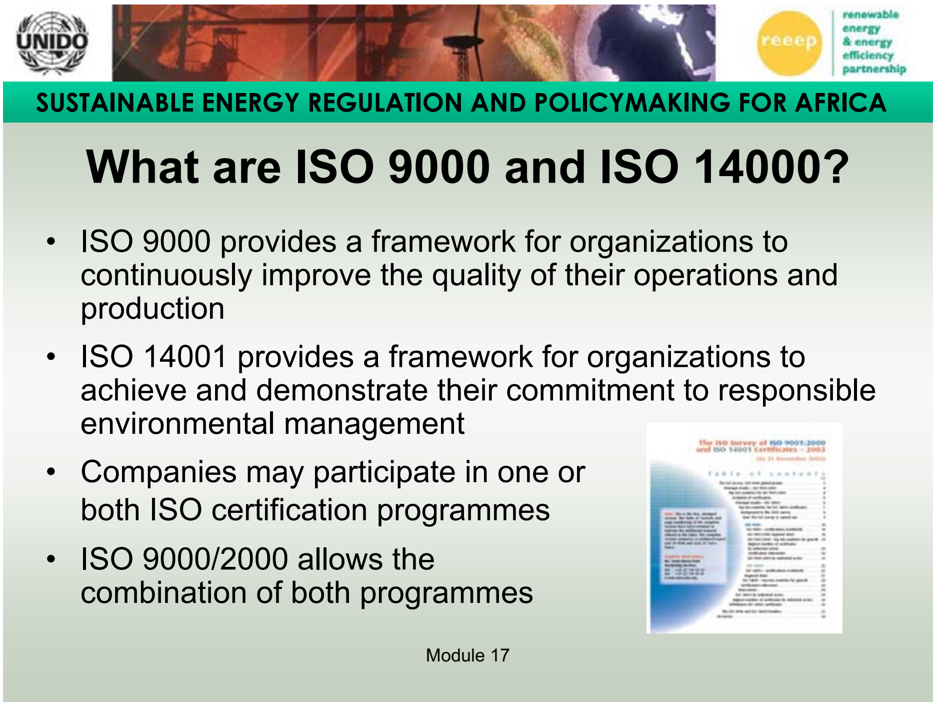
- Involve industry early—both suppliers and users
- Be consistent and transparent in both planning and implementation
- Plan meetings well—avoid wasting the participants' time
- Be balanced—avoid any appearance of product bias

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Learning from Process Management

- Like industrial systems, successful industrial processes are complex and changing, but they are:
  - Consistent
  - Adaptable
  - Resource efficient
  - Continually improving
- These goals are often achieved through widespread adoption of a management system to maintain and improve quality, such as:
  - International Organization for Standardization (ISO)
  - 6 Sigma
  - Total Quality Management

What if system energy efficiency were fully <u>integrated</u> into these management systems?



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What are ISO 9000 and ISO 14000?

- ISO 9000 provides a framework for organizations to continuously improve the quality of their operations and production
- ISO 14001 provides a framework for organizations to achieve and demonstrate their commitment to responsible environmental management
- Companies may participate in one or both ISO certification programmes
- ISO 9000/2000 allows the combination of both programmes

The ISO Survey of ISO 9001:2000 and ISO 14001 Certificates – 2003

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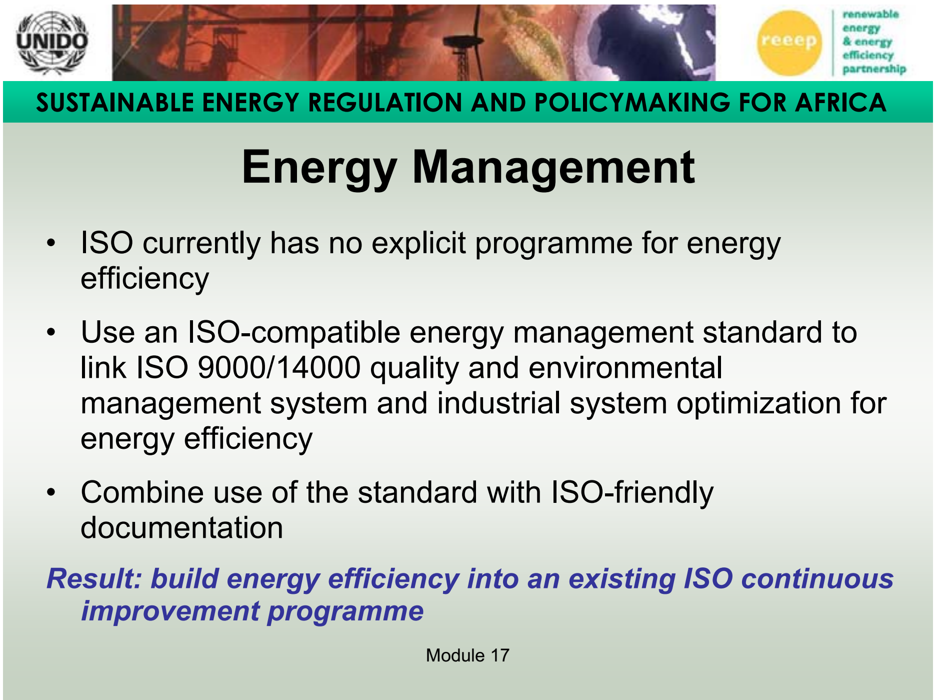

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management

- ISO currently has no explicit programme for energy efficiency
- Use an ISO-compatible energy management standard to link ISO 9000/14000 quality and environmental management system and industrial system optimization for energy efficiency
- Combine use of the standard with ISO-friendly documentation

Result: build energy efficiency into an existing ISO continuous improvement programme

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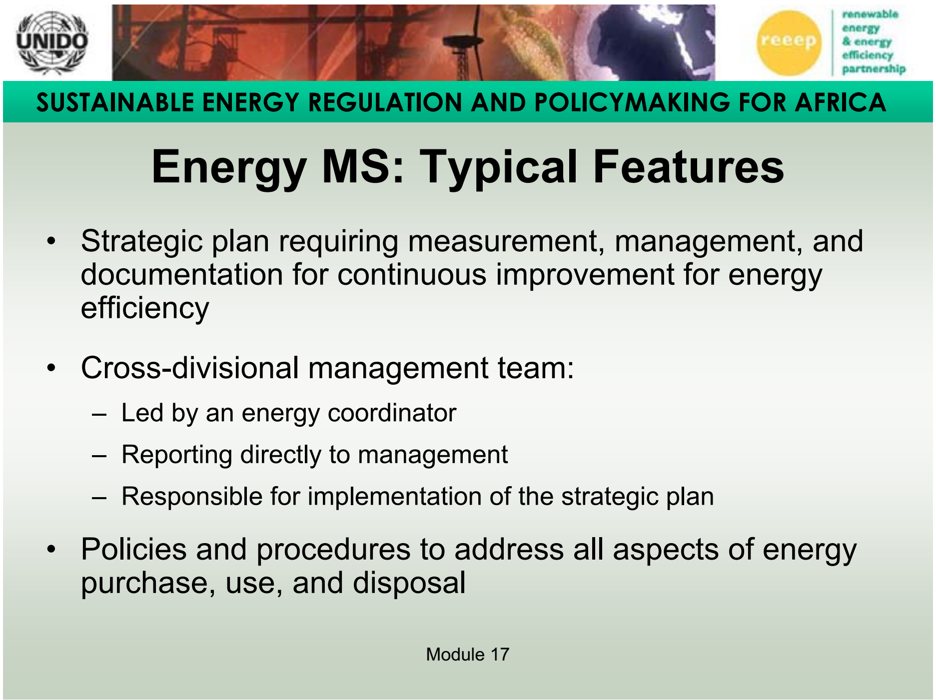
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Management Standards

- Objective: achieve permanent change in the corporate culture of an industrial facility using the structure, language, and accountability of the ISO management system
- Existing examples of energy management standards in the US, Denmark, Sweden, and Ireland; reference ISO principles
- UNIDO is facilitating international cooperation on energy management standards



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Energy MS: Typical Features

- Strategic plan requiring measurement, management, and documentation for continuous improvement for energy efficiency
- Cross-divisional management team:
  - Led by an energy coordinator
  - Reporting directly to management
  - Responsible for implementation of the strategic plan
- Policies and procedures to address all aspects of energy purchase, use, and disposal

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy MS: Typical Features (2)

- Projects to demonstrate continuous improvement in energy efficiency
- Creation of an energy manual—a living document that evolves over time as additional energy saving projects and policies are undertaken and documented
- Identification of key performance indicators, unique to the company, that are tracked to measure progress
- Periodic reporting of progress to management based on these measurements

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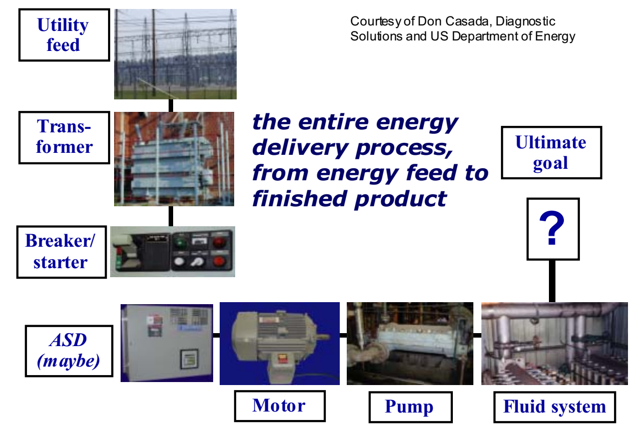
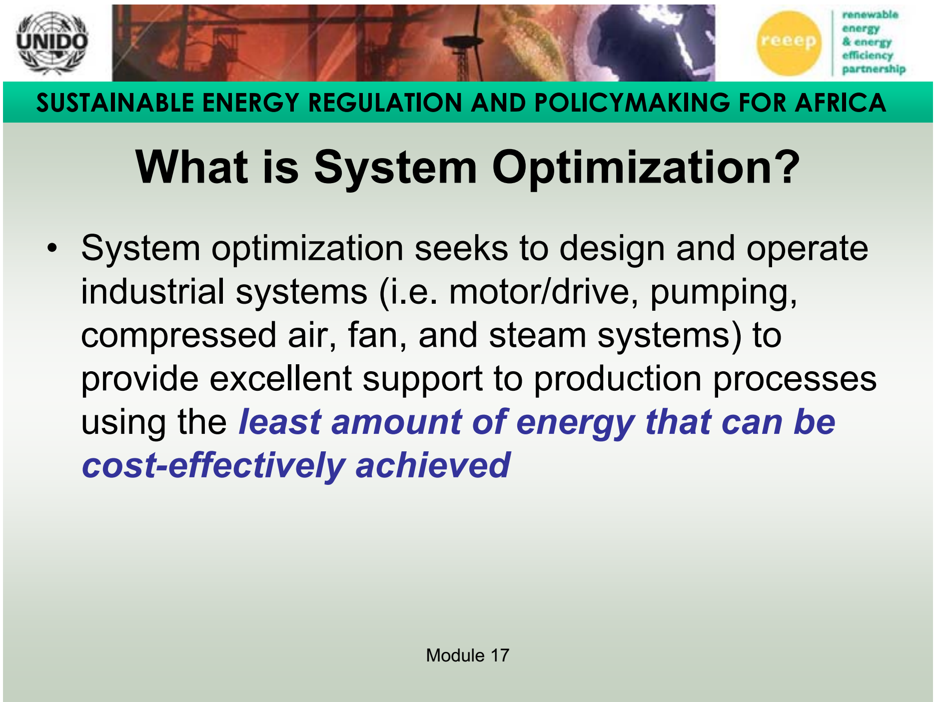
What is a System?



Courtesy of Don Casada, Diagnostic Solutions and US Department of Energy

the entire energy delivery process, from energy feed to finished product



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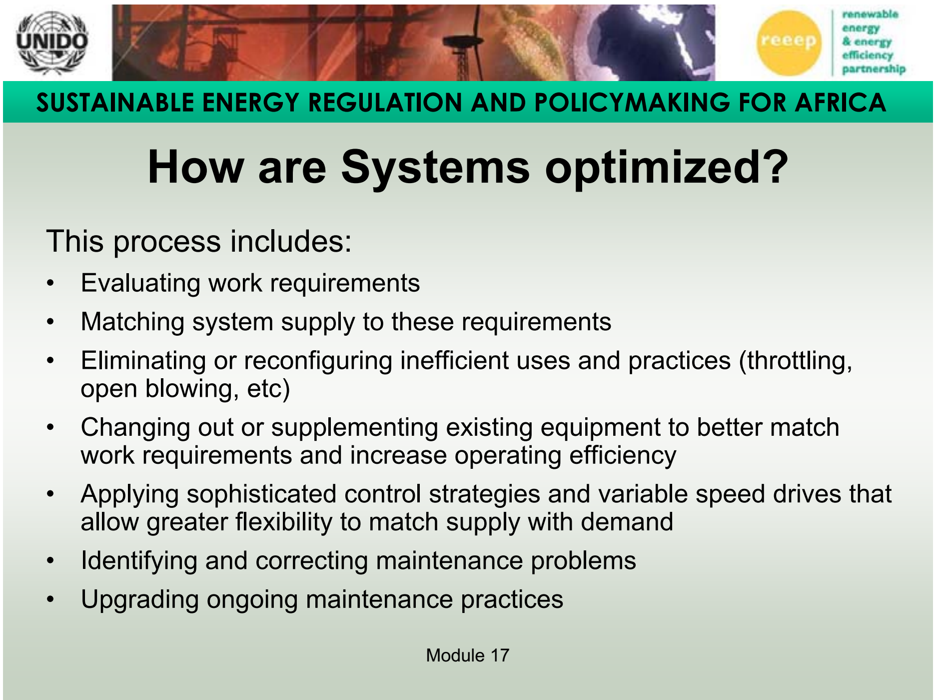
What is System Optimization?

- System optimization seeks to design and operate industrial systems (i.e. motor/drive, pumping, compressed air, fan, and steam systems) to provide excellent support to production processes using the ***least amount of energy that can be cost-effectively achieved***



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How are Systems optimized?

This process includes:

- Evaluating work requirements
- Matching system supply to these requirements
- Eliminating or reconfiguring inefficient uses and practices (throttling, open blowing, etc)
- Changing out or supplementing existing equipment to better match work requirements and increase operating efficiency
- Applying sophisticated control strategies and variable speed drives that allow greater flexibility to match supply with demand
- Identifying and correcting maintenance problems
- Upgrading ongoing maintenance practices

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Building Technical Capacity

- UNIDO has worked with a team of international experts:
  - Developed and a training curriculum specifically designed to build the necessary technical capacity
  - Piloted successfully in China 2001-2005

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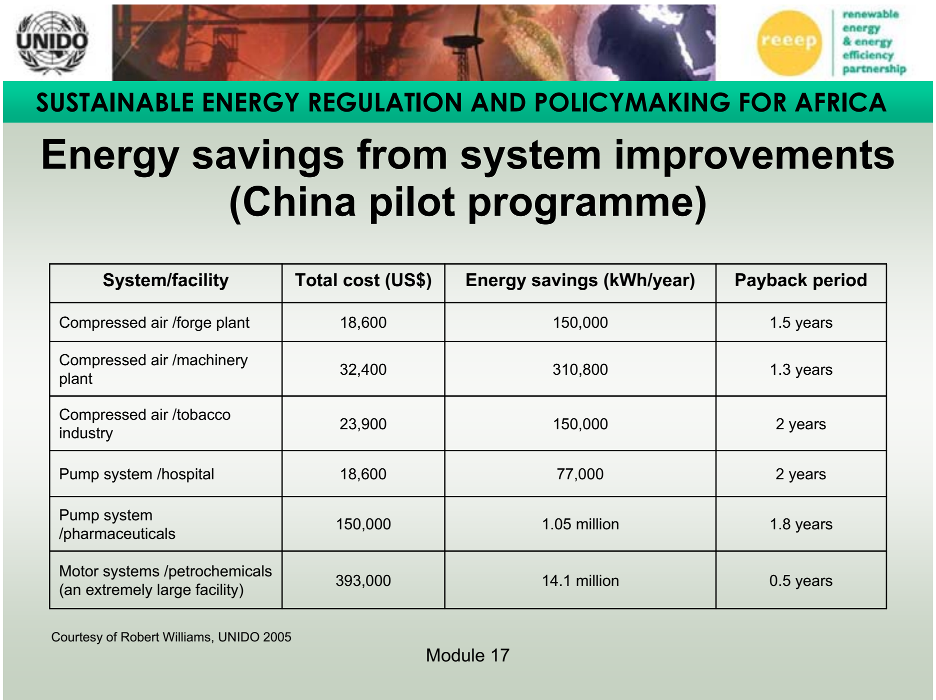

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Energy savings from system improvements (China pilot programme)

System/facility	Total cost (US$)	Energy savings (kWh/year)	Payback period
Compressed air /forge plant	18,600	150,000	1.5 years
Compressed air /machinery plant	32,400	310,800	1.3 years
Compressed air /tobacco industry	23,900	150,000	2 years
Pump system /hospital	18,600	77,000	2 years
Pump system /pharmaceuticals	150,000	1.05 million	1.8 years
Motor systems /petrochemicals (an extremely large facility)	393,000	14.1 million	0.5 years

Courtesy of Robert Williams, UNIDO 2005

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building Technical Capacity: System Optimization Training

- Goal: create a cadre of highly skilled system optimization experts
- Target groups: individuals with prior background in mechanical or electrical engineering from:
  - Government-sponsored or NGO energy centres,
  - Industrial facilities,
  - Equipment manufacturers and distributors,
  - Consulting firms and engineering services companies.
- Selection of trainees is *critically* important to overall success of programme

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

System Optimization Training

- Conducted by a team of international experts
- Training is intensive and system specific
- Both classroom & hands-on measurement training in industrial facilities
- Prepares trainees to:
  - Conduct system assessments
  - Develop energy efficiency improvement projects
  - Offer awareness training to industrial facilities on system optimization techniques

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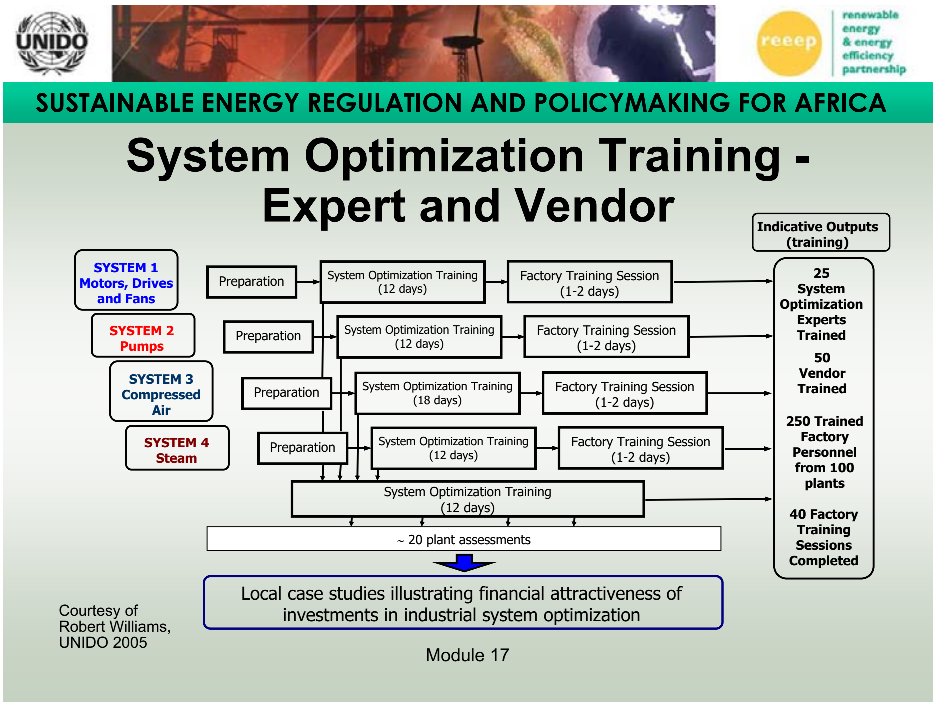

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System Optimization Training - Expert and Vendor

SYSTEM 1 Motors, Drives and Fans → Preparation → System Optimization Training (12 days) → Factory Training Session (1-2 days)

SYSTEM 2 Pumps → Preparation → System Optimization Training (12 days) → Factory Training Session (1-2 days)

SYSTEM 3 Compressed Air → Preparation → System Optimization Training (18 days) → Factory Training Session (1-2 days)

SYSTEM 4 Steam → Preparation → System Optimization Training (12 days) → Factory Training Session (1-2 days)

System Optimization Training (12 days)

~ 20 plant assessments

Local case studies illustrating financial attractiveness of investments in industrial system optimization

Indicative Outputs (training)

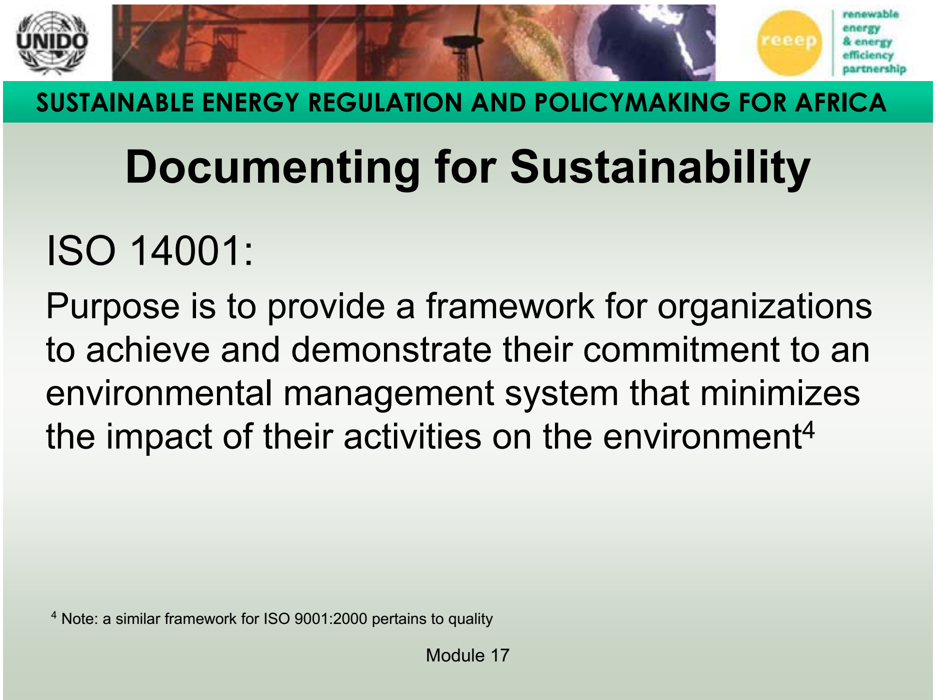
25 System Optimization Experts Trained

50 Vendor Trained

250 Trained Factory Personnel from 100 plants

40 Factory Training Sessions Completed

Courtesy of
Robert Williams,
UNIDO 2005



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Documenting for Sustainability

ISO 14001:

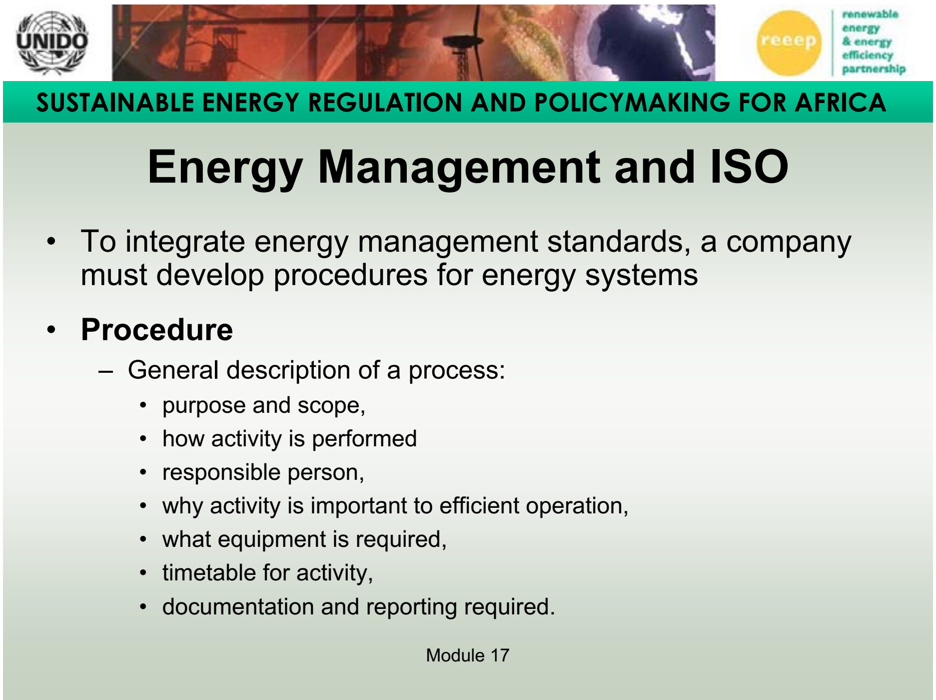
Purpose is to provide a framework for organizations to achieve and demonstrate their commitment to an environmental management system that minimizes the impact of their activities on the environment[4]

[4] Note: a similar framework for ISO 9001:2000 pertains to quality

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

ISO Certification Process

- Each participating company establishes a management system that supports continuous improvement
- To maintain certification, companies must maintain a Quality Environmental Management (QEM) Manual
- ISO-certified independent auditors regularly check for company compliance
- If non-compliant, a company must file and implement a plan of correction



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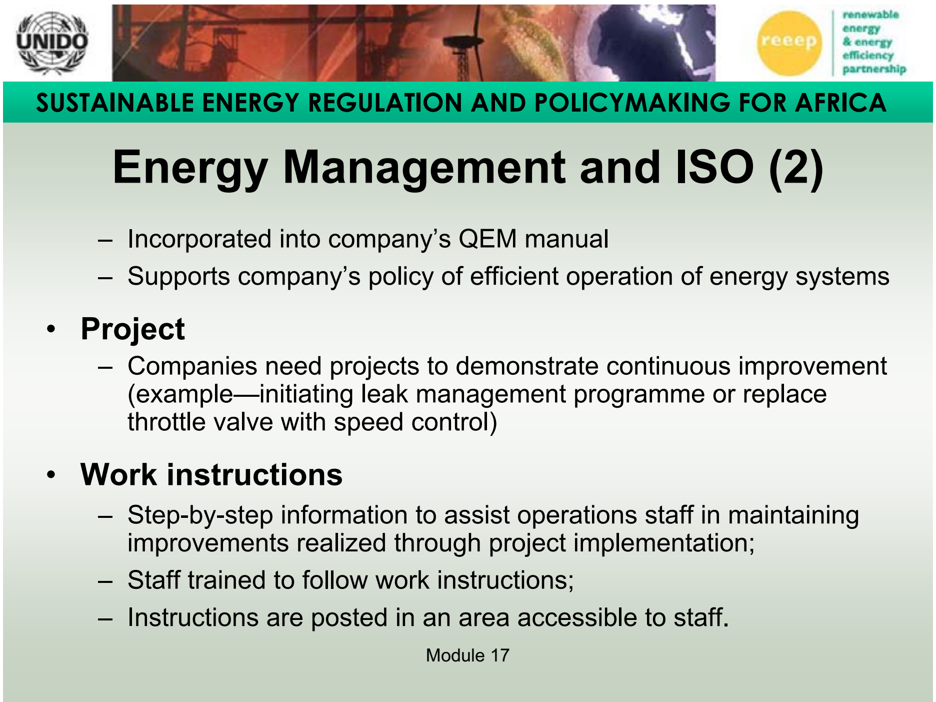
Energy Management and ISO

- To integrate energy management standards, a company must develop procedures for energy systems
- **Procedure**
  - General description of a process:
    - purpose and scope,
    - how activity is performed
    - responsible person,
    - why activity is important to efficient operation,
    - what equipment is required,
    - timetable for activity,
    - documentation and reporting required.



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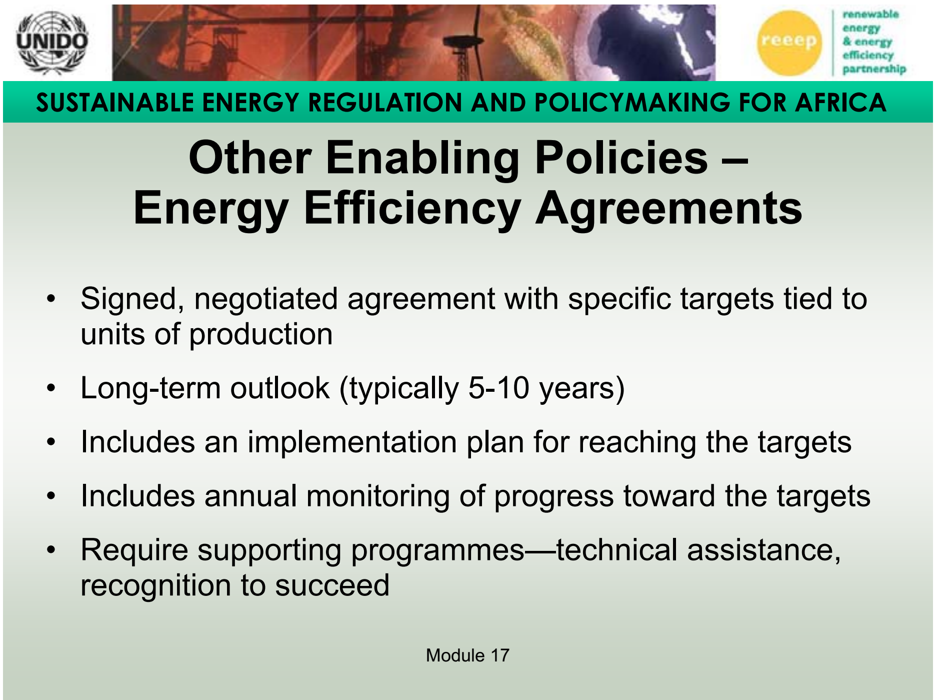
Energy Management and ISO (2)

  - Incorporated into company's QEM manual
  - Supports company's policy of efficient operation of energy systems
- **Project**
  - Companies need projects to demonstrate continuous improvement (example—initiating leak management programme or replace throttle valve with speed control)
- **Work instructions**
  - Step-by-step information to assist operations staff in maintaining improvements realized through project implementation;
  - Staff trained to follow work instructions;
  - Instructions are posted in an area accessible to staff.



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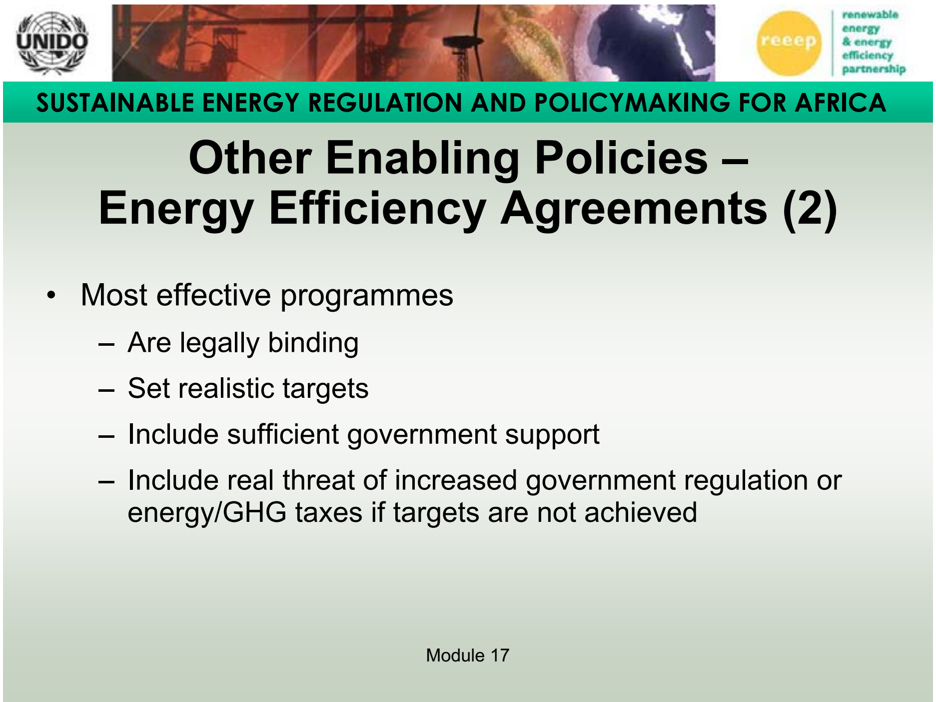
Other Enabling Policies – Energy Efficiency Agreements

- Signed, negotiated agreement with specific targets tied to units of production
- Long-term outlook (typically 5-10 years)
- Includes an implementation plan for reaching the targets
- Includes annual monitoring of progress toward the targets
- Require supporting programmes—technical assistance, recognition to succeed



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Other Enabling Policies – Energy Efficiency Agreements (2)

- Most effective programmes
  - Are legally binding
  - Set realistic targets
  - Include sufficient government support
  - Include real threat of increased government regulation or energy/GHG taxes if targets are not achieved

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building a Market for Industrial Energy Efficiency Services

- Role of government
  - Develop and issue energy efficiency standards
  - Support the provision of training and tools to industry, consultants, and suppliers to aid in compliance
  - Recognize industrial facilities that comply with standards
- Role of industry
  - Responsible for compliance with national standards for corporate energy management
  - Implement system optimization projects

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Building a Market for Industrial Energy Efficiency Services (2)

- Role of suppliers
  - Participate in vendor training
  - Introduce industrial customers to system optimization concepts
- Role of consultants and energy service companies
  - Participate in experts training
  - Conduct system assessments and develop projects

Module 17

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Developing Enabling Partnerships

Partnerships are needed to:

- Build ownership to change existing practices and behaviours for greater energy efficiency
- Reach industrial firms with the system optimization message through existing business relationships
- Develop credibility within specialized industrial sectors
- Ensure that proposed policies are practical
- Engage the financial community and help them understand the financial benefits of energy efficiency
- Recruit the best talent to become trained in system optimization techniques
- Successfully launch an industrial energy efficiency programme

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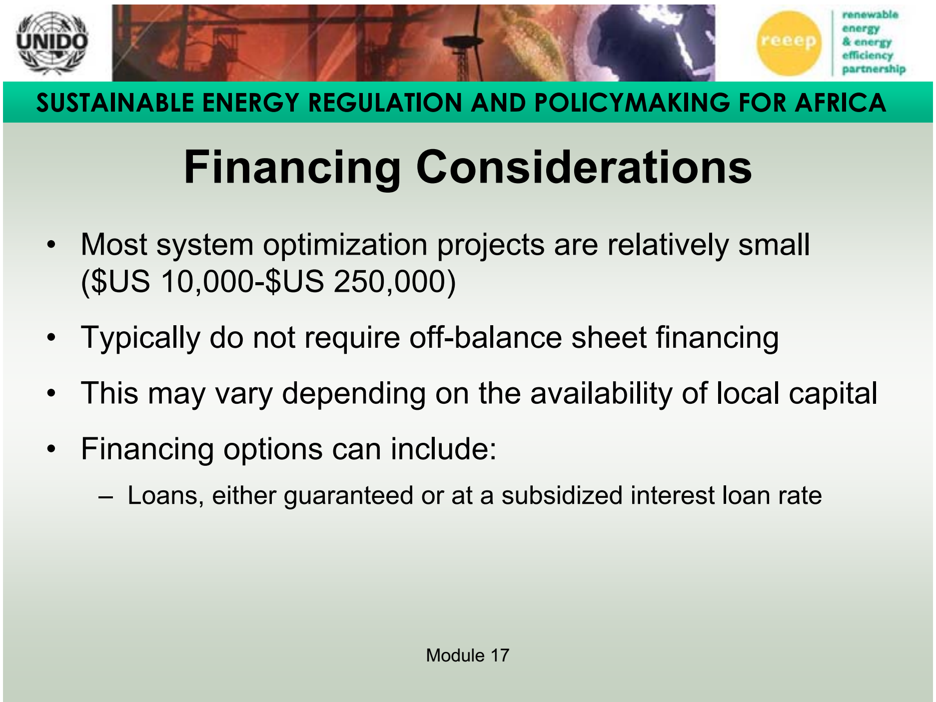

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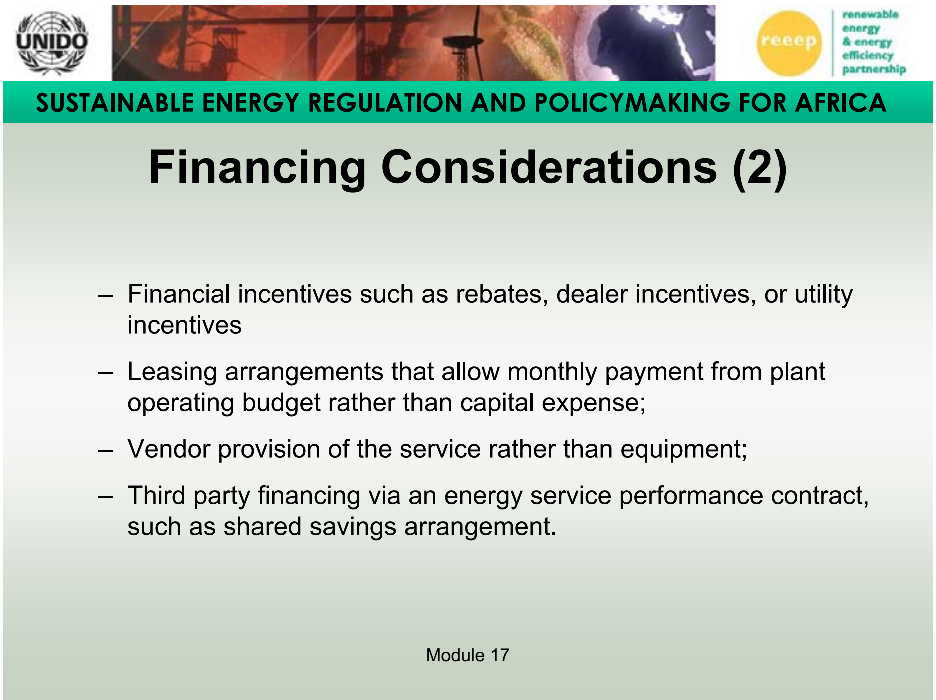
Financing Considerations

- Most system optimization projects are relatively small ($US 10,000-$US 250,000)
- Typically do not require off-balance sheet financing
- This may vary depending on the availability of local capital
- Financing options can include:
  - Loans, either guaranteed or at a subsidized interest loan rate



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Financing Considerations (2)

- Financial incentives such as rebates, dealer incentives, or utility incentives
- Leasing arrangements that allow monthly payment from plant operating budget rather than capital expense;
- Vendor provision of the service rather than equipment;
- Third party financing via an energy service performance contract, such as shared savings arrangement.

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Industrial Standards Framework

- Framework includes:
  - Energy management standards
  - Policies, such as recognition and agreements
  - Training, for energy management and system optimization
  - Tools, such as the System Optimization Library
- Purpose:
  - Standardize, measure, and recognize industrial system optimization efforts
  - Provide flexibility so that factories can approach system optimization incrementally
  - Produce *permanent change in corporate culture* -integrate energy efficiency into management practices

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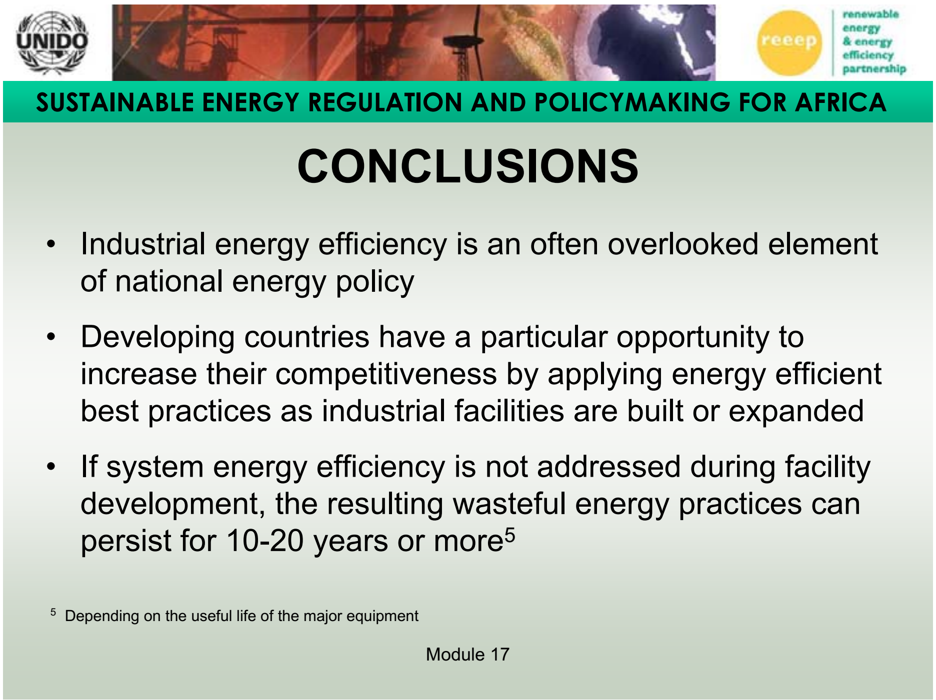

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Industrial energy efficiency is an often overlooked element of national energy policy
- Developing countries have a particular opportunity to increase their competitiveness by applying energy efficient best practices as industrial facilities are built or expanded
- If system energy efficiency is not addressed during facility development, the resulting wasteful energy practices can persist for 10-20 years or more[5]

[5] Depending on the useful life of the major equipment

Module 17

Module 18

Energy efficiency in buildings

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Globally the building sector accounts for more electricity use than any other sector, 42 per cent. No wonder considering that we spend more than 90 per cent of our time in buildings. With increasing urbanization, higher in developing countries, the number and size of buildings in urban areas will increase, resulting in an increased demand for electricity and other forms of energy commonly used in buildings. Africa's rate of urbanization of 3.5 per cent per year is the highest in the world, resulting in more urban areas with bigger populations, as well as the expansion of existing urban areas. There are currently 40 cities in Africa with populations of more than a million and it is expected that by 2015 seventy cities will have populations of one million or more.

In many developing countries there is normally very little margin between existing power supply and electricity demand. With increasing electricity demand, new generation needs to be brought in. Although renewable sources of electricity such as hydro, geothermal or wind provide electricity at a much lower cost, their capital outlay is large, they are complex and take much longer to implement. Diesel-based generation is usually brought in the short term to meet this demand, which results in increased cost of electricity.

Investments in energy efficiency in a building can be compared with the cost of capital investments necessary on the supply side of the energy system to produce a similar amount of peak capacity or annual energy production. Usually, the capital costs of efficiency are lower than comparable investments in increased supply and there are no additional operating costs of efficiency compared to substantial operating costs for supply-side options. In addition, energy efficiency investments generally have much shorter lead times than energy supply investments, a particularly important consideration in countries where the demand for energy services is growing rapidly.

One consistent quality in the building sector is that it is subject to a high degree of regulation. Building codes often influence material use and appliance standards that have a significant effect on energy efficiency. Regulatory regimes, to the extent that they exist, may therefore provide a pathway to improve efficiency for both building construction and a variety of building appliances.

This module is designed to provide an overview of energy efficiency in buildings; it aims to help policymakers and regulators understand the potential benefits, the opportunities for improving the efficiency of buildings and give them a background on the key issues to be addressed when developing suitable policies and a framework for implementation. In addition, it briefly discusses the methodology used for determining the efficiency of buildings and the mechanisms that can be used to finance energy efficiency measures.

It concludes with a discussion on the process of developing and implementing policy on energy efficiency in buildings and gives a summary on policy tools that can be used to facilitate implementation of energy efficiency in buildings.

1.2. Module aims

The aims of this module are:

- To introduce the concept and benefits of energy efficiency in buildings.
- To give an overview of the methodology used to determine the energy efficiency of buildings.
- To present the different opportunities and measures for reducing energy use in buildings without sacrificing comfort levels.
- To describe the different mechanisms for financing energy efficiency measures in buildings.
- To give a summary of legislative and policy tools that have been successful in promoting energy efficiency in buildings.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- To appreciate the significance and benefits of energy efficiency in buildings.
- To have a general understanding of the methodology used to determine the energy efficiency of buildings, the different opportunities for improving the energy efficiency of buildings and the potential savings.
- To have an overview of the different mechanisms for financing energy efficiency measures.
- To have conceptualized an approach to setting out and implementing policies to facilitate energy efficiency in buildings in their country.

2. INTRODUCTION

More than 90 per cent of our time is spent in buildings i.e. either in the office or at home. Energy used in buildings (residential and commercial) accounts for a significant percentage of a country's total energy consumption. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capita, the prevailing climate, as well as national and local policies to promote efficiency. The following are estimated figures for different regions:

- European Union countries > 40 per cent[1]
- Philippines 15-20 per cent[2]
- Brazil 42 per cent[3]
- Florida/USA 47 per cent[3]
- California 66 per cent[4]

In many countries, buildings consume more energy than transport and industry. The International Energy Agency (IEA) statistics estimate that globally, the building sector is responsible for more electricity consumption than any other sector, 42 per cent.[5]

The building sector encompasses a diverse set of end use activities, which have different energy use implications. Space heating, space cooling and lighting, which together account for a majority of building energy use in industrialized countries, depend not only on the energy efficiency of temperature control and lighting systems, but also on the efficiency of the buildings in which they operate. Building designs and materials have a significant effect on the energy consumed for a select set of end uses. On the other hand, building design does not affect the energy use of cooking or appliances, though these end uses are nonetheless attributed to the building sector. Appliance efficiency matters more for some end uses than for others. Water heating and refrigeration each account for significant shares of building energy use since they are in constant use. By contrast, cooking and small appliances (including computers and televisions)

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[1] Directive 2002/91/ec of the European Parliament and of the Council on the Energy Performance of Buildings, 2002.

[2] Energy Efficiency Division of the Philippines Department of Energy (DOE), 2002, Philippines Guidelines for Energy Conserving Design of Buildings and Utility Systems.

[3] Michael Laar and Friedrich Wilhelm Grimme, 2002. Sustainable Buildings in the Tropics. Institute of Technology in the Tropics ITT, University of Applied Sciences Cologne: Presented at RIO 02 – World Climate & Energy Event, January 6-11, 2002.

[4] California Energy Commission, 2005, Options for Energy Efficiency in Existing Buildings.

[5] IEA. 2004b. Energy Balances for OECD Countries and Energy Balances for non-OECD Countries; Energy Statistics for OECD Countries and Energy Statistics for non-OECD Countries (2004 editions) Paris.

generally account for only small percentages of building energy consumption, owing to their intermittent use.

In general, building energy consumption is higher in industrialized countries. Thus, development has an important effect on energy demand from the building sector, implying that building efficiency becomes more significant as countries become more prosperous. The importance of energy efficiency in building sector is especially significant in developing countries, owing to rapid new construction with opportunities to employ efficient materials and best practices.

Analysis of the building sector produces mixed conclusions, owing to the diversity of influences and end uses that the sector embodies. International trade and a small number of multinational corporations play a significant role in the production and distribution of most building appliances, including cooking appliances, lighting, heating and cooling systems. However, the opposite is true for building construction, which is dominated by small local firms. Many materials essential to building efficiency, such as cement and timber, are not heavily traded (aluminum and steel are notable exceptions), and building practices and materials vary widely depending on available resources, customs and prevailing climate.

One consistent quality in the building sector is that it is subject to a high degree of regulation. Building codes often influence material use, and appliance standards, both mandatory and voluntary, have a significant effect on energy efficiency. Regulatory regimes, to the extent that they exist, may therefore provide a pathway to improving efficiency for both building construction and a variety of building appliances. Furthermore, government operations in commercial buildings often constitute a significant share of total building use, as government activity at all levels is building-dependent. By choosing energy-efficient designs and materials for their own use, governments can thus exert significant influence over the building sector as a whole.[6]

2.1. What is the energy efficiency of a building?

The energy efficiency of a building is the extent to which the energy consumption per square metre of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions.

Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared.

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[6] Kevin A. Baumert, Timothy Herzog and Jonathan Pershing, 2005, Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, World Resources Institute.

The benchmarks are derived by analysing data on different building types within a given country. The typical benchmark is the median level of performance of all the buildings in a given category and good practice represents the top quartile performance. Comparisons with simple benchmarks of annual energy use per square metre of floor area or treated floor area (kWh/m^2/annum) allow the standard of energy efficiency to be assessed and priority areas for action to be identified.

Benchmarks are applied mainly to heating, cooling, air-conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity consumption for external lighting. The benchmarks used vary with the country and type of building.

The measure of heat loss through a material, referred to as the U-Value, is also used as a way of describing the energy performance of a building. The U-value refers to how well an element conducts heat from one side to the other by rating how much the heat the component allows to pass through it. They are the standard used in building codes for specifying the minimum energy efficiency values for windows, doors, walls and other exterior building components. U-values also rate the energy efficiency of the combined materials in a building component or section. A low U-value indicates good energy efficiency. Windows, doors, walls and skylights can gain or lose heat, thereby increasing the energy required for cooling or heating. For this reason most building codes have set minimum standards for the energy efficiency of these components.

2.2. Why is energy efficiency in buildings important?

Governments have a responsibility to ensure that there is secure supply of energy to ensure economic growth. In many developing countries there is normally very little margin between existing power supply and electricity demand. With increasing electricity use from existing consumers and new connections, new generation needs to be brought on line to meet increasing demand. In addition, due to changing climate patterns and the increasing risk of drought, countries that are highly dependent on electricity from hydro as their main source of electricity are losing much of their generation capacity resulting in intensive power rationing.

Although renewable sources of electricity such as hydro, geothermal or wind provide electricity at a much lower cost than electricity generation from petroleum, their capital outlay is large, they are complex and take much longer to implement. Petroleum-based generation is usually brought in in the short term to meet this demand, which results in increased cost of electricity, over dependence on petroleum and subsequently vulnerability to oil price fluctuations.

Investments in energy efficiency in a building can be compared with the cost of capital investments necessary on the supply side of the energy system to produce a similar amount of peak capacity or annual energy production. Usually, the capital costs of efficiency are lower than comparable investments in increased supply and there are no additional operating costs of efficiency compared to substantial operating costs for supply-side options. In addition, energy efficiency investments generally have much shorter lead times than energy supply investments, a particularly important consideration in countries where the demand for energy services is growing rapidly. By setting energy efficiency targets for buildings, governments share the burden and cost of ensuring the security of energy supply with end-users.

The need to increase generation capacity in developing countries is unavoidable. However governments can solve peak demand constraints by finding a balance between reducing demand and increasing supply. To increase supply, governments in developing countries often have to allocate funds to subsidize new generation capacity or subsidize the cost of petroleum-based generation.[7] Reducing demand by setting up a low interest, easy payment energy efficiency revolving fund to incentivize consumers to implement energy efficiency measures would be a more sustainable approach and repayments could be based on energy savings.

The main benefit from measures to improve energy efficiency buildings is lower energy costs but there are usually other benefits to be considered too. Energy efficiency measures are meant to reduce the amount of energy consumed while maintaining or improving the quality of services provided in the building. Among the benefits likely to arise from energy efficiency investments in buildings are:

- Reducing energy use for space heating and/or cooling and water heating;
- Reduced electricity use for lighting, office machinery and domestic type appliances;
- Lower maintenance requirements;
- Improved comfort;
- Enhanced property value.

In developing countries where electricity is intermittent and power rationing is frequent, there is a large demand for diesel or renewable energy-based back-up/stand-by power generation from end-users. Reducing power and energy requirements in buildings reduces the capital outlay required and the running costs of these stand-by systems.

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[7] Independent power producer tariffs are a function of the capacity charge as well as volume of energy generated and the prevailing fuel prices. Whereas the cost of energy generated and fuel price are transferred to the customer, the capacity charge is usually borne by the government.

In industrialized countries, policy, incentives, climate change targets and corporate image drive more efficient approaches to energy use in buildings. Codes and practice on energy regulations for buildings in developed countries include obligations for energy audits, requirements for building certification with ratings based on energy efficiency, carbon reduction targets for buildings, levies on energy consumption—charged per unit consumed to discourage high consumption, incentives such as exemption from building tax for good energy efficiency ratings, access to interest free/low-interest loans and grants for undertaking energy efficiency measures in buildings and, as part of their corporate social responsibility, some companies would like to be seen as a green company that promotes energy efficiency.

Box 1. **The success of California's energy efficiency buildings policy**

Reducing energy consumption and peak demand through greater energy efficiency is the cornerstone of the State of California's energy policy. Homes and commercial buildings consume 66 per cent of the State's electricity.

California's homes and buildings are relatively energy-efficient today, compared to those in other states and many countries of the world. Since the passage of the Warren-Alquist Act in 1975, homes and buildings in California have been made increasingly efficient, due to periodically updated efficiency requirements in Building and Appliance Standards. In this same 30-year period, the California Public Utility Commission has directed the investor-owned utilities to commit over $US 5 billion to energy efficiency information, technical assistance and incentive programmes, an estimated 85 per cent of which has been targeted at retrofit energy efficiency investments in existing buildings.

There are over 13 million existing buildings in California, compared to the approximately 200,000 constructed each year. More than half of the existing buildings were built before the first Energy Efficiency Standards were established in 1978. While many have been upgraded over time, these older buildings represent a large reserve of potential energy and peak demand savings.

Over half of the energy savings attributed to the Appliance Standards are from the installation of new appliances in existing buildings. Over time, as existing homes and buildings replace their energy-using equipment, the Appliance Standards increase the efficiency of energy use in those homes and buildings.

While the Building Standards are usually seen as improving energy efficiency in newly constructed buildings, they also apply to all additions and many alterations made to existing buildings and have affected many vintages of existing buildings constructed since they were first enacted in the late 1970s. Figure I shows the energy savings achieved by the California Building Standards within the existing building stock.

California has held electricity consumption per capita steady for the past 30 years, while the rest of the United States experienced a 50 per cent growth in electricity consumption (and slower economic growth than in California). Figure II shows that while average per capita electricity sales have continued to increase significantly for the nation as a whole, the per capita figure for California began leveling off in the mid to late-1970s and has remained basically constant since.

Figure I. Savings achieved within California's existing building stock

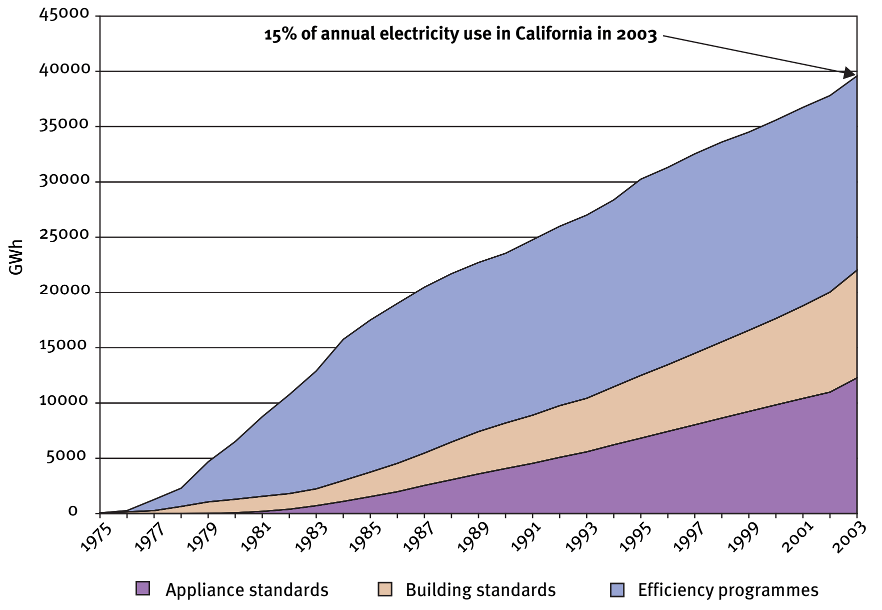
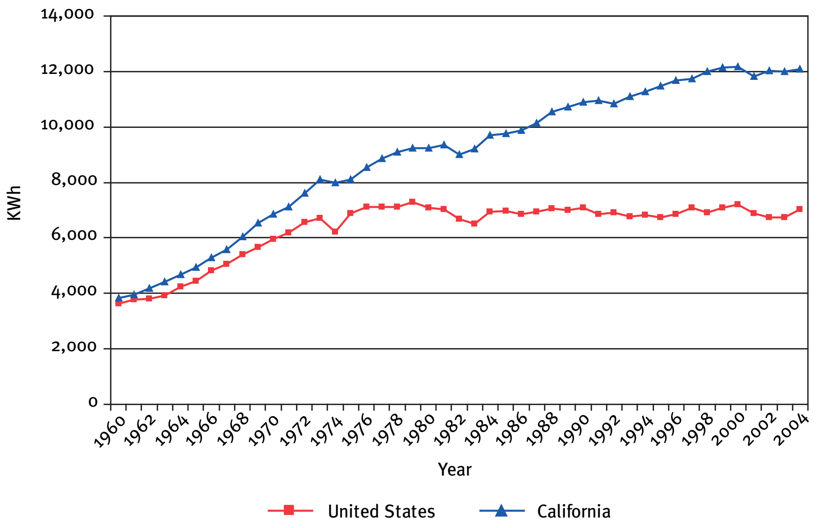


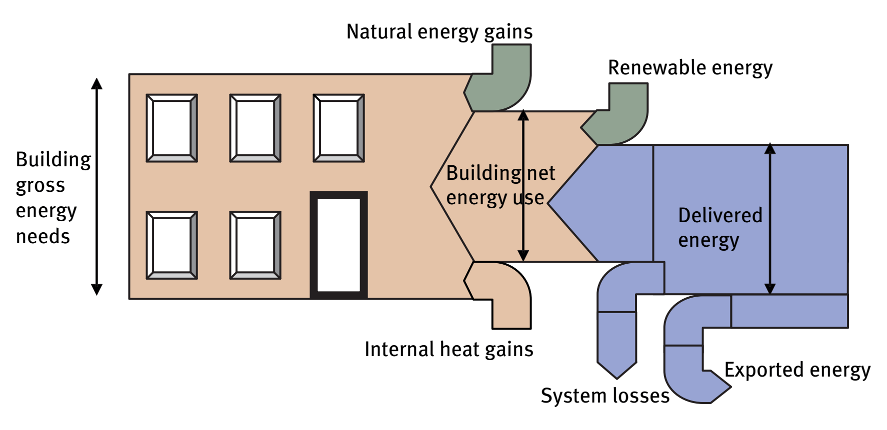
Figure II. Total electricity sales, per capita, in the United States and California between 1960 and 2001



3. ENERGY EFFICIENCY IN BUILDINGS METHODOLOGY

3.1. Typical energy flow in buildings

Figure III. How energy flows are linked in buildings[a]



[a] EU Energy Performance in Buildings – Directive Implementation Advisory Group, Explanation of the General Relationship between various standards from the European Committee for Standardization and the Energy Performance of Buildings Directive (EPBD).

Figure III above illustrates the typical energy flows in a building. The building gross energy needs represent the anticipated buildings requirements for heating, lighting, cooling, ventilation, air conditioning and humidification. The indoor climate requirements,[8] outdoor climatic conditions and the building properties (surface/transmission heat transfer and heat transfer due to air leakage) are the parameters used for determining what the gross energy needs of the building will be.

As illustrated in the diagram above, delivered energy, natural energy gains and internal heat gains all contribute to providing the energy needs of a building.

Natural energy gains

These include passive solar heating, passive cooling, natural ventilation flow, and daylight. Intelligent maximization of natural energy gains can result in significant

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[8] The indoor climate is a term that summarizes the thermal environment, the air quality and the acoustic and light environment of a building. Indoor climate regulations and guidelines are usually part of the building code.

reduction of delivered energy required to meet a building's energy needs. Environmentally smart buildings make intelligent use of energy resources, while minimizing waste.

Natural energy gains can be maximized by exploiting the potential contribution to a building's performance offered by the site and its surroundings through:

- A building plan which places functions in locations that minimize the need for applied energy;
- A shape which encourages the use of daylight and natural ventilation, and reduces heat losses;
- An orientation that takes account of the potential benefits from solar gains while reducing the risk of glare and overheating;
- Effective use of natural daylight combined with the avoidance of glare and unwanted solar gains;
- Natural ventilation wherever practical and appropriate, with mechanical ventilation and/or air conditioning used only to the extent they are actually required;
- Good levels of thermal insulation and prevention of unwanted air infiltration through the building envelope;
- Intrinsically efficient and well-controlled building services, well-matched to the building fabric and to the expected use.

This is best achieved at the building's design stage but can also be done during refurbishment.

Internal heat gain

Internal heat is the thermal energy from people, lighting and appliances that give off heat to the indoor environment. Whereas this is desirable in cold weather as it reduces the energy requirements for heating, in hot weather it increases the energy required for cooling. In office buildings, commercial stores, shopping centres, entertainment halls etc., much of the overheating problem during the summer can be caused by heat produced by equipment or by a high level of artificial lighting. When there are a large number of occupants or clients their metabolic heat can also add to the problem.

Delivered energy

This is the amount of energy supplied to meet a building's net energy demand i.e. to provide energy for heating, cooling, ventilation, hot water and lighting. It is usually expressed in kilowatt hours (kWh) and the main energy carriers are electricity and fuel, i.e. gas, oil or biomass for boilers. As seen from figure III, the delivered energy could be supplemented by on-site renewable energy, this could be in the form of solar PV, solar water heaters or wind.

Exported energy

This is the fraction of delivered energy that, where applicable, is sold to external users.

System losses

System losses result from the inefficiencies in transporting and converting the delivered energy, i.e. of the 100 per cent delivered energy, only 90 per cent may be used to provide the actual services, e.g. lighting, cooling or ventilation, due to the inefficiency of the equipment used.

When addressing the energy efficiency issue in buildings the main focus is on the energy used to attain the required indoor climate standards. The amount of energy a building will be required to purchase to attain this is dependant on:

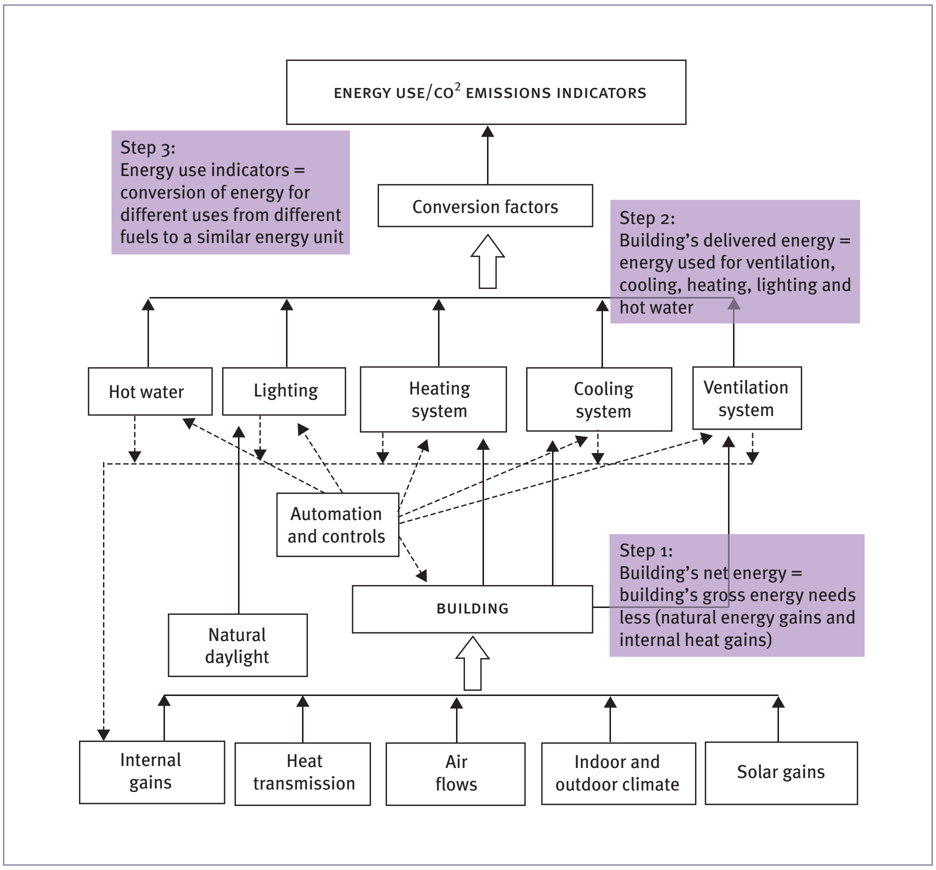
- The properties of the building:
  - The level of heat transfer: the lower the heat transfer the lower the heat loss during cold weather and heat gain during warm weather. This will reduce the energy requirements for heating or cooling;
  - Whether the building is designed to minimize the need for applied energy depending on the outdoor climatic conditions.
- How efficiently the delivered energy is used to meet the building’s net energy demand i.e. the efficiency of the equipment and appliances used;
- How efficiently energy is used by people in the building;
- The percentage of the building’s energy requirement that is supplied by renewable energy.

3.2. Determining a building’s energy performance

Energy use indicators

The calculation of energy use in buildings is based on the characteristics of the building and its installed equipment. It is structured in three levels as illustrated below and the calculation is performed from the bottom up.

Figure IV. Overview of the calculation process of energy use indicators for buildings[a]



[a]EU Energy Performance in Buildings – Directive Implementation Advisory Group, explanation of the general relationship between various standards from the European Committee for Standardization and the Energy Performance of Buildings Directive (EPBD).

1. Step One is the calculation of the building's net energy requirements, i.e. the amount of energy required to provide the indoor climate requirements[9] as specified by the building code. The calculation is used to determine the net energy required based on the outdoor climate and indoor climate requirements while considering the contributions from internal gains, solar gains and natural lighting and losses due to building properties, i.e. heat transmission and airflows (air infiltration and exfiltration). This calculation is used to determine the intrinsic energy performance of the building.
2. Step Two is the determination of the building's delivered energy, i.e. the energy performance of the building in actual use. This is the amount of energy used for heating, cooling, hot water, lighting, ventilation systems, inclusive of controls and building automation, and includes the auxiliary energy needed for fans, pumps, etc. Energy used for different purposes and by different fuels is recorded.

3. Step Three is the determination of the overall energy performance indicators: It combines the results from Step 2 above for different purposes and from different fuels to obtain the overall energy use and associated performance indicators. Since a building can use more than one fuel (e.g. gas and electricity), the different energy sources have to be converted and combined in terms of primary energy to provide the optional end result of the calculation of energy performance. Commonly used energy indicators for buildings are kWh/m^2 (energy consumption in kilowatt hours per metre square of floor area) or CO_2 emissions

For purposes of this calculation, buildings are classified into categories depending on whether they are residential or non-residential, the type of building design and the building size and use. In addition to calculating the performance of existing buildings, energy performance calculations are also undertaken at the design stage for new buildings and refurbished buildings to simulate their energy performance.

It is the government's responsibility to provide, at national or local level, calculation guidelines and methodologies for determining energy performance. In most instances, software is developed for these calculations.

3.3. Benchmarks

Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared. The two main purposes of benchmarks are:

- To identify if a building's energy performance is good, average or poor with respect to other buildings of its type;
- To identify potential savings, shown by the variance between the actual data and the benchmarks: the worse the performance against a benchmark, the greater the opportunity for improving performance, and making cost savings.

Benchmarks can be categorized into two types—modeled benchmarks and empirical benchmarks.[9]

Modeled benchmarks are obtained by using a simulation model to determine the performance of a building, usually at the design or refurbishment stage. The model calculates the delivered energy needed based on the use of the building, the indoor environment, the external climate and the properties of the building.

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[9] EU Energy Performance in Buildings – Directive Implementation Advisory Group: Methodologies in support of the Energy Performance of Buildings Directive: The UK approach to implementation for buildings other than dwellings.

Empirical benchmarks are obtained from statistical data from detailed studies of 20-100 buildings per sector. The minimum information required for benchmarking is how much energy has been used over the last year, which is best obtained from meter readings and energy bills and the floor area. Ideally the studies involve energy audits and in some cases sub-metering (metering the different energy end uses individually), but in most cases only bulk data on the building's energy use is collected. This data sets the good practice and typical standards for each energy use in the building.

3.4. Certifying energy efficiency

An energy efficiency certificate is a summary of the building energy audit. It is meant to give information on the building's energy consumption and its energy efficiency rating.

The purpose of energy efficiency certificates is to:

- Inform tenants and prospective buyers of the expected running costs;
- Create public awareness;
- Act as a prerequisite of measures to improve its energy efficiency;
- To effect incentives, penalties or legal proceedings.

Inform tenants and prospective buyers of the expected running costs – With buyers and prospective tenants better informed, builders and landlords will have greater incentive to incorporate energy-efficient technologies and designs into their buildings, in return for lower running costs.

Create public awareness – In large buildings, regularly visited by the public, display of energy performance certificates will raise awareness among citizens of the issue of energy efficiency in their local community.

Act as a prerequisite of measures to improve its energy efficiency – In the final analysis, knowledge of a building's energy efficiency is also the prerequisite of measures to improve its energy efficiency. The energy efficiency certificate is therefore essentially accompanied by modernization recommendations for low-cost improvement of the building's energy efficiency.

To affect incentives, penalties or legal proceedings – Any effects of these certificates in terms of incentives, penalties or any form of legal proceedings are subject to national legislation. Some countries, e.g. Bulgaria, offer 5-10 year exemptions on building tax to buildings that have high-energy efficiency ratings.

In addition to information on the building's energy performance, a range of recommended and current indoor temperatures and, when appropriate, other relevant climatic factors may also be displayed on the certificates.

What information should be displayed on energy performance certificates, and how that information should be interpreted is a key issue. In order to facilitate comparisons between buildings, the energy performance certificate should include reference values such as current legal standards and benchmarks and recommendations for cost effective investments which can be undertaken in the building to improve its energy performance.

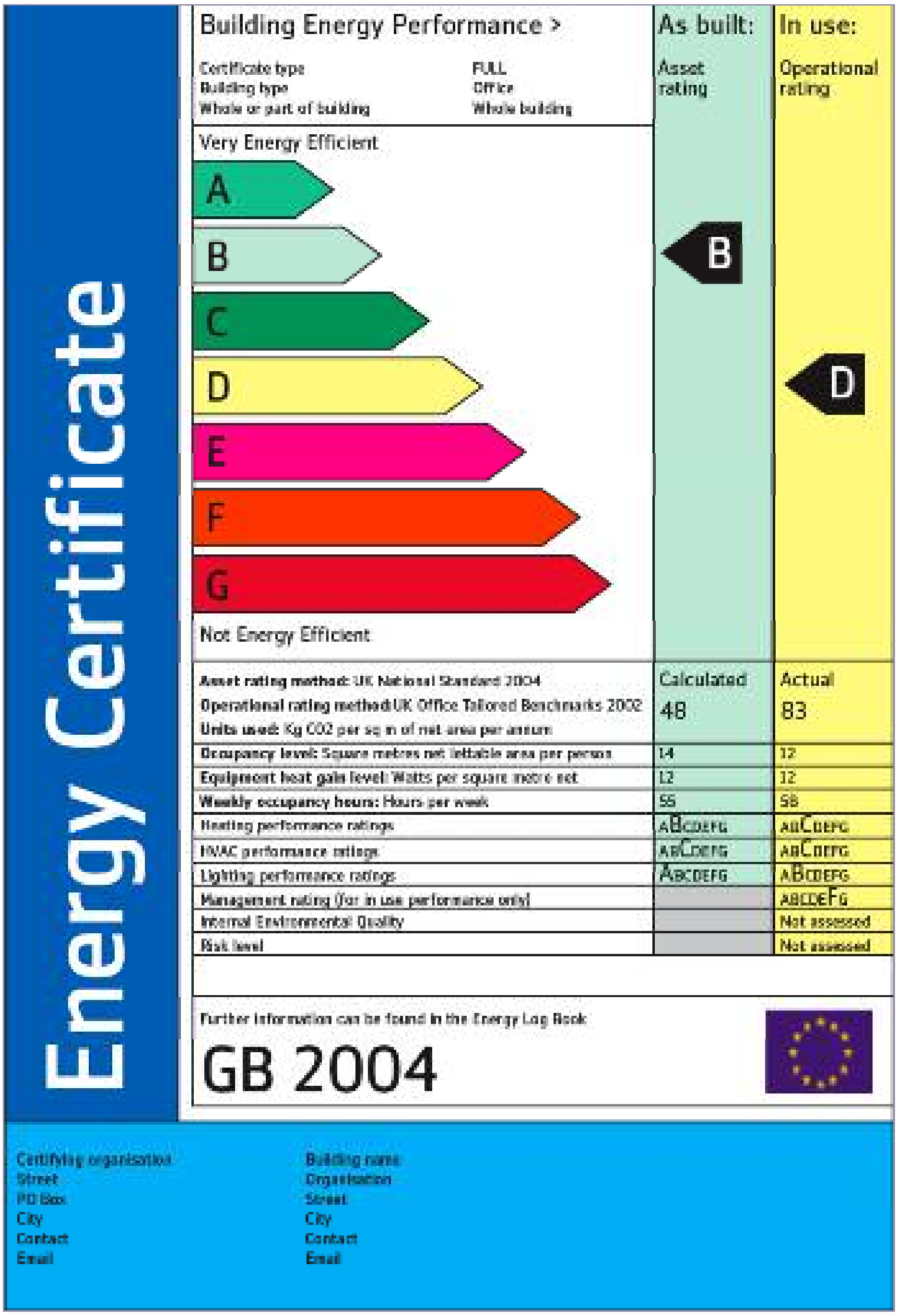
The empirical and modeled benchmarks mentioned above are used to indicate how a particular building compares to the rest of the stock. These benchmarks are used for two ratings normally displayed on the energy performance certificates—the asset rating and the operational rating.

Modeled benchmarks are typically used to rate the intrinsic performance potential of the building and contribute to the building's **asset rating**. This is a rating of the standard of the building fabric and building services equipment and is based on theoretical values.

Empirical benchmarks are typically used to rate the in-use performance of the building—the **operational rating**. This will be influenced by the quality of the building (as measured by the asset rating), but also by the way the building is maintained and operated. The operational rating is based on actual metered energy consumption, normalized in some way to account for the effects of building size, pattern of use, weather, etc.

To supplement certification, in some European countries regular inspection of heating and air-conditioning systems to assess their efficiency and sizing compared to the heating and cooling requirements is carried out.

Figure V. Illustration of a possible format for a non-domestic building energy certificate, proposed by the Europrosper project[a]



Energy Certificate

Building Energy Performance >

		As built:	In use:
Certificate type	FULL	Asset rating	Operational rating
Building type	Office		
Whole or part of building	Whole building		

Very Energy Efficient

Not Energy Efficient

	Calculated	Actual
Asset rating method: UK National Standard 2004 **Operational rating method:** UK Office Tailored Benchmarks 2002 **Units used:** Kg CO2 per sq m of net area per annum	48	83
Occupancy level: Square metres net lettable area per person	14	12
Equipment heat gain level: Watts per square metre net	12	12
Weekly occupancy hours: Hours per week	55	58
Heating performance ratings	A**B**CDEFG	AB**C**DEFG
HVAC performance ratings	AB**C**DEFG	AB**C**DEFG
Lighting performance ratings	**A**BCDEFG	A**B**CDEFG
Management rating (for in use performance only)		ABCDE**F**G
Internal Environmental Quality		Not assessed
Risk level		Not assessed

Further information can be found in the Energy Log Book

GB 2004

Certifying organisation
Street
PO Box
City
Contact
Email

Building name
Organisation
Street
City
Contact
Email

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[a] European Programme for Occupant Satisfaction, Productivity and Environmental Rating of Buildings 2004: Certification of Existing Building Energy Performance—The Energy Performance Label.

Box 2. **Building energy performance certification and labelling**

The Europrosper project produced a proof-of-concept methodology for determining an “operational rating” for office buildings, and was successfully tested by 79 users across 13 of the EU-15 countries (pre EU-expansion). The method has the following main steps:

- Calculate the building's energy intensity;
- Calculate energy benchmarks appropriate to the specific building and its use;
- Compare energy intensity with benchmarks to determine energy efficiency grade;
- Determine how the energy supplied is broken down by end use;
- Analyse and prioritize potential energy efficiency measures for their cost effectiveness and calculate the potential improvement in the energy efficiency grade;
- Produce an energy certificate that reports all of the above.

Review question

What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

4. ENERGY EFFICIENCY MEASURES FOR BUILDINGS

Energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. They can typically be categorized into:

- Reducing heating demand;
- Reducing cooling demand;
- Reducing the energy requirements for ventilation;
- Reducing energy use for lighting;
- Reducing energy used for heating water;
- Reducing electricity consumption of office equipment and appliances;
- Good housekeeping and people solutions.

Reducing heating demand

Heating demand can be reduced by:

- Limiting the exposed surface area of the building;
- Improving the insulation of the building's fabric;
- Reducing ventilation losses;
- By selecting efficient heating systems with effective controls.

Limiting the exposed surface area of the building

The shape of a building determines how much area is exposed to the outdoors through exterior walls and ceilings. To save energy, try to keep this exposed area to a minimum. The most economical house to build and heat is one with a simple square or rectangular floor plan. Complex shapes increase the exposed surface area as well as the construction and energy costs when a house has a complex shape.

Improving air tightness

Air leaks reduce a building's energy efficiency. Air can leak through cracks or holes in walls, ceilings, floors and around doors and windows. A typical building can lose about one-third of its heat through this infiltration (outside air coming in) and exfiltration (inside air escaping). An airtight house will reduce heat and air movement and be quieter and cleaner. Infiltration and exfiltration losses can be reduced by:

- Installing continuous vapor retarders on walls and ceilings;
- Caulking any holes or cracks on the inside surfaces of walls and ceilings;
- Caulking around windows and door trim on the outside;
- Sealing around window and door trim, and electrical outlets on the inside;
- Sealing around any pipes or ducts that penetrate the exterior walls;
- Weather-stripping windows and doors.

Improving the insulation of the building's fabric

The other two-thirds of heat loss occurs by conduction through foundations, floors, walls, ceilings, roofs, windows and doors. Heat flow in and out of the building from conduction can be reduced with high levels of insulation in the attic, sidewalls, basement walls and doors. Windows should have a low U-value.

Effectively using controls

The main controls used in a heating system are time, temperature and boiler controls and ensuring these are set correctly is the best place to start when looking for savings in a heating system. Time controls turn the heating on and off at predetermined times; advanced time controls monitor internal and/or external temperatures and switch the heating on at the right time to ensure the building reaches the correct temperature by the time it is occupied.

Temperature controls are essential to avoid space overheating and should be used to ensure minimum comfort conditions for employees. The more active the employees, the lower the temperature can be to provide comfort. Temperature controls can be used to pre-cool small office buildings so that they take less power to cool during peak demand and to reduce heat and cooling temperature during unoccupied periods in offices or when occupants are sleeping (in the case of homes or hotels).

By turning the thermostat back 10° to 15° for eight hours, savings of about 5 per cent to 15 per cent a year on heating bills are achievable—a saving of as much as 1 per cent for each degree if the setback period is eight hours long. The percentage of savings from setback is greater for buildings in milder climates than for those in more severe climates. In the summer, similar savings can be achieved by keeping the indoor temperature higher when there are no occupants.[10]

Studies have also shown that significant cooling energy use savings can be achieved if ceiling fans are used in conjunction with higher thermostat set points.[11]

Identifying a suitable heating system

The most appropriate and efficient form of heating for a building will vary depending on the use to which the building is to be put. For buildings which are used intermittently (such as churches) or which have large air volumes (such as industrial units) radiant heating may be an effective form of heating. For buildings which are used more regularly and with smaller air volumes, conventional central hot water systems will be more effective. For non-domestic buildings with varying loads, modular boilers should be used to prevent boilers operating at part load. Condensing boilers should be used in place of conventional boiler plant due to their higher seasonal efficiency; they can be up to 30 per cent more efficient than standard boilers if operating correctly. Where condensing boilers are installed, the use of weather compensation controllers and under-floor heating systems, will improve their efficiency by reducing water flow temperatures.

Reducing cooling demand

Energy use in typical air-conditioned office buildings is approximately double that of naturally ventilated office buildings. The need for air-conditioning or the size of the systems installed can be reduced by:

- Controlling solar gains through glazing;
- Reducing internal heat gains;
- Making use of thermal mass and night ventilation to reduce peak temperatures;
- Providing effective natural ventilation;
- Reducing lighting loads and installing effective lighting controls.

Avoiding excessive glazing

Windows should be sized to provide effective day light while avoiding excessive solar gains. Large areas of glazing will increase solar heat gains in summer and

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[10] Programmable Thermostats – U.S. DOE, Energy Efficiency and Renewable Energy Network, Consumer Energy Information, www.energyguide.com/library/EnergyLibraryHome.asp?bid=austin&prd=10.

[11] P. W. James, et al., “Are Energy Savings Due to Ceiling Fans Just Hot Air?” Florida Solar Energy Center (FSEC), www.fsec.ucf.edu/en/publications/html/FSEC-PF-306-96/index.htm.

heat losses in winter making it more difficult to provide a comfortable internal environment.

Use of shading

Solar gains can be reduced by the use of external shading, mid pane blinds (where blinds are integrated between the panes of the double or triple glazing unit) or by internal blinds. Internal blinds are the least effective method of controlling solar gains as the heat will already have entered the space. External blinds are the most effective but may be difficult to maintain and are less easily adjusted for controlling glare. Mid pane blinds often provide an effective compromise. They can be raised when solar gains and glare is not an issue or lowered when required. High angle summer sun can be controlled on south facing elevations by the use of overhangs and fixed shading devices. Solar gains to east and west glazing are more difficult to control and will require adjustable shading devices.

Solar control glass

Glazing is available with a range of selective coatings that alter the properties of the glass; ideally glazing should be selected with the highest light transmittance and the lowest solar heat gain factor. This will help provide daylight while reducing solar gains. All major glass manufacturers provide data on the properties of their products, including those with coatings as described here.

Selecting equipment with reduced heat output

Selecting office equipment with a reduced heat output can reduce cooling demands and by ensuring equipment has effective controls that automatically switch it off when not in use. The use of flat screen monitors can significantly reduce heat gains, while at the same time reducing energy use for the equipment and using office space more effectively. These benefits usually compensate for the higher cost of flat screen monitors.

Separating high heat load processes from general accommodation

Where a building includes energy intensive equipment such as mainframe computers, these are best located in a separate air-conditioned space, avoiding the need to provide cooling to the whole building.

Making use of thermal mass and night ventilation to reduce peak temperatures

Thermal mass is the ability of a material to absorb heat energy. A lot of heat energy is required to change the temperature of high-density materials such as concrete, bricks and tiles. They are therefore said to have high thermal mass. Lightweight materials such as timber have low thermal mass.

Thermal mass is particularly beneficial where there is a big difference between day and night outdoor temperature. Correct use of thermal mass can delay heat flow through the building envelope by as much as 10 to 12 hours, producing a warmer house at night in winter and a cooler house during the day in summer. A high mass building needs to gain or lose a large amount of energy to change its internal temperature, whereas a lightweight building requires only a small energy gain or loss. Allowing cool night breezes and/or convection currents to pass over the thermal mass, draws out all the stored energy.

Reducing heat gains from lighting

Heat gains from lighting can be reduced by making best use of day lighting and by providing energy-efficient lighting installations with good controls.

Predicting the impact of passive cooling strategies

Computer simulation tools can be used to predict the likely comfort conditions in buildings and optimize glazing and shading arrangements.

Reducing the energy requirements for ventilation

When the cooling demand is sufficiently reduced by implementing the above measures, it may be possible to reduce heat gains so that air-conditioning is unnecessary and comfort conditions can be maintained through the use of natural ventilation. The energy required for ventilation can be minimized by:

- A building design that maximizes natural ventilation;
- Effective window design;
- Use of mixed mode ventilation;
- Using efficient mechanical ventilation systems.

Building design

The most effective form of natural ventilation is cross ventilation, where air is able to pass from one side of a building to the other. For this to work effectively it typically dictates that buildings are no more than 12-15 m in depth. However, in deeper plan spaces, natural ventilation can be achieved by introducing central atria and making use of the "stack effect" to draw air from the outer perimeter and up through the centre of the building.

Figure VI. Cross ventilation[a]

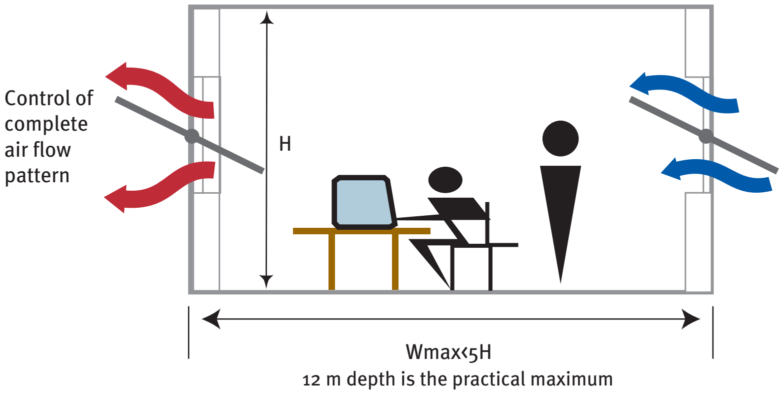
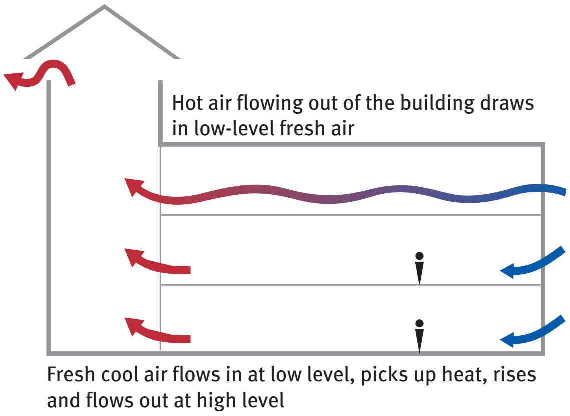


Figure VII. Stack effect[a]



[a]Building Research Energy Conservation Support Unit for the Energy Efficiency Best Practice programme Good Practice Guide 290 Ventilation and cooling option appraisal—a client's guide.

Effective window design

Windows should allow ease of control by building occupants and controlled ventilation that will not blow papers off desks, or cause draughts.

Night ventilation can be an effective method of maintaining comfort conditions in summer. Where night ventilation is used, it is important that building occupants understand how the building is intended to be operated, or that effective control measures are introduced, as it is counter intuitive to open windows before leaving a building at night. Other factors to consider include maintaining security, and controlling wind and rain. In some cases, high ambient noise levels or air pollution may prohibit the use of natural ventilation.

Mixed mode ventilation

Mixed mode ventilation strategies allow natural ventilation to be used for most of the year or to serve parts of a building. Mechanical cooling is used to deal only with peak design conditions in summer or to serve areas of the building that experience a higher build up of heat.

Reducing energy use for mechanical ventilation

The main use of energy for both mechanical cooling and for air conditioning is the fans needed to circulate the air. Fan energy use for mechanical ventilation can be reduced by:

- Designing the system to reduce pressure drops;
- Selecting efficient fans;
- Utilizing variable speed fans to respond to varying load requirements;
- Avoiding excessive air supply volumes.

Reducing energy use for lighting

This can be accomplished through:

- Making maximum use of daylight while avoiding excessive solar heat gain;
- Using task lighting to avoid excessive background luminance levels;
- Installing energy-efficient luminaires with a high light output to energy ratio;
- Selecting lamps with a high luminous efficacy;
- Providing effective controls that prevent lights being left on unnecessarily.

Maximizing the use of daylight

Introducing natural light into buildings both saves energy but also creates an attractive environment that improves the well-being of building occupants. The provision of effective daylight in buildings can be assessed using average daylight factors and by ensuring that occupants have a view of the sky.

The average daylight factor will be influenced by the size and area of windows in relation to the room, the light transmittance of the glass, how bright internal surfaces and finishes are, the depth of reveals, and presence of overhangs and other external obstructions which may restrict the amount of day lighting entering the room.

Window design has a key impact on day lighting. As a rough rule of thumb, a window will introduce effective daylight into a room to a distance twice the head height of the opening. The use of high ceilings and clerestory windows can be effective in providing good daylight. Sunpipes and skylights can be used to introduce daylight to windowless areas.

Energy-efficient lighting system

An efficient lighting installation should be able to provide the required illuminance level for a particular use with minimum energy consumption. Efficient lights should be able to provide illuminance levels of 500 lux[12] on a working plane for less than 12W/m^2 of installed power.

Lighting controls

Lighting controls should be designed so that small groups of lights can be controlled individually with the controls provided adjacent to the work area. Perimeter lighting should be controlled separately to core lighting so that perimeter lights can be switched off when there is adequate daylight. Absence detection should be provided to rooms that are used intermittently. This should switch lights off automatically after a room or space has been unoccupied for a set period of time. Daylight sensors and timed switches should be used to prevent external lighting being left on unnecessarily. Daylight sensors can also be used to switch off internal lighting when daylight levels are sufficient.

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[12] The lux is the SI unit of illuminance. It is used in photometry as a measure of the intensity of light per square metre. Achieving an illuminance of 500 lux might be possible in a home kitchen with a single fluorescent light fixture with an output of 12,000 lumens. To light a factory floor with dozens of times the area of the kitchen would require dozens of such fixtures.

Reducing energy used for heating water

This can be achieved by:

- Installing time controls, and setting them to correctly reflect the hours of hot water requirement;
- Setting sanitary hot water thermostats to the appropriate temperature—no more than 60°C for normal requirements (but ensure the water does not drop below 56°C);
- Switching off electric heating elements (immersion) when hot water from the boiler is available;
- Switching off any associated pumps when hot water is not required;
- Replacing any damaged or missing insulation from all hot water pipe work and cylinders, except where the pipes are providing useful heat into the space;
- Identifying a suitable hot water system.

Hot water provision is either provided via a central generation plant, with a distribution network to provide hot water to the required areas within a building, or by localized provision at the point it is required. Combined heating and hot water systems and separate heating and hot water systems are the two types of centralized hot water systems. In the case of localized hot water systems, water is heated and stored locally or is provided on demand. The most significant reduction in energy use for hot water can be achieved by providing solar water heating.

Reducing consumption of office equipment and appliances

Most businesses rely on a range of office equipment in order to function. From the basic essentials such as computers, monitors, printers, fax machines and photocopiers to projectors, scanners and teleconference facilities, it is widely recognized that these items have become integral to daily activity.

Office equipment is the fastest growing energy user in the business world, consuming 15 per cent of the total electricity used in offices. This is expected to rise to 30 per cent by 2020. There are also associated costs that are often overlooked, specifically those of increasing cooling requirements to overcome the additional heat this equipment produces. As ventilation and air conditioning are major energy consumers themselves, it makes good business sense to ensure they are only used when absolutely necessary.

Typical measures to reduce consumption which also apply to household appliances are:

- Switching off – switching off or enabling power down mode reduces the energy consumption and heat produced by equipment, which in turn lowers cooling costs;
- Upgrading existing equipment – some energy-efficient appliances may cost more to buy but will recoup savings over the lifetime of the equipment;
- Matching the equipment to the task – bearing in mind current and predicted requirements and purchase equipment that meet these;
- Taking advantage of energy labelling schemes – some well know energy labelling schemes are Energy Star, European Ecolabel Scheme, Energy Saving Recommended and The Market Transformation Program.

Box 3. **Energy Star energy efficiency equipment and appliance labelling**

Energy Star labeled products are the same or better than standard products, only they use less energy. To earn the Energy Star, they must meet strict energy efficiency criteria. Energy Star is a US programme for office equipment, appliances, commercial foodservice products, home electronics, home envelope products, lighting, residential heating, cooling and ventilation equipment, new homes and other products. It is widely used and accepted across the commercial sector.

Energy Star models have the following benefits:

- Computers – use 70 per cent less electricity than computers without enabled power management;
- Monitors – use up to 60 per cent less electricity than standard models;
- Printers – use at least 60 per cent less electricity and must automatically enter a lower power setting after a period of inactivity;
- Fax machines – use almost 40 per cent less electricity and may have the capability to scan double-sided pages, reducing both copying and paper costs;
- Refrigerators are at least 15 per cent more efficient than standard models;
- TVs – consume 3 watts or less when switched off, compared to a standard TV, which consumes almost 6 watts on average;
- Light bulbs (CFLs) – use two-thirds less energy than a standard incandescent bulb and must meet additional operating and reliability guidelines;
- Furnaces – are 15 per cent more efficient than the standard.

Figure VIII. The Energy Star label

Good housekeeping and people solutions

The level of achievable energy savings from office equipment is down to the everyday management by staff. A simple energy conservation programme for an organization would consider:

- Setting up an energy policy for the organization;
- Appointing an energy champion;
- Involving staff;
- Setting targets;
- Using notices and reminders;
- Conducting walk-rounds;
- Taking meter readings.

Setting up an energy policy

Commitment to energy efficiency has to come from the top and should be backed up by a personalized mission statement and energy policy. It is also important to appoint an energy champion. In very small businesses, this may be the owner or manager but in larger companies, an appointed staff member will often improve involvement and awareness across the whole organization. Show management commitment by developing a procurement policy whereby energy-efficient products are specified when purchasing.

Involving staff

All staff are important in saving energy, so they must be made aware of wastage areas and be trained to operate equipment and controls correctly. Motivate staff—ask for opinions and encourage people to review their own working practices to increase energy savings. The best ideas usually come from those that use the equipment on a daily basis. Competitions, campaigns and team projects are great ways to get buy-in. Reinforce the benefits of improving the working area and give staff a sense of ownership of energy management.

Setting targets

Tell staff how much energy is currently being a consumed and set a realistic savings target. As the energy-saving programme gathers momentum, it will be possible to track progress and highlight energy savings.

Using notices and reminders

Use notices and reminders on turning off equipment. They can also be used to highlight how this makes the working environment more pleasant.

Conducting walk-rounds

Carrying out regular good housekeeping walk-rounds in your building to find out where energy is being used. Note down when equipment is being used and act on any wastage or maintenance measures needed. As patterns of energy use vary throughout the day, it is advisable to carry out a series of walk-rounds at different times to get a better idea of where and when energy is being wasted. Walking round your office after everyone has left, before everyone comes in and when offices are empty during the day, gives an idea of what equipment tends to be left on out of office hours.

Take meter readings

Meter readings can give a picture of the energy usage in the office. Meter readings can be used to determine electricity use during and after office hours. These figures give an idea of the energy used every hour the office is empty and to find out how much energy is used when no one is in the building. In most offices, the overnight energy consumption should only be a small percentage of the overall energy use.

Exercise

From the measures mentioned above, list:

1. Those easiest to implement in your country.
2. Those with the highest potential savings.

5. FINANCING ENERGY EFFICIENCY IN BUILDINGS

There is a tendency in many businesses and public sector enterprises to undervalue cost reduction where this itself requires investment. This happens when the organization fails to see the connection between the investment and the benefits derived from it. Conventional financial management information systems do not make visible the benefit the business derives from energy saving investments.

Financial appraisal involves finding and evaluating the best projects to invest in whatever they are and wherever they arise. It gives energy savings the priority they merit when compared with other aspects of cost reduction or business expansion. The six key steps in financial appraisal of energy efficiency investment in buildings are:

- Locating the buildings which have the potential;
- Identifying the area in each of these buildings where a saving can be made and identifying the measures required to release these savings;
- Establishing the costs and the savings for each measure and calculating the key financial indicators, such as payback period and net present value;
- Optimizing the financial return measured by these indicators for each project, and the portfolio of projects;
- Establishing how much investment capital is available and identifying new sources of capital;
- Deciding which projects make best use of the organization’s available capital.

The most common reason for the failure of financial appraisals is that they are too optimistic and in most cases do not give a true financial picture of a project, either through overstating the benefits or understating the costs. Costs for energy saving projects in buildings are usually easier to establish than savings. A good energy monitoring system will make it easier to predict the effect of a proposed project on energy use and cost.

5.1. Energy efficiency financing mechanisms

After appraising the required energy efficiency measures, the next challenge is sourcing the necessary capital to implement them. Listed below are several options for financing energy efficiency measures for buildings.

Internal funds

Energy efficiency improvements are financed by direct allocations from an organization's own internal capital or operating budget. The most direct way to pay for energy efficiency improvements is to allocate funds from the internal capital or operating budget. Financing internally has two clear advantages over the other options: it retains internally all the savings from increased energy efficiency, and it is usually the simplest option administratively. All or some of the resulting savings may be used to decrease overall operating expenses in future years or retained within a revolving fund and used to support additional efficiency investments. Many public and private organizations regularly finance some or all of their energy efficiency improvements from internal funds.

Debt financing

Energy efficiency improvements are financed with capital borrowed directly by an organization from private lenders and include municipal bonds. Direct borrowing of capital from private lenders can be an attractive alternative to internal funding for energy efficiency investments. For both public and private organizations, this approach avoids tapping internal funding, and financing costs can be repaid by the savings from increased energy efficiency. Additionally, municipal governments often issue bonds or other long-term debt instruments at substantially lower interest rates than private corporate entities. As in the case of internal funding, savings from efficiency improvements, less only the cost of financing, are retained internally. Debt financing is administratively more complex than internal funding.

In general, debt financing should be considered for large projects that involve multiple buildings and pose relatively little risk in achieving their energy savings targets. When considering debt financing, organizations weigh the cost and complexity of the type of financing against the size and risk of the proposed projects.

Lease or lease-purchase agreements

Energy-efficient equipment is acquired through an operating or financing lease of 5-10 years with no up-front costs. Leasing and lease-purchase agreements provide a means to reduce or avoid the high, up-front capital costs of new, energy-efficient equipment. These agreements may be offered by commercial leasing corporations, management and financing companies, banks, investment brokers, or equipment manufacturers. As with direct borrowing, the lease should be designed so that the energy savings are sufficient to pay for the financing charges.

Financing leases are agreements in which the lessee essentially pays for the equipment in monthly installments. Although payments are generally higher than for an operating lease, the lessee may purchase the equipment at the end of the lease for a nominal amount.

Guaranteed savings leases are the same as financing or operating leases, but with an additional guaranteed savings clause. Under this type of lease, the lessee is guaranteed that the annual payments for leasing the energy efficiency improvements will not exceed the energy savings generated by them. The building owner pays the contractor a fixed payment per month. However, if the actual energy savings are less than the fixed payment, the owner pays only the amount saved and receives a credit for the difference.

Energy performance contracts

Energy efficiency measures are financed, installed and maintained by a third party that guarantees savings and payments based on those savings. Energy performance contracts are generally financing or operating leases provided by an energy service company (ESCO) or equipment manufacturer. What distinguishes these contracts is that they provide a guarantee on energy savings from the installed retrofit measures, and they usually also offer a range of associated design, installation and maintenance services.

Under an energy performance contract, the ESCO provides a service package that typically includes the design and engineering, financing, installation and maintenance of retrofit measures to improve energy efficiency. The scope of the improvements can range from work that affects a single part of a building's energy-using infrastructure (such as lighting) to a complete package of improvements for multiple buildings and facilities. Generally, the service provider will guarantee savings as a result of improvements in both energy and maintenance efficiencies.

An energy performance contract must define the methodology for establishing the baseline costs and cost savings and for the distribution of the savings to the parties. The contract must also specify how the savings will be determined and address contingencies such as utility rate changes and variations in the use and occupancy of a building.

Utility incentives

Rebates, grants, or other financial assistance offered by an energy utility for the design and purchase of certain energy-efficient systems and equipment usually as a result of the implementation of a policy to promote energy efficiency. Some utilities offer financial incentives for the installation of energy-efficient systems and equipment. These incentives are available for a variety of energy-efficient products including lighting, heating, ventilation and air-conditioning systems, energy management controls and others. The most common incentives are equipment rebates, design assistance and low-interest loans (see box 4). In general, the primary purpose of utility incentives is to lower peak demand. Overall energy efficiency is an important but secondary consideration. Incentives can be in several forms:

Equipment rebates

Offering rebates on the initial purchase price of selected energy-efficient equipment. An electricity consumer for instance who switches from incandescent lights to efficient compact fluorescent lights could get a refund on the tax they paid through the electricity utility company for the lights through a reduction on their electricity bill by a similar amount.

Box 4. **Energy efficiency commitment of the United Kingdom**

The Energy Efficiency Commitment (EEC) was introduced in April 2002, by the Department of Environment, Food and Rural Affairs (Defra), and set a three-year energy savings target for domestic energy suppliers to help reduce carbon emissions by improving energy efficiency in households. The EEC is administered by Ofgem, the Office of Gas and Electricity Markets.

This energy-saving target is met through measures such as offering cavity wall and loft insulation, using energy-efficient boilers, appliances and light bulbs. At least half of these savings are aimed at low-income consumers in order to alleviate fuel poverty.

As a result of the EEC, the U.K.'s fuel utility companies set up an energy efficiency commitment fund. The money contributed by the fuel companies is used to fund various energy efficiency schemes for homeowners and tenants. Some schemes are UK-wide, whilst others are run locally. Some are run directly by the fuel companies, whilst others are carried out in partnership with local councils, housing associations and other relevant agencies.

The first EEC period from 2002 to April 2005, saw energy suppliers set an overall three-year target of 62 TWh total energy savings. The total was exceeded, reaching 86.8 TWh savings. The current EEC period began in April 2005 and has a three-year energy savings target of 130 TWh. It is estimated energy suppliers will have to invest approximately £1.2 billion in order to meet the challenge.

Design assistance

Provision of direct grants or financial assistance to architects and engineers for incorporating energy efficiency improvements in their designs. This subsidy can be based on the square footage of a building, and/or the type of energy efficiency measures being considered. Generally, a partial payment is made when the design process is begun, with the balance paid once the design has been completed and installation has commenced.

Low-interest loans

Provision of loans with below-market rates for the purchase of energy-efficient equipment and systems. The source of funding could be through loans from development banks accessed through government for this aim or from an energy efficiency fund levied from utilities.

Local authority and national assistance

Matching grants, loans or other forms of financial assistance may be available from the local or state governments. In countries with energy efficiency policies, a variety of state-administered programmes for building efficiency improvements are often available, some of which are funded through grants and programmes and national energy programme funds.

Box 5. **Salix: working with the public sector to reduce carbon emissions through investment in energy efficiency measures and technologies in the United Kingdom**

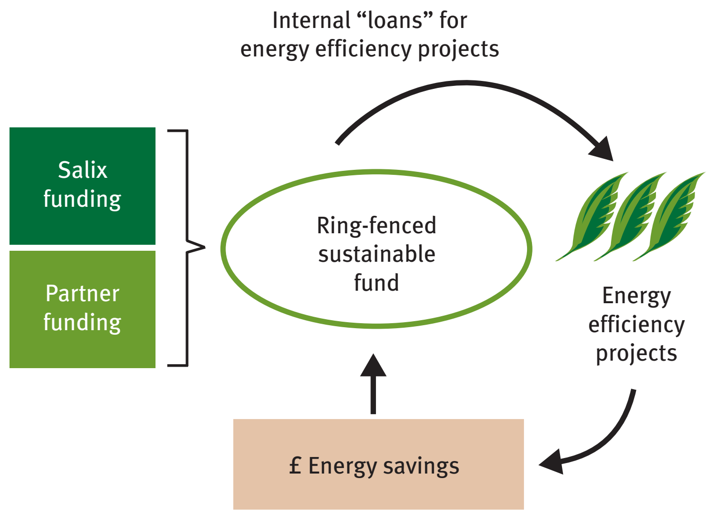
Escalating energy prices and the urgency attached to climate change has increased the need to significantly scale up the implementation rate of energy saving measures and technologies in the United Kingdom. Salix is an independent company set up by The Carbon Trust—a government-funded company—which helps the United Kingdom's business and the public sectors cut carbon emissions. Salix was established in 2004 to work with the public sector to reduce carbon emissions through investment in energy efficiency measures and technologies. Due to the success of its pilot, the Local Authority Energy Finance Scheme, Salix is extending the range and scale of its operations by increasing the number of local authorities that it currently works with as well as opening the scheme to a larger number of qualifying public sector bodies.

By combining grant funding and its expertise, Salix gives organizations an opportunity to both improve energy efficiency and reduce energy costs while taking a leadership role in tackling climate change. Salix will provide a grant of typically £200,000 to kick-start an energy efficiency drive affecting all components of the partner's estate. The partner organization will be required to supplement this grant to make up the total "invest to save" ring-fenced fund.

Monies dedicated to implementing energy saving projects will be provided by this fund through interest-free internal "loans". Loans are repaid using a minimum of 75 per cent of annual savings. Once the project loan has been repaid to the fund the project recipient will continue to benefit from the ongoing energy savings. As repayments are recycled into the fund they become available for re-investment, hence creating a self-sustaining fund.

The United Kingdom's Carbon Trust also offers interest-free energy efficiency loans to small or medium-sized enterprises (SMEs) that have been trading for at least 12 months. SMEs can borrow from £5,000 to £100,000 unsecured, interest free and repayable over a period of up to four years.

Figure IX. The Salix funding mechanism



Review question

List and describe four mechanisms for financing energy efficiency in buildings.

Discussion question

Outline how at least two of the finance mechanisms outlined here would be applied in your country highlighting how they would be affected and which organizations would be involved.

6. DEVELOPING AND IMPLEMENTING POLICY ON ENERGY EFFICIENCY IN BUILDINGS

To ensure effective implementation of energy efficiency in buildings involves the development and formulation of an energy efficiency policy and the enactment of a legal and institutional framework.

The formulation of an energy efficiency policy should be developed by the relevant ministry[13] in partnership with relevant stakeholders. The policy is owned by the ministry and guides the ministry on what it would like to achieve, how long it will take and what it should do to achieve it. The energy efficiency policy does not have to be exclusive to buildings and can cover energy efficiency in buildings, industry as well as supply and demand-side management if policies for these do not already exist. The drafting of a law to implement and enact the policy is the only guaranteed means to ensure its application. An "Energy Efficiency for Buildings Act" will:

- Establish an energy efficiency agency or bureau and define its functions and powers;
- Establish or identify a body to facilitate and enforce efficient use of energy in buildings;
- Establish penalties for failure to comply to the energy efficiency building standards[14] and set up a body or office with powers to adjudge compliance;
- Establish an appellate tribunal and appeal framework to hear appeals of those who have been adjudged and penalized.

6.1. The formulation of an energy efficiency policy

Policy is formulated on a need basis, and therefore policymakers require a clear picture of the contribution of buildings to the country's total energy consumption, the future impact of urbanization and increase in the number of new buildings vis-à-vis energy demand and the potential for energy savings from large-scale implementation of energy efficiency measures in existing and future buildings.

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[13] Ministry of Energy, but requires participation from the Ministry Public Buildings of Works (responsible for monitoring the building industry).

[14] Penalties for failure to comply with standards can be established during the formulation of the policy or by the regulator. Under India's Energy Conservation Act, those who fail to comply with the energy efficiency provisions are liable to a penalty of up to $US 230 for each failure and an additional $US 23 per day in the case of continuing failures. In Bulgaria, the penalty is $US 330-2000.

Policymakers also need to understand the potential benefits of more energy-efficient buildings, these benefits being:

- Improving the security of supply and reducing the need for imported energy;
- Reducing the needs for new investments in energy generation;
- Having a favourable social effect, bringing down energy bills and needs for subsidies;
- Reducing the adverse impact of energy production and energy use on the environment.

In most developing countries there is little or no information on the energy consumption of buildings or the potential energy savings. There are methodologies that have been developed to collect this data, but they have to be adapted to the local situation. This information gap is a major barrier to making a convincing argument towards the formulation of an effective policy. Therefore an initial data collection and information-sharing phase is required to kick-start the process.

During the policy formulation phase, the relevant ministry should involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers. The policy should:

- Outline the need for and benefits of energy efficiency in buildings;
- Estimate potential savings both in terms of energy use and reduction of capacity;
- Set achievable targets and timelines;
- Outline an approach to achieve the targets and monitor them;
- Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;

Consider the financial support instruments for undertaking energy efficiency measures.

6.2. Implementing policy on energy efficiency in buildings

To implement policy, certain bodies need to be set up to operationalize it. These would consist of an agency whose role is to develop and recommend a framework for the policy, a regulator to facilitate and enforce the policy, an adjudicating body to mete out penalties and an appellate tribunal to hear appeals against the orders of the adjudicating body. These bodies are set up by an act of parliament, through which their functions and powers are defined.

The energy efficiency agency

The role of the agency would be to develop and recommend a framework for application of the policy, create awareness, provide guidance and information to stakeholders, and actively promote energy efficiency in buildings.

The functions of the agency would be to:

- Recommend the application and exemption i.e. which buildings based on application, size, and/or energy consumption the policy will target or exempt;
- Develop standard methodology for assessing the energy requirements of existing or proposed buildings and specify the manner and intervals of time in which energy audits shall be conducted;
- Develop energy efficiency benchmarks to gauge the level of efficiency of a building and to set energy efficiency targets/requirements for buildings;
- Develop a certification and labelling criteria for buildings and appliances to prescribe guidelines for energy conservation building codes;
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy in buildings;
- Promote research and development in the field;
- Strengthen consultancy services in this field;
- Formulate and facilitate implementation of pilot projects and demonstration projects for promotion of efficient use of energy in buildings;
- Promote use of energy-efficient processes, equipment, devices and systems;
- Promote innovative financing of energy efficiency projects;
- Give financial assistance to institutions for promoting efficient use of energy and its conservation;
- Levy fee, as may be determined by regulations, for services provided for promoting efficient use of energy in buildings;
- Specify, by regulations, qualifications for accredited building energy auditors;
- Register and maintain a list of accredited building energy auditors;
- Prepare educational curriculum on efficient use of energy and its conservation for educational institutions, boards, universities or autonomous bodies and coordinate with them for inclusion of such curriculum in their syllabus;
- Implement international cooperation programmes;
- Create awareness and disseminate information for efficient use of energy in buildings.

The energy efficiency agency will require advisory committees to guide it in performing these functions as it builds its own internal capacity. The committees also ensure contributions and participation from experts and key stakeholders. The energy efficiency agency is also best placed to make recommendations of suitable penalties and incentives.

The energy efficiency regulator

The energy efficiency agency could also double up as the regulator, but it has to be structured so that both arms are complementary. In some developing countries, a regulatory body for electricity or energy already exists and could be mandated to be the energy efficiency regulator as well instead of establishing a new body. The regulatory body would have authority to:

- Specify and prescribe the energy efficiency norms and standards for buildings and appliances;
- Specify the application and exemption i.e. which buildings based on application, size, and/or energy consumption the policy will target or exempt;
- Specify equipment or appliance or class of equipments or appliances, for which the law/act applies;
- Prohibit manufacture, sale, purchase or import of equipment or appliances specified unless such equipment or appliances conforms to energy consumption standards;
- Specify certification and labelling of buildings and appliances;
- Direct any designated consumer to get an energy audit conducted by an accredited energy auditor;
- Direct any designated consumer to furnish to the designated agency, information with regard to the energy consumed and action taken on the recommendation of the accredited energy auditor;
- Direct any designated consumer to designate or appoint an energy manger in charge of activities for efficient use of energy and its conservation and submit a report, in the form and manner as may be prescribed, on the status of energy consumption at the end of the every financial year to the designated agency;
- Direct every designated consumer to comply with energy consumption norms and standards;
- Prescribe energy conservation building codes for efficient use of energy;
- Amend the energy conservation building codes to suit the regional and local climatic conditions;
- Direct every owner or occupier of the building or building complex, being a designated consumer to comply with the provisions of energy conservation building codes for efficient use of energy and its conservation.

The regulator could also be required to:

- Make available all compliance material for buildings and create awareness and disseminate information on this material;
- Appoint inspecting officers for the purpose of ensuring compliance with energy consumption standards specified;
- Arrange and organize training of personnel and specialists;
- Encourage preferential treatment for application of energy-efficient measures and use of energy-efficient equipment or appliances;
- Constitute a fund for the purpose of promotion of efficient use of energy and its conservation to be credited all grants and loans that may be made by the government or any other organization or individual for the purposes of this Act.

The energy efficiency adjudicating body

The functions of this office would be to:

- Set penalties (fine or jail) and how they would be applied in case of failure to comply to energy efficiency standards;
- Holding inquiries, establishing and meting out penalties.

The appellate tribunal

The tribunal would be responsible for:

- Developing an appeal framework to hear appeals of those who have been adjudged and penalized:
- Hearing and judging on appeals against the orders of the adjudicating officer/body.

Review question

List five functions of the energy efficiency agency.

Discussion questions

1. What would be the most suitable model in your country with regard to the bodies required to operationalize an “Energy Efficiency in Buildings Policy” and their functions?
2. How would you set up an energy efficiency fund in your country? Where would the funds be sourced from and what criteria would you use to allocate the funds?

7. POLICY TOOLS TO PROMOTE BUILDING EFFICIENCY

The most effective programmes are designed not only to ensure that a particular target level of energy efficiency improvement is realized but also to assure that the market is prepared continually to introduce better and better technologies for energy efficiency.

This process of continuous improvement in energy efficiency should be anticipated in the developmental process for energy efficiency codes by requiring that the codes be reviewed periodically—such as every three or four years—and updated to include requirements for the use of newer technologies that are cost-effective and feasible.

Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:

- Codes and standards for new construction and performance-based economic incentives to go beyond the standards;
- Long-term incentives with ambitious energy efficiency targets;
- Normative labels to distinguish the most energy-efficient buildings and equipment;
- Informative labels that provide the information necessary to measure energy efficiency and annual energy costs for operation;
- Education and outreach to promote market acceptance of energy efficiency technologies and energy-efficient designs, most notably efficiency demonstration centres;
- Government-funded research and development on energy efficiency in buildings.

7.1. Codes and standards

Codes refer to mandatory energy efficiency requirements for new construction in buildings. New construction refers either to an entirely new building being erected, or the construction of a new energy-using system (such as a lighting system or an air conditioning system) in an existing building. Standards refer to minimum mandatory requirements for equipment used in buildings, such as air conditioning units, furnaces or boilers, water heaters, office equipment, appliances, etc.

Before adopting codes and standards, the regulator must first develop testing protocols and methodologies to determine how much energy the whole building uses, how much each of the energy-using components contribute to the total energy use and benchmarks for new and existing buildings. Ideally, compliance with these protocols will yield databases listing the performance of each product or building offered for sale, and labels publicizing the tested performance.

Residential and non-residential buildings

All of the major energy-related choices—the thermal conductivity of insulation, the thermal transmission qualities of windows, the heat capacity of building materials, the solar heat transmission qualities of windows, the visible light transmission of windows, the air and water movement output of fans and pumps, the efficiency of motors, heat transfer efficiencies of heaters for air and water, etc.—must be determined by standardized measurements. Before advanced energy-efficient equipment requirements can be determined for either a mandatory or a voluntary programme, test protocols and labelling rules must be established and enforced.

For building energy efficiency, the most effective codes offer two options of compliance, called prescriptive and performance-based.

Prescriptive standards set requirements for the components of a building, for example, the thermal conductivity of insulation or the efficiency of a heating or cooling device. They do not offer the designer the flexibility to vary from many of these minimum specifications.

Performance-based standards, on the other hand, set maximums on the energy consumption or annual predicted energy cost of a building taken as a whole. They allow the designer to specify less energy efficiency in some components in return for more efficiency in others. They are more economically efficient because they allow the designer or builder to optimize the selection of efficiency measures to minimize first costs. They also tend to lead to innovations in which the efficiency measures actually used are better than the ones that were required in the prescriptive standards.

In addition to establishing protocols for testing buildings and components and regulating minimum acceptable levels of performance, the regulator must develop plans for implementation and enforcement of the standards. These can be more difficult to establish at first, since the goal is to establish a positive feedback cycle in which companies and individuals that comply receive positive reinforcement in the marketplace, where those that are out of compliance face potential penalties. Once it is established that a code will be enforced, it is not difficult to maintain these positive expectations, but a jurisdiction must plan to make significant initial efforts to enforce the code with credibility.

Certain categories of buildings may be exempted from these standards, e.g. buildings and monuments designated officially as protected, places of worship, temporary buildings with a planned time of use of two years or less, non-residential agricultural buildings with low energy demand, buildings whose useful floor area is below a certain range (e.g. less than 1,000 square metres)

New constructions

Standards for new construction can be adopted legislatively or administratively. Where legislative adoption has been used, the legislative body has often adopted the local requirements of a national or international model, rather than having the details worked through the legislative process.

Authority is often delegated to an administrative agency which is provided with general instructions or criteria that code revisions must meet. These typically require that the code incorporate all energy efficiency measures that are technologically feasible and cost effective to the consumer over the lifetime of the building.

A second general process is for the agency to allow public comment on draft standards and require the agency to respond to this commentary. Public comment identifies areas with problems for implementation in advance and can create a more positive attitude among the design and construction community towards eventual compliance. The authorizing legislation usually specifies what agencies are responsible for implementing the energy standard. It may or may not be the same agency that adopts it.

Implementation will require a programme of outreach and education to enforcement officials, building designers and the construction industry. At a minimum, this includes a means for disseminating current and updated versions of these standards and a process for compiling and publicizing interpretations of the standards as they are made.

Implementation should also include the development and dissemination of design manuals that show how to construct buildings or details such that they comply. The design manuals should almost motivate the designer to meet or do better than the energy code.

There also needs to be an agency to provide fast-response telephone and e-mail answers to questions concerning the meaning of the code. Frequent training of code enforcement officials as well as building industry officials has proven necessary. Government as part of the legislation authorizing the standards can provide funding for training. But usually other funding sources have been used. Some form of third-party inspection by government officials or independent private sector inspectors is necessary to assure quality control.

In many countries, building inspectors at the local level already certify building compliance with construction codes with respect to fire safety, electrical safety, etc. These officials can also enforce energy codes. But they will require frequent training as well as motivation to get them to do so. Some jurisdictions, instead of relying on building code inspectors, allow or require the use of independent third-party private sector inspectors. In this case, the energy agency must establish standards for technical expertise, professional conduct and financial independence of the inspector from the builder in order to assure that the private sector inspectors are doing their job.

Refurbishing and renovations

There are two ways to affect energy efficiency in existing buildings. The first is to require that energy efficiency measures be installed when a major renovation or reconstruction is taking place. This could include something as minor as a new tenant moving into an existing commercial building and installing a replacement lighting system; in this case, the codes require that the new lighting system comply with the same energy efficiency standards as if it were an entirely new building. Similarly, when a component in a building is replaced in a fashion that requires a building permit, the component can be required to have the same energy efficiency as it would for a new building (or even a somewhat different level of efficiency).

A second way of addressing the problem of existing buildings is to require retrofits at a particular time, typically, point of sale. In this case, the code requires the owner to undertake construction projects that would not have been undertaken at all but for the energy code, in contrast to requiring that upgrades already being undertaken be done in an energy-efficient manner. However, mandatory energy efficiency standards for retrofit buildings are relatively rare.

7.2. Incentives

Economic incentives complement codes and standards. They depend on the prior existence of these standards both to establish the criteria by which superior performance can be measured and to establish levels of efficiency at which economic incentives are justified. In turn, incentives can complement standards by providing for differentiation in the marketplace between low efficiency, typical and high efficiency buildings or products. Incentives can also encourage the widespread use of new technologies that may later be appropriate for standards, but which it is impossible to require at a given time due to questions of availability or universality of application.

Although incentives are often more effective than regulation, they must be balanced against the need to provide a financial revenue source for the incentives. Standards require a dramatically smaller investment by the government in producing a given level of energy efficiency. They also guarantee that at least a basic level of efficiency will be met in all cases covered by them.

Legislation establishing programmes for energy efficiency incentives must provide a funding mechanism for the incentive as well as an administrative mechanism for spending the money in the most effective way.

7.3. Certification and labelling

Labels can typically be distinguished as normative or informative.

Normative labels

Normative labels mark products or buildings that achieve an “exemplary” or recommended level of energy efficiency higher than the typical level of efficiency. Normative labels can be established as a freestanding government programme, or as private sector programmes.

Government policy can make use of normative labels by requiring that products purchased by the government directly or on government contracts qualify for the appropriate label.

Informative labels

Information labelling as a policy tool can be a meaningful part of energy efficiency policy. It could encompass new and existing buildings or could be limited to new buildings only. The European Union, for example, has recently required that all buildings be rated for energy efficiency over the next several years. However, the EU is yet to implement a standardized test protocol with which to do such ratings. These ratings would apply to all buildings, both existing and new.

Box 6. **Energy benchmark pool for commercial buildings in Frankfurt**

The energy agency of Frankfurt organized an energy benchmark pool for commercial buildings. Users, owners and investors of buildings are invited to analyse and optimize the energy use of their buildings in small groups of up to 10 participants and the results are published anonymously. The aim is to enforce competition of energy-efficient buildings in Frankfurt and to give owners and investors clear figures to describe energy efficiency for their planners.

Facilitation of a benchmark process with the owners, users or investors of a commercial building:

- Step 1: Introduction workshop (questionnaire and determination of the benchmark process);
- Step 2: Data collection through the participants;
- Step 3: Data analysis through the energy agency;
- Step 4: Discussion of the analysis, experience and information exchange and best practice presentation in up to three workshops;
- Step 5: Collection and public presentation of the (anonymous) results;
- Step 6: Continuous experience exchanges twice a year.

The results from the process were:

- On average, 25 per cent of the total energy demand of the buildings was identified as a saving potential with a payback time of less than five years.
- Typically 10-15 per cent of the total demand could be saved only by optimizing the running time of the equipment without any investment
- For the first time, the electricity demand in 10 big office buildings in Frankfurt was analyzsed in great detail (parts of lighting, HVAC, office equipment, etc.) showing large deviations in specific demands as well as high saving potentials.

The implementation of the defined potential energy saving initiatives is still in process.

Lessons learned

A huge improvement in the energy efficiency awareness of the responsible manager is one of the positive aspects of project implementation. It is necessary to hold a process that is attractive to both the technical and financial departments.

8. CONCLUSION

With the current rate of urbanization and the subsequent increase in energy demand, energy efficiency in buildings has a significant role to play in contributing to energy security in developing countries. With the increasing cost of complexity of new energy sources and the escalating cost of energy, governments should share the burden and cost of ensuring security of supply with end-users through energy efficiency.

Technological improvements in building design and appliances offer new opportunities for energy savings. Furthermore, many of these technologies are yet to be adapted to African environments and other developing countries suggesting a huge potential for savings. Resistance to change and the cost of implementing energy savings means that unless a policy and regulatory framework is set up, there is unlikely to be any change.

The lack of information on energy consumption trends in buildings and the opportunities and potential for energy savings is a significant barrier. These numbers are imperative to develop effective policies and set realistic and achievable targets.

Policy formulation should be consultative and involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers. An effective policy for energy efficiency in buildings should:

- Outline the need for and benefits of energy efficiency in buildings;
- Estimate potential savings both in terms of energy use and reduction of capacity;
- Set achievable targets and timelines;
- Outline an approach to achieve the targets and monitor them;
- Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;
- Consider the financial support instruments for undertaking energy efficiency measures.

An appropriate institutional framework is necessary to implement policy. These institutions would have the functions of developing and recommending a framework for the policy, facilitating and enforcing the policy, meting out penalties and hearing appeals against penalties. These institutions are set up by an act of parliament, through which their functions and powers are defined.

LEARNING RESOURCES

Key points covered

The module covers the following key points:

- The building sector is an important contributor to any country's total energy consumption. Globally, the building sector is responsible for more electricity usage than any other sector—42 per cent. While building sector energy consumption is generally greater in developed countries than in developing countries, it is still an issue (and a growing issue) for developing countries, particularly for those with restricted generating capacity.
- While the building sector is a major energy consumer, including residential, commercial and industrial buildings, very considerable energy savings are possible—with many being achievable at a relatively low cost.
- There are many different energy flows within any given building—into and out of the building. Methodologies are available to measure a building's energy performance.
- Energy efficiency measures for buildings are approaches through which the energy consumption of a building can be reduced while maintaining or improving the level of comfort in the building. They can typically be categorized into:
    - Reducing heating demand;
    - Reducing cooling demand;
    - Reducing energy requirements for ventilation;
    - Reducing energy used for lighting;
    - Reducing energy used for heating water;
    - Reducing electricity consumption of office equipment and appliances;
    - Good housekeeping and people solutions.
- To ensure effective implementation of energy efficiency in buildings involves the development and formulation of an energy efficiency policy and the enactment of a legal and institutional framework. To implement policy, certain bodies need to be set up to operationalize it. These would consist of an agency whose role is to develop and recommend a framework for the policy, a regulator to facilitate and enforce the policy, an adjudicating body to mete out penalties and an appellate tribunal to hear appeals against the orders of the adjudicating body. These bodies are set up by an act of parliament, through which their functions and powers are defined.
- There is a tendency in many businesses and public sector enterprises to undervalue cost reduction where this itself requires investment. This happens

when the organization fails to see the connection between the investment and the benefits derived from it. Conventional financial management information systems do not make visible the benefit the business derives from energy saving investments. However, as the different real-life experiences presented in the module and case studies show, energy efficiency in buildings can yield significant financial benefits. Financial appraisals need to be conducted (and in the right way) to demonstrate a project's potential to save energy and hence save money for the building's owner/operator.

Answers to review questions

Question: What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

Answer:

Energy efficiency benchmarks are representative values of energy consumption for common building types against which a building's actual performance can be compared.

To determine how efficient or inefficient a building is, its energy consumption is compared with the benchmark for a building of its type, use and performance in a similar climatic zone

Question: List and describe four mechanisms for financing energy efficiency in buildings

Answer:

1. Internal funds: Direct allocations from an organization's own internal capital or operating budget. All or some of the resulting savings may be used to decrease overall operating expenses in future years or retained within a revolving fund and used to support additional efficiency investments.
2. Debt financing: Capital borrowed directly by an organization from private lenders. As in the case of internal funding, savings from efficiency improvements, minus only the cost of financing, are retained internally.
3. Lease or lease-purchase agreements: Energy-efficient equipment is acquired through an operating or financing lease with no up-front costs. Leasing and lease-purchase agreements provide a means to reduce or avoid the high, up-front capital costs of new, energy-efficient equipment.
4. Energy performance contracts: Energy efficiency measures are financed, installed and maintained by a third party that guarantees savings and payments based on those savings. Energy performance contracts are generally financing or operating leases provided by an energy service company (ESCO) or equipment manufacturers. They provide a guarantee on energy savings from the installed retrofit measures, and they usually also offer a range of associated design, installation and maintenance services.

5. Utility incentives: Rebates, grants or other financial assistance offered by an energy utility for the design and purchase of certain energy-efficient systems and equipment usually as a result of implementation of a policy to promote energy efficiency.

Question: List five functions of the energy efficiency agency

Answer:

- Recommend the application and exemption i.e. which buildings based on application, size and/or energy consumption the policy will target or exempt.
- Develop a standard methodology for assessing the energy requirements of existing or proposed buildings and specify the manner and intervals of time in which energy audits shall be conducted.
- Develop energy efficiency benchmarks to gauge the level of energy efficiency of a building and to set energy efficiency targets/requirements for buildings.
- Develop certification and labelling criteria for buildings and appliances to prescribe guidelines for energy conservation building codes.
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy in buildings.
- Promote research and development in the field.
- Formulate and facilitate implementation of pilot projects and demonstration projects for promotion of efficient use of energy in buildings.
- Promote use of energy-efficient processes, equipment, devices and systems.
- Promote innovative financing of energy efficiency projects.
- Give financial assistance to institutions for promoting the efficient use of energy and its conservation.
- Levy fee, as may be determined by regulations, for services provided for promoting efficient use of energy in buildings.
- Specify, by regulations, qualifications for accredited building energy auditors.
- Register and maintain a list of accredited building energy auditors.
- Implement international cooperation programmes.
- Create awareness and disseminate information for efficient use of energy in buildings.

Presentation/suggested discussion topic

Presentation:

ENERGY EFFICIENCY – Module 18: Energy efficiency in buildings

Suggested discussion topic:

1. What incentives would you recommend to facilitate energy efficiency measures in buildings in your country and how would you implement them?

Relevant case studies

1. Sustainable energy authority in Australia.
2. Improving energy efficiency in Ekurhuleni Metropolitan Municipal (EMM) Buildings, South Africa.
3. Efficient lighting in Latvian Academy of Sport Education (LASE), Latvia.
4. Passive design in local government offices in Ireland

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www.diag.org.uk/documents.jsp

EU Energy Performance in Buildings - Directive Implementation Advisory Group: Methodologies in support of the Energy Performance of Buildings Directive: The UK approach to implementation for buildings other than dwellings.
www.diag.org.uk/documents.jsp

European Programme for Occupant Satisfaction, Productivity and Environmental Rating of Buildings 2004: Certification of Existing Building Energy Performance—The Energy Performance Label.
www.eplabel.org

Robert Cohen, Energy for Sustainable Development 2004: Display and Disclosure.
www.eplabel.org/Links/DandDArticleBSJ.pdf

Building Research Energy Conservation Support Unit for the Energy Efficiency Best Practice program Good Practice Guide 290 Ventilation and cooling option appraisal—a client's guide.

Department of Trade and Industry New and Renewable Energy Program: 2000. Extended Renewable Eergy Case Study: Channelling Light To Dark Places. www.leicester.gov.uk/housing/PDFs/DTI25.pdf

www.salixfinance.co.uk

INTERNET RESOURCES

www.carbontrust.co.uk

Carbon Trust is a government-funded company which helps UK business and the public sector cut carbon emissions. The Carbon Trust website was developed to demonstrate best practice and make businesses aware of the cost of carbon emissions and climate change.

The website houses a large online collection of free independent energy efficiency publications. Below are links to some useful publications.

> www.carbontrust.co.uk/publications/publicationdetail?productid=CTV007
>
> Maximizing energy savings in an office environment—an overview for office-based companies introducing the main energy saving opportunities for businesses and demonstrating how simple actions save energy, cut costs and increase productivity.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=ECG019
>
> Energy use in offices—a guide to raise awareness of the potential to improve the energy and environmental performance of offices and encourage positive management action. It outlines technical and management measures to help reduce energy consumption and costs and provide additional detail to assist diagnosis, analysis, technical and managerial improvements.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GIL124&metaNoCache=1
>
> Heating fact sheet—an introductory guide to heating systems and their components, simple energy saving tips covering heating systems and controls commonly found in commercial and industrial buildings.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GIL126&metaNoCache=1
>
> Lighting fact sheet—information on energy saving measures for lighting.
>
> www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=GPG290&metaNoCache=1
>
> Ventilation and cooling options appraisal—the focus of the guide is cooling and ventilation strategies that give value for money while ensuring good quality internal environments, simple systems which can be readily understood, managed and maintained and run in an energy-efficient manner.

www.greenhouse.gov.au/yourhome/technical/fs00.htm

Australia's guide to environmentally sustainable homes—a technical manual showing how to design and build comfortable homes that have less impact on the environment.

www.energy.ca.gov/title24/2005standards/index.html

2005 Building Energy Efficiency Standards for California—manual designed to help owners, designers, builders, inspectors, examiners and energy consultants comply with and enforce California's energy efficiency standards for residential and non-residential buildings. The manual is written as both a reference and an instructional guide.

www.cibse.org/pdfs/GPG075.pdf

Financial aspects of energy management in buildings—a guide outlining the key steps in the financial appraisal of energy efficiency investment in buildings.

www.diag.org.uk/pdf/CIBSE_Briefing.pdf

The Energy Performance of Buildings Directive—a summary of the objectives and contents of Directive 2002/91/EC of the European Parliament and Council, on the energy performance of buildings. It came into force on 4 January 2003 to increase awareness of energy use in buildings, and will lead to substantial increases in investments in energy efficiency measures within domestic and non-domestic buildings.

The complete directive is available at: www.diag.org.uk/pdf/EPD_Final.pdf

www.keralaenergy.gov.in/ecact/ecact_main.htm

India's Energy Conservation Act of 2001—the Act provides for efficient use of energy and its conservation. It establishes and incorporates a Bureau of Energy Efficiency, gives power to the Central Government to enforce efficient use of energy and power of State Government to enforce certain provisions for efficient use of energy and its conservation, establishes a State Energy Conservation Fund for the purposes of promotion of efficient use of energy and its conservation within the State and gives authority to the designated agency to appoint inspecting officers for the purpose of ensuring compliance with energy consumption standards specified.

www.doe.gov.ph/downloads/default.htm

Philippines guidelines for energy conserving design of buildings and utility systems

www.mi.government.bg/eng/norm/rdocs/mdoc.html?id=190688

Bulgaria's Energy Efficiency Act

www.seea.government.bg/index_en.php?mid_val=39

Policy documents for energy efficiency in buildings from Bulgaria's Energy Efficiency Agency

GLOSSARY/DEFINITION OF KEY CONCEPTS

Blinds	A blind is a covering for a window, usually attached to the interior side of a window. Exterior blinds (for the outer side of the window) and mid pane blinds (located in the cavity of the double glazing), are also available. Blinds hide from sight an external view from the window or reduce sunlight. Blinds have varying thermal effects: they can block unwanted heat in summer and keep heat inside during cold weather. But in both these applications, they also reduce light to varying degrees, depending on the design. Many kinds of blinds attempt varying balances of blinding external views and allowing sunlight.
Caulking	Refers to the activity of closing up joints and gaps in buildings. The function of caulking is to provide thermal insulation and noise mitigation. This is mostly done with ready-mix construction chemicals sold as caulk.
Climate change levy	This is a tax on energy levied on users in the United Kingdom. Its aim is to provide an incentive to increase energy efficiency and to reduce carbon emissions. The levy applies to most energy users, with the notable exceptions of those in the domestic and transport sectors. Electricity generated from new renewables and approved cogeneration schemes is not taxed. From when it was introduced, the levy was frozen at 0.43p/kWh on electricity, 0.15p/kWh on coal and 0.15p/kWh on gas. A reduced levy applies to energy-intensive users provided they sign a climate change agreement. Revenue from the levy was offset by a 0.3 per cent employers' rate reduction in National Insurance. However, the 2002 Finance Act subsequently increased that rate by 1 per cent, reversing the reduction. Part of the revenue is used to fund a number of energy efficiency initiatives, including the Carbon Trust.
Condensing boilers	A condensing boiler one that achieves enhanced efficiency by incorporating an additional heat exchanger that uses the heat in the exhaust gases from the boiler to preheat water as it enters the boiler, and so recapturing energy that would otherwise be lost. When a condensing boiler is working at peak efficiency the water vapour produced by the consumption of gas or oil in the boiler condenses back into liquid water. The condensation of exhaust gases releases the latent heat of vaporization of the water, a more significant source of energy than the transfer of heat by cooling the vapour. The design has its greatest advantages with gas-fired boilers, because less water

	is produced in burning oil or solid fuel, but it is still practicable with oil.
Floor area	The floor area of buildings is the sum of the area of each floor of the building measured to the outer surface of the outer walls including the area of lobbies, cellars, elevator shafts and in multi-dwelling buildings all the common spaces. Areas of balconies are excluded.
Glazing	Glazing is a transparent part of a wall, usually made of glass or plastic. Common types of glazing used in architectural applications include clear and tinted float glass, tempered glass and laminated glass, as well as a variety of coated glasses, all of which can be single, double or even triple-glazed units.
Hydroboils	The hydroboil is an instant boiling water heater. It is up to three times more energy efficient than the traditional electric kettle (urn) and just as efficient as a well-managed kettle. It uses less power on stand-by than a 60-watt light bulb and when connected to the cold water and power supply, boiling water is continuously available, around the clock, at a touch of the tap. It is available in models delivering from 12 to 300 cups of boiling water at one time. The hydroboil fully contains all the steam within the system, condensing it, thus preheating the incoming cold water.
Indoor climate	The indoor climate is a term that summarizes the thermal environment, the air quality and the acoustic and light environment of a building. Indoor climate regulations and guidelines are usually part of the building code.
Passive cooling	Passive cooling refers to technologies or design features used to cool houses naturally. In building design, the two principles of passive cooling are: *(a)* to prevent heat from entering a building in the first place; in domestic buildings this usually means shading from the sun and *(b)* to purge unwanted heat from a building, usually by natural ventilation.
Passive solar heating	Passive solar heating makes use of the building components to collect, store and distribute solar heat gains to reduce the demand for space heating. It does not require the use of mechanical equipment because the heat flow is by natural means (radiation, convection and conductance) and the thermal storage is in the structure itself.
Retrofit	The modification of a building to incorporate new functions not included in the original building design.

Skylight	A flat or sloped window built into a roof structure for day lighting
Solar gains	Solar gain refers to the increase in temperature in a space, object or structure that results from solar radiation. The amount of solar gain increases with the strength of the sun, and with the ability of any intervening material to transmit or resist the radiation.
Useful floor area	This is the total area of all enclosed spaces measured to the inside face of the external walls, including sloping surfaces such as staircases but excluding areas that are not enclosed such as open floors, covered ways and balconies.
Vapour retarder	Is any material, usually a plastic or foil sheet, that resists the passage of both air and moisture through walls, ceilings and floors. It helps prevent interior moisture from penetrating into and condensing in unheated attics, basements, crawlspaces and wall cavities. This is especially important in well-insulated homes, where there is often a great difference in temperature between the air in conditioned space and the air in unconditioned space. The vapour barrier is placed in between the insulation and the conditioned space.

Case study 1.

SUSTAINABLE ENERGY AUTHORITY IN AUSTRALIA

CONTENTS

1. BACKGROUND

In order to implement a greenhouse gas reduction strategy, the Government of Victoria has developed the Sustainable Energy Authority, an agency established to promote energy efficiency and support and facilitate the development and use of renewable energy. Its aim is to achieve environmental and economic benefits for the Victorian community. These initiatives will also act as a significant stimulus for the development of a sustainable energy industry.

The Sustainable Energy Authority of Victoria (SEAV) has established six Energy Smart Advisory Centers that provide a range of information products to assist all sectors of the community to select energy smart appliances; design and construct energy smart buildings; reduce energy costs through energy saving practices; and utilize renewable energy. They also distribute independent advice and information, media campaigns, seminars and targeted promotions.

SEAV has introduced a range of "Energy Smart" programmes:

- Energy Smart Appliances (Reach for the Stars programme);
- Energy Smart Housing;
- Energy Smart Business;
- Energy Smart Government;
- Renewable energy.

2. ENERGY SMART APPLIANCES

The Reach for the Stars programme is a joint Commonwealth and state government initiative to increase the purchase of energy-efficient, energy smart appliances, which reduce energy bills and help the environment. In October 2000, the Australian Government introduced the Energy Label for Appliances initiative. It rates appliances on a scale of five stars, the more stars the appliance has, the more environmentally friendly it is.

3. ENERGY SMART HOUSING

The Energy Smart Housing programme aims to facilitate house energy ratings as the energy efficiency benchmark for housing and the introduction of energy performance standards. Activities include development of the First Rate house energy rating software, provision of user training and accreditation of third party rating providers. It includes Energy Smart Builders and Energy Smart Commercial Buildings, which use Building Greenhouse Rating scheme.

4. ENERGY SMART BUSINESS

The Energy Smart Business programme helps small, medium and large enterprises to adopt and integrate sustainable energy solutions by providing expert technical advice, best practice information, free seminars, networking opportunities and case studies.

5. ENERGY SMART GOVERNMENT

The Energy Smart Government programme provides support services to government departments and agencies to undertake energy management programmes. It includes Energy Smart Local Government, Energy Smart Schools, Travel to Work programmes. The Energy Smart Local Government programme is helping Victorian municipalities to reduce energy consumption, recurrent energy costs and greenhouse gas emissions within their own operations. It builds upon the results of earlier benchmarking studies and provides services to develop energy management activities. The Energy Smart Schools programme establishes partnerships with both state and private schools to introduce improved energy management in the operation of school facilities. Travel for Work is a programme designed to help businesses help themselves reduce the costs and environmental impacts of work-related travel. It also improves employee health through promoting walking and cycling.

6. ENERGY SMART LOCAL GOVERNMENT

SEAV provides lot of help to local authorities to develop sound energy management and to achieve reductions in recurrent energy costs. Firstly it provides help in developing an energy management programme. The only effective way to manage energy consumption and costs is by assigning responsibility to an internal "energy manager". The size and structure of the energy management team depends on the nature of the local government. SEAV gives advice on appropriate team structure. SEAV also helps with creation of the energy management programme especially in defining aims, specific targets, priorities, time frames, responsibilities and budget allocation of resources.

SEAV also provides a series of workshops called the Municipal Energy Management Support Programme to train municipal staff. It was designed to help local governments gain an understanding of basic energy management principles. They also developed an easy to use Municipal Energy Management Tool, a software package to assist councils track and report their energy consumption and greenhouse performance. The software is capable of delivering comparisons with other councils because it contains benchmarking data.

Case study 2.

IMPROVING ENERGY EFFICIENCY IN EKURHULENI METROPOLITAN MUNICPAL (EMM) BUILDINGS, SOUTH AFRICA

CONTENTS

1. BACKGROUND

The project of improving energy efficiency in EMM buildings started in June 2005 with the call on all suitably-qualified entities to submit quotations to carry out all the necessary work to achieve the set objective of saving energy and reducing GHG emissions.

The first proposal included the supply, delivery and installation of solar water heaters, compressors and 10 KW solar photovoltaic panels. A preliminary analysis of a building's infrastructure, design and plumbing systems determined that the installation of solar energy would add more complexity and time to the work. The retrofitting project was to be completed before the end of the municipal financial year.

The second proposal was the use of different mechanisms to reduce energy consumption in lighting and heating/boiling water. The mechanisms included the replacement of conventional incandescent lights with compact fluorescent light bulbs (CFLs), the replacement of cool-beam down lighters with light-emitting diodes (LED) lights, the replacement of urns and kettles with hydroboils, and the installation of geyser and lighting timers. These measures were determined to be more cost effective and could be implemented within the set time frames and allow significant reductions.

The CFLs are very efficient and inexpensive over their lifetime with high return on savings after the initial investment. They have been designed to screw into standard light sockets, which allow them to be used very easily instead of incandescent light. LEDs are small, solid light bulbs, which are extremely energy-efficient. The zip hydroboil is a wall mounted, instant-boiling water heater, which means that boiling water is available instantly. It cuts down on water bills, as there is no evaporation due to escaping steam. It also saves electricity/energy because it consumes less compared to urns and all the water that is boiled is used. Geyser timers regulate when the water can be heated by connecting electricity to the geyser at specified times. This saves energy because water is not heated throughout the day.

Summary of equipment:

- 23 zip hydroboils;
- 2,003 CFLs;
- 90 LED lights;
- Two lighting timers;
- 15 geyser timers;

- Replacement of 96, eight-foot double fluorescent light fittings with open channel, five-foot double fluorescent lights with electronic ballasts.

2. COSTS AND IMPLEMENTATION

The work started in December 2005. The total cost of the project, including labour and equipment, was R249,120 ($US 41,063). ICLEI (Local Governments for Sustainability) secured a grant totaling R242,761 ($US 40,000) from the United States Agency for International Development (USAID) to fund this project. The unit price of equipment as quoted by the service providers is shown in the following section.

3. RESULTS

A small-scale retrofit project, such as the EMM's buildings project, results in 328,988 kWh of energy saved in one year, representing economic savings in the order of $US 50,664 per year (using the value of $US 0.157/kWh for Ekurhuleni Municipal Buildings). A simple payback period, taking into account the total investment, will be 0.8 years.

Table 1. Equipment costs per unit

Equipment	Cost in South Africa Rand (ZAR)	Cost in $US*
Hydroboils	4,775.00	786.64
75 W (low wattage) CFLs	15.00	2.47
LED lamps	15.00	2.47
Lights timer	450.00	74.21
Geyser timer	450.00	74.21
5-foot double fluorescent lights	104.50	17.23

*The exchange rate used is for 02/02/2006: $US 1 = 6.06375 ZAR.

Table 2. Results on energy savings

Equipment	Pre retrofit energy use (kWh/year)	Post retrofit energy use (kWh/year)	Energy savings (kWh/year)	Percentage of savings
Lighting (CFLs and LEDs)	366,694	91,673	275,020	75
Lighting (5-foot double fluorescent lights with electronic ballast)	21,024	18,221	2,803	13
Water heating (Ums replaced with zip hydroboil)	214,072	171,256	42,814	20
Geyser timer	20,878	12,527	8,351	40
TOTAL	622,668	293,679	328,988	53

4. KEY REPLICATION ASPECTS

The creation of the policy on Energy Efficiency in Council Buildings and on Council Premises, the State of Energy Report, draft Energy Efficiency Strategy of Ekurhuleni, and the subsequently implemented retrofitting project are all part of an easily-replicable strategy that can be used in other South African cities interested in reducing energy costs and minimizing the negative environmental impacts of their municipal operations.

Case study 3.

EFFICIENT LIGHTING IN THE LATVIAN ACADEMY OF SPORT EDUCATION (LASE), LATVIA

CONTENTS

1. BACKGROUND

The project was carried out in the framework of the Efficient Lighting Initiative (ELI) programme, implemented in Latvia between 2000 and 2003 and was designed to accelerate the penetration of energy-efficient lighting technologies and to develop and encourage the use of energy service companies (ESCOs). An energy audit in LASE was carried out in October 2001 in order to estimate and evaluate the possibilities for lighting system improvement in one of the sport halls on the campus.

The existing lighting system in this sport hall consisted of 33 spotlights mainly mounting 1000 W halogen bulbs and an additional six light points using high-pressure bulbs with capacity of 750 W each. In the balcony of the sport hall there were 10 separate luminaries, each with 500 W incandescent bulbs. The lighting system was used seven months a year for 12-15 hours a day—a total of 4100 hours per year.

2. THE ENERGY AUDIT

The energy audit pointed out several problems, of which the main were:

- Eight per cent of the luminaries were not in working condition;
- Lighting quality did not correspond to existing local and European quality standards;
- The existing control system did not contribute to efficient use of the lighting system;
- There was no evacuation lighting;
- The shock protection bars over the luminaries reduced the quality of light;
- Low cleaning and maintenance of the system, causing dust settlement reducing the quality of light;
- Some of the bulbs were replaced with inappropriate bulbs causing bad interconnection and as result some of the wires were burned;
- The yearly electricity consumption in the sport hall was 173,120 kWh/year representing costs of €8,900/year;
- Total installed capacity of the lighting system was 42.5 kW.

3. FINANCING

Based on the results of the energy audit, which showed project feasibility and profitability, the administration of LASE agreed to refurbish the lighting system and announced a call for tender addressed to energy service companies. LASE was convinced to have an ESCO mainly for three reasons: the possibility to attract third-party financing, the possibility to have the operation and maintenance of the system included in the contract, and in particular the idea of a guarantee on energy savings.

The project was fully financed through the ESCO. Total project costs were €28,500. The ESCO has taken a loan of €14,250 from a Latvian commercial bank and the rest was covered from its own resources.

4. IMPLEMENTATION

The ESCO has replaced lamp units in the academy sport hall. The new units have a greater optical efficiency and the new casings have a much longer lifespan than their predecessors. They are vibration resistant and keep out dirt. They are also easier to service, which means lower maintenance costs. Lighting design and computer simulations work has been done to calculate the right number and wattage of the units and to make sure that new units are positioned correctly in terms of their positions and angle. In particular the project included the following parts:

- Replacement of old light points with 66 new luminaries with 250 W capacity for a total capacity of 16.5 kW;
- Automatic lighting control system;
- Electricity consumption control meter with possibility to read the data on PC from the technical department of LASE;
- Eight motion sensors and one outside lighting sensor;
- Emergency exit lighting;
- Electrical wires have also been changed, which will ensure the system runs smoothly for years to come.

5. RESULTS

The project has achieved its main objective, which was to reduce energy consumption and stop the physical degradation of the lighting system in the sport hall. By using better technology, the network's energy use has been cut by 83,720 kWh per year. The system now has a much better control system—including the possibility of having different light levels in the hall in function of different applications and sports played. The project can be judged a success and also the objective of using third-party financing was achieved, in spite of the difficulty in involving ESCOs in small-scale projects.

The table below shows a comparison of the situation before and after project implementation.

Table 1. Comparison of old and new lighting system in LASE

	Old system	New system
Operating time	4,064 hours/year	4,064 hours/year
Installed capacity	42.5 kW	16.5 kW
Electricity consumption	173,120 kWh/year	89,400 kWh/year
Energy savings		83,720 kWh/year

Case study 4.

PASSIVE DESIGN IN LOCAL GOVERNMENT OFFICES OF IRELAND

CONTENTS

1. SUMMARY

The design of Fingal County Hall, completed in 2000, incorporates passive design principles including daylighting, passive heating, passive cooling and natural ventilation as well as ground source heat pump technology. A building of this type would generally rely on mechanical ventilation and air conditioning but by using passive techniques the need for mechanical ventilation and air conditioning has been minimized. The capital costs of such services were reduced from the typical figure of 30 per cent of total building cost to 17 per cent. In addition, operational costs (lighting, heating and air conditioning) have been reduced.

The design of the building was taken from the winning entry in a competition held amongst interested architects and so even before construction the process of promoting sustainable design had begun.

This is an example of an initiative where a local authority, as building owner and occupier, has lead by example to promote and develop passive design in local architectural practices and reduce energy consumption in its own buildings.

The local authority has also benefited from the public relations which tend to follow these projects and the work of environmental officers has been made easier by sustainability issues having been placed more visibly within the authority's agenda.

2. THE SCHEME

Fingal County Council, as a new local authority anxious to assert a clean green image, decided from the outset in 1995 to put sustainable design into practice in its own new headquarters in Swords, Co. Dublin, Ireland. As an owner-occupier, Fingal County Council was interested in both the initial cost of the building and its operating costs. Completed in 2000, the design of the building and its services employ passive design principles and ground source heat pump technology.

3. TECHNOLOGY

Incorporating passive design into a building can improve energy performance in three areas: lighting, cooling and building heating.

“Day lighting” involves the use of devices and techniques to capture and direct light into the building, whilst avoiding glare. As electric lighting in a typical office building can account for up to 20 per cent of total energy usage, the use of daylight should be carefully considered. A combination of orientation, shallow building plan, light shelves, the curved profile of the exposed ceiling slab and recessed roof lights serve to reflect day light into the building. The office bars maximize south-facing natural daylight.

Passive cooling involves the use of shading devices, natural ventilation and thermal mass. The shallow plan design lends itself to a natural ventilation strategy and façade elements provide the means for its implementation. Both the stairwell at the end of each office bar and the atrium contain ventilation louvres at the upper level to provide stack-effect ventilation. The thermal mass of the exposed concrete ceiling slab is cooled by night ventilation during the summer and absorbs heat from the room throughout the day. Nighttime pre-cooling of the building is controlled in office areas by motorized office windows and the stairwell stack dampers.

Passive heating involves the collection, retention, storage and distribution of heat, and also avoids overheating. While the south-facing orientation of the office sections will provide a degree of solar gain from low winter sunshine, the thermal mass of the exposed concrete slab absorbs peak afternoon casual gains (heat from people, lighting and office equipment) and retains the heat so reducing the following morning’s pre-heat.

A heat pump is an environmental energy technology that extracts heat from low temperature sources (ground, water, air), upgrades it to a higher temperature and releases it where it is required for space or water heating. A ground source heat pump delivers heat to the atrium’s under-floor heating system. For its heat source, water is drawn from a borehole drilled to a depth of 160 m below ground level.

There are no light switches within the office areas. The lighting above each desk group is controlled by occupants using their telephone. Mechanical ventilation was deemed necessary for the toilet areas, the canteen and lower ground floor. The latter includes a heat recovery system. The council chamber is the only area requiring mechanical cooling. To reduce the energy used, a displacement ventilation system has been installed to take advantage of free cooling when available. Heating is provided by high-efficiency gas-fired condensing boilers with thermostatic radiator valves for local occupant control.

4. PROJECT TEAM

Fingal County Council, as owner occupier of their new building, lead the project with an holistic view of costs since it had an interest in both the initial cost of the building as well as its operating costs.

The project team needed for the construction of a passively designed building does not differ dramatically from that of a conventional building apart from an interest in life-cycle costs on the part of the owner and architects/engineers who are aware of passive design principles. Both these essential factors were present in this project, with the right architects being located through the innovative means of using a design competition.

5. FINANCING

By using passive techniques, the costs of mechanical ventilation and air conditioning services were reduced from the typical figure of 30 per cent of total building cost to 17 per cent. In addition, operational costs have been reduced. Estimates from the UK DETR suggest that a naturally ventilated building consumes 50 per cent of the energy of an air-conditioned building.

The cost of constructing a passively designed building of this sort need not be more than for a conventional construction. Any additional costs associated with the passive design may be offset by the reduced costs of mechanical services. Lower operational costs are another important factor where the building owner and occupier are the same organization.

6. LOCAL CONDITIONS FOR RENEWABLE ENERGY

Ireland has a relatively low penetration of renewable energy technologies. However, driven by national policy, government buildings are increasingly designed with environmental issues and the minimization of energy requirements in mind.

The real driving force behind this initiative was the desire on the part of Fingal County Council to make a fresh start in a new building and help develop a green image.

Ireland has a relatively mild, temperate climate with large amounts of diffuse sunlight year-round, making it well suited to the use of passive design principles.

7. OVERCOMING BARRIERS

The primary barrier to the increased use of passive design is lack of awareness and experience which means that it is rarely part of a design brief. There is also a reluctance to make investments in unfamiliar technologies.

The fragmented nature of the construction industry also inhibits their use. The client often knows little about building design and may not intend to own the building after its construction. The financial benefits of sustainable design generally accrue to the occupant in terms of lower operating costs, but it is rarely the client who commissions the building.

The financial cost and commercial value of employing passive design is difficult to accurately quantify at design stage and is rarely quantified by post-occupancy evaluation of building performance. Consequently, there is a lack of hard data to promote the widespread application of sustainable design.

These barriers were overcome because the client was a local authority so that:

- The client team included architects and engineers who were aware of passive solar design principles;
- The client was also the owner and occupier of the building and was, therefore, interested in the total life-cycle costs of the building;
- Government strategy was implemented which seeks to promote sustainable design, including leading by example.

By placing sustainable design as a central part of the original design brief, the local authority drove the sustainable design agenda. By using an architectural competition as the means of selecting the architects, the local authority was able to select architects with experience and interest in this area.

8. RESULTS AND IMPACTS

Mechanical ventilation and air conditioning tend to be electrically-driven and operational throughout the building's occupied life, which makes them both expensive to operate and, depending on the combined efficiency of national power generation plant, a significant source of greenhouse gas emissions. Removing them from the building design and replacing them with passive designs will have a significant impact over the life of the building. For instance, it is estimated that air-conditioned office buildings consume approximately 250 kWh/m^2 per annum, while naturally ventilated office buildings consume 120 kWh/m^2 per annum. Similarly, with day lighting reducing the need for artificial lighting, the life-cycle impact will be substantial.

Occupants' response to their environment is influenced by the quality of the environment, the perceived level of individual control, the quality of the management of services and response to complaints, and the desire to be close to a window. Buildings that make good use of natural light and ventilation, in which occupants have the opportunity to make local adjustments, often prove to be more acceptable work environments. This building provides occupants with local control of lighting, heating and natural ventilation, and also satisfies the desire to be close to a window.

9. REPLICATION

This building illustrates that comfortable conditions can be achieved within high density, heavily glazed office spaces in the Irish climate without recourse to mechanical ventilation or air conditioning. The well-publicized energy-saving features of the building have served to raise awareness amongst building designers and procurers. The local authority planners who occupy the building are intimately familiar with the features and their effectiveness and are in a position to influence the design of other buildings.[1]

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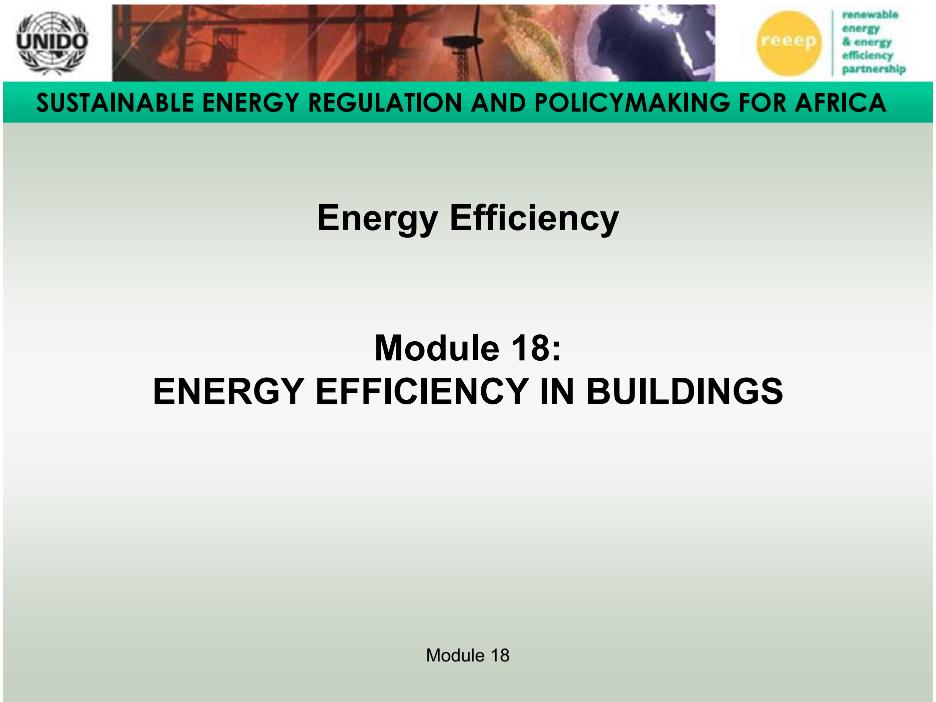
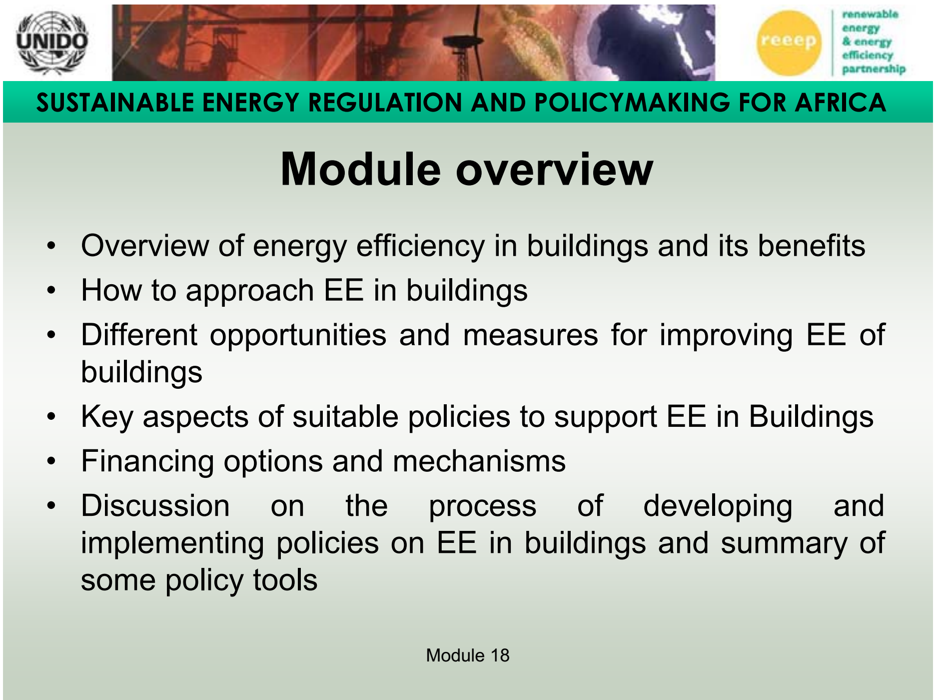
[1] For further information contact: Stephen Dunn, (Stephen.Dunne@fingalcoco.ie), Building Services Manager, Fingal County Hall, Main Street, Swords, Fingal, Co. Dublin, Republic of Ireland, +353 1 890 5000 or Chris Croly (CM-Croly@bdp.ie), Building Design Partnership (BDP), Blackhall Green, Dublin 7, Republic of Ireland, +353 1 474 0600.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy Efficiency

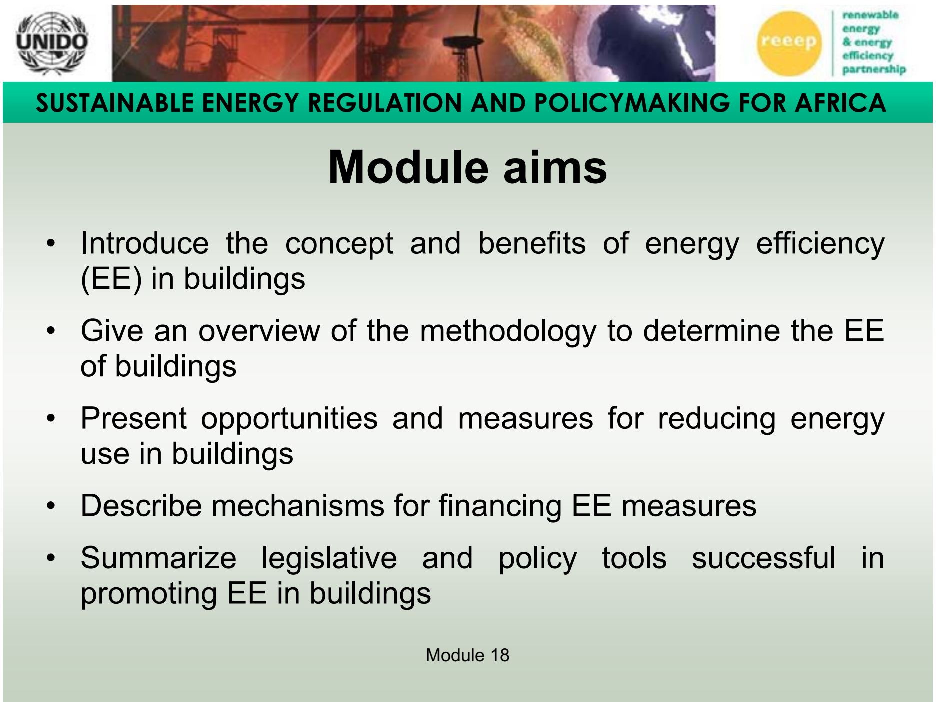
Module 18:
ENERGY EFFICIENCY IN BUILDINGS



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Overview of energy efficiency in buildings and its benefits
- How to approach EE in buildings
- Different opportunities and measures for improving EE of buildings
- Key aspects of suitable policies to support EE in Buildings
- Financing options and mechanisms
- Discussion on the process of developing and implementing policies on EE in buildings and summary of some policy tools

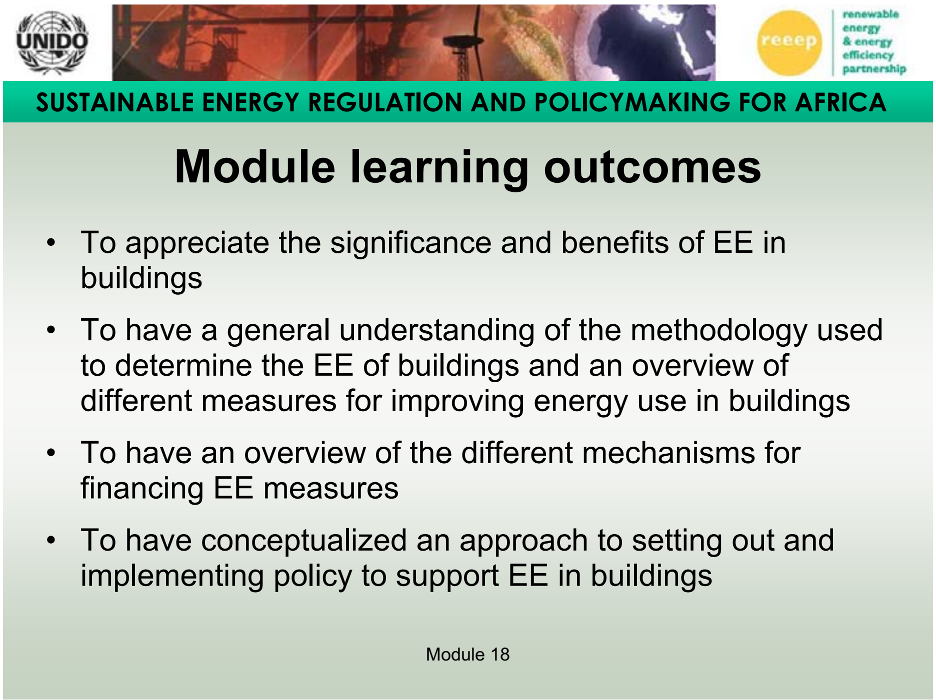


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

- Introduce the concept and benefits of energy efficiency (EE) in buildings
- Give an overview of the methodology to determine the EE of buildings
- Present opportunities and measures for reducing energy use in buildings
- Describe mechanisms for financing EE measures
- Summarize legislative and policy tools successful in promoting EE in buildings

Module 18

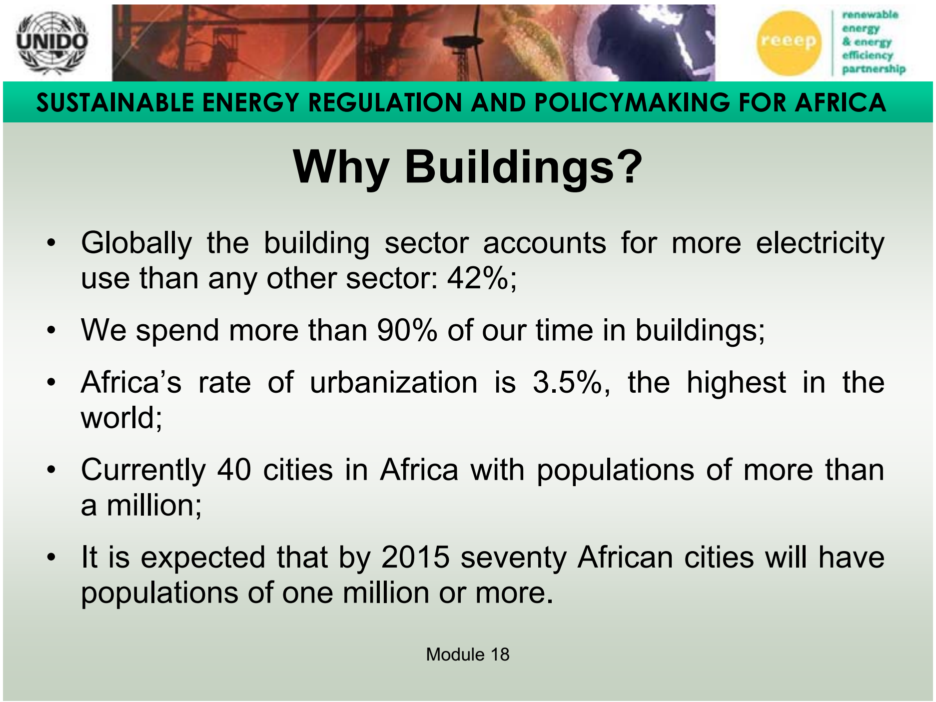


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

- To appreciate the significance and benefits of EE in buildings
- To have a general understanding of the methodology used to determine the EE of buildings and an overview of different measures for improving energy use in buildings
- To have an overview of the different mechanisms for financing EE measures
- To have conceptualized an approach to setting out and implementing policy to support EE in buildings

Module 18

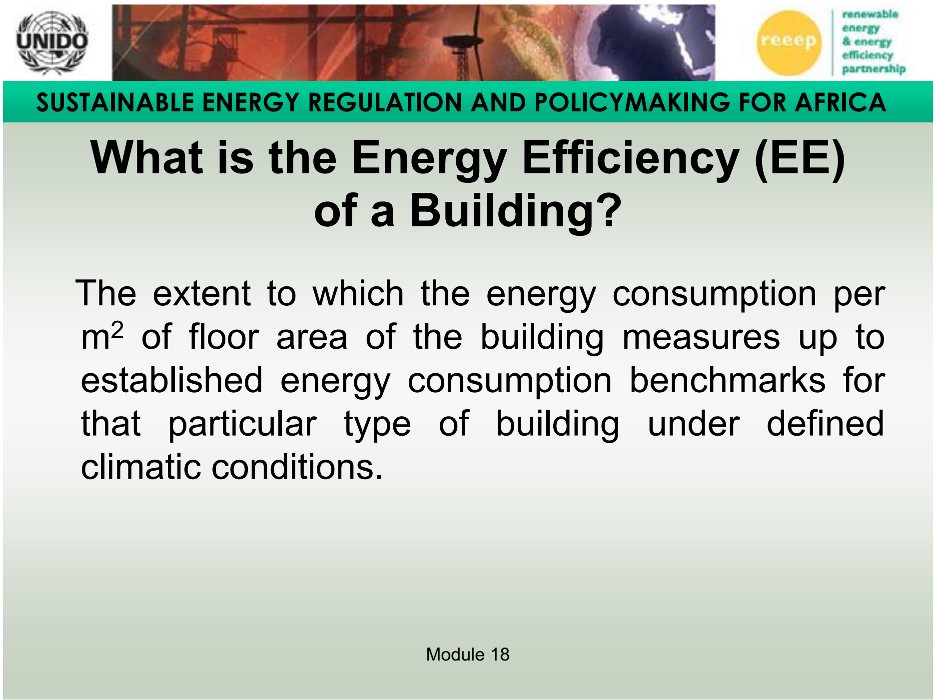


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why Buildings?

- Globally the building sector accounts for more electricity use than any other sector: 42%;
- We spend more than 90% of our time in buildings;
- Africa’s rate of urbanization is 3.5%, the highest in the world;
- Currently 40 cities in Africa with populations of more than a million;
- It is expected that by 2015 seventy African cities will have populations of one million or more.

Module 18

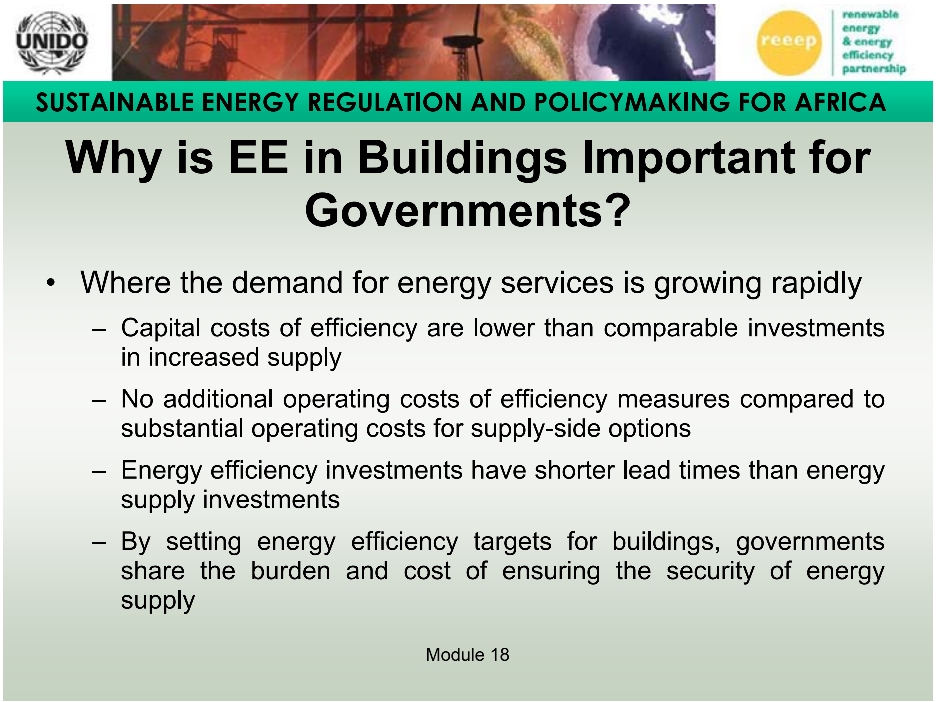


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

What is the Energy Efficiency (EE) of a Building?

The extent to which the energy consumption per m^2 of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions.

Module 18

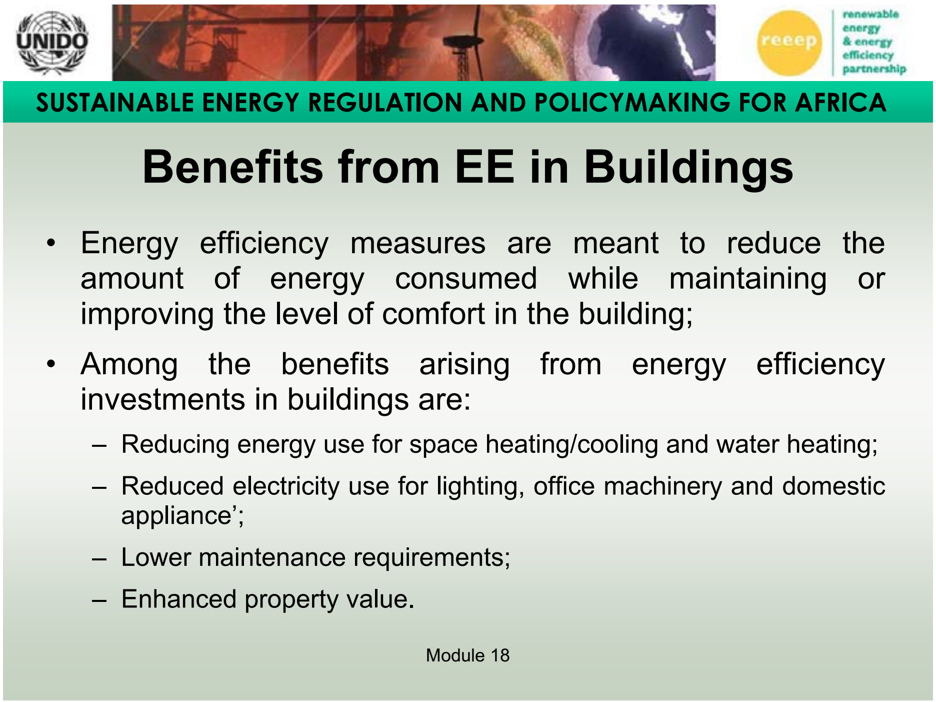


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Why is EE in Buildings Important for Governments?

- Where the demand for energy services is growing rapidly
  - Capital costs of efficiency are lower than comparable investments in increased supply
  - No additional operating costs of efficiency measures compared to substantial operating costs for supply-side options
  - Energy efficiency investments have shorter lead times than energy supply investments
  - By setting energy efficiency targets for buildings, governments share the burden and cost of ensuring the security of energy supply

Module 18

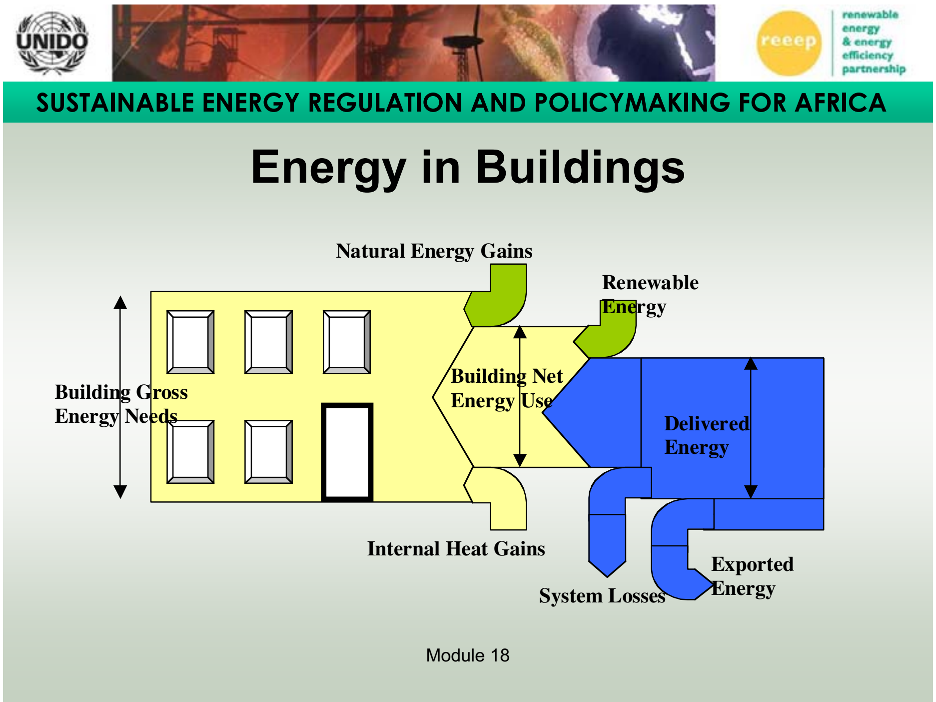


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Benefits from EE in Buildings

- Energy efficiency measures are meant to reduce the amount of energy consumed while maintaining or improving the level of comfort in the building;
- Among the benefits arising from energy efficiency investments in buildings are:
  - Reducing energy use for space heating/cooling and water heating;
  - Reduced electricity use for lighting, office machinery and domestic appliance';
  - Lower maintenance requirements;
  - Enhanced property value.

Module 18



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings

Natural Energy Gains

Renewable Energy

Building Gross Energy Needs

Building Net Energy Use

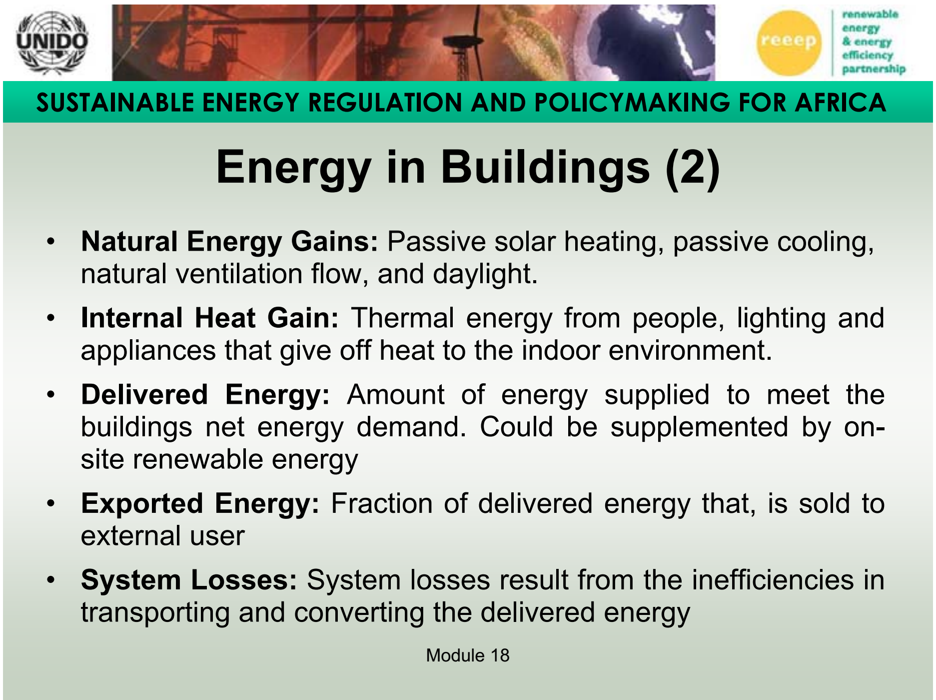
Delivered Energy

Internal Heat Gains

System Losses

Exported Energy

Module 18

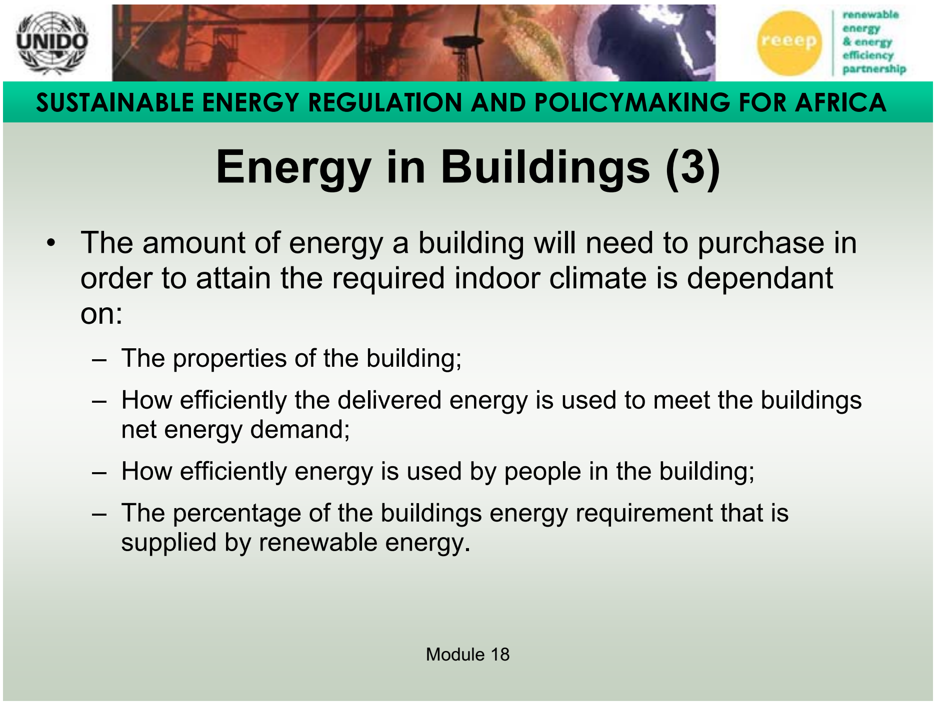


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings (2)

- **Natural Energy Gains:** Passive solar heating, passive cooling, natural ventilation flow, and daylight.
- **Internal Heat Gain:** Thermal energy from people, lighting and appliances that give off heat to the indoor environment.
- **Delivered Energy:** Amount of energy supplied to meet the buildings net energy demand. Could be supplemented by on-site renewable energy
- **Exported Energy:** Fraction of delivered energy that, is sold to external user
- **System Losses:** System losses result from the inefficiencies in transporting and converting the delivered energy

Module 18

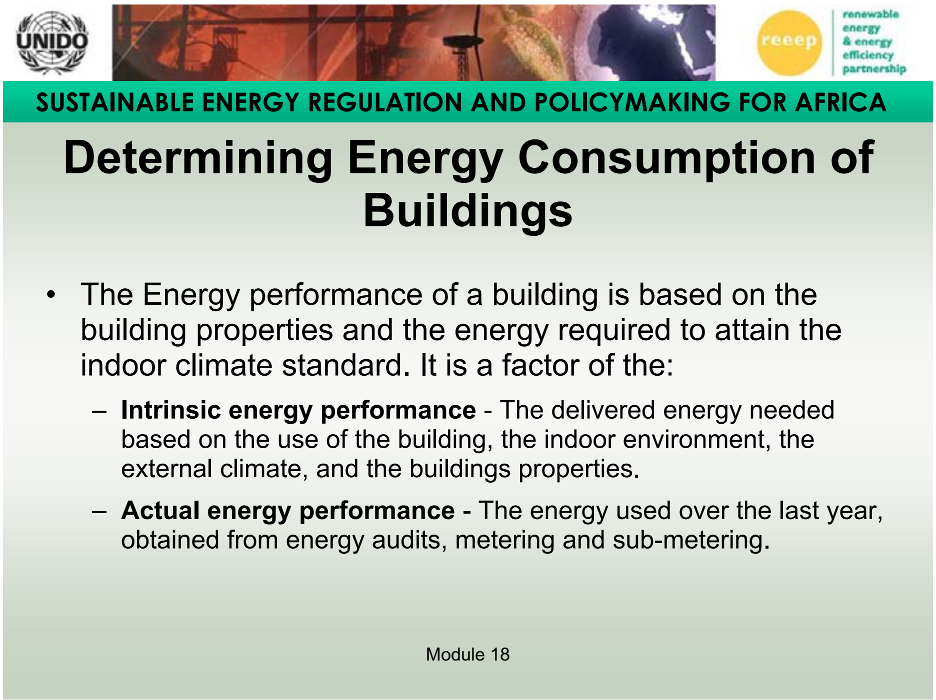


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Energy in Buildings (3)

- The amount of energy a building will need to purchase in order to attain the required indoor climate is dependant on:
  - The properties of the building;
  - How efficiently the delivered energy is used to meet the buildings net energy demand;
  - How efficiently energy is used by people in the building;
  - The percentage of the buildings energy requirement that is supplied by renewable energy.

Module 18

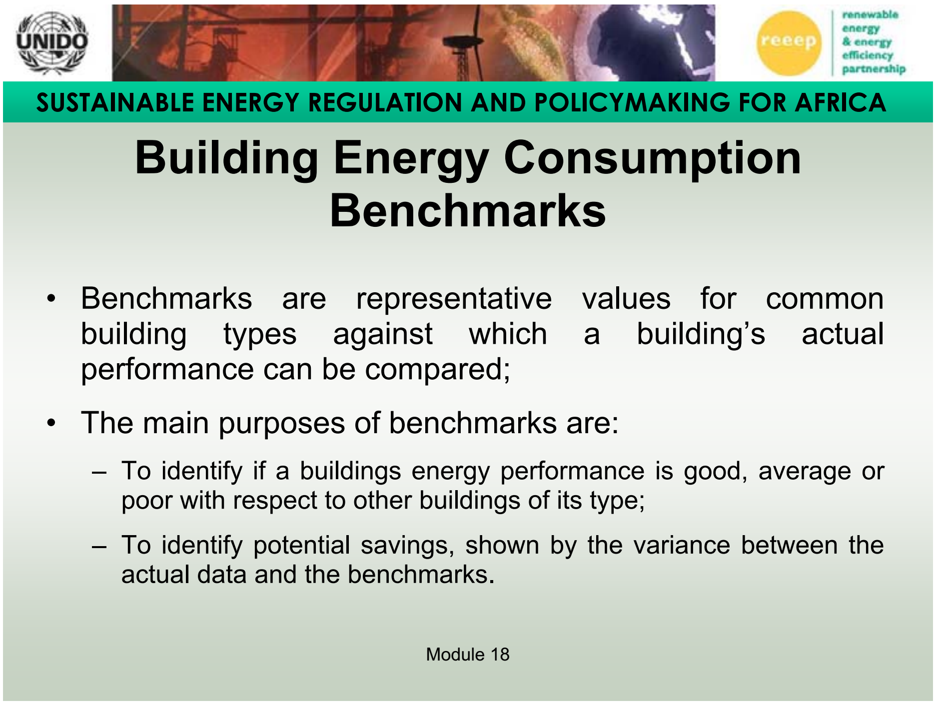


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Determining Energy Consumption of Buildings

- The Energy performance of a building is based on the building properties and the energy required to attain the indoor climate standard. It is a factor of the:
  - **Intrinsic energy performance** - The delivered energy needed based on the use of the building, the indoor environment, the external climate, and the buildings properties.
  - **Actual energy performance** - The energy used over the last year, obtained from energy audits, metering and sub-metering.

Module 18

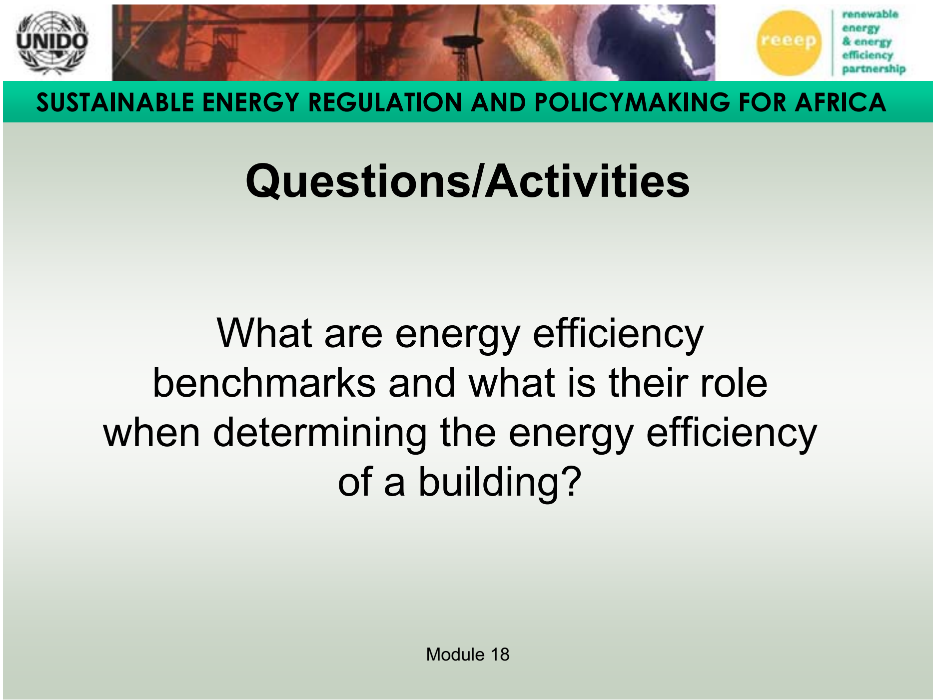


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Building Energy Consumption Benchmarks

- Benchmarks are representative values for common building types against which a building’s actual performance can be compared;
- The main purposes of benchmarks are:
  - To identify if a buildings energy performance is good, average or poor with respect to other buildings of its type;
  - To identify potential savings, shown by the variance between the actual data and the benchmarks.

Module 18

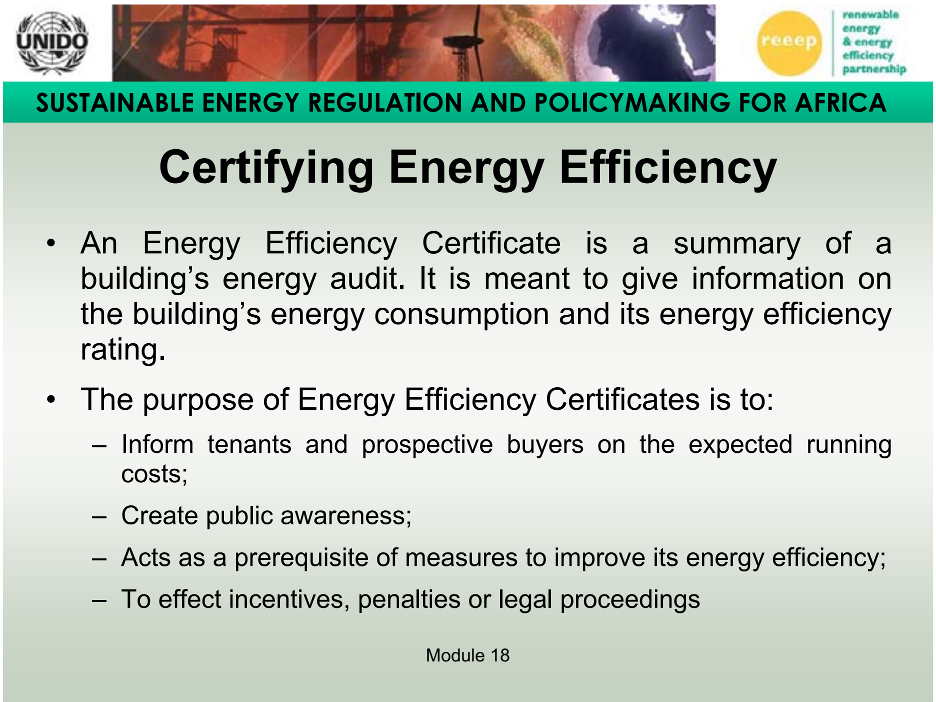


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

What are energy efficiency benchmarks and what is their role when determining the energy efficiency of a building?

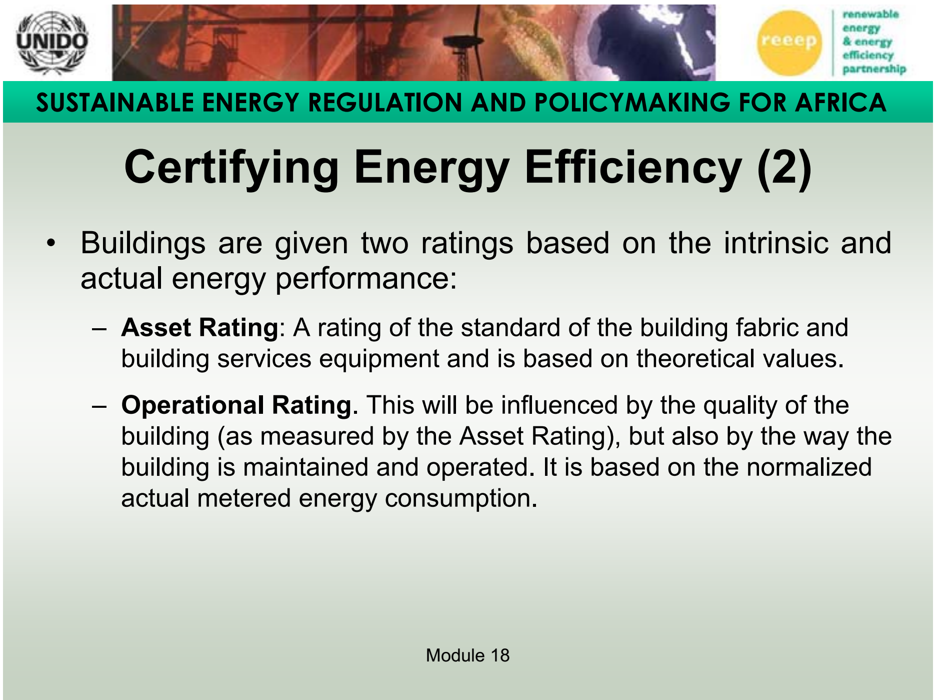
Module 18



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Certifying Energy Efficiency

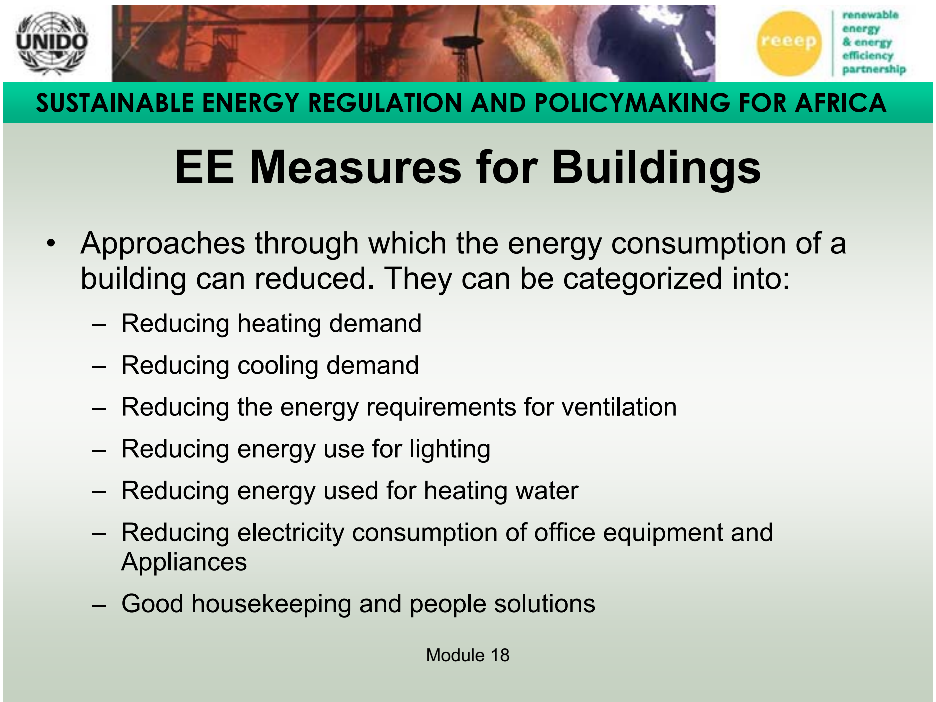
- An Energy Efficiency Certificate is a summary of a building's energy audit. It is meant to give information on the building's energy consumption and its energy efficiency rating.
- The purpose of Energy Efficiency Certificates is to:
  - Inform tenants and prospective buyers on the expected running costs;
  - Create public awareness;
  - Acts as a prerequisite of measures to improve its energy efficiency;
  - To effect incentives, penalties or legal proceedings



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Certifying Energy Efficiency (2)

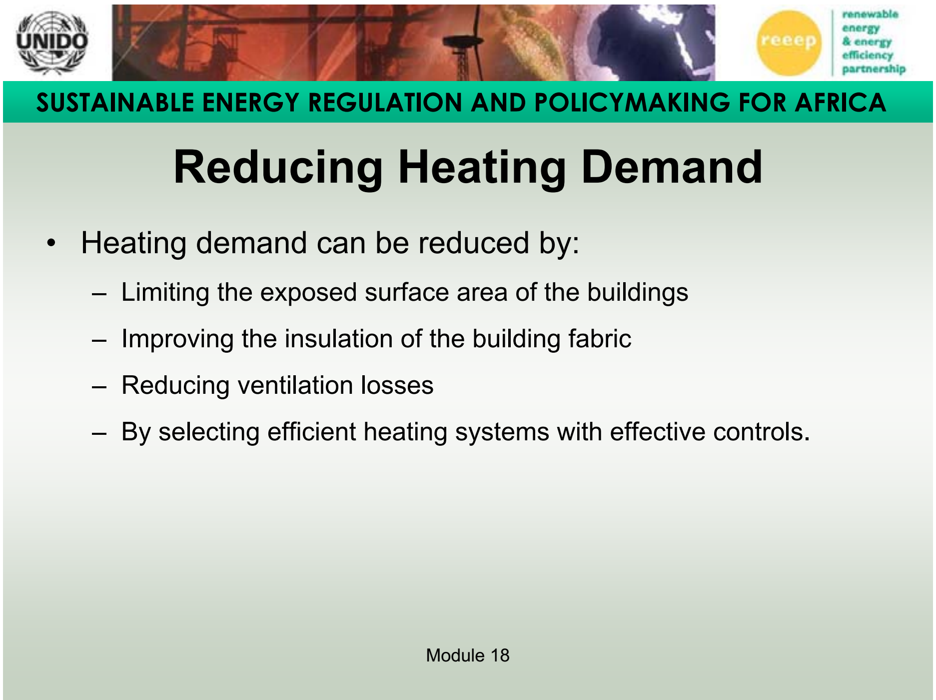
- Buildings are given two ratings based on the intrinsic and actual energy performance:
  - **Asset Rating**: A rating of the standard of the building fabric and building services equipment and is based on theoretical values.
  - **Operational Rating**. This will be influenced by the quality of the building (as measured by the Asset Rating), but also by the way the building is maintained and operated. It is based on the normalized actual metered energy consumption.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

EE Measures for Buildings

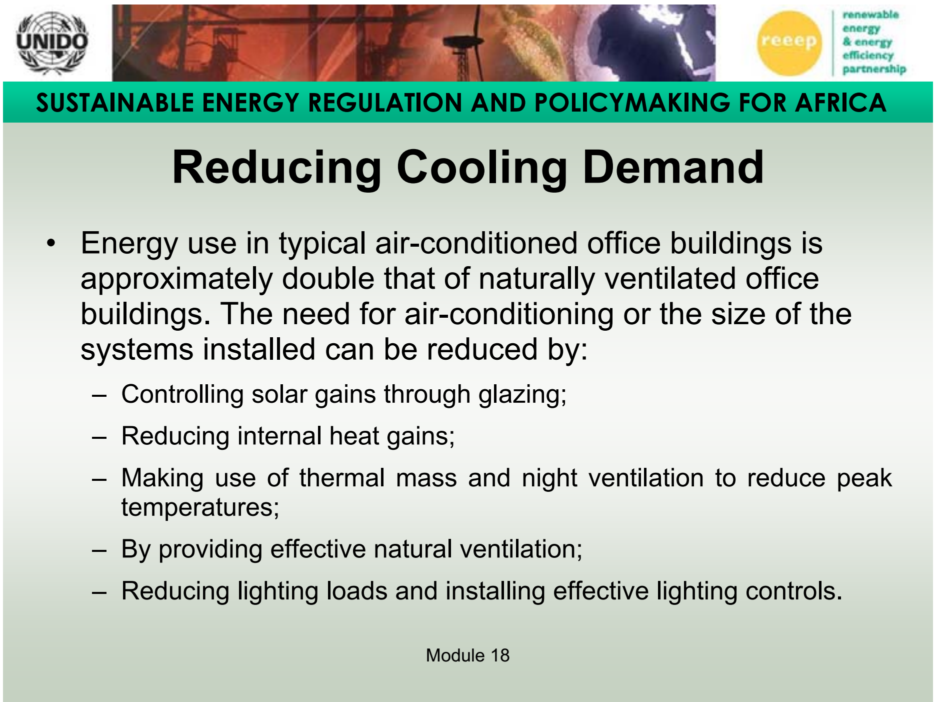
- Approaches through which the energy consumption of a building can reduced. They can be categorized into:
  - Reducing heating demand
  - Reducing cooling demand
  - Reducing the energy requirements for ventilation
  - Reducing energy use for lighting
  - Reducing energy used for heating water
  - Reducing electricity consumption of office equipment and Appliances
  - Good housekeeping and people solutions



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Heating Demand

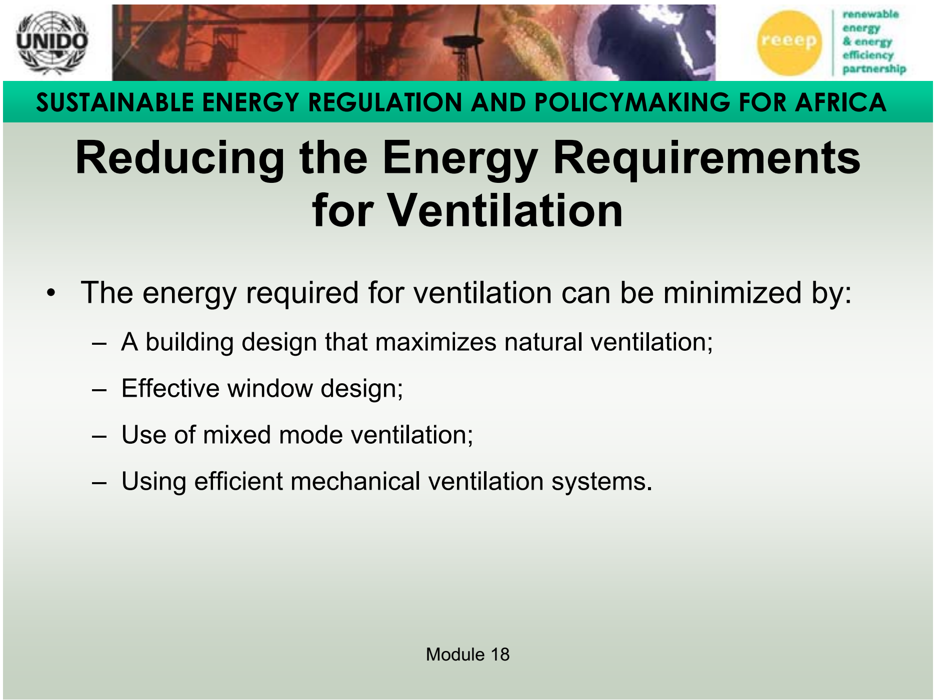
- Heating demand can be reduced by:
  - Limiting the exposed surface area of the buildings
  - Improving the insulation of the building fabric
  - Reducing ventilation losses
  - By selecting efficient heating systems with effective controls.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Cooling Demand

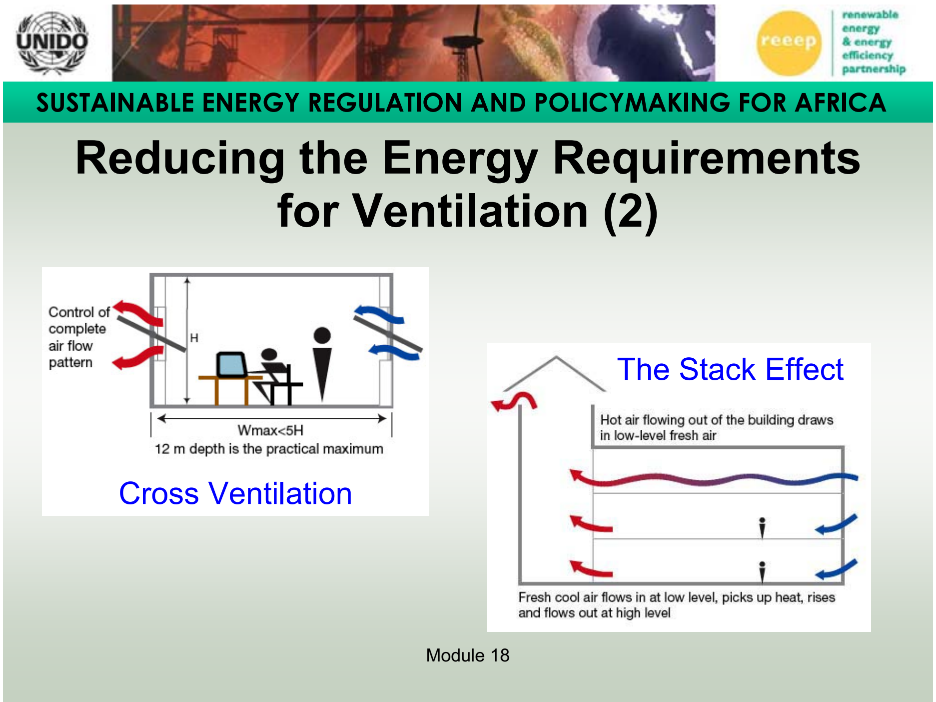
- Energy use in typical air-conditioned office buildings is approximately double that of naturally ventilated office buildings. The need for air-conditioning or the size of the systems installed can be reduced by:
    - Controlling solar gains through glazing;
    - Reducing internal heat gains;
    - Making use of thermal mass and night ventilation to reduce peak temperatures;
    - By providing effective natural ventilation;
    - Reducing lighting loads and installing effective lighting controls.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing the Energy Requirements for Ventilation

- The energy required for ventilation can be minimized by:
    - A building design that maximizes natural ventilation;
    - Effective window design;
    - Use of mixed mode ventilation;
    - Using efficient mechanical ventilation systems.



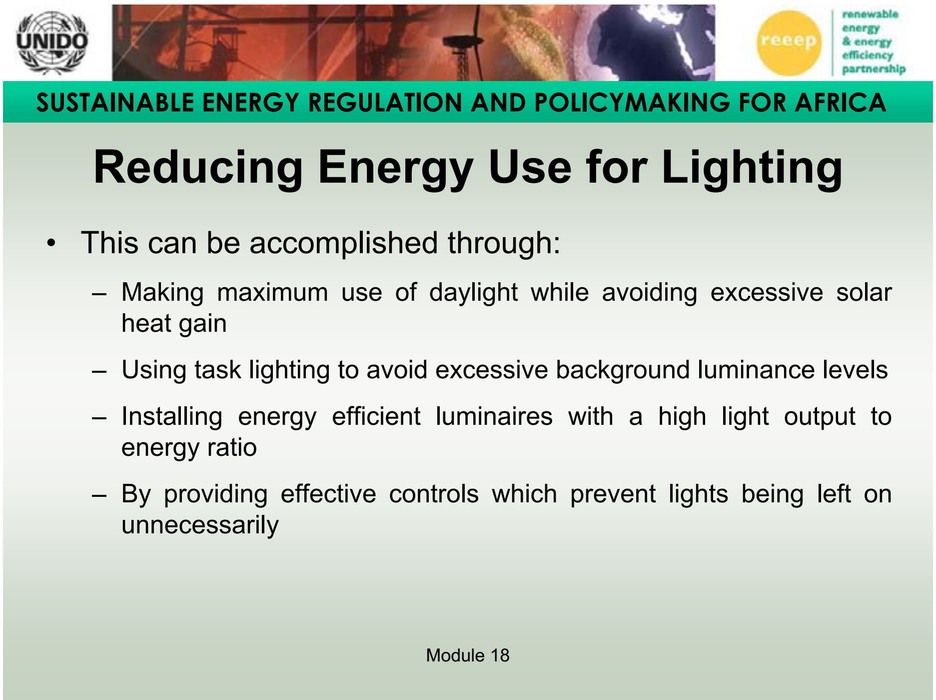
SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing the Energy Requirements for Ventilation (2)

Cross Ventilation

The Stack Effect

Fresh cool air flows in at low level, picks up heat, rises and flows out at high level



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

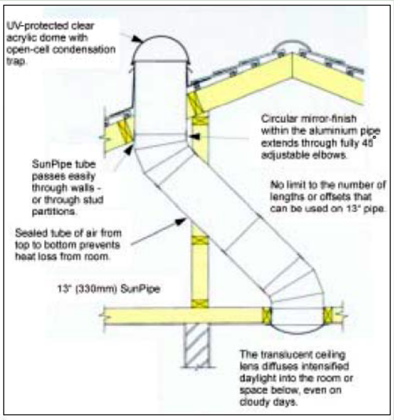
Reducing Energy Use for Lighting

- This can be accomplished through:
  - Making maximum use of daylight while avoiding excessive solar heat gain
  - Using task lighting to avoid excessive background luminance levels
  - Installing energy efficient luminaires with a high light output to energy ratio
  - By providing effective controls which prevent lights being left on unnecessarily

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Energy Use for Lighting (2)

- Natural light provides healthier working conditions than artificial light—and it is free;
- Large modern buildings often have many areas being starved of natural light;
- Therefore the challenge is to channel natural light to areas without windows;
- Sunpipes can be used to introduce daylight to windowless areas.



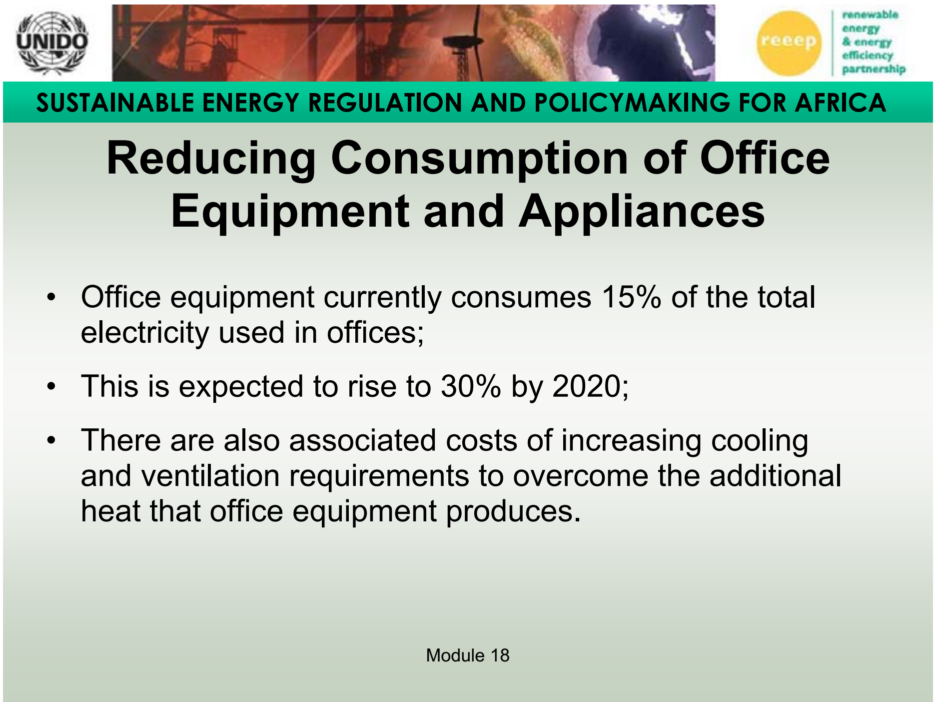
Module 18

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Energy Use for Heating Water

- Installing time controls and setting them to reflect the hours of hot water requirement;
- Setting sanitary hot water thermostats to the appropriate temperature;
- Switching off electric heating elements (immersion) when hot water from the boiler is available;
- Switching off any associated pumps when hot water is not required
- Replacing damaged or missing insulation from hot water pipe work and cylinders;
- Identifying a suitable hot water system.

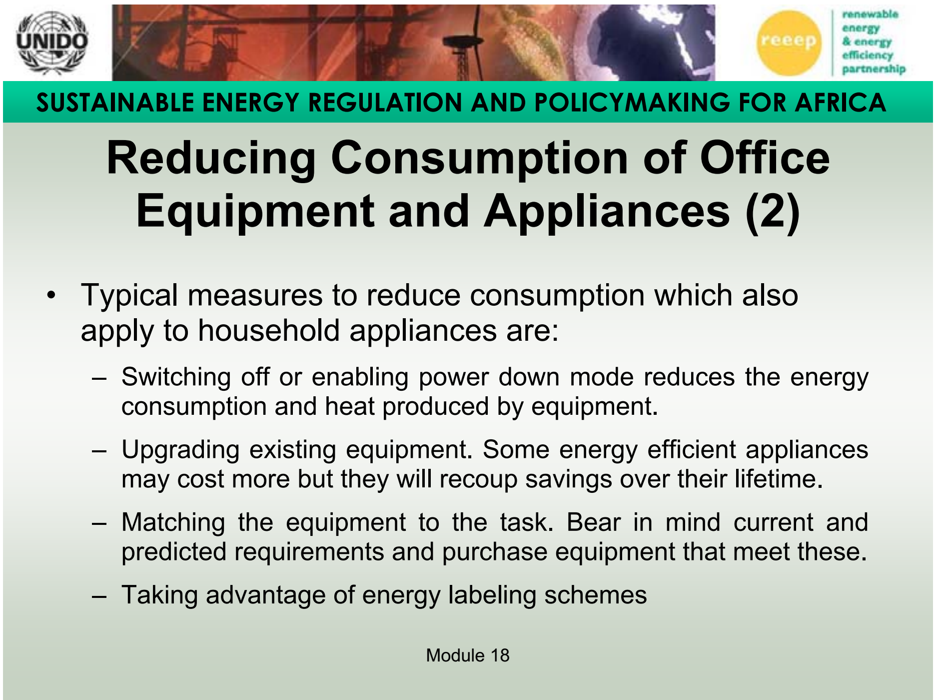
Module 18



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Consumption of Office Equipment and Appliances

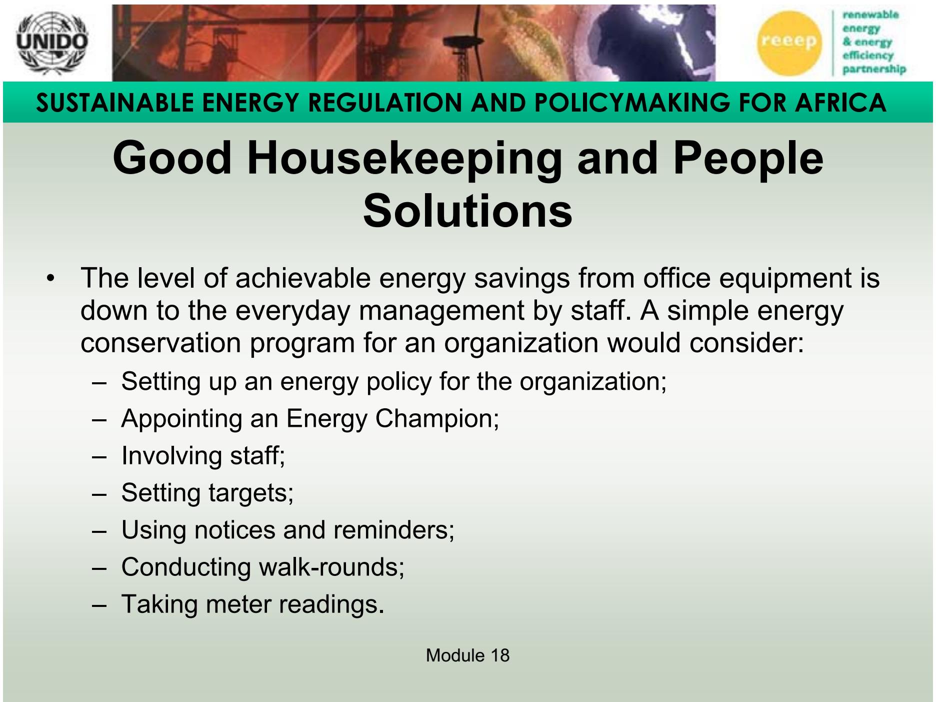
- Office equipment currently consumes 15% of the total electricity used in offices;
- This is expected to rise to 30% by 2020;
- There are also associated costs of increasing cooling and ventilation requirements to overcome the additional heat that office equipment produces.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Reducing Consumption of Office Equipment and Appliances (2)

- Typical measures to reduce consumption which also apply to household appliances are:
  - Switching off or enabling power down mode reduces the energy consumption and heat produced by equipment.
  - Upgrading existing equipment. Some energy efficient appliances may cost more but they will recoup savings over their lifetime.
  - Matching the equipment to the task. Bear in mind current and predicted requirements and purchase equipment that meet these.
  - Taking advantage of energy labeling schemes

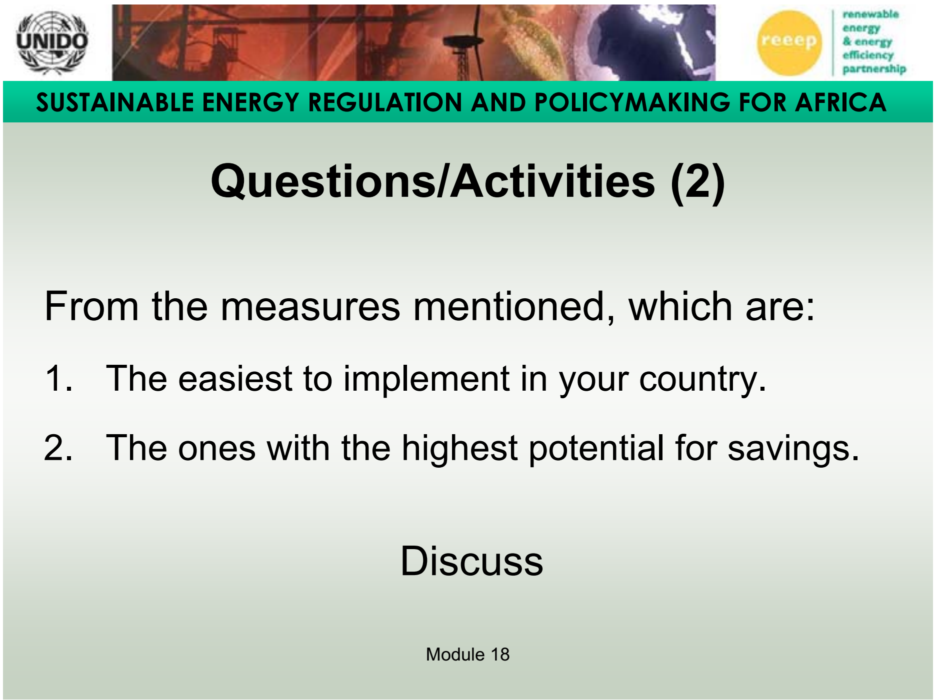


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Good Housekeeping and People Solutions

- The level of achievable energy savings from office equipment is down to the everyday management by staff. A simple energy conservation program for an organization would consider:
  - Setting up an energy policy for the organization;
  - Appointing an Energy Champion;
  - Involving staff;
  - Setting targets;
  - Using notices and reminders;
  - Conducting walk-rounds;
  - Taking meter readings.

Module 18



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

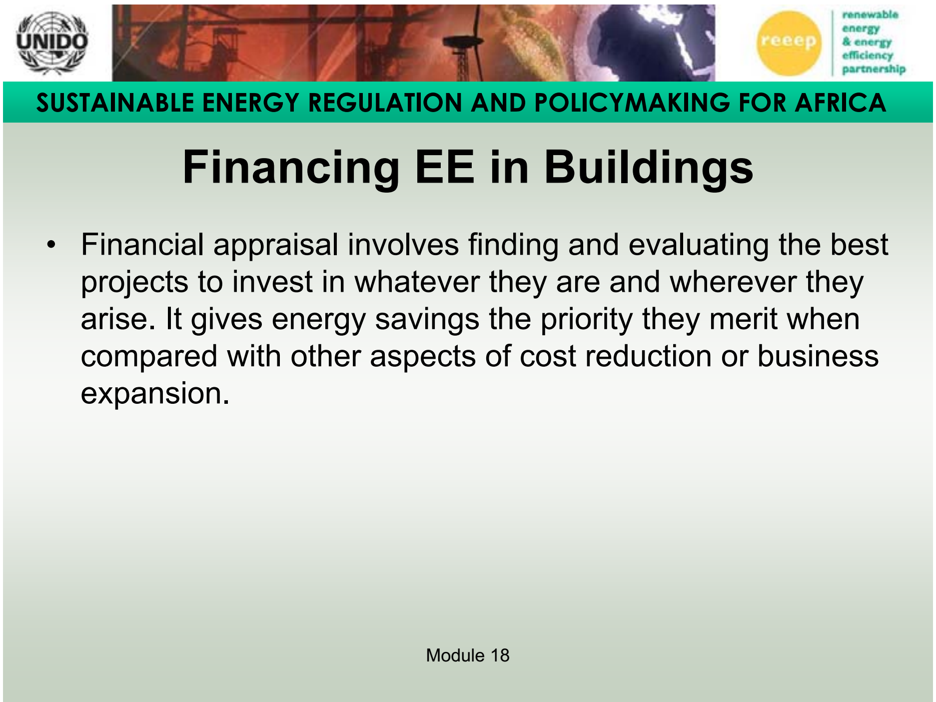
Questions/Activities (2)

From the measures mentioned, which are:

1. The easiest to implement in your country.
2. The ones with the highest potential for savings.

Discuss

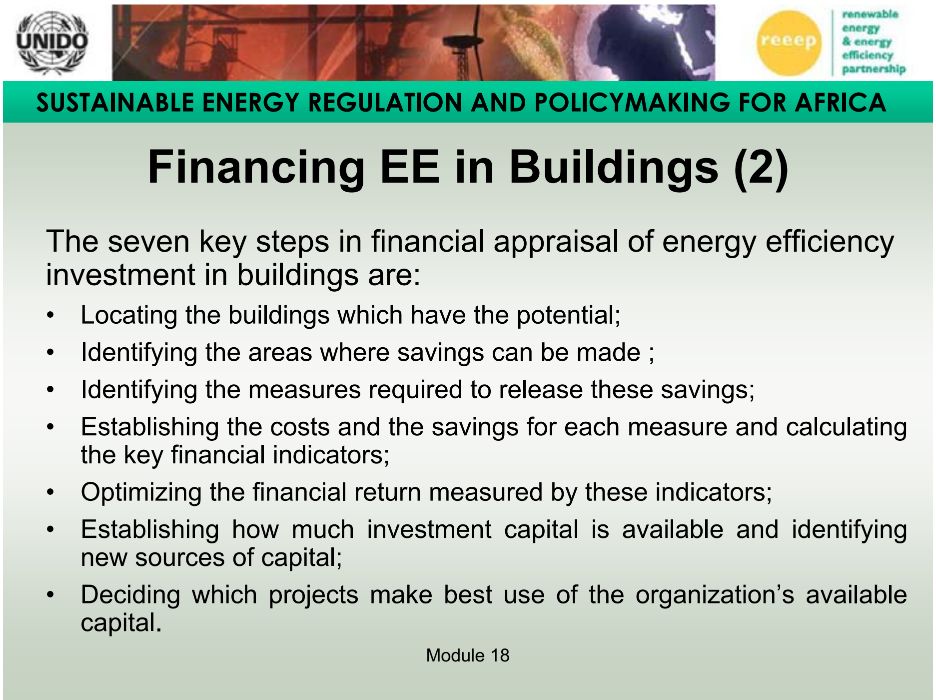
Module 18



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings

- Financial appraisal involves finding and evaluating the best projects to invest in whatever they are and wherever they arise. It gives energy savings the priority they merit when compared with other aspects of cost reduction or business expansion.

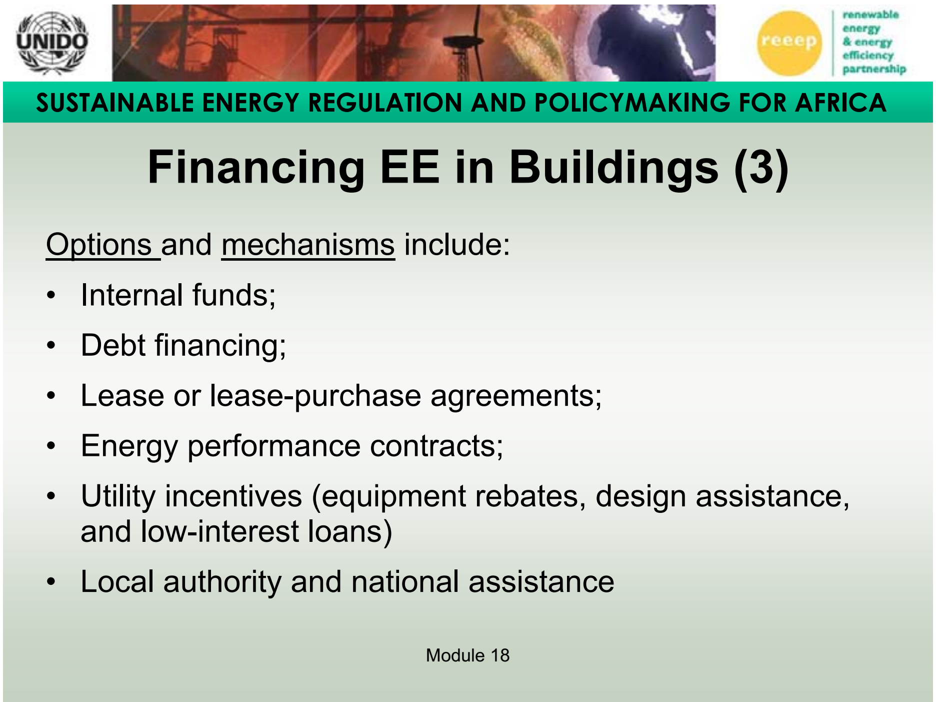


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings (2)

The seven key steps in financial appraisal of energy efficiency investment in buildings are:

- Locating the buildings which have the potential;
- Identifying the areas where savings can be made ;
- Identifying the measures required to release these savings;
- Establishing the costs and the savings for each measure and calculating the key financial indicators;
- Optimizing the financial return measured by these indicators;
- Establishing how much investment capital is available and identifying new sources of capital;
- Deciding which projects make best use of the organization’s available capital.

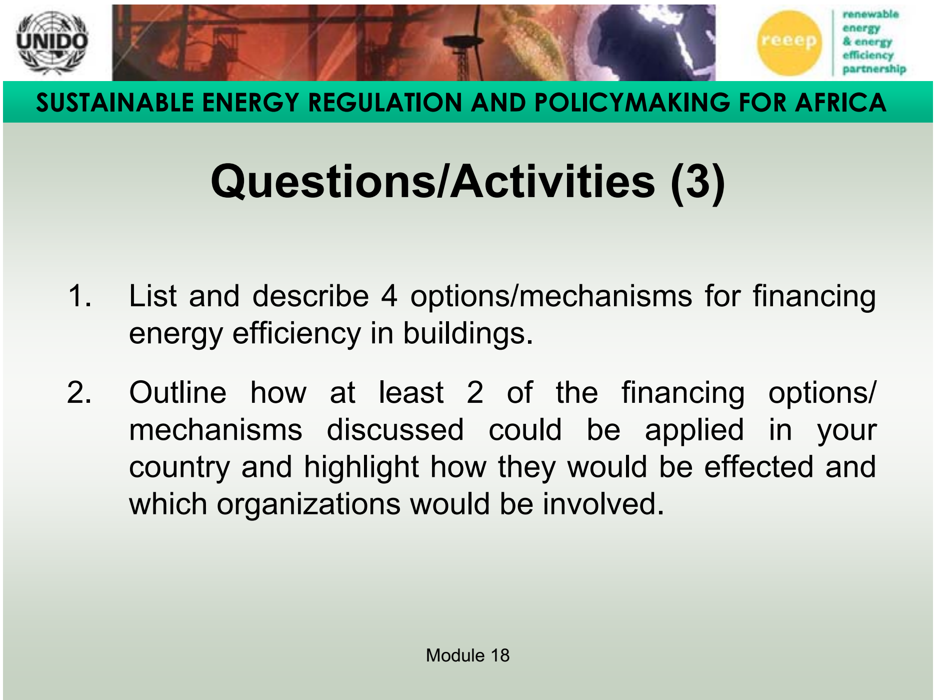


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing EE in Buildings (3)

Options and mechanisms include:

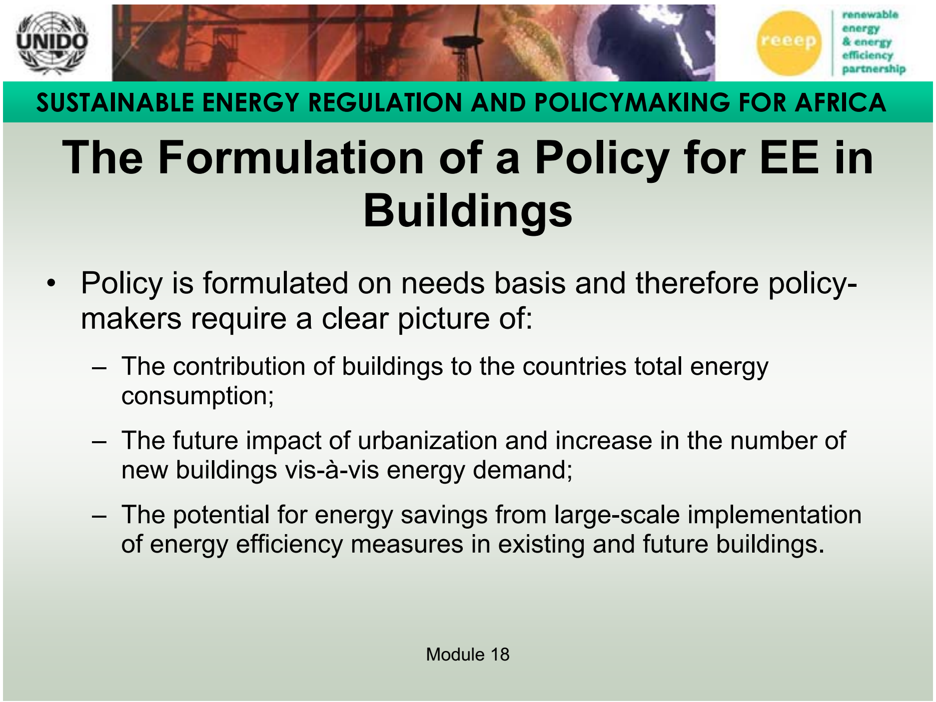
- Internal funds;
- Debt financing;
- Lease or lease-purchase agreements;
- Energy performance contracts;
- Utility incentives (equipment rebates, design assistance, and low-interest loans)
- Local authority and national assistance



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (3)

1. List and describe 4 options/mechanisms for financing energy efficiency in buildings.
2. Outline how at least 2 of the financing options/ mechanisms discussed could be applied in your country and highlight how they would be effected and which organizations would be involved.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings

- Policy is formulated on needs basis and therefore policy-makers require a clear picture of:
  - The contribution of buildings to the countries total energy consumption;
  - The future impact of urbanization and increase in the number of new buildings vis-à-vis energy demand;
  - The potential for energy savings from large-scale implementation of energy efficiency measures in existing and future buildings.

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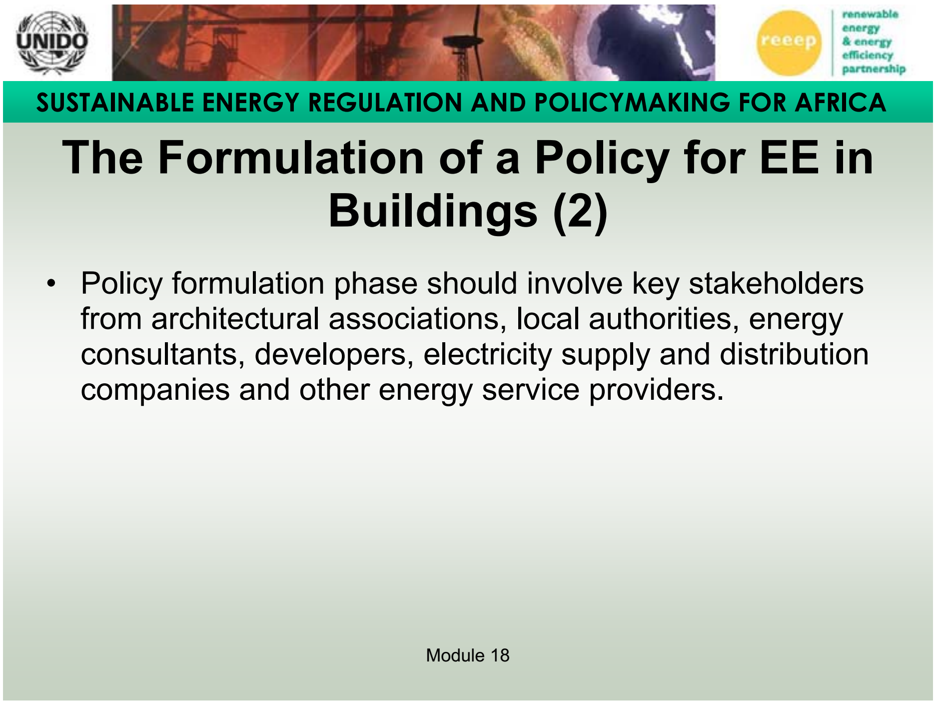

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings (2)

- Policy formulation phase should involve key stakeholders from architectural associations, local authorities, energy consultants, developers, electricity supply and distribution companies and other energy service providers.

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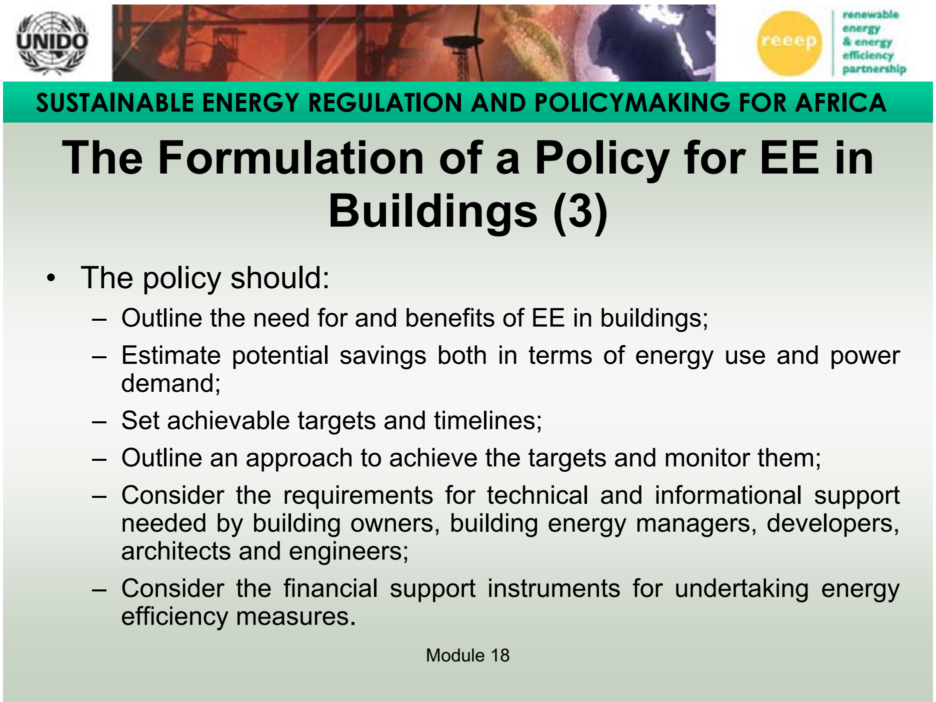
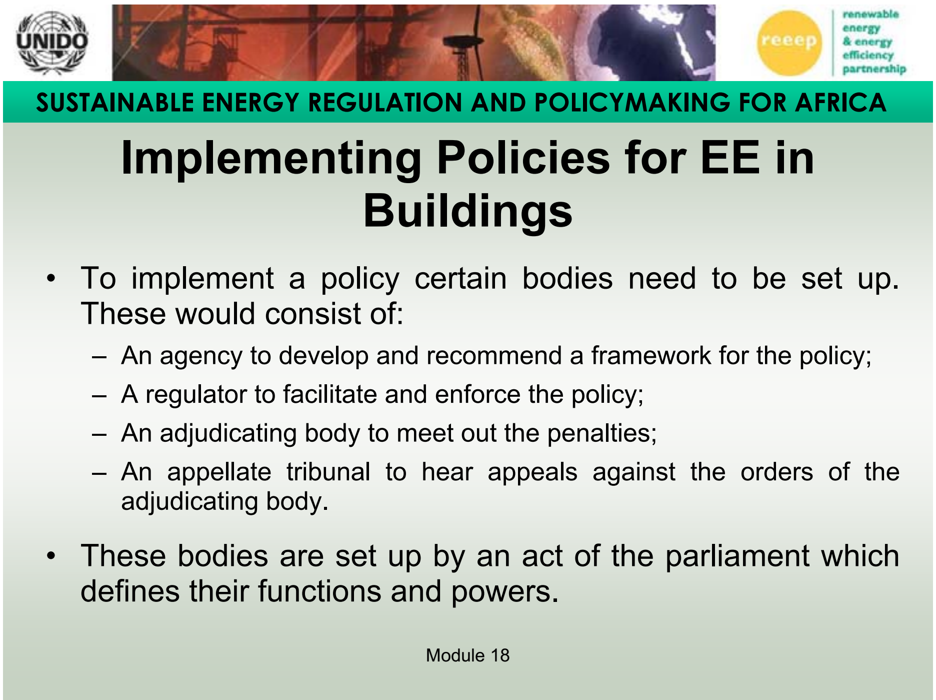


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Formulation of a Policy for EE in Buildings (3)

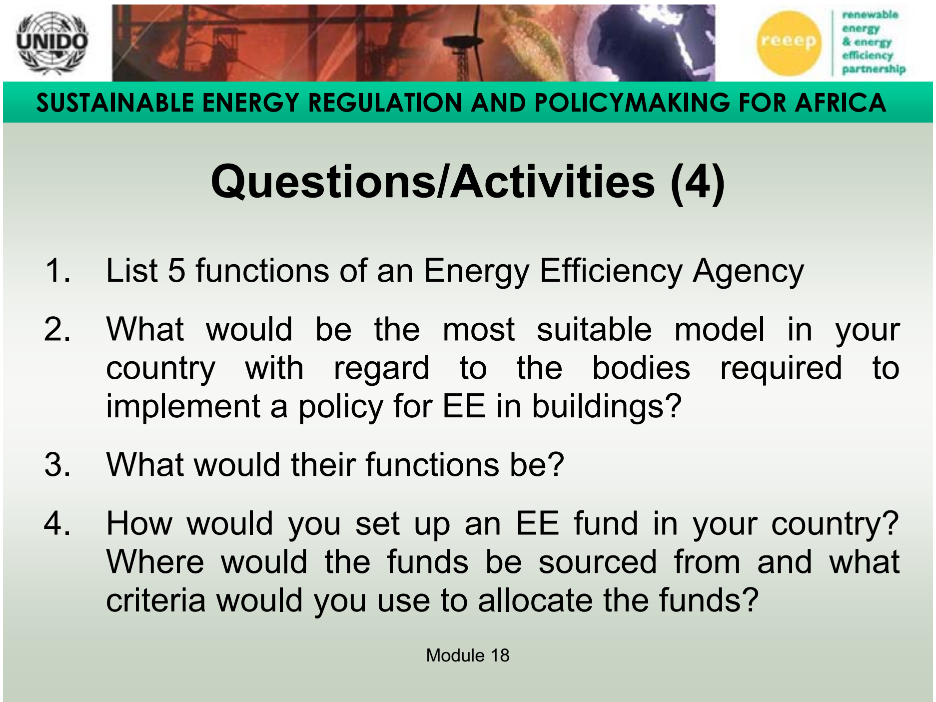
- The policy should:
  - Outline the need for and benefits of EE in buildings;
  - Estimate potential savings both in terms of energy use and power demand;
  - Set achievable targets and timelines;
  - Outline an approach to achieve the targets and monitor them;
  - Consider the requirements for technical and informational support needed by building owners, building energy managers, developers, architects and engineers;
  - Consider the financial support instruments for undertaking energy efficiency measures.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Implementing Policies for EE in Buildings

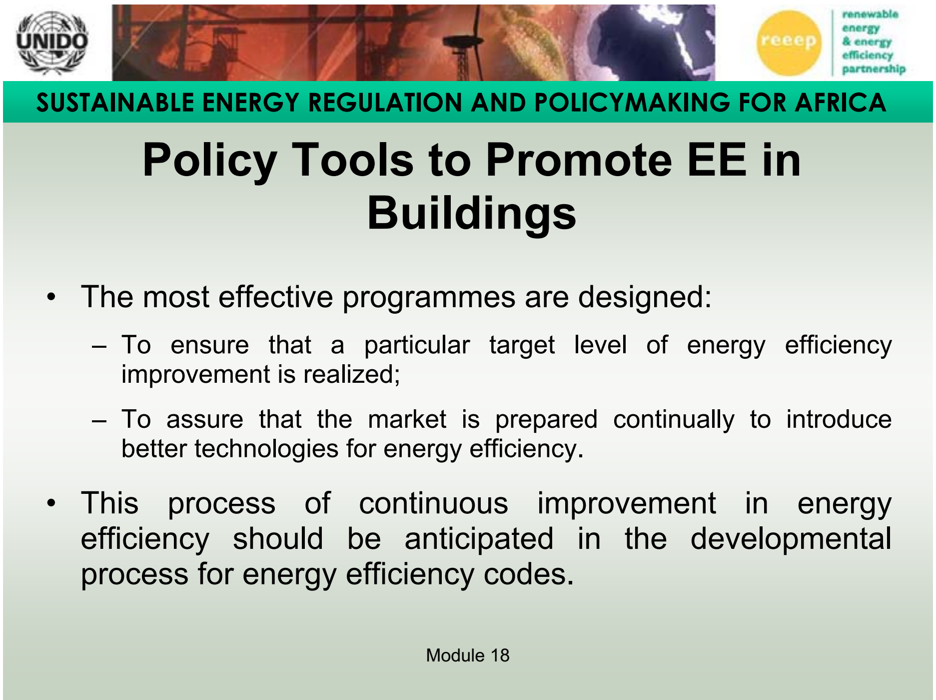
- To implement a policy certain bodies need to be set up. These would consist of:
  - An agency to develop and recommend a framework for the policy;
  - A regulator to facilitate and enforce the policy;
  - An adjudicating body to meet out the penalties;
  - An appellate tribunal to hear appeals against the orders of the adjudicating body.
- These bodies are set up by an act of the parliament which defines their functions and powers.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (4)

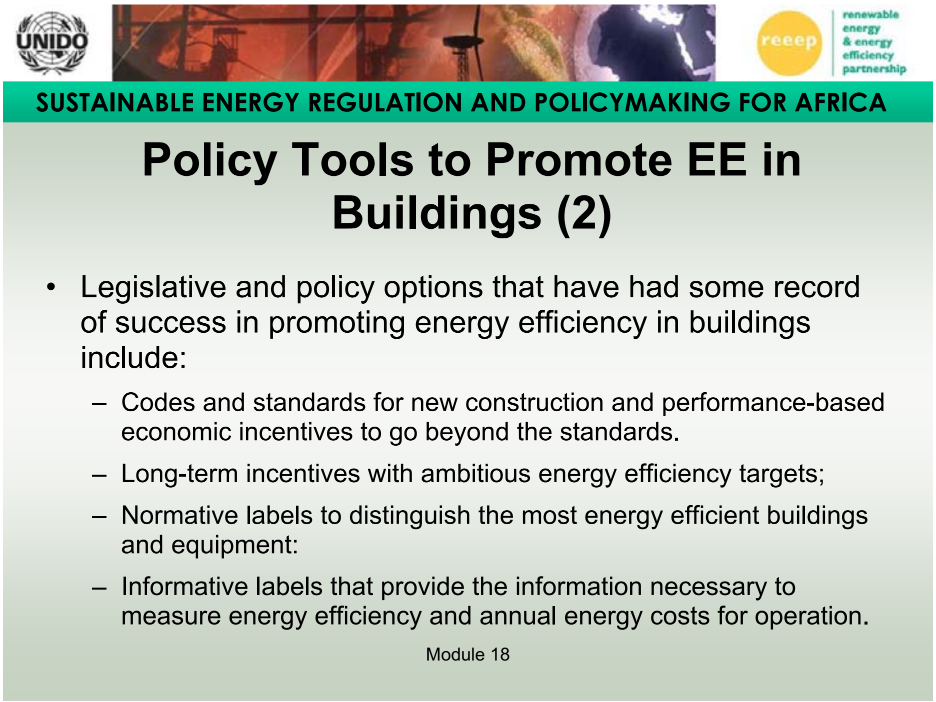
1. List 5 functions of an Energy Efficiency Agency
2. What would be the most suitable model in your country with regard to the bodies required to implement a policy for EE in buildings?
3. What would their functions be?
4. How would you set up an EE fund in your country? Where would the funds be sourced from and what criteria would you use to allocate the funds?



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings

- The most effective programmes are designed:
  - To ensure that a particular target level of energy efficiency improvement is realized;
  - To assure that the market is prepared continually to introduce better technologies for energy efficiency.
- This process of continuous improvement in energy efficiency should be anticipated in the developmental process for energy efficiency codes.



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings (2)

- Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:
  - Codes and standards for new construction and performance-based economic incentives to go beyond the standards.
  - Long-term incentives with ambitious energy efficiency targets;
  - Normative labels to distinguish the most energy efficient buildings and equipment:
  - Informative labels that provide the information necessary to measure energy efficiency and annual energy costs for operation.

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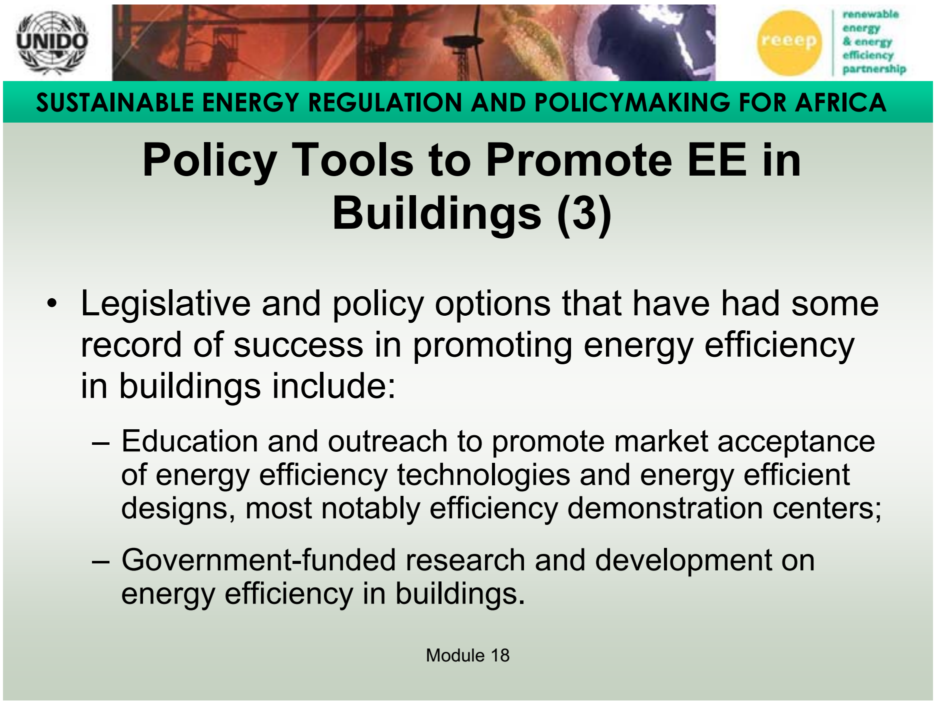

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Policy Tools to Promote EE in Buildings (3)

- Legislative and policy options that have had some record of success in promoting energy efficiency in buildings include:
  - Education and outreach to promote market acceptance of energy efficiency technologies and energy efficient designs, most notably efficiency demonstration centers;
  - Government-funded research and development on energy efficiency in buildings.

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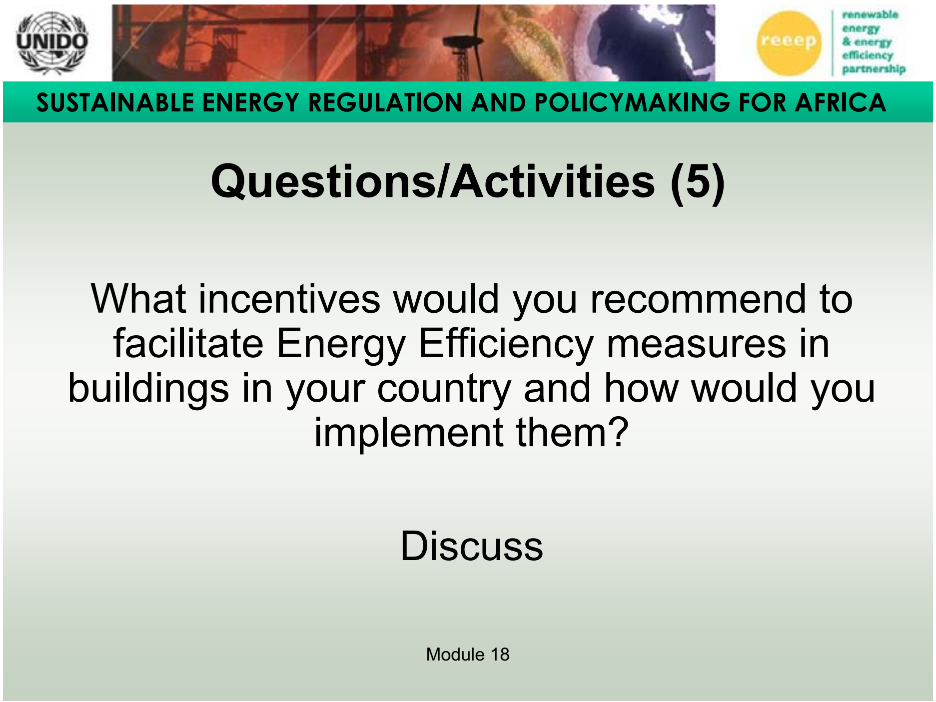
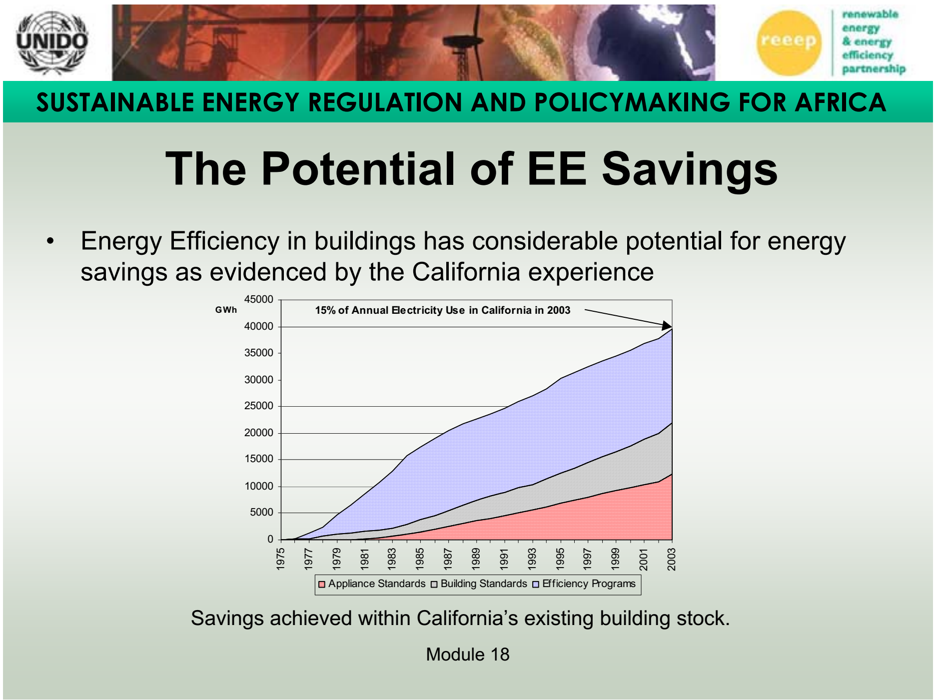


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities (5)

What incentives would you recommend to facilitate Energy Efficiency measures in buildings in your country and how would you implement them?

Discuss

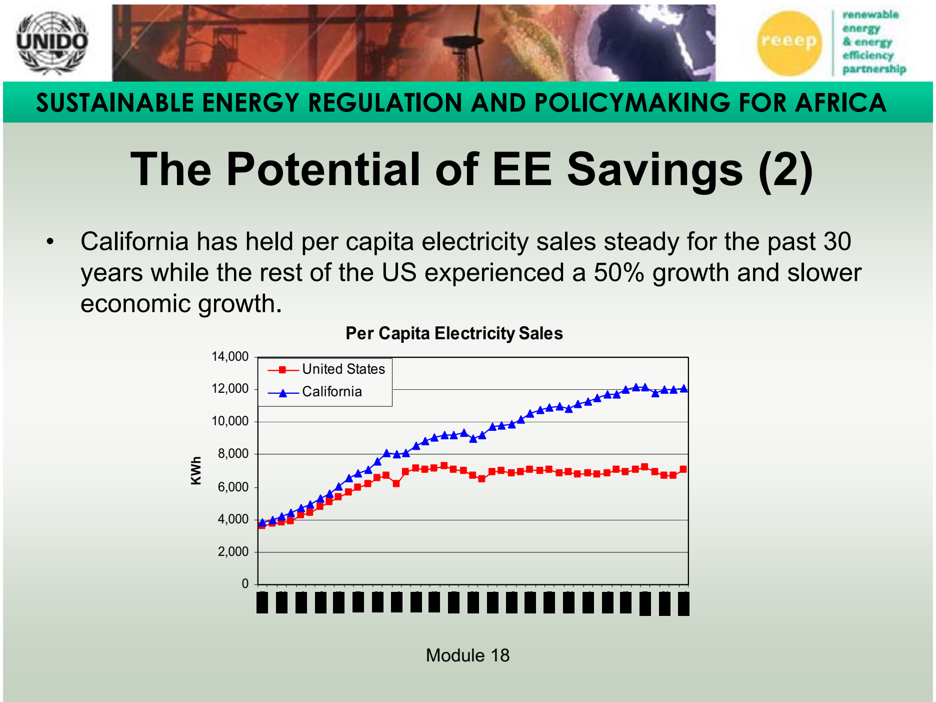


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Potential of EE Savings

- Energy Efficiency in buildings has considerable potential for energy savings as evidenced by the California experience

Savings achieved within California's existing building stock.

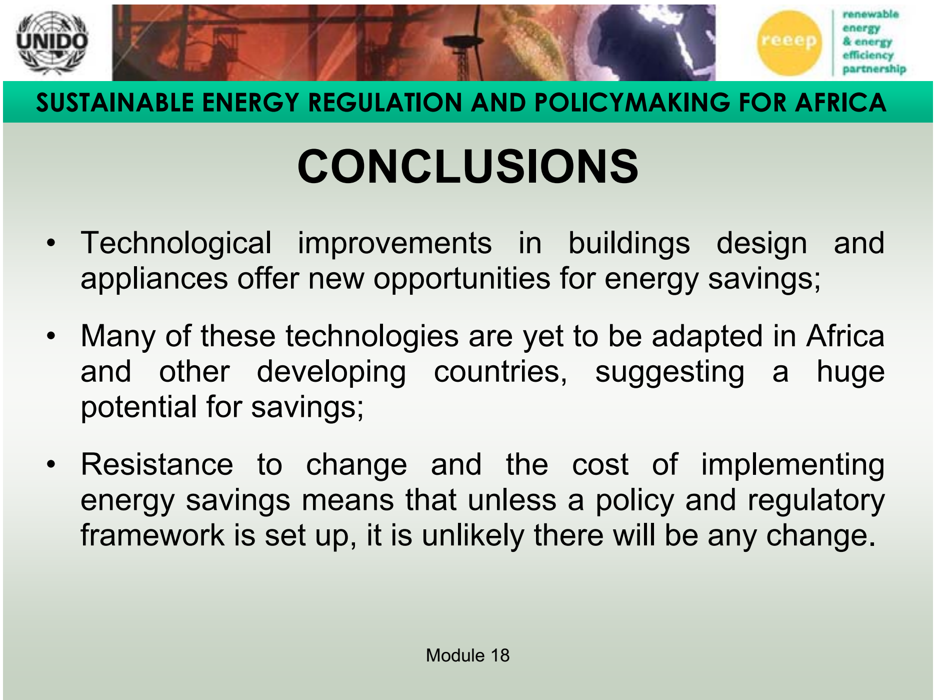


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Potential of EE Savings (2)

- California has held per capita electricity sales steady for the past 30 years while the rest of the US experienced a 50% growth and slower economic growth.

Per Capita Electricity Sales



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Technological improvements in buildings design and appliances offer new opportunities for energy savings;
- Many of these technologies are yet to be adapted in Africa and other developing countries, suggesting a huge potential for savings;
- Resistance to change and the cost of implementing energy savings means that unless a policy and regulatory framework is set up, it is unlikely there will be any change.

Module 19

Financing options for renewable energy and energy efficiency

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

Financing is one of the largest barriers to the development of sustainable energy in Africa and this is true for both renewable energy and energy efficiency. This module will consider and evaluate the impact finance and the banking sector has on the development of renewable energy and energy efficiency.

In terms of renewable energy projects, particularly for rural electrification, a large amount of work has been conducted on financing models for the delivery of energy services to rural populations. A similar situation exists for energy efficiency in Africa, where the lack of access to finance impedes the uptake and development of more energy efficient methods of industrial production, despite projects being identified where considerable savings in both energy and cash are realizable.

This module examines what kind of laws, policies, regulations, and incentives could better facilitate or convince these financial institutions to actively participate and support the renewable energy/rural electrification sector and energy efficiency improvement projects in their countries.

1.2. Module aims

This module aims are as follows:

- To present the different financing models that have been developed and tested for renewable energy projects in rural communities and energy efficiency improvement projects.
- To explain the point of view of banking and financing institutions and the risks associated with renewable energy and energy efficiency projects.
- To give an overview of the possible approaches, policies and incentives to increase the involvement of banking and financing institutions.
- To show examples in different developing countries.

1.3. Module learning outcomes

This module attempts to achieve the following learning outcomes:

- To be able to explain the existing financing models, including the reasons for their success or failure.

- To understand which risks and elements are key for financing institutions when evaluating renewable energy and energy efficiency projects.
- To understand different options for policies and regulatory/support mechanisms to provide incentives for financial institutions.
- To be able to argue which policy or regulatory approach suits best, given the national or regional situation.

2. INTRODUCTION

The deployment of renewable energy sources and the realization of energy efficiency projects often require substantial amounts of money, in order to plan the project, purchase and install the equipment, as well as to train staff for the operation and maintenance of the system installed.

Renewable energy (RE) and energy efficiency (EE) projects have so far had a rather poor reputation with the financing community as they are still viewed as higher risk investments, resulting in stiffer requirements for investors and developers alike.

The reasons behind the relatively limited financing for renewable energy in Africa, thus far are multiple:

- Market-related issues:
    RE and EE potential is often only roughly estimated;
    A limited number of feasibility studies are available;
    There are few RE/EE project developers active in the market;
    Market information is still largely unavailable.
- Political and policy-related issues:
    Most African country policy documents do not prioritize RE/EE;
    Undeveloped regulatory and operational frameworks;
    Operational risks and regulatory uncertainty.
- Technology:
    High up-front costs of RE/EE projects compared to conventional energy sources;
    Inadequate access to finance for research, development and manufacturing;
    Perception of high investment risks by financiers.
- Inherent nature of projects:
    Governments have traditionally been the main investors in energy and have tended to focus on centralized power projects, whereas the greatest potential for RE and EE is in decentralized projects;
    Small-scale nature of the projects.

These factors usually result in the risk of a proposed RE/EE project being over-rated and the required viability hurdle rate becoming untenable. Affordable financing is therefore one of the critical factors inhibiting the wider realization of RE and EE projects.

As the issues, barriers and approaches for both RE and EE investments are to a large extent similar, the module will not be split up into separate parts on RE and EE. Different examples throughout the module will be provided focusing on either RE or EE projects.

3. THE FINANCIERS' PERSPECTIVE

Before looking at different sources of financing, it will be briefly explained how financiers make lending and investment decisions. Overall, financial institutions will aim to create a package that includes the total finance amount and: *(a)* the repayment terms, *(b)* the interest rate, *(c)* the repayment schedule and *(d)* any guarantees or securities.

3.1. Risk assessment and management

For any given project, financial institutions will estimate both the risks and returns of the project. The financier will analyse each individual risk and look at how to manage its potential impact on the project. As for the returns, the projected costs and revenues will be verified and then compared with the cost of the financing instruments to be used.

Different risk categories include business risk, country risk, market risk, money or interest rate risk, project risk, and foreign exchange risk.[1] For example, business risk includes the risks incurred in operating a business: raw material costs, sales volumes, fluctuating prices, affected by demand disruption, strikes, natural disasters, etc. Country risk includes the risk of regional economic recession, national economic mismanagement, and political unrest. Foreign exchange risk includes the possibility that exchange rates may fluctuate during the course of the loan. The risk finally depends on the design of the project or programme, e.g. the business model, time frame, location, etc.

The likelihood of a risk-event is generally assessed by examining similar programmes in similar countries that have already been completed. If no similar projects are available for comparison, financiers will consider the risk to be "uncertain". Many commercial financiers are usually unwilling to loan to projects with "uncertain" risks, except by applying higher interest rates to cover themselves in what is perceived to be a higher risk situation, or they may demand guarantees from international development financiers.

Ultimately the investors and lenders aim for a deal that allocates the risks to the party best able to handle them, that provides ways to measure the project's performance and that gives some monetary safeguards to project investors and lenders.

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[1] *Finance for the Developing Countries,* by Richard Kitchen, 1986.

Distinct types of financiers look at renewable energy projects in distinct ways; investment bankers expect to earn a fee, lenders expect to receive long-term and fixed payments and equity investors expect to earn a shorter-term payback and return. Each of the players in these deals will do its own due diligence or examination of the project before committing money to the project. This analysis may include a review of:

- The business plan;
- Projected cash flows, margins, IRR, NPV;
- Reliability of technology involved;
- Creditworthiness of all parties involved;
- Likelihood of changes in regulatory and policy environment;
- Permits and environmental approval—required for project to begin construction and operation.

Once assessed, a risk never actually disappears—it is simply transferred (allocated) to somebody else's balance sheet. Project sponsors usually focus on business and non-commercial risks. Fund investors, guarantors and governments are often more concerned about operational and financial risks being taken on by the project sponsor relative to its financial and management capability.

Once a structure for risk sharing is identified and agreed upon, each of the key risks involved can be allocated and priced under contractually binding arrangements.

For projects in developing countries, governments (often backed by bilateral or multilateral agencies) need to partially or fully assume the risks that result from their own actions (or lack thereof) including policy, regulatory and country risks. Risks concerning events that neither governments nor project sponsors can control will have to be covered by insurance or other contracts/solutions from private sources. Where such insurance is unavailable or premiums are too expensive, then public assistance is required to mitigate the risk.

For example, the Multilateral Investment Guarantee Association (MIGA) was formed by the World Bank specifically to provide guarantees to development work.

3.2. Returns

After having assessed the risks, financial organizations are willing to lend or invest money when they expect to make a profit, e.g. a return on investment (ROI) or a return on equity (ROE). The return is generally earned in the form of interest (in the case of loans) and dividends (in the case of equity investment). The higher the perceived risk of a programme or project, the higher the required return in order to attract investors to it.

A schematic overview of the methodology for analyzing risks and returns, and the resulting risk/return profile for a typical wind project are shown in figure I and figure II.

Figure I. **Analysis of risks and returns**

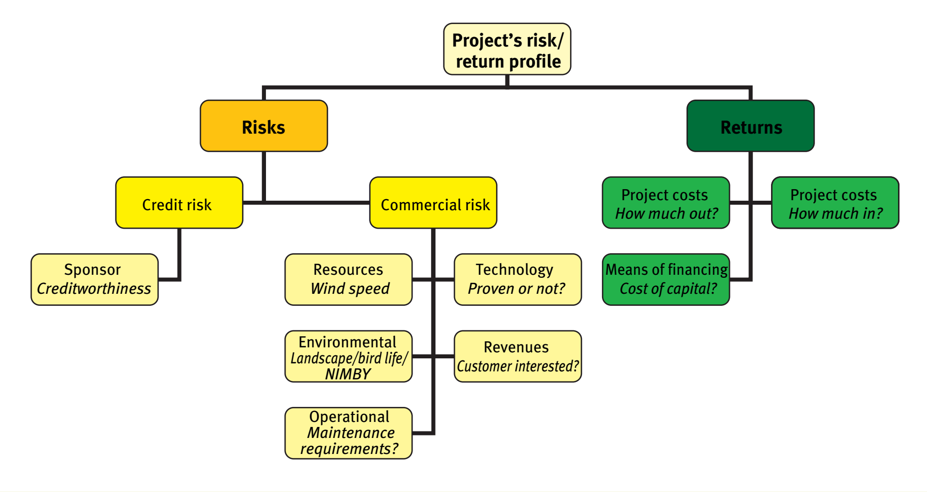
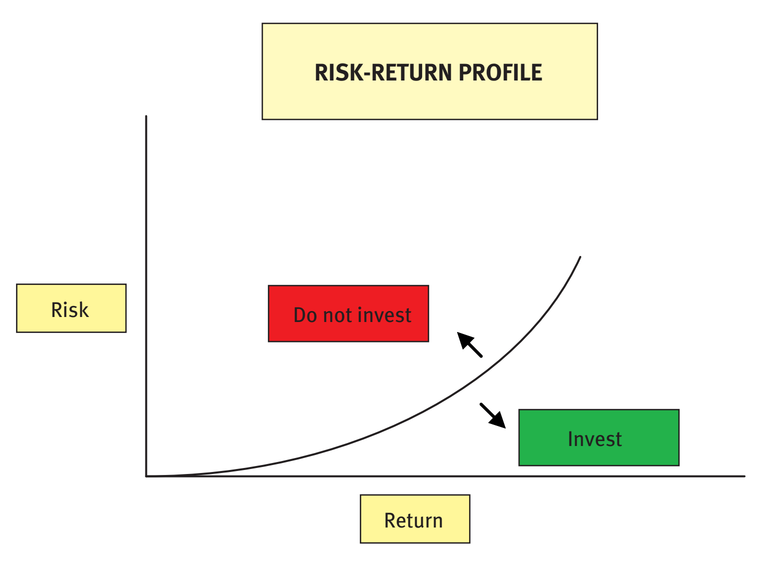


Figure II. **Risk/return profile**



4. BASIC TYPES OF FINANCING

4.1. Debt

Debt financing involves taking a loan or issuing a bond to provide capital and require repayment of both the amount of money borrowed and the interest charged on that amount. In contrast to equity investors, lenders who provide debt financing to a project do not own shares in the project. They provide capital for the purpose of earning interest. Because lenders must be repaid before distributions can be made to shareholders, lenders bear less risk than equity holders. For this reason, the potential return to lenders is limited to risk-adjusted market interest rates.

Loans are a very common financing vehicle for development projects because they continually replenish the development fund from which they are drawn. Loan payments usually must be made on a specific schedule, and if they are late or if the loan is defaulted, the borrowing organization may have an extremely difficult time accessing financing in the future.

The major sources of debt financing are international and national commercial banks. Other sources of debt financing include multilateral development banks (MDBs) and the International Finance Corporation (IFC), debt/equity investment funds, equipment suppliers, and private investors. These banks can play a major role by syndicating the debt financing of a major project among several banks so as to minimize their own risk exposure on any given project.

International funds dedicated to development projects will often create loans with generous repayment terms, low interest rates and flexible time frames. Such loans are called “soft-loans,” and precisely because of their lower interest rates and flexible terms, they are generally preferable to commercial loans.

An additional consideration with loan funding is that foreign loans are subject to foreign currency oscillations, risking that the principal amount borrowed and the interest owed could increase dramatically if exchange rates fluctuate. The economies of many developing countries tend to be unstable, and the costs of labour, goods, or equipment could fluctuate during the course of a long-term project, while the loan currency might fluctuate as well.

Subordinated debt is a debt instrument falling between debt and equity. Principally, subordinated debt is provided by a friendly investor or a project partner and is subordinated to other primary debt in case of project default. In return, subordinated debt usually commands a higher interest rate than normal debt to reflect the higher risks associated with this investment. Similarly mezzanine debt refers to non-conventional debt that has a greater element of risk than secured debt but has less risk than equity.[2]

4.2. Equity

Equity investors provide capital in a project in return for a share of the equity of the project. It involves high-risk financing that expects high returns and therefore requires finding interested investors who are willing to buy into the project, and matching the investors with the project and the risks. It entails sharing ownership and/or revenues with the investment partner(s) through ordinary or preferential shareholding, including that equity investors maintain the right to get involved in the decision-making process of the project or company in order to protect their investment. The expected return on equity is generally two or more times greater than return on debt. In return for the higher expected yield, equity investors bear the greatest risks and have rights to distributions from the project only after all other financial and tax obligations are met.

Common investment channels to acquire equity financing include project developers, venture capitalists, equity fund investors, equipment suppliers, multilateral development banks, and institutional (banks, insurance companies) and individual investors. Because venture capitalists invest in new companies in their earliest and riskiest stages, they expect to earn even higher returns.

Quasi-equity financing is a financing term for funding that is technically “debt” but has some of the characteristics of equity financing, such as unsecured funding with flexible repayment terms. Stakeholders in a project may loan the project money with a formal postponement of repayment.[3]

4.3. Grants and guarantees

Grants do not require repayment: they are essentially “gift” money with specific requirements or terms for use. Governmental and international organizations offer grants to promote environmental and development policies. Usually they include a statement of the work that will be performed using the money, including restrictions on how the money can be spent and the time frame during which it can be spent. Grants will often be directed towards the purchase of hardware and equipment required for a project.

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[2] strategis.ic.gc.ca

[3] strategis.ic.gc.ca

These financing vehicles often originate from private foundations, but can sometimes be procured from international development organizations such as the World Bank (WB), the Global Environment Fund (GEF), bilateral funding organizations, or through national renewable energy funding divisions as well.

Guarantees are a contractual promise from a financing or otherwise well-capitalized organization to take responsibility for payment of a debt if the primarily liable organization fails to pay. For example, when an individual purchases a house, the house is secured as collateral. If the individual defaults on the loan, the house may be claimed by the lender to offset the incurred losses. In the case of RE and EE projects, there is often little or no acceptable collateral to pledge as security against the risk of the loan. Instead, a developer might seek a guarantee from a large, well-capitalized organization, and should the project or national programme fall into arrears, the guarantor will cover the loss. This makes lending to and investing in RE and EE projects more attractive to commercial lenders.

Guarantees are offered by multilateral development banks and national development banks. For example, the Multilateral Investment Guarantee Agency (MIGA) is organized by the World Bank to help investors and lenders to deal with political risks by insuring eligible projects against losses relating to currency transfer restrictions, breach of contract, expropriation, war and civil disturbance, as such facilitating developing countries to attract and retain private investment.[4]

Review question

List the different types of financing and think of the (combination of) types that have been used to finance a RE or EE project in your country.

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[4] www.miga.org

5. TYPES OF FINANCING MODELS

Thus far most of the financing for RE and EE projects in developing countries has been in the form of development assistance focused on providing technology in demonstration projects, and usually initiated and managed by the national government or external donor programmes.

In recent years new financing models have been developed based on local capacity and higher involvement of consumers. The best known are micro credit consumer programmes for small-scale RE systems, and seed capital provision for small and mid-size enterprises (SMEs) to assist local entrepreneurs in starting up new businesses in clean energy products and services. The rationale behind these deal structures is to prepare young enterprises for later growth capital from more commercial sources.[5]

It can be expected that in the near future these emerging and still perceived high risky sectors will continue to rely at least partly on non-commercial investment. Eventually though, RE and EE project development will have to be induced by market-based incentives, allowing them to attract conventional sources of finance.

The following section will present the most commonly adopted as well as the upcoming financing models in RE and EE development programmes.

5.1. Government-led model

As mentioned earlier, most of the financing programmes are still managed by a government body or donor organization, although the actual model can take on several different forms and include different market players.

For example in the PRONASOL[6] project financing programme in Mexico, the overall management and allocation of funds remained under federal government control, but it also involved some form of private sector participation, as a vendor of goods and services (not as the owner-operator) and a high degree of participation from the communities.

Approved projects were reviewed and technically approved by the utility Comisión Federal de Electricidad (CFE) in order to guarantee quality, before being let to tender to get the lowest prices.

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[5] www.uneptie.org/energy/projects/REED

[6] Financing Renewable Energy Projects—a guide for development workers.

The programme aimed at two categories for project financing:

- Productive users included agro-industries and similar applications. The funding consisted of a preferential loan scheme from the Mexican development bank, and the money had to be repaid from the project's economic surplus.
- Life improvement projects, such as electrification of individual houses, schools, communal houses and health clinics, were granted 50 per cent of the project costs from the federal government, 30 per cent from the state government and the remaining 20 per cent from the local government and the community (or the individual in case of housing electrification).

In both cases, the local community had to provide the financial means to pay for the operation, repair, maintenance and possible capacity expansion of the system, and mostly a revolving fund[7] was applied. This programme was part of the national poverty alleviation policy, was not supported by international funding, but it turned out quite successful in developing a PV market in rural areas. The programme increased the rural electrification level to over 40,000 systems.

In Chile, the rural electrification programme PER (Programa de Electrificación Rural) was primarily based on a 60-70 per cent subsidy from the state to cover the initial investment, but was furthermore designed for joint financing from the electricity companies and the users.[8]

Companies were required to invest their own resources and users contributed both to the investment phase and during the operation of projects, to increase their commitment and to support adequate service and maintenance. Users had to cover the costs of the in-house wiring, the electric meter, and the coupling to the grid. These expenditures, nearly 10 per cent of the costs of each project, were initially financed by the distribution company and repaid by the users over time. Once the project was operating, the users had to pay the regulated tariffs. Contrary to the PRONASOL programme in Mexico and in order to increase their commitment, the electricity companies were handed the ownership and operation of the systems.

Although new electricity supply was provided to more than 90,000 households, exceeding targets, most projects were on-grid extension and diesel systems for off-grid rather than renewables.

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[7] A revolving fund is usually seeded by a combination of grants and debt financing. Usually the costs of the funds are the purchase of new systems and the provision of the credit service, while the revenues come from customers' repayments under the lease or rental arrangements.

[8] A Case Study on Rural Electrification in Chile, www.worldbank.org/html/fpd/esmap/energy_report2000/ch9.pdf

A similar model has also been found in China to finance energy services in rural areas. Apart from the government controlling the financial model, market elements are included in the policy options. In 2001, the Chinese government launched a village power programme, to install 700 village power systems with central and local government financial inputs.

In this model, the government is the financial agency with the installation company and the local service company playing a crucial role for supplying energy services in rural areas.

Although mostly successful and including some private sector involvement, it must be clear that the above described models depend highly on continuing government support.

5.2. Market-based models

Due to the perceived high risk and low return on investment for RE and EE projects, few success stories using a market-based model are available. However, international aid agencies have been developing several market-based business models, especially for rural electrification programmes.

To become economically viable with less or ultimately no governmental or donor support, RE and EE projects should strive to get embedded in conventional economic activity, by integrating more private actors in the process, by gradually increasing income through the delivery of energy services and the differentiation of the client base.

There is a need for innovative instruments for households with limited cash to overcome the high initial investment costs. These instruments aim to increase affordability for users by spreading the repayment of the capital costs over longer periods and by reducing the initial payment, and to provide a framework for private initiatives to design and offer their services. Examples include the consumer finance, leasing and fee-for-service model,[9] which will be discussed below. These models have mainly been developed and used for solar home systems, but the same principles can be applied to other technologies and target groups.

Consumer finance

The consumer financing (CF) approach implies consumers purchase their system from a dealer on credit by making a down payment and financing the balance

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[9] ESMAP, www.esmap.org

with a loan, making periodic payments of capital and interest. The customer gets (gradual) ownership of the system. The loan plan is generally funded by a separate, small-scale and unregulated financial institution.

Successful programmes have kept the down payment at or below 25-30 per cent of the cash cost. By maintaining a high volume of installations, dealers can also reduce the price because fixed costs are spread over a larger number of units. The flexibility of interest rates is limited. Sustainable CF programmes can only reduce rates by seeking affordable financing, controlling operating costs, minimizing loan defaults, and ensuring timely recovery of capital and interest.[10] Finally, adequate after sales service and end-user education are important since they prevent poor system performance and therefore maintain cost recovery and achieve financial stability.

The main advantage of this approach is the increased affordability because the end-user can spread out the repayment of the high initial cost.

The key issues to consider are:

- Creditworthiness of the customer;
- Creditworthiness of the financial institution;
- System quality and warranties provided by the dealer;
- Clear and contractual arrangements between the dealer and the financial institution(s).

Leasing

In the leasing model, the leasing company procures systems on a wholesale basis, and then offers them to households through retail lease agreements. In contrast to the CF approach, the leasing company retains ownership of the system, although it is often gradually transferred to the customer. The leasing company usually is a dealer or a related financial or development institution. The payments from the customer cover the equipment costs of the leasing company minus a slight residual value, interest costs and a return on capital.[11] Most programmes also allow the customer to purchase the system when the lease expires.

The main advantages of this model are the increased affordability for households thanks to the leasing option and the decreased transaction costs. Since the

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[10] *Financing Renewable Energy Projects—a guide for development workers,* IT Power and the Stockholm Environment Institute, 1997.

[11] Leasing to Support Small and Micro Enterprises, World Bank, 1997.

leasing company retains ownership of the system, it may be easier for the leasing company than in the case of consumer financing to secure capital and to disconnect delinquent customers.

The key challenges are the achievement of financial stability, since lease lives are typically longer than consumer loan lives. Robust cash flow management is essential, and will be more complex and expensive than under CF.

Fee-for-service or ESCO

A fee-for-service approach, also known as an energy service company (ESCO) model, seems to offer rural households the best prospect for widespread access to sustainable energy services. ESCOs intervene in two aspects of the financing structure: first, in downsizing the high initial costs of systems by offering a staggered payment and fee for service models; second, in serving as financial intermediaries in consumer bank loan procurements and guarantees for securing loans. This form of intervention induces a reduction in risk perception in the banking sector, enables consumer access to bank lending and enhances sales for manufacturers and suppliers of equipment.

The main advantages of this approach are:

- Simplicity: the customer signs a contract with a service provider for the installation, maintenance and repairs of the system, and agrees to make periodic payments in return;
- Flexibility for customer and service provider: since the customer never takes ownership of the system, the service provider can simply remove the system and transfer it to another customer if the customer no longer wants to pay for the service;
- Affordability: since the investment can be recovered over the life of the system, the periodic payments and the transaction costs are lower than for the alternative models, and unexpected large-scale expenses for major components or repairs are avoided.

The key challenges lie in the more complex management requirements, due to the large amount of customers necessary to make the business viable and the long cost recovery periods.

The leasing and ESCO approach have been successfully applied by private commercial actors in Honduras and the Dominican Republic (by Soluz),[12] in India, Sri Lanka and Vietnam (by SELCO)[13] and E&Co.[14]

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[12] www.soluzusa.com/redcos

[13] www.selco-intl.com/where-we-operate.html

[14] www.eandco.net

Private participation for increasing energy services for rural areas has also successfully worked for small hydro power (SHP) in China. SHP development initially requires a large investment in construction, but is a cost effective option in the long term. The programme stimulated private financing in China's SHP development by allowing investors from multiple levels and areas to gain by investing in SHP, in line with the principle "who invests, who owns, who benefits". Moreover shareholding and cooperative systems have proven to be very effective in attracting funds. The programme is finally assisted by (decreasing) government support and (increasing) bank loans.

The above mentioned examples and variants are described in more detail in module 11: Increasing energy access in rural areas.

Box 1. A case of micro financing in South Africa: solar home systems, school and clinic electrification system, water pumping

The solar home system (SHS) programme was part of a larger energy services development project in South Africa.

An energy committee was established to handle installation, sales and maintenance of SHS. Decisions regarding financing options for the SHS were made in consultation directly with the community. A small community-based organization was set up to market the SHS and also provide assistance for the processing of loans.

The South African company Solar Engineering Services (SES) assisted with quality monitoring, preparation of marketing materials, and project management and provided training for installation technicians under contract to SELF.

Financing components:

- To finance the SHS, KwaZulu Financing and Investment Corporation (KFC) provided community loan financing to buyers over three to four years at commercial interest rates. The US Department of Energy provides guarantees for this loan funding.
- A small community-based cooperative took responsibility for marketing SHS, purchasing SHS directly from the supplier, and also providing assistance for the processing of loans.
- The SHSs were imported and sold to households for between R 2500 and R 3000 at a repayment rate of R57 to R82 per month. The SHS were guaranteed for the period of the loan (replacement is subject to payments being up-to-date).

- The South Africa Department of Minerals and Energy provided a partial contribution to project management costs and financial support for project demonstration.
- The Solar Electric Light Fund (SELF), being the programme initiator, provided a portion of the project management funding as well as experience and expertise.
- The South African Government provided core start-up grants to cover project management and project demonstration. Loan guarantees were provided by the US Department of Energy.

This project is generally regarded as a success, mainly based on the fact that the overhead costs for training, supervision, travel, marketing, financing, quality control could be shared over the large number of projects.

Source: db.sparknet.info

An illustration of a combination of consumer finance by microfinancing institutes and the ESCO approach is presented in the section 9.1 “Sri Lanka Energy Services Delivery Project” of this module.

ESCO for EE project funding

The ESCO model also works for EE projects. Being especially known in the United Kingdom, the United States and in some developing countries, ESCOs represent a relatively new means of funding EE capital investments for many parts of the developing world.

An ESCO essentially is a company that helps an enterprise to identify suitable EE projects and assists in project design, equipment selection, project implementation and post-commissioning testing to verify savings.

ESCOs primarily focus on industries whose energy costs represent a relatively high proportion of manufacturing expenses and as such have a strong interest in reducing energy costs. ESCOs aim to activate the savings potential through the use of proven technologies and look for high value projects with a short pay back and a high replication potential. For example, hotels and chicken factories may offer relatively easy savings opportunities for lighting projects, with quick installation and short pay back times, whereas more complex steel mill projects can take much longer to implement and require much greater ESCO administrative costs.

The ESCO will provide funds (all or part) and agree with the host company on terms of repayment. Usually these take the form of profit sharing, so the host company has a minimum of funds to find itself and repays the ESCO out of the savings achieved. The repayment terms will include an element of profit to the ESCO. After repayment has been completed, the host company can continue to save on energy costs for years to come. Other forms of contract are also used, such as equipment leasing.

The key issue for a successful ESCO business is the proper management of risk. There are often a variety of low risk EE investments available in a country and an ESCO (and potential host companies) should avoid high risk and high cost investments. Low risk investments can be highly profitable to the ESCO and the host.

Probably the most obvious example is the improvement of lighting and lamps in hotels, offices and industrial buildings, usually with a major replication potential in similar facilities such as commercial centres, hospitals and schools. Several industries offer savings potential in terms of transformer retrofitting, electric motor and boiler combustion efficiency improvements, power factor correction at motors, insulation packages and waste heat recovery systems.

Box 2. The People’s Republic of China, energy service company project finance fund

ESCOs are a growing industry in the People’s Republic of China (PRC), where they are known as energy management companies (EMCs), supported in part by the World Bank and PRC government development programmes and other market trends. Many ESCOs have been formed in the PRC, but are constrained by a lack of equity and project finance.

This opportunity is being addressed by the Noble Group: a substantial Hong Kong listed company with approximately $4 billion in market capitalization and a $US 12 billion annual turnover. Noble has partnered with the United States’ ESCO finance company, Energy Performance Services (EPS), to form a new company to finance EMC projects in the PRC by purchasing project assets and revenue streams. In addition to the pipeline of projects being developed by the PRC’s EMCs, Noble may generate project deal flow from its existing trade relationships with multiple Chinese industries which are good targets for EE investment.

The Asian Development Bank (ADB) considers investment in this initiative and the possible tools being considered are:

- Equity investment in the new Noble EPS Capital entity, proceeds of which will be used exclusively for the equity component of EE project finance (not working capital);

- Partial credit guarantee, supporting project finance loans from local financial institutions. Technical assistance (TA) tools that would help Noble EPS to develop projects and build capacities of its ESCO investees are also possible.

This type of opportunity could be developed in other countries as their ESCO industries develop. ADB TA programmes to develop ESCO industries could be followed by such an investment.

Source: Report of the Energy Efficiency Initiative, March 2006, www.adb.org

? Review question

Name two financing models for RE or EE project funding and give an example for each of them.

6. EXISTING POLICIES AND REGULATIONS

Private investment occurs when investors can recover the investment made over a reasonable period of time with a profit. Since the financial sector perceives RE and EE projects as involving high risks, high transaction costs and often low returns, there is a need for specific policy intervention to stimulate private sector investment and financing by financial institutions.

The major policy instruments to stimulate financial institutions to play a greater role in RE and EE projects have focused on decreasing the investment costs for project developers and investors, by adopting tax and subsidy schemes favouring RE and EE projects, and more sophisticated market-based support instruments such as quota and feed-in systems. Furthermore multilateral and regional development banks are dedicating specific funds to clean energy investments. These will be described in detail below.

6.1. Fiscal measures

Taxes and tariffs on the one hand can be imposed on specific market actors, e.g. electricity suppliers or grid operators, sourcing development funds which then are used to finance RE and EE projects directly, in the form of instance subsidies, or to provide the funds for the operation of a regulator, or for infrastructure and planning studies.

Fiscal measures on the other hand can be applied to stimulate investments; acting in much the same way as subsidies by decreasing investment costs for project developers, investors and end-users.

The government can allow companies to deduct a percentage of RE or EE investments from their taxable profit.

The same can be applied for end-users with tax breaks when purchasing equipment. Examples include tax breaks for PV and solar water heating systems, heat pumps, double-glazing, insulation, and for more energy efficient electric devices such as refrigerators, washing machines and lighting.

Green taxation

There is a tendency in several European countries to restructure the existing tax system to shift classic forms of taxation towards taxation based on environmental performance. For instance, cars would be taxed based on their emissions (g CO_2 per km) rather than on the horsepower or cylinder content.

6.2. Subsidies

Direct subsidies are often applied by governments and regulators to make investments more attractive to project developers and investors. They are often used as the first economic incentive to trigger the development of new markets, and once the markets become more mature and self-sustaining, the subsidy levels decrease over time or they are replaced with market-based instruments.

It is important for both subsidy and tax schemes to be embedded in a clear and longer term framework in order for project developers and investors to be able to plan their investments and to avoid being faced with sudden changes.

6.3. Market-based instruments

Quota and feed-in systems

Two main types of government policy instruments have been initiated in recent years to create incentives for investment in RE projects: those in which the government guarantees prices or provides a fixed level of subsidy and the market determines the quantity of renewable energy supplied (e.g. feed-in tariff systems); and those where the government guarantees or mandates a given market share or quantity of renewable energy and the market sets the price (e.g. renewable obligation, renewable portfolio standard, mandated market share). Feed-in systems and similar pricing policies were adopted in Austria, Brazil, Canada, China, France, Germany, South Africa, Spain, and Switzerland. Quota systems were introduced in Belgium, Italy, Sweden, United Kingdom and some of the United States.

As for EE, target setting instruments for energy efficiency were developed, including public service obligations for distribution companies, the EU Emissions Trading System, voluntary agreements with industries and the use of white certificates.

For a detailed description of these instruments see modules 10: Regulatory and Policy Options to Encourage Development Of Renewable Energy and 17: Regulation and Policy Options to Encourage Energy Efficiency.

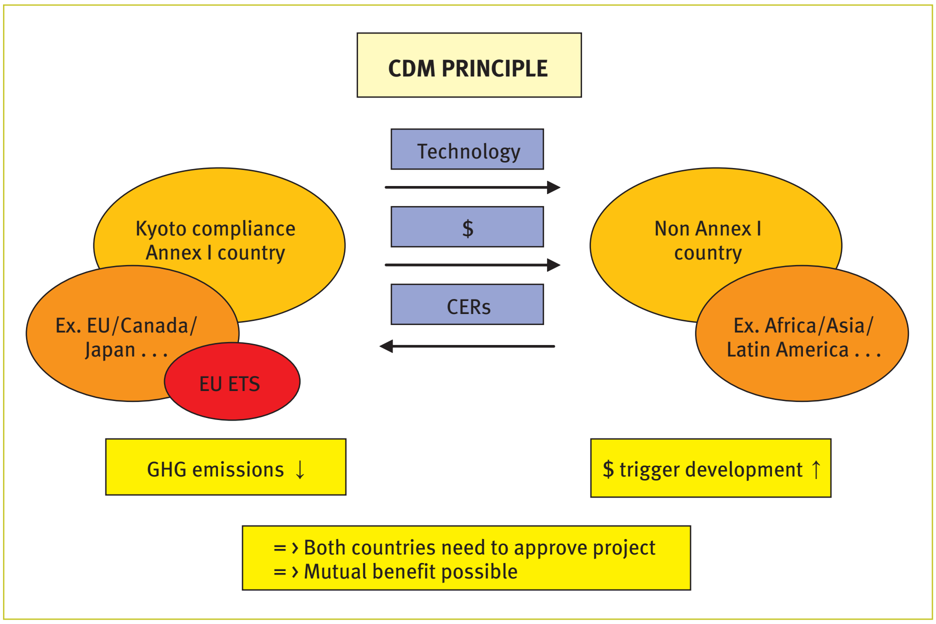
Clean development mechanism

In addition to renewable portfolio standards (RPS) and renewable energy feed-in tariff laws, the Clean Development Mechanism (CDM) under the Kyoto Protocol to the United Nations Convention on Climate Change (UNFCCC) is considered to be an instrument that can open the door to new opportunities for private sector finance in RE and EE projects. CDM allows industrialized countries with a greenhouse gas reduction commitment (so-called Annex II countries) to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries. The CDM is supervised by the CDM Executive Board (CDM EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the UNFCCC.[15]

Approved CDM projects produce Certified Emission Reductions (CERs), which can be traded with businesses, industries, or countries that are not meeting their own CO_2 emission targets nationally.

Although CDM through the income of CERs is not likely to be a key investment driver, it is capable of acting as a catalyst in increasing return on investment, thus providing projects more credibility and facilitating the securing of funds from financial institutions.

Figure III. **CDM principle**



There is a need though to streamline CDM within country policies and financial instruments. Moreover, and of particular interest for African countries, the further development of innovative solutions like programmatic and unilateral CDM

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[15] www.unfccc.org

are expected to address issues, such as the lack of financial resources and infrastructure and the high transaction costs for small-scale projects.

Experiences in Latin America show that such constraints can be overcome through both regional cooperation and active policy support by governments.[16]

6.4. Energy audits and feasibility studies

The lack of RE and EE investments is partly due to the limited information on specific energy consumption data in a given organization and a lack of awareness of the technical solutions available. Energy audits are conducted by energy experts for any industrial, office or household environment and result in a suggested ranking of the main energy savings measures and renewable energy investments that can be taken to reduce energy bills, based on technical and economical criteria.

To increase awareness and activate this potential, energy audits are often funded or even offered free by governments and public agencies, especially for small-scale enterprises and households, which often have a limited understanding of their energy consumption profile. In other cases, energy conservation laws impose the mandatory use of energy audits for specific sectors.

Once an audit has pointed out the main sources of energy consumption in the organization and measures are suggested, a feasibility study is conducted to provide a detailed insight in the pros and cons of a considered measure. Feasibility studies are generally carried out for measures requiring substantial investments and a revision of the technical and organizational set-up.

The feasibility study evaluates the likely costs and benefits of the proposed project and helps to justify both company funds and investments from local, national or international banks or institutions.

A typical feasibility study includes a summary of the proposed budget, an estimate of the rate of return for the investment (presenting the expected cash flows and how the enterprise expects to repay any lending institution involved) and a sensitivity analysis to determine how possible changes for key parameters could affect the rate of return.

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[16] Workshop on Mainstreaming Policies and Investment in Low Carbon: opportunities for new approaches to investment and flexible mechanisms, ESCAP, Bangkok, August 2006.

6.5. Institutional finance

Rather than provide direct support to projects, this policy option consists of creating a financial institute with the specific purpose of investing and funding RE and EE projects, and attracting and channelling funds from various sources into RE and EE sector development. Being capital intensive, the success of RE projects often depends on access to start-up and expansion capital. As a lack of focus for creating an investor-friendly atmosphere to invest in RE technologies is a major barrier for RE and EE technology development in Africa, the creation of this type of institutional finance is often essential for direct incentives such as subsidies and tax breaks to be effective.

Box 3. National resource example: Indian Renewable Energy Development Agency

A dedicated financial institution, such as the Indian Renewable Energy Development Agency (IREDA), can provide both technical guidance and suitable financing to project developers. In addition, IREDA acts as a nodal agency in RE sector financing and is effective in attracting funds from multilateral/bilateral agencies. Special purpose financial institutions for RE operate through instruments such as capital finance, debt and equity finance, lease finance or lending through financial intermediaries. The lending instruments should be able to respond to the needs of various actors involved in the financing of RE. The experience of IREDA in India indicates that such an institution can create confidence in investors and attract funds from multilateral and bilateral institutions. The policy is expected to increase the capital for RE projects and markets, increase manufacturing and after sales service, and ultimately change the perception of mainstream financial institutions that are reluctant to invest in the RE sector. The viability of special purpose financial institutions in the long term is an important issue. In particular, it is necessary to formulate an exit strategy when the market situation is dynamic and other financial institutions start operating in RE sector financing. The exit time is essential for maintaining the primary objective of a special purpose institution, which is to be a front-runner in driving private sector finance—and not a replacement for it.[a, b]

Some Indian states have RE or EE development agencies, such as the Punjab Renewable Energy Development Agency and the Maharashtra Energy Development Agency. Such entities could be sponsors and borrowers of sub-sovereign public sector loans. They would on-lend their funds as debt and project finance to RE and EE projects, using various financial structures.

[a] Structuring RE&EE Projects and Risk Assessment for Investment and Financing—Training for African Development Bank.

[b] Indian Renewable Energy Development Agency Ltd, www.iredaltd.com

Source: www.iredaltd.com

It seems quite clear that in the coming years the multilateral and regional development banks will have a key role to play in mobilizing private sector participation through their investment frameworks. Representatives of both private sector and development banks will discuss specific issues and opportunities for enhancing private sector financing, outcomes being expected at the International Gleneagles Dialogue on climate change in September 2007.[17]

Several regional development banks have recently been starting up specific funds and initiatives in order to increase investment in RE and EE projects.

Asian Development Bank (ADB): the energy efficiency initiative

The ADB recently set up the Asia-Pacific Fund for Energy Efficiency (APFEE) as a vehicle to mobilize donor resources to blend with the ADB's clean energy investments. The target fund size is $US 500 million for the period 2008-2010.[18] The key features of this fund are threefold:[19]

- Activate local finance and mitigate risk: the ADB will provide guarantees and associated funding lines to local EE finance partners for up to 50 per cent of commercial risk and 100 per cent of political risk for eligible EE projects (50 per cent of fund). The rationale is to activate local resources into EE projects and catalyze future investments;
- Access to technology: grants and concessional loans will be provided to finance the additional cost for EE technology. Options include zero or low-interest loans for EE projects, EE equipment production and start-up energy service companies (ESCOs) (35 per cent of fund);
- Capacity-building: provide technical assistance and capacity-building for local partner financial institutions, awareness-raising, etc. (15 per cent of fund).

The Energy Efficiency Initiative (EEI), which was launched in July 2005, is currently in Phase II, where medium-term investment and action plans are being developed.

The target of EE investments covers many diverse and distinct market segments, including investments in energy generation, delivery and end-use equipment, facilities, buildings and infrastructures which deliver higher useful energy outputs or services. The initiative expects to cover both small-sized, widely distributed EE projects, and a small number of high-impact large interventions that will help

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[17] Press release of Financing Clean Energy: A framework for public-private partnership to address climate change, March 2007, www.ebrd.com

[18] Report of the Energy Efficiency Initiative, March 2006, www.adb.org

[19] ADB presentation at UN ESCAP workshop "Mainstreaming Policies and Investments in Low Carbon", Bangkok, August 2006.

establish EE technologies for the next decade. Since the small-sized projects are expected to be numerous, the key challenge will be the design of a suitable management system, with an extremely low transaction cost for loan approval balanced by an effective mechanism for the monitoring and evaluation of results during project implementation and operation (the actual period of energy saving).

The Regional Renewable Energy and Greenhouse Gas Abatement Equity Investment Fund would invest in local clean energy sub-funds, which would be managed by professional fund managers who then would invest corporate and project equity in sustainable energy companies and projects. The regional Clean Energy funds set up by the ADB are summarized in table 1.

Examples of the type of projects being supported by the EEI are given in box 4.

Table 1. Summary of proposed ADB Clean Energy funds

Fund name	Purpose	Main investment modalities	Proposed amount
Asia-Pacific Fund for Energy Efficiency	Support and facilitate investments in EE projects through risk mitigation, increasing access to EE technology and capacity building	Partial credit guarantees; below-market loans and subordinated loans; TA grants	$25 million from ADB; up to $500 million total fund size
Regional Renewable Energy and GHG Abatement Equity Investment Fund	Provide and mobilize equity investments for RE and EE companies and projects	Equity investment in a series of sub-funds, which, in turn will make equity investments in EE and RE projects and companies	$100 million from ADB; maximum investment of 25 per cent in each sub-fund; related TA facility would help prepare investments and build capacities of investee companies
Carbon Market Initiative	Provide financing for qualified EE, RE and GHG abatement projects;support preparation of projects for investment	Purchase CERs and other GHG emissions reduction units generated by qualified projects; the CMI fund could pay up-front for CER deliveries over time, bridging certain delivery and performance risks, so carbon sale can play a greater role in project finance plans; provide TA support	$150-200 million

Source: Report of the Energy Efficiency Initiative, March 2006.

Key:

CER= Certified Emission Reductions, CMI=Carbon Market Initiative, EE=Energy Efficiency.

GHG=Greenhouse Gas, RE=Renewable Energy, TA=Technical Assistance.

Box 4. The Asian Development Bank's Energy Efficiency Initiative: investment concepts and examples

India: Commercial Bank Partial Credit Guarantee for Energy Efficiency Projects Loans

Partial credit guarantees (PCGs)[a] can be offered to local commercial banks to support their lending in target EE sectors. The PCGs would mobilize liquidity in local financial institutions (FIs) by sharing in the credit risk of EE sub-loans from banks who would make loans with their own resources. This structure would build on the recent experience of the ADB's Private Sector Operations Department (PSOD) with a similar small and medium-enterprise (SME) PCG programme in Pakistan. The PCG helps overcome credit risk barriers and expand access to lending to SMEs, industries and energy service companies (ESCOs). In India for example, a large potential for industrial EE has been identified. ADB's South Asia Department (SARD) and PSOD have prepared a study of India's EE market and recommended industrial EE measures.

This would be a private sector investment. Credit risk barriers are a common problem and the PCG instruments could have a broad application. For example, Thailand has also expressed strong interest in a PCG programme. Thailand has an existing Energy Conservation Fund (ECF), with balances of $500 million accrued from oil levies; some ECF funds are being lent on to commercial banks at below market rates for lending to EE projects. A PCG, coupled with bank training on EE finance, and possibly also other TA to help develop EE projects, could expand this programme.

The People's Republic of China (PRC): Electric Utility Power Plant Rehabilitation and Modernization Investment Programme

The PRC's State Power Economic Research Centre has identified 20 GW of small (less than 50 MW) old coal power stations and estimates that 5 GW should be decommissioned. It would be economic to rehabilitate and upgrade the remaining 10 to 15 GW to include cogeneration. These projects have the potential for large efficiency gains and are a government priority.

This rehabilitation project could be a public sector investment and has large potential for replication around the region, not only for thermal plants, but also for small hydropower plants. For example, an ADB public sector investment currently under preparation to India's Power Finance Corporation includes funding for the renovation and modernization of several small hydropower plants as well as the rehabilitation of existing transmission and distribution systems, which, among other goals, will reduce system losses.

[a] A partial credit guarantee represents a promise of full and timely debt service payment up to a pre-determined amount. Typically, the sum that IFC pays out under the guarantee covers creditors irrespective of the cause of default. The guarantee amount may vary over the life of the transaction based on the borrower's expected cash flows and creditors' concerns regarding the stability of these cash flows. www.ifc.org

Source: Report of the Energy Efficiency Initiative, Appendix 8, March 2006.

European Bank for Reconstruction and Development: the Sustainable Energy Initiative

The European Bank for Reconstruction and Development (EBRD), focusing on economies in transition throughout Eastern Europe and the former Soviet Union, launched its Sustainable Energy Initiative in May 2006, aiming to achieve investments in sustainable energy to €1.5 billion in the period 2006-2008.

The initiative essentially works through Sustainable Energy Financing Facilities (SEFFs), which are credit lines or guarantees provided by the EBRD to local banks. Those local partner banks then on-lend the funds to borrowers undertaking sustainable energy projects in the corporate, municipal and residential sectors.[20]

Alongside the credit line or guarantee, technical consultants funded by donors will be engaged to assist prospective borrowers in preparing energy efficiency or renewable energy projects.

Targeted investments in the private sector include cogeneration, heat and steam recovery, automation and control systems, upgrade and replacement of utilities, fuel switching (coal/mazut fuel oil to gas), process optimization and renewable energy investments.

The investment in industrial energy efficiency and renewable energy implies a significant input from private sector financing as EBRD financing does not generally exceed a third of the total project cost. Private sector financing can come from strategic investors or local corporate entities, and from foreign or local banks or funds, which will be co-financing projects alongside the EBRD.[21]

The rationale behind the Initiative is not to subsidize projects that would not be otherwise bankable, but to provide the necessary grant funding to both scale-up and accelerate the pace of sustainable energy investment in order to address a broad range of barriers which currently affect the behaviour of sponsors, borrowers, banks and investors. These barriers include:

- Lack of awareness on technologies and the cost of various investment options over their life-cycle (i.e., taking into account up-front capital and subsequent operating costs);
- Institutional and organizational gaps, such as lack of skills, and capacity to identify, appraise and implement energy-saving measures and investments; regulatory incentives and uncertainty—many investments in this area,

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[20] Sustainable Energy Financing Facilities: Working through the Financial Sector, www.ebrd.com

[21] Sustainable Energy Initiative Summary Document, July 2006, www.ebrd.com

particularly in the power sector, require a long time frame and some are discouraged by prevailing regulatory arrangements (e.g., grid access, cost-plus regulation);

- High transaction costs, particularly for small projects; and the fact that environmental "externalities" such as the emission of greenhouse gases and other pollutants are not reflected in the energy price.

In 2006 around 750 million euro was signed under the SEI. In line with the characteristics and issues of the region covered by EBRD the vast majority of projects (90 per cent) funded were energy efficiency projects.[22]

International Finance Corporation

The International Finance Corporation (IFC) is developing a similar programme with gas distribution utilities in China, which will provide project development, implementation and financing programmes to energy users to implement EE and gas-using projects.

Similarly to the ADB programme, the selected EE projects will be financed by local banks and supported by a partial credit guarantee from IFC.

Hybrid programmes are possible, combining public sector investment with utility and private sector investment.[23]

IFC also runs the $US 100 million Renewable Energy and Energy Efficiency Fund (REEF), which is designed to invest in private sector projects.[24]

African Development Bank

The African Development Bank (AfDB) currently runs several sustainable energy programmes, most notably the Financing Energy Services for Small-Scale Energy Users programme (FINESSE) and the Clean Energy Investment Framework.

The FINESSE programme aims to assist African countries in setting up policy and regulatory frameworks for RE and EE, and to increase the capacity of AfDB staff to deal with the specific nature of RE and EE projects, and to mainstream RE and EE projects into normal AfDB activities.[25]

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[22] Personal communication with EBRD

[23] Report of the Energy Efficiency Initiative, March 2006, www.adb.org

[24] www.ifc.org

[25] finesse-africa.org

The Clean Energy Investment Framework was initiated in July 2005 at the G8 Gleneagles meeting, and is currently being set up by the World Bank and regional development banks, and essentially aims to shift a growing share of investments in the energy sector towards cleaner or more efficient energy technologies. The framework is expected to be fully operational by 2008.

Within the Clean Energy Investment Framework, the AfDB is designing its own plan of action taking into account issues that are particularly important for African countries, notably the increasing vulnerability of ecosystems, societies and economies to environmental and climate risks. Therefore the approach will not only have to facilitate the transfer of finance and technology, but also improve the capacity of countries to adapt to climate change.

On the policy side, the aim is to improve the investment climate and to increase public funding facilities with tariffs and subsidies. The financial institutions are expected to expand existing risk management products in order to mainstream RE and EE finance.

New financial instruments are being considered in order to bring down the initial investment costs and to mitigate technology risks. In order to finance strategic research, venture capital funds could promote the adoption and penetration of new technologies in the market.[26]

Review question

Name different policy options that governments can adopt to decrease investment costs for RE and EE projects.

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[26] Presentation on AfDB Sustainable Energy Activities, A.P. Mhlanga, www.fao.org/forestry/webview/media?mediaId=11351&langId=1

7. DESIGN ASPECTS FOR MEASURES TO ATTRACT PRIVATE INVESTMENT

Box 5. **Private sector perspective**

"The three most important 'deal breakers' to private investors have been found to be:

- Insufficient legal protection and framework for protection of investor rights;
- Lack of payment discipline and enforcement;
- Too few guarantees from governments or multilateral institutions."

Regulation in Africa—Investors and Operators Regulatory Concerns, Mr. T. Horvei, Chief Executive, SAD-ELEC (Pty) South Africa, Report of the Proceedings of the 2nd Annual Conference of the African Forum of Regulators (AFUR), March 2005

Key regulatory risks experienced by investors

- Weak and ever-changing regulatory frameworks;
- Right of government to override regulatory decisions;
- Lack of clarity about power of regulator;
- Regulator without necessary minimum skills, capacity and competence;
- Unilateral regulatory decisions undermining project and investment returns;
- Playing field tilted in favour of dominant industry player (most often a state-owned enterprise).

(Extract from the AFUR discussion paper "Infrastructure Investment and Regulation in Africa—Investors and Operators' Regulatory Concerns" presented at the AFUR 2nd annual conference)

7.1. Institutionalizing clean energy policies

On the institutional side, RE and EE policies and their implementation should be formalized through laws or national programmes approved by the government.

Secondly, public RE and EE agencies should be established to implement national policies, the mission being to:

- Design, implement and evaluate programmes and measures;
- Contract a range of stakeholders, such as companies, local authorities, or non-governmental agencies (NGOs);

- Ensure coordination with higher or lower levels of authorities (international, national, regional and local).[27]

7.2. Decreasing investor investment costs

The first and principal aim for policies and regulations to enhance private sector financing is to shift some of the investment costs away from the investor (e.g. to the public sector). Indeed, most of the policies and regulations described in the previous section essentially aim at reducing investment costs for project developers and investors, as do direct subsidies, tax exemptions, feed-in systems, green certificate schemes and the Clean Development Mechanisms, which all provide an additional income for the project and improve the return on investment.

The design of a set of policies and regulations to improve the profitability of RE and EE projects is not sufficient to activate the private sector though, and it should be backed by additional measures to reduce the perception of high investment/lending risks.

7.3. Increasing investor confidence

However promising the support policy and regulations for RE and EE are, the involvement of the private sector will depend highly on the perceived stability and commitment of the government in the medium and long term. Therefore the government should ideally embed long-term targets and incentives in a solid legal framework in such terms, as a guaranteed certain market size and a guaranteed certain price on any quantity delivered.

The legally provided guaranteed minimum prices for electricity from RE sources for a period of 10 years, as foreseen in feed-in tariff schemes and some green certificate systems, is an example of additional security for investors.

7.4. Decreasing investor risk

As pointed out in box 5, high risks and lack of guarantees are important barriers for the securing of financing for RE and EE projects.

This issue can be addressed by the provision of different types of guarantees from financing institutions and governments, but have to be coupled with the

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[27] Report of the Energy Efficiency Initiative, March 2006, www.adb.org

development of new and innovative risk management and risk financing instruments addressing the specific nature of RE and EE investments.

The development of these tools is expected to increase insight into RE and EE project's risks, thus decreasing insecurity for private investors and improving the attractiveness of RE and EE projects.

Internally, financiers can play their part by evolving from defensive to proactive banking strategies by understanding the business case and the competitive advantage offered by RE and EE funding and by recognizing low carbon-related issues as drivers for developing new products and services, generating additional revenue and increasing market share.

Moreover financiers should ideally develop policies and guidelines for integrating environmental dimensions into the investment strategy; e.g. reflecting the cost of environmental risks in the pricing of financial and risk management products.[28]

7.5. Decreasing transaction costs

As EE and RE projects are often small and distributed across a large number of end-users, the existing procedures in both development and commercial banks involve high transaction costs for these types of projects. A major issue will therefore be to develop strategies and instruments to bring down transaction costs per project.

Especially for Clean Development Projects in Africa, it is hoped that the so-called "programmatic CDM" will address the specific issues of small-scale carbon saving projects.

7.6. Increasing awareness

Last but not least, the policy strategy should always involve an important component of information and capacity-building among key stakeholders, including local bankers and fund managers, but also transmission and distribution system operators, development and electrification agencies, and representatives from the industry.

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[28] Sustainability Banking in Africa, 2004, www.aiccafrica.org

This may consist of the adoption of legislation to support capacity-building and systemic approaches, voluntary agreements, the organization of dissemination workshops for best practices, information campaigns, and the support of energy audits and feasibility studies.

Review question

What are the corner stones of a policy strategy aiming to attract more private sector involvement?

8. LIST OF POTENTIAL DONORS AND FUNDS

The most common options to be explored as sources of finance for RE and EE projects are described below.

8.1. International multilateral funding

Funding is available through multilateral development banks such as the World Bank, the Global Environment Facility (GEF) or the European Commission. This type of formal funding in general is only accessible for governments and not for private developers and most often consists of loans at an interest rate or pay-back periods below commercial averages, and sometimes grants are applied. The large development banks also offer guarantees to mitigate the risk of the project and facilitate other forms of financing (such as loans from commercial sources). Examples include the International Bank for Reconstruction and Development (IBRD) and the International Finance Corporation (IFC).

For CDM and low carbon projects, several "Carbon Funds" were recently established, including the Prototype Carbon Fund, the Community Development Carbon Fund and the Carbon Fund for Europe.[29]

8.2. Regional development banks

Regional development banks act in much the same way as multilateral development banks, and focus on a specific continent or region. Examples of formal regional development banks include the Asian Development Bank (ADB), the African Development Bank (AfDB), the European Bank for Reconstruction and Development (EBRD), the Inter-American Development Bank (IADB), the Islamic Development Bank (IDB), the East Africa Development Bank (EADB), and the Development Bank of South Africa.

Examples of private regional development banks are the Atlantic Development Group for Latin America (ADELA) and the Private Investment Company of Asia (PICA).

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[29] For a full list see carbonfinance.org

8.3. Bilateral agencies

Apart from multilateral organizations, developed countries through their development programmes often provide funding to developing countries. Examples include the Department for International Development (DFID, UK), the *Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung* and the *Gesellschaft für Technische Zusammenarbeit* (BMZ and GTZ, Germany), the Agency for International Development (USAID, USA), the International Cooperation Agency (JICA, Japan), and the Agency for International Development (AusAID, Australia).

This type of funding is generally only accessible for governments, and, due to political priorities or historical relations, often specifies preferred target regions or countries.

8.4. Government finance

In many developed countries, public funding is still the most important source of financing for RE and EE. This funding is usually provided in the form of loans or grants, and is combined with financing from multilateral and bilateral organizations.

8.5. Private sector finance

Commercial banks

Provided that a proper business plan, acceptable risks and returns on investment can be presented, commercial sources can be interested in financing RE and EE projects through loans and equity investment.

Commercial financing organizations apply market conditions in terms of pay-back periods and interest rates, thus making it harder for project developers to secure the financing, but on the other hand this form of financing is still usually more flexible than funds from multi and bilateral organizations.

Ethical banks

Some banks provide funding for sustainable projects in both industrialized and developing countries. Examples include Triodos Bank and Cooperative Bank. Most of the classic commercial banks have recently developed specific ethical products.

In 1999 the Dow Jones Sustainability Indexes were launched to provide reliable and objective benchmarks for leading sustainability-driven companies worldwide.[30]

Microfinance banks

Local communities, both in urban and rural areas, are emerging actors in the financing of clean energy, especially for the low-scale application of RE products and technologies. This trend takes the form of microfinance or community-based "green funds" as mechanisms of consumer financing.

8.6. Private foundations and charities

Private foundations include for example the Shell Foundation, an independent, grant-making charity created by Royal Dutch/Shell in June 2000, providing capital in the form of grants or soft loans for a range of socially responsible projects. Part of the Shell Foundation is the Breath Easy Kenya Fund, aiming to develop market-based solutions that get smoke out of kitchens. Concepts being tested include consumer credit and enterprise financing for cleaner fuels and more efficient stoves.

E&Co is an independent non-profit organization established in 1994 with the strategy of providing enterprise development services and modest amounts of money (up to $US 250,000 in the form of loans and equity investments) to economically, socially and environmentally sustainable energy enterprises in developing countries.[31]

An overview of the different sources and types of funding are summarized in table 2.

Table 2. Matrix of financing instruments

	Market-based loans	Soft loans	Grants	Equity investments	Guarantees	Technical assistance	Other
Multilateral development banks	X	X	Some	Some	X	X	
Bilateral aid	X	X	Some			X	
Funds/foundations	X	X	X	Some			
Green investment				X			X
National development funds	X	X			X	X	
Commercial loans and investment	X			X			

Source: IEA PVPS, Sources of financing for PV-Based Rural Electrification in Developing Countries, 2004

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[30] www.sustainability-index.com

[31] Sources of financing for PV-Based Rural Electrification in Developing Countries, IEA PVPS, 2004, www.iea.org

9. EXAMPLES

9.1. Sri Lanka Energy Services Delivery Project[32]

The Energy Services Delivery (ESD) project was set up in 1997 to finance renewable energy implementation in Sri Lanka. Core funding to design and build capacity for the ESD came from the World Bank's Asia Alternative Energy Unit, and the Sri Lankan Government. One of the major components of ESD was a national solar home system (SHS) promotion and implementation programme. The SHS programme involved several stakeholders and service providers at various levels. Other players included the SHS dealers and participating credit and microfinance institutions (MFIs). Financing for the SHS was provided through a loan from the World Bank that was distributed through national financial institutions and a grant provided by the Global Environment Facility (GEF) to subsidize the cost of each system. The grant reflected the environmental value of SHS over competing fossil fuel alternatives.

The Development Finance Corporation of Ceylon (DFCC) provided a monitoring programme to ensure that all systems were in fact installed, that they were installed properly and that they were functioning to specifications. The Sri Lankan government has linked its rural electrification programme to the market-based SHS programme, thus lending credibility to the private sector and increasing consumer acceptance. The government has also acted to promote the programme through legislation. It has modified standards twice, each time allowing smaller systems, better suited to consumer demand and solar insolation in the country.

The project supported the creation of a Solar Industry Association (SIA), whose members include dealers and microfinance institutions. The SIA communicates with the project, the World Bank, the government, and the national utility board on matters affecting its members. Currently, the SIA is addressing training and accreditation issues.

One of the key partnerships in the national programme was established with the Sarvodaya Shramadana Society, one of the largest NGOs in Sri Lanka with an extensive network of rural contacts. SHS financing is provided through Sarvodaya Economic Enterprise Development Services (SEEDS),[33] the NGOs finance arm, while its technical division Rural Technical Services (RTS) fulfils the role of SHS dealer.

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[32] International Financing Facilities, Training for African Development Bank, IT Power, 2006.

[33] www.seeds.lk

The distribution process is as follows:

- Photovoltaic supplier introduces customers to SEEDS;
- SEEDS complete a credit appraisal; customers sign credit agreements if accepted;
- SEEDS pays the supplier and is responsible for repayment from customers. The supplier receives 20 per cent up-front
- The supplier installs the system and forwards “Customer Acceptance Certificate” to SEEDS;
- SEEDS pays the balance of the loan to the supplier. The dealer provides technical support.

Financing mechanism

The SHS programme is executed by the Development Finance Corp. of Ceylon (DFCC) Bank of Sri Lanka. The financing has two components: $US 19.7 million from the International Development Agency as credit and $US 3.8 million in grants from GEF. The former is distributed as 10-year loans by refinancing through participating credit institutions and MFIs. Credit lines provide 80 per cent refinance with 10-year repayments. The GEF grant is used for a co-financing scheme in the form of a capital subsidy to reduce the initial cost and covers other costs, such as consultants. The GEF grant provided capital subsidy in the following amounts:

- $US 70 for system capacities of 20-30 Wp
- $US 100 for system capacities of 30-45 Wp
- $US 150 for system capacities of › 45 Wp

The initial cost of a system was approximately $US 11/Wp. As local suppliers entered the market, the price dropped to $US 10/Wp. Initially a 30 Wp system would have cost $US 330—and with the subsidy of $US 70 (grant) it would cost $US 260.

The three basic financing models used for dissemination are as follows:

- SHS Consumer financing by dealers: this arrangement saw credit extended by financing organizations directly to the SHS dealers. Subsequently, the dealers completed the marketing, technical support and finance management. This method was largely found to be untenable because dealers were not equipped to manage customer financing, and did not have an extensive network in the rural areas to facilitate collection and communication.
- SHS fee-for-service: This arrangement saw the dealers install SHS systems but maintain ownership, instead of collecting a monthly fee from customers.

The dealer found that the collection costs were high and that lack of ownership often translated into poor maintenance.

- Consumer financing by MFIs: under this arrangement, a project developer/dealer approaches the MFI with a project, which the MFI evaluates. If accepted, the MFI applies to the DFCC for refinancing. The MFI pays the dealer/developer for installed systems. Eighty per cent of this loan can be refinanced. The MFI designs a consumer loan package (for end-users), including an initial down payment, with monthly payments following. The benefits of this method include: freedom of dealers to focus on marketing and technical support (and not financing), freedom of private sector and NGOs, who often have extensive rural networks, to manage financing. SEEDS is an example of an MFI. The initial failures of dealer financing and fee-for-service models show that grassroots infrastructure is a significant enabling factor for successful implementation.

9.2. Kenya solar home systems—SACCO financing[34]

Muramati is a savings and credit cooperative (SACCO) for farmers in the tea sector. With a membership of over 30,000 farmers, Muramati offered the opportunity to explore expansion of the solar market and to test a rural financing scheme in Kenya.

SACCOs operate on a similar basis to credit unions and are instrumental in providing basic financial services to groups typically excluded from the conventional mainstream banking sector. In the case of Muramati, the membership consists of 15,000 farmers in the tea and coffee industry. PV systems will be installed and maintained by ASP (K) Ltd, a Kenyan solar company with over 20 years' experience in the sector, which is expanding its infrastructure into the region to service the project.

The Photovoltaic Market Transformation Initiative (PVMTI)[35] has committed a total of $US 0.6 million in loans and grants to the project to co-finance Muramati's new programme of solar loans. Within a short span of time, the company was successful in financing installations of 180 systems. However, Muramati's operations have been fraught with challenges, ranging from adverse economic developments, component failure on early installations, difficulty in providing timely and speedy after-sales services due to geographic terrain, etc.

One of the important initiatives to address the raised issues has been to train local freelance technicians to provide maintenance services for the systems

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[34] PV MTI, Newsletter August 2006, www.pvmti.com

[35] www.pvmti.com

installed in the region. Even though growth has been sluggish, Muramati has decided to mainstream PV as one of its loan products and to continue working with the local freelance PV technicians already trained under PVMTI.

9.3. Morocco—PV rural electrification programme[36]

The project encompasses the introduction by Salafin SA of a credit scheme to support sales of PV systems in rural areas of Morocco. Salafin is a subsidiary of Banque Marocaine du Commerce Extérieur, a leading Moroccan financial services group, and has established a strong reputation for the successful introduction of innovative new credit products.

The project has enabled Salafin to enter the rural credit markets by sharing the risk of this new venture and by establishing a strong partnership with Afrisol, who have the rural network essential to market the loans and to collect repayments, and other IFC-approved technical service providers. In addition to installation and maintenance of PV systems, Afrisol will assist in marketing the loans, collecting information required for credit appraisal, and collecting loan repayments.

IFC has committed a total of $US 1 million as a guarantee facility and grant to support the project. The guarantee facility aims to reduce to an acceptable level the risk to Salafin of entering the fledgling market for solar loans by covering a proportion of end-user defaults.

Within the framework of this programme, some subsidy is provided, and consumers pay a monthly instalment for a period of 10 years under a fee-for-service scheme.

It is believed that rural credit markets represent an attractive potential for new business, as the majority of households cannot access financial services from mainstream banks.

The direct supply of SHS through small entrepreneurs, mostly at weekly marketplaces, is well established. Sales volumes have however reduced substantially in recent times as a result of price increases in solar modules, and the expectations of some villages of being included in the national programme for electrical grid expansion. The installed capacity of PV systems in the country was around 7 MW in 2003; it is expected to increase to around 15 MW by 2010.

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[36] PV MTI, Newsletter August 2006, www.pvmti.com

9.4. Asia Regional Initiative, bagasse cogeneration[37]

There are opportunities for region-wide initiatives in target sectors that have common sustainable energy technology solutions. A good example is bagasse cogeneration, using proven technology that can typically produce thermal energy for sugar processing and power for site use and/or grid sale at a very economical cost. Bagasse is typically burnt at very low efficiencies, and has minimal alternative productive uses. The Asian Development Bank's (ADB) regional Technical Assistance (TA) to Promote Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (PREGA) programme studied these opportunities in Bangladesh, Indonesia and Viet Nam. Extrapolating those results to developing member countries (DMCs) where production of sugar cane is known, the additional capacity available from installing modern bagasse cogeneration plants would be 100 MW in Bangladesh, 500 MW in Viet Nam, 1,000 MW each in Indonesia and Philippines, 2,000 MW in Pakistan, 4,000 MW in PRC and 10,000 MW in India. Of course, developing this potential requires significant work, and for power sales, an enabling regulatory and legal framework would be necessary. Further issues exist with respect to the creditworthiness of sugar industries. The scale and breadth of the opportunity warrants exploration. Approaching the development of such projects systematically, in collaboration with respective DMC government agencies and possibly private sector project developers, could lower transaction costs, aggregate projects for development and finance, build targeted project development capacities, and accelerate their development. Other areas where such regional opportunities exist include the utilization of rice husks; waste manures from piggeries, poultry and livestock operations and municipal solid waste. Both public sector and private sector investments could be applicable in these areas, and could be coupled with the investment programmes identified above.

9.5. China's industrial state-owned enterprise energy efficiency project lending programme[38]

The People's Republic of China (PRC) Medium and Long-Term Energy Conservation Plan (January 2005), issued by the National Development and Reform Commission (NDRC) identifies EE investment in energy-intensive state-owned enterprises (SOEs), such as iron and steel, cement, petrochemicals, aluminium, pulp and paper, as a national priority. Compared with the industrial country averages, energy use per unit of production in the PRC is 21 per cent higher in steel, 45 per cent higher in cement, and 31 per cent higher in ethylene. Priority investments identified by the NDRC include *(a)* waste heat recovery power generation

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[37] Report of the Energy Efficiency Initiative, March 2006, www.adb.org

[38] www.adb.org

in the cement industry, *(b)* power generation from blast furnace gas in the steel industry, *(c)* bio-mass cogeneration in the pulp and paper industries, and *(d)* motor/drive system efficiency investments in all the above. Typical individual project sizes will be $US 10-20 million. Many EE measures have common applications within particular industries. Industry-wide applications could be designed to promote common technical solutions, and thereby reduce transaction costs. NDRC agencies responsible for EE have begun developing a pipeline of projects.

An ADB public sector investment programme could be designed to address these investment needs. The loans could be coupled with technical assistance programmes to help develop projects, and also potentially, some government capital subsidies. There is a potential application for a multitranche financing facility, as the investment programme would consist of a series of subprojects, each taking considerable time to develop, and/or sub-sovereign loans direct to the SOEs themselves, subject to credit approval. Alternatively, loan funds could be lent to commercial banks or China Development Bank for on-lending to the SOEs. The commercial banks would then bear the credit exposure. This approach would also encourage greater commercial bank EE lending experiences. ADB must analyse whether this method can offer a competitive fund cost to borrowers. Longer loan tenors facilitated by ADB funding could provide important developmental benefits to both banks and borrowers. Similar investment opportunities exist with SOEs across the region.

Discussion questions

Bearing in mind the corner stones for a strategy to increase private sector investments, analyse and discuss the current situation in your country.

Based on your experience, what are the main barriers for increased private funding? Which measures can be taken by whom to overcome these barriers?

10. CONCLUSION

The financier’s perspective and approach towards RE and EE investments is based on the assessment and control of risks on the one hand, and the calculation and estimation of returns on the other. The resulting risk/return profile determines the attractiveness for the investor, highlights the remaining uncertainties and establishes the conditions for the project developer to secure the financing.

A range of funding options and combinations is available, including debt, loans, equity, grants and guarantees. Different models are available and have been tried, from models coordinated and managed by governments, with or without some form of interaction with private market players, to the ESCO models, which involve a higher degree of market participation.

A strategy aiming to attract more private sector funding should provide the following incentives:

- Lower investment costs for investors and project developers: instruments include subsidies, tax measures, feed-in or quota schemes and a use of the Clean Development Mechanism;
- Fewer risks for investors: governments and development organizations can provide guarantees, while private investors should get familiar with the specific nature of RE and EE projects in order to better assess, control and price the risks and returns;
- More investor confidence by adopting legal frameworks setting long-term targets and incentives;
- More awareness: there is a clear need for capacity-building among a range of stakeholders, including local bankers, industries, transmission system operators, electrification agencies and NGOs;
- Lower transaction costs by developing new and innovative tools to address the often small-scale nature of RE and EE projects. The first initiatives have appeared recently, introduced usually by regional development banks. When successful, these new approaches could be capable of triggering the involvement of commercial banks.

Existing and upcoming examples include rural electrification programmes, for instance in Sri Lanka and Kenya, and energy conservation programmes in the energy intensive industries of China and India.

LEARNING RESOURCES

Key points covered

This module covers the following key points:

- General understanding of how the financial sector perceives RE and EE investments;
- Different types of funding;
- Options for funding models and examples for RE and EE investments;
- Analysis of existing policies and regulations to increase RE and EE investments;
- Cornerstones of a policy strategy aiming to attract private sector capital;
- List of possible donors and fund resources.

Answers to review questions

Question: List the different types of financing and think of the (combination of) types that were used to finance a RE or EE project in your country.

Answer:

Debt

Equity

Grants and guarantees

Question: Name two financing models for RE or EE project funding and give an example for each of them.

Answer:

1. Model managed and overlooked by the government—examples are PRONASOL in Mexico, the rural electrification programme in Chile and the village power programme in China
2. Market-based models include consumer finance, leasing and the ESCO or fee-for-service model. Examples of ESCOs include Soluz in Honduras and Dominican Republic for PV, SELCO and E&Co for India, Sri Lanka and Vietnam, and the small hydropower programme and EE ESCOs in China.

Question: Name different policy options that governments can adopt to decrease investment costs for RE and EE projects.

Answer:

1. Investment subsidies
2. Tax breaks
3. Feed-in or quota/certificate systems
4. Clean Development Mechanism (CDM)—governments can stimulate and assist sectors to take part in the CDM process

Question: What are the cornerstones in a policy strategy aiming to attract more private sector involvement?

Answer:

1. Institutionalize RE and EE policies
2. Decrease investment costs
3. Decrease investor risks
4. Decrease transaction costs
5. Increase investor confidence
6. Increase awareness

Exercise

After having read the text below answer and discuss the following questions:

- What were the critical issues to the success of this community energy project?
- What part did financing play in making this project a success?
- What lessons can be drawn from this case study for future investment models?

Write a 2-3 page essay answering these questions.

Microhydro for community projects, Mburiri Village, Kenya—an example of effective community participation in a RE and EE project

The project involved diverting flow from the Tungu River through a microhydro plant that provides electricity for an enterprise centre (a new building housing local enterprise). The Tungu-Kabiri Community Micro Hydropower Project was formed to own and operate the microhydro scheme. Shares in the project were issued to local residents in return for cash and/or labour. The organization sets its own tariff which it charges the centre.

The objectives were to improve livelihoods and to provide communities with energy for commercial activities. At present, the energy is distributed only to the Enterprise Centre as power is only allowed to be distributed to households by the Kenya Power and Lighting Company—the national utility. Implementation was undertaken by the Ministry of Energy (Dept. of Renewable Energy) and the Intermediate Technology Development Group (ITDG-East Africa), with funding support from UNDP-GEF. The project was part of a national project to assess the potential of micro-hydro power. The village of Mbuiru was selected from a list of candidate project sites based on predetermined characteristics. Core funding was provided from the UNDP-GEF small grants programme.

Extensive support was provided by the community during the consultation process. Local labourers donated one day per week to the construction of the facility.

Financing mechanism

The community raised funds to acquire land, donated materials and labour to the project, and paid cash for required licences and shipping of materials to the community. Two hundred community members each bought $US 50 shares in the micro enterprise. ITDG provided advice to the enterprise regarding implementation of tariffs for the use of power and rent for the use of stalls in the micro-enterprise centre. The community has complete ownership of the facility. ITDG secured funding from the UNDP-GEF small grants programme ($US 63,700) and other donors, as well as providing technical expertise. Government support was also provided (both technical and other assistance) by the Ministries of Energy, Land, Water, as well as the Social Service Department and the local government authority.

Presentation

Presentation: Finance—Module 20: Financing Options for Renewable Energy and Energy Efficiency

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African Institute of Corporate Citizenship, Sustainability Banking in Africa, 2004, www.aiccafrica.org

INTERNET RESOURCES

World Bank, Carbon Finance Unit: carbonfinance.org

Asian Development Bank: www.adb.org

Multilateral Investment Guarantee Agency (MIGA): www.miga.org

Rural Energy Enterprise Development (REED): www.uneptie.org/energy/projects/REED, www.areed.org

European Bank for Reconstruction and Development: www.ebrd.org

World Bank Group, International Finance Corporation: www.ifc.org

African Development Bank, www.afdb.org

GLOSSARY/DEFINITION OF KEY CONCEPTS

Energy efficiency	Energy efficiency investments are defined as economic investments in energy generation, delivery and end-use equipment, facilities, buildings, and infrastructure that deliver higher useful energy outputs or services (e.g., lighting, heating, refrigeration, pumped water). Market segments include: supply-side efficiency in generation, transmission and distribution; industrial energy efficiency, including changes in production technology; building end-use efficiency in commercial, governmental and residential sectors; municipal infrastructure (street lighting, water, waste and sewage); transport efficiency, including urban mass transit; bio-fuel use to substitute for fossil fuels; irrigation (e.g., efficient pumps, foot valves and piping); and equipment/appliance standards.
Energy service company (ESCO)	An ESCO is a company offering to reduce a client's energy costs by implementing measures, which reduce energy consumption and costs in a technically and financially viable manner. The cost savings are usually split with the client through an energy performance contract or a shared-savings agreement.
Equity investment	The buying and holding of shares of stock on a stock market by individuals and funds, in anticipation of income from dividends and/or capital gain as the value of the stock rises. It also sometimes refers to the acquisition of equity (ownership) participation in a private (unlisted) company. When the investment is in infant companies, it is called venture capital investment, which in general means to be higher risk than investment in listed companies.

Financing	The process of gathering funds through grants, loans, equity investment or other means.
Renewable energy sources	Renewable non-fossil and non-nuclear energy sources, including wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

ANNEX I. SCREENING ENERGY EFFICIENCY PROJECTS USING FINANCIAL AND ECONOMIC RATES OF RETURN

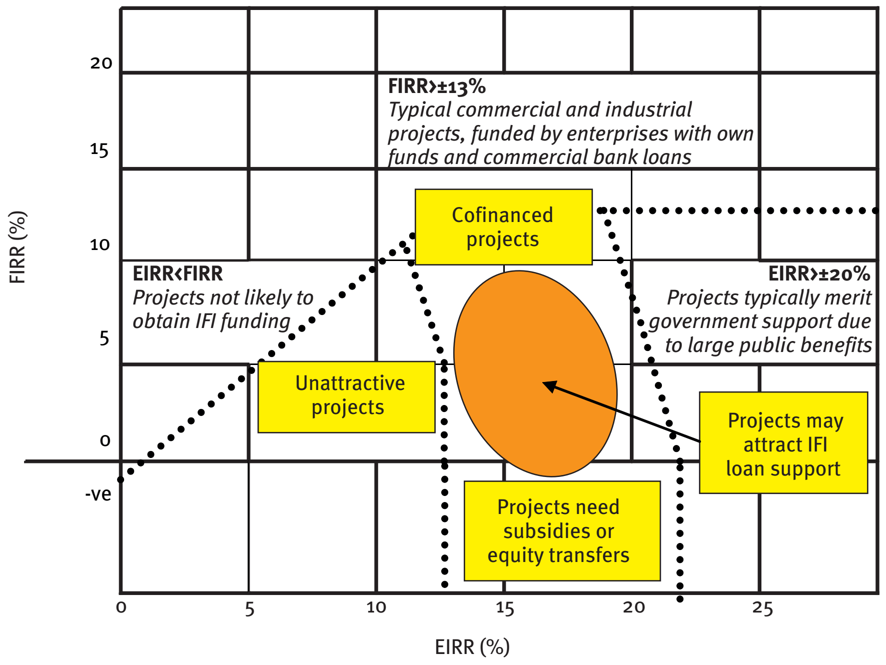
Criteria for screening EE projects

Enterprises will have their own procedures for evaluating potential investment projects and these will typically be focused on the financial internal rate of return (FIRR) for a project. This is the return that an enterprise will expect, based on capital expenditures and on the value of energy savings achievable. Items such as improved environmental emissions will not normally be included in the calculation. If these environmental benefits are included—and this is not always easy to do—then an economic internal rate of return (EIRR) can be computed to reflect the return to society as a whole.

Most companies will set a lowest allowable FIRR based on their cost of capital (broadly speaking, the interest rate payable to borrow money). If a project FIRR is greater than the lowest limit, the project will be looked upon favorably by management. Provided funds are available, the project would normally be implemented. However, even for projects with a low FIRR, the EIRR may be large enough to persuade an international financial institution (IFI, such as the World Bank) to lend money because the overall benefits to society are good.

Figure I compares the EIRR and FIRR for projects and suggests an “area” where a project might be supported by an IFI.

Figure I. Funding possibilities for projects with low FIRR



In summary, the figure indicates those projects with high FIRR (above say 13 per cent, for discussion purposes, typically industrial or commercial projects) will attract funding by the enterprise or utility itself, depending on other investments competing for funds. For projects with FIRR below 13 per cent, the EIRR needs to be evaluated. Where potential projects have an EIRR less than their FIRR, it is very unlikely that these can justify any funding support, by IFIs or anyone else. These projects are to the left of the dotted diagonal line.

Although some projects may have a modest FIRR (say less than 13 per cent) they could have large public benefits and their EIRRs will therefore be high. Those projects with high EIRR's could attract government support to achieve the public benefits through project implementation, and lie to the right of the "frontier" illustrated as a dashed line in the exhibit.

Projects to the left of this frontier line will have moderate FIRR values and lower EIRRs. Those projects with relatively high FIRRs (but not high enough to be funded by private sources) may be funded through co-financing to reduce non-project risks and to reduce repayment risks to individual lenders. If several lenders are willing to back a project, it provides a signal that key political factions are supportive. Co-financing appears to be an important element of many loan guarantees because it signals that the enterprise, local authorities and provincial authorities support the project and will do what they can to make the project a success.

Projects with very poor FIRR but attractive EIRR (for example, a hazardous waste facility that is a public service but is barely profitable or losing money) are not likely be funded using loan guarantees. While schools, roads and other public projects may be funded through loans, a private money-losing venture is not likely to be viewed in same way. Private ventures most likely will be expected to pay back their borrowings out of project income. This argues that subsidies will be required to increase the FIRR to levels sufficiently high to attract outside investors. Attracting IFI funding may require the smallest subsidies since IFIs generally can accept projects with a low FIRR.

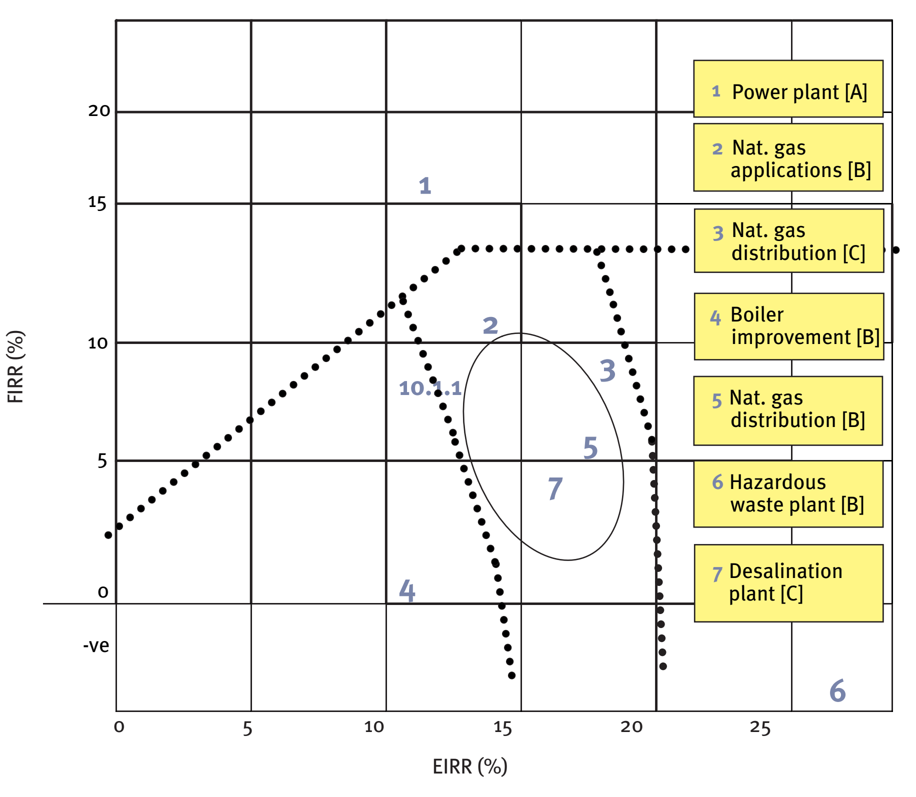
A second "frontier" line (combined dots and dashes) marks the lower limit of project EIRRs below which it is very unlikely that public benefits from a project would be attractive to government. The area between the "frontiers" represents the zone in which most projects that can attract IFI financial support will fall. IFI lending is likely to be concentrated on projects (or packages of projects) that meet a threshold in size sufficient to overcome possibly large transaction costs of negotiating the loan, have medium to high EIRR but relatively modest FIRR, that need funding for relatively long periods of time, and that can be guaranteed by local or national governments (often a prerequisite for a loan).

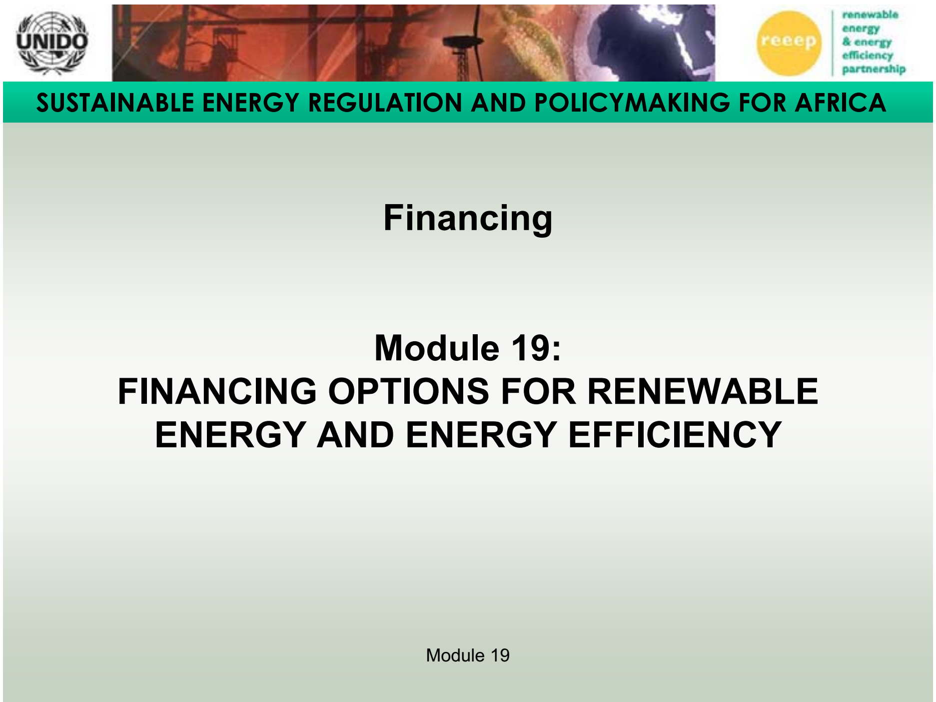
Examples of projects

To illustrate a range of energy and environmental projects, none of which, other than number 1, has a sufficiently high FIRR to lead to investments by the enterprises themselves. Figure II below shows several typical projects (actually identified in China, ADB project, 2002). These are:

No.	Project	City	Remarks
1	Power plant expansion	A	Large, privately funded joint venture
2	Natural gas applications for industrial plants (miscellaneous equipment)	B	Very small investments
3	Natural gas distribution extension	C	Large investment but no loan guarantee (municipality not interested in IFI loan)
4	Environmental improvement by upgrading boilers	B	Very small investment
5	Gas distribution system extension	B	Small county-level investment.
6	Hazardous waste treatment facility	B	Modest investment; needs subsidies
7	Desalination plant	C	Modest investment

Figure II. **Examples of typical projects**



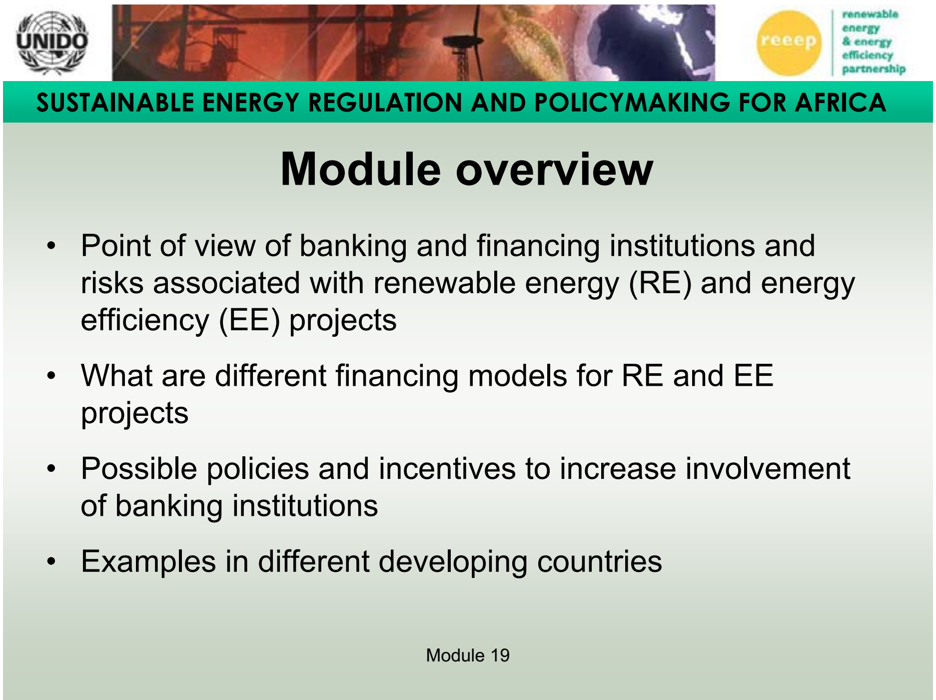


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing

Module 19:
FINANCING OPTIONS FOR RENEWABLE ENERGY AND ENERGY EFFICIENCY

Module 19

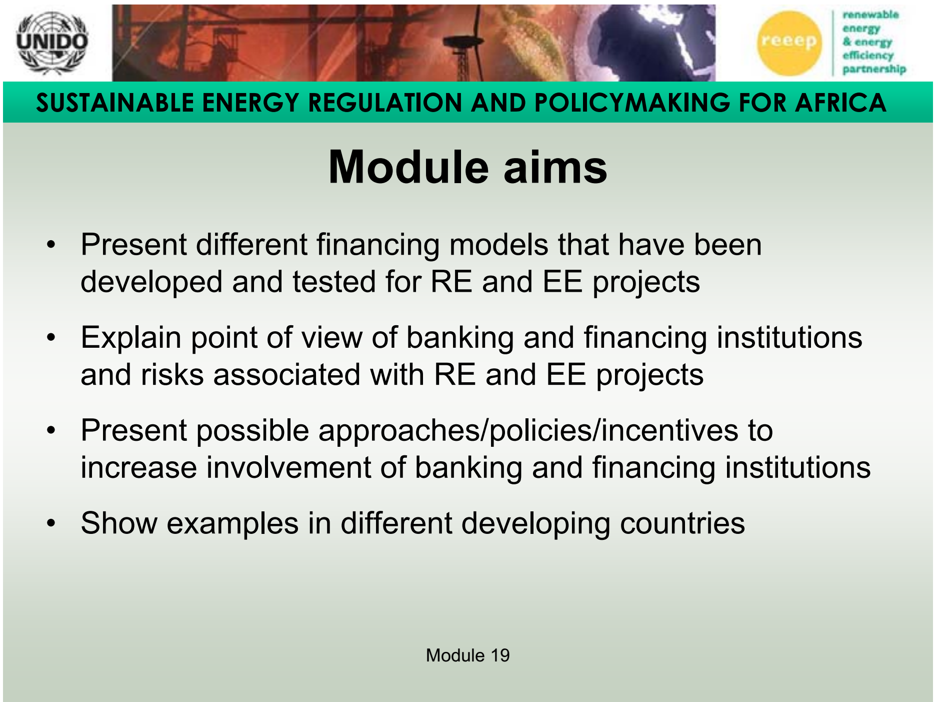


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module overview

- Point of view of banking and financing institutions and risks associated with renewable energy (RE) and energy efficiency (EE) projects
- What are different financing models for RE and EE projects
- Possible policies and incentives to increase involvement of banking institutions
- Examples in different developing countries

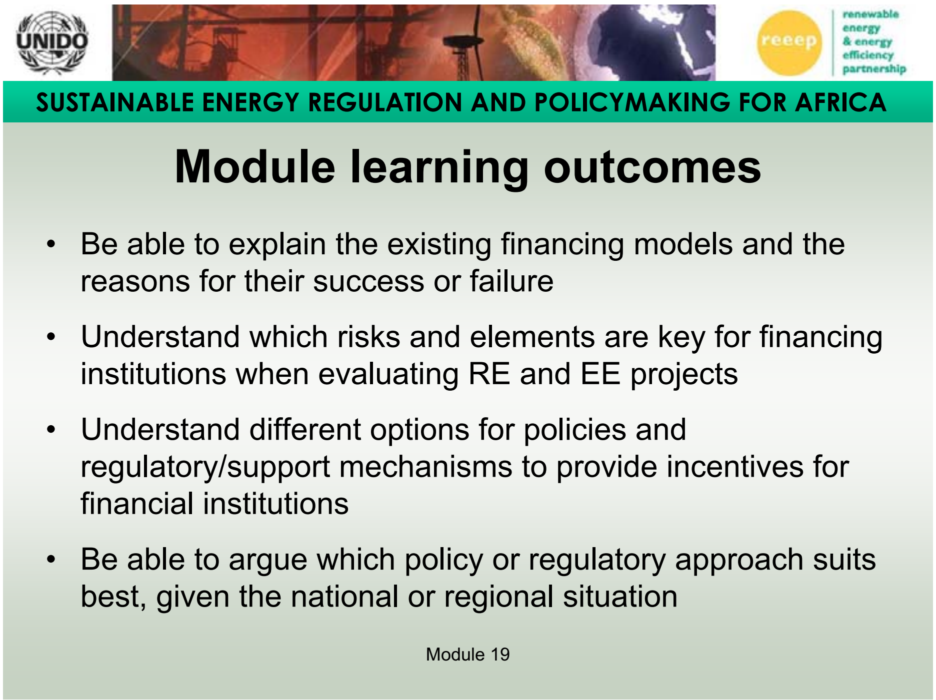
Module 19



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module aims

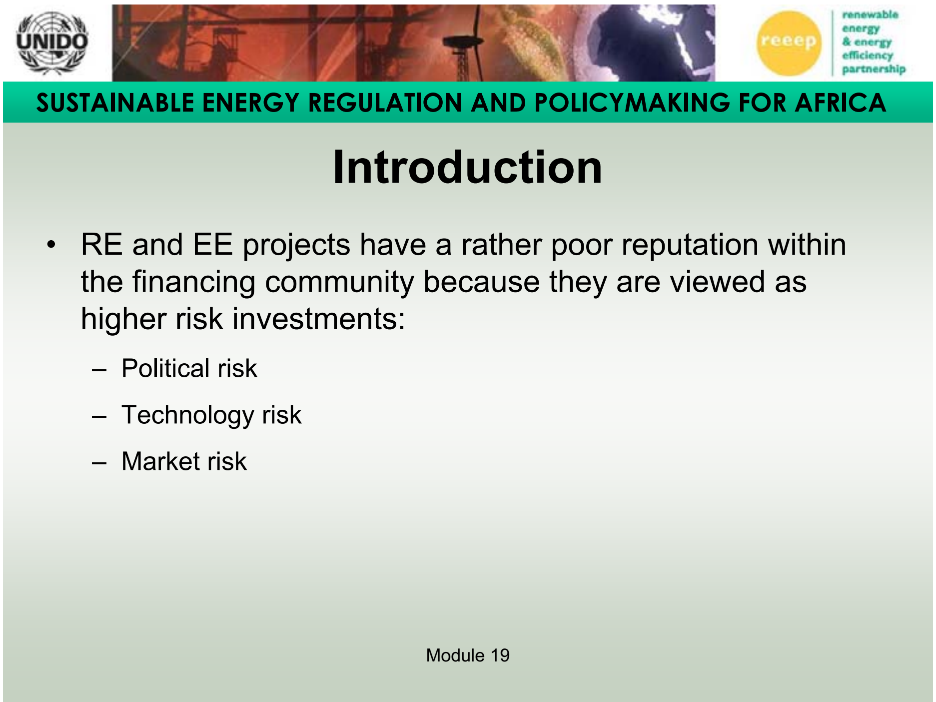
- Present different financing models that have been developed and tested for RE and EE projects
- Explain point of view of banking and financing institutions and risks associated with RE and EE projects
- Present possible approaches/policies/incentives to increase involvement of banking and financing institutions
- Show examples in different developing countries



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Module learning outcomes

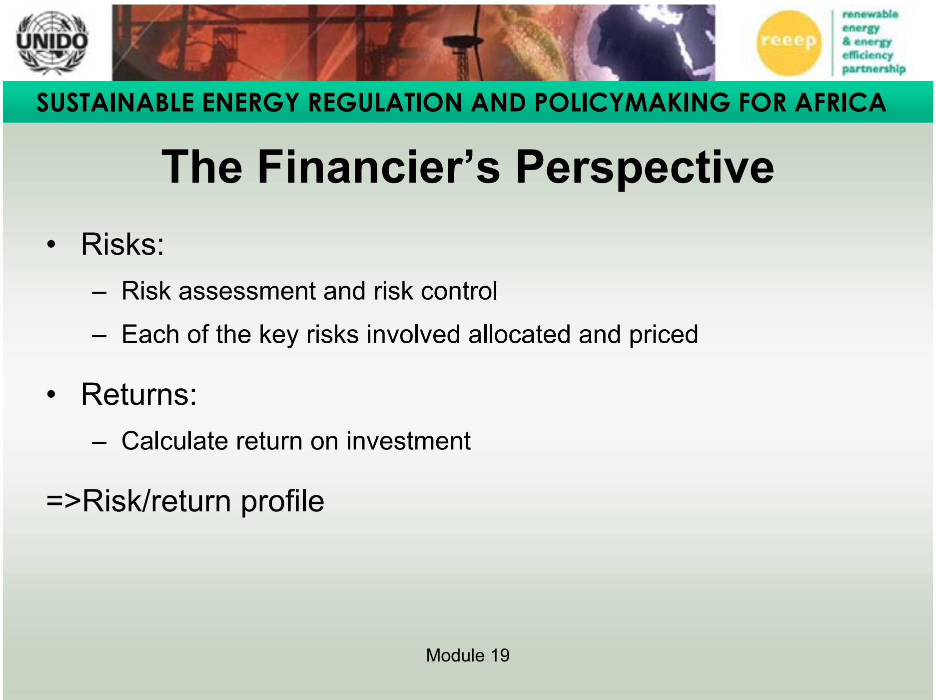
- Be able to explain the existing financing models and the reasons for their success or failure
- Understand which risks and elements are key for financing institutions when evaluating RE and EE projects
- Understand different options for policies and regulatory/support mechanisms to provide incentives for financial institutions
- Be able to argue which policy or regulatory approach suits best, given the national or regional situation



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Introduction

- RE and EE projects have a rather poor reputation within the financing community because they are viewed as higher risk investments:
  - Political risk
  - Technology risk
  - Market risk

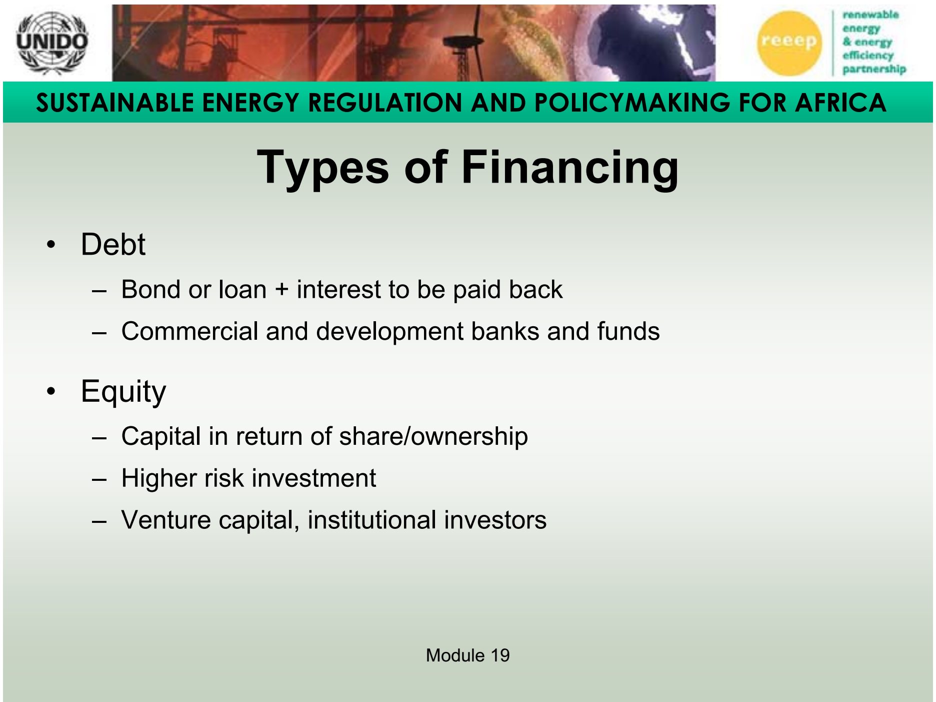


SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

The Financier's Perspective

- Risks:
  - Risk assessment and risk control
  - Each of the key risks involved allocated and priced
- Returns:
  - Calculate return on investment

=>Risk/return profile



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types of Financing

- Debt
  - Bond or loan + interest to be paid back
  - Commercial and development banks and funds
- Equity
  - Capital in return of share/ownership
  - Higher risk investment
  - Venture capital, institutional investors

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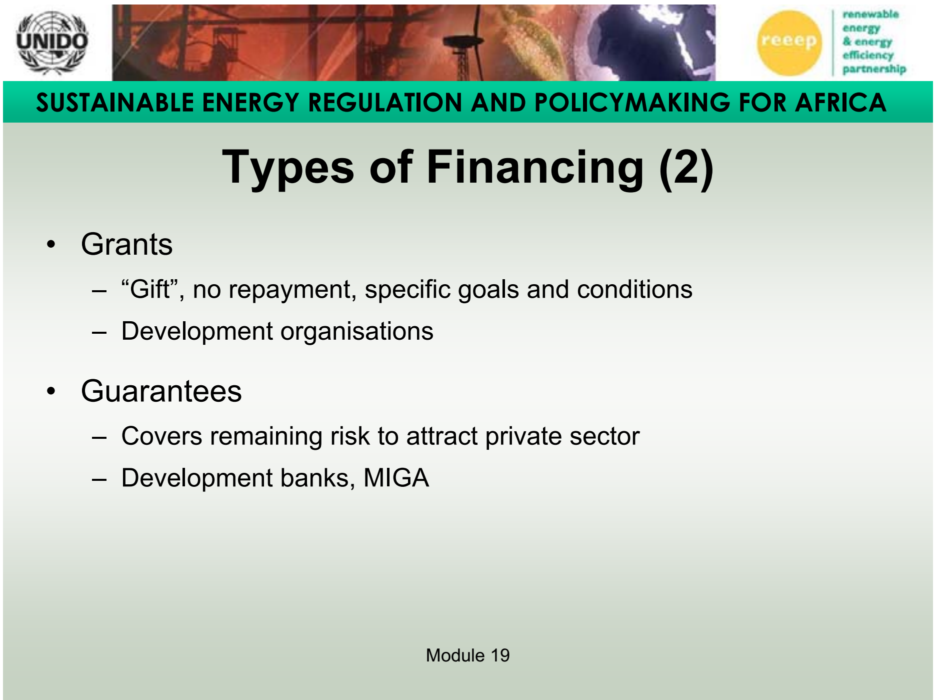

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Types of Financing (2)

- Grants
  - “Gift”, no repayment, specific goals and conditions
  - Development organisations
- Guarantees
  - Covers remaining risk to attract private sector
  - Development banks, MIGA

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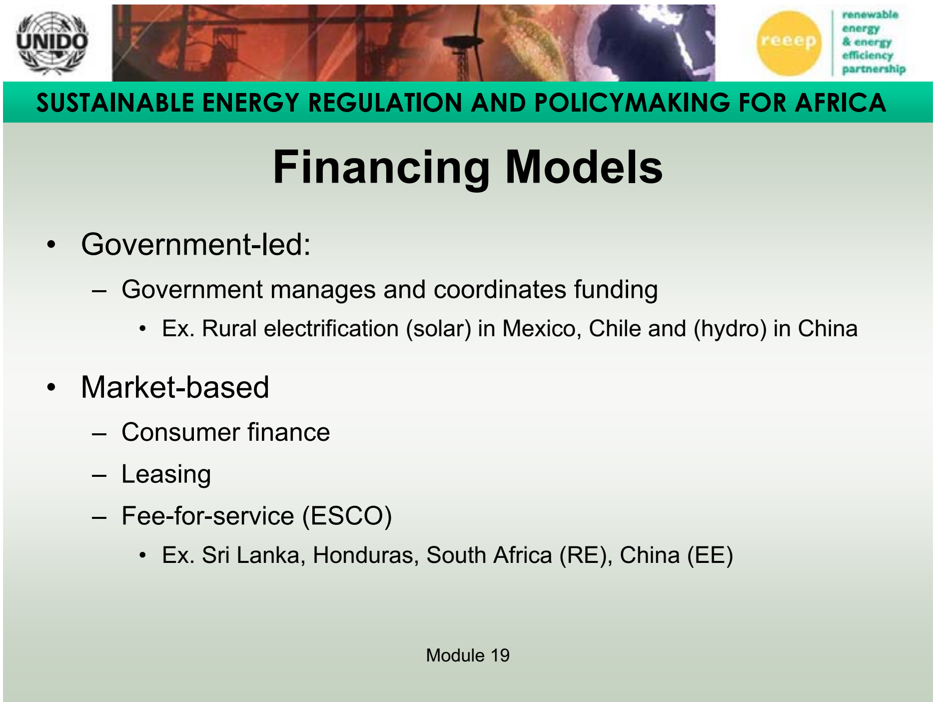

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Financing Models

- Government-led:
  - Government manages and coordinates funding
    - Ex. Rural electrification (solar) in Mexico, Chile and (hydro) in China
- Market-based
  - Consumer finance
  - Leasing
  - Fee-for-service (ESCO)
    - Ex. Sri Lanka, Honduras, South Africa (RE), China (EE)

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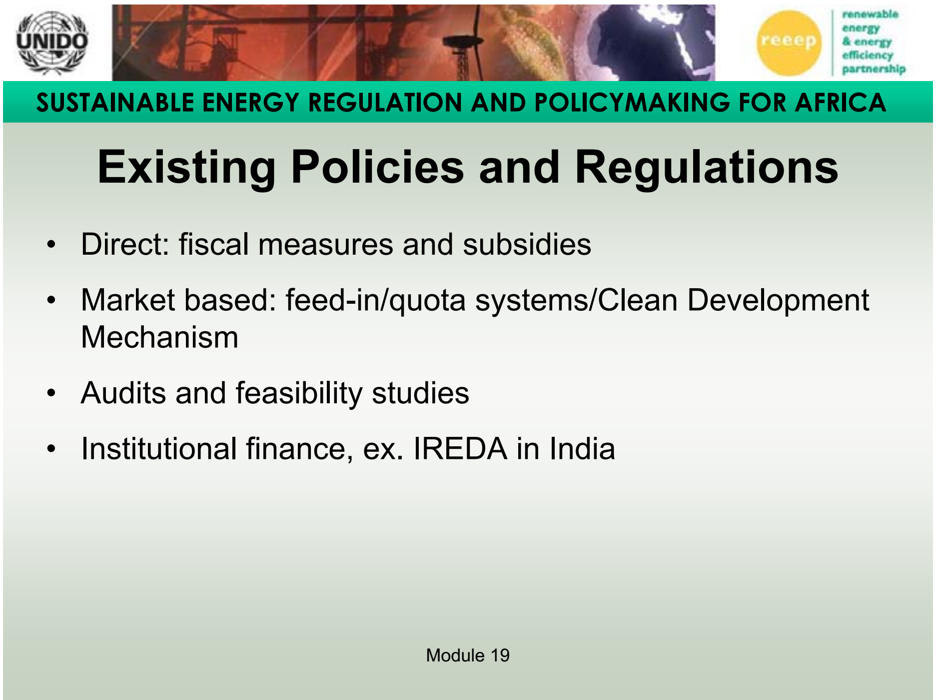

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Existing Policies and Regulations

- Direct: fiscal measures and subsidies
- Market based: feed-in/quota systems/Clean Development Mechanism
- Audits and feasibility studies
- Institutional finance, ex. IREDA in India

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Existing Policies and Regulations (2)

- New funds and initiatives from development banks:
  - Energy Efficiency Initiative / RE Investment Fund—Asian Development Bank
  - Sustainable Energy Initiative—EBRD
  - African Development Bank
  - IFC

Module 19

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Design Aspects to Attract Investments

- Institutionalize clean energy policy:
  - Adopt laws, decrees and regulations
  - Appoint dedicated agency to implement policy initiatives
- Decrease investment costs:
  - Cf. subsidies/tax breaks/feed-in and quota systems/Clean Development Mechanism
- Decrease investor's risk:
  - Provide guarantees
  - Investors to develop risk assessing tools tailored to specific nature of RE and EE projects

Module 19

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Design Aspects to Attract Investments (2)

- Increase investor's confidence:
  - Include long term targets and incentives in legal framework
- Increase awareness among key stakeholders:
  - Bankers / TSOs / local agencies
- Decrease transaction costs:
  - Tools to be developed cf. EEI-ADB and programmatic CDM

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SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

List of Funding Resources

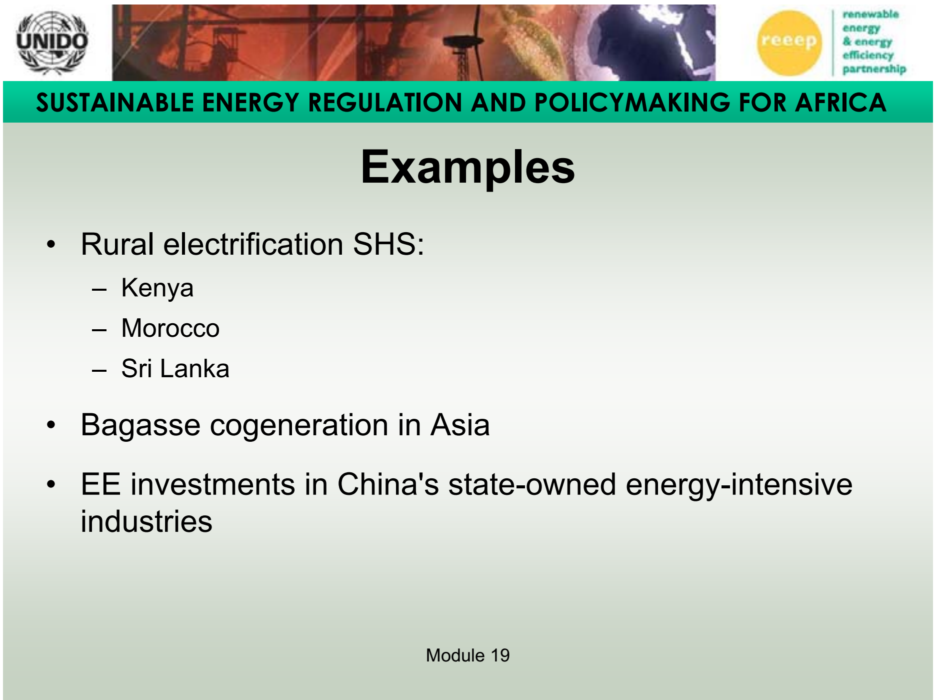
- International multilateral funding
  - Ex. World Bank, GEF, IFC
- Regional development banks
  - Ex. ADB, AfDB, EBRD
- Bilateral agencies
  - Ex. DfID (UK), GTZ (Germany), US AID

Module 19

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

List of Funding Resources (2)

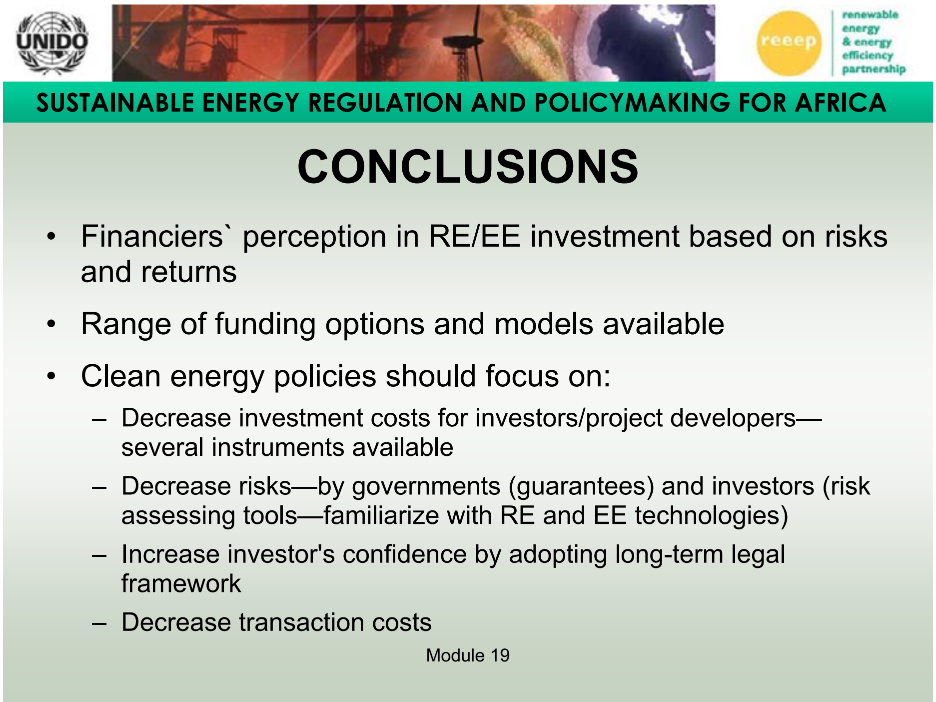
- Government finance
- Private funds
  - Ex. commercial banks/ethical banks/micro finance banks
- Private foundations and charities
  - Ex. Shell Foundation – BreathEasy Kenya



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Examples

- Rural electrification SHS:
  - Kenya
  - Morocco
  - Sri Lanka
- Bagasse cogeneration in Asia
- EE investments in China's state-owned energy-intensive industries



SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONCLUSIONS

- Financiers` perception in RE/EE investment based on risks and returns
- Range of funding options and models available
- Clean energy policies should focus on:
  - Decrease investment costs for investors/project developers—several instruments available
  - Decrease risks—by governments (guarantees) and investors (risk assessing tools—familiarize with RE and EE technologies)
  - Increase investor's confidence by adopting long-term legal framework
  - Decrease transaction costs

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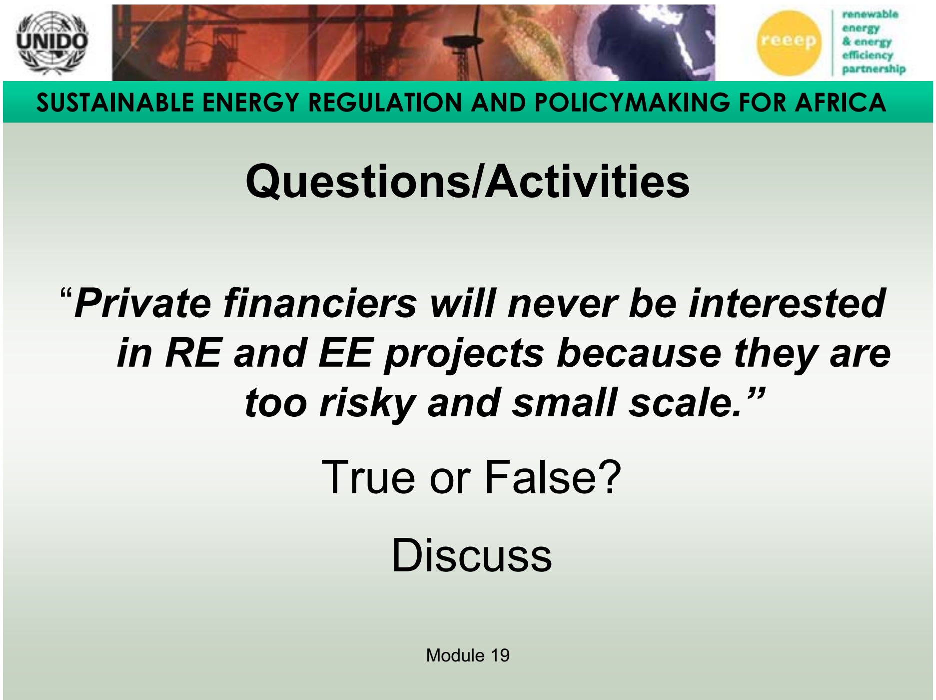

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

Questions/Activities

“Private financiers will never be interested in RE and EE projects because they are too risky and small scale.”

True or False?

Discuss

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