Smart Incentives for Mini-Grids through Retail Tariff and Subsidy Design

A Guide for Policymakers

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ABOUT

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Smart Incentives for Mini-Grids through Retail Tariff and Subsidy Design: A Guide for Policymakers

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African Mini-Grids Community of Practice (AMG-CoP) and Electric Capital Management, 2019

DISCLAIMER

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Base of the pyramid (BoP)

Commission de Régulation du Secteur de l'Electricité (CRSE)

Electricity and Water Utilities Regulatory Agency (EWURA)

Electricity Distribution Company (DisCo)

Electricity Regulatory Authority (ERA)

Electrification Rurale d'Initiative Locale (ERIL)

Feed-in Tariffs (FiTs)

Geographic information systems (GIS)

Internal rate of return (IRR)

International Energy Agency (IEA)

International Finance Corporation (IFC)

LEDS GP African Mini-Grid Community of Practice (AMG-CoP)

Levelized cost of energy (LCOE)

Multi-Year Tariff Order (MYTO)

National Renewable Energy Laboratory (NREL)

Nationally Determined Contributions (NDCs)

Nigerian Energy Regulation Commission (NERC)

Public Utilities Regulatory Commission (PURC) Act

Results Based Financing (RBF)

Rural Energy Agency (REA)

Uniform National Tariff (UNT)

United Nations Sustainable Development Goals (SDGs)

EXECUTIVE SUMMARY

Clean energy mini-grids are receiving increasing attention as a cost-effective means to deliver energy access and achieve climate change commitments. However, the economics of mini-grids in developing countries remains challenging, as mini-grids often have high upfront capital and operational costs and tend to serve a lower-revenue customer base. How tariff and subsidy policies are designed has become a central factor in determining the viability of private sector participation in scaling deployment of mini-grids as an effective energy access solution. This analysis provides:

- a primer for policymakers and donors regarding the scope of options within their policy toolkit, with specific country examples highlighting lessons learned from countries that have implemented early policies and programs.
- an annotated resource list of key publications and studies that have been published on these issues and that have informed this analysis.
- information on several toolkits that can be utilised to inform the assessment of tariffs and subsidies, including the EUEI-PDF Mini-grid Policy Toolkit – Support Tools that can calculate retail tariffs rates and feed-in-tariffs, and the NREL REopt decision support model that enables evaluation of the economic viability of a renewable energy mini-grid.

A number of countries have already begun to adopt policy frameworks for private sector retail tariffs or have implemented grant or subsidy programs to support the deployment of mini-grids in their country. Where available, early learnings from these experiences have informed this work.

This analysis examines the key elements of tariff and subsidy policy design and finds the following:

- **Retail tariff policies:** When setting retail tariff policies, policymakers must balance between the politics of tariff rates in different communities, developers who need to maintain viable business models and customers who want access to energy at a tariff that they can afford and are willing to pay.

  There are a range of possible retail tariff policy approaches that include imposing low flexibility approaches (requiring mini-grid operators to utilize a uniform national tariff) to allowing high flexibility (tariffs that are set solely between the community and the mini-grid operator based on the value provided), with options for cost-reflective tariffs (set on a case-by-case basis or utilizing a standardized approach) or auctions. When selecting a tariff policy approach, policymakers are advised to consider mini-grid operators' sustainability and profitability, customer affordability and willingness to pay, the benefits of flexibility in tariff structures, and means to minimise administrative overhead and uncertainty for the mini-grid project developer/operator. An emerging approach is for policymakers to regulate mini-grids differently based on the size of the mini-grid (typically based on generation capacity), enabling more flexibility for smaller mini-grids and more oversight for larger mini-grids.

- **Subsidy policies:** There are a number of ways effective subsidy policy can be designed. Subsidies can be delivered by either supplying certain elements to the developer directly, or by a financial transfer paid for inputs or outputs, generation or distribution outcomes, or on a capital or operational basis. Of note, output-based capital subsidies for distribution outcomes (connections) are a common option. Policymakers must also select how the subsidy will be disbursed, in terms of both timing (on which milestones disbursements are made, impacting project finance requirements) and verification (balancing certainty with effectiveness), as well as how to quantify the subsidy amount. The value of the subsidy should be high enough to ensure that the mini-grid operator is sustainable and profitable, but low enough to maximise the impact of limited subsidy resources.

In selecting an approach for providing subsidies, policymakers are advised to consider how to provide confidence to mini-grid operators over timely subsidy disbursement, how to minimise administrative and documentation burden, and how subsidy design choices impact access to finance, long term sustainability, technology utilised, and community selection. Mini-grid developers are wary of subsidies that may be subject to either delay in payment or have a perceived risk of non-payment. Reducing bureaucratic processes and documentation and ensuring effective management of the subsidy to enable its timely delivery to the developers will reduce administrative burden while building confidence between granting agency and mini-grid developers, thereby maximising the impact of the subsidy.

Overall, regulators of mini-grid tariffs and subsidies are faced with a dynamic, complex and interlinked set of considerations when establishing policy. They must consider the needs of the local community and their ability and willingness to pay, the costs of serving those communities, and the needs of the mini-grid operators to cover their costs and deliver a return to their companies and their investors. These conditions vary significantly across geographies, and there is no one size fits all approach to establishing effective, fair tariff, and subsidy structures. This analysis discusses key considerations for regulators in the design and establishment of mini-grid tariffs and subsidies as they seek to balance considerations of equity, transparency, and efficiency (for themselves, the developers, and the communities they serve) when designing policies and procedures related to tariff and subsidy establishment, approval, issuance, and review.

This case study was developed as an input into discussions of the AMG-CoP regarding the optimal means of incentivising private sector participation in scaling up investment in mini-grids and accomplishing energy access and rural electrification objectives. An extensive literature review formed the basis of the study, with the objective of capturing and synthesising previously documented knowledge to inform policymakers and stakeholders. Semi-structured key informant interviews were held with industry stakeholders to add supplementary information from the perspective of the private project developer.

INTRODUCTION

The LEDS GP African Mini-Grid Community of Practice (AMG-CoP) is exploring effective ways to accelerate the development of mini-grids to achieve national and global goals on energy access and to stimulate private sector investment. The AMG-CoP examined a range of possible policies that governments could adopt to provide smart incentives for private operators to build and expand mini-grids, focusing on policies for retail electricity tariffs and the design of subsidy programs, and explored considerations related to different policy options drawing from member country experience and insights. This paper focuses on the key building blocks of mini-grid tariff and subsidy. Companion case studies may be developed in cooperation with AMG-CoP members, and additional work products will be developed in consultation with the AMG-CoP.

METHODOLOGY

This case study was developed as an input into discussions of the AMG-CoP regarding the optimal means of incentivising private sector participation in scaling up investment in mini-grids and accomplishing energy access and rural electrification objectives. An extensive literature review formed the basis of the study, with the objective of capturing and synthesising previously documented knowledge to inform policymakers and stakeholders. Semi-structured key informant interviews were held with industry stakeholders to add supplementary information from the perspective of the private project developer. The case study was presented at the AMG-CoP meeting held in Nigeria in November 2018, where members of the AMG-CoP provided feedback on the content. Country examples of the different types of both retail tariff regimes and subsidy implementations were added based on countries of relevance and their input. This case study was then provided to members of the AMG-CoP and external stakeholders for review and feedback from the reviewers was incorporated into the final study.

CONTEXT

Clean energy mini-grids are receiving increasing attention from governments, donors, and rural stakeholders as a cost-effective means to deliver energy access to un-electrified communities across Africa and to advance efforts towards Nationally Determined Contribution (NDCs) commitments governments have made under the Paris Agreement. Private sector operators and investors see the possibility of building sustainable and profitable business models for mini-grids. The International Energy Agency (IEA) estimates that over 40% of universal access to electricity by 2030 will be most economically delivered by mini-grids and will play a leading role in addressing the nearly 600 million people across Africa who still lack any access to electricity[1].

However, the economics of energy access through mini-grids remain challenging; mini-grids often have high upfront capital and operational costs due to long distances from locations where materials are supplied, low population densities, as well as lower revenues as they tend to serve poorer customers (wealthy customers are more likely to live in urban areas) who demand smaller amounts of electricity due to less income available to spend on electricity. To be sustainable and profitable, mini-grid operators must have revenues that exceed costs and provide for an attractive return on investment. What is considered an "attractive" return on investment varies by investor but is generally considered a return that has an appropriate risk/reward return profile (e.g. the risk that an investor will not get any of his or her money back is outweighed by the reward of the financial return). In the mini-grid sector, more positive investor returns are generally achieved either by increasing revenues or cutting costs. This study examines approaches to enabling higher revenues for private mini-grid operators through retail tariff policies and subsidy design.

This analysis provides a primer for policymakers and donors regarding the scope of options within their policy toolkit, with specific country examples highlighting lessons learned from countries that have implemented early policies and programs. A number of countries have already begun to adopt policy frameworks for private sector retail tariffs or have implemented

[1] [Energy Access Outlook, International Energy Agency, 2017]

grant or subsidy programs to support the deployment of mini-grids in their country. Where available, early learnings have informed this work.

THE VIABILITY GAP: MINI-GRID BUSINESS MODELS ARE ECONOMICALLY CHALLENGING

Mini-grids can be cost-effective solutions for rural electrification across Africa, particularly for higher tiers of service that enable productive and commercial use. In the 2017 Energy Access Outlook, the IEA estimates that investments roughly on the order of $32 billion annually will be required to achieve universal access to modern energy service in sub-Saharan Africa by the year 2030, more than 40% of which is expected to be for mini-grids. This scale of investment is unlikely to be met by governments and donors alone, making mobilisation of private investment critical to the achievement of the United Nations Sustainable Development Goals (SDGs).

However, mini-grids face the fundamental challenge of universal electrification: rural customers are often unable to pay for the cost of the energy delivered to them, as the cost to connect and service customers is high, and customers are generally poorer and demand smaller amounts of electricity. For mini-grids to be commercially viable they must be able to collect revenues from tariffs or other sources at levels that are sufficient enough to cover costs, as well as provide an acceptable return to investors for the level of risk (both real and perceived). The difference between the revenue that a mini-grid operator is able to collect from the communities they serve and the costs and profit that are required is termed the 'viability gap'.

There has been increasing private sector engagement in mini-grids across sub-Saharan Africa and Asia over the past 10 years, but returns to investors remain low and private sector investment is lagging. A review of companies that privately operate mini-grids by the International Finance Corporation (IFC) published in 2018 indicates that average capital expenditure payback periods for mini-grids exceed seven years. In order for mini-grids to be commercially viable, the payback period cannot exceed 4-6 years, which would be in line with commercial investor expectations of projected equity returns of 15-20% per year. As a result of the viability gap, private sector developers struggle to attract the needed capital to grow their businesses and begin to capture the economies of scale that will help drive down capital expenditure costs and increase revenues and profitability over time.

HOW TO IMPROVE MINI-GRID ECONOMICS

There are three basic approaches to improving mini-grid economics:

- **Reduce costs:** Cost reductions can be achieved in several ways, including: 1) more accurately sizing systems, 2) reducing the level, quality or the hours of service, or engaging in demand management 3) adopting lower technical standards or less rigorous maintenance requirements, 4) targeting denser communities or communities closer to existing infrastructure, or 5) reducing overhead and transaction costs by bundling projects or utilizing management tools that enable quicker or easier site selection, such as geographic information systems (GIS) or satellite imagery.

- **Increase revenues:** Revenues are a function of the i) quantity of electricity or service consumed and ii) the tariff that can be charged per unit delivered. The quantity of demand can be improved through various strategies to increase loads, including productive uses (such as cold storage, agricultural equipment, etc.), while the tariff charged is a function of both ability (or willingness) of customers to pay as well as prevailing government policy.

- **Subsidies:** Subsidies can be provided to either i) the consumer (customers or individuals in the area served by a mini-grid), which are derived on the basis of a price-gap approach or ii) producers (the mini-grid private operator). Producer subsidies are administratively easier and enable greater flexibility in structuring the subsidy. Resources for a subsidy can come from cross-subsidization (from urban or industrial customers), government revenues (from domestic taxpayers), or donors (from development partners or development finance institutions). Determining the amount of the subsidy needed and the structure of the subsidy has multiple options.

The focus of this case study is on i) options for mini-grid retail tariffs, and ii) how to structure and quantify a subsidy.

RETAIL TARIFF SETTING

OPTIONS FOR APPROACHES TO MINI-GRID RETAIL TARIFF SETTING

Governments have traditionally approached electricity tariffs (particularly, residential electricity tariffs) from the perspective of equity and affordability. Tariff rates of utilities in most emerging economies in Africa are well below their average cost of service. Large, typically government-owned, utilities are subsidised directly through the government or donor-funded programs and infrastructure projects, and low-consumption residential customers are often further cross-subsidized from industrial or higher-consumption customers. Residential customers also often pay the same tariff regardless of geography or the actual cost to service them.

While mini-grids are often the least-cost solution for providing electricity to remote, rural communities on a per kWh basis (when compared to grid extension), they often deliver electricity that is more expensive than what existing national utility customers would be paying because they do not enjoy the same subsidies that larger utilities are offered and their costs to serve these communities are higher. While national uniform tariffs in Africa are in the $0.05 – 0.30 per kWh range[2], developers often need $0.50 - $1.00 per kWh to be commercially viable[3], though some developers are able to deliver prices as low as $0.20 per kWh in particular circumstances[4]. However, mini-grids provide energy services that are often less expensive than the alternatives, including fuel-based lighting, mobile phone charging or individual generators. A study by the IFC in 2017 estimated "implied tariffs" of $1-3 for alternatives to mini-grids depending on the type of energy service (with an average of $1.75 per kWh equivalent in east Africa), while the price of energy for small, specific services can range up to $100 /kWh equivalent (for mobile charging)[5].

[2] [Tariff Considerations for Micro-grids in sub-Saharan Africa, NREL, 2018]

[3] [NREL, 2018]

[4] Microgrid Market Analysis and Investment Opportunities in India, Tanzania and Indonesia, Microgrid Investment Accelerator, 2017] and information provided by Africa Mini-grid Developers Association

[5] [Operational and financial performance of mini-grid DESCOs, IFC, 2017]

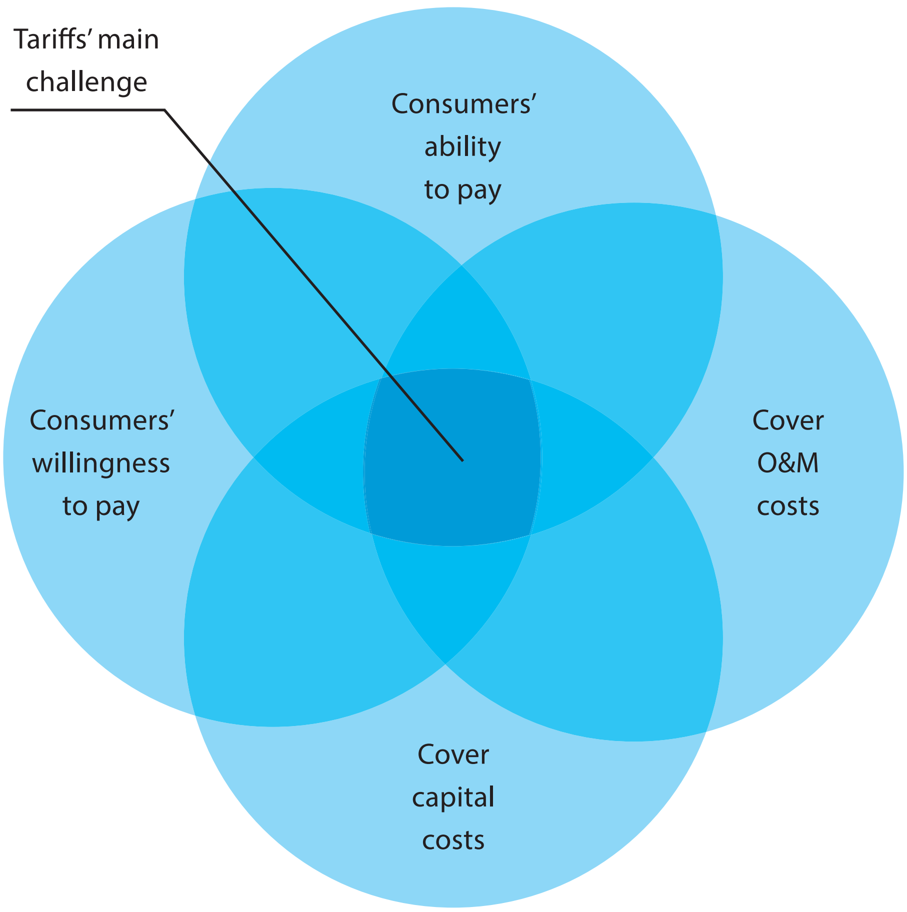

Figure 1: Main challenge of tariff setting - balancing different needs

Graphic from: D. Philipp, Billing Models for Energy Services in Mini-Grids, GIZ Workshop on Hybrid Mini-Grids 2014

Tariff setting for mini-grids is thus a balancing act between governments who must manage the politics of tariffs in different communities, developers who need to maintain viable business models, and customers who want access to energy at a tariff they can afford and are willing to pay.

A variety of approaches to setting and regulating tariffs exist across countries, which range from specifying a uniform tariff to enabling mini-grid operators full flexibility to charge for the value of their services, often to reflect their costs and required return[6].

[6] Much of the outline of different tariff approaches is derived from the report Tariff Considerations for Micro-grids in sub-Saharan Africa by the National Renewable Energy Laboratory (NREL) from 2018, and the academic article Tariff structures to encourage micro-grid deployment in sub-Saharan Africa: Review and recent trends by Reber and Booth. Both are included in the annotated bibliography, and are suggested reading for more information on tariff approaches.

• **Uniform Tariff:** Customers are charged the same tariff regardless of whether they are connected to the national utility grid, a utility-owned isolated mini-grid, or a privately owned and operated mini-grid. The private mini-grid operator would be required to follow the uniform tariff, regardless of the cost of service provision or the value to potential customers. Governments may prefer a uniform tariff, as it is perceived as more equitable to customers; however uniform national tariffs are typically too low to attract private operators or investors for mini-grids in the absence of capital and operational subsidies. In that case, the mini-grid operator may be allowed to apply for an exemption from the uniform tariff, but the exemption application process can be slow, imposing a significant transaction cost, and there remains uncertainty as to whether the exemption will be approved.

Ghana: Uniform tariffs

Ghana has a policy of a Uniform National Tariff (UNT), where domestic customers anywhere in the country pay the same electricity tariff. This is part of the principle that rural low-income dwellers should not have a cost of electricity that exceeds that paid by more affluent Ghanaians living in urban areas or elsewhere in the country. However, under the Public Utilities Regulatory Commission (PURC) Act, a mini-grid utility may apply for a special rate agreed between the utility and its customer for the services provided by the utility.

• **Cost-reflective Tariff:** Mini-grid operators are allowed to set their tariffs at a level high enough to enable them to recover their costs – both capital and operational – as well as provide for a reasonable return to investors, often referred to as "cost-plus". Typically, assets funded by grants are excluded from the capital cost base as it is viewed as inappropriate for the private sector to earn a return on a donor's capital. Cost-reflective tariffs will typically be higher than uniform tariffs, but truly cost-reflective tariffs can exceed customers' ability or willingness to pay.

  • *Case-by-case (upfront) tariff setting:* The tariff is decided in advance through a regulatory approval process on a project-by-project or "package-of-projects" basis, based on information on costs from the mini-grid operator and utilising a specified methodology to assess the appropriate tariff level. This assessment often involves significant administrative overhead in terms of both cost and time, as the mini-grid operator must gather and prepare a significant volume of documentation that the regulator must then review. However, a mini-grid operator has increased certainty about the tariff level on an on-going basis as the regulator has approved it in advance.

Kenya: Case-by-case upfront tariff setting

Mini-grid developers must submit a tariff model (e.g. an excel spreadsheet detailing the assumptions and the financial workings) as part of the license application, showing the project's financial sustainability for both investor and end user. Fairness of return to the investor and tariff level for the end user is the principle of evaluation, with a maximum internal rate of return (IRR) cap of 18%. The higher the tariff, the greater the likelihood it will not be approved and so developer must ensure economically efficient implementation and justify that it is low cost.

Uganda: Case-by-case upfront tariff setting

Uganda's independent regulatory body the Electricity Regulatory Authority (ERA) regulates retail service for mini-grids in a similar manner as it regulates national grid distribution operators. Each mini-grid electric service provider must submit a proposed tariff to ERA, which is reviewed by regulatory staff and subsequently adjusted or approved. Developers in Uganda have noted the current review process can be quite lengthy, and anticipate that if mini-grid applications were to increase, the process could become rather burdensome both with respect to time and cost.

- *Case-by-case (based on a post-operational review upon request) tariff setting:* The mini-grid operator is free to set their tariff through negotiation with a community, but it is subject to review by the regulator if a certain percentage of the population served request a review. This enables a mini-grid operator to avoid an upfront administrative tariff setting process that would increase project development costs and time, which could delay or prevent the project in the first place, enabling increased speed for mini-grid deployment. Mini-grid operators run the risk of the regulator enforcing a change to their tariff after they have begun operating (and have already incurred investment costs). However, that risk can be mitigated by i) providing clarity on the methodology the regulator will utilise to decide the appropriateness of the tariff levels, and ii) ensuring the confidence of mini-grid operators in the independence of the regulator from political pressures to revise tariffs. Mini-grid operators can also mitigate this risk through community engagement to ensure that the population served does not feel the need to appeal to a regulator for a review.

Tanzania: Case-by-case tariff review after operations and a review requested

Mini-grids in Tanzania are not subjected to upfront retail tariff setting restrictions if they are less than 100kW in size, so a mini-grid developer is free to set the tariff through negotiation with the community it will serve. However, if 15% of households in the area served by the mini-grid submit a petition to the Electricity and Water Utilities Regulatory Agency (EWURA) and EWURA determines that prices being charged exceed what which would be 'reasonably' expected in a cost-recovery tariff, EWURA can mandate a change in the tariff. This ability for EWURA to consider a tariff review based on a threshold of households in the area introduces a level of policy uncertainty for many business models; however, mini-grid developers are optimistic EWURA will support their tariffs if they are cost-reflective. Few mini-grids have undergone a review of their tariff by EWURA upon such a request, and for those that have EWURA reportedly has not mandated a change in the tariff.

- *Standardised assessment:* The regulator determines a standardised tariff level for mini-grids utilising a 'model' mini-grid, perhaps based on specific categories of geography, size, technology, service levels, or subsidies received. This tariff differs from the uniform tariff for the national grid, and it would typically be higher. The government determines the standardised tariff that it believes reflects a cost-reflective tariff based on assumed costs and a developed methodology for a model or example mini-grid. This involves significant upfront work by the regulator, as the regulator would need to develop cost information and a methodology and may lag technology developments unless frequent updates are performed (adding to regulatory workload). Alternately, the standardised tariff could be determined as a cap, enabling the mini-grid operators to set their tariff below the standardised tariff if i) their costs are less than assumed by the regulator and ii) the willingness to pay from the community is lower than the standardized tariff.

Senegal: Standardized tariff caps based on technology and subsidy level

The Commission de Régulation du Secteur de l'Electricité (CRSE) concluded the effort required for case-by-case cost-reflective ('cost-plus') tariff setting in mini-grids exceeded the benefit in kWh delivered to customers. CRSE ended using a case-by-case method and developed a new approach to set tariff caps for solar-battery mini-grids utilizing a cost-reflective assessment of several existing mini-grid businesses and compared the outcomes, deriving tariff caps for different subsidy levels of solar-battery hybrid systems. For example, operators of systems with a 50% capital subsidy may charge a higher tariff than operators of systems with a 90% capital subsidy.

Nigeria: Standardized Methodology through Multi-Year Tariff Order

The Nigerian Energy Regulation Commission (NERC) has established a methodology to determine the electricity tariff for mini-grids that are subject to tariff regulation. The Multi-Year Tariff Order (MYTO) is a tariff model used to set cost-reflective tariffs in a standardized way, with minor reviews each year on changes in a limited number of parameters (e.g. inflation, interest rates, exchange rates and generation capacity) and major reviews every five years. The tariff calculation tool is online to allow both developers and customers to agree on a project-specific tariff, which will be approved by NERC. The tool constrains the fair return on capital, depreciation, and technical and non-technical losses.

- **Auction-based Tariff:** Auction-based tariffs are usually applicable to concession-based systems, where a mini-grid operator is granted a license to be the operator (typically sole operator) in a particular area serving a set of customers. The agency/government defines a particular geographic area, and mini-grid operators are invited to bid in a reverse-auction to determine the lowest tariff to be offered. The government may include additional criteria, such as the number of customers served and level of service.

Mali: Auctions based on concessions

Mini-grids are implemented through concessions granted for up to 15 years, with ownership of the fixed assets remaining with the state. The granting of concessions is through either i) soliciting bids for the electrification of areas and selecting based on lowest tariff proposed, or ii) selecting projects based on a developer's proposal within a fixed investment subsidy.

Mini-grid site in Minna, Niger State

• **Value-based or avoided-cost tariff:** The tariff is set by negotiation between the private mini-grid operator and the customers the operator wishes to service, based on the value of the service they wish to provide (i.e. on a “willing buyer” and “willing seller” basis). The regulator assumes a minor role in the actual determination of the level or structure of the tariff but may provide the regulatory environment that allows the mini-grid operator and willing customers to be able to do so legally. The tariff level is limited not by a government or regulator but by the alternatives available to customers, such as fuel-based lighting, individual generators, or standalone solar systems (if available). A regulator may do so if the mini-grid is getting no other public support; alternatively, a regulator could benchmark an allowable tariff based on an assessment of the avoided-cost that customers would otherwise pay for a similar level of energy service, either on a case-by-case basis or on a standardised basis.

Uttar Pradesh (India): Value-based tariff if no public subsidy utilized by mini-grid

The Uttar Pradesh Electricity Regulatory Commission regulations enable mini-grids generating electricity from renewable sources to set tariffs as mutually agreed with their customers, if that mini-grid is being developed without public subsidy. If the mini-grid operator accepts a public subsidy, then they are subject to regulation that specifies the retail tariff and minimum service standards.

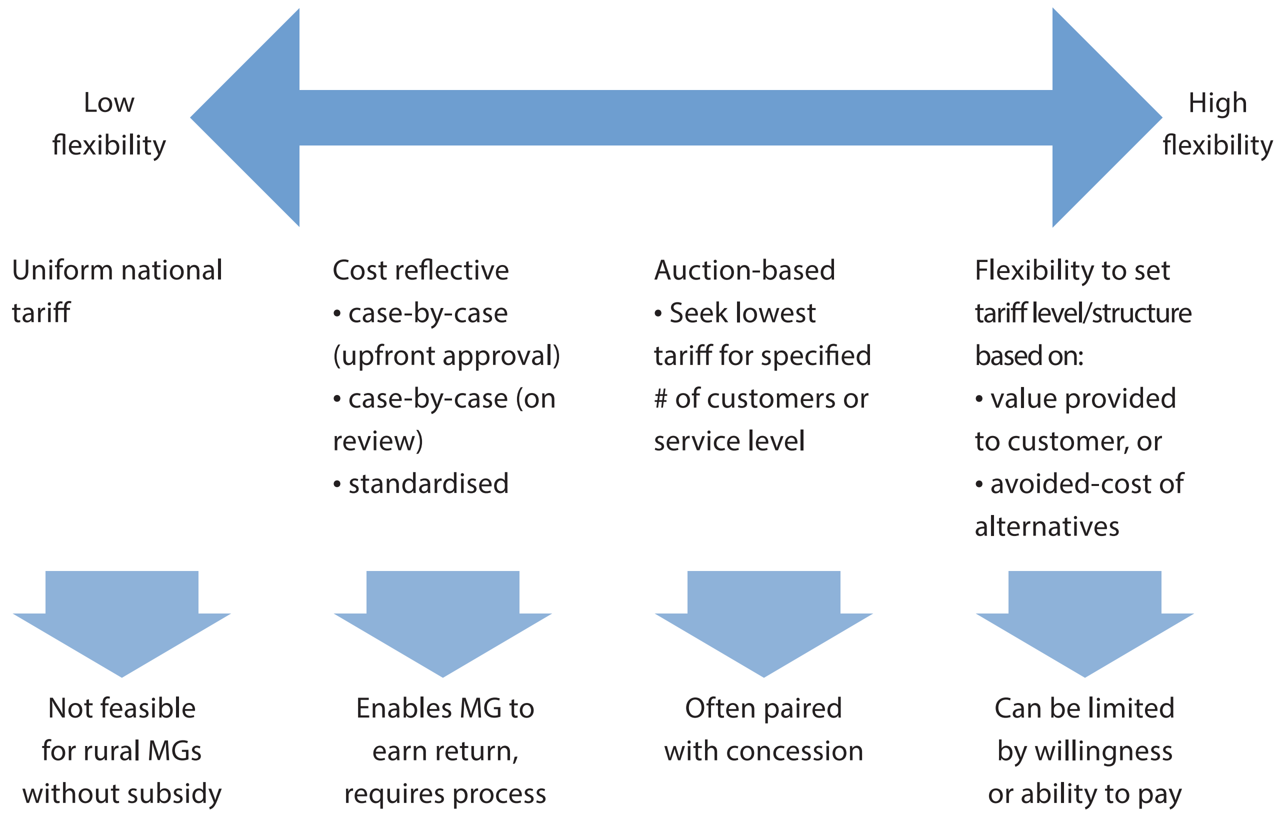

Figure 2: Possible options for regulatory flexibility for mini-grid operators on tariff setting process

Nigeria: Tariff based on agreement with community, subject to requirement it be cost-reflective

To encourage mini-grid development, Nigeria introduced cost-reflective retail tariffs that are expected to be higher than the current Electricity Distribution Company (DisCo) retail tariffs. However, they will be lower than any electricity supply of the same quality generated from conventional sources in these areas. Two mechanisms for determining these tariffs are through (1) the MYTO calculation tool (explored above), or (2) by an agreement between the Mini-Grid Operator and the Community (defined as a minimum number of electricity customers representing 60% of the electricity output of that same Community). The setting of this tariff is subject to the Commission's right to intervene and adjust the tariff that has been agreed with the Community where the rate of return of the Mini-Grid Operator exceeds a usual non-recourse commercial debt interest rate in local currency and with adequate tenure.

DIFFERENT TYPES OF TARIFF STRUCTURES

Once a basis for setting the tariff level has been agreed, there are a number of options regarding how to structure the tariff charged to customers, ranging from a variable charge based on energy consumed to a fixed charge based on available power or services[7].

- **Energy tariffs (/kWh):** customers' pay based on the units of energy consumed (e.g. $/kWh consumed). While cost is based on energy consumed, there are different options for how to price that energy:

  - *Fixed rate:* the tariff rate per unit of energy (/kWh) consumed is fixed and does not vary with time or volume consumed. Fixed rate energy tariffs are easy to implement and generally widely accepted, appropriate for either post-paid or pre-paid basis.

  - *Block tariffs, or stepped rate tariffs:* customers are divided into different classifications and the tariff rate per unit of energy (/kWh) consumed varies based on the rate specified for each classification. This could be based on power needs (higher power users pay more), customer class (residential, commercial, public services, etc.), or more commonly, their consumption level, with price adjustment as the volume of consumption in a particular time frame (e.g. 1 month) increases to step into the next block. Block rate tariffs can be either "progressive" or "regressive". Progressive block tariffs have higher prices as the volume of consumption increases, known as 'Increasing Block Tariffs' or 'Inverted Block Tariffs'. Such a block structure may include a 'lifeline' or social tariff with a lower cost for the first amount of consumption in a specified time frame to meet affordability criteria, typically cross-subsidised from higher volume energy consumers. Regressive block tariffs have lower prices as the volume of consumption increases, giving higher volume customers a bulk discount, reflecting the likely economic reality of decreasing marginal returns for increasing amounts of electricity and possibly having residential customers cross-subsidise productive users.

  - *Time of use, including daily and seasonal adjustments:* different rates are charged depending on the time at which the energy is consumed, with higher rates being charged when demand is high or supply is low (e.g.

[7] Much of the discussion regarding the different tariff structures is derived from the academic article Tariff structures to encourage micro-grid deployment in sub-Saharan Africa: Review and recent trends by Reber and Booth. This article is included in the annotated bibliography, and is suggested reading for more information on tariff structures.

cloudy or rainy days or at night for solar technologies), and low rates during time of low demand or high supply (e.g. midday when the sun is shining and residential consumption is low). The different rates can be based on a daily or weekly schedule, seasonally, or be dynamic based on current demand and supply. Time of use rates can shift consumption to mitigate peaks and valleys in demand (smoothing system operation) or to better match production (e.g. solar availability during the day, hydro during the wet season). This can simplify system design, improve reliability, and reduce overall costs, which can then result in lower overall tariffs or increased profitability. Time of use pricing has gained traction in developed country utilities. However, it is not yet widely utilised by mini-grids (although some operators have begun to utilise it)[8].

• **Power tariffs (/kW) or Flat rate tariffs:** the tariff is charged as a flat fee or 'subscription' based on the maximum peak power draw, and is independent of the amount of actual energy consumed. The tariff is based on a fixed capacity cap, sometimes implemented through a simple load limiter rather than a meter (in low-cost implementations). Power or flat rate tariffs have several advantages for the mini-grid operators: i) they can provide more revenue certainty as they do not depend on consumption, ii) they can obfuscate the per kWh cost of the energy, which can mitigate against customers engaging in tariff comparisons to the national grid, and iii) they are particularly appropriate for renewable energy projects where the marginal cost of energy production is zero (e.g. hydro). However, the disadvantages are that i) they can encourage inefficient and excessive use by customers as they are not paying per unit of consumption, and ii) consumers usually do not like high fixed costs and prefer tariffs based on their actual energy usage since this allows them to be more financially flexible.

• **Fee-for-service or Fee-per-device:** customers are charged for a defined amount of energy using services, typically a monthly amount based on a particular set of appliances that they have, for example, a charge for a light bulb or a TV. The mini-grid operator may provide the appliances themselves, and their cost may be included in the service fee, bundled with the energy necessary to power them. Fee-for-service or Fee-per-device may be simple for customers that are unfamiliar with a utility bill model, and in the case

[8] Author's primary research

where the operator provides the appliances can i) enable customers to have appliances that they would otherwise not have access to due to upfront cost and ii) provides incentives for the mini-grid operator to emphasize energy efficiency. However, fee-for-service faces implementation challenges including requiring regular checks on each customer's appliance inventory and service, maintenance, and repair challenges.

Energy-based (/kWh)	Power-based (/W or /kW allowed)	Fee-for-service / Fee-for-device
Fixed rate (linear) Blocks/stepped tariffs • Progressive: "lifeline" • Regressive: subsidize productive use Time of use • Daily/seasonal • Smooth demand or match production	Flat Fee or 'Subscription' based • Independent of actual energy consumed (obfuscate /kWh rate)	Defined set of energy services • Cost per time (e.g. month) for particular set of appliances • Appliances may be bundled with fee for energy to power them

Figure 3: Generalized scope of types of retail tariff structures

CONSIDERATIONS FOR GOVERNMENTS REGARDING RETAIL TARIFF REGULATIONS

Regulators of mini-grid tariffs are faced with a dynamic, complex and interlinked set of considerations when establishing tariff policy. They must consider the needs of the local community and their ability and willingness to pay, the costs of serving those communities, and the needs of the mini-grid operators to cover their costs and deliver a return to their companies and their investors. These conditions vary significantly across geographies, and there is no one size fits all approach to establishing effective and fair tariff and subsidy structures. This section discusses key considerations for regulators in the design and establishment of mini-grid tariffs, as they seek to balance considerations of equity, transparency, and efficiency (for themselves as well as the developers and the communities they serve) when designing policies and procedures related to tariff approval and review.

ECONOMIC CONSIDERATIONS

• **Tariffs are fundamental to private mini-grid operators' sustainability and profitability in the long-term:** At a minimum, tariffs must enable the mini-grid operator to cover their operation and maintenance expenses (to break-even) plus a reasonable return for their management and net capital investment (to provide an incentive to scale). If they do not, even a 100% subsidy for the capital expenditure (for all generation and distribution equipment and associated costs) will not result in a sustainable mini-grid business, as the mini-grid will lose any potential revenue every year of operation. A study by the IFC of 20 mini-grid companies across 12 countries indicated that typical operating expenditures were in the range of $0.37-0.75 per kWh, representing approximately 60% of revenue[9]. Renewable energy mini-grids, particularly solar, have low operating expenses that can reduce operating and maintenance costs. In these instances, lower allowable tariffs may be more acceptable to the mini-grid operator if an increased subsidy covers the higher capital cost. However, further capital expenditures will be expected over the lifetime of the mini-grid (to replace aging and degraded battery systems and for equipment replacement and repairs), so either the capital subsidy must be periodically available again for additional expenditures in the long term (for example, replacement of batteries or solar panels), or the maintenance costs considered must include an allocation for this longer-term expected maintenance (as part of operational expenditures).

• **Making cost-plus assessments requires a methodology and judgment:** Regulators must establish a methodology that includes predictions about customer demand, make assumptions about costs, or be able to judge if costs are reasonable, and make a value-judgment about the acceptable return that a private mini-grid operator can make. There are toolkits that have been developed that regulators can draw from to inform this methodology (see section on toolkits). Financial return expectations from investors active in the market today generally range between 5-20%, depending on the type of investment (lower expected rates for debt investments, with higher expected rates for equity investment) and type of investor[10], with some (often social impact-focused) investors willing to accept rates of return at the lower end of this spectrum, while commercially-focused investors expecting returns at the higher end of the range. This investor expectation can inform regulators about what return should be utilised when calculating the allowable tariff amount based on a cost-plus model. However, the cost and availability of capital varies by market

[9] [Benchmarking mini-grid DESCOs 2017 Update, IFC, 2018]
[10] Based on survey data of investors that focus on mini-grids


Mini-grid site in Minna, Niger State

and developer and it should be understood before setting cost-plus rates. Given the relatively small number of investors active in the market today, engagement with developers and financiers regarding the tenor, cost and conditions attached to their capital in a given market and the challenges of commercially viable models for mini-grids can help ensure tariff policy that reduces rent-seeking but ensures that the market is advancing towards sustainable and profitable business models.

- **Tariffs are limited by affordability and willingness to pay:** Alternatives and perceptions limit the upper end of tariffs that mini-grid operators can charge to potential customers. Some regulators may believe that a mini-grid with no limit on their tariffs may be able to act as a monopoly and charge economic rents; however, mini-grids do not operate without competitors: mini-grids face competition from traditional sources of energy, including fuel-based lighting or individual generators, as well as from other energy service providers such as solar home system companies. All potential tariff levels are affected by affordability and willingness to pay, including both cost-reflective and value-based tariffs. Demand for electricity in many of these communities is highly elastic, meaning that if the price is too high customers will simply

consume less, or stop consuming at all. In the case where a cost-reflective tariff exceeds affordability or willingness to pay in a community, which is often the case, then a mini-grid is not viable without a subsidy.

• **Enable flexibility in tariff structuring:** There are a number of options for how a mini-grid operator can structure their tariffs. Each structure has different advantages and disadvantages, including simplicity, reducing overall costs to customers, reducing revenue variability for the mini-grid operator, the likelihood of non-payment by the customer, enabling cross-subsidisation, and customer preference. Each of these structures is more applicable to certain types of mini-grids depending on the prevailing circumstances. Regulators that specify one type of structure can impede the ability of mini-grid operators to innovate or to select the most appropriate structure. Most mini-grid operators are actively evolving their business models, and while none interviewed for this study highlighted that tariff structure flexibility was a key concern, several are adopting more innovative structures such as charging based on time of use, that are improving commercial performance of the mini-grids and better serving customer needs. Enabling mini-grid operators to have flexibility in how they structure their tariffs while ensuring appropriate consumer protections and predictability of the regulatory requirements for mini-grid operators is key to enabling mini-grids to succeed.

MANAGEMENT CONSIDERATIONS

• **Reducing uncertainty:** Governments should provide as much clarity as possible to mini-grid operators over tariffs and the tariff setting process, as risk is a cost to mini-grid operators and their investors that will ultimately be passed on to their customers. Mini-grid stakeholders -- particularly investors-- often identify policy uncertainty as a primary challenge to the scale-up of mini-grids. Clarity on the rules related to setting retail electricity tariffs and any review process and confidence in the implementation of those rules, along with clarity on other elements of the regulatory regime for mini-grids, would significantly reduce uncertainty.

• **Reducing administrative overhead:** Adopting a tariff-setting process that reduces upfront review from a regulator, such as allowing tariffs to be negotiated between the mini-grid operator and the community instead of approved by a regulator, adopting cost-reflective tariffs in a standardized way instead of on a case-by-case basis, or only reviewing tariffs on a case-by-case basis once they are in place and on request only could significantly reduce the upfront cost, time, and the administrative overhead that mini-grid developers have reported as impeding their development.

- **Regulate differently for different sizes/types of mini-grids:** Some regulators differentiate between sizes of mini-grids for both tariff determination as well as overall mini-grid regulation. In terms of tariff setting process, developers of smaller mini-grids are generally more sensitive to the upfront project development cost and time involved in tariff approval processes than those of larger mini-grids. As a result, some countries have chosen to enable smaller mini-grids to negotiate with communities directly, only evaluating tariffs upon a request for a review, or have set a standardized tariff. Developers of larger mini-grids may be more interested in obtaining certainty from upfront approval, as more capital is at risk, and larger grids are more likely to have unique elements that affect costs and revenue, including generation and diversity of their demand profile. Larger mini-grids are also more likely to receive political attention for their tariffs, so a regulator may wish to evaluate the mini-grid in advance. Differentiating based on generation capacity (kW) is a recent trend among regulators in Africa, with smaller mini-grids receiving exemptions from tariff setting approvals and licensing requirements, sometimes requiring registration only (where information is provided to the regulator, but no approvals are required). Alternately, differentiation could be based on the service levels as defined by the Mini-grid Quality Assurance Framework published by the National Renewable Energy Laboratory (NREL), or another country-appropriate criterion.

Differentiated regulation based on generation capacity

Differentiating regulatory environments for mini-grids based on generation capacity (kW) is a recent trend among regulators in Africa. Tanzania and Nigeria both use 100kW to define the maximum size of a grid that receive exemptions from both tariff setting approvals and licensing requirements, and in Tanzania a mini-grid that exceeds 100kW but is less than 1MW is exempted from obtaining an electricity generation license (but must submit to approval of retail tariffs). The Zimbabwe Energy Regulatory Authority also exempts projects under 100kW from licenses and permits, while Namibia uses 500kW as the cut off for exempting for applying for a license. Rwanda has a simplified regulatory framework to exempt or expedite licensing for mini-grid projects, which differentiates requirements for large, medium, small, and very small mini-grids, including clarity on tariff determination; mini-grids of less than 50kW are exempt from licensing procedures but must notify the authorities, while mini-grids 50kw to 1MW are able to obtain a simplified license that allows a cost-reflective tariff.

SUBSIDY DESIGN

If a mini-grid operator cannot set a tariff level that enables them to recover their costs plus a reasonable financial return to their investors, limited either by regulations on the allowable tariff or by customer willingness to pay, then a subsidy will be required to enable a mini-grid to provide that community with access to modern energy services. The need and scale of a subsidy are thus the 'flip side' of the possible tariffs, and the decision about each must consider the other.

In sub-Saharan Africa, few private mini-grid operators are able to operate a viable mini-grid business completely without subsidy: the ability to pay of rural customers is-- in general-- too low compared to the costs for mini-grids to deliver energy services at current capital and operational expenses[11]. While there are some exceptions, including sites that have the right mix of loads, income levels, and proximity to transportation or urban areas, in the current context, a subsidy is generally necessary for mini-grids to be able to scale. With scale and as the costs of technology continues to decline (in particularly battery energy storage), the need for a subsidy may decline.

Subsidies have a long history in rural electrification. Extension of the national grid to rural communities is typically highly subsidised and funded by national governments, donors, or through cross-subsidisation from other users (although cross-subsidisation is generally limited to operational costs of the national utility rather than capital investments in the extension of the grid). The subsidy levels required for grid extension in sub-Saharan African countries have been significant in order to meet electrification policy objectives.

The subsidy required by a developer to build a mini-grid to supply rural communities with electricity is often considerably less than the cost of grid extension[12]. A number of African governments have implemented subsidy programs to support the building of mini-grids, in part recognising the cost-effectiveness from the perspective of energy access gained for a given quantity of fiscal resources.

[11] [Mini-grids for the base of the pyramid market - a critical review, Bhattacharyya, 2018] and information provided by Africa Mini-grid Developers Association

[12] Based on comparison of average investment costs per user for a mini-grid (included in [IFC, 2018]) and the cost for grid extension per new connection in various countries. This comparison will be country and geography specific.

Where the resources for a subsidy comes from -- donors, governments or other electricity consumers -- is ultimately a political decision not addressed in this paper, however, how a subsidy can be disbursed to maximise incentives is discussed below.

OPTIONS FOR SUBSIDY STRUCTURING AND DISBURSEMENT

Mini-grids -- at the broadest level -- have two functions: i) to generate electricity and ii) to distribute and retail electricity. Each side of the business has costs. Mini-grids also broadly have two types of costs: capital expenditures ('capex', paid upfront at construction or during project development) and operational expenditures ('opex', paid over time).

Beyond the type of costs that subsidies can seek to offset, the amount of the subsidy can be quantified based on either:

- **Inputs:** typically a percentage of the input costs

- **Outputs:** based on a metric of achievement, often titled "Results-based Financing" or "Output-based Aid". There are a variety of output metrics that can be utilised to quantify the subsidy amount, such as number of new connections by the amount of energy (kWhs produced).

Capex subsidies may be provided on either inputs or outputs, while opex subsidies are almost exclusively output-based.

Finally, mini-grids may be effectively subsidized by eliminating the private costs for a particular component of the mini-grid project directly:

- **Direct Supply:** Instead of providing a financial contribution to pay for the project developer to complete that component partially, the component could be provided directly by the subsidising agency.

This could be applicable -- for example -- for local distribution systems, where the distribution system would (in this case) be built by an entity that is not the project proponent (e.g. a contractor to the rural energy agency), and it would be transferred or leased to the project proponent for operation. In effect, this is a capital subsidy as it eliminates an upfront capital expenditure of building the distribution system; the difference is which entity is implementing the build out. This approach has been used with success in Ghana as one of the forms of incentive the government has pursued in their energy access work. Alternately, a subsidising agency could do the same for other key components (e.g. providing generation assets, such as solar panels, for free), although this has not been commonly utilised as a capital subsidy method.

There are eight basic options for disbursing a subsidy for mini-grids:

CAPITAL	GENERATION	DISTRIBUTION (INCLUDING RETAIL)
Input-based	Paid based on the cost of the generation asset, as a percentage of the cost basis	Paid based on the cost of building out the distribution network, as a percentage of the cost basis
Output-based	Paid based on the installed capacity of the generation assets, on a /kW basis	Typically paid based the number of connections (i.e. mini-grid connected customers) Other output metrics may be possible (e.g. the distance of distribution or transmission lines extended) although not currently utilised for mini-grids
Direct supply	Selected key generation assets supplied for free	Distribution assets supplied by and built by an entity that is not the project proponent, and transferred/leased to the project proponent for long-term operation
Operational		
Output-based	Paid based on the energy delivered (/kWh)	Paid based on the number of current customers (e.g. paid on a monthly or annual basis). This has not been utilised as a subsidy mechanism for mini-grids in Africa

The most utilised subsidy scheme is the output-based capex subsidy for distribution assets, sometimes including a limitation based on the input costs. An output-based opex subsidy for generation assets have often been used for grid-connected renewable energy production but has not been widely explored for a mini-grid application. Both are detailed below.

- **Output-based capex subsidy based on distribution:** This type of subsidy has been utilised in a number of countries, including Kenya, Tanzania, and Nigeria. Mini-grid project developers typically respond to a call for proposals from the granting agency, identifying i) the location of the mini-grid, ii) the anticipated number of connections, and iii) the intended service level. Developers then provide detailed technical, financial, and other information about the project, including a feasibility study, business plan and environmental and social analysis, as well as demonstrated organisational execution capacity. The amount of subsidy is quantified based on i) the number of new connections and ii) a fixed per connection subsidy amount, typically ranging from 50-75% of the cost per connection[13].

Mini-grid developers overall investment per connection average in the $900 range (an IFC bench-marking across 20 companies had average investments of $920 per use, while the African Mini-grid Developers Association reports an average connection cost of around $900 across their members, though connection costs as low as $400 have been reported)[14], and per connection subsidies generally range between $300-600. On average, approximately 50% of the capital investment cost for a mini-grid is for the distribution network[15], although this can vary significantly based on population density of the area served, technical standards and other factors. The fixed amount per connection may vary based on the level of service the operator intends to deliver, and may have other restrictions such as a maximum percentage of capital cost of the inputs that can be covered by the subsidy (i.e. if the mini-grid is very cost-effective and actual costs are close to or lower than the subsidy amount). Mini-grid developers are typically given a window of time to complete the project or else the subsidy allocation expires. In addition, while the total amount of the subsidy is based on the final number

[13] Based on estimates of investment cost per connection and the available subsidy amounts based on different programs. The exact investment costs will vary by site (often, the subsidy amount will not vary by geography, but may vary by level of service), making calculation of the percentage of capital costs covered by a subsidy difficult to determine. Several subsidy regimes stipulate a maximum subsidy of 75% of direct investment costs.
[14] From [Benchmarking mini-grid DESCOs 2017 Update, IFC, 2018], as well as interview with representative of the Africa Mini-grid Developers Association (AMDA), with reported data based on member data in 2018.
[15] [IFC, 2018]

of verified connections, disbursements may come in advance based on certain project development milestones, calculated on the anticipated number of connections from the proposal.

Tanzania: Results Based Financing based on proposed number of connections

The subsidy amount under the ongoing Results Based Financing program for mini-grids managed by the Rural Energy Agency (REA) is calculated based on the number of connections and level of service the project developer proposed to achieve in their application, with a maximum subsidy of 75% of the total investment cost for both the generation and distribution system. The amount of the subsidy is independent of the electricity generation capacity, except where generation capacity impacts the level of service available to customers. Developers were required to submit detailed documents that outlined their capability and project details, representing a considerable investment by the project proponent to prepare and REA to review.

- **Output-based opex subsidy based on generation:** This type of subsidy is paid based on the amount of electricity produced by the mini-grid. This subsidy can be considered to either i) cover the difference between what the cost-reflective tariff would be and the tariff that the mini-grid is mandated to charge is, or ii) provide an incentive for renewable energy (if specified only for renewable energy production), shifting the risk of electricity production from government to the mini-grid operator (as opposed to using a capital subsidy to provide an incentive for renewable energy). The latter would be an adaptation of the Feed-in Tariff (FiT) incentives that have been used successfully for grid-connected renewable energy; though few countries have implemented FiTs explicitly tailored for off-grid or mini-grid systems.

An additional aspect to consider is how the subsidy will be disbursed: the subsidy disbursement process includes both i) the disbursement timing and ii) the verification necessary before disbursement.

- **Timing:** will the subsidy be disbursed i) all in advance, ii) after the completion of the project, or iii) in tranches based on some intermediate 'triggering events' such as signing of a contract with the project proponent, verified delivery of materials to the construction site, completion of connections, or, in the case of a generation subsidy, a periodic report of electricity production. Different triggers could result in different scales of tranches that are matched with the project developer expenditures, or to build trust with the developer that payments will come in a timely manner.

Disbursing payments in tranches that are matched (timing wise) with the capital needs of the project can reduce the upfront financing needs of the developer (compared to disbursement upon completion), but increases the risk that subsidy resources will be disbursed for projects that will not be completed. Early disbursement can thus increase risk on the granting agency, so a granting agency may take steps to increase their confidence that projects may be completed.

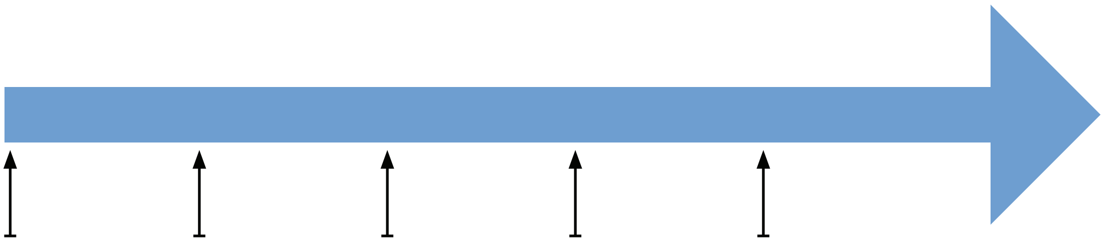

Figure 4: Possible timing of subsidy payments along the progression of the project cycle

Tanzania: Results Based Financing paid in tranches based on anticipated connections

Under the on-going Results Based Financing (RBF) program for mini-grids managed by the Rural Energy Agency, the total RBF amount for a selected mini-grid project is calculated based on the number of connections and the level of service the project developer proposed to achieve. The disbursements are paid in tranches according to fixed percentages of the anticipated total RBF payment at specified milestones, with 35% on grant agreement contract signing, 35% on verified delivery of equipment to the site, and the remaining 30% on verification of the number of connections. In order to ensure that disbursements are paid to developers that will deliver, applications for the RBF program includes extensive documentation from developers.

- **Verification:** disbursements are typically done based on a triggering event that has been verified by the granting agency. Verification may include a site visit (e.g. for connections), document review (e.g. receipts for costs expended) or data provided to the granting agency (e.g. electricity production data). The cost of verification, on both the project developer and granting agency, as well as the time to verify are critical to a subsidy program that aims to have an impact. In general, the longer and more expensive the verification process, the less connected the subsidy is to the outcomes it is seeking as mini-grid developers will discount the value of the subsidy and deviate less from what they would have done in the absence of a subsidy. Further, the more resources spent by the granting agency to perform verification, fewer resources are available to fund the action that is being subsidised, so the subsidy program can achieve less overall. Verification is thus a balance between certainty (that subsidies are only paid for actual outcomes) and effectiveness (that verification cost or time does not reduce the impact of the subsidy). As some mini-grids can be remote and far from major urban areas or transportation corridors, the cost of on-site verification can be significant. There are opportunities to use mobile connectivity and modern data systems to streamline the verification process, such as performing verification utilising the remote monitoring systems that mini-grid operators have developed and utilise to manage their remote mini-grids.

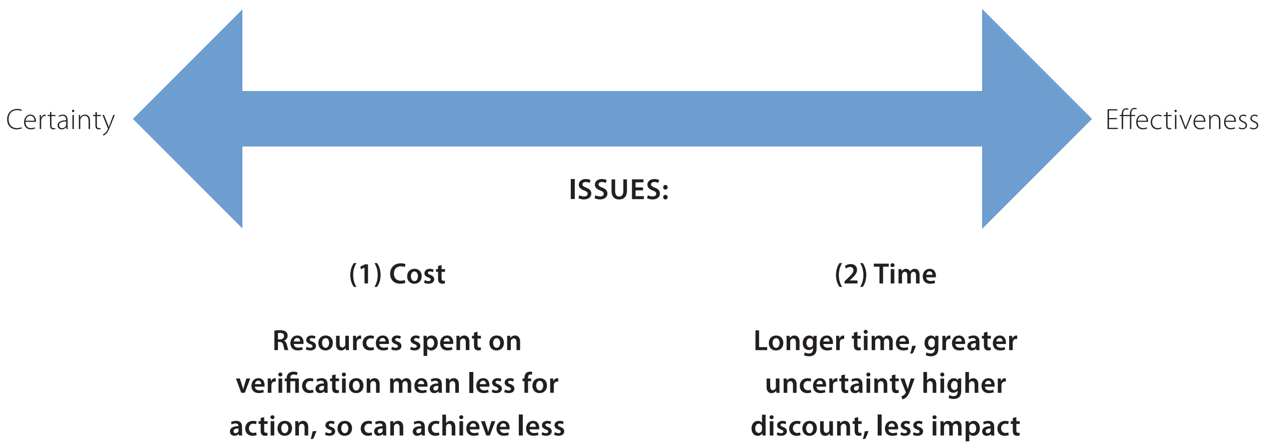

Figure 5: Balance of considerations for verification of triggering events for disbursement of a subsidy payment

QUANTIFICATION OF SUBSIDY AMOUNT

Once the structure of the subsidy is decided, the question remains: how much should the subsidy be? For example, how much should a per-connection subsidy be (an output-based capex subsidy based on distribution)?

At a fundamental level, the value of the subsidy should be high enough to ensure that the mini-grid operator is sustainable and profitable, but low enough to ensure that limited subsidy resources are able to maximize the number of people that are able to get access to electricity through the program. There are several considerations to setting the value of the subsidy:

- **Percentage of costs:** the subsidy is a fixed percentage of expenditures for a particular type of asset, for example, generation asset or distribution network. Percentage of costs is most commonly used for capital subsidies.

India: Subsidy on input costs if there is a viability gap

In Uttar Pradesh, mini-grids in areas where there is insufficient or non-existent electricity distribution are eligible for a subsidy, if they comply with service standards and retail at regulated tariff amounts. Projects are provided a 30% subsidy based on input costs, paid for the budget available from State government and based on an evaluation of the viability gap funding required.

- **Return-based, based on anticipated costs and revenues:**
  - *Fixed/standardised:* based on a standardised amount for all mini-grids that receive a subsidy from a particular program or round of programs. The granting agency needs to assess upfront the costs and potential revenues that a mini-grid might expect in a variety of circumstances and based on a particular or assumed tariff structure and level, and estimate what level of subsidy would produce the required returns. While fixed, the amount can be differentiated based on the level of service or based on other mechanisms of differentiation (e.g. geographic). A standardised subsidy amount requires more upfront administration but has savings during the implementation of the subsidy in terms of both cost and time. However, some mini-grids will receive a subsidy that exceeds what is required for a reasonable return, while other potential mini-grid locations will remain undeveloped, as the subsidy was insufficient to earn a return. As mini-grid cost and revenue structures differ from site-to-site, the required subsidy

amount will also differ. This can be mitigated somewhat by the granting agency being overly generous in the initial subsidy amount, but then restricting the maximum percentage of capital cost that can be subsidised, ratcheting down the subsidy amount for a mini-grid that would otherwise receive an excessive subsidy.

Tanzania: Results Based Financing standardized per connection based on economic assessment

In order to calculate the amount of the subsidy per connection for different levels of service, the Rural Energy Agency and the donor (the Swedish International Development Agency and the UK Department for International Development) retained an independent consultant to review the economics of mini-grids in Tanzania and propose the levels of subsidy that would be necessary to enable private investment in mini-grids in various locations throughout the country. This amount was standardized on a per-connection basis for all mini-grid projects in Tanzania regardless of location and size, with differentiation based on the level of service according the Sustainable Energy For All Global Tracking Framework (e.g. a Tier 4 mini-grid receives US$500 per connection while a Tier 3 mini-grid receives US$300 per connection).

- *Case-by-case:* the subsidy amount is assessed based on the financial proposal from the mini-grid developer. The tariff level would either need to be specified (e.g. if regulated) or based on an assessment of community willingness to pay. The granting agency or administrator develops a methodology to assess costs and expected revenues (based on the tariff and assumptions about customer demand), or rely on the mini-grid developer to provide a methodology (which the granting agency can assess for reasonableness). This process would require the most considerable amount of administrative activity for each mini-grid subsidy application. However, the subsidy amount would be targeted for each mini-grid to ensure that mini-grid operators do not receive an excessive subsidy. It is also likely that a broader range of communities would be able to be electrified, as mini-grids in more uneconomic communities would be able to receive a more substantial subsidy amount.

Kenya: Green Mini-Grid Facility based on case-by-base assessment of costs

The Green Mini-Grid Facility provides investment grants to eligible mini-grid developers in Kenya. The Facility provides two types of grants: i) investment grants, to assist developers with capital expenditure costs including power generation, distribution and associated infrastructure, which are calculated on a cost basis when specific milestones are met; and, ii) Output-Based Grants, calculated on a per connection basis, with the amount per-connection varying from project to project depending on the choice of technology, level of service, approved end-user tariff, local conditions of the site, and other factors.

- **Avoided-cost:** the subsidy amount would be based on the avoided-cost of grid extension per the regulator's determination of those costs. Grid extension is typically subsidised on a national basis, and mini-grids would be eligible to receive that subsidy as well, as both grid extension and mini-grids serve the same purpose: expand energy access. This would require the government to think holistically about electrification planning and budgeting for expanding energy access. If the subsidy amount is matched to the amount typically offered to utilities for grid extension, the subsidy amount could exceed what is necessary to ensure a reasonable return for the mini-grid developer, as the subsidy for grid extension is often quite high, and mini-grids are generally more cost-effective.

- **Auction-based:** the subsidy is determined in a reverse auction with mini-grid developers, with the objective of expending the lowest subsidy necessary to achieve specified electrification goals. This would typically be paired with a concession to operate a mini-grid for a particular area. Auctions enable real price discovery in a transparent and competitive process and address the problem of information asymmetry between the granting agency and project developers. In order for an auction to be viable, the granting agency would need to define specific characteristics: geographic area, level of service, the minimum number of connections, and tariff levels, among others. Reverse auctions for subsidies for grid-connected renewable energy production (i.e. auctions to determine the FiT) has achieved significant price savings over other methods of subsidy allocation.

Senegal: Auction of concession based on subsidy and number of connections

Senegal has two potential routes for mini-grid development: i) formal top-down identification of concessions followed by a tendering process, and ii) developments by entrepreneurial mini-grid developers in 'mini-concessions', called Electrification Rurale d'Initiative Locale (ERIL, translated to 'Locally Initiated Rural Electrification'). For top-down concessions, auctions are done on a maximum subsidy basis (80% of capital expenditure) with bidders stating the number of connections they can achieve within three years. Developers may have the option of connecting customers to the main grid, to a mini-grid, or with a solar home system.

Philippines: Auction for subsidy amount

For 'unviable' areas where the utility is unwilling to provide power without an external subsidy, there is a public tender for an private party to provide electricity production to the local distribution utility (in a power purchase style arrangement, as the local utility/electric cooperative manages the distribution), who then bid based on the required subsidy amount. Alternately, a private party may operate both the electricity production as well as the distribution and receive a subsidy to do so.

The granting agency must also select or develop a methodology:

- For a bottom up determination of the subsidy amount, whether on a case-by-case basis or as a standard amount based on a 'model' mini-grid, the granting agency would need to develop a methodology for translating assumptions about costs, revenues and other financial data into an expected return; by adjusting the subsidy amount in the model, a granting agency can adjust the internal rate of return of the project until it meets the threshold defined for being commercial (some countries have used 15-18% as the threshold[16]).

- Quantifying the avoided-cost of grid extension requires an assessment of expenditures by the agency responsible for achieving electrification targets, typically a rural energy or electrification agency, rather than an assessment of mini-grid costs and revenues.

[16] Kenya uses 18% as the permitted internal rate of return, while Tanzania uses approximately 15%.

• For an auction-based subsidy determination, the granting agency does not need to develop a methodology for calculating a subsidy amount based on costs and revenues of a mini-grid but would need to define the methodology for operating the auction.

There are several tools available that can aid a granting agency in developing such a methodology based on the detailed economics of mini-grid development (see section on Tools).

Images from the AMG-CoP Meeting 4, Abuja, Nigeria (Nov. 2018)

CONSIDERATIONS FOR SUBSIDY CHOICE

MANAGEMENT CONSIDERATIONS

- **Confidence is key to effectiveness:** mini-grid developers interviewed report being wary of subsidies that are disbursed by government agencies, given past experience with delays in receiving payments or perceived risks of non-payment[17]. If a mini-grid developer is not confident that they will receive the subsidy in a timely manner, they will discount the value of the subsidy, reducing its impact. For example, in response to delays to disbursements, mini-grid developers may phase their developments (e.g. only do a pilot project, or a particular mini-grid build out in sections as they are paid), putting less capital at risk and slowing deployment of mini-grids, when the goal of the subsidy is to accelerate mini-grid deployment and leverage private capital. Lack of confidence will result in developers continuing their business as usual activities (what they would have done in the absence of the subsidy), with the subsidy a bonus rather than changing developer decisions. Confidence is most critical with subsidies that are paid over time, as it is risky for a private project operator to place their trust in on-going public financial support given potential changes in policy, budget, and political regimes; for this reason, subsidies paid upfront for capital expenditures are often preferred by private operators. To counteract this, governments should take definite steps to build trust with mini-grid developers in order to maximise the impact of the subsidy. One possibility to build trust would be to implement the subsidy program through a private, third-party agent that has a pre-existing, trusted reputation and a track record of effective and efficient program management and capital disbursement.

- **Disbursement timing vs. documentation requirements:** for a capex subsidy, granting agencies often require significant documentation upfront, including technical details, business plans, financial statements, and other information. Providing this documentation takes time and is costly, both for the mini-grid developer to provide and the granting agency to review. In part, this documentation can be justified as the granting agency is making

[17] Author's primary research

disbursements based on milestones --before completion of the mini-grid -- and they want to do due diligence on the developer's capability and commitment to complete the mini-grid project, as the subsidy resources could otherwise be misspent. If disbursements are made only after completion, based on verified outputs (e.g. connections), then the granting agency has no risk that early disbursements will have been misspent if the mini-grid developer fails to complete, so there is less need for detailed documentation to build granting agency confidence in the mini-grid developer. The documentation requirements could alternately be lifted for developers that have already completed at least one mini-grid, as they have already demonstrated their capability. These approaches could be combined (for instance, if a mini-grid developer has completed one mini-grid previously, they can be exempt from much of the documentation if disbursement of the subsidy is only made when verification of connections is completed) to reduce application overhead, shortening the time and cost for subsidy allocation.

- **Complexity requires the capacity of granting agency and project developers:** several subsidy approaches require the utilisation of different methodologies that rely on the capacity of the granting agency implementing the subsidy to be able to apply the methodology, and project proponents to be able to supply the information needed and apply the methodology to their projects. For example, subsidy approaches that rely on an assessment of costs, revenues, and other financial data can be complex, requiring the development or understanding of a model, an ability to assess data inputs for veracity, and judgment on the appropriate inputs (such as permitted rate of return). Other approaches, such as an auction, require rules to designed and implemented. The need for and source of capacity development -- both of the granting agency as well as of project developers -- on the implementation of a chosen subsidy approach should be a key consideration to ensure that the subsidy is able to be delivered effectively.

ECONOMIC CONSIDERATIONS

- **Access to finance:** access to finance is a challenge for many mini-grid developers, particularly debt from local and international financial institutions. Having subsidy disbursements based on milestones that are matched to capital expenditures at each stage of project development can reduce the financing needs, particularly for smaller or early-stage companies. However, developers often struggle to raise the "matching capital" for these tranches given the dearth of funders active in the energy access mini-grid market today. In a business environment where access to finance is

Mini-grid site in Minna, Niger State

a significant barrier to mini-grid development, structuring a subsidy to include earlier disbursement tranches can significantly help overcome the access to finance barrier, but additional tools and interventions may also be necessary to facilitate scaled access to finance.

- **Opex subsidies improve long-term sustainability:** long-term subsidies are more likely to achieve long-term sustainability if the granting agency is able to remain committed to such a subsidy. First, opex subsidies improve the unit economics of electricity sold, so the likelihood the mini-grid can continue to at least break-even and continue to operate is higher with an opex subsidy. Second, capex subsidies are more likely to attract mini-grid developers that are looking at the short term.

- **Connection subsidies mean dense communities get priority:** a fixed connection subsidy is likely to encourage developers to focus on more densely populated locations, as the mini-grid developer can minimise their costs (with a smaller but more densely developed mini-grid systems) while retaining the same subsidy amount. Dispersed communities are thus less likely to get connected using a subsidy that is based on the number of connections. This can be mitigated by including other metrics in the subsidy calculation, including the distance of new distribution lines and others.

- **Renewable energy generation can achieve lower cost-reflective tariffs in the near term, but the capital replacement must be accounted for:** renewable energy mini-grids generally have lower operational costs, and are able to manage lower tariffs in the near term if the additional capital cost of the renewable generation asset is subsidised. In the long term, unless there is a further capital subsidy for replacement of the renewable energy generating asset, a cost-reflective tariff should account for capital replacement.

SUMMARY

Overall, regulators of mini-grid tariffs and subsidies are faced with a dynamic, complex and interlinked set of considerations when establishing policy. They must consider the needs of the local community and their ability and willingness to pay, the costs of serving those communities, and the needs of the mini-grid operators to cover their costs and deliver a return to their companies and their investors. These conditions vary significantly across geographies, and there is no one size fits all approach to establishing effective and fair tariff and subsidy structures. This analysis discusses key considerations for regulators in the design and establishment of mini-grid tariffs and subsidies as they seek to balance considerations of equity, transparency and efficiency (for themselves, the developers, and the communities they both serve) when designing policies and procedures related to tariff and subsidy establishment, approval, issuance and review.

AVAILABLE TOOLS

There are several toolkits that regulators and granting agencies can utilise to inform the assessment of tariffs and subsidies that provide an adequate return. Two are highlighted here:

- **EUEI-PDF Mini-grid Policy Toolkit – Support Tools:** These tools are simple excel tools, with a methodology that requires input data on capital costs, operating costs, financing costs and other information, as well as assumptions about revenue. There are two relevant tools to this study: one that calculates the required retail tariffs to achieve the desired financial return, and the other designed for the calculation of technology-specific Feed-in Tariffs (FiTs) for mini-grids selling power into the main grid.

See http://minigridpolicytoolkit.euei-pdf.org/support-tools.html for more details

- **NREL REopt:** a techno-economic decision support model that can enable evaluation of the economic viability of a renewable energy mini-grid. REopt is a dynamic software tool, which can optimise energy systems for micro-grids and determine the Least Cost of Energy (LCOE) given a set of input constraints. The LCOE can be used as the proxy for the cost-reflective tariff, or the difference between the calculated LCOE and the allowable tariff is the required subsidy amount.

See https://reopt.nrel.gov/ for more details

ANNOTATED REFERENCES

A number of documents were reviewed for this study; the list below includes the most significant documents that can be used to help explore retail tariff policy, subsidy design, and related policy and regulatory issues for mini-grids.

ENERGY ACCESS AND MINI-GRID MARKET HIGH-LEVEL ASSESSMENTS:

Energy access outlook: From poverty to prosperity

International Energy Agency, 2017

https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf

This report is the International Energy Agency flagship publication on energy access. It comprehensively reviews recent trends and policy efforts on access to electricity in developing countries and includes an in-depth focus on sub-Saharan Africa, looking at current and future trends for both electricity access and clean cooking, and how the region can achieve access to modern energy for all by 2030. The report also explores the wider implications of achieving the SDG goal on access to energy for all in relation to energy demand, greenhouse gas emissions, investment, gender equality, and health.

Green mini-grids in sub-Saharan Africa: Analysis of barriers to growth and the potential role of the African Development Bank in supporting the sector

P. Weston, S. Verma, L. Onyango, A. Bharadwaj, N. Peterschmidt, M. Rohrer (Energy4Impact and INENSUS)

Africa Development Bank (AfDB) Green Mini-Grid (GMG) Market Development Program (MDP) Document Series #1, 2016

https://greenminigrid.se4all-africa.org/sites/default/files/GMG-MDP-Document-Series-N1.pdf

This paper analyses the issues involved with developing green mini-grids for rural electrification, providing a background on mini-grids, barriers to the development of mini-grids, and viable solutions to those barriers. Five main barriers are suggested, including gaps in the policy and regulatory framework, specifically issues around tariffs, licensing, and arrival of the national grid.

Mini-grids for the base of the pyramid market: A critical review
S. C. Bhattacharyya, Energies, Vol XI, 2018, p. 1-21.
https://www.mdpi.com/1996-1073/11/4/813
This paper explores whether mini-grids can be a solution for the base of the pyramid (BoP) market and the challenges faced in deploying mini-grids in such markets, including the conclusion that mini-grids targeting the BoP market is not attractive in business profitability terms and requires financial support. The paper also discusses the impact that policy and regulatory environments have on the financial viability of projects, as well as interventions to support mini-grid deployment.

REPORTS ON POLICY AND REGULATORY ENVIRONMENTS MORE BROADLY THAT ALSO INCLUDE ELEMENTS ON RETAIL TARIFFS AND SUBSIDY DESIGN:

From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa
Bernard Tenenbaum, Chris Greacen, Tilak Siyambalapitiya, and James Knuckles
World Bank Group – Directions in Development series, 2014
https://openknowledge.worldbank.org/handle/10986/16571
This book is a seminal and extensive exploration of the policy and regulatory environment for mini-grids. It covers both small power producers as well as mini-grids and includes technical and economic considerations, subsidy design, tariff policy, quality of service issues, other regulatory issues, and numerous example case studies. It is the definitive book that covers policy issues related to mini-grids, although the examples may be several years old.

Policies and regulations for private sector renewable energy mini-grids
International Renewable Energy Agency (IRENA), 2016
http://www.irena.org/publications/2016/Sep/Policies-and-regulations-for-private-sector-renewable-energy-mini-grids
This comprehensive report explores a range of policy and regulatory issues related to mini-grids, including sections on cost recovery and tariff regulation. It highlights numerous examples of implementation of different policies throughout and outlines a number of recommendations for policymakers.

Policies and regulations for renewable energy mini-grids

International Renewable Energy Agency (IRENA), 2018

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_mini-grid_policies_2018.pdf

This report is an update of the 2016 edition published by IRENA, with a reflection of the current status and trends. The substantive components of the report contain eight detailed case studies in Africa, Asia and South America that cover the timeline of policy development, key policies including subsidies and retail tariff setting, and development of the mini-grid market over time in each country.

Mini-grid Policy Toolkit: Policy and Business Framework for Successful Mini-grid Roll-outs

European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF), 2014

http://www.euei-pdf.org/en/recp/mini-grid-policy-toolkit

This policy toolkit includes the basics of mini-grids and rural electrification in Africa. It has a detailed focus on mini-grid operator models, assesses mini-grid economics at length, discusses stakeholder interests and contributions, and describes current policies and frameworks for mini-grids in Africa. It is a key resource for policymakers contemplating their mini-grid regulatory environment.

Policy catalogue for green mini-grids in Africa

D. Cooper, J. Felton, D. Schroth, K. Brown (Clean Energy Mini-Grids Partnership / CEMG)

Africa Development Bank (AfDB) Green Mini-Grid (GMG) Market Development Program (MDP) Document Series #7, 2017

https://greenminigrid.se4all-africa.org/afdb-mini-grid-publications

This paper compares the existing policy environments for green mini-grids in African countries, specifically the sub-Saharan African region. Policy documents for each country are listed, along with a small summary. Noteworthy policy documents from seven countries outside of Africa are listed as well as related policy documents from international organisations. Readers are introduced to 10 top considerations for Green Mini-Grid sector development.

Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required?

S. C. Bhattacharyya, D. Palit, Journal of Energy Policy, Vol 94, 2016, p. 166-178. https://doi.org/10.1016/j.enpol.2016.04.010

This research paper summarises research findings from four demonstration projects over a five-year timeframe, suggesting that both cost-effective universal electricity service and reaching the sustainable development goal of universal electrification target by 2030 remain a challenge. The paper explores financial, organizational, and governance weaknesses that hinder successful implementation of projects in many countries and provides 10 policy recommendations to promote mini-grids as a complementary mechanism to grid extension.

REPORTS ON SPECIFIC IMPLEMENTATIONS OF MINI-GRIDS, FINANCING, OR DATA COLLECTION EXERCISES:

Hybrid Mini-grids for Rural Electrification: Lessons Learned

USAID, Alliance for Rural Electrification (ARE), 2014

https://ruralelec.org/publications/hybrid-mini-grids-rural-electrification-lessons-learned

The report summarises the lessons learned from the implementation of mini-grid projects by members of the Alliance for Rural Electrification. Relevant to this study is the discussion of financial and operational issues, including tariff structures that are appropriate and subsidy programs necessary for funding projects. The report examines technical issues in detail as well presents different business models for mini-grids, including community-based, private sector-based, utility-based, and hybrid models, and discusses the influence of business, economic and social factors on business models.

Operational and financial performance of mini-grid DESCOs

International Finance Corporation (IFC), 2017

https://cleanenergysolutions.org/resources/operational-financial-performance-mini-grid-descos-findings-insights-pioneer-benchmarking

This report provides benchmarks on a number of metrics, including the number of connection, average electricity demand, grid capacity and setup time, technology choices, tariffs, revenue amounts and mix, costs, financing, and profitability. The aim of the report is to help lenders and investors better assess the bankability of mini-grid DESCOs by developing a set of standardized metrics (financial and other) against which mini-grid DESCOs can be assessed, providing indicative ranges and/or thresholds within which performance against these metrics should ideally fall and sharing an initial analysis of the current performance of a selection of mini-grid DESCOs along these dimensions. The report includes data from 20 companies operating in seven different countries.

Benchmarking Mini-Grid DESCOs 2017 Update: Summary of Findings

International Finance Corporation (IFC), 2018

https://www.ifc.org/wps/wcm/connect/f5fdab8c-b567-43d4-8f62-8f6edc15c1c1/IFC+Mini-grid+DESCO+Benchmarking+2017+Update.pdf?MOD=AJPERES

This is an update of the "Operational and financial performance of mini-grid DESCOs" publication by IFC, and includes benchmarking data covering a sample of 20 mini-grid DESCOs operating across 12 countries. This document provides a clearer summary of key data points than the previous version.

Productive use of energy in African micro-grids: Technical and business considerations

S. Booth, X. Li, I. Baring-Gould, D. Kollanyi, A. Bharadwaj, P. Wesston.

National Renewable Energy Laboratory (NREL) and Energy4Impact, 2018

https://www.nrel.gov/docs/fy18osti/71663.pdf

This report examines best practices for promoting productive use of energy and the business models used by developers. The report is on application specific data working with a range of micro-grid developers in East Africa, and considers productive use from both business and technical perspectives.

Microgrid Market Analysis and Investment Opportunities in India, Tanzania and Indonesia

Microgrid Investment Accelerator and Allotrope Partners, 2017.

https://www.microgridinvest.org/s/MIA_Market_Report_2017.pdf

This report examines the financial, policy and regulatory environments and current market dynamics for mini-grids in India, Tanzania and Indonesia in 2017 and provides market insights and recommendations.

REPORTS AND PAPERS WITH A SPECIFIC FOCUS ON RETAIL TARIFF SETTING:

Tariff Considerations for Micro-grids in sub-Saharan Africa

Tim Reber, Sam Booth, Dylan Cutler, Xiangkun Li and James Salasovich

National Renewable Energy Laboratory (NREL), USAID, Power Africa, 2018

https://www.nrel.gov/docs/fy18osti/69044.pdf

This is a comprehensive document detailing the drivers and considerations of tariff decisions for mini-grids in sub-Saharan Africa. Different kinds of tariff schemes are discussed, along with their benefits and drawbacks. Furthermore, sub-Saharan countries are presented as example cases for different kinds of tariffs that are being applied. The role of cross-subsidies is discussed, and different simulation analyses are carried out, where Levelized cost of energy (LCOE), tariffs and subsidies are the main discussion points.

Tariff structures to encourage micro-grid deployment in sub-Saharan Africa: Review and recent trends

T. Reber, S. Booth, 2018

http://doi.org/10.13140/RG.2.2.33679.28323

This article reviews trends for micro-grid tariffs in sub-Saharan Africa from two perspectives: guidelines for setting tariffs and methods for structuring tariffs. Different approaches are briefly described, and general benefits and drawbacks are presented based on recent experiences and available literature. The article suggests that cost-reflective tariffs are a critical enabler for mini-grid scale-up, which can be coupled with subsidies or hybridised approaches to maintain affordability for low-income customers and financial sustainability for mini-grid operators.

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