Risk Quantification and Risk Management in Renewable Energy Projects

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Authors:

Altran Italy
- Jean Michelez
- Nicola Rossi

Altran Spain
- Rosario Blazquez
- Juan Manuel Martin
- Emilio Mera

Altran Netherlands
- Dana Christensen
- Christian Peineke

Altran Germany
- Konstantin Graf

Arthur D. Little
- David Lyon
- Geoff Stevens

Contact:

Altran GmbH & Co. KG
Konstantin Graf

Veritaskai 3
21079 Hamburg
Germany

+49 (0) 40 797156-0
konstantin.graf@altran.com
www.altran.de

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David de Jager IEA-RETD Operating Agent, Louis Fananas Deutsche Bank, Eduardo Foz BP Solar,Carlos Montoya IDEA, David Jack Lux Energia Solar, Rafael Luna Naturener Solar, Jorge Castano Sunpower, Juan Carlos Sirviente Naturener Solar, Antonio de la Torre Abengoa Solar, Florian Klein Abengoa Solar, Van Gansewinkel Henk Eneco, Bos Tiemen Jan Eneco, Horst Max EWT, Buddenbaum Ed EZ (regulator), Jongkind Anne Nuon/Weom, Jongste Niels Green Giraffe, Stefan Hochbruck Bard Offshore

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Name: see above	Name: Jean Michelez, David Lyon, Emilio Mera	Name: David de Jager	Name: IEA-RETD

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Executive summary: Risk Quantification and Risk Management in Renewable Energy Projects

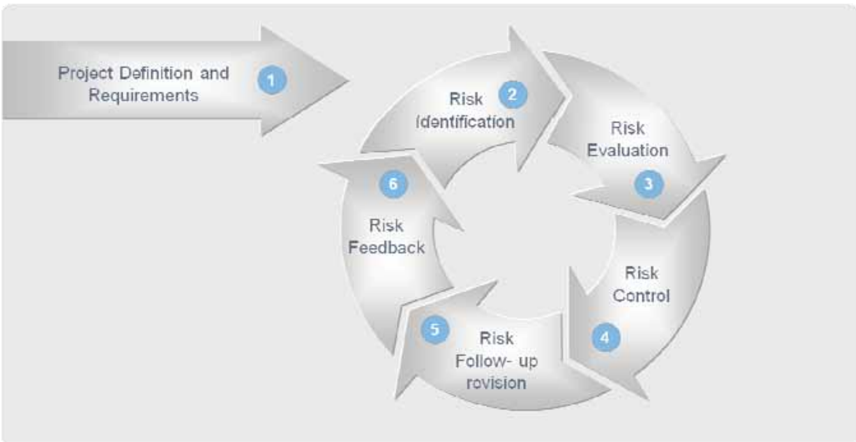
Renewable energy plays an important role in the transition towards a low carbon economy and the provision of a secure supply of energy. Many years of research and development have brought a number of renewable energy technologies to a stage where they are technologically mature and ready for a more widespread market introduction. However, perceptions of the associated risks have constrained the progress of renewable energy; as a consequence there is still a gap between Renewable Energy Systems (RES)[1] promoters and financing organizations:

- **Venture capital and project finance gap**. The further development of renewable energy projects is restricted by the challenge of bridging the technology development and scale-up gap. This reflects the very different requirements of Venture Capital (VC) investing in emerging technology, and project finance supporting established technologies (often supported by a stable regulatory regime).
- **Availability of venture capital to sustain emerging technologies**. Emerging technologies (e.g. wave and tidal) need to raise working capital for both sustaining the operations of technology companies as well as the demonstration projects. Markets now recognize the high capital, high risk, long lead time involved with these technologies; unless venture capital firms are following their own previous investments, they are now pulling away altogether.

A key challenge in obtaining financing at a reasonable cost is the ability to quantify and manage the different elements of risk (i.e. organizational, political, technical, commercial) associated with RES projects. This project commissioned by the International Energy Agency and conducted by Altran and Arthur D. Little provides reproducible and transparent techniques to assess the risk/return profiles of RES investments. In doing so, the project provides RES-specific guidelines in classification, assessment and management of different risk elements associated to support project valuation.

Conventional energy projects have been developing and refining methodologies for risk assessment for many years. The project considers the lessons learnt in detail in order to understand what is transferable to RES projects. Using specific RES project case studies and involving conventional energy, RES and risk management experts, the project has resulted in a methodology applicable for RES projects. The methodology is broken down into a number of key (and established) elements:

Figure 1 Generic Project Risk Management Process



[1] In this document renewable energy sources and technologies will be referred to as RES.

Risk management methodologies can (and should) be the same between RES and conventional energy projects. In particular, any RES project risk management approach should structure and apply a conscious approach to risk identification, risk appraisal, risk handling and risk review.

The key is to be able to tailor the complexity of the risk analysis and associated management processes to the size and nature of the projects. An important requirement is to avoid “oversizing” risk assessment and to avoid introducing low value complexity.

1. Project definition and requirements: The first step requires a detailed description of the context in which the analysis is carried out. Project descriptions of RES projects are likely to differ from conventional projects in a number of key areas:

- Technologies such as wind, PV are much more **“modular”** than other types of projects. Where grid connection and other enabling construction costs are lower (e.g. PV), the investment critical mass is lower and capability for plant growth is higher.
- RES projects can include **less mature technologies** where technical standards have not been developed. These projects follow a very different logic to purely commercial projects (e.g. for a demonstrator project the performance is more important than build time, hence delay might be acceptable).
- Compared to other infrastructure projects, RES technologies (with the exception of biomass and biofuels) have relatively **low O&M costs** compared to up-front investment.
- There are **complex permitting processes** which need to be described. This includes administrations at different levels and for different matters (e.g. planning, environmental permits, subsidy permits, and grid connections).
- Specific issues associated with **dispatchability** have to be documented carefully. This applies to technologies such as wave, wind or PV, but not to tidal or biomass/biofuels. Given the incapacity to store and/or forecast energy generated with the same accuracy as other conventional generation technologies, renewable energies are often much more sensitive to the supply-demand balance in the grid.
- All RES projects are based on a **distributed generation model**. Therefore the project description should describe the operational model of utilities (which can be much more complex than with conventional generation).
- Given the limited **sources for finance** of smaller RES projects (compared to conventional energy projects) and the limited commercial background of sponsors, these need to be documented carefully. Project finance and its associated fee structure requires projects sufficiently large to support the fees with sufficient cash flow to justify modest interest rates. Venture capital could absorb the higher risk but requires higher returns which are not compatible with taxpayer subsidised schemes.

2. Risk identification involves ensuring all key topics are considered, and lessons learnt from past projects are incorporated. In practice this process is improved by the use of a Risk Breakdown Structure (using a structured approach to list risks that could be encountered), the use of a facilitated workshop and the drawing from “risk libraries” based on past experiences.

There are a number of issues that are often particularly critical for RES projects which often inform the identification of risks such as:

- **Technology maturity:** Many RES technologies are immature and may not deliver the design output and / or the design service factor. Therefore in many cases risk identification covers management of risk in the R&D phase as well as project realization. At the same time, the evolution of RES product lines and technologies is much quicker compared to traditional energy projects. It is therefore much more vital to appraise new product options.

- **Integration of the RES project into the existing conventional energy grid:** Renewable energy sources tend to be distributed with variable power output, whereas grids need to supply any (to include low demand and high wind conditions...) demand with high reliability irrespective of the weather or light conditions.
- **Dependency on weather:** RES Technologies such as PV, wind, and wave technologies are dependent on weather patterns which creates uncertainty in projected revenues.
- **Long term taxpayer support for the financial position of the RES project:** Compared to conventional energy projects, RES projects rely on long-term subsidy scheme frameworks put in place by governments. As a result they need to consider risks associated with public policy and its implementation.
- **Large land take typically required:** Risk assessment needs an adequate treatment of the social objections to RES projects. These can include the land-used for PV or onshore wind projects or the land required to grow feedstocks. The land required can often be in rural or remote locations, where industrial activity has not occurred in the past.
- **Permitting:** RES projects often involve a multiplicity of interfaces in permitting which can become critical risks in project delivery.
- **Market factors in the procurement of main items of equipment:** Many technologies are subject to pinch points in supply-demand. The sector as a whole is growing very rapidly; at the same time there are “tactical” demand restrictions at the time of policy review periods. This results in cyclical oversupply followed by supply shortage periods affecting product availability and price. For some technologies the supply chains are still in early stage of development with renewable energies competing against established industries.

3. Risk evaluation draws from an understanding of outcomes from previous related projects and the future context in which the project in question will be carried forward. This context includes market aspects, the political and social context and financial factors affecting potential investors' views.

Given the modularity of RES technologies, they often involve smaller projects compared to standard infrastructure projects. In these cases, the balance of analysis vs. judgement has to be adjusted slightly towards judgement with more emphasis on workshop approaches. These workshops appraise the probability of occurrence, potential impact on the project and manageability of each of the risks.

In the simplest RES projects, risk assessment can be conducted through a management team discussion on each topic. As projects become more complex, the structuring of facilitated workshops using independent experts with additional sophistication in analysis tools is important. Different experts/stakeholders will differ in their assessment of risks. These uncertainties can be combined in Monte Carlo-based simulations resulting in the production of a probability function of budget, timeline and profitability of the project.

It is important that the technique chosen for comparative assessment of the impact of the various risks must be clearly explained and understood by those undertaking the assessment.

4. Risk Control and follow-up: The risk analysis is then followed by a formal corporate control procedure which places a requirement for the analysis on the project promoter and allocates responsibility for action. In practice this can be conducted through the sequential project stages (e.g. Appraise- Select- Define-Execute-Operate) with an incremental amount of investment/risk in each subsequent phase. The management strategy for each risk normally includes: a risk management plan (e.g. specific objectives, resources, timeline, accountability and reporting indicators and frequency), and allocation of contingency budget to the project execution through the measurement P50-P80 values in probability functions.

5. Risk Feedback At the end of a given project, the project risk plan is compared against the actual project journey and results. From this review, lessons learned are extracted and incorporated into the risk library to enrich future risk management exercises.

The report discusses innovative support measures to address key sources of risk for RES projects:

- For political risks (often characterised by discrete events and therefore hard to control), country credit default swaps, risk sharing schemes, and insurance are important
- Economic risks can be managed through mechanisms such as JVs and other arrangements, including insurance, guarantees, derivatives, and risk transfer approaches.
- Social risks can be captured as part of health safety, social and environmental impact assessments and stakeholder engagement plans. Specific mitigation measures are then developed by subject matter experts into a Health, Safety, Social and Environment (HSSE) management plan.
  For technical risks these can be managed through guarantees, warranties, insurance, as well as agreements or other organisational arrangements between key parties. Therefore, there is significant overlap with measures to address economic risks.

The report finally makes a number of recommendations which are organised by the stakeholder group:

- The public sector should encourage the further development of the methodologies to support its important role in promoting / developing key support measures.
- Developers can benefit from this systematic approach to risk management; they can also benefit from linking this approach to measures to manage project risk.
- Investors can promote this methodology to developers and participate in risk assessment workshops for significant investments. They can also use this methodology to promote and develop support measures.

The project also identifies a number of general opportunities to develop and refine the methodology further, to engage key players on the methodology and to capture information on key risks associated with renewable energy (ensuring critical lessons are learnt).

While many of the techniques and approaches will not be new to banks and others, there is a real need for key players to speak the same language. Once this has been achieved, it is possible to have a meaningful debate on what risks to accept, avoid or transfer. Finally, the approach will allow key players to have a realistic understanding of risks involved in renewable energy technologies and develop appropriate support measures (or avoid counterproductive measures).

At the same time the development of a structured and rigorous approach to risk assessment and management will allow parties, such as smaller project promoters to engage effectively with potential investors; the use of the Risk Breakdown Structure (RBS) will ensure that critical risks are less likely to be overlooked; the use of probabilistic modelling allows a discussion of uncertainty - without creating a "black box" where the workings of the underlying model are not visible.

1 Introduction

1.1 The Study

While there has been substantial growth in Renewable Energy Systems (RES) over recent years, they are not necessarily meeting their full potential. In particular, different perceptions of risk by investors, developers and other stakeholders have constrained the potential for Renewable Energy. To address this issue, IEA-RETD commissioned Altran and Arthur D. Little to develop a methodology for risk quantification and risk management for renewable energy projects.

This report therefore presents a ***transparent and reproducible set of techniques to assess the risk/return profiles of RES investments***. In doing so, the project aims to develop RES-specific guidelines for the classification, assessment and management of different risk elements associated with RES project valuation. The specific objectives addressed in this report include:

- To identify and assess major risk elements (and sub-elements) in renewable energy projects;
- To define potentials of, and methodologies for the quantification and management of different risk elements;
- To assess existing instruments to reduce risk (e.g. risk-insurance, public bonds, public funds to pool risks, public grants);
- To identify and assess innovative support measures which could reduce the financing costs by changing the risk profile of a particular project.

This study was undertaken through an ***iterative approach involving key stakeholders in RES projects***. This approach has resulted in a set of pragmatic tools for all key parties involved in RES risk management, including policy makers involved in policy instrument design or project evaluations, as well as project developers with limited experience in risk assessment and mitigation.

Our approach is described as follows:

Step 1: Our first step was a workshop bringing our experts in risk management from traditional energy industries (e.g. upstream oil & gas) together with our renewable energy experts. Risk Management best practices and renewable energy case studies were presented and approaches compared. In this brainstorming session, an assessment of risk management methodologies and frameworks was conducted to identify candidate approaches for renewable energy projects.

Step 2: The second step involved the formalization of workshop results into an initial risk management approach for renewable energy projects.

Step 3: This approach was tested in two case study workshops with industry professionals. Stakeholders involved in each step of the project lifecycle including investors, developers, policy makers, equipment manufacturers were involved in the workshops. This ensured all the perspectives of and requirements for risk management in renewable energy were represented. Following the workshops, we conducted a number of interviews and web based questionnaires to explore specific issues related to the methodology with investors and others.

Step 4: The results and feedback from these workshops were analyzed by our financial services, risk management and renewable energy experts. The knowledge gained throughout the process was integrated into a final version of the methodology and is presented in this report.

1.2 Report Structure

This report describes approaches for risk assessment in conventional energy projects and draws on this to develop an approach to be applied to renewable energy projects. In particular:

- **Chapter 1** and **2** provide an introduction and overview of the report to the reader.
- **Chapter 3** introduces a proposed risk management approach based on a conventional energy project case
- **Chapter 4** links risk management of conventional energy projects with renewable energy; it introduces particular features of renewable energies and implications for approaches used for risk management.
- **Chapter 5** presents the risk management approach in detail with illustrations from case studies.
- **Chapter 6** reviews innovative support measures and their effect on renewable energy project risks.
- **Chapter 7** provides a conclusion and recommendations.

The annexes provide further details on the methodology including feedback from the industry stakeholders gathered during the workshops.

1.3 Report rationale: Challenges for Renewable Energy Projects

While renewable energy installed capacity in Europe has increased rapidly over the past decade, the scale of investment significantly slowed down in 2008 and levelled off in 2009 and 2010. At present, despite substantial government commitments, few countries generate more than 10% of their electricity needs based on renewable energy sources. These trends vary by technology with some cooling down (e.g. onshore wind), others with moderate growth (biomass and geothermal energy) and some with the potential for significant growth (e.g. offshore wind technology and solar energy).

This will require a substantial investment: In Germany alone an average investment of eight billion Euros per year was recorded between 2004 to 2010. Similar levels of effort are being discussed in other regions such as Asia, North America and Australia. (see Figure 2).

Figure 2 Global financial new investment in sustainable energy, quarterly trend (Q1/2004 – Q2/2010) in €bn.

A deeper look into the finance of RES projects suggests that there are growing barriers to obtain finance (although investors are becoming more accustomed to renewable technologies over time).: As Figure 3 illustrates, the fraction of on-balance sheet finance has reduced in 2008 to the level comparable to 2005[2] but increased significantly in 2009 as a result of the financial crisis. This is especially true for projects associated with the more conventional RES technologies such as onshore wind and solar-PV, as a recent poll by the NREL[3] has shown (see Figure 4). Other less known technologies, for example CSP (Concentrated Solar Power), still largely depends on balance-sheet finance.

[2] "Global Trends in Sustainable Energy Investment 2010", UNEP/NEF, 2010
[3] : NREL - REFTI, results questionnaire Q3/2009

Figure 3 Asset financing for new investment by type of security

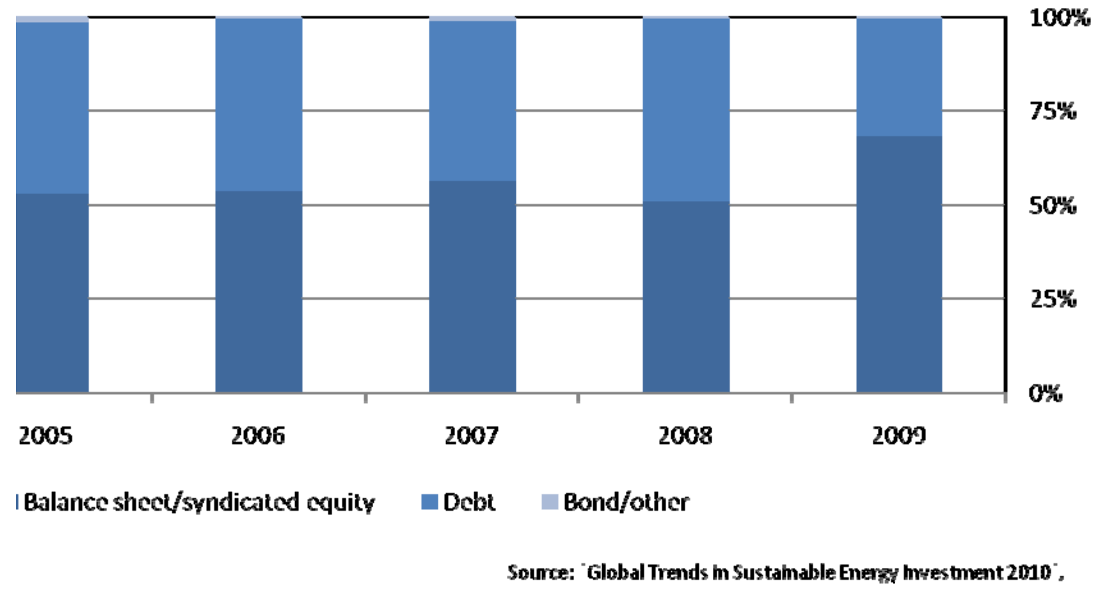
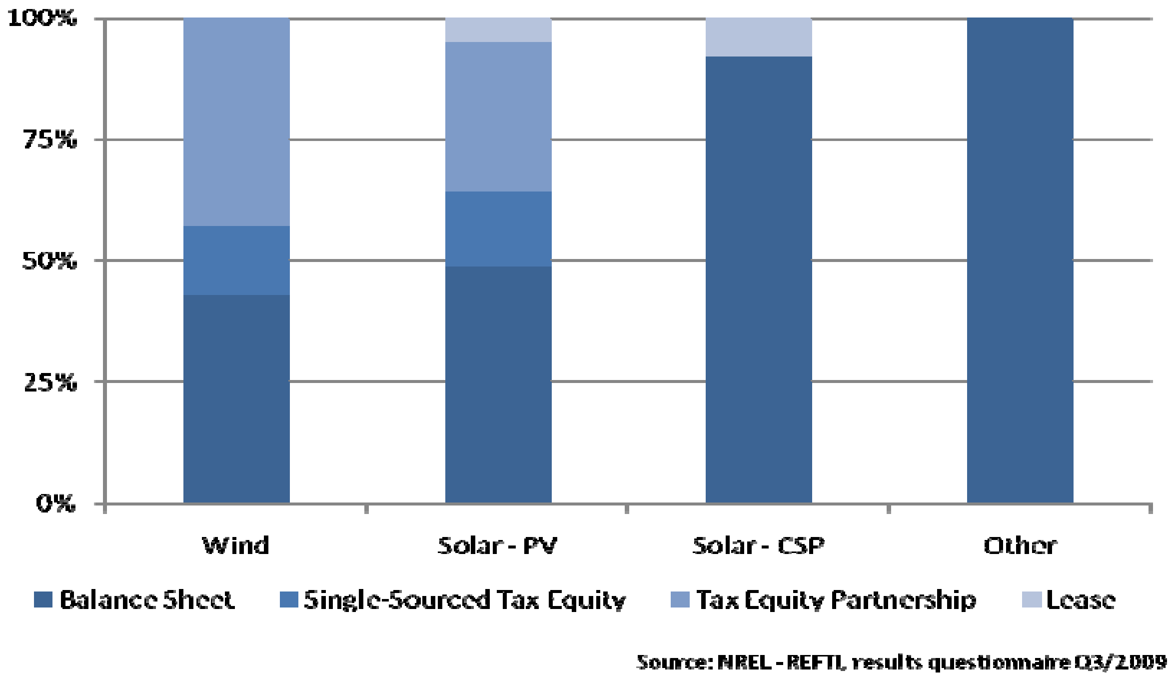


Figure 4 Asset financing by technology with focus on US Market



There are a number of challenges specific to renewable energies which have to be considered to understand barriers behind ensuring financial closure of a given project (Table 1).

Table 1 Barriers for renewable energy systems

Inherent barriers of **Renewable Energy**	Inherent challenges of RES **project sponsors**	External challenges in the **energy sector**	Barriers in the **financial sector** (especially in least developed countries)
Cost: Capital cost intensive structure; Analysis: insufficient data for prudent project analysis; Risk: High or unclear risk, including difficulties in guaranteeing cash flow and no enforceable securities.	Weak project developers and lack of project experience; Limited financial / managerial capacity; Limited credit-worthiness, particularly due to lack of complementary own funds. Securing operating permissions, long-term power purchase contracts, environmental impact assessments and contracts that mitigate risks in the construction and operational phase.	Politics: regulatory and policy issue which favor conventional energy types or hamper RES; insecure legislation in the energy sector ; Energy market: deficiencies in the financial, legal and institutional framework conditions as well as imperfections of the market mechanism; Lack of reliable partners for takeoff contracts / feed in laws. Public acceptance issues against projects implementation.	Lack of funds and/or improper financial conditions for renewable energy with regard to interest rates, collateral requirements and debt maturities. Local financial institutions often lack instruments to stimulate renewable energy. Lack of sector know-how and willingness to invest in renewable energy due to low level of awareness and understanding of renewable energy as well as insufficient information for prudent investment analysis.

Altran / ADL research,[4]

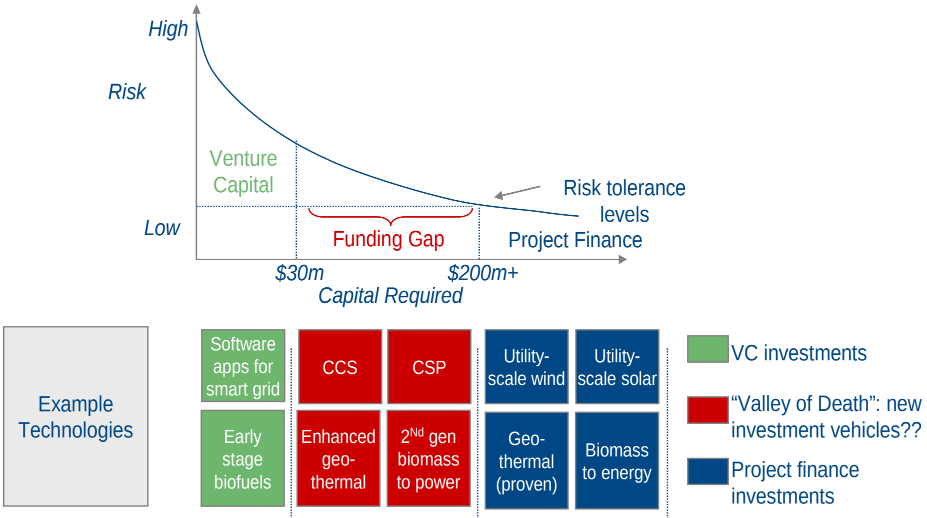
The understanding and management of risks is critical to address the barriers outlined above. In particular, there are a number of specific issues which need to be considered:

- The venture capital and project finance gap
- Availability of capital for emerging renewable energy technologies
- Managing dependencies on support mechanisms and public policy risks

[4] Adapted from Lindlein and Mostert (2005)

Venture capital and project finance gap:
Research and development efforts have brought a number of renewable energy technologies to a stage where they are technologically mature and ready for a more widespread market introduction. However a key challenge for the further development of renewable energy projects is the gap between investments in emerging technology by venture capital (VC) and project finance supporting established technologies (often supported by a stable regulatory regime). In particular in projects struggle to secure investment where there is both construction risk as well as technology risk.

Figure 5 Funding Gap



Source: Investing in Clean Technology Deployment', 2009, Kassia Yanosek, Hudson Clean Energy Partners" , referenced in Chatham House EEDP paper 09/04, Adapted by ADL,

Availability of capital for emerging RES technologies:
A key challenge for emerging technologies such as marine renewable energies (i.e. wave and tidal) involves raising working capital to sustain the operations of the technology companies, while at the same time, raising money for demonstration projects. Markets now recognize the high capital, high risk, long lead time involved with these technologies; unless venture capital firms are following their own previous investment, they are now pulling away altogether.

Managing dependencies on support mechanisms and public policy risks:
Many renewable energies find it challenging to compete with fossil fuels in the market place. This is driven by cost and maturity of technology, infrastructure requirements, existing government/fiscal support mechanisms and the ability to place a price on carbon. As a result a variety of support schemes have been put in place to accelerate the uptake of renewable energies.

For renewable electricity, support schemes can generally be divided into several categories:

- Feed-in-tariff
- Feed-in-premium
- Quota obligation schemes
- Secondary support measures (notably fiscal)

Feed-in tariffs:
Feed-in tariffs (FiTs) set a fixed guaranteed price at which power producers can sell renewable power into the electric power network, they normally oblige grid operators to guarantee grid access to renewable energy and oblige them to buy at government-fixed prices from generators that feed renewable energy onto the grid. They are set at a level required to guarantee the security of long-term investment in renewable energy, encouraging long-term contracts that are usually of 10-20+ years' duration.
Feed-in tariffs vary according to the type of technology and are often reduced over time as technologies mature and costs decrease.

Feed-in Premium (or premium feed-in tariffs):
These are fixed premiums which are provided on top of the market price received for energy sold to the electric power network. They normally make up the shortfall between the market electricity price and the (often higher) cost of producing electricity from renewable sources.

Quota Obligations:
Quota obligations such as Renewable Portfolio Standards or Renewable Obligations oblige electricity suppliers to produce a certain percentage of their electricity from renewable sources. Meeting the quota obligation is usually measured in terms of tradable green certificates, each of which represents one megawatt hour (MWh) of renewable electricity generated. Utilities can then either produce their share themselves or buy the corresponding amount of certificates on the market.

Secondary support measures (notably fiscal):
Additional support measures include fiscal incentives such as tax exemptions and reductions; these can be used to make investment in renewable energy more attractive. Renewable electricity producers can be exempted from paying carbon taxes. It is rare to see countries rely entirely on tax incentives to encourage the use of renewable energy, but they are often used to complement other measures.

There are a number of risks associated with governmental support mechanisms:

- **Reduction in support from feed-in tariff schemes** has a significant impact on project economics. These schemes typically have an adjustment mechanism to reduce support by a certain percentage, set for each technology over time as the market develops. The reduction rate is designed to provide an incentive to push forward technological improvement and take into account falling costs of parts and installation, of solar panels or wind turbines, for example. Recently, Germany and France have announced cuts in solar tariffs as a result of the rapid growth of the solar photovoltaic market (EurActiv 21/01/10)[5].
- In quota schemes, the target for the amount of renewable energy is set by the government, but the certificate price is determined by the market. The market price of the **certificates are difficult to forecast** and lack the long-term certainty needed to encourage investors
- Tax incentives while usually used in conjunction with other policy measures can be **repealed quickly and easily** – creating a risk for project economics.

These risks are more apparent as the costs for renewable energy become more widely known across society; A recent estimate in the UK put total energy investments required over the next decade in generation, grid and energy efficiency programs at £265 billion (or around £450 per year for every man, woman and child living in the UK). This at a time when the UK is struggling to recover from recession and when access to funds is much tighter than it has been over the last decade[6].

[5] Germany, France cut support for solar power / 2010
[6] Dieter Helm, James Wardlaw and Ben Caldecott / Policy Exchange / 2009

2 Conventional energy projects and related uncertainties

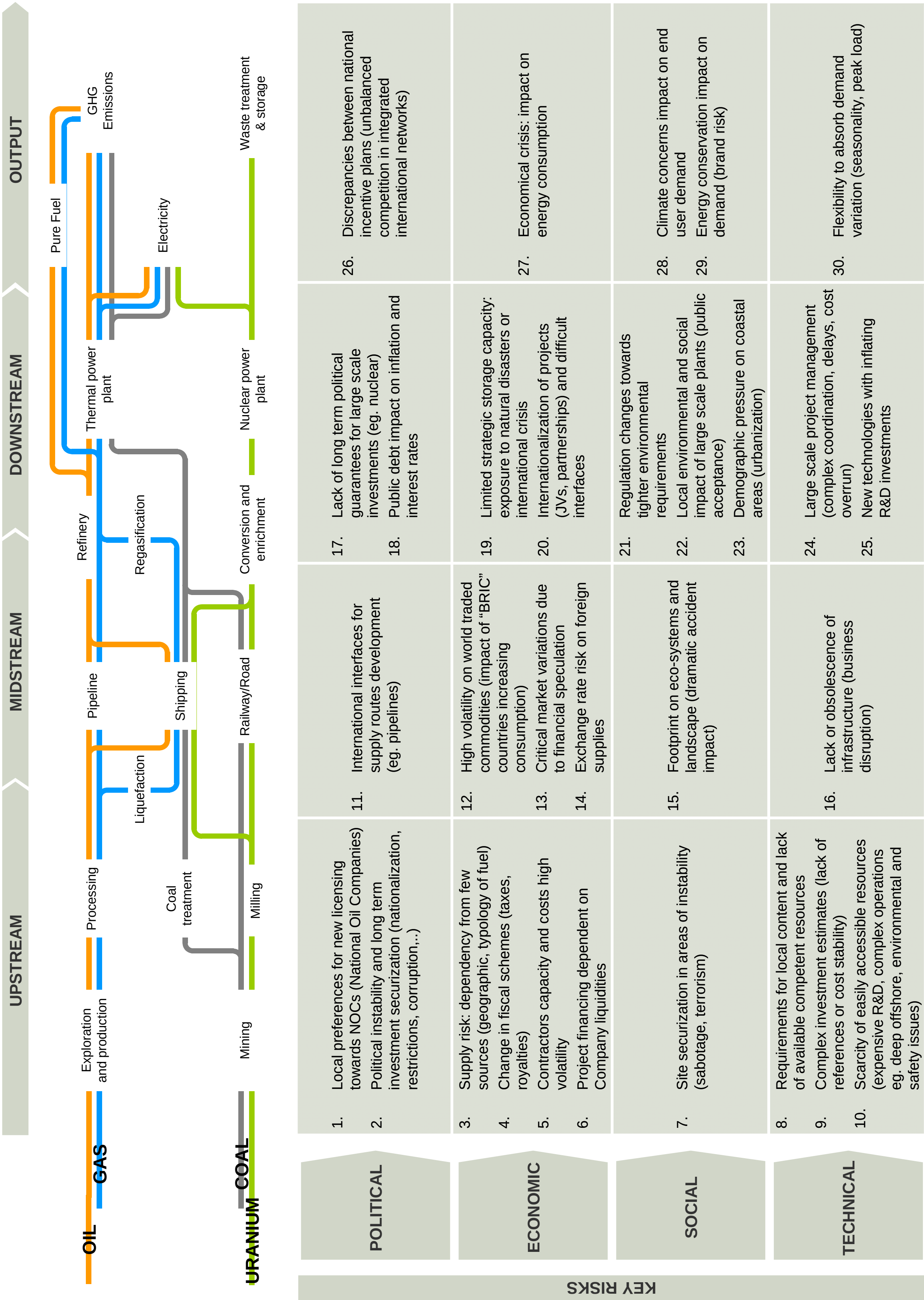
The objective of this chapter is to present the main risk characteristics faced in conventional energy investments and to provide some guidelines on typical risk control strategies and on the methodology applied to handle project risk management activities.

2.1 Risks associated with conventional energy projects

The value chain for conventional energy ranges from exploration and production activities to local power supply. When considering risks associated with power production it is pertinent to consider uncertainties affecting the whole supply chain. For example, the success of investment in a gas power plant is dependent on the pipeline network, regasification plant, transportation, liquefaction plant, and gas field exploration and production.

Conventional energy investments are subject to many future uncertainties (organizational, political, and technical) that can jeopardize the profitability of a project. The concerns of different players in a project also vary; for example, EPC (Engineering, Procurement and Construction) contractors will focus on contract execution within budget and time allocated, while the operator will focus on operating cost and electricity price variations. Typical risk categories are presented in Figure 6.

Figure 6 Conventional Energy Risk Map

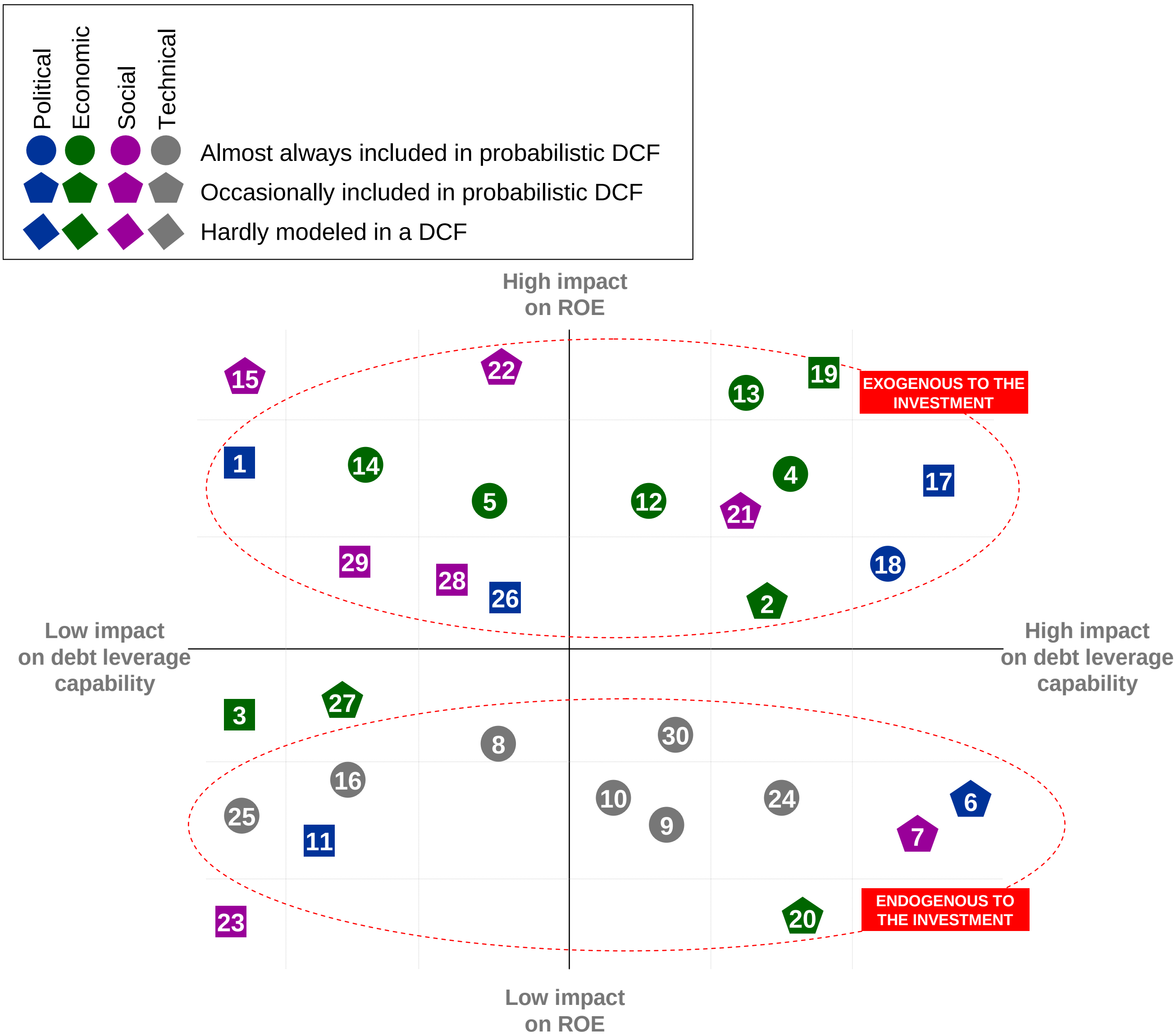


The above identified risk issues can be addressed in terms of common impact and visibility:

- **Impact:** how much could each risk reduce the investment debt capacity on the one hand and the investment profitability on the other hand.
- **Visibility:** how much could each risk be evaluated qualitatively or quantitatively (i.e. in a cash flow probabilistic model).

These impact and visibility criteria can be graphically mapped as shown in the figure below:

Figure 7 Conventional Energy Impact and Visibility Mapping (the numbers correspond to the risks of Figure 6). Abbreviations: DCF (Discounted cash flow), ROE (Return on Equity)



For example, the risk no. 17 (Lack of long term political guarantees for large scale investments) is almost never included in the cash flow of a financial analysis, but it could have a high impact on the return on equity (ROE) and the negotiated debt structure. On the opposite, risk no. 16 (Lack or obsolescence of infrastructure - business disruption) is always included in the cash flow of a financial analysis, but often it has a low impact on ROE and the negotiated debt structure. Obviously the positioning of the risks in the map could slightly change from one investment to another because uncertainties are specific to each investment.

Thus, the mapping has to be revisited for each single investment; however some general conclusions could be given:

- risks related to Social and Political areas are hardly included into the cash flow of a financial analysis; usually these risks are assessed only from a qualitative point of view;
- on the opposite, risks related to Economic and Technical areas are frequently included into the cash flow of a financial analysis creating a probabilistic discounted cash flow (DCF);
- risks exogenous to the investment have a high impact on ROE and are hardly included in the cash flow analysis;
- risks endogenous to the investment have a low impact on the ROE and are often included in the cash flow analysis.

In response to these risks, there are a number of control strategies that have been used for projects:

Political

Substantial hydrocarbon (oil, gas and coal) and uranium reserves are located in countries which are politically or economically less stable than most OECD countries. An economic downturn or adverse political framework can compromise the ability to operate in such countries, jeopardizing investment profitability.

Political risks can also be important in OECD countries but are different in nature; the level of support that the hosting country can give for large investment can vary. This can complicate the financing and authorization process, which in turn can lengthen the time needed for project completion. For example, in the 90s Italy did not support the development of regasification terminals; as a consequence some projects experienced long delays in the authorization process (up to 10 years for the Edison's offshore regasification terminal); this doubled the total capital investment of the project.

Even if the occurrence of these events is not easily predictable, major companies (especially in the oil & gas sector) assess the profitability of the investments by considering the risk profile in each country. In addition, there are common strategies to manage political risks in order to provide investors and lenders with greater confidence and better understanding of local risk conditions. Common solutions are:

- Political risk insurances (PRI): These instruments can cover a wide range of risks such as the expropriation by sovereign and sub-sovereign countries, break of contract when governments are contractual partners, currency inconvertibility, and losses in the event of war or terrorist activity. There are dedicated Export Credit Agencies and/or Multi-Lateral Agencies (e.g. MIGA, World Bank, COFACE) that can provide this kind of insurance. Such insurances are commonly used in the infrastructure, mining and oil & gas sector: for example, MIGA supported BG in Tunisia for the construction and operation of offshore platforms at the Miskar gas field in 1995, as well the development of the West African Gas Pipeline for transporting natural gas from Nigeria to markets in Benin, Ghana, and Togo, which started 2005. The participating shareholders include ChevronTexaco, West Africa Pipeline Co, Nigeria National Petroleum Corp., Shell, and Takoradi Power.
- Partnership/Join ventures: The objective of this strategy is to share the risk of large investments. In particular, a main approach is to involve local partners (e.g. NOCs – National Oil Companies) to have greater support from the local government. For example in the current giant development of Kashagan in Kazakhstan the shareholders include ENI, Total, Royal Dutch Shell, ConocoPhillips, ExxonMobil, Inpex and the Kazahstan national oil company KazMunaiGas.
- Country Credit default swap (CDS): CDS are financial instruments that can help to partially hedge the political risks. CDS are contracts in which the buyer makes a series of payments to the protected seller. In exchange, the buyer receives a payoff if a loan or bond defaults.

Economic

Economical risks in conventional energy investments could be categorised into the following types: commodity risk, market/commercial risk (supply/demand fluctuation), exchange rate risks, interest rate risk, liquidity and credit risk. In addition, there are typical risks that are specific to individual businesses and cannot be generalized for the entire supply chain. For example, the risks associated with the exploration and production of hydrocarbon and uranium.

Exploration activities require high investment but are subject to natural hazards and other uncertainties including those relating to the characteristics of reservoir/fields or failure to find commercial quantities of hydrocarbons/uranium.

There are several financial and contractual instruments to manage these risks. Some are dedicated to secure cash flow variations in particular:

- Commodity risk (especially for oil and refinery products) is usually managed by ensuring the negotiation of hedging derivatives traded on the ICE and NYMEX markets (futures) and derivatives traded over the counter (swaps, forward, contracts for differences and options).
- Market risk (demand side) is generally analysed on a day-to-day basis through a statistical assessment of the potential gain or loss in fair values, due to changes in market conditions. Market risk (supply side) is often managed through long term contracts with take-or-pay clauses. This provides a predictable cash flow, reducing the uncertainty on the supply price variation.
- Exchange rate risk derives from the fact that operations are conducted in different currencies. Cash flows denominated in foreign currencies may be significantly affected by exchange rates fluctuations due to the time lag existing between execution and definition of relevant contractual terms (economic risk) and conversion of foreign currency (transactional risk). Traditionally, to eliminate exchange rate risk many companies have implemented financial hedging strategies through financial instruments, carrying large cash balances or borrowing in the currency of the countries in which they operate. For example, the purchase of a contract to exchange Dollars for Euros at today's exchange rate at a fixed date in the future.
- Interest rate derivative transactions, in particular interest rate swaps, are the typical way to effectively manage the balance between fixed and floating rate debt. Such derivatives are evaluated at fair value on the basis of market prices provided from specialized sources. Typically, in big companies, the finance departments define maximum tolerable levels of risk exposure to changes in interest rates and foreign currency exchange rates, pooling Group companies risk positions.

Other instruments aim at securing investment payback:

- Production Sharing Agreements (PSA): commonly used for exploration and production companies. A PSA is a contract signed between a government and an extracting company, or a group of companies, defining the share of the extracted resource (usually oil) that each involved party will receive. Usually, a PSA ensures that the investor (normally the extracting company) will have a high payback ratio at the beginning of the production, in order to reimburse its investment, and then the hosting government will progressively increase its share of revenues.
- Guarantee: A guarantee contract guarantees the holder of a debt obligation, a payment in time of principal and interest when they become due. If there is a default on debt service, the guarantor pays the amount due under the guarantee based on simple guarantee call procedures.

Social

Environmental performance, sustainability, and social responsibility are critical to the success of an investment. In addition, well-designed environmental and social plans can help to manage potential reputation risks for investors, reduce social conflicts within communities, protect the environment and help reduce political risks. There are several instruments that are fast growing in the last years, which are applied to manage social risks in the conventional energy sectors:

- Environmental and social impact assessments: The aim of this analysis is to identify and evaluate potential environmental and social risks, to determine ways to improve project planning, and to manage adverse environmental impacts. Environmental assessments take into account the impact on the environment (air, water, land, noise - both local and global), on human health and safety, as well as peoples' living standards (livelihood, productive and cultural assets). A common instrument used in the oil & gas sector is the Environmental, Social and Health Impact Assessment (ESHIA): the purpose of an ESHIA is to examine how a proposed project will impact locally the environment and the quality of life of individuals and communities. The process implemented is iterative and requires engagement with input from key stakeholders throughout the project's life cycle.
- Environmental and social standards: Many energy projects now ensure they are compliant with the Equator Principles (based on the environmental and social standards of the International Finance Corporation (IFC)). The standards including the de facto standard for banks and investors on how to assess major development projects around the world.
- Public consultation and participation: In order to strengthen project sustainability, public consultation and disclosure are implemented, allowing for the engagement of civil society both locally and internationally. An example of successful public consultation was done in Australia, for the Pilbara LNG project. In order to create "sustainable engineering solutions" an extensive study for the LNG terminal localization was done in a transparent manner, and involved consultations with a wide range of stakeholders (including the engagement of an independent focus group to test key findings). As a result, none of the local communities opposed to the site selection.
- Compensation: in order to facilitate the acceptance of a project, often some form of monetary or infrastructural compensations (e.g. schools, roads etc.) are given to the hosting town/area. This approach is important in building a community's support for a facility, but is not always able to solve all the public acceptance problems (the involvement of local communities and a clear information program are often decisive factors). For example, in Italy (Civitavecchia) Enel presented a project of revamping an oil power plant and shift from oil to coke. The local community opposed the change of fuel due to environmental issues. The final approval was granted after several years of delays when the local administration agreed on a compensation package worth 100 M€ (including building a university, supporting the energy technology related research, abandoning an previous power plant area, and burying electrical cables).

Technical

Technical risks affecting conventional energy investments vary considerably across the sector (e.g. power plants have peculiar risks different from an oil & gas field). Nonetheless, it is possible to highlight common risks along the supply chain, which are also present in all conventional energy investments:

- Complex investment estimates due to the lack of references, cost stability, implementation of new technologies, complex operations;
- Difficult project management (complex coordination, several contractors for construction and maintenance, interface problems).

These technical risks can be managed in different ways, mainly through financial agreement and contracts:

- Insurances: Typical instrument that can provide financial protection from delays, damages, during construction, transport, installation, operation, maintenance and decommissioning of the project.
- Guarantee: The instrument is the same as for covering economical risks. But regarding the technical point of view, the guarantees are contracts such as construction contracts, off take contracts, operation and maintenance agreements between EPC contractors, operator or maintenance operator. For example, a typical guarantee is between EPC supplier and the operator: the EPC will secure a start-up date, a minimum production or an overall plant performance against a payment (incentive or penalties).
- Risk-sharing with contractor(s): The objective of this strategy is to share the risk of the construction and/or maintenance with one or more of the contractors in order to increase their commitment in quality. When an EPC becomes a shareholder or sponsor, it can generate profits both as a shareholder and as a contractor.
- Organization hedging: Organisations (mainly public) can support market restructuration for a better production continuity (e.g. building a peak capacity or guaranteeing supplies through upstream or downstream companies acquisition).7

[7] IEA Power Generation Investment in Electricity Markets (2003)

The main risk control actions implemented in the conventional energy sector and their level of applicability to the RES investments are summarised in the table below. The application of these measures for renewable energy projects are discussed more detailed in Chapter 6.

Table 2 Conventional Energy risk control actions and relative applicability to RES investments

	Conventional Energy Investment	Applicability to RES Investments
Political	Political Risk Insurances	+
	Partnership/Join ventures (involving hosting country)	++
	CDS	+
Economical	Futures, swaps, forward, contracts for differences and options	-
	Long term contracts with take-or-pay clauses	++
	Contracts to cover exchange risks	-
	Interest rate derivative transactions	+
	Guarantee	++
Social	Environmental and social impact assessments	++
	Environmental and social safeguards policies	+
	Public consultation and participation	++
	Compensation	+
Technical	Insurances	++
	Guarantee	++
	Risk-sharing with contractor(s),	++

Altran / ADL research

Key: (-) not useful / not relevant (+) possible positive applicability (++) could be transferred successfully to RES investments

Most of the risk control strategies have relevant applications for RES investments. Nonetheless, RES projects are usually dependent on local supplies and local consumption. This limited geographical factor is minimising the need for exchange rate or complex supply contracting strategies. Some exceptions:

- In large scale bio energy investments, future contract strategies can be relevant for supply continuity.
- Procurement of sophisticated equipment (solar panel) can be subject to exchange rate variations.

2.2 Risk Management Approach in Energy Projects

Conventional energy projects are almost always assessed with a standardized project risk management approach in order to identify, evaluate and manage the risks in investment. This section presents a short overview of the established risk management approaches, benefits and main standards.

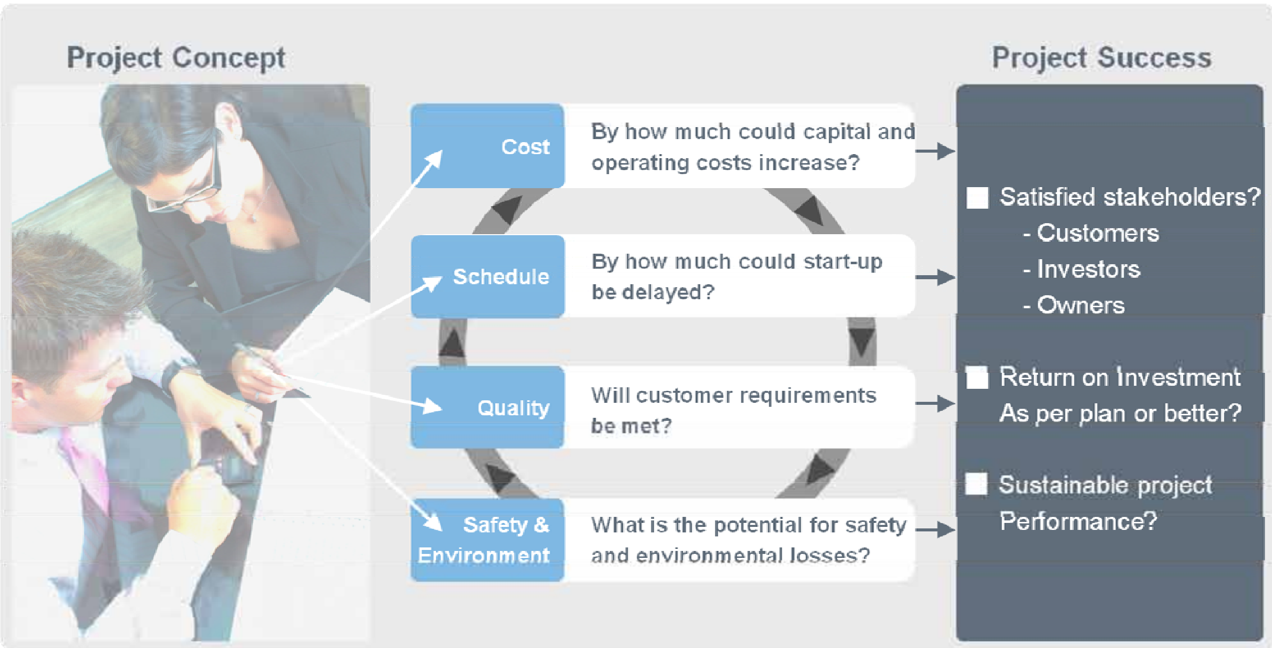
2.2.1 Objectives of Project Risk Management Approach

A project sponsor evaluating a project concept will have several concerns, as illustrated in the figure below. In particular, these may include:

- The cost and schedule for the project (critical for the project cash flow and hence critical to attract other investors or lenders);
- The quality of the project both in terms of the ability to meet market requirements as well as the quality of the plant and hence its reliability in service, in order to secure revenues and investment profitability;
- The safety and environmental impact of the project which could result in an impediment of it by not gaining permission or losing its license to operate.

The objective of Project risk management is to provide a systematic framework to analyse these concerns[8].

Figure 8 Project Objectives



[8] Barkley, *Project Risk Management: A Proactive Approach.*

Standard methodologies

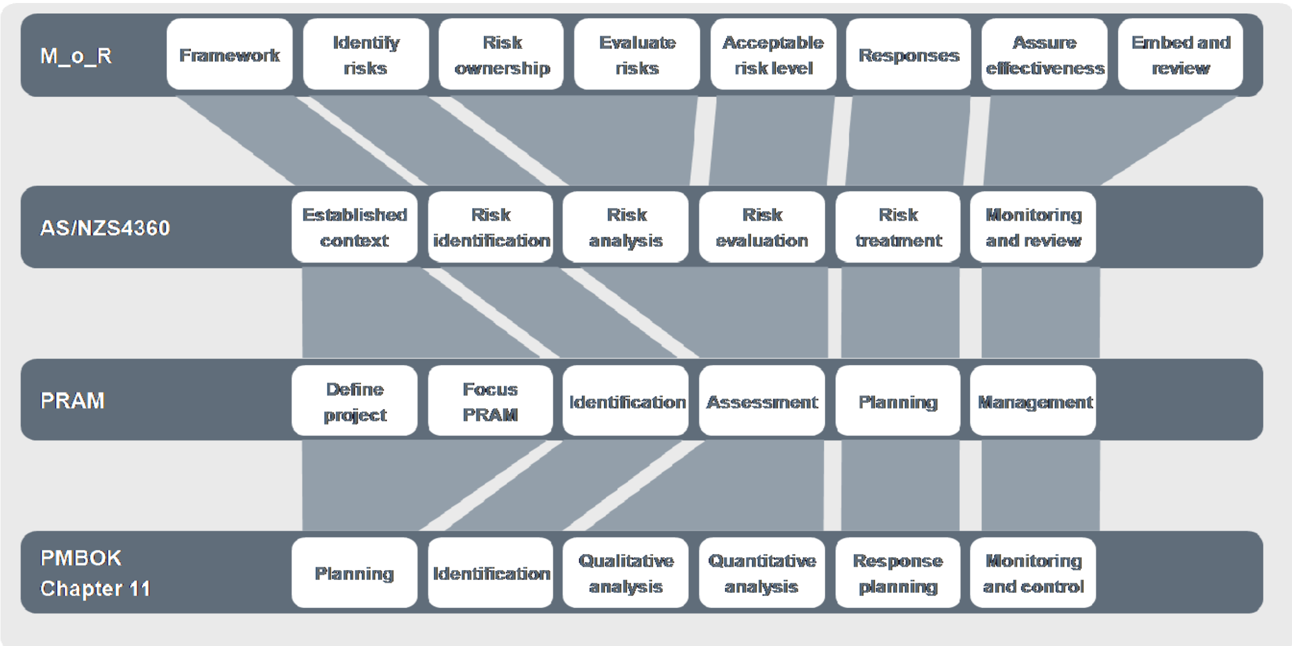
Investments in energy projects are usually addressed systematically through a risk management approach adapted to the Corporate Control procedures of the company sponsoring the project.These procedures include both general project management procedures as well processes used by dedicated functions – most notably the Health Safety and Environment (HSE) function. It is considered good practice to ensure a high degree of coordination between HSE and project risk management functions, so they can exchange on critical issues and optimise response plans.

The aim of the risk management approach is to identify, evaluate and control uncertainties in future investment. Sponsors need to provide their own management, joint venture partners and lenders with confidence that there is sufficient contingency in the project budget and sufficient float in the schedule to accommodate unforeseen risks. Above all, these stakeholders need to know the project will work as advertised, be ready on-time and not suffer significant cost overruns.

Project risk management is a well-known and standardized system implemented in many organizations associated with a project such as the project sponsors (usually operators), contractors and financing partners etc.

The process can follow a different number of steps, according to several acknowledged standards. However these standards follow a common workflow, as shown in the Figure 9 below:

Figure 9 Benchmark of Project Risk Management Standards

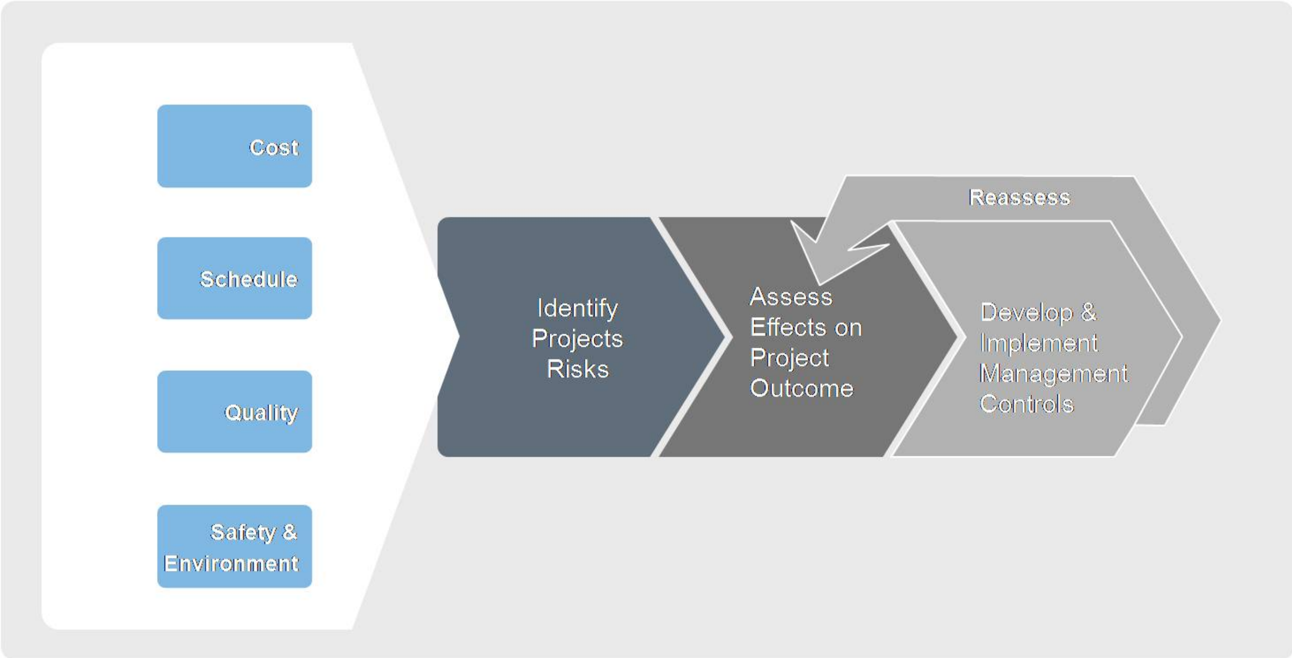


The differences between these standards are based on the organisations involved in their development and their intent:

- The Australian and New Zealand Standard AS/NZ 43/60, Risk Management. Published in 1993 and updated in 1999 and 2004, it is a generic standard for risk management. It can be a guide for both individual use and complex businesses.
- The Project Management Institute PMI, PMBOOK, Chapter 11 explains project risk management that is seen as a mandatory part of the entire process of project management.
- The Association for Project Management has published The Project Risk Analysis Management PRAM Guide which divides the risk management process into stages and describes the methods that can be used at the different steps.
- The Management of Risk guideline, M_o_R. is written for the public sector and highlights the process from the strategic aspects to the operative context.

However all processes involve putting in place a feedback loop between the implementation of management controls, the reassessment of risks which might affect the project and the estimated outcome in terms of project final cost and date for completion and commissioning (after which revenue generation can be expected).

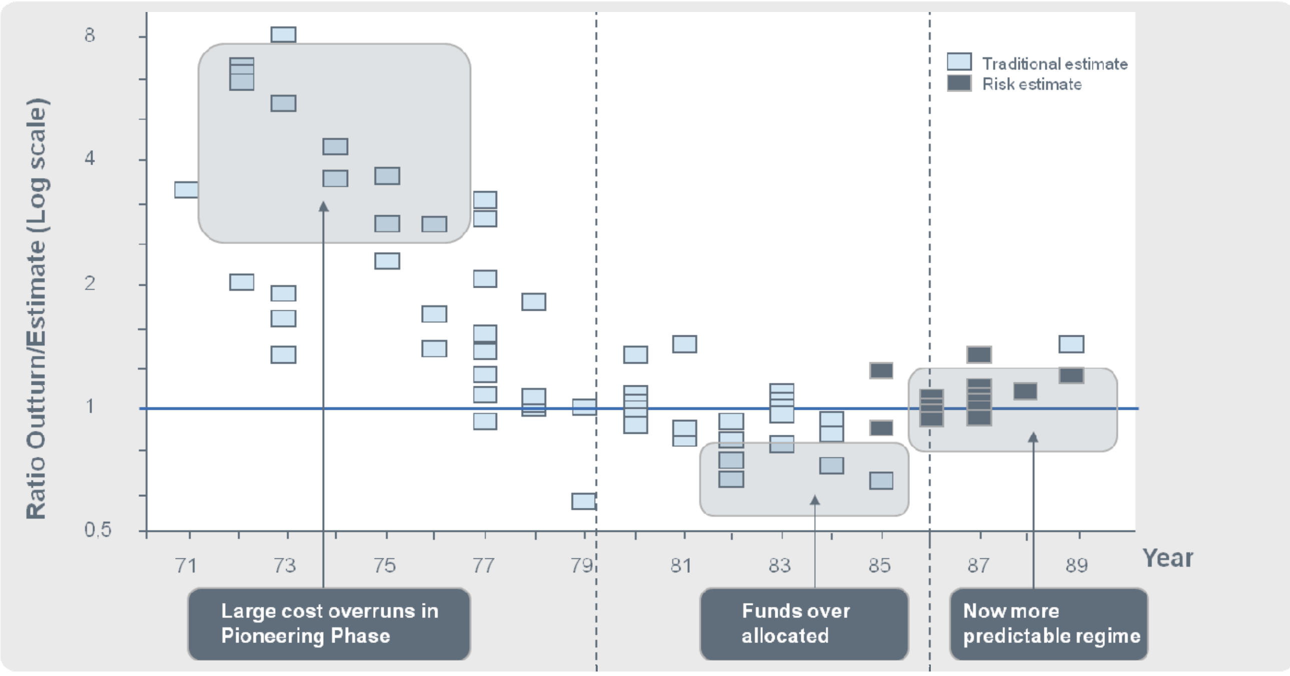
Figure 10 Project Risk Management Iterative Process



This project has based the methodology for managing renewable energy projects on this approach and is presented in detail in Chapter 5.

Recognized benefits
A good illustration of the positive impact of risk management activities on conventional energy investment is presented in the following figure. This graph plots project actual cost against initial estimates, for conventional energy projects over the past twenty years.

Figure 11 Project Risk Management Benefits in Conventional Energy Investments



The graph shows that in the first 10 years (the pioneering phase) when new technology was initially being used in adverse environments, dramatic cost overruns were the norm. In the early to mid 1980s, a period of conservatism set in, with projects being given very large contingencies and being delivered well below budget. As far as capital efficiency is concerned, this outcome was no more satisfactory than project overruns (though it may be less demanding for the project managers). In the period from 1985 the risk assessment method was introduced and project outcomes became much more predictable. Project sponsors and lenders can have greater confidence when projects (in this data typically lasting 3 to 4 years) are delivered close to the cost and timeline as initially estimated.

3 Uncertainties in RES investments

In order to develop a risk assessment methodology for Renewable Energy projects it is important to understand particular features of renewable energies and implications for managing risk.

This chapter gives an overall picture of RES projects (Section 3.1); specific features of RES technologies and uncertainties impacting the feasibility and success of RES investments are discussed in Section 3.2.

3.1 RES Project Characteristics

Conventional energy and RES technologies differ in a number of aspects, and a comparison between the two helps to relate risks from one technology to the other. These major differences are summarized in the table below.

Table 3 Major differences between conventional and RES projects

	RES	Conventional Energy
Track record	Relatively short (<20yrs)	>>20yrs
New Technology Time to Market	Fast	Medium
Familiarity with technology throughout the value chain/stakeholders	Low	High
Operating margins	Low	High
Investment horizon	Typically >10yrs	10 -15 yrs
Debt/Equity	70/30	from 0/100 (upstream) to 30/70 (downstream)[9]
Dependence on government support mechanisms	High	Low
Risk of unknown factors influencing the project profitability	High	Medium
Sensitivity to variation in oil prices	High	High
Sensitivity to variation in electricity prices	High	Medium
Sensitivity to delay in completion	High	Medium
Supply Chain maturity/stability	Low	High
Level of development of technical standards	Low-Medium	High
Modularity (related to min/typical investment)	High	Low
Investment life cycle criticalities:		
• R&D	High	Medium
• Prospection (licenses)	High	High
• Financing	High	Low
• Conception	Medium	High
• Procurement	Medium	Medium
• Construction	Low	High
• Operations	High	Low
• Abandon	Low	High

Altran / ADL research

[9] Source http://www.mees.com/postedarticles/oped/v49n40-5OD01.htm

Conventional and RES projects differ mainly in the maturity of the markets and the related track record in terms of deployment of technology and the number of established projects:
.

- Fossil fuel power plants have been developed over many years; the risks involved are well understood through previous experience, design specifications or statistical records. This eventually allows smooth planning and permitting procedures. Conversely as a result of the comparatively short track record of RES, certain risks might not have been encountered previously; for instance risks that occur at the end of the lifetime of a RES project might not be visible, yet. Even technologies with a track record of more than 20 years, such as onshore wind energy, have gone through a rapid technology development; the turbine size has increased significantly in the past decade and completely new designs (e.g. direct drive turbines) have entered the market.

Unlike RES, conventional production methods have already experienced cost reductions through technology deployment (project learning curve). Under these circumstances the operating margins for conventional energy are higher than for RES. However conventional projects experience a higher financial impact from production downtime or fluctuations in global energy prices.
Rapid development of RES allows quick progress towards higher efficiencies and yields, eventually improving the financial viability of the sector/technology as a whole. This, however, quickly renders systems and technologies outdated and asset value at the end of the project might be significantly lower than initially anticipated.
The number of suppliers for state-of-the-art technologies is relatively limited, which results in a number of risks related to the availability of components (e.g. supply chain bottleneck) and increases the probability of delay in completion.

- To mitigate the impact of the fast moving technological environment and low margins, governments step in with subsidies to facilitate the implementation of and stimulate investments towards RES technologies. However, the projects financed under subsidy schemes are inherently coupled to political ambitions and agendas – this introduces an additional variable and adds extra risks other than those for conventional energy.
- A major difference between conventional and RES system is the source of energy itself. Typically fossil fuels are shipped from all over the world to the power plants, and it is possible to set up a diverse supply chain. Therefore the supply risk can be spread over different suppliers from different global regions. For most RES sources such strategies are impossible due to the local nature of the resource (wind, sun, currents, waves etc) and the fact that the primary energy cannot be stored. Individual projects thus depend very much on the availability of a single resource.

As shown in this chapter diverse risks for both conventional and RES exist. For the latter a large degree of uncertainty arises from the shorter track record, the rapid speed of development and the local nature of the source. However beyond these general differences between conventional energy and RES, there are risks related to a specific technology; these are discussed in the next section.

3.2 Risks associated with specific RES technologies

While in the previous section the general risks of renewable energy were discussed in comparison to those of conventional energy, this section focuses on the characteristics and specific risks associated with particular RES technologies. Specifically this section summarises the technological characteristics and examples of key risks for solar thermal, photovoltaic, biomass, wind, wave, tidal and geothermal technologies. As summarised in table 4, there are both similarities and differences between technologies when considering the current challenges for assessing risk. In particular, data availability and quality is a key factor of accuracy in risk assessment and is scarce for young technologies.

Table 4 Challenges for assessing risk

Challenges in assessing risks associated with Technology	public policy or implementation	supply and demand	availability of data on resource/ weather patterns	availability of data on technology performance	grid integrat-ion	operational risks	intangible risks, as e.g. stakeholder opposition, public perception	Existing extent of current risk analysis in projects
Solar Thermal technologies	H	M (Few major players)	L (reliable data available for large regions)	L-H (depending on the technology maturity)	H	M (dis-patchability, water availability)	M (depending on local conditions)	L
Photovoltaic Technologies	H	M-H (Rapidly growing market Silicon, ribbon material, low-iron-glass, soldering paste, etc...)	L (reliable data available for large regions)	M (long term information on device performance)	M	M (Sensitivity of module reliability to manufacturing quality control)	L-M (depending on scale of installation)	M
Biomass Technologies	H	L	M	L-H (depending on the technology maturity)	M	H (security of feedstock supply)	H	M
Wind Energy	M (some long-term regimes in place)	M (Rapid growth in offshore wind could be an issue)	M	M (long term information on device performance, esp. offshore)	H	H (True life cycle costs¸ including overhauling costs and related logistics)	H	M
Geothermal Plants	M (Some existing plants with less dependency)	L	H (resources insufficiently mapped)	H	M	H Equipment reliability, tectonic changes)	L	H
Wave and tidal stream devices	H	L (Emerging technology	L (reliable data available)	H (emerging technology)	H	H (Equipment reliability)	M	L
Tidal barrages and lagoons	H	L (Few competing projects and supply chain barriers)	M	M-H (few installations, very location specific)	H	H (Equipment reliability)	H	M

Altran / ADL research
H = High factor of uncertainty (poor reference data available, low level of accuracy); M = Medium factor of uncertainty; L = Low factor of uncertainty (good reference data available, good level of accuracy)

3.2.1 Solar Thermal technologies

Dish concentrators

Technology Characteristics	
• A parabolic dish made of individual mirror elements reflects light onto a central receiver, powering a Stirling/Brayton engine • Small units can be applied in large arrays • Due to the distributed nature of the installation it is not easy to couple the array to a heat storage facility • The technology is suitable for sloped/rugged land • Mechanical trackers maintain optimum insulation. • The modularity of the system reduces the risk of total system failure	
Risks **Supplier**: 1. Production capacity of mirrors **Operation and Maintenance** 2. Difficulty in maintenance on rugged terrain 3. Failure of mechanical parts 4. Increased need for maintenance due to dirt build up on mirror 5. Efficiency loss due to tracking failure 6. Lifetime of mirrors (degrading in harsh conditions) 7. High maintenance costs 8. Fluctuations in supply to and hence electricity price on grid (potential overcapacity during daytime) 9. Material durability (given high temperatures involved)	

Heliostat fields (Power tower)

Technology Characteristics

- An array of individual, flat, sun-tracking mirrors (heliostats) focuses solar energy on a central receiver positioned in a tower
- Steam is generated in the central receiver either through a heat exchanger or by direct steam generation
- Energy is generated in a conventional steam Rankine cycle
- The technology is suitable to directly melt salt for heat-storage
- The technology can be combined with conventional back-up burners to improve reliability / uptime
- Can be potentially used in unleveled land

Risks

Supplier:
10. Only few suppliers for receiver technology

Operation and Maintenance
11. Failure of mechanical parts
12. Reflectivity of mirrors not meeting specification (aging and after production)
13. Corrosiveness of salts for thermal storage
14. Dirt build up on mirror
15. Efficiency loss due to tracking failure
16. Material failure due to harsh environment (receivers)
17. Lifetime of components
18. Maintenance costs

Project:
19. Receivers and steam cycle are single points of failure

Trough/Fresnel Technologies

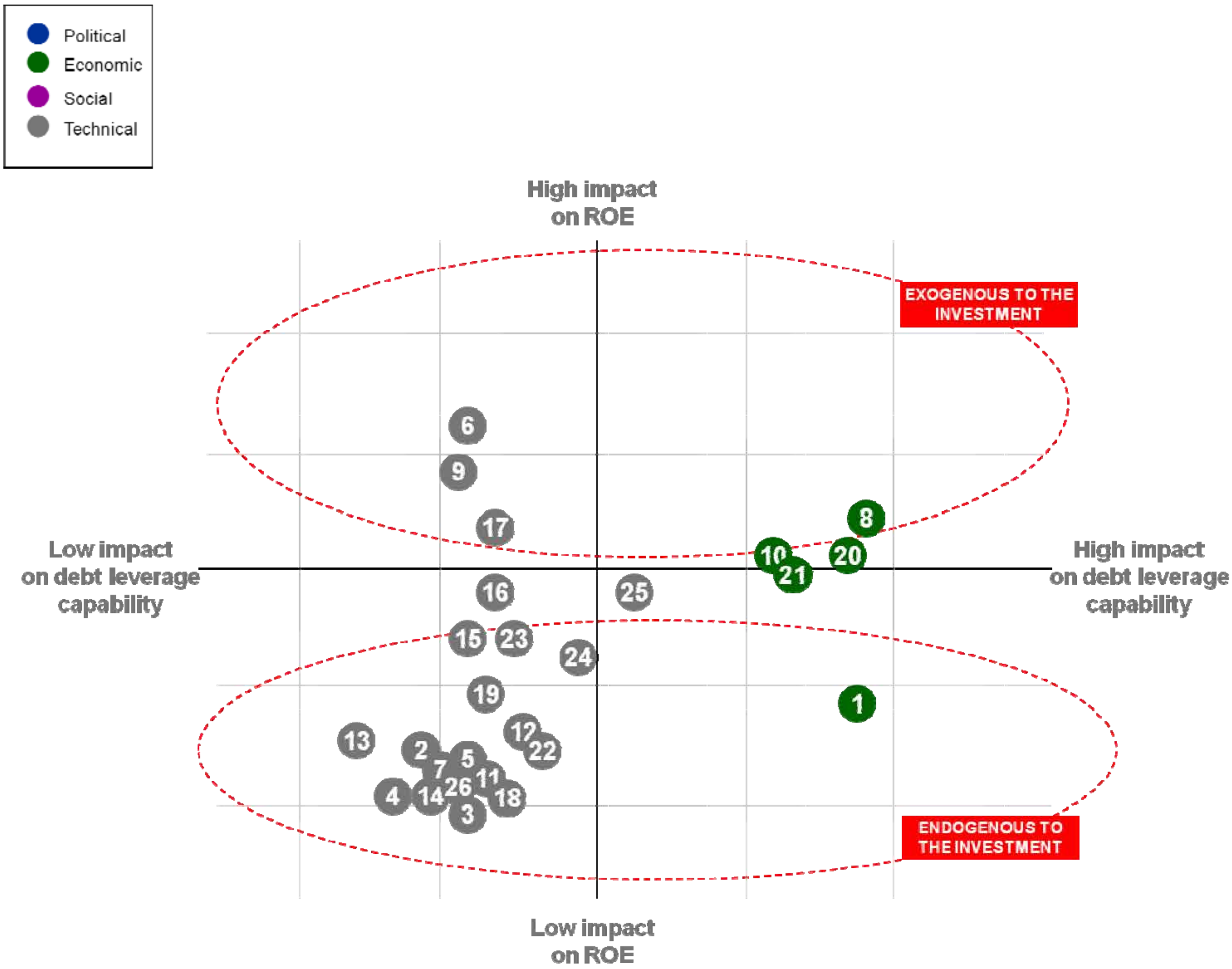
<table>
<tr>
<td>
<u>Technology Characteristics</u>

• Concentration of sunlight by parabolic mirrors or Fresnel arrays onto linear receivers
• Steam generation either in heat exchanger or by direct steam generation
• Energy generation in a conventional steam Rankine cycle
• The technology can be combined with conventional back-up burners to improve reliability/ uptime
• The technology can be combined with heat-storage
</td>
<td></td>
</tr>
<tr>
<td colspan="2">
<u>Risks</u>

Supplier:
20. Tube receivers only produced by few companies
21. Only few manufacturers of mirror troughs exist

Operation and maintenance:
22. Mechanical failures
23. Efficiency loss due to tracking failure
24. Lifetime of components
25. Safety related to molten salts
26. Maintenance costs
</td>
</tr>
</table>

Figure 12 Solar Thermal Technologies Impact and Visibility Mapping



3.2.2 Photovoltaic Technologies[10]

<u>Technology Characteristics</u>

- Sunlight is directly converted into DC electricity
- The system is highly modular, i.e. it can be expanded in small increments
- A wide variety of output voltages is possible
- The technology is suitable for green fields and for building integration
- The structures and electrical topology heavily depend on the type of application

<u>Risks</u>

Supplier

1. Supply capacity bottlenecks and price volatility (with a CAGR of 30-40% the succession of capacity expansions along the value chain coupled with the changing support regimes result in supply/demand non-equilibrium situations with periods of surplus and low prices followed by periods of scarcity and higher prices);
2. Medium term availability/costs of some of the key raw materials (silicon, glass, ribbon, soldering paste etc.);
3. Many new module manufacturing entrants (low barriers), resulting in uneven module quality across market places (lifetime, power loss, water ingress, etc.).

Operation and Maintenance:

4. Uptime heavily dependent on low cost component (inverters). The disproportionate impact of inverters reliability on effective production is often neglected due to the comparatively low cost of the component. This can result in poor selection and/or inadequate inverter maintenance programs ultimately affecting negatively the production.
5. Price and market risk (O&M suppliers market still in a developing stage)
6. Vandalism[11]

Project

7. Unstable support policies
8. Overestimated efficiency coming from absence of in-field power rating of modules/systems

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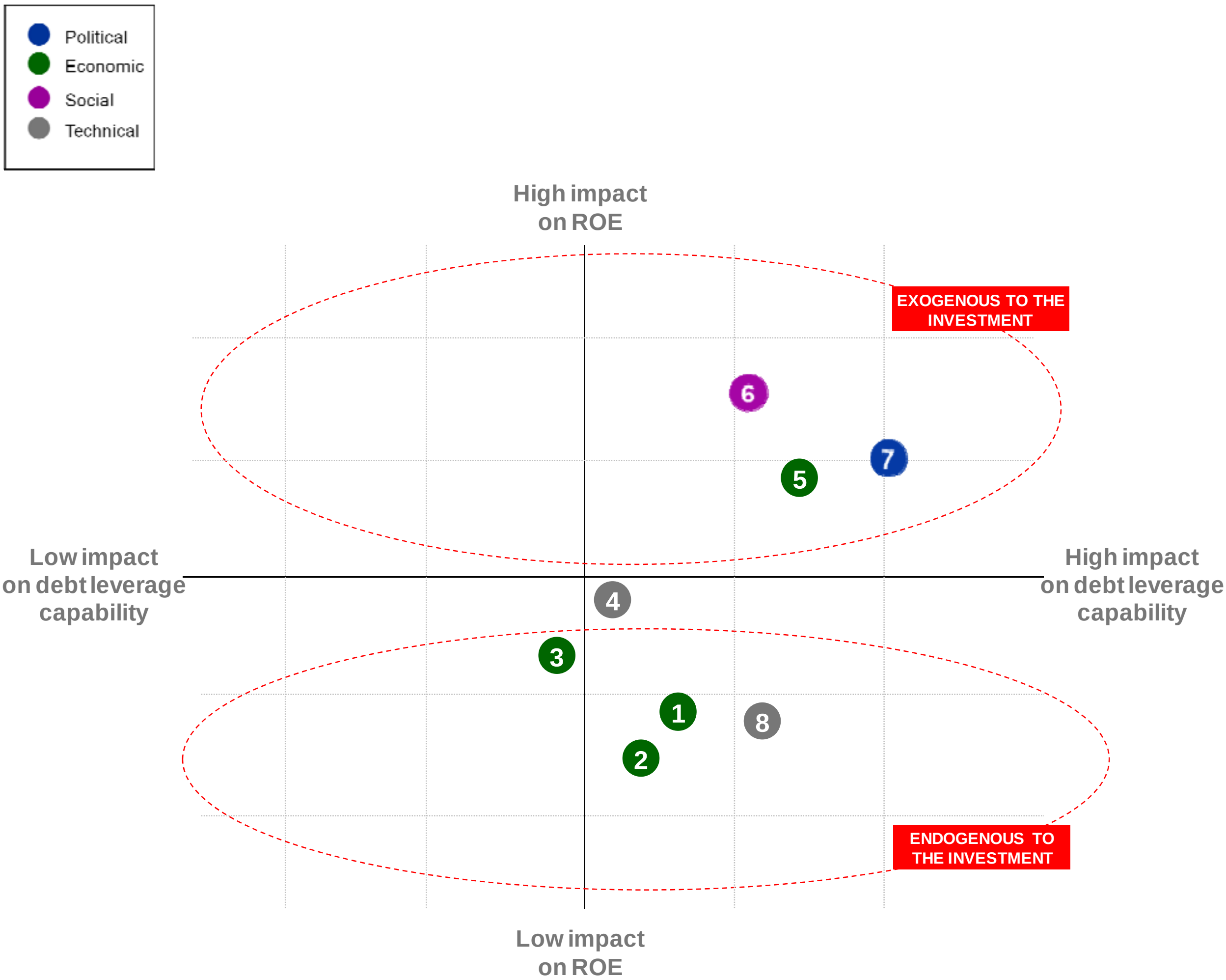
[10] Information gathered during PV Workshop

[11] UNEP 2004, Financial risk management instruments for renewable energy projects.

Figure 13 Photovoltaic Technologies Impact and Visibility Mapping



3.2.3 Biomass Technologies

Fischer-Tropsch Process

Technology Characteristics • Biomass is gasified and converted into liquid fuels (gasoline/middle distillates), e.g. for transportation • Installations must be large scale to be economic • The energy efficiency is limited • The product is a "pure" fuel • The process requires high temperatures & pressures and specific catalysts • The process is insensitive to fluctuations in the waste stream if the gas feed is purified	
Risks **Supplier**: 1. Limited availability of catalyst 2. Price volatility of catalyst 3. Price volatility and availability of feedstock[12] **Operation and Maintenance** 4. Potentially hazardous residues 5. Failure of gas-washing installation 6. Oxygen production related cost (operators and safety) 7. Effect of changing input composition[13]	

Pyrolysis oils/catalytic cracking

Technology Characteristics • Biomass is converted into liquid fuels (gasoline/middle distillates) in a process similar to crude oil cracking • The scale of the process varies by technology • The quality of the output depends on the composition of the input • Specific catalysts are needed	
Risks **Supplier** 8. Limited availability of catalyst 9. Price volatility of catalyst 10. Price volatility of feedstock[14] 11. Competition with more efficient processes for feedstock **Operation and Maintenance** 12. Contamination of the installation 13. Product quality control 14. Certification of product 15. Effects of changing input waste 16. Energy requirements and cost	

[12] UNEP 2004, Financial risk management instruments for renewable energy projects.
[13] UNEP 2004, Financial risk management instruments for renewable energy projects.
[14] UNEP 2004, Financial risk management instruments for renewable energy projects.

Plant/Waste Oil conversion

<u>Technology Characteristics</u>

- Oils are converted into liquid fuels by esterification or hydrogenation
- The scale of the process varies by technology
- The quality of the output depends on feedstock composition
- Specific catalysts are needed

<u>Risks</u>

Supplier:

17. Feedstock availability[15]
18. Competition with more efficient processes for feedstock

Operation and Maintenance:

19. Contaminants in feedstock
20. Water content
21. Contamination with microorganisms & fungi
22. Out of spec production
23. Quality control
24. Certification

Alcoholic fermentation/digestion

<u>Technology Characteristics</u>

- Ethanol/methanol/methane is produced in digesters
- The product can be either liquid fuel (gasoline additive) or fermentation gas
- The product needs to be purified before use

<u>Risks</u>

Supplier:

25. availability of feedstock[16]
26. market prices of feedstock / additives[17]
27. Competition with more efficient processes for feedstock

Operation and Maintenance

28. technical stability of the fermentation process
29. contaminants in the digester
30. sale of digestion by-products out of spec production (certification/quality control)

Project

31. permitting issues (e.g. handling manure)
32. public resistance due to smell[18]

[15] UNEP 2004, Financial risk management instruments for renewable energy projects.
[16] UNEP 2004, Financial risk management instruments for renewable energy projects.
[17] UNEP 2004, Financial risk management instruments for renewable energy projects.
[18] UNEP 2004, Financial risk management instruments for renewable energy projects.

Co-firing of biomass

<u>Technology Characteristics</u>

- Solid or liquid biomass is combusted together with conventional fuels, e.g. wood/coal burners or crude/vegetable oil burners
- Conventional power plant technology is used

<u>Risks</u>

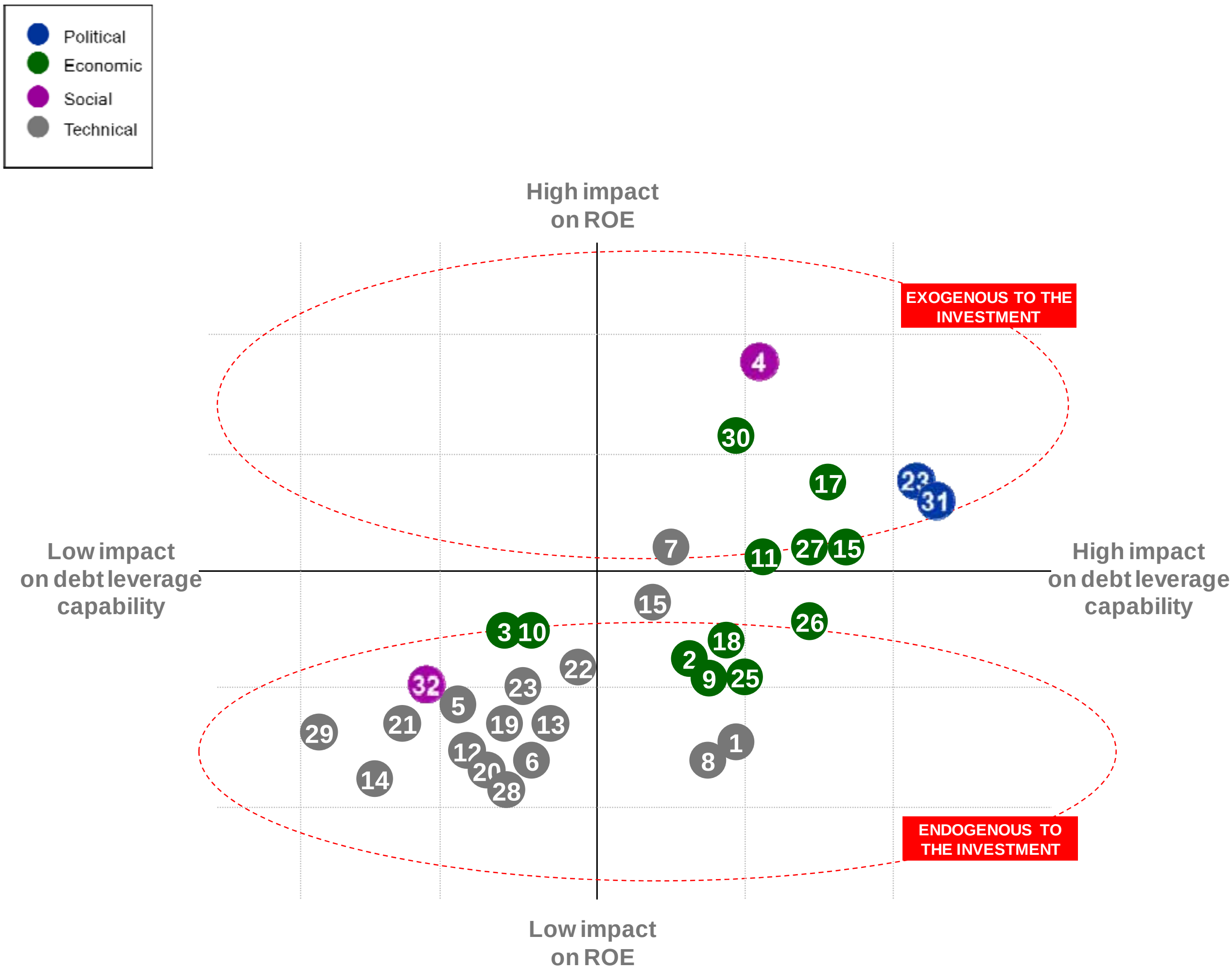
Supply
33. stable supply of feedstock[19]
34. price fluctuations of feedstock[20]
35. Competition with more efficient processes for feedstock

Operation and Maintenance
36. contamination of feedstock (e.g. with hazardous substances when waste is fired)
37. impact of low quality feedstock on burner (ash, slag, etc.)
38. variable moisture levels;
39. complexity of operation (particularly in fluidized bed boilers)

Project
40. resistance of interest groups (e.g. regarding used biomass)

[19] SEFI "Scoping study on financial risk management instruments for renewable energy projects", NNEP
[20] UNEP 2004, Financial risk management instruments for renewable energy projects

Figure 14 Biomass Technologies Impact and Visibility Mapping



3.2.4 Wind Energy

Offshore Wind[21]

<u>Technology Characteristics</u> • Turbines are placed on foundations resting on the seabed. • Different turbine types and foundation concepts are available • The turbines are coupled to the land connection via an offshore transformer station	

<u>Risks</u>

Supplier
- Delay of production because of unavailable or missing construction vessels
- Delay and higher costs due to bad weather conditions during installation
- Potential bottlenecks in the supply chain (due to high level of differences between onshore and offshore wind)
- Impact of the cost of raw materials

Operation and Maintenance
1. High O&M cost (due to complexity of maintenance)
2. Failure of grid connection (single point of failure)
3. Limited knowledge on maintenance issues
4. Difficult maintenance in windy areas offshore
5. Downtime due to delayed repair/maintenance
6. Corrosion issues (complexity of add-on systems)
7. Transport and logistics complexity of blades

Project
8. Changes in policy
9. Planning & permitting issues (environmental interest groups, also govt - e.g. disturbance of radar
10. Exceeding construction cost due to delay[22]
11. Non mature co-operation between offshore and non offshore partners in the supply chain
12. Transport and logistics complexity of blades

[21] Information gathered during Offshore Workshop
[22] UNEP 2004, Financial risk management instruments for renewable energy projects

On-shore wind[23]

Technology Characteristics

- Wind turbines are placed on land
- The technology is almost handled as a commodity
- The permitting procedure is known
- A variety of technologies on different scales exist, i.e. there is a broad range of turbine sizes

Risks

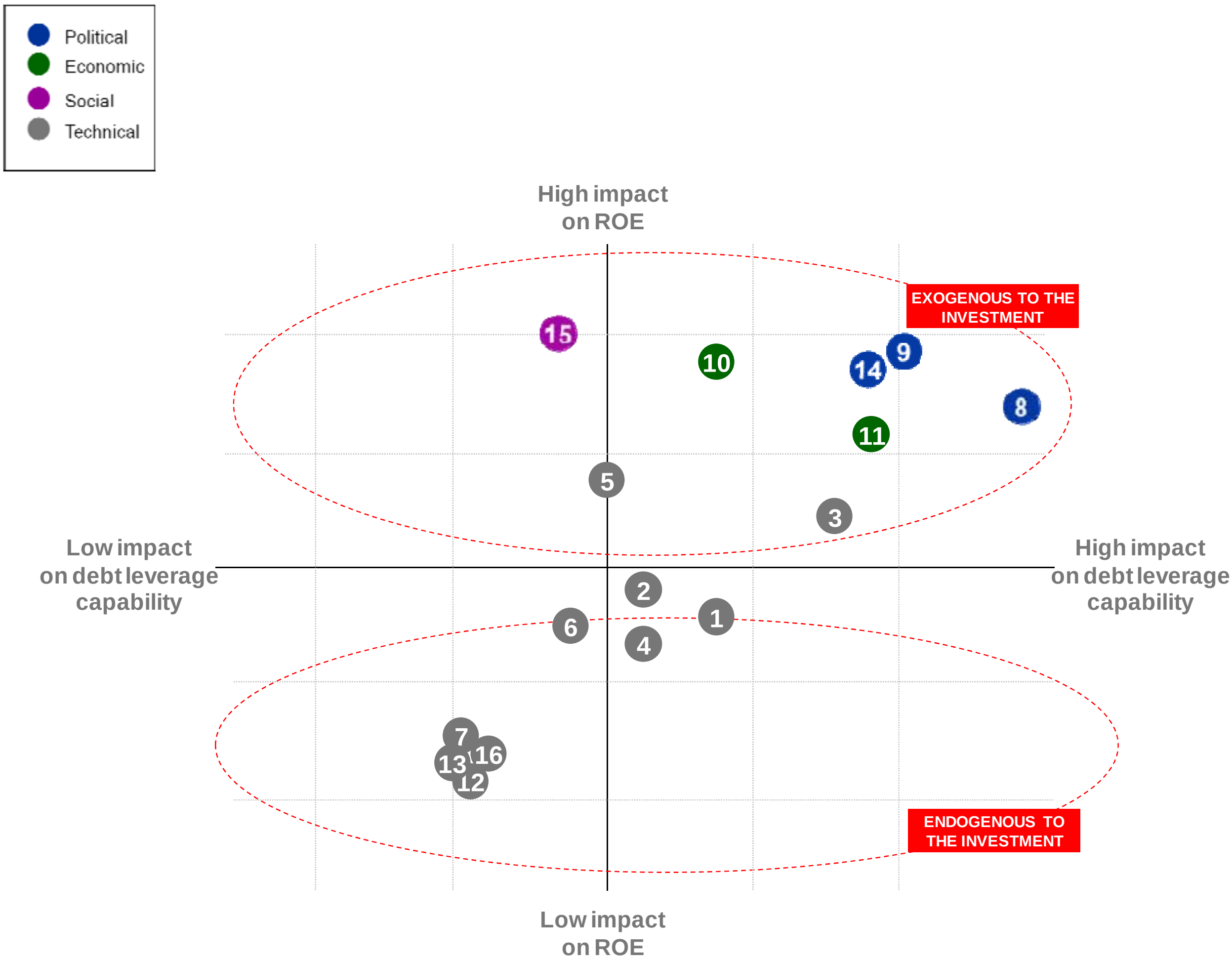
Operation and Maintenance

13. Transport and logistics complexity of blades (especially for those of larger sizes)

Project

14. Permitting issues
15. Resistance by interest groups
16. Transport and logistics complexity of blades

Figure 15 Wind Energy Impact and Visibility Mapping



[23] Information gathered during Offshore Workshop

3.2.5 Geothermal Plants

Geothermal installations

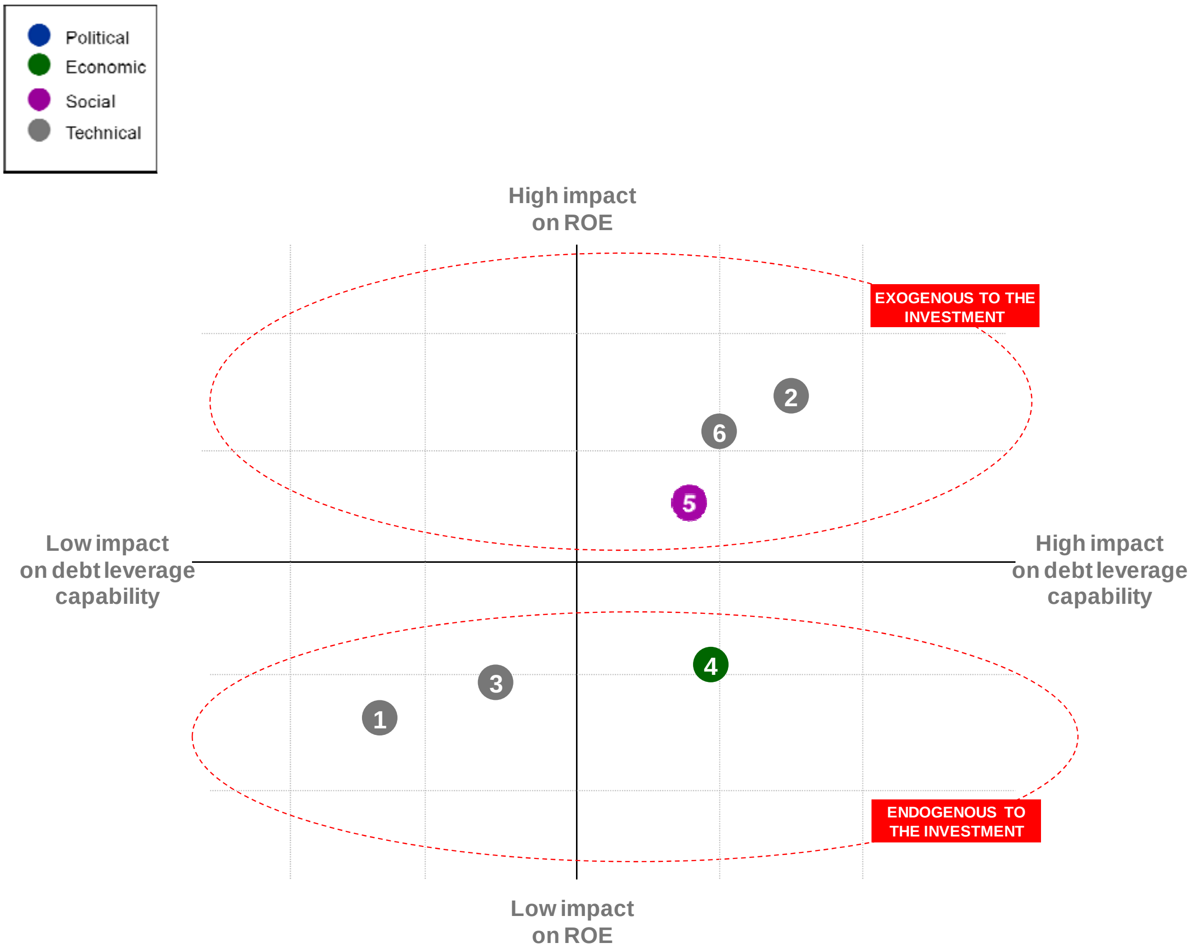
Technology Characteristics

- Wells are drilled with conventional oil and gas technology to reach hot rock and/or water layers
- "conventional" steam cycles or low temperature cycles, e.g. organic Rankine cycle or Kalina cycle, can be used
- The economy depends on region and available temperatures in the bedrock

Risks

1. Risks involved with well drilling (comparable to oil and gas)[24]
2. Uncertainty of accessible temperatures and energy quantities[25]
3. Failure of surface installations
4. Limited number of suppliers for technology
5. Potentially hazardous chemicals in energy cycle (e.g. ammonia in Kalina cycle)
6. Source depletion

Figure 16 Geothermal Technology Impact and Visibility Mapping



[24] UNEP 2004, Financial risk management instruments for renewable energy projects
[25] SEFI "Scoping study on financial risk management instruments for renewable energy projects", NNEP

3.2.6 Wave and tidal stream devices

Wave Energy Converters

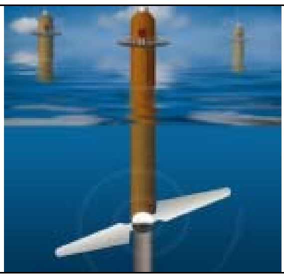
<table>
<tr><td>
<u>Technology Characteristics</u>
• Emerging technology
• The technology is scalable by multiplication
• The installation is anchored to the ground
• Currently multiple concepts under development, for example:

Oscillating water columns
• The relative motion of individual segments is converted into energy

Attenuating wave energy converter (Power snakes)
• Waves drive pressure changes in an air chamber, which drive a Wells turbine to generate electricity
• Air chamber typically is a concrete enclosure on the shore
</td><td></td></tr>
<tr><td colspan="2">
<u>Risks</u>
1. Only few installations in place with very short track record[26]
2. extreme conditions at sea can damage installations[27]
3. stability of coastline around installation
4. Impact on marine/coastal life unknown
5. Accessibility for maintenance
6. Limited numbers of suppliers
7. design bottlenecks
</td></tr>
</table>

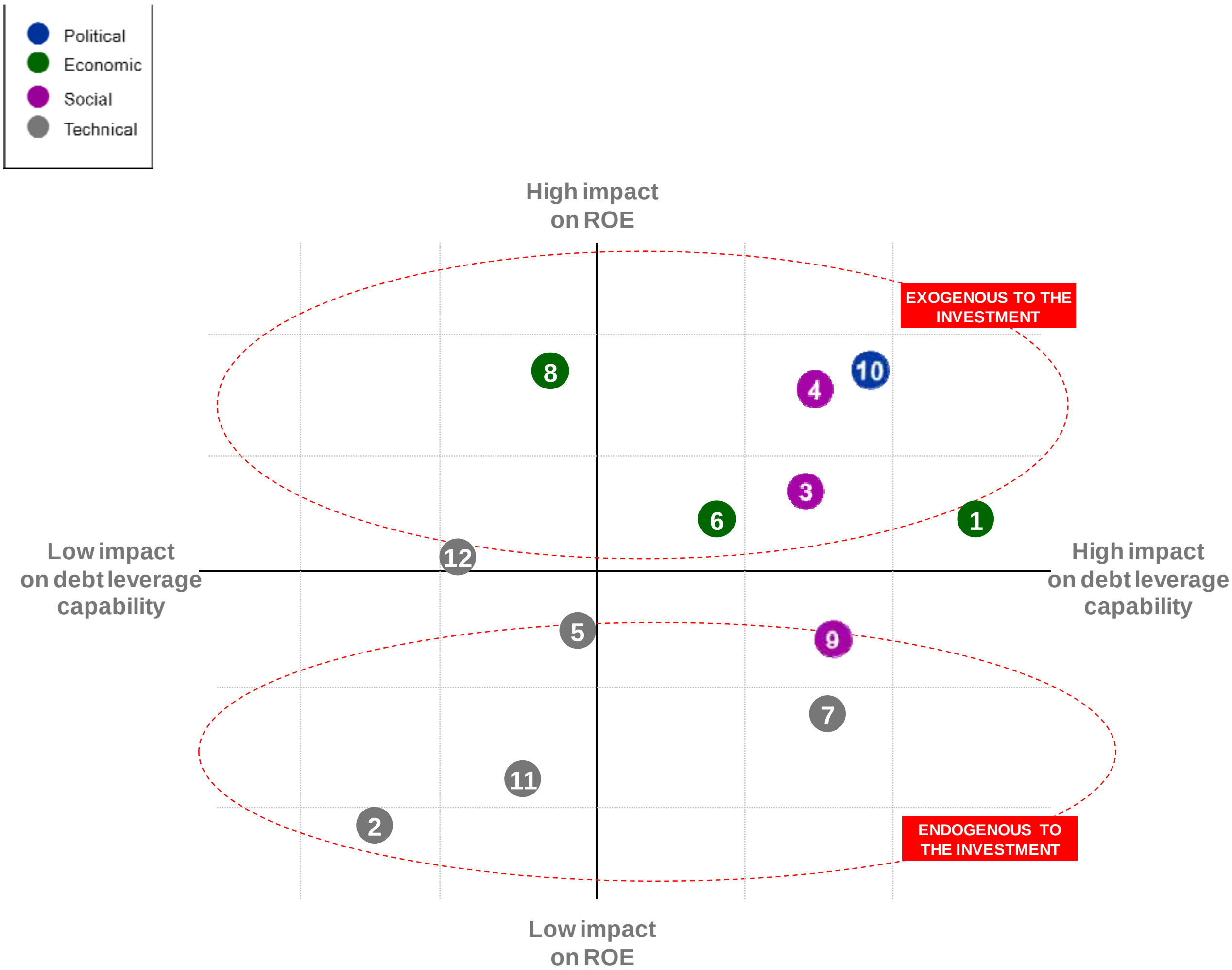
Tidal stream systems

<table>
<tr><td>
<u>Technology Characteristics</u>

• Tidal systems make use of the kinetic energy of moving water to power turbines, similar to turbines that use "moving air".
</td><td></td></tr>
<tr><td colspan="2">
<u>Risks</u>
8. high capital/infrastructure cost
9. effects on ecosystem
10. regional limitations
11. corrosion in salt water,
12. maintenance issues in deeper water
</td></tr>
</table>

26 UNEP 2004, Financial risk management instruments for renewable energy projects
27 UNEP 2004, Financial risk management instruments for renewable energy projects

Figure 17 Wave and Tidal Stream Impact and Visibility Mapping



3.2.7 Tidal barrages and lagoons

Tidal barrages

Technology Characteristics	
Technology Characteristics • Potential energy in the difference between high and low tides is used • Typically dams across the width of a tidal estuary are built with very high civil infrastructure costs. • The number of viable sites is very limited worldwide • The installations have a severe environmental/ecological impact.	
Risks **1.** cost/complexity of maintenance **2.** resistance by interest groups **3.** environmental impact; **4.** equipment likely custom-built; **5.** few suppliers; 6. specialized maintenance	

Tidal lagoons

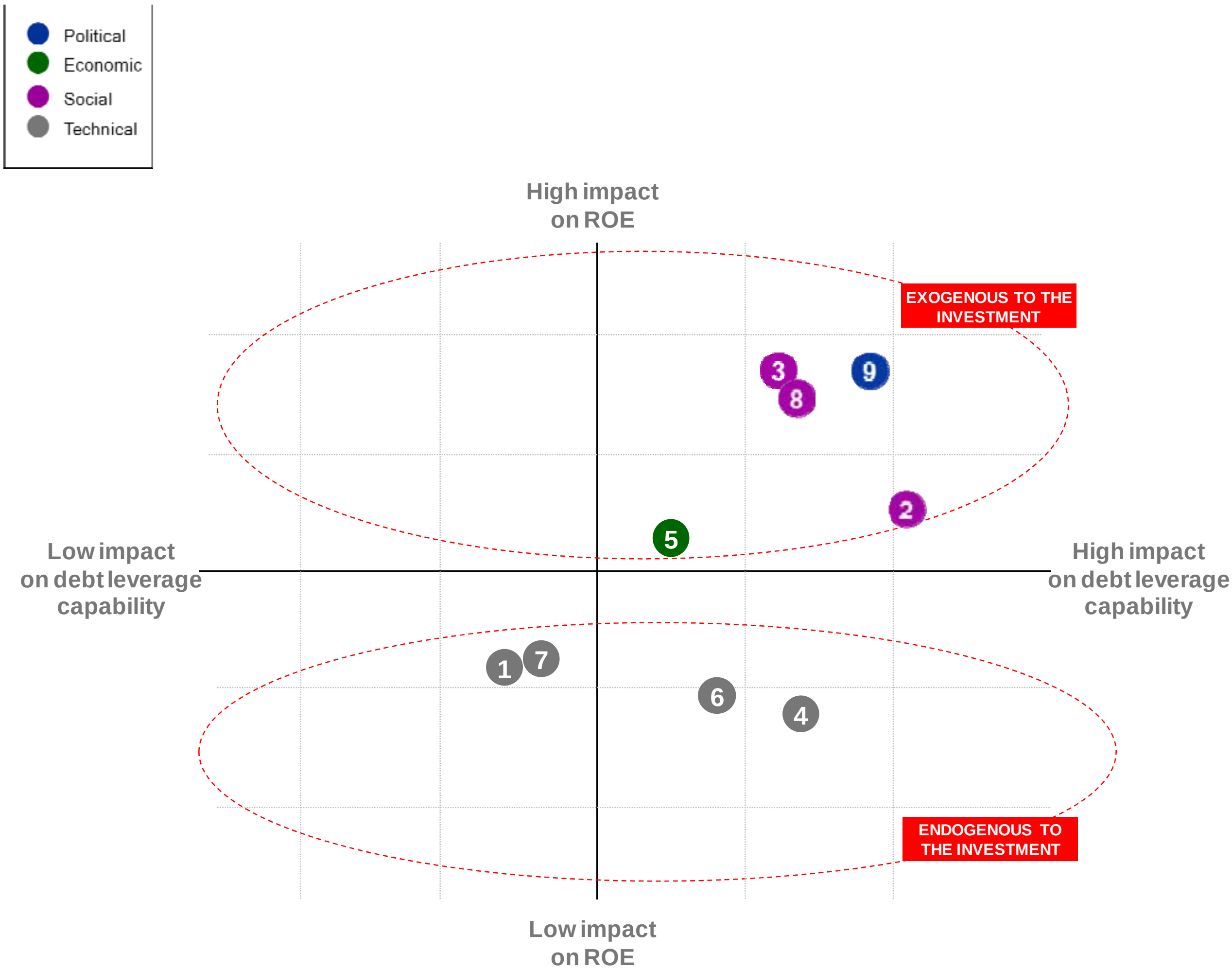
Technology Characteristics

- Lagoons are similar to barrages, but can be constructed as self contained structures
- They do not reach fully across an estuary, and are claimed to incur much lower cost and impact overall.
- They can be configured to generate continuously

Risks

7. high capital/infrastructure cost
8. effects on ecosystem
9. regional limitations

Figure 18 Tidal Barrages and Lagoons Technologies Impact and Visibility Mapping



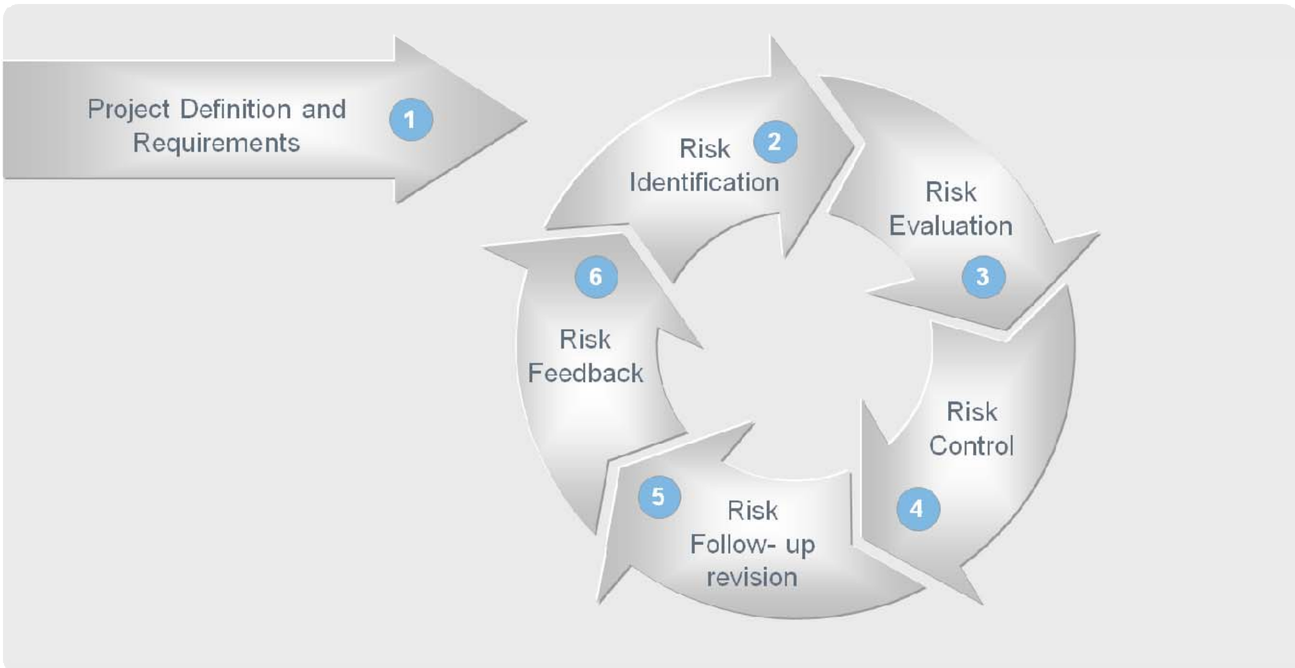
4 Recommended Risk Management Methodology in Renewable Energy Projects

This chapter draws the understanding of approaches to manage risks in conventional energy projects (Chapter 2), the specific issues faced by RES projects/technologies (Chapter 3), to present a proposed methodology for managing risks in RES projects. Two case studies presented in Annex 1 (a Photovoltaic (PV) Plant project in Spain and an Offshore Wind project in the Netherlands) are used to illustrate this approach and to evaluate the benefits.

As discussed in previous chapters renewable energy projects are subject to many similar risks as conventional energy projects. Therefore the proposed overall project risk management approach structured in 6 steps (Figure 19) is closely drawn from established approaches.

At this stage it is important to remind that, if the **approach** is reproducible, on the contrary the **results** are not reproducible. Actually, uncertainties are specific to each investment characteristics and therefore might produce completely diverse results from one project to another one, even if planned in the same country or in the same technological field. Thus, the process has to be revisited for each single investment, and results must not be generalized.

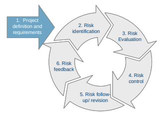
Figure 19 Generic Project Risk Management Process



The entire approach was tested and discussed among RES experts during the workshops organised for case studies. A number of remarks / suggestions were addressed and taken in consideration in the methodology (see Feedback from participants in the case studies in Annex 1).

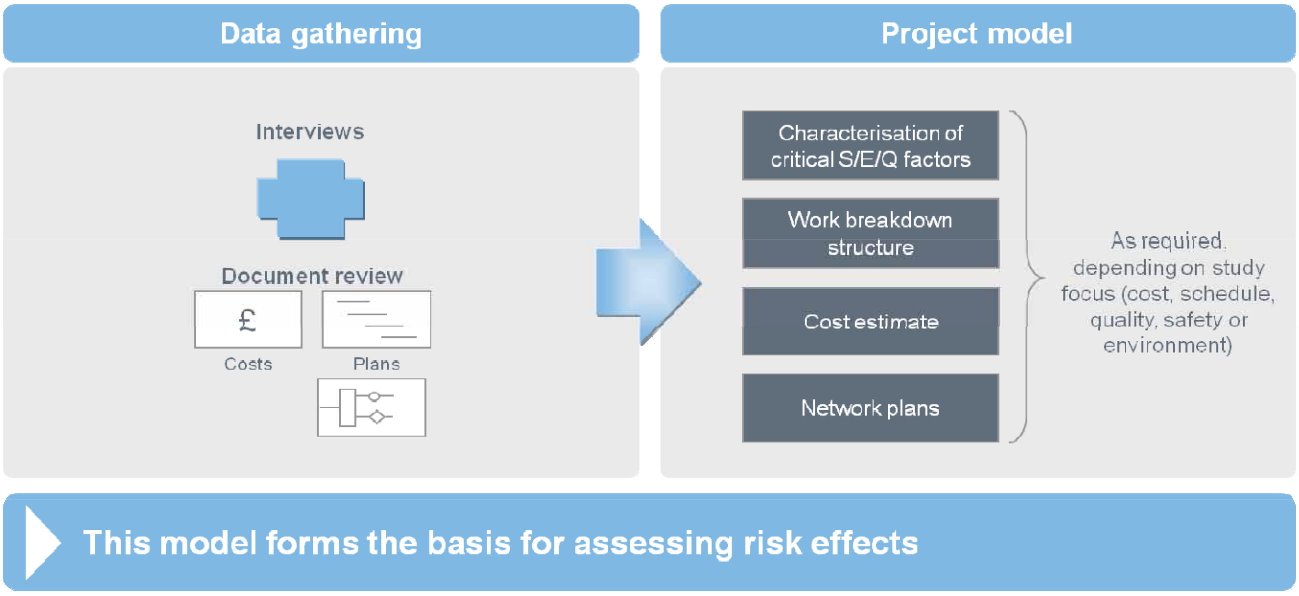
In particular, reluctances are common about probabilistic modelling. For this reason, a simple and integrated model was specifically developed for the two case studies in order to demonstrate the practical use of such instruments.

4.1 Project Definition and Requirements



The first step of the Risk Management process starts with a definition of the project in order to bring a complete picture of project scope and challenges. This picture must also contain different project perspectives, ranging from those of the engineer to those of the banker.

Figure 20 Data Collection for Project Definition (S/E/Q: Safety / Environment / Quality)



This step involves the collection of the project documentation (technical, financial, organizational, legal etc.). Critical data for collation includes:

Project description
Documents describing the scope of the project, main players, strategic objectives, third parties, and environment (physical, social and legal) and Safety / Environment / Quality (S/E/Q) considerations should be included. These descriptions can be illustrated in various ways: by sketches, maps, pictures etc.

In some cases it can be interesting to have a representation of the project at different time dates, to understand the physical evolution of the investment.
For many RES projects it is important to describe the local environment in detail including resource (wind, tidal etc.) and sensitive areas (natural sanctuaries, populated or tourist areas etc).

Process Diagrams
For a continuous flow project such as biomass technologies, a flow diagram showing the relationship between equipment, process inflows/outflows, physical parameters (heat, pressure, solid, liquid etc.) is important. The level of detail of such process diagrams is expected to increase along project life cycle. At the primary stages of project development, such process diagrams can be very synthetic.

CAPEX / OPEX / DECAB
Cost elements of the project are usually expressed in terms of CAPital EXpenditures (CAPEX) and OPerating EXpenditures (OPEX).

CAPEX covers all costs related to the initial investment for facilities implementation (studies, procurement, construction, installation, tests, etc.).

OPEX covers all costs related to the expenses requested to operate the facilities once they are in production (personnel, services, commodities, maintenance etc.).

Another important cost category is the costs for decommissioning and abandoning of facilities (DECAB). These are costs related to the dismantling of the facilities (engineering, deconstruction, recycling, cleaning etc. In the past DECAB was often neglected in the project cost estimates. Nowadays it is mandatory to include them.

In some cases however, facilities are installed for a very long period of time, or are planned to be reintegrated or revamped at the end of the initial production life. If such probability exists, it should be valorised as an opportunity in project economics.
All cost information must be structured through a Work Breakdown Structure (WBS), so cost information can be associated with a scheduled activity, a contract, or a physical package of equipment.

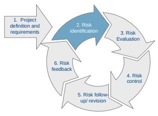
Project Schedule
The project schedule must be provided typically through a Gantt Chart. Other formats, such as PERT (Project Evaluation and Review Technique), are also appropriate. The objective is to understand project milestones, critical path, time float and logical links between project activities. For complex projects, a dedicated schedule risk analysis can also be performed on a probabilistic basis.

Term Sheet
Term Sheet present the financing strategy developed to realize the investment. It covers main rules and roles of project promoters and financiers, as well as financing conditions.
Lenders including bankers will expect to receive a term sheet explaining the proposed financial arrangements including the sources of equity available to the project sponsor as well as the debt structure and the way in which project cash flows are proposed to be used to service the various debt structures. Other elements in the term sheet may be insurances to be taken for example contractors bond, mechanical performance or construction all-risks insurance.

Regulations
The legal and authoritative frame is a key dimension of project environment. Obviously any change in this frame can have dramatic impact on project objectives, so it is worth to gather any additional info about regulation evolutions or political changes. This includes key support mechanisms for a given renewable energy technology.

Discounted Cash Flow
Discounted Cash Flow (DCF) is the sequence of cash movements from and towards the project entity. This is the ultimate consolidation document that combines cost, revenues and financing. Ultimately, an investment decision is based on ratios and computation made from this DCF (Net Present Values, Internal Rate of Return etc.).
For lenders and sponsors the cash flow statement is an important document showing the expected outflow of cash during design and construction and the timing of revenue flow once the project has been put into service. The DCF sheet will also contain tax treatment and an outline finance plan. This way the DCF becomes the main indicator of the overall project risk exposure. In fact, most of the uncertainty is measured on the project profitability. Any subsequent mitigation action can be measured in terms of cost/benefit effect in the DCF.

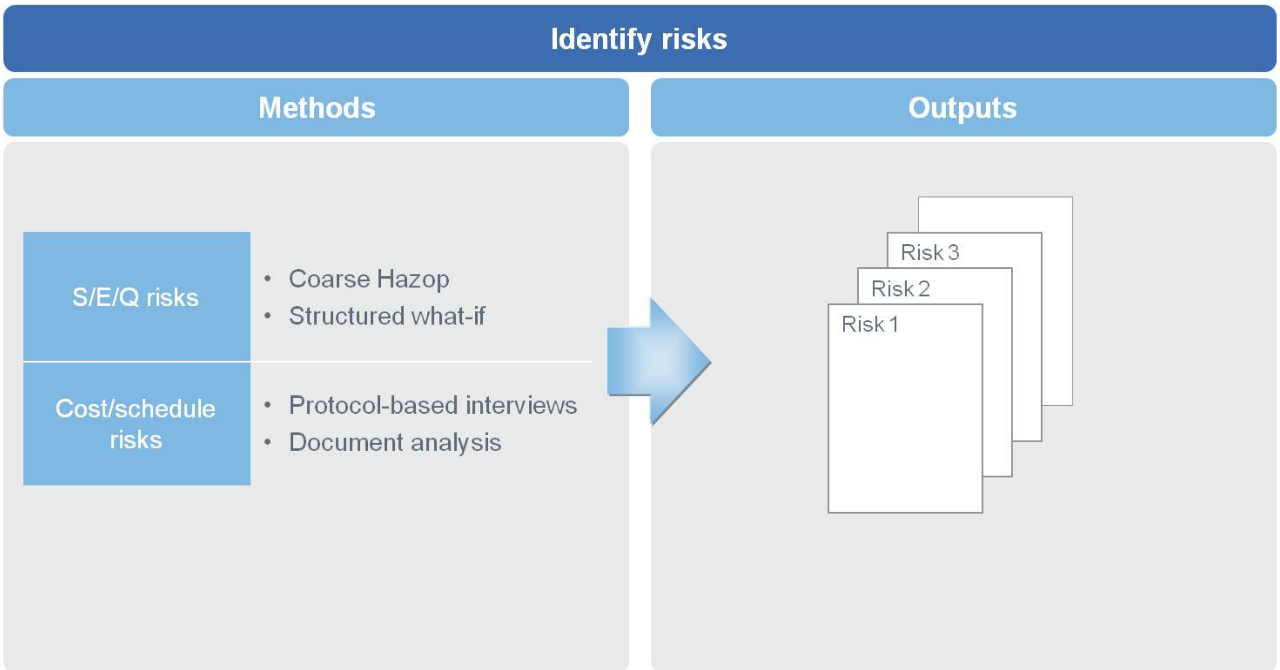
4.2 Risk Identification



By definition a project risk is an uncertain event or condition that, if it occurs, has a **positive** or a **negative** effect on at least one project objective. Thus the starting point is to define and qualify project objectives (that can be profitability, time, cost, revenue etc.).

Risk identification involves identifying all the potential risks associated with the project objectives. The Risk Identification process results in a project Risk Register, where risks are described and qualified.
The Risk Register is subsequently amended with the results from qualitative risk analysis and risk response planning, and is reviewed and updated throughout the project, as illustrated below:

Figure 21 Risk Identification Sequence
We use the most appropriate risk identification techniques to identify the full range of risks affecting the project.



4.2.1 Risk Identification techniques

There are several ways to identify risks.[28] The selection of the most suitable approach depends on the data and project player availability:
:

- **Brainstorming** is a method involving bringing together stakeholders/experts under a facilitator to generate and clarify ideas of potential risks. This approach is the most straight forward in terms of opinions sharing and data collection. Therefore it is the most appropriate for RES projects that can allocate only limited resources (personnel, time, and budget) to perform this kind of analyses.

[28] Cooper, Grey, Raymond, & Walker, *Project Risk Management Guidelines: Managing Risk in Large Projects and Complex Procurements*.

- **Delphi method** is a way to gain the experts agreement or disagreement about a problem; the experts should express their opinion about the problem (i.e. risk posed on the project) and a process administrator should aggregate the opinions received and send these back to the experts as anonymous feedback. The experts might revise their opinion and generate new ideas or keep the previous ones. The process is repeated 4-5 times, and the areas of agreement or disagreement documented. The main advantage of this method is to avoid the direct mutual influence on judgments among the experts. This method was used for the Wind Energy case study as presented in Annex 1.

- **Experts Interviews**: interviews are the simplest method and consist of asking various experts for their opinion

- **Checklist**: provides a typical list of risks and experts would be consulted for the completeness of that list

- **HAZOP**: the HAZard and OPerability analysis (HAZOP) is the identification of project hazards that can occur as a result of operating procedures and operational setbacks in the process. At earlier stage in the project, the analysis is called "Coarse HAZOP", since detailed procedures are not yet available. In HAZOP, risk consequences are measured in terms of Health Safety and Environment (HSE), however many of these risks will also have an impact in economic terms.

- **Database**: the collection of all risks experienced by the company in various projects; the database can be inquired to decide whether a certain identified risk could reasonably occur, or which are the likely risks that the project could be exposed to. This approach is less applicable for emerging RES projects where such data does not exist.

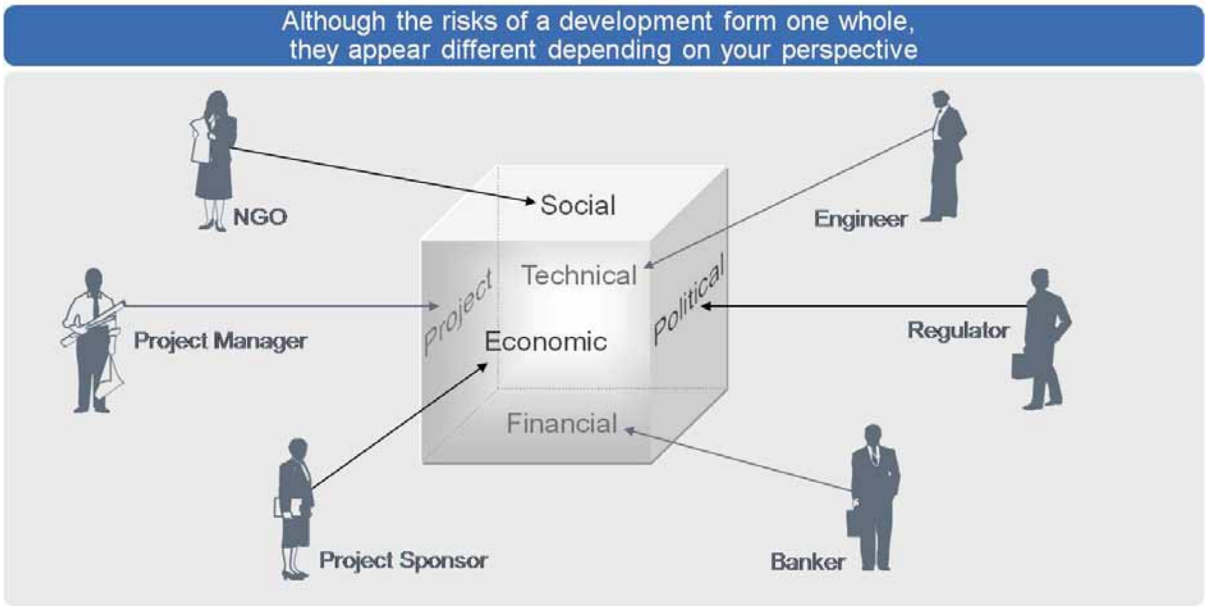
- **Cause / effect diagrams**: are diagrams supporting the analysis of the root cause of the risk to which the control strategy should respond

For most RES projects, we recommend organising dedicated workshops to handle brainstorming and real time Delphi approaches. In particular, workshops are not only time efficient, they also allow direct interaction between participants with different perspectives. This is also the approach used for the first case study in this report. Other techniques can be considered as complementary to the workshops and can be used discretionally.
The key instructions to perform a brainstorming exercise in a workshop are as follows:

1. Ensure risk identification is presented as a structured process which can be relied on to draw out all the main risks in the problem which affect the outcome of the project in question.
2. Conduct the identification exercise in a workshop with all types of project key players (sponsor, contractors, bankers etc.).
3. Start the process by working from the checklist of risks based on experience with previous projects.
4. Conduct a brainstorm so that participants are able to bring up any issues of concern to themselves within and outside their own field of expertise.
5. Involve a checking process such as PEST (see Risk Breakdown Structure in paragraph 4.2.2) to ensure broad coverage of risk without concentrating on particular specialist concerns.
6. Ensure each risk identified is captured within a risk register (see 4.2.3).

A key aspect of this process is the need to identify all aspects of risk associated with a RES project. It must be structured to consider the viewpoints of a wide range of stakeholders (Figure 22).

Figure 22 RES Project Stakeholders
Although the risks of a development form one whole, they appear different depending on your perspective.



At the beginning of the workshop, stakeholders can share their views from their own perspectives:

Table 5 Project Stakeholders Role

Roles	Expectations	Expertises
Project Sponsor	is leading the commercial aspects of the development	Represents the commercial intent using a Discounted Cash flow spreadsheet which shows the projected cash flows throughout the project.
Project Manager	is concerned with delivering the project on time to budget	Summarises the project using a Gantt chart for schedule and a cost plan for financials built to a common work breakdown structure.
Technical / Engineers	are concerned that the project meets its technical specification	Use a number of diagrams to represent the project such as a Process Flow Diagram showing the equipment to be installed for the project.
Investors / Bankers	is attending to the financial structure of the deal	Present several strategies for project finance.
Regulator / Policy maker	is ensuring the project meets Government and Regional requirements	Relies on the legal framework and its requirements for projects.
Interest Groups / NGO's	are concerned with the social and environmental impact of the project	Gives a description of the project environment.

4.2.2 Risk Breakdown Structure

In order to ensure that the risk identification exercise has been exhaustive, we suggest that a risk breakdown structure is used as a checklist in a brainstorm session. Practically, the risk identification should be performed freely in a first stage (independently from the technique used). Then, in a second stage, the information is consolidated and organised according to the Risk Breakdown Structure (RBS). At last, an attentive screening of the RBS categories might raise some hidden risk issues, not identified previously.

Also all the risks identified should be structured according to a Risk Breakdown Structure to provide an overview of risks identified.
The RBS reflects all stakeholders' perspectives and is structured to distinguish between risks during the conception, procurement, construction, operation or abandonment phases of the project.
RBS is divided into 4 main risk categories that are chosen following the PEST analysis: Political, Economic, Social and Technological.

The following RBS has been developed to suit any RES project. This RBS has been reviewed and amended by RES professionals during the workshops organised for this report. It has a 3 level structure and a number of keywords to explain each item.

Table 6 RES projects Risk Breakdown Structure

Level 1	Level 2	Level 3	Keywords
Political	Country	Regime stability	expropriation, nationalisation, insurrection,
		Energy and climate policy changes	election, referendum, changes in feed in tariffs, quotas, market mechanisms
		International Policy	sanction, imf, kyoto, eu targets, access to carbon markets
	Fiscal	Taxation rates	tax, tax credits
		Applicable allowances	amortisation, depreciation, export credit guarantee, national grants
		Regional differences	regional investment subsidy / grants / incentives
		Infrastructure Investment	port, grid, road,
	Legal	Recourse	legal access, independent justice, arbitration
		Remedy	enforcement of court award e.g. damages
	Regulatory	Environmental permitting	light, noise, air, water (contamination), wildlife protection
		Health & safety	Seveso directive, safety reports, authorisations
		Multiple permitting authorities	national, regional, local, land use planning, right access, way leave
		Energy regulator	grid connection, pricing, volume requirements
Economic	Financial	Interest rates	source of funds, seniority of debt
		Credit risk	credit worthiness, cost of capital, re-financing
		Currency	exchange rate fluctuation
		Insurance premium	mechanical breakdown, collision, third party liability, theft, property loss, business interruption
		Option price	derivative, hedge, swap
	Price volatility	Feedstock	consumables e.g. biomass or other operating requirements

Level 1	Level 2	Level 3	Keywords
		Product	energy prices, CO 2 spot price, by-products, rents
		Labour	man-hour, unemployment
		Land lease	rent negotiation
		Reactive power	spot price fluctuation,
	Volume	Feedstock	security of supply, weather condition,
		Product	reduction in customer turnover, failure to fulfil supply contract
		Storage	battery, compressed air, hydrogen, rotation capacity,
		Reactive power	availability on demand,
	Contractual	Counterparty default	bankruptcy, wilful non compliance
		Force majeure	war, sabotage, windstorm, earthquake, flood
		Renegotiation	price re-opener
Social	Safety	Process	damage to equipment, Simultaneous Operations
		Personnel	lost time injury
		Third Party	damage to third parties, neighbours
	Environment	Natural resources	limited availability, water,
		Fauna / flora	damages to the fauna, flora, on ground, water, air, loss of reputation,
		Pollution	effluents, thermal, air, water, biocides, chemicals, dust,
		Waste	construction / operation waste, decommissioning waste / recycling
	Labour	Availability	sufficient resources to meet plan, strikes,
		Skills	locally available, construction, operating, maintenance,
		Employment law	local content,
	Public	Criminality	sabotage, terrorism, insurgency, corruption
		Acceptance	local communities, Non Governmental Organizations ("ONG"),
Technical	Performance	Yield	kWh, merit order,
		Efficiency	conversion efficiency, Performance Ratio,
		Quality	phase voltage,
	Service factor	Reliability	mean Time Between Failure, manufacturer warranty,
		Maintainability	access, weather, logistics, spare parts, shutdown, Mean Time To Repair
		OPEX	inflation, unforeseen requirements, changes in regulation, excessive labour force,
	Project	Schedule	weather, Long Lead Items, vendor bankruptcy,
		CAPEX	raw material, services, change of specifications / regulations
		Scope	key components omitted, interfaces, incorrect specification, change orders,
		DECAB	cost and time related to decommissioning, abandonment, cleaning, de-pollution
		Contract strategy	variation orders, coordination, relationship between (sub)contractors
		New Technologies	scale-up, design lead time,

The systematic use of an RBS provides a number of advantages all along the risk management process such as:

- RBS, by covering a wide range of topics, support a risk identification in the most exhaustively manner;
- Classifying the risks allows statistical analysis by risk categories and related risk mapping;
- As later detailed in the section 4.6 Risk Feedback, the risk management approach must be continuously improved through a post investment feedback on how accurate the risk identification was, how fair the risk evaluation was, how efficient the risk mitigation actions were, etc. All this feedback information from past investments must be properly handled in a corporate database and the RBS is the ideal classification for such risk data consolidation and analysis.

4.2.3 **Risk Register**

The risk register is the repository for all identified risks (as document or database). It can be developed to provide views on the range of the risk and the parameter(s) affected. It provides a common, uniform format for the presentation of risk-related information which is updated and maintained as a live document during the project.

The fields that could appear in the risk register include the following information (the evaluation and control steps will be completed during the 3rd and 4th step of the risk management process, and are presented in the following sections):

Table 7 Risk Register Information

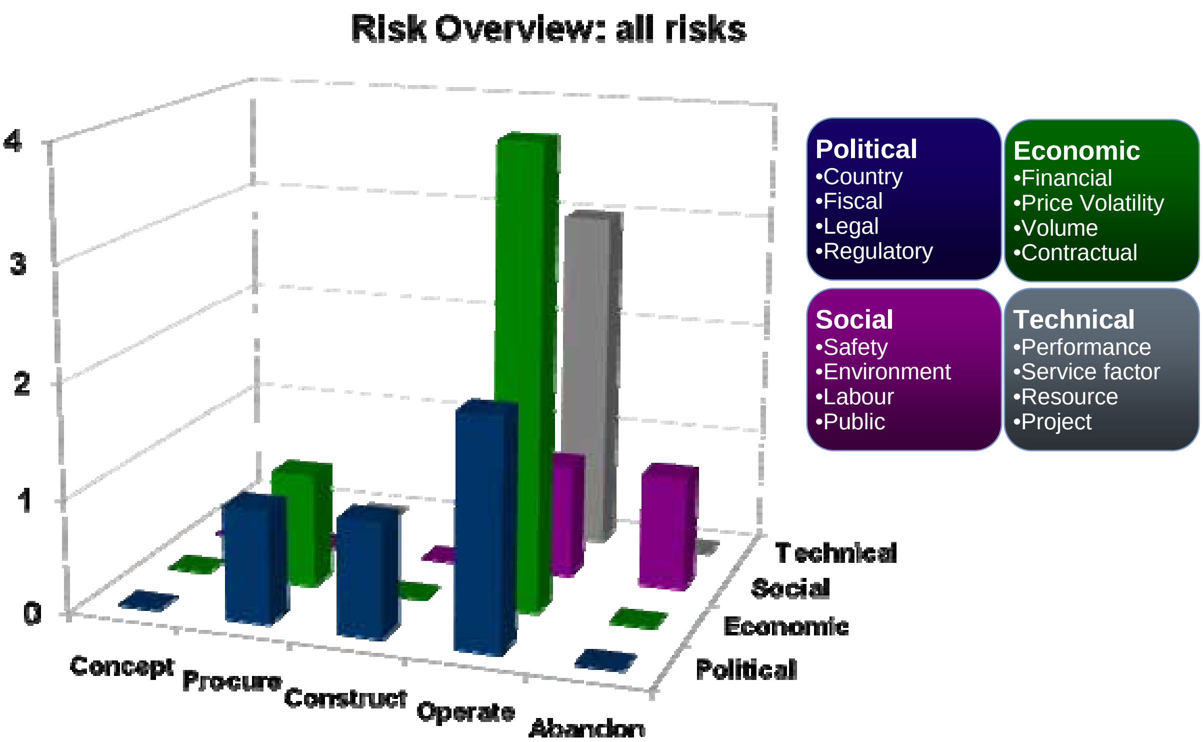
Step	Information
Identification	Risk name and number
	Category
	Owner
	Risk description (risk causes and consequences)
Evaluation	Probability of risk occurrence
	Consequences of risk occurrence on project objectives
Control	Management strategy (action, responsible, planned dates, and actual completion dates).

The case studies in Annex 1 illustrate the risk registers developed for a PV and offshore wind project.

4.2.4 Check for Risk Identification: Consistency and Completeness

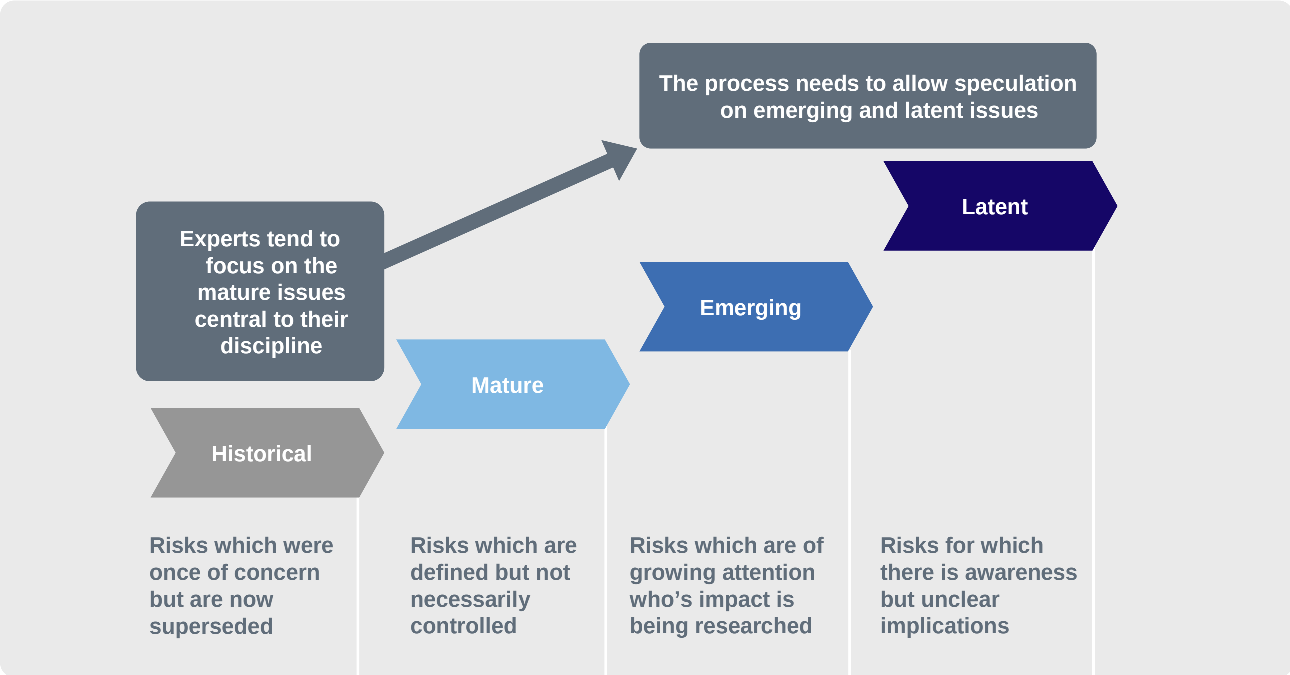
The Risk Breakdown Structure (RBS) is also used to check that the coverage of risks is adequate and to identify any gaps. This helps to recognise areas where risks are widely identified and areas where risks are considered in less detail. A graphical way to check the coverage is illustrated in the graph below: all the risks are classified according to the PEST categories and the project phase affected. The number of risk items for each project phase is shown in the histogram:

Figure 23 Example of graphical representation of the risk coverage (taken from the PV Case study – Annex 1)

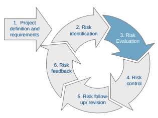


Risk maturity (Figure 24) is another interesting way of mapping prior to risk evaluation. It helps to highlight some risk issues that should develop over time as new political, social or environmental concerns emerge, and where experience is less relevant to anticipate them. Obviously no historical risk is expected to be in a risk register since the related concerns are superseded. RES projects will present strong discrepancies in risk maturity according to the technology used. Higher uncertainties should be measured (and accepted) for projects providing innovative technologies.

Figure 24 Risk Maturity Structure
It is important to recognise that risk issues develop over time as new political, social or environmental concerns emerge.



4.3 Risk Evaluation



Risks can be evaluated in two complementary ways: qualitative and quantitative. Qualitative approaches deal with the evaluation of <u>single</u> risk issues, while quantitative approaches deal with the evaluation of <u>all</u> risk combined.

In "qualitative" evaluations information is relatively descriptive and mainly based on expertise, so the results is presented in descriptive (risk register) or graphical (risk mapping) formats. In "quantitative" evaluations information is based on numerical data so the results can be presented as probabilistic curves or histograms etc. "Quantitative" risk analyses approaches provide a global picture of the risk exposure for the project.

These two approaches are highly complementary, as shown in the table below:

Table 8 Difference of Qualitative and Quantitative Analysis

<table>
<tr><th>Source</th><th>How it is done</th><th>What is evaluated</th></tr>
<tr><td rowspan="2">Expertise</td><td>• Words (risk description)
• Matrixes (risk Mapping)</td><td>Single risk = QUALITATIVE</td></tr>
<tr><td>• Simple distributions (Discrete, Triangular, Uniform)</td><td rowspan="2">All risks combined in stochastic (Monte Carlo) model = QUANTITATIVE</td></tr>
<tr><td>Reference data</td><td>• Normal type distributions</td></tr>
</table>

4.3.1 Qualitative Risk Evaluation

The purpose of qualitative risk analysis is to provide a high level understanding and prioritisation of the risks of a project. Such analysis may increase the alertness of the management, team members, and all personnel towards the top risks they need to manage effectively.

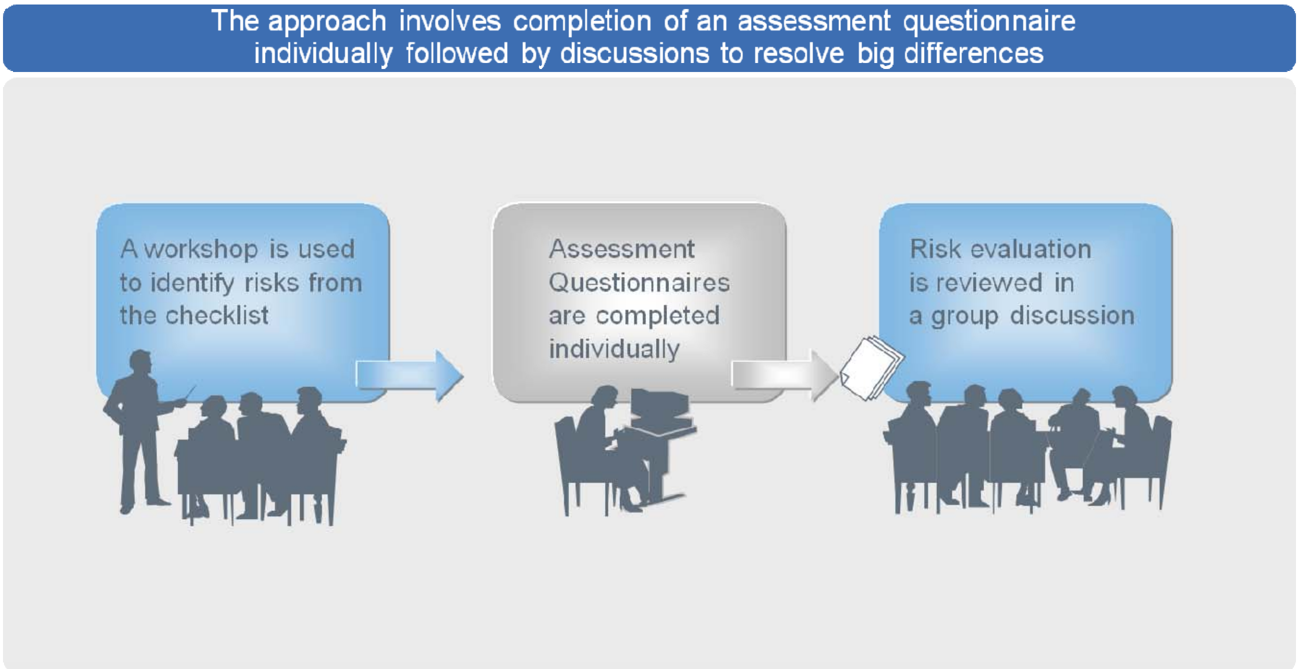
Qualitative risk assessment calls for typical risk characteristics to be estimated:

- Risk probability.
- Risk consequence (or impact) on one or more of the project objectives:
  - Cost (CAPEX, OPEX, DECAB, taxes)
  - Duration (schedule)
  - Financing (Interest rates)
  - Revenues

Any of these impacts can be later built into the probabilistic model during the quantitative evaluation.

In practice risks are categorized in words or in categories; this allows the risks to be ranked and at a later stage, a risk management approach to be developed. At the workshop, participants are individually provided with the risk assessment sheets, and the facilitator explains how to fill them in. Later in the risk assessment process, related mitigation actions are discussed collectively. The overall process is summarised in Figure 25.

Figure 25 Collective Risk Assessment Process



Risk Assessment Matrices

One of the tools used to assign risk ratings is a qualitative risk assessment matrix. The matrix combines the probability and consequence of a risk to identify a risk rating for each individual risk. Each of these risk ratings represents a judgment as to the relative risk to the project and categorizes them according to the following minimum criteria:

- **Probability**: 5 levels evaluation scale from 1 (low) to 5 (high) with relative percentages for probability of occurrence.

- **Consequence**: 5 levels evaluation scale from 1 (low) to 5 (high) for each relevant impact with relative percentages on how much the project objectives (schedule, cost, revenues,…) will be impacted.

Typically ranges used for probability and consequence are structured into the following 5X5 level matrix:

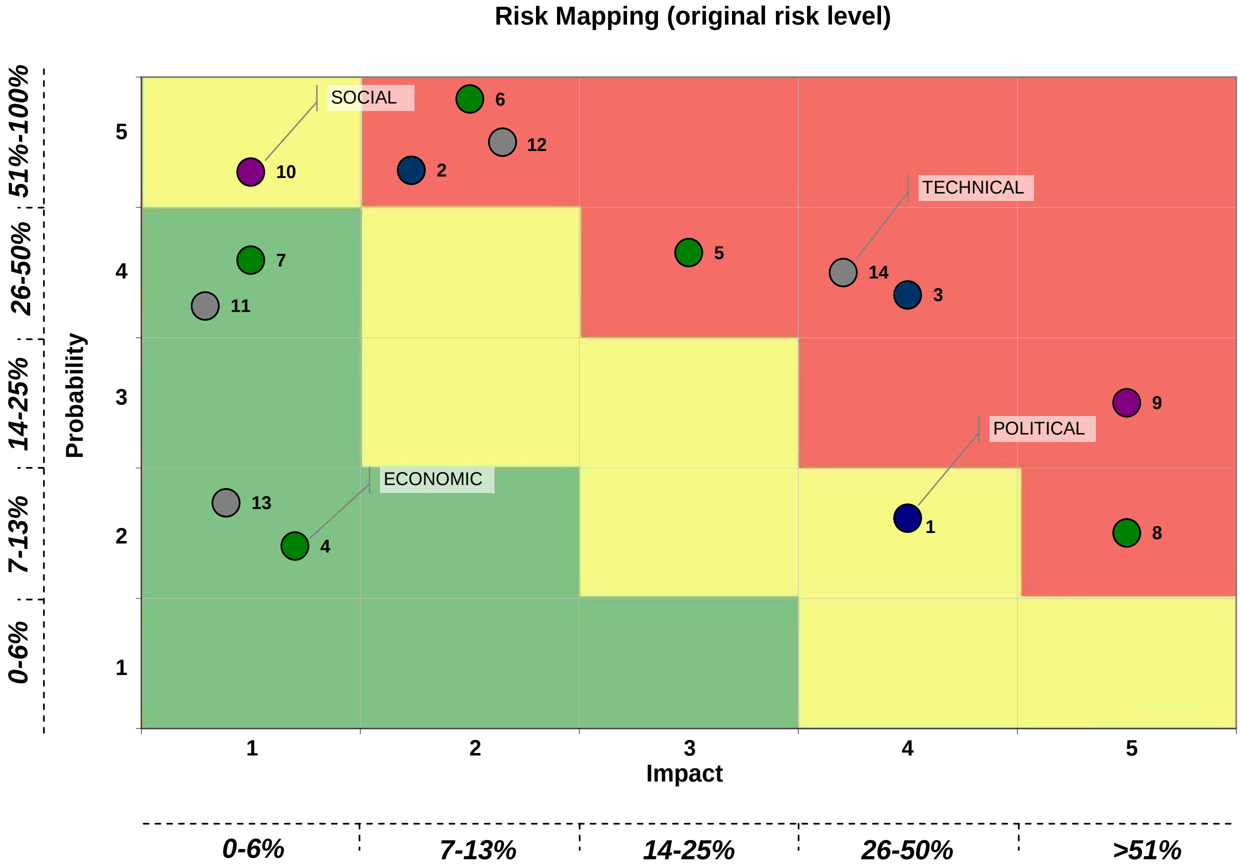
Table 9 Qualitative Risk Evaluation Matrix

			Consequence				
			0-6%	7-13%	14-25%	26-50%	>51%
			1	**2**	**3**	**4**	**5**
Probability	51-100%	**5**					
	26-50%	**4**					
	14-25%	**3**					
	7-13%	**2**					
	0-6%	**1**					

	Intolerable / must be reduced to ALARP (As Low As Reasonably Possible)	The risk cannot be tolerated and mitigation is mandatory / The risk is high and reasonable means to reduce must be sought
	Might be reduced to ALARP	The risk is moderate and might be reduced if there are reasonable means
	Acceptable	The risk is as low as reasonably practicable / The risk is broadly acceptable

The risk matrices must be set up and calibrated appropriately for each project. The matrices can be used to rank each individual risk in terms of its relative impact on the project. In this way the more serious risks can be selected for priority attention and mitigation.

Figure 26 Example of Risk Mapping (ALARP stands for "as low as reasonably practicable"). This graph is taken from the PV Case study - Annex 1)



4.3.2 Quantitative Risk Evaluation

Quantitative risk analysis is a numerical analysis of the probability and consequence of all individual risks combined on parameters affecting the project life cycle financial performance (DCF). The result of the analysis includes a probability that a project will meet its quantitative objectives (for example schedule, budget or cash flow projection). Therefore project risk management is a major input into the overall project life cycle financial estimates (DCF).

When available, the estimate can be based on historic data from other projects and takes the form of a probability distribution for the risk selected. Where good data is available from comparable completed projects, it can be more objective than qualitative methods.

Where there is no data or a lack of suitable expertise to provide numerical estimates, using numbers is in itself no guarantee of objectivity. Then a dedicated expertise is necessary to review statistical data or build simple distributions, based on the risk identification that has been made previously.

All probability distributions are incorporated into a Monte Carlo (or stochastic) model which allows the simultaneous evaluation of all identified and quantified risks. The result is a distribution of the chosen quantitative measure (for example net present value of future cash flows).

Distributions modelling
As the costs and schedule ranges are captured for each risk for input into the Monte Carlo simulation runs, the assumptions that formed the basis for those ranges should be captured. This requirement is met through a properly documented risk register.

The reasons for capturing those assumptions are to form a historic database for future projects, a historic database for the current project, a reference to substantiate how the projected contingency or the contractor management reserve/contingency was derived, and as a basis to determine the possible range of error that may exist in the data.

In practice, the modelling process requires an initial identification of:

- the type of distribution for a given risk
- underlying parameters and
- the element of the project affected (i.e. cost, revenues or schedule)

Distributions can be continuous probability distributions where there is a range of parameter values or discrete distributions. The Table 10 below illustrates the mapping of a number of risks for the PV case study.

Table 10 Risk Register Example (taken from the PV Case study - Annex 1) Risk Level: L (Low), M (Medium), H (High)

						IMPACT			
Nb.	Risk	Probability	Affects	Distribution	Absolute/ Percentage	MIN	MOST LIKELY	MAX	Risk Level
1	Reduction in Feed in Tariffs by 25% in 5 years time	10%	Revenue	Triangular	Percentage	20%	25%	30%	M
2	VAT increase by 2% in 6 months time	90%	Tax	Discrete	Percentage		11%		H
3	Delay of 6 months in transferring licensing from SPV to the operator	25%	Schedule	Triangular	Absolute	120 days	180 days	210 days	H

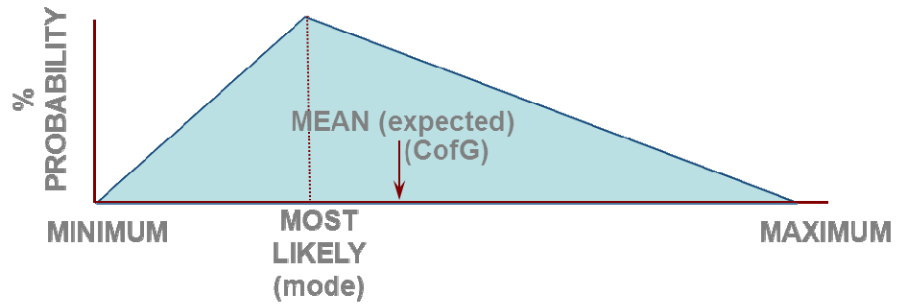
Risk level (Low, Medium, and High) is measured from the qualitative evaluation matrix as presented in the previous paragraph 4.3.1. Qualitative Risk Evaluation. The impact values can be assessed in many unit formats (percentages, days, cost, production, rates etc.) as most relevant for each risk at the evaluation stage. These values are then computed in the model in order to convert each impact in economic terms (revenue or cost).

Continuous distributions

For continuous distributions the most common methodology is to use a three-point approach:

- least value is the optimistic view
- mid-point is the most likely view
- largest value is the pessimistic view of the range

Figure 27 Triangular Distribution (CofG stands for Center of Gravity)



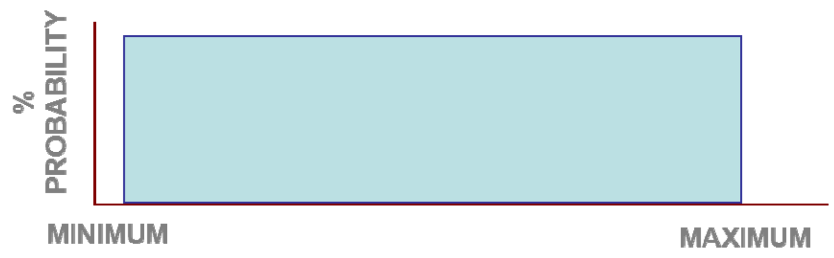
Most Likely	That value which, if the opportunity existed to repeat the activity, would occur most frequently. (Normal constraints on resources and reasonable allowance for technical problems).
Minimum	Best case envisaged, given maximum use of resources and (optimistic) minimum technical problems. This extreme point has a zero probability of occurrence.
Maximum	Worse case envisaged, barring disasters, given minimum (pessimistic) resources and considerable technical problems. This extreme point has a zero probability of occurrence.

Such a three point distribution could be typically applied to

- cost of items in the work breakdown structure(WBS)
- duration of items in the WBS

If the parameter being assessed has no “likely” value (i.e. opinion cannot achieve consensus on the centre point of the triangular distribution) a uniform distribution can be used which simply expresses the least and largest value expected for the parameter.

Figure 28 Uniform Distribution



Minimum	Best case envisaged, given maximum use of resources and (optimistic) minimum technical problems.
Maximum	Worse case envisaged, barring disasters, given minimum (pessimistic) resources and considerable technical problems.

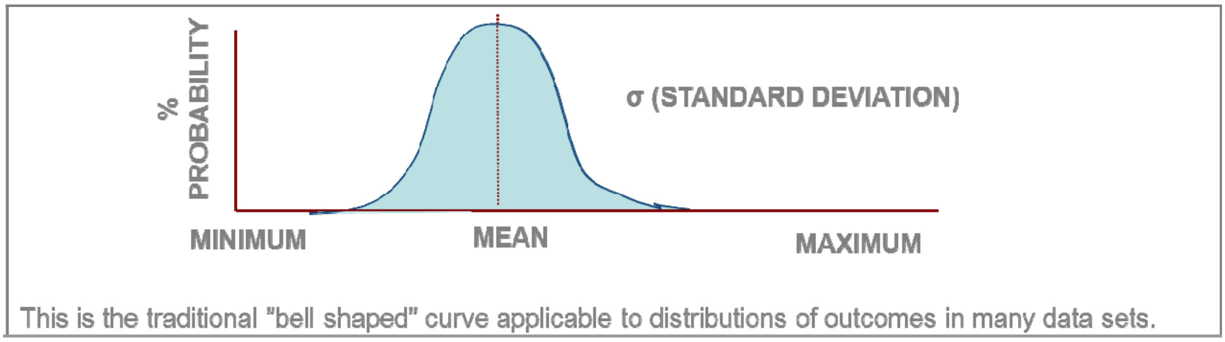
Every value across the range of the uniform distribution has an equal likelihood of occurrence.

Such a uniform distribution could be typically applied to

- cost increase for equipment supply on medium term (e.g. long lead items)
- time delay due to local opposition, or authorization process

Where there is sufficient data available from past comparable projects, distributions can be derived by curve fitting (most probabilistic software packages offer this function). Such distributions can be symmetrical (such as the Normal distribution) or asymmetrical such as log normal or beta distribution. These latter distributions are commonly obtained from real projects data sets.

Figure 29 Normal Distribution



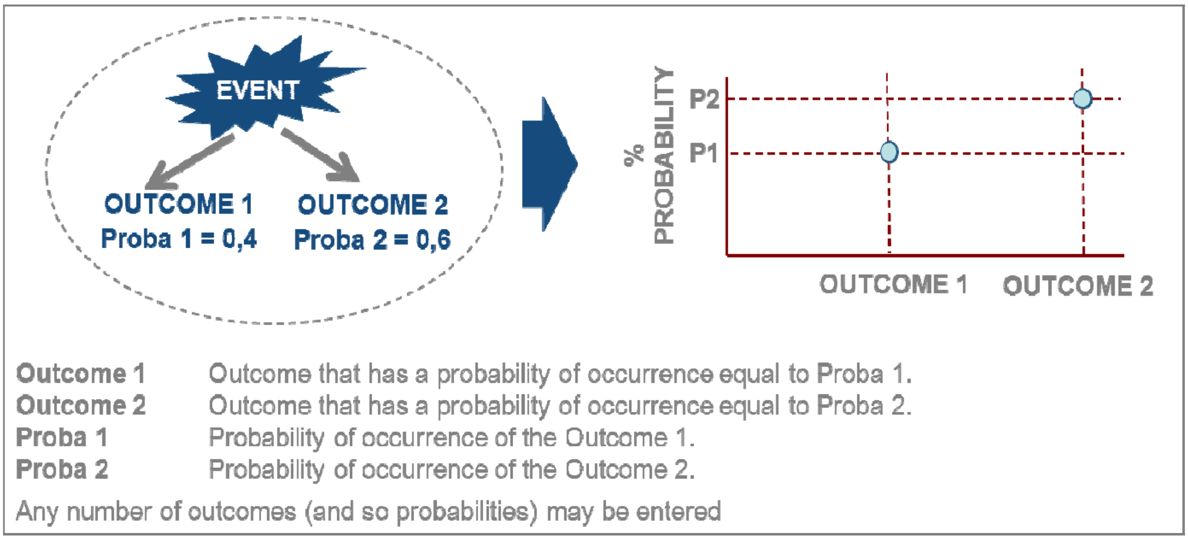
Such a uniform distribution could be typically applied to

- weather conditions or wind regularity (both based on meteorological statistics)
- equipment reliability

Discrete distributions

Models can incorporate decision points where radically different outcomes are possible. For example either a project environmental permit is issued or permission is refused. This “either or” situation (which could lead to delay and additional costs in a project) can be modelled using a discrete distribution.

Figure 30 Discrete Distribution



Such a uniform distribution could be typically applied to

- reduction in support measures (e.g. Feed in Tariffs)
- partner/supplier bankruptcy

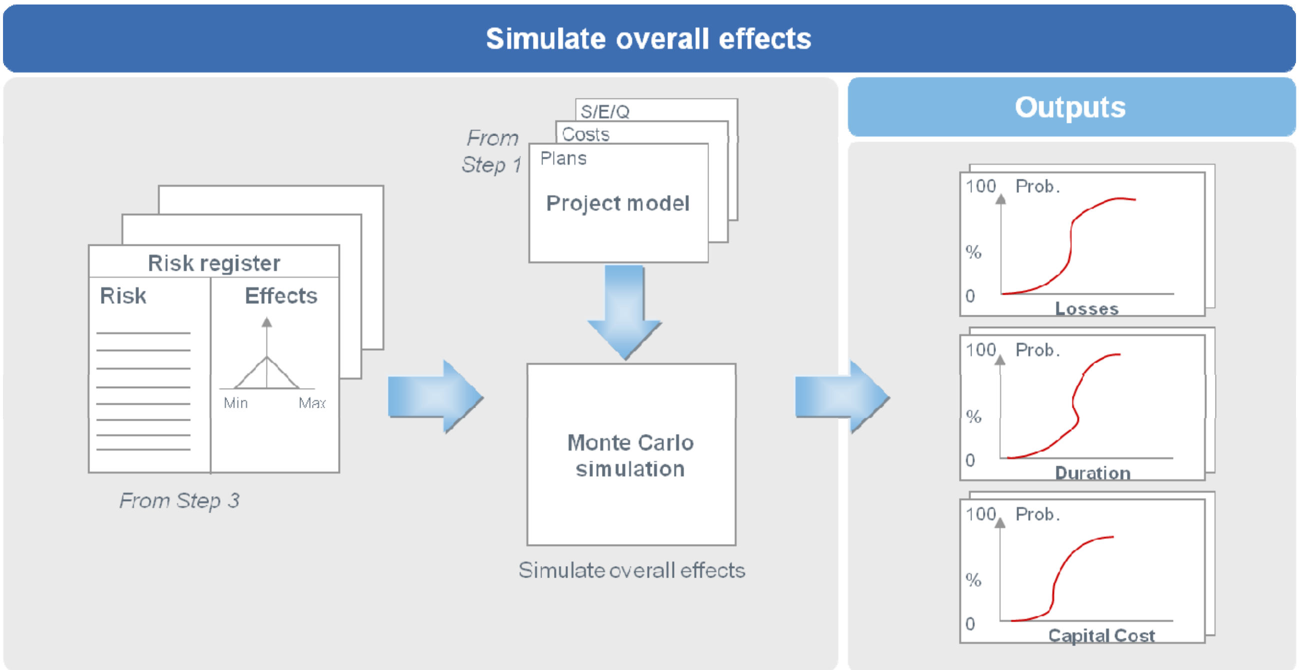
Combining Distributions in a Stochastic Model
Impacts presented in the case study models are mainly addressed through triangular or uniform distributions. All distributions are then built directly into the DCF table, in order to assess cost, revenues and schedule implications.

A non stochastic way (not recommended) will make best / mean / worst “what if” cases by combining minimum or most likely or maximum values together: Such an approach is very restrictive and not representative of different distribution profiles. On the other hand, trying all possible cases would require a huge number of calculations.

A solution is provided by Monte Carlo simulation that gives a very consistent representation of all possible cases. The simulation allows random sampling of probability distribution functions as model inputs to produce hundreds or thousands of possible outcomes (in terms of impacts on the project budget and schedule).

Monte Carlo simulation can be held through dedicated software such as @Risk™ or Primavera™. In our case studies, stochastic models were developed and ran through macros on a standard version of MS Excel™, demonstrating that the proposed approach is not software dependent.

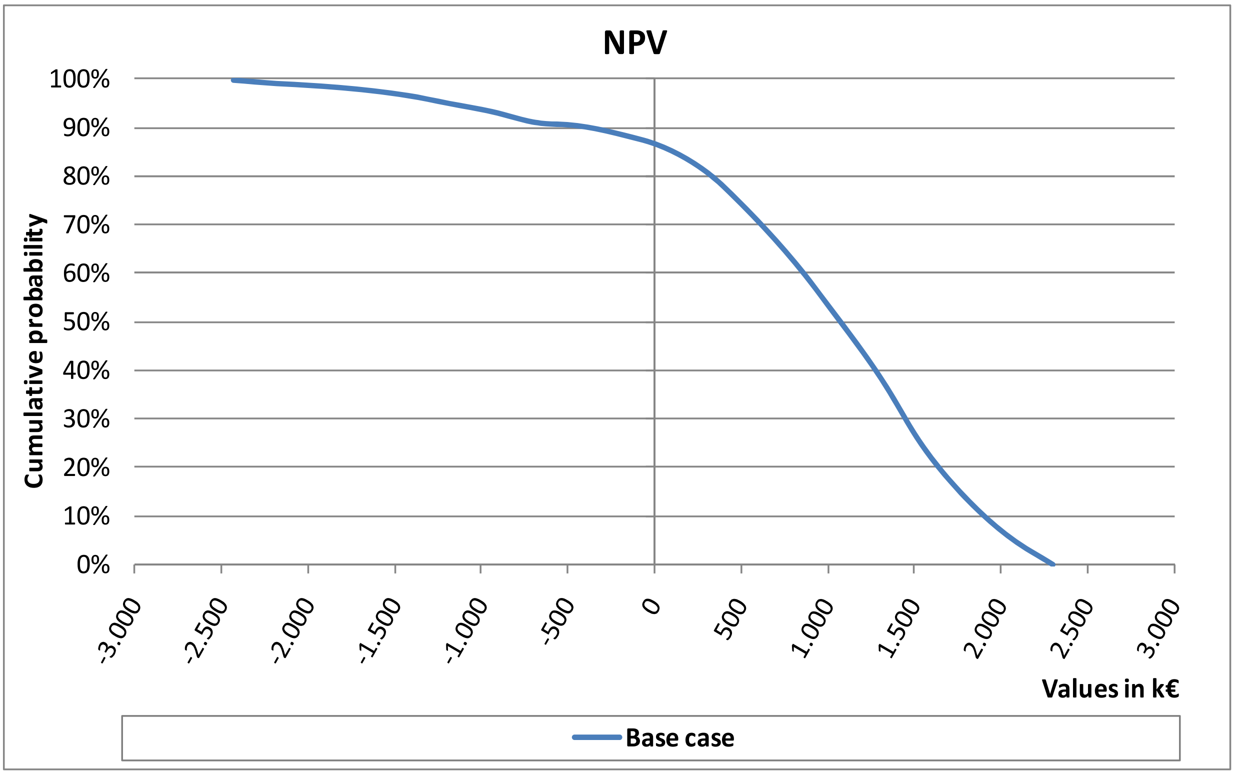
Figure 31 Monte Carlo Simulation
The combined effect of the risks on the total project outcome is modelled, using simulation techniques.



The simulation produces a range of possible project outcomes represented in a cumulative probability distribution, addressing a level of confidence for each different outcome.

Cost and time values increase as confidence level increases (low cost = optimistic, high cost = conservative), so the probabilistic curve is ascending. On the contrary revenues or benefits (like NPV, Net Present Value) decreases as the confidence level increases, thus presenting a decreasing probabilistic curve (high revenue = optimistic, low revenue = conservative), as shown in Figure 32 below.

Figure 32 Cumulative probability of the Net Present Value of the PV case study (taken from the PV Case study - Annex 1)



Risk dependencies and correlations

Time / cost dependency: In a more sophisticated approach, the effect of risk on both schedule and cost is considered together. A probability distribution is chosen to represent each risk and it may then be applied to the cost and duration of particular activities. For such an analysis a common work breakdown structure must be available for the budget and the critical path network.
Careful dependency of risks must be included in the model. For example a risk affecting material quality (for example a particular grade of steel) can be expected to have both cost (it may cost more to procure) and schedule (it may take longer to deliver).

In the case studies presented in Annex 1, time consequences were addressed in the cash flow sequence.

Variables dependency: In reality, the occurrence of a certain event can increase the probability of other events occurring, through direct or indirect chain of events. These dependencies must be included in the model to better reflect real conditions. For example, in the PV case study, the supplier failure risk (risk no. 8) is dependent from another risk regarding PV modules quality (risk no. 12). These dependencies were built through “if” conditions.

Variables correlations: In real life, many uncertainties are interrelated (e.g. interest rates, inflation, purchasing, prices).
This correlation is necessary when, in reality, two input variables move to some degree in tandem.

The model can create dependencies or correlations between variables over 2 criteria:

- Positive or negative (inverted): is the capacity of the variables to move toward the same direction (variable 1 increases then variable 2 increases as well) or inverted directions (variable 1 increases then variable 2 decreases). An example of negative correlation is a political tendency to decrease the FiT that creates more difficult conditions for project financing and potentially an increase in financing cost.

- Full or partial: is the extent to which variables are dependent or correlated. Correlation coefficients ranges from 0 (no correlation at all) to +1 (full correlation) or -1 (full inverted correlation). The values of the coefficient can be calculated from statistical records of different variables, when available. Alternatively it can be estimated by experts during the risk evaluation step, through individual interviews or Delphi method.

In the case study correlation was built through coefficients or "if" conditions set between variables. In probabilistic simulation software, a dedicated function helps to build correlation matrixes between multiple variables.

Without correlations, random variations will tend to understate the risk and reduce artificially the range of results. Correlations and dependencies are a decisive parameter in probabilistic modelling, simply because they represent reality.

Sensitivity analysis
Sensitivity analysis is the study of how the variation (uncertainty) in the output of a mathematical model can be apportioned to different sources of variation in the input of a model[29].

The main objectives of the sensitivity analysis are:

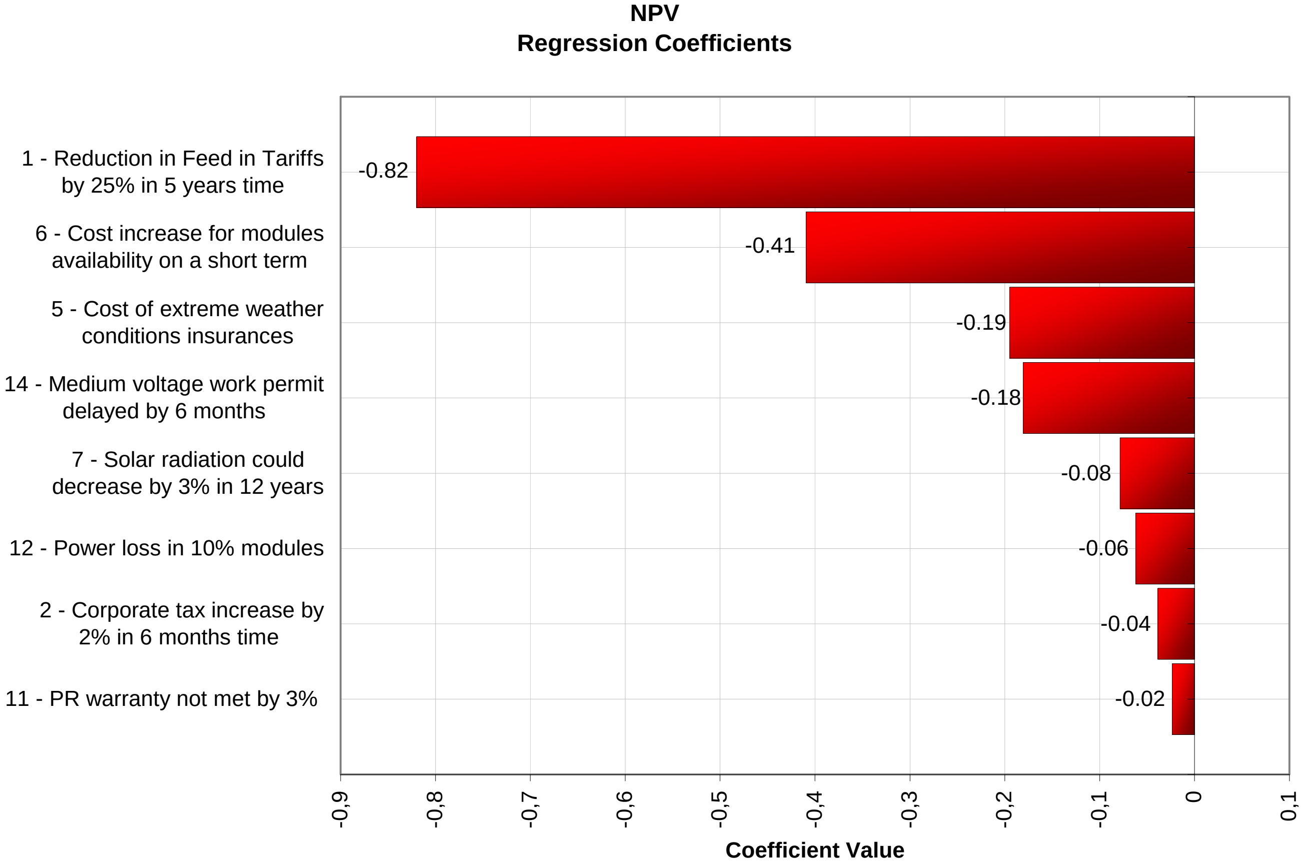
- Investigate the robustness of a study
- Identify what source of uncertainty weights more on the study's conclusions

The sensitivity analysis is automatically provided by most of the Monte Carlo simulation tools. It gives a tornado representation of the most correlated uncertainties to the results.
Thus, the tornado diagram highlights the variables on which efforts must be focused in order to change the spread or the values of the output. Attention must be paid to the fact that Coefficient Values lower that 0.5 have very limited impact on the result if taken individually. An understanding of the relative influence of risk factors helps in making Mitigation Plans for the control of project objectives (paragraph 4.4).

In figure 33 below is reported the sensitivity analysis of the Total Investment NPV created on the PV Case study (Annex 1). The greater uncertainty is regarding the possible reduction in Feed in Tariffs by 25% (risk no. 1). Other variables that impact greatly the Investment NPV is the cost increase for modules availability (risk no. 6).

[29] Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D. Saisana, M., and Tarantola, S., 2008, Global Sensitivity Analysis. The Primer, John Wiley & Sons

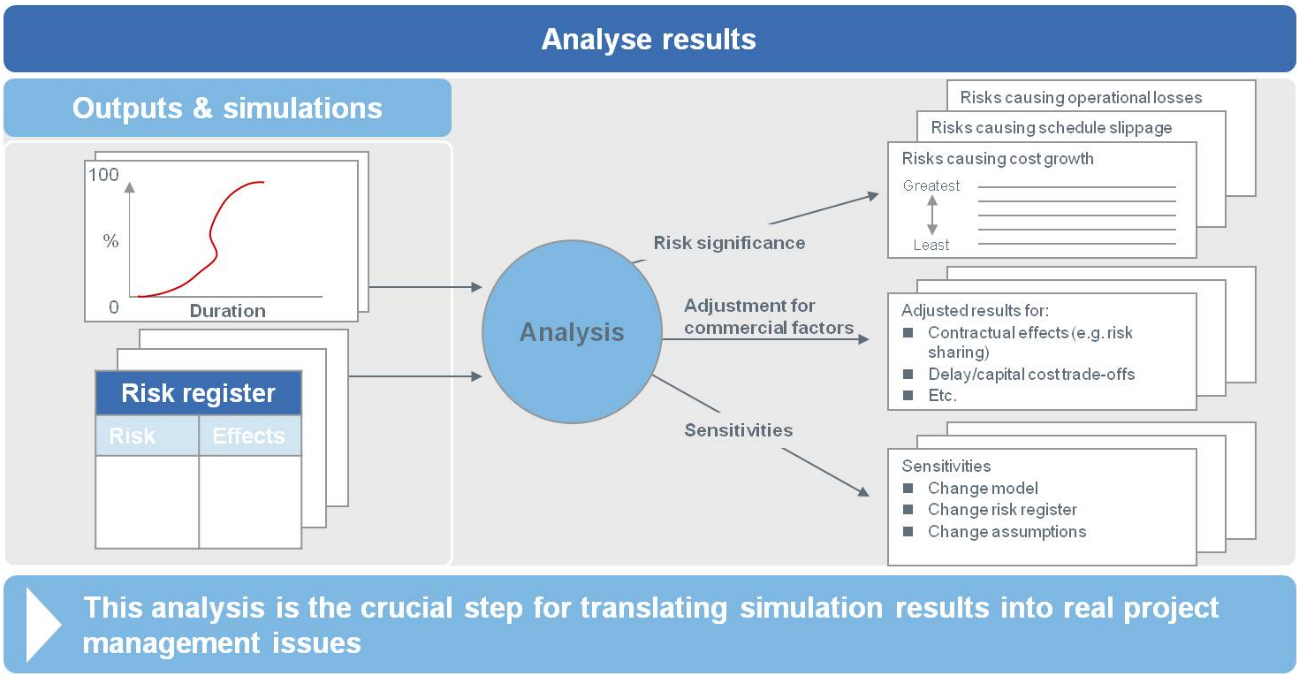
Figure 33 Example of tornado diagram (created on data of the PV Case study - Annex 1)



Interpreting the results from Monte Carlo simulation

Quantitative risk analysis results provide an overall picture of investment risk exposure and project NPV. It is then possible to provide decision-makers with a basis to discuss relevant project risks and management strategies that could be implemented (Figure 34). Illustrations of these different results are presented in the case studies in the Annex 1.

Figure 34 Quantitative analysis
The results of the simulation are analysed in order to fully understand risk significance and sensitivities.



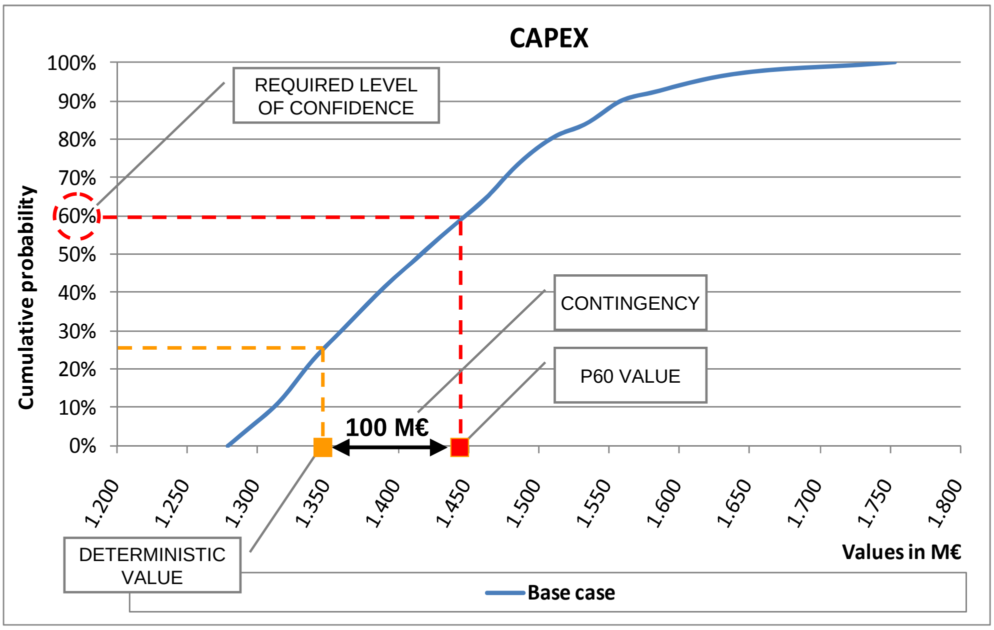
Quantitative risk analysis can also be used to provide important information on:

- Implications to payback time, IRR, CAPEX, OPEX, revenues, time among others;
- distribution of all possible output results, i.e. ranges between minimum – maximum values, most likely value;
- Measurement of the cost/benefit impact of a risk mitigation plan. By doing this, the investment sponsors can optimise their investment plan through the selection of the most efficient control actions;
- the most sensitive variables driving the output;
- level of confidence calculated for each single value in the distribution, i.e. P50 is the value at 50% confidence, or the value that has 50% chance to be unreached and 50% chance to be superseded.

The quantitative analysis also provides a method to determine the level of cost (CAPEX, OPEX) and schedule (float) contingency. This determination is carried out for the project sponsor who decides the capital allocation the Project Manager is authorized to spend. In this way the project manager receives a capital allocation which is expected to be required to complete the project within the level of confidence required by the Investor.

Corporations take different views of this expectation. In conventional energy, companies like Exxon allocate funds at the 50% probability (i.e. half of the time the project manager is expected to require more funds for completion). At BP the allocation has been at the mean of the probability curve (i.e. typically 55-60% probability). An example is given in the graph below for a 60% probability confidence level taken as a reference for contingencies calculation.

Figure 35 Example of Cumulative probability of the CAPEX and contingency calculation

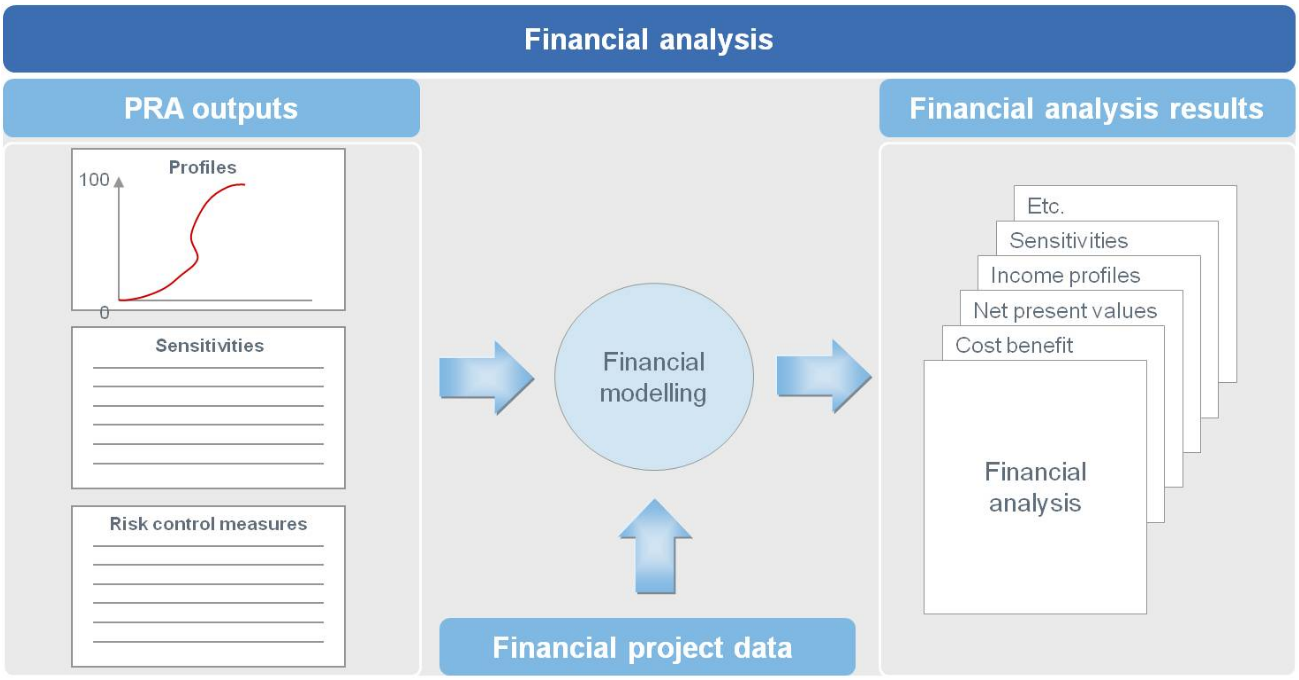


The above graph should be read as follows:

- The **Deterministic Value** represents the most likely target (1350 M€ on the above graph) for project cost (neither the best nor the worst case). As such it does not include any unplanned events (risks).
- The **Required Level of Confidence** is the acceptable level of risk that the investor would take (in the graph 60% also called **P60**). The economic value of that confidence level can be reported on the X axis (in that case 1450 M€).
- As a matter of fact the **Contingency** shall cover the gap between the most likely target (deterministic) and the requested level of risk acceptance (in this case P60). So the economic value of the contingency is calculated on the X axis (in our example 1450-1350=100M€).

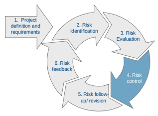
Quantitative risk analysis has in the past been reserved for multi-year, large, and/or complex projects in order to address all financial forecast in the most accurate manner, as illustrated in the Figure 36 below.

Figure 36 Financial modelling
Financial modelling enables the assessment of the full financial impact of key project decisions.



The quantitative approach is expected to become a best practice applied systematically on RES projects. However, resources to be allocated to probabilistic modelling should be adequate to each RES project according to the level of innovations involved, contractual complexity, project size, experience in the area of investment etc. The qualitative risk mapping provides a good indication of project global uncertainties and consequently on the level of detail which the quantitative analysis should be performed. Through the provision of detailed and structured financial data, the quantitative model can increase the confidence of investors and lenders.

4.4 Risk Control



Following risk identification and evaluation, the logical successive step is to propose / assess some control actions to minimise risk impacts to a reasonable level. This process is usually conducted by stakeholders following the risk identification and evaluation exercises, as shown below:

Figure 37 Risk mitigation workflow

Management intervention can apply at different stages in a project: Some are appropriate for the construction phase of a project; others apply to the management of risk in operating projects or abandonment when the plant is out of service.

Risk manageability
At any particular time of the investment life cycle, the risk management approach must address the extent to which risks are manageable. In the risk register, this control is qualified through the risk maturity categories presented in paragraph 4.2.4 above.

- Known (mature risks)
- Known unknowns (emergent risks)
- Unknown unknowns (latent risks)

The extent to which a company engages with latent and emerging risks is an indication of its ambitions to be a market leader or a follower.

Risk control strategies

Risk handling strategies should consider the probability and consequence of the risk and focus on the main risks evaluated through analysis as described in paragraph 4.3.1. All risk control strategies are documented in the risk register.

Generally, four different strategies are accepted in controlling risk issues: the first 3 strategies are pro-active, while the last is passive (Table 11). These are discussed in further detail in Chapter 5.

Table 11 Risk control strategies

Avoid	Change the project plan to eliminate the risk or to protect the project objectives (time, cost, scope, quality) from its impact. This can be achieved by modifying scope, adding contingency to the project plan either as additional time for critical path activities, or adding resources. Some threats that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.
Mitigate	Reduce the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk is often more effective than trying to repair the damage after the risk has occurred. Risk mitigation may take resources or time and hence may represent a trade off. However, the overall result may reduce risk to the overall project objectives
Transfer/Share	Shift the negative impact of a threat to a third party through: insurance, performance bonds, warranties, guarantees, incentive/disincentive clauses, A+B Contracts, provided the price for the risk transfer can be supported by project cash flow. Transference reduces the risk only if the person to whom the risk is transferred (such as the contractor) is better able to take steps to reduce the risk and does so. Risk transference nearly always involves payment of a risk premium to the party taking on the risk.
Acceptance	Adopted if is either not possible to eliminate that risk from a project or the cost in time or money of the response is not warranted by the potential impact of the risk. The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the threat or opportunity.

The relevance and desirability of any of these strategies depends on a number of factors such as:

- Risk severity (e.g. a critical safety issue tend to be avoided);
- Risk maturity (usually latent risk issues are candidates for risk transfer);
- Relative cost/benefits of different control strategies (e.g. subcontract to the most competent party, but only at reasonable cost).

Some recommendations / limits inherent to each control strategy implementation are described on the following pages.

Avoidance
Avoidance, as a risk handling strategy, is done by planning the project activities in such a way as to eliminate the potential threat. As such, avoidance should be considered the most desirable risk handling strategy. However, avoidance should be analysed for its cost/benefit to the project within the current funded boundaries of the project. The cost/benefit analysis should also take into consideration the impact on the overall project especially where avoidance involves the adoption of new or untried technology.

An example for RES projects would be to use a known material for construction, rather than an untested material that shows promise under the conditions that would be present, if the costs of the materials are within the range that is acceptable to the project and if the unknowns presented by the untested material present cost risks that outweigh the benefits.

As another example, to remove the uncertainty of whether or not human resources will be available for an action at a certain time, one may extend the contract and have the resources available and working on other efforts at the site. Thus, it is ensured that the resources will be available for the project but at substantial cost and with the potential for poor control of interface between separate activities.

Mitigation
Mitigation is a risk handling strategy that is taken to reduce the likelihood of occurrence and/or impact of an identified negative risk or threat, or to increase the likelihood of occurrence and/or benefit of an identified positive risk or opportunity. The goal of a mitigation risk handling strategy is to reduce the negative consequences to an acceptable level.

With regard to the introduction of RES technologies needing further development, the technology development plan should be linked directly with the risk management strategy. Deployment or implementation of a technology may introduce risk that requires specific risk management strategies. The mitigation strategy of the risk should be developed as a step-wise plan that can be included in the project baseline. The mitigation plan should be analysed to ensure that it is feasible, that resources are available and the costs of mitigation are less than the anticipated benefits.

Transfer/Share
Transferring risk often involves the purchase of an insurance contract whereby the risk is passed to the insurance company for payment of a premium. For the insurance to remain effective there will typically be a number of covenants which the insured must undertake and which could invalidate the cover if not implemented according to the insurer requirements. Several insurance packages are dedicated to RES projects development by large insurance companies.[30]
When risk has been transferred, the transfer of the risk should be reviewed to ensure it did not create other risks (for example default of the insurer, below mentioned as “secondary risk”). Therefore, as was done for the acceptance strategy, an analysis review should be conducted to fully understand inter-relationships.
The term “share” is associated with risks that present positive consequences. To share a risk is to allocate the ownership of the risk with one or more other parties. For instance, a risk could be shared between the investor and the contractor, between and among various projects, or a combination thereof.
As presented in Chapter 3, many conventional energy projects are developed through consortium, in order to mutualise risks that could not be insured. In general, the risk benefits should extend to the parties that shared the risk. Risk sharing is typically used to engage a stronger partner for the development (for example a better capitalized or technically stronger partner than the project sponsor) thereby making it more attractive for investors.

[30] Survey of Insurance Availability for Renewable Energy Projects (United Nations Environment Programme, Marsh, 2006)

Acceptance

Acceptance is not a pro-active, but a passive risk management strategy. The intentional choice to retain an identified risk can be taken only if it is felt that the project is best positioned to manage it effectively. Retention should not be a decision by the Project Manager alone but taken in consultation with corporate risk managers and their independent advisers.

Acceptance of the risk does not mean that the risk is ignored. The risk should be included in the cost and schedule contingency impact analysis. An example of a risk that might be accepted is the fact that there will be fewer bidders on a design-build request-for-proposal than might be desired, but that there will still be some competition. This is described as a “risk” but what it amounts to is a minor deviation from procedure. The risk is that inadequate competition leads to higher bid pricing or inadequate skill or capacity to deliver the scope offered. Having two bidders rather than four bidders is not a particularly strong management of these risks (there should be a qualification procedure for bidders to check resource or capability as well as a cost analysis to check the bid elements correspond to competitive market pricing).

Residual and Secondary Risk

Residual risk is what remains after the risk management strategy has been performed. The crucial requirement is that the risk should be reduced to “as low as reasonably practicable”; recognizing that the cost of further risk reduction may be excessive by comparison with the benefit associated. The Project Manager may choose to execute further Monte Carlo simulations beyond the overall schedule and cost runs. One common comparison is to rerun the model with and without specific risk management control measures. Also, the residual risk can be measured through the quantitative model to calculate the proper level of contingencies to be assigned to the investment.

Those residual risks for which no risk strategies are planned are accepted and should be clearly communicated to the team and management.

Secondary risk includes risks which are introduced as a result of implementing a risk management strategy. A secondary risk may often be able to be predicted and should also appear on the risk register. An example of a secondary risk might be deciding to insure against a particular outcome (e.g. construction all risks insurance) and then finding when a claim is made that the insurance does not respond (for example if the insurer has gone into liquidation).

Control Strategies Trough Risk Assessment Matrix

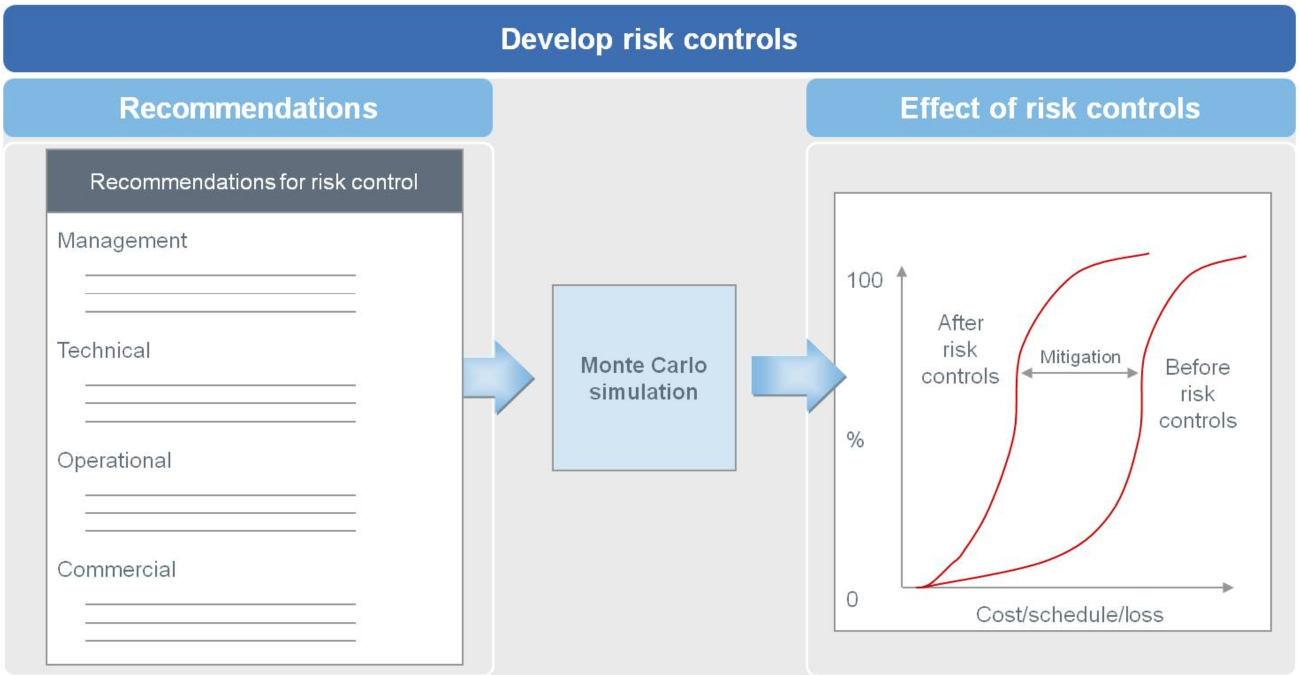
If a ranking matrix is used in project evaluation, gaps in the project risk management plan can be identified graphically. Response plans effects can be measured onto the matrix (see examples from cases studies in the Annex).

Control Strategy Cost / Benefit Analysis

The Project Manager may choose to execute further Monte Carlo simulations beyond the overall schedule and cost runs. These may include targeted runs pertaining to specific risks or key risks and their affects on various planned activities or the overall project.

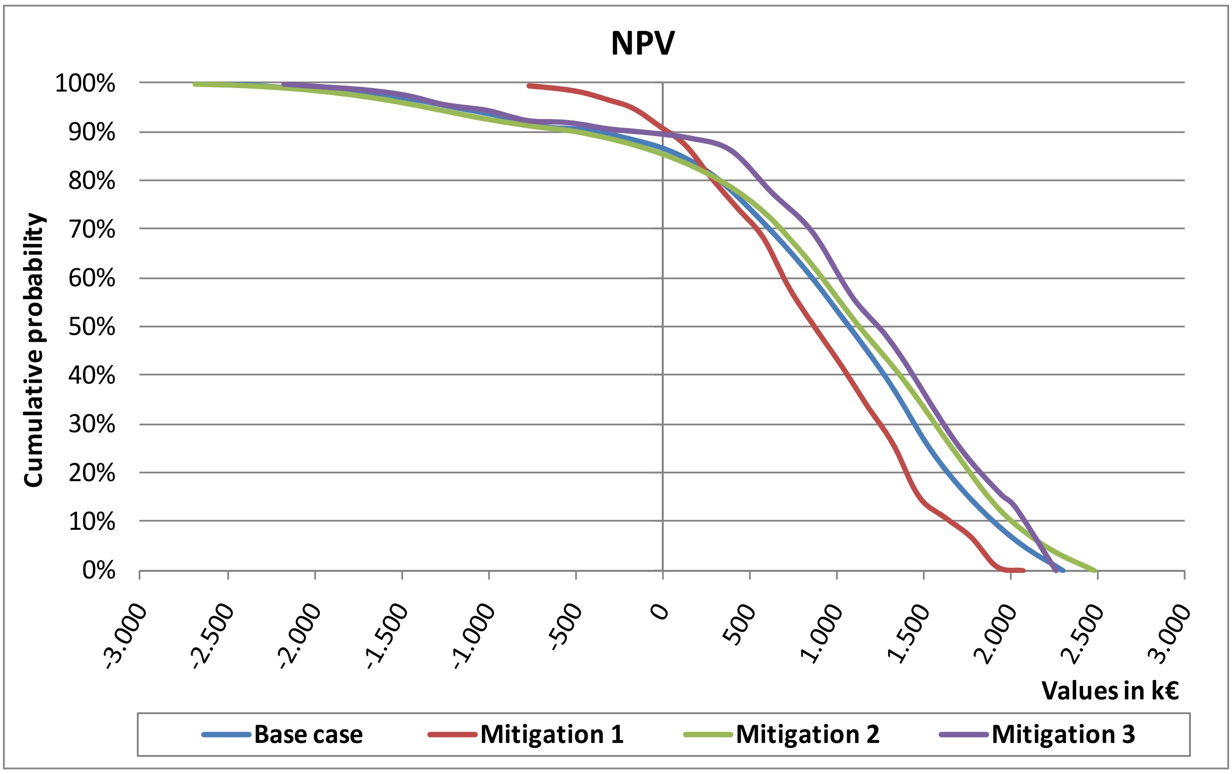
One common comparison is to rerun the model with and without specific risk management control measures.

Figure 38 Cost/benefit analysis
Recommendations are developed for risk control measures. The direct effect of these measures can be assessed by repeating the risk simulation.



As an illustration, several cost/benefit analyses were performed and explained in the case studies. The result from the example taken from the PV case study is shown below (details for this figure 39 are presented in the Annex 1).

Figure 39 Cumulative probability of the NPV of the project for the base case and after the implementation of the three control actions (taken separately). Example taken from the PV Case study – Annex 1.



Further probabilistic analyses can be undertaken in RES projects to measure:

- Risks within project, that managers can control as opposed to those outside his influence;
- Ability to meet key milestones in the project plan (probabilistic planning), especially when incentives / penalties schemes are provided on productions start-up;
- Key financial criteria such as breakeven or payback time (see case studies in appendix), giving higher visibility to the investors.

These simulations can be used to assess the efficiency of proposed control strategies over investment lifecycle.[31]

[31] Cleijne, H. and W. Ruijgrok, 2004: Modelling risks of renewable energy investments

4.5 Risk Follow-up

Risk follow-up involves three different objectives:

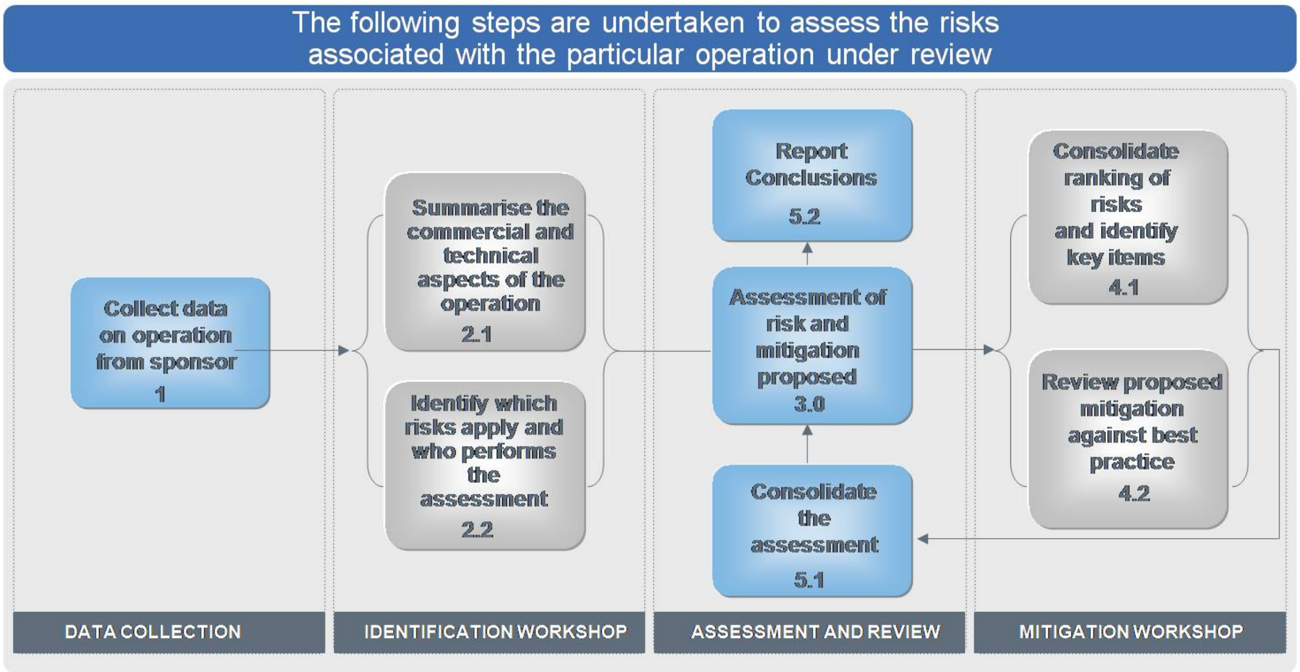
- Updating of the analyses according to investment environment evolution
- Monitoring of control actions plan
- Reporting towards investment stakeholders

Risk update

Risk management activities are iterative to account for project changes over time. Such evolutions, like changes in scope of the project, available resources, internal and external environments, technical advancements, regulation changes, can have significant impact on risk evaluation and related control strategies.

The following steps are undertaken to assess the risks associated with each project update:

Figure 40 Risk update workflow



Risk update provides information that can assist in identifying new risks or changes in the assumptions for risks captured previously on the risk register.

Risk monitoring

Once the project is commissioned and in service, some risks remain and require active risk monitoring, to ensure that the project is able to achieve its financial objectives over its life cycle. Risk monitoring involves the systematic, continuous tracking and evaluation of the effectiveness and appropriateness of the risk management strategy, techniques, and actions established within the risk management plan. The risk monitoring process should provide both information to decision-makers regarding the progress of the risks and risk management actions being tracked and evaluated.

If the risk was identified, the analysis should determine:

- If the risk is at the level that was originally predicted in the assumptions, or
- If the handling strategy or response was inadequate, or
- If the residual risk was greater than anticipated, or
- If the accepted risk was greater than what was anticipated

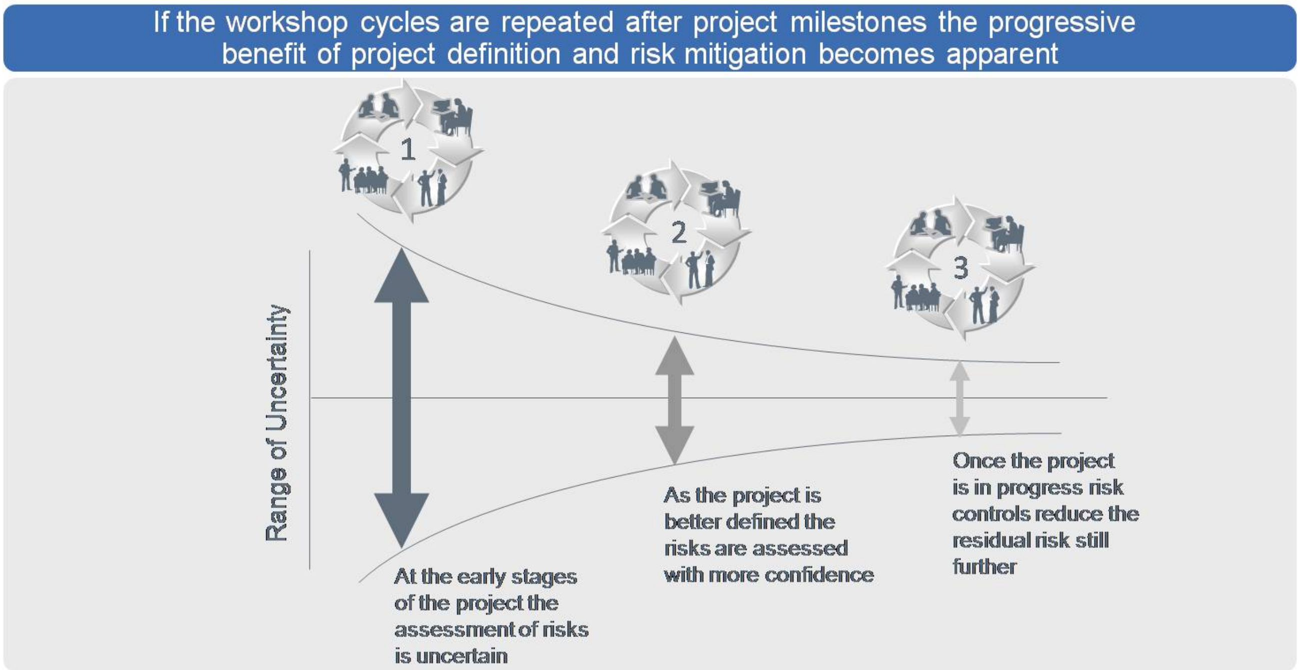
If the risk was not identified, explanations must be provided. Additionally, a retrospective analysis process may be needed to determine if the risk was hidden or latent due to other risks or perhaps other project factors.

These results should be used to initiate another risk identification process or, at the end of the project to build a lesson-learned study (as presented in the next Risk Feedback section 4.6).

Risk Reporting

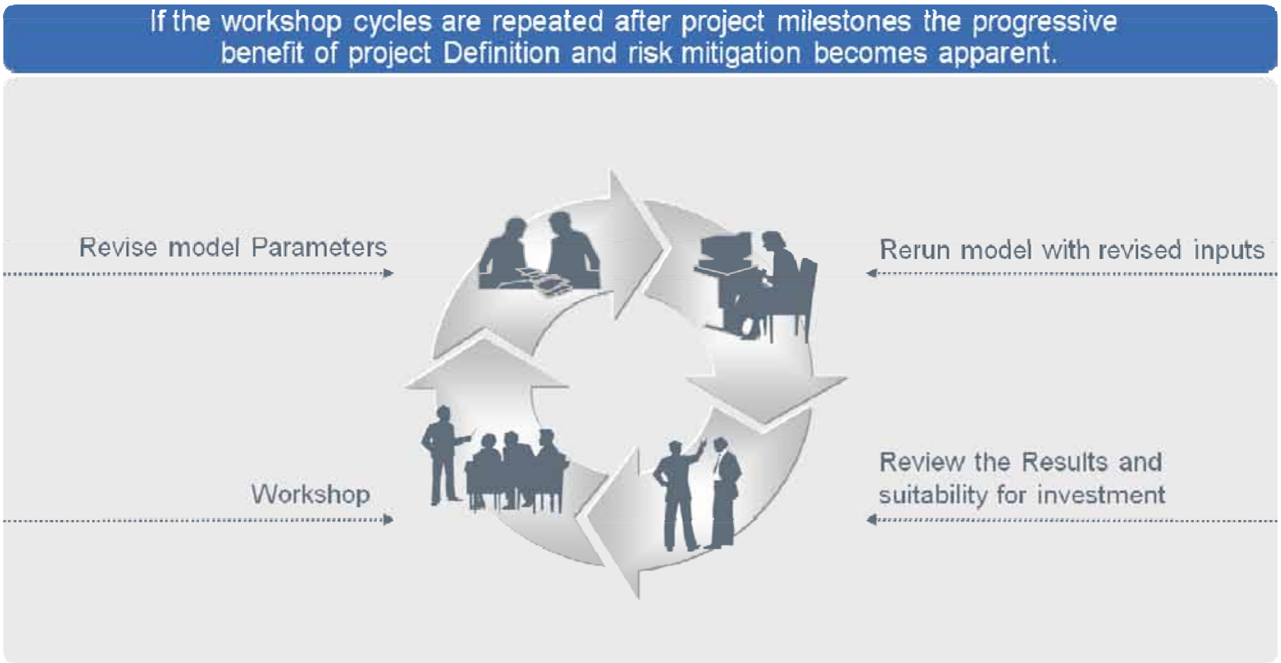
Reporting on implementation of risk control measures assigned through a risk register can be a formal process; however it is critical for investors and other project stakeholders' confidence. This will contribute to a better communication among RES project stakeholders, hopefully increasing common confidence.
In a well-run project the accuracy of the estimates should improve with successive iterations of the risk assessment as work is completed and more potential risks are effectively managed.

Figure 41 Risk management uses an iterative process to improve estimates accuracy



If the risk assessment process is repeated during the course of project implementation, the effect of risks is expected to decline as work is progressively completed and this narrows the remaining uncertainty as far as project parameters such as CAPEX and schedule are concerned, as shown in the above figure.
In Figure 42 the detailed cycle is described.

Figure 42 Workshop cycles for refining parameters



4.6 Risk Feedback

While the project is under way and some activities are completed, variance analysis can be undertaken to compare the forecast cost, duration, revenues of the activity to the outturn. This analysis is important part of the project closeout report.

The final investment outturn is used to update the Database used for risk management of the technical aspects of future projects such as CAPEX, OPEX, schedule and revenues. In this way lessons learned in one project provides feedback for future projects and embodies a continuous learning process. The requirements for feedback must be recognized and budgeted as early as possible in the project to ensure provision is made for passing on lessons learned.

Participants in the risk management process should understand the requirement to provide feedback throughout the investment or project cycle particularly whenever their perception of a risk materially changes.

Project feedback should be carried out in a formal or informal manner conforming to corporate control procedures. A project close-out report should be written to a prescribed format including full DCF and schedule analysis.

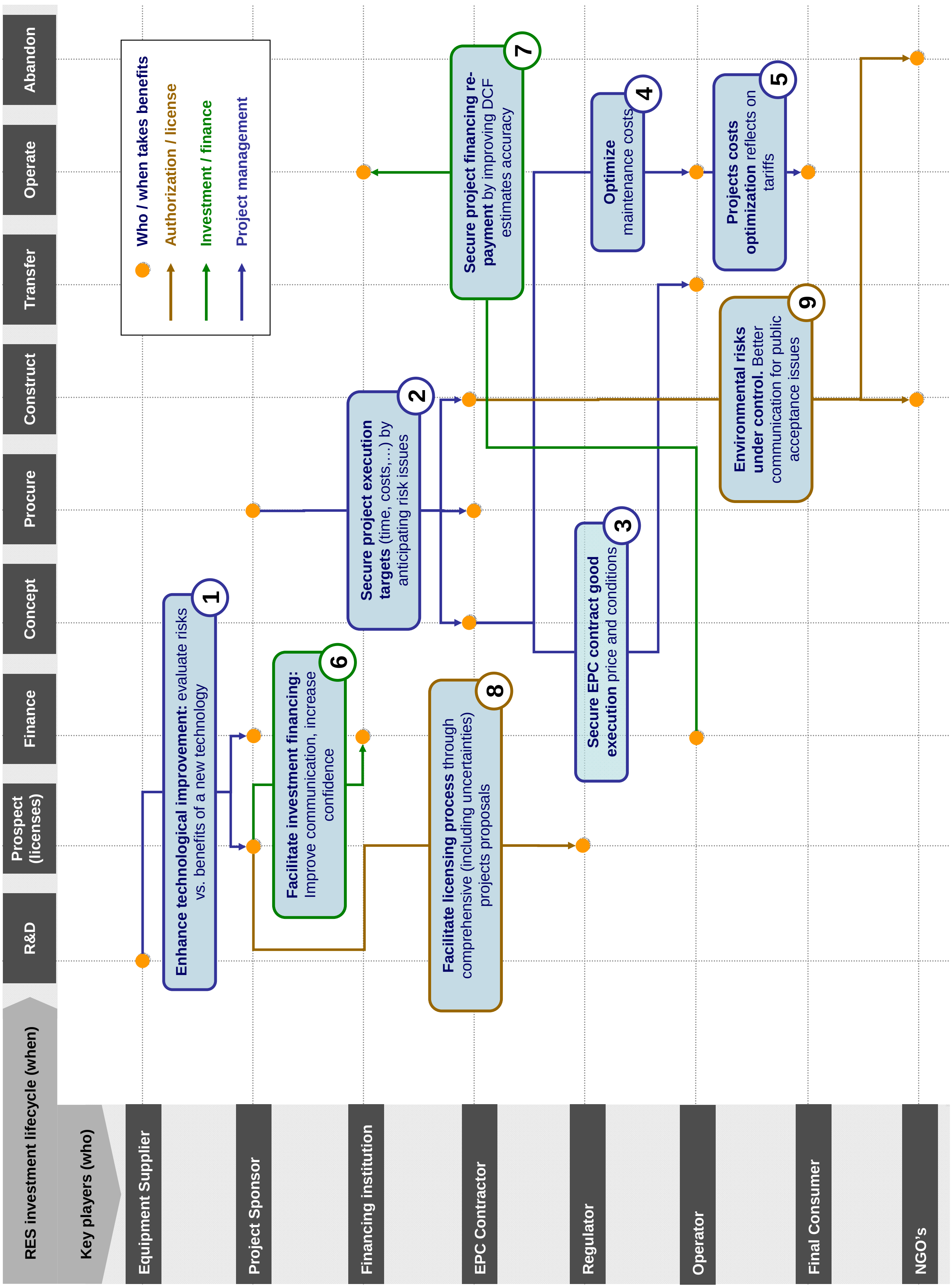
Data bases or other virtual repositories are suitable for project stakeholders in order to build up a corporate or sector memory. Where possible (bearing in mind the requirements of commercial confidentiality) information should be shared between companies working in related technical areas. As a preliminary recommendation at this stage, it is suggested that a dedicated risk database for RES industry be developed, in order to register various risk situations and the associated lessons learned.

4.7 Risk Management Implementation in RES investment lifecycle

Finally, the above risk management activities can be handled by different parties and at different stages of the investment life cycle. The following matrix interfaces RES investment lifecycle and associated stakeholders in order to identify where, when and how project risk management can creates value by:

- Closing the gap between the different parties involved
- Increasing visibility on investment decision
- Supporting investment to meet its targets

Figure 43 Project risk management implementation



Project Management

1. In R&D activities risk management can be used either for R&D activities planning and budgeting (for equipment supplier), or to assess potential benefits on futures investments (for project sponsors).
2. The most common application of project risk management is in supporting project management and contractors to secure their targets in project execution (in terms of budget, schedule and quality).
3. Project risk management support the whole contracting scheme of the project, from tender evaluation (evaluating the risk of each bid), to contractors management (pro active management of contractors failures).
4. By covering the whole investment life cycle, risk management anticipate reliability issues and help to optimize maintenance strategies accordingly.
5. If projects are executed with optimized budgeting and risk reduction strategies, the final customer shall see benefits in tariffs.

Finance

6. By performing risked DCF estimates, the project sponsor increases its chances to get financing with lower spread. The money lender will appreciate higher transparency and uncertainties analysis, as part of the estimates process.
7. Better investment estimates reduce the risk of credit default from the investors.

Authorization / license

8. Increasing visibility of the regulator on the risk supported by the industry, can help to promote adapted support measure.
9. Risk analyses are standard instruments to communicate towards local communities and groups of influence, to demonstrate the impact of a project and to determine balanced compensation schemes.

5 Definition and assessment of support measures

5.1 Introduction

The risk assessment and risk management methodology presented in Chapters 3 and 4 provide a consistent and effective means to understand risks. This chapter uses the results of this methodology to identify and assess innovative support measures which can be used to manage the risks and reduce financing costs.

Building on the generic options to control risks (Section 5.4), this chapter identifies and describes examples of specific instruments such as insurance, grants, incentives, public bonds among others that can be used to manage risks in renewable energy projects.

In each section, we then consider how these instruments and structures could address specific risk elements that create barriers for commercial financing; this includes guidance on how these measures can be incorporated into the methodology described in Section 5.

It is important to define what we mean by innovative measures to mitigate risk in renewable energy projects. Simplistically, an innovative measure to mitigate risk could be defined as follows:

An action, instrument or legal stipulation undertaken by a counterparty to a transaction, or a third party that may have a material influence on the transaction, which results in the avoidance, mitigation, (risk control) retention or transfer (risk transfer) of an identified risk

As such, this chapter considers measures where governments or other third parties act as counter parties to ensure delivery; this includes both non-financial and financial enablers. It does not consider the wider process of national or international policy design.

The next sections describe some of the key measures which can range from the more traditional to the innovative. These are organised by nature of the risk they are addressing. For each category, we discuss the when the measure could be deployed and the impact on the cash flow statement.

5.2 Measures to address political risks

For certain overseas projects and investments political risks may be of more concern than commercial risks. The availability of measures to address possible losses resulting from political action or inaction by the host government can have a major impact on the willingness of investors to participate in major investments in politically risky countries. In many cases, these risks can be characterised by discrete events and are therefore hard to control.

There are several types of measures that can be considered to address these risks:

Country CDS
Deployment of renewable energy projects typically enjoys government backed financial support schemes (e.g. investment subsidies, feed-in-tariffs, Government financial guarantees, preferential credit lines, tax incentives); the ability of the incumbent Government to honour their obligations under those schemes is therefore critical.

The risk of a Government “defaulting” in meeting their financial support obligations can be linked to the ability of the Government to serve the debt of its loans. Therefore the acquisition of Credit Default Swaps can be used to hedge this type of risk. CDS are contracts in which the buyer makes a series of payments to the protection seller. In exchange, the buyer receives a payoff if a loan or bond defaults.

Risk sharing schemes
When there is uncertainty about the stability of specific government backed financial support schemes, investment transactions can be hedged through risk sharing schemes between the “selling” and “buying” parties (i.e., between developers and investors, respectively). These schemes can include elements such as:

- Equity payment deferral by the investor for a percentage of the agreed price, subject to stability of the support scheme
- Bank Guarantees by the Developer that can be executed by the investor in case of a negative support scheme modification within an agreed period.

Price discount to cope with the increased risk to balance the risk/reward equation

Insurance
Political Risk insurance (PRI) can help a financial institution increase its available lending capacity for high-risk countries through the minimization of risk presented by existing loan exposures. By guaranteeing a future minimum value, risk finance instruments may be able to help convert political commitment (e.g. Renewable Obligation Certificates (ROCs)) into bankable instruments through which it will be possible to support the finance of renewable energy project construction.

Table 12 Measures to address political risks

Name of measure	Type of measure	Impact on financing costs	Risks managed by deployment of measure	Integration in risk management model: implications to cash flow/ profit & loss account
Country (CDS)	Avoid	→	Government defaulting in paying its subsidy commitments	These measures are designed to respond to *discrete* decision points where different outcomes to *revenue* can occur
Risk sharing schemes	Transfer	↓	Government modifying subsidy scheme during a given period.	
Political risk insurance	Transfer	↓	Reduction in government commitment to renewable energy and associated weakening of support mechanisms.	
Lobbying local government	Accept	→	Reduction in government commitment to renewable energy/ permit delays etc...	
Guarantee by the developer of an “income start date” after which the investors would receive “base case” income	Transfer	↓	Project delays related to permitting, transfer of licensing	These measures will manage risks to the schedule (based on triangular distribution)
Engagement with government and articulating economic impact of delays	Avoid	↑	Project delays related to permitting, transfer of licensing	These measures will manage risks to the schedule (based on triangular distribution)

5.3 Measures to address economic risks

There are a number of measures to address economic risks including JVs and other arrangements, insurance, guarantees, derivatives, risk transfer approaches.

Joint ventures and strategic agreements
There are therefore a number of organisational structures including Joint Ventures and/or strategic agreements which vary by the strength of the link between different organisations. These exist between different parties such as:

- Developer/EPC/investor/Utility: This agreement can ease the connection permitting process; it will also assist utilities enter into new business models. (Utilities are the best placed to navigate through permitting for electricity generation projects, connections etc, and at the same time, they are interested in finding "natural ways" to access attractive renewable energy projects and develop new business models based on distributed generation which could put them ahead of competition in this area).
- Module supplier/developer/EPC: This relationship can secure a long term order book for suppliers; at the same time it can ensure security of supply and lower prices for the developer/EPC and provide comfort to lenders.
- Developer/operator/investor: This relationship can provide comfort for the financing bank and investors.

While banks generally prefer to have one contractual partner in the form of an EPC or a developer to avoid internal disagreement etc, this is often not possible for large RES infrastructure project due to the reluctance of one party to be hold most of the risk. In practice, there are often multi-contracting arrangements – sometimes tied together through an "interface agreement" with the right on lenders to step-in.

Relationships can also include opportunities where public bodies play an active role within an investment and are supported by private contractor or partners. Examples of different public-private partnerships (PPP) include:

- Service Contracts: The private partner has to provide a clearly defined service to the public partner. (short term).
- Management Contracts: The private partner is responsible for core activities like operation and maintenance of the system (long term).
- Design, Build and Operate (DBO): The private contractor is responsible for the design, construction and operation (long term).

Insurance schemes
There are a number of special insurance schemes which address a number of business risks including:

- Loss of business due to force majeure
- Property damage
- Weather variability

There is an important role of government in supporting the development of Special Purpose Underwriting Vehicles focusing on the RES sector. As discussed earlier in the report, the inherent technology and project risks associated with renewable energy have to be characterised through a significant data collection/analysis effort. The public sector should play an important role in rating the risks in projects (especially those technologies with limited operational experience).

Guarantees

There are a number of different types of bank guarantees that may be considered. These include

- Secure plant operation/energy selling date is achieved by Developer/EPC supplier;
- Secure quality/time of permitting delivered with the project by Developer/EPC supplier;
- Ensure minimum performance of the plant under management by O&M Supplier;
- Insurance against fiscal contingencies of any type by developer (this is particularly relevant when the investment includes the acquisition of an SPV from the developers).

There are further guarantees which cover creditors (not equity investors) irrespective of the cause of default and there are a variety of structures and currencies available to choose from (*Partial Credit Guarantee)*. Governments can play an important role from loan guarantees and underwrite a proportion of the loans for a given project (possibly resulting in 1-2% reduction in interest rates and more favourable debt service conditions[32])

As specific issues emerge, there are new products available on market addressing specific issues such as:

- Carbon Delivery Guarantee. These guarantees can be used to address Certified Emission Reductions (CER) bankability. This is in response to the risk that CER's are not recognized as bankable revenue streams (i.e. able to support debt service obligations). This includes the political risk of CER delivery shortfall or failure due to host country political action (e.g. expropriation, nationalization, confiscation and prohibitions in connection with the sale of CERs).
- *Dismantling guarantee*. There are also guarantees across the entire lifecycle of a project; for instance measures ensuring a land owner can secure the return of land to original state at the end of plant life through dismantling guarantees.

There are areas where a guarantee is either not widely available or not “standardized”, and badly needed such as:

- Weather guarantees (whether irradiation/isolation, average wind speeds, etc); this can be a barrier for new entrants who can have an amplified sensitivity against the lack of control of those key elements (the “fuel for the plant”).
- Standard insurance against product guarantee default by the supplier in long term guarantee items such as PV modules (there are some developing insurance products in the market but, again, far from widely available or standardized).

Credit Risk and Credit Derivatives

Securities that offer protection against credit/default risk of bonds or loans. The evolution of products such as credit derivatives highlights investors and lenders concern with credit risk. This is largely conditioned by participants’ perception of the probability of default or downgrade. Examples of credit risk and derivatives include:

Credit Default Swaps (CDS) transfer the credit risk of an asset from one party to another. The holder/buyer of a credit instrument (often a bond) pays periodic fees to the seller of the swap. If there is a predefined “credit event” (default, bankruptcy, credit downgrade, etc) then the buyer receives an agreed payment.

First Default Basket Products protect against the first default of a basket of names. Pricing depends on individual default risks as well as on default correlations. These products are tailor made for clients and account for a marginal but growing share of the market.
Also *Weather derivatives* (e.g. Wind power derivative), *Synthetic Collateralized Debt Obligation (CDOs) Total-return swaps, and credit-spread put options*

[32] These figures are derived from the RETD (PID0810) : Policy instrument design to reduce financing costs in renewable energy technology projects

Financial Risk Management (Alternative Risk Transfer - ART)
These products, which blend elements of corporate finance and insurance, are designed to protect balance sheets from the financial repercussions of natural and man-made disasters. ART products are known informally as the derivatives of the insurance industry and a fair amount of attention has been given to the so-called convergence of the insurance and capital markets over the last few years. Examples include

- Blended covers - Typically a combination of traditional re/insurance product lines with other risk management products in a single aggregated policy. These are commonly arranged on a multi-year basis;
- Finite Risk Products - Re/insurance policy with an ultimate and aggregate limit of indemnity often with direct link between premium and claim amounts;
- Contingent Capital Structures (Synthetic Debt & Equity).

Alternative Securitisation structures
There are a number of securititization structures
- Collaterized debt obligations (CDO) where loans/bonds are securitized through income of the underlying assets;
- Insurance CDOs;
- Insurance Linked Securities.

Cash and payment management options
A range of cash management options are used within the structuring of transactions (e.g. a *cash sweep* where surplus cash is used to prepay debt and secure debt service). It can also be used to provide extra security for lenders, instead of paying it out to investors.

There are also measures associated with deferring payments. In particular deferring payment to EPC and/or component suppliers can allow for time for a given renewable energy technology to demonstrate performance.

Table 13 Measures to address economic risks

Name of measure	Type of measure	Impact on financing costs	Risks managed by deployment of measure	Integration in risk management model: implications to cash flow/ profit & loss account
JVs and other arrangements	Avoid	↓	Various risks depending on the risk appetites of the JV (Joint Venture) partners. These can include permitting processes, insecurity of supply, price instabilities or doubts on developer´s bankability	These measure try to limit either the negative impact in cash flow and IRR of: • income delays (long permitting or late supply) • higher investments (price increases) or difficulties in getting bank loans due to questionable developer bankability
Insurance	Transfer	↓	Construction delays, failures of counterparties. This can also cover loss of business due to weather, vandalism or force majeure in general,	These measures limit the worst case minimum income when affected by those events
Guarantees	Transfer	↓	Ability of EPC contractor (or other party) not able to deliver on time and on quality	Implications on *schedule* based on *uniform* distribution. Other guarantees can manage Opex (e.g. performance of turbines) or Capex
Derivatives and risk transfer approaches	Transfer	↓	Various risks depending on the focus of the derivative or risk transfer product. (credit risk, counterparty risk or regulatory risks likely in respect of economic factors)	OPEX to service financial commitments of the financial instruments. Continued balance sheet strength if an “event” happens which is covered by the agreement
Cash management options	Avoid	→	Risks (for the lender) of the project not servicing the debt obligations as a consequence of allocation of debt service cash to other purposes	Risks (for the lender) of the project not servicing the debt obligations as a consequence of allocation of debt service cash to other purposes

5.4 Measures to address social risks

While social risks are not as prominent as economic risks in a typical renewable energy project, these can include important issues which need to be addressed. Many of the measures to address these risks are captured as part of health safety, social and environmental, impact assessments.

Specific mitigation measures are then developed by subject matter experts into HSSE plan to tackle technology specific risks (e.g., incapability to switch off PV modules while there is sunlight and consequential electrical shock or electrical fire risks).

There are also a number of further measures to manage risks identified within the plan including liability insurance against damages to third parties (people or property), which can happen in Renewable Energy projects due to their, often, remote location and low level of man presence required for operations.

Table 14 Measures to address social risks

Name of measure	Type of measure	Impact on financing costs	Risks managed by deployment of measure	Integration in risk management model: implications to cash flow/ profit & loss account
Integrated impact assessment	Accept		Numerous safety, social, environmental and health risks	These impacts typically result in an increase in Opex or Capex. In the example of underlying resource availability, revenue can also be affected
Specific mitigation and monitoring measures identified through assessment	Avoid		There are numerous risks identified in an assessment ranging from biodiversity impact to theft of modules	This measure will manage risks to both Capex and Opex..
Stakeholder engagement	Avoid		local communities opposition	Avoidance of delay to schedule by pro-active engagement.

5.5 Measures to address technical risks

A number of the measures address technical risks overlap closely with economic risks. These include guarantees, warranties, insurance, as well as agreements or other organisational arrangements between key parties.

Product guarantees
Beyond the product guarantees backed up by first request bank guarantees, there are measures to cover potential default of the supplier to honour their guarantees (Product guarantee insurance). Government organisations play an important role in this area by underwriting all or a proportion of the debt of a project. This can reduce the risk if a project does perform or defaults.
Additionally Governments can help reduce the product failure risk by requiring the compliance with quality standards for a product to be qualified for utilization under specific subsidy schemes.

Guarantees can focus on overall plant performance from the EPC supplier to secure a minimum production figure or can include specific components. They include agreements under which parties with contractual obligations, in connection with construction or operation of a project, accept liability to the lenders for their performance.

Insurance
Insurance can provide financial protection from delays or damage during fabrication, transport, installation, construction and operational stages of the project.

Warranty Insurance offers significant scope for equipment manufacturers to “offload” future warranty liabilities and reduces balance sheet provisions. Other examples also include Construction Risk Insurance.

Organisational arrangements
As discussed in the economic risks review above, there are a number of different organisational arrangements which can manage technical risks. For instance, structures for working with organisations for local project management, EPC management and specialist service contracts.

Funding
Working through partnerships with private sector banks, the public sector can provide mezzanine finance to support technologies which do not have the necessary track record of performance (e.g. marine renewable energy). Governments can also increase the private sector leverage by avoiding non-repayable and poorly focused grants and using commercially-structured approaches.

Table 15 Measures to address technical risks

Name of measure	Type of measure	Impact on financing costs	Risks managed by deployment of measure	Integration in risk management model: implications to cash flow/ profit & loss account
Product guarantee insurance or First request bank guarantee by supplier	Mitigate / Transfer	↓	Higher failure rate of equipment	Increase in OPEX; reduction in revenues
Insurance (weather)	Mitigate	↓	Difficulty in accessing sites due to bad weather conditions.	Higher OPEX and reduction in revenue.
Service Level Agreements (Organisational Arrangements)	Mitigate	↓	Maintenance service company failure	Higher OPEX and compensation for service level failure
First request bank guarantee against minimum O&M Service level	Transfer	↓	Maintenance service company failure	Higher OPEX and compensation for service level failure

5.6 Generic interventions

Beyond specific support/mitigation measures to address specific impacts, there are a number of generic interventions which can address numerous impacts.

As discussed above, structuring of a given transaction plays a critical role in managing risk. This includes the role of different parties in mitigating risk (e.g. an infrastructure fund can take construction risk; MFIs can bring a political risk guarantees). It also includes the different points of entry/exit from a given transaction.

There is also an important role for 3rd party due diligence to verify technical and legal opinion e.g. production data or regulatory certainty. In some cases assessments on harder to quantify risks are important (e.g. track record of management team).

Governments are well positioned to play an active role in removing barriers to renewable energy projects. These include specific barriers such as *improving permitting procedures, and improving grid connection*. Public bodies can also provide *subsidies* particularly supporting demonstration and introduction of new technologies and provision of *low-interest loans. In the current absence of loan syndication markets for large projects, governments through (concepts such as Green Investment banks) can play a direct role in provision of capital. In many cases,* governments can play an important role when risks when projects are subdivided and they can then focus on a specific part of the project such as grid infrastructure.

Table 16 Generic interventions to address risks

Name of measure	Type of measure	Impact on financing costs	Risks managed by deployment of measure	Integration in risk management model: implications to cash flow/ profit & loss account
Loan Facilitation (funding)	Mitigate	↓	Purchase and securitising project finance loans or identifying mechanisms for credit enhancement of publicly traded bonds, would free up capital that is not flowing to the sector.	Stronger balance sheet through opening up opportunities for further private sector investment
Funding (Pari Pasu)	Mitigate	↓	General risks reducing confidence of private sector investments	

5.7 Conclusions and outstanding barriers

While this section has identified a number of risk management measures, a number of barriers remain including:

- Binary risks associated with the endurance of public sector support schemes (recent examples such as the scrutiny by the Spanish Government on opportunities to reduce the support for PV in Spain have reiterated concerns on this topic).
- Lack of confidence in emerging technologies from the infrastructure players.
- Lack of confidence in equipment manufacturers given their sometimes short track record. Permitting processes are too long and convoluted to accept. In many cases risk mitigation products cannot shorten the process.
- Lack of technical standards in a number of domains:
    - Building integration
    - System level ratings
    - Safety standards for system designs

6 Conclusions and recommendations

6.1 Conclusions

A number of developers, utilities, investors and others engaged through the workshop and Delphi process have welcomed the approach taken to risk management in this project. While many of the techniques and approaches will not be new to banks and others, there is a real need for key players to speak the same language. Once this has been achieved, it is possible to have a meaningful debate on what risks to accept, avoid and transfer. Finally, the approach will allow key players to have a realistic understanding of risks involved in renewable energy technologies and develop appropriate support measures (or avoid counterproductive measures).

At the same time the development of a structured and rigorous approach to risk assessment and management will allow parties such as smaller project promoters to engage effectively with potential investors; the use of the RBS will ensure that key risks are less likely to be overlooked; the use of probabilistic modelling allows a discussion of uncertainty - without creating a "black box" where the workings of the underlying model are not visible.

The overall objective of this project is to provide reproducible and transparent techniques to assess the risk/return profiles of renewable energy investments. This includes providing specific guidelines for renewable energy projects to support the classification, assessment and management of different risk elements. To meet this objective, we have looked at three underlying questions:

A. What are the best practices for risk management from mature industries (focusing on workshop based methodologies for information gathering)

B. What are the similarities and differences between conventional and RES projects?

C. What are the specific features of an adjusted risk management approach for RES projects?

D. What are recommendations for innovative support measures?

A. What are the best practices for risk management from mature industries (focusing on workshop based methodologies for information gathering?

Many approaches have been described for the analysis of risk in conventional energy projects typically paying attention to the analysis process (i.e. identify, assess, mitigate) or the particular technique employed (i.e. qualitative, quantitative, simulation). Whichever approach is adopted, there are several characteristics which form Best Practice.

1. The approach must clarify fully the context in which the analysis has been carried out. This means being explicit about the analysis terms of reference, the limitations on the scope of inquiry and areas of risk which were not considered (for whatever reason).

2. The approach should embody independent judgment from many perspectives of the various stakeholders associated with the project. We suggest this is best achieved using a workshop approach involving representatives of the many organisations interacting with the project to be analysed. Wherever possible the approach should avoid the analysis being subverted either to justify narrow expert opinion or serve vested interests.

3. Best practice for risk identification involves ensuring all key topics are considered, and lessons learnt from past projects are incorporated. In practice this process is improved by several activities:

- A Risk Breakdown Structure (RBS) with graphical tools is useful that it guides the team to achieve a full coverage of risks and not become preoccupied with one risk area; for instance technical experts may focus too much on the engineering aspects to the detriment of Political or Social concerns which can be as vital for project success.
- The use of a facilitated workshop draws on a broad set of experience. Through this approach experts, representing all stakeholders, are invited to go through a journey from brainstorming to eventually converge into a list of project risks.
- The use of previous “risk libraries” from the track record of relevant industries can also be used to assist in the identification process.

4. The approach used for the assessment of risk needs to embody adequate understanding of outcomes in previous related projects and the future context in which the project in question will be carried forward. This context must include market aspects affecting costs and supply of equipment needed, the political and social context in which the project is carried forward and financial factors affecting potential investors' views of the proposed scheme.

5. Risk appraisal is effectively conducted through a facilitated workshop where probability of occurrence, potential impact in the project and manageability of each of the risks are agreed. Risks are then plotted in a matrix where severity (probability X consequence) is plotted against manageability.

   In addition to inherent uncertainties involved, different experts/stakeholders will differ in their assessment of risks. These uncertainties can be combined in Monte Carlo-based simulations resulting in the production of a probability function of both budget and timeline of the project.

   The technique chosen for comparative assessment of the impact of the various risks must be clearly explained and understood by those undertaking the assessment. Complex models assembled by individuals and embodying simplifying assumptions or algorithms are all too easily dismissed as 'black boxes' with little or no notice paid to the findings by those in a position to implement risk management.

6. The risk analysis becomes more powerful when embodied in a formal corporate control procedure. This places a requirement for the analysis on the project promoter and allocates responsibility for action from the analysis findings within the framework of corporate authority (in particular authority for expenditure). The aim is to ensure adequate contingency is provided for all risks before the project is implemented (as well as financial and project aspects such as cost and schedule this should also cover environmental liability, all aspects of safety and corporate reputation for situations with catastrophic potential).

   This can happen through the sequential project stages (e.g. Appraise- Select- Define-Execute-Operate) with incremental amount of investment/risk in each subsequent phase. The phases are separated by “gates” whereby permission and financing is sought to proceed to the following stage. Each gate involves a panel peer review based on a workshop where project teams present progress of the project which is compared against a number of pre-agreed gate approval conditions.

   Following the assessment, the decision has to be made on the management strategy for each risk. That is typically done through the following best practices:

- Risk management plan includes specific objectives, resources, timeline, accountability and reporting indicators and frequency. In the project reports and project peer reviews, progress against the plan and related decisions are presented, discussed and decided. The risk management plan might be supported by contingency analysis workshops where experts review the potential scenarios that can develop and the requirements for alternative plans.
- Allocation of a contingency budget to the project which is either allocated to the project manager or to a project sponsor to whom the project manager needs to justify the need of its use, should it become necessary.
- Modification of the deterministic duration and declaration of a P50-P80 date for project completion.

7. At the end of a given project, the project risk plan is compared against the actual project journey and results. From this review, lessons learned are extracted and incorporated into the risk library to enrich future risk management exercises.

While there are some differences between conventional energy projects and renewable energy projects, it is possible to transfer the best practices identified above.

B. What are the similarities and differences between conventional and RES projects?

While the risk footprint of RES projects shares a lot of common ground with more "standard projects", such as conventional energy or infrastructure projects, it also includes some specific threats, randomness and complexities that need to be addressed:

1. Compared to conventional energy projects, RES projects rely on long-term subsidy scheme frameworks put in place by governments. As a result they are much more sensitive to public policy and its implementation.

2. Many technologies are subject to pinch points in supply-demand. The sector as a whole is growing very rapidly; at the same time there are "tactical" demand restrictions at the time of policy review periods. This results in cyclical oversupply followed by supply shortage periods affecting product availability and price. For some technologies the supply chains are still in early stage of development with RES competing against established industries (e.g. both the oil & gas industry and offshore wind markets have competed for construction vessels)

3. Compared to other infrastructure projects, RES technologies (with the exception of biomass and biofuels) have relatively low O&M costs compared to up-front investments.

4. RES Technologies such as PV, wind, and wave technologies are dependent on weather patterns which create uncertainty to projects; while significant effort is often spent to understand wind speeds, irradiation, precipitation, etc., uncertainty remains.

5. There are complex permitting processes involving a multiplicity of interfaces. This includes administrations at different levels and for different matters (e.g. planning, environmental permits, subsidy permits, and grid connections.

6. Compared to traditional energy projects, the evolution of RES product lines and technologies is much quicker. It is therefore much more vital to appraise new product options.

7. There are challenges with investing in less mature technologies where technical standards have not been developed. For example there are many demonstration RES projects; these follow a very different logic compared to commercial projects in that the performance is more important than build time and hence delay might be acceptable.

8. Technologies such as wind, PV are much more "modular" than other types of projects. Where grid connection and other enabling construction costs are lower (e.g. PV), the investment critical mass lower and capability for plant growth is higher.

9. Renewable energy technologies can have specific issues associated with dispatchability. This applies to technologies such as wave, wind or PV, but not to tidal or biomass/biofuels. Given the incapacity to store and/or forecast energy generated with the same accuracy as other conventional generation technologies, renewable energies are often much more sensitive to the supply-demand balance in the grid; "priority" schemes put in place by regulatory bodies to decide which plant goes first in case of grid oversupply can also have a significant impact.

10. All RES projects are based on a distributed generation model (as opposed to the traditional energy centralized generation model). This makes the operational model of utilities much more complex than with conventional generation. Furthermore some conventional utility companies are reluctant to embrace distributed generation-related business models.

11. In many cases, RES projects can be land intensive and visible. This can include the land-used for PV or onshore wind projects or the land required to grow feedstock. The land required can often be in rural or remote locations, where industrial activity has not occurred in the past.

As result of these specific aspects of RES projects, unlike most conventional energy projects, there is an absence of a standard approach to risk rating and risk management for RES projects. This prevents a more consistent and quicker proliferation of these types of projects.

C. What are the specific features of an adjusted risk management approach for RES projects?

Risk management methodologies can (and should) be the same between RES and conventional energy projects. The key is to be able to tailor the complexity of the risk analysis and associated management processes to the size and nature of the projects. A key requirement is to avoid "oversizing" risk assessment and to avoid introducing low value complexity.

In particular, any RES project risk management approach should structure and apply a conscious approach to risk identification, risk appraisal, risk handling and risk review. In the simplest projects, this could be conducted through a management team discussion on each topic. As projects become more complex, the structuring of facilitated workshops (using independent experts) with additional sophistication in analysis tools (such as Monte Carlo based simulations) is important.

RES technologies often involve smaller projects compared to standard infrastructure projects given their modularity. As a result the balance of analysis vs. judgement has to be adjusted slightly towards judgement. Therefore workshop approaches for risk assessment and management are particularly important for RES projects: judgement is typically of a much better quality when done by a group or by a manager after having been through a workshop where the particular item is discussed.

The ideal standard approach to risk appraisal and risk management of RES projects through a workshop approach would ideally fulfil the expectations of a number of customers with different but complementary interests:

- Developers and investors require an effective investment evaluation and management tool.
- Banks (and the lending community in general) require a standard way to rate the debt service capacity of a project and its sensitivity to its main driving factors expressed in terms comparable with more standard projects.
- Governments require a tool that allows them to back those projects with maximum chances of success and more prone to generate "multiplication effects" for their policies.

Considering the similarities and differences discussed above, there are a number of specific aspects which need to be considered within the risk assessments of RES projects:

- **the technical risks involved in the particular technology**: risk assessment methodologies will need to cover management of risk in the R&D phase as well as project realization;
- **long term taxpayer support for the financial position of the RES project**: the assessment needs to be strong on its treatment of political risk to develop a thorough treatment of the financial position of the project in the face of policy changes;

- **limited sources for finance given the smaller size of projects and limited commercial background of sponsors:** Project finance and its associated fee structure require projects to be sufficiently large to support the fees with sufficient cash flow. Venture capital could absorb the higher risk but requires higher returns which are not compatible with tax payer subsidised schemes;
- **large land take typically required**: the analysis needs an adequate treatment of the social objections to projects and the local opposition they can provoke;
- **market factors in the procurement of main items of equipment**: RES projects are dependent on taxpayer support, so when support schemes are enacted, the demand for specific equipment e.g. turbines can outstrip supply leading to supply demand constraints affecting equipment price and delivery schedule.

6.2 Recommendations for innovative support measures

As discussed above, the absence of a standard approach to risk rating and risk management for RES projects prevents a more consistent and quicker proliferation of these types of projects. The ideal standard approach to risk appraisal and risk management of RES would ideally fulfil the expectations of a number of customers with different, but complementary interest elements in the field:

- Developers and investors, by providing them with an effective investment evaluation and management tool.
- Banks and the lending community in general, who would be looking for a standard way to rate the debt service capacity of a project and its sensitivity to its main driving factors expressed in terms comparable with more standard projects.
- Governments who would be interested in a tool that allows them to back those projects with maximum chances of success and more prone to generate "multiplication effects" for their policies.

Through the paper, we have analysed the specific risks of RES projects and have identified an effective way of appraising and managing them along the project life cycle. From this exercise, the following recommendation can be extracted to address the needs of the key actors:

A. Recommendations for the public sector

- Sponsor the development of international technical standards (and competent bodies charged with the application of those standards) for system quality assurance, system rating, design safety for the RES technologies which will permit discriminating (and “labelling”) “good” projects, hence reducing the technical uncertainty faced today by lenders, investors and developers.
- Sponsor the development of a risk rating process standard for RES projects (such as the one proposed in this report) and facilitate the access to reasonable cost of debt by backing up developers and investors guarantees in front of lenders, when a project complies with subject standard.
- Simplify the subsidy and permitting application processes by critically analyzing current process through evaluating value based on “lean thinking” principles.
- Sponsor the development of specific financial and insurance products such as RES specific bank guarantees and insurances which covers the situations highlighted above.

B. Recommendations for developers and investors:

- Include a systematic approach to risk management that uses a meaningful RBS (such as the one proposed in this report) and risk management plan.
- Explore the development of strategic alliances with complementary players in the value chain such as component suppliers, EPC companies, utilities and financial institutions to create risk resilient consortiums then hedging the significant risks associated to the disconnection across value chain steps (look for association with other developers to get to critical mass consortiums with more appeal for other players in the value chain).

- Liaise with Government bodies and lenders from the very early stages of the projects so as to create a critical mass of interest and receive valuable early feedback to be used to improve the risk management planning.
- Explore the use of bank guarantees and/or insurances to secure the ability of EPC and component suppliers to honour their contractual quality and service obligations.
- Use payment deferrals linked to demonstration of performance in their EPC contracts
- Consider country risk hedging using the instruments highlighted above.

C. Recommendations for lenders

- Embrace and/or require developers to use a systematic approach to project risk appraisal and risk management based on the methodology developed in this report.
- Explore the development of risk rating standards for renewable energy projects based on the approach proposed in this report. This should provide room to capture all the randomness dimensions of RES, through the use of Monte Carlo simulation techniques.
- Develop a palette of RES specific standard financial guarantee products to tackle the issues highlighted in the report. These would allow bank guarantees to hedge key risks and therefore better serving the increasing demands of developers/investors.

D. General recommendations

Beyond these actions for specific stakeholders, there are a number of general opportunities which should be considered.

There are further opportunities to develop and refine the methodology developed in this project including:

- The methodology can be enhanced through the preparation of further case-studies of other renewable energy technologies such as biomass.
- The approach has illustrated how mitigation measures can be integrated into the assessment. Additional work could take this further and demonstrate how *all* types of mitigation measures can be modelled.
- There are opportunities to develop further approaches to consider and integrate causal linkages between different elements into the methodology.

It is important to continue to engage with key players on the methodology and its potential. This could include:

- Facilitate further project level workshops where key parties sit together.
- Embed the methodology rapidly into the public sector investment decisions (e.g. demonstration projects).
- Disseminate the methodology among RES professionals through articles, participation in conferences and virtual communities.

Capturing information on key risks associated with RES projects through reviews of assessments will ensure critical lessons are learnt. Key actions could include:

- Develop a database to capture key risks identified and those that occurred in practice.
- Conduct further detailed assessments of mitigation measures using the model.

7 List of Figures and Tables

Figures

Tables

8 References

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9 Annexes

Annex 1 Case Studies and Feedback from REN Players

Appendix 1a: Photovoltaic Project (PV) Case study

The first workshop trialled the risk assessment methodology developed by Altran & ADL on a realistic solar energy project. The aim of this session was to involve PV investment experts to demonstrate and then to refine it by following their feedback.

The workshop took place in Madrid on the 8th April 2010 and involved a cross section of key project players: project sponsors, banks, PV panel producers, project managers, technical experts. In a structured brainstorming session (using our RBS) the workshop participants collectively identified key risks.

Table 17 Workshop participants

Organization
Deutsche Bank
PV Actionable Value/Lux Energia Solar/BP Solar
Altran (Spain)
BP Solar
IDAE (partially)
Lux Energia Solar
Sunpower
Naturener Solar
Abengoa Solar
Altran (NL)
ADL (UK)
Altran (Italy)

Step 1: Project Definition and Requirements

The first session of the workshop involved sharing the main characteristics of the project.

Table 18 Main characteristics of the PV Case Study

Plant name and size (MWp):	Sevilla - 2,930 MWp
Total Investment	€ 12,013,000 (4.14€/Wp)
Location:	Sevilla, Spain
Short description of site:	• Agricultural terrain • Land lease
Radiation /Production:	
- Irradiance Level:	Global horizontal irradiation: 2,032 kWh/m2
- Specific Yield:	1,585 kWh/kWp (1st year)
PR Warranty:	75%
Authorisations	• Permit to build from Town Hall confirmed. • Permit to build from the Regional Authority confirmed • Permit for evacuation of electricity from Utility confirmed (Connection Point) • Permit to build Medium Voltage Line (MVL) in progress • FiT (Feed in Tariff) assigned
Utility:	Endesa
Construction, O&M	BP Solar
Timing:	Expected start of works: Nov, 2009 Execution time: 8 months (Aprox.)
Technical components	
Module:	BP 4175 Monocrystalline, 175 Wp Certified according to IEC 61730 (replaces IEC61215 and TÜV Class II)
Inverter:	SMA, SIEMENS or INGETEAM.
System (fixed/tracker):	Fixed Structure
Structures	Galvanised steel structures
Operations & Maintenance Cost	€ 29,000/MWp*yr
Land Lease Cost:	€ 8,300/ MWp*yr
Security Service:	€ 4,500/ MWp*yr
Insurance:	€ 7,300/MWp*yr (Aprox.)

Step 2: Risk Identification

In a structured brainstorming session (using our RBS) the workshop participants collectively identified key risks.

This process of risk Identification was informed by the Risk Breakdown Structure (RBS) developed by the project. This also allowed risks to be classified according to the PEST structure (Political, Economic, Social and Technological) and divided in:

- Mature: risks which are defined but not necessarily controlled;
- Emergent: risks which are of growing attention who's impact is being researched;
- Latent: risks for which there is awareness but unclear implications.

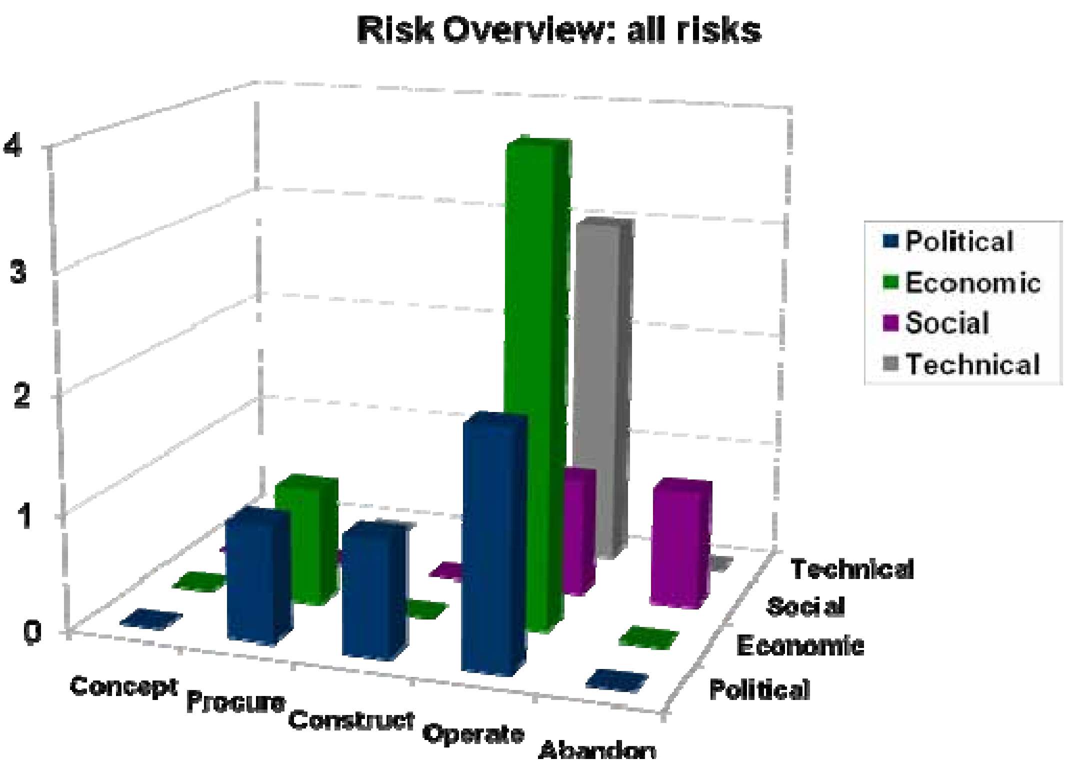
The fourteen risks identified are presented below:

Table 19 List of the risks identified during the workshop
P=Political, E=Economic, S=Social, T=Technical.

			In which phase(s) does the risk cause concern?					
Nb.	**Category***	**Risk**	**Concept**	**Procure**	**Construct**	**Operate**	**Abandon**	**Risk Phase**
1	P	Reduction in Feed in Tariffs by 25% in 5 years time				x		Emergent
2	P	VAT increase by 2% in 6 months time		x	x			Mature
3	P	Delay of 6 months in transferring licensing from SPV to the operator				x		Emergent
4	E	Additional guarantees to limit cash distribution				x		Emergent
5	E	Cost of extreme weather conditions insurances				x		Latent
6	E	Cost increase for modules availability on a short term		x				Mature
7	E	Solar radiation could decrease by 3% in 12 years				x		Latent
8	E	Ability to enforce guarantee of key suppliers (replacing 10% of the modules)				x		Latent
9	S	Regulation for recycling/decommissioning of plant						Mature
10	S	Modules theft leads to insurance and security cost increase				x		Mature
11	T	PR (Productivity Rate) warranty from the panels manufacturer not met by 3%				x		Latent
12	T	Power loss in 10% modules				x		Latent
13	T	Maintenance service company failure, leads to maintenance late re negotiation				x		Latent
14	T	Medium voltage work permit delayed by 6 months			x			Mature

The coverage of the risks, according to project phase and risk class (PEST), was done through the analysis of the graph below. The workshop participants did not highlight any risks in the Concept phase because the project has already been financed. Most of the risks (ten out of fourteen) have an impact on the Operation phase and only one has an impact on the Construction and Abandon phases. From the technical point of view all the risk are related to the maintenance and the loss of efficiency of the modules; no technical risks are related to the construction of the PV plant, since the technology is well proven.

Figure 44 Graphical representation of the risk coverage



Step 3: Risk Evaluation

Each risk identified in the previous step, was characterised in terms of probability and impact individually by workshop participants. The result is the Risk Register, describing the risk and its impact on CAPEX, OPEX, revenues, schedule etc. The impact of the risks is represented as an “Absolute” value (e.g. additional €, days) or as a “Percentage” (e.g. Risk 1 has a minimum impact that is 20% of the Revenues).
The Risk Level (Low, Medium, High) is measured on the qualitative risk matrix presented in the chapter 4.3.1 Qualitative Risk Evaluation, through each risk probability and maximum impact.

Results are presented in the following chart.

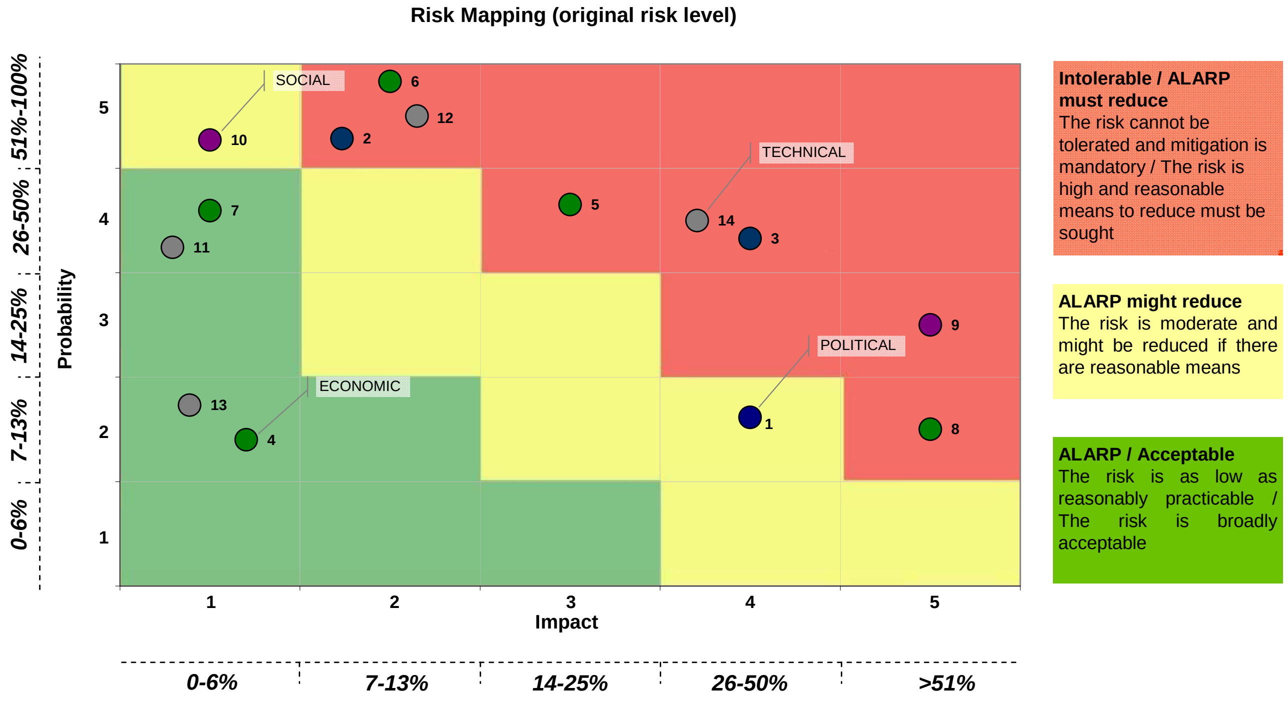
Table 20 Risk Register

						IMPACT			
Nb.	**Risk**	**Probability**	**Affects**	**Distribution**	**Absolute/ Percentage**	**MIN**	**MOST LIKELY**	**MAX**	**Risk Level**
1	Reduction in Feed in Tariffs by 25% in 5 years time	10%	Revenue	Triangular	Percentage	20%	25%	30%	**M**
2	VAT increase by 2% in 6 months time	90%	Tax	Discrete	Percentage		11%		**H**
3	Delay of 6 months in transferring licensing from SPV to the operator	25%	Schedule	Triangular	Absolute	120 days	180 days	210 days	**H**
4	Additional guarantees to limit cash distribution	10%	Revenue	Uniform	Percentage	2%		5%	**L**
5	Cost of extreme weather conditions insurances	30%	OPEX	Discrete	Absolute		50.000€		**H**
6	Cost increase for modules availability on a short term	50%	CAPEX	Uniform	Percentage	5%		10%	**H**
7	Solar radiation could decrease by 3% in 12 years	30%	Revenue	Discrete	Percentage		3%		**L**
8	Ability to enforce guarantee of key suppliers (replacing 10% of the modules)	10%	OPEX	Discrete	Absolute		500.000€		**H**
9	Regulation for recycling/decommissioning of plant	20%	OPEX	Discrete	Absolute		1.000.000€		**H**
10	Modules theft leads to insurance and security cost increase	50%	OPEX	Uniform	Percentage	1%		2%	**M**
11	PR warranty not met by 3%	25%	Revenue	Triangular	Percentage	1%	3%	5%	**L**

Nb.	Risk	Probability	Affects	Distribution	Absolute/ Percentage	IMPACT MIN	IMPACT MOST LIKELY	IMPACT MAX	Risk Level
12	Power loss in 10% modules	50%	Revenue	Discrete	Percentage		10%		H
13	Maintenance service company failure, leads to maintenance late re negotiation	10%	OPEX	Uniform	Percentage	0%		5%	L
14	Medium voltage work permit delayed by 6 months	30%	Schedule	Triangular	Absolute	150 days	180 days	210 days	H

The risks are mapped according to probability, impact and category (Political, Economic, Social, and Technical).

Figure 45 Risk Mapping (ALARP stands for "as low as reasonably practicable")



The most critical issues are either economic (e.g. possible increase both in the cost of insurance for extreme weather conditions and for the PV modules), or political (e.g. delays for the licensing and the probable increase in the corporate tax). From the technical perspective, the brainstorm participants highlighted the potential reduction of the performance of the modules and the delay in the medium voltage works (because of delays in the licensing) as critical issues.

Following the workshop, the risks were quantitatively assessed in relation to the relevant element of the DCF by the project team.

Furthermore two types of correlation were considered within the model:

- Correlation among different risks, in order to reflect the dependency of one risk to another one (e.g. Risk 8 could happen only if Risk 12 happens)
- Correlation among the same risk in different years, in order to consider that some risk will have the same impact on the project life cycle (e.g. risks numbers. 1, 2, 5, 7, 11)

The cumulative distribution of the NPV of the project (calculated with a cost of capital of 6.6%) is reported in the graph below. The probability that the project will be profitable (NPV>0) is around 86%, but the spread among the minimum NPV (-2500 k€) and the maximum one (2300 k€) is very high. The gap between the P90 (NPV at 90% of confidence) and the maximum is high due to some risks with a low probability of occurrence but significant impact (jeopardizing the project profitability). The main risks with these characteristics are Risk 1 (Reduction in Feed in Tariffs by 25% in 5 years time) and Risk 4 (Additional guarantees to limit cash distribution), both with an impact on the revenues. Through the analysis of the cumulative revenues curve, it is clear that there are risks with limited probability (less than 15%) that can reduce the revenues of the overall project from 42 M€ to less than 35 M€ (-16%).

Figure 46 Cumulative probability of the Net Present Value of the project (calculated with a cost of capital of 6,6%)

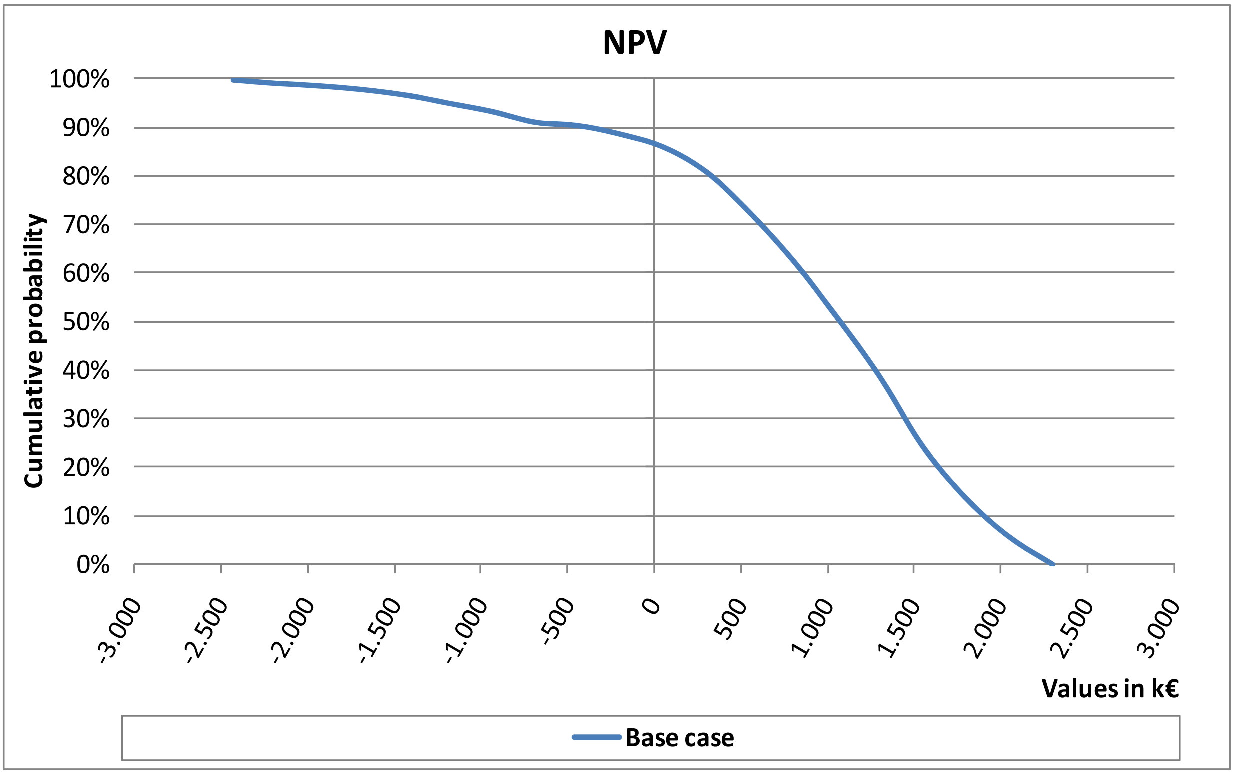
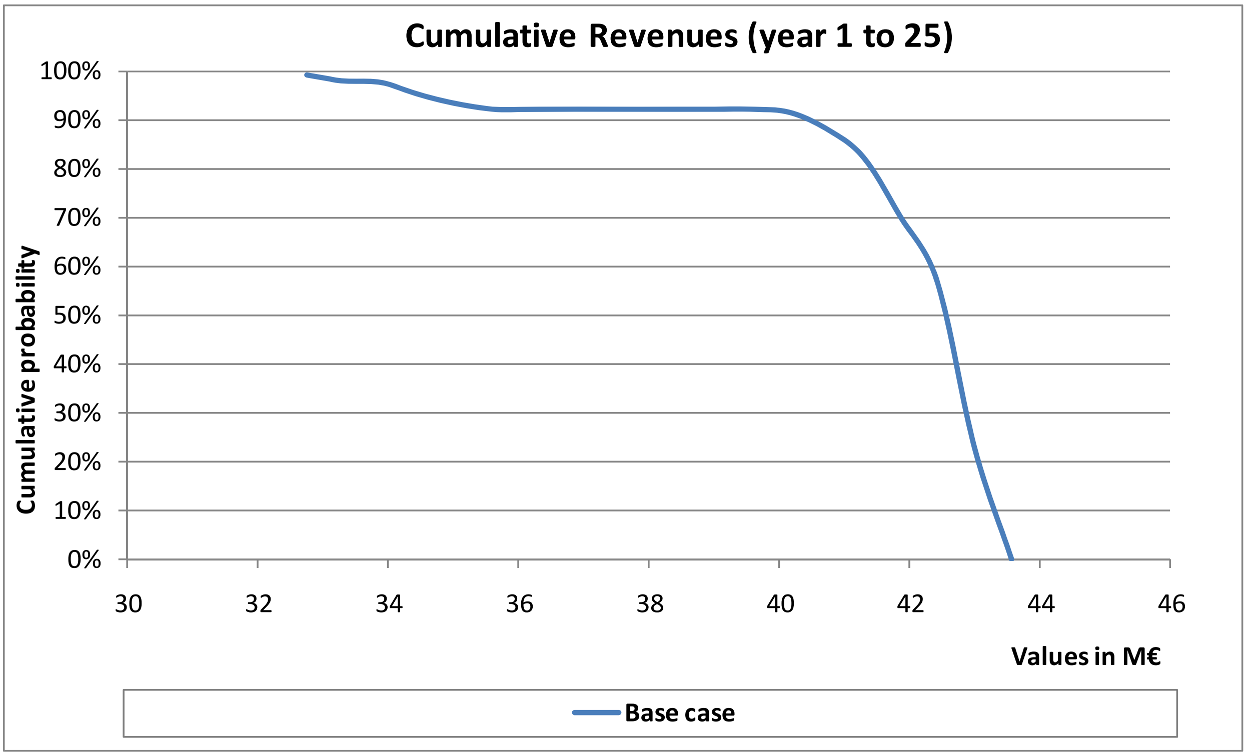
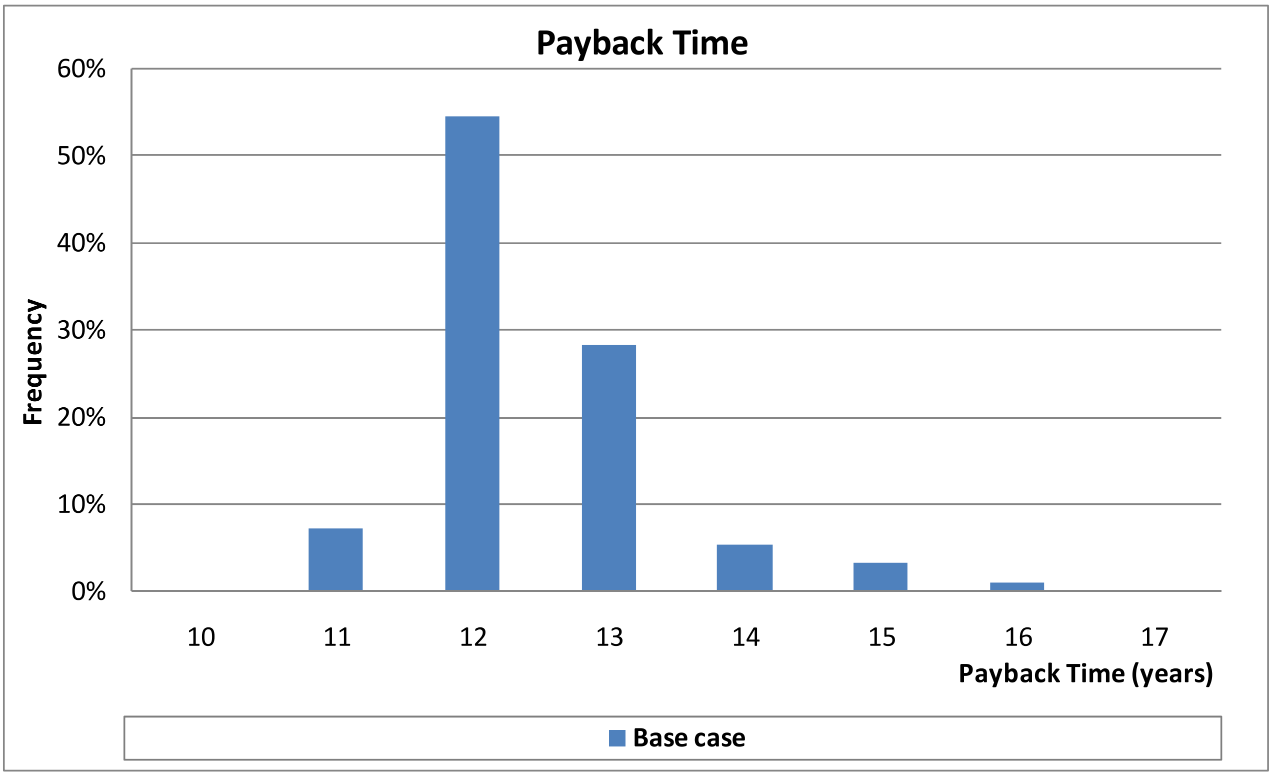


Figure 47 Cumulative probability of the overall Revenues



The distribution of the payback time varies between 11 and 16 years, but the most likely value is around 12 years, with more than 50% of probability (Figure 48). The chance that the payback time will be over 13 years is limited (around 8%).

Figure 48 Distribution of the payback time



Step 3: Risk Control

In a real-life project, the results of the risk assessment would be shared again through a second workshop with participants. However in this case-study project the consideration of risk control had to be conducted within the same workshop as the risk identification.

The risk control step of the risk management process was limited to the discussion of three mitigation actions for this case study due to time constraints. This allowed workshop participants to understand and see examples of how the qualitative and quantitative approach would function. Therefore while some risks with a high level of criticality (in the red area of the matrix) were not mitigated, in a real project further management measures would have been identified.

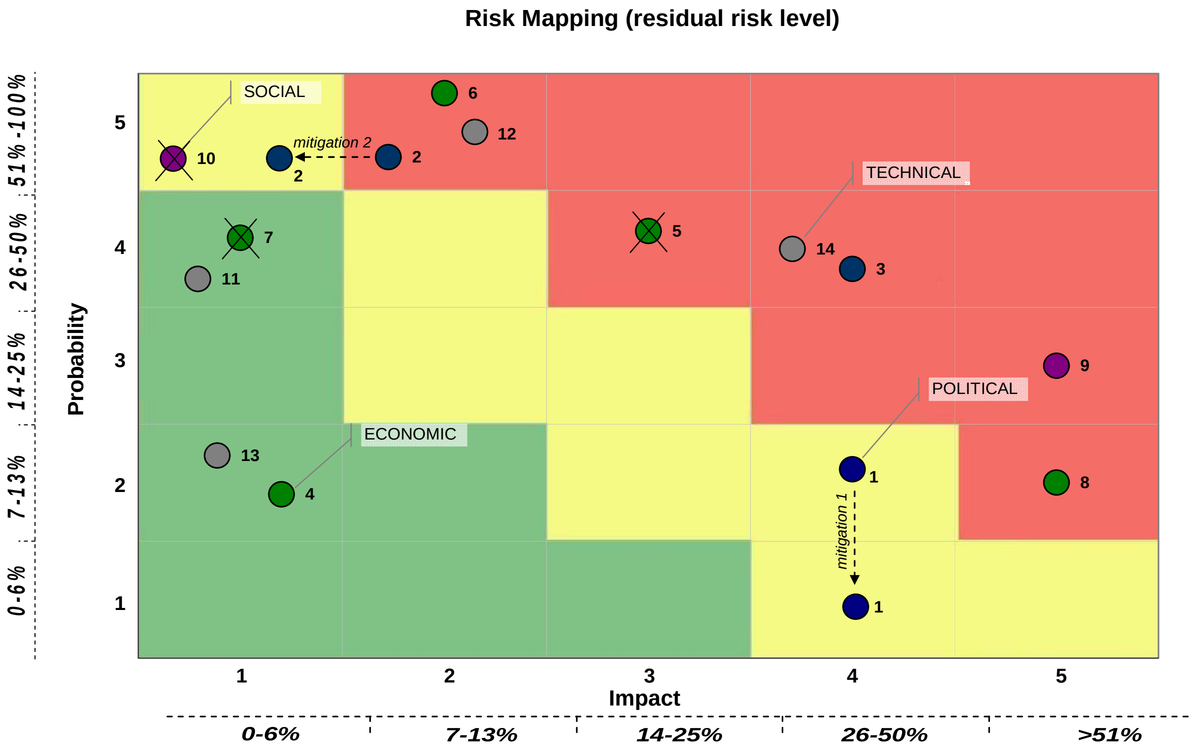
Each control action is described in terms of the control strategy involved and specific details of the measure (Table 20):

Table 21 List of illustrative control actions

Nb.	Control Action	Control Strategy	Description
1	EPC guarantee to avoid FIT next tranche	Mitigate	Change the probability of risk Number 1 (Reduction in Feed in Tariffs by 25% in 5 years time) from 10% to 5% due to the EPC guarantee to finish in time. In this way it is possible to avoid the project having a next (lower) tranche of FiT. In this scenario the guarantee is evaluated as a fix increase in the total CAPEX equal to 2.5%.
2	Anticipated depreciation	Mitigate	The depreciation method is changed from linear to double-declining in order to reduce the impact of a probable increase in the Corporate VAT (risk no. 2).
3	Insurances	Transfer	The Risk numbers 5, 7 and 10 are avoided adding a set of dedicated insurances (14.000 €/year).

From a qualitative point of view, the control strategies were also presented on the risk map:

Figure 49 Distribution of the payback time



Each control action was fed into the risk model to assess the specific impacts on the business model spreadsheet:

- Control action Number 1 has a positive impact both on the NPV and the Payback Time. It reduces the overall spread towards either minimum values or maximum values, reducing the total uncertainty of the project profitability. As a consequence the payback period is concentrated between years 12 and 14 as opposed to the base case where the payback is spread between 11 and 16 years.
- The anticipated depreciation (control action Number 2) was introduced to decrease the consequence of a probable increase in Corporate VAT. While it reduces the probability of an NPV>0 (-2%), it also increases the maximum NPV (2500 k€ instead 2300 k€); this therefore enhances the probability of a short payback time.
- The control action Number 3 is based on further insurance provision; it increases the probability that the project will be profitable up to 90% and reduces the minimum value of the NPV (-2100 k€ instead -2300 k€).

These results were illustrated in the following figures.

Figure 50 Cumulative probability of the NPV of the project for the base case and after the implementation of the three control actions (taken separately).

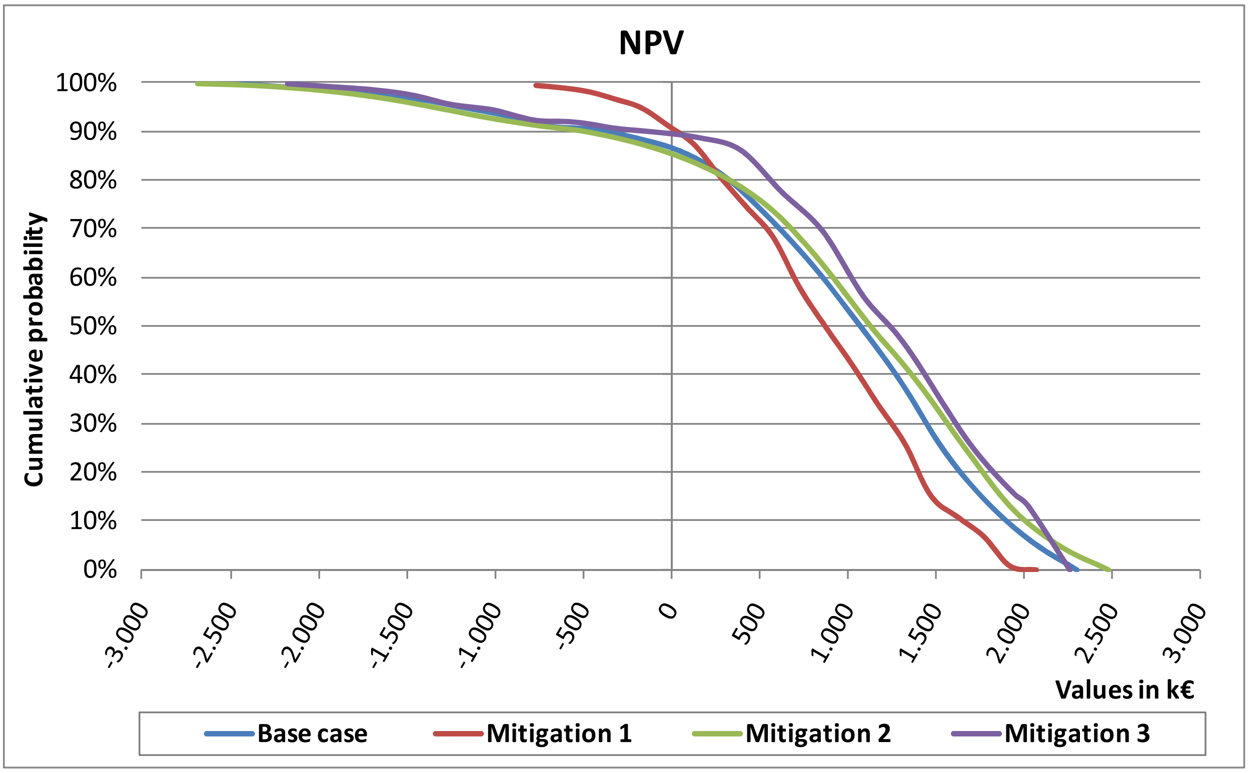
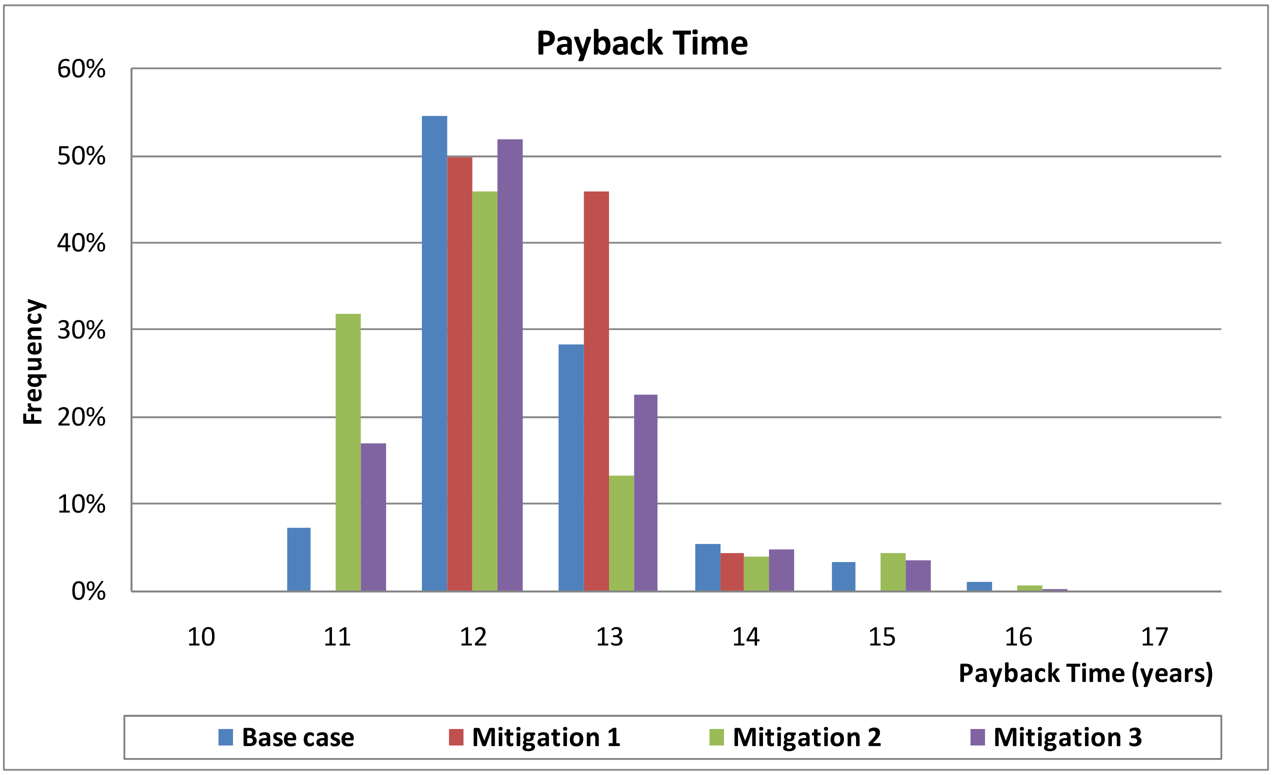
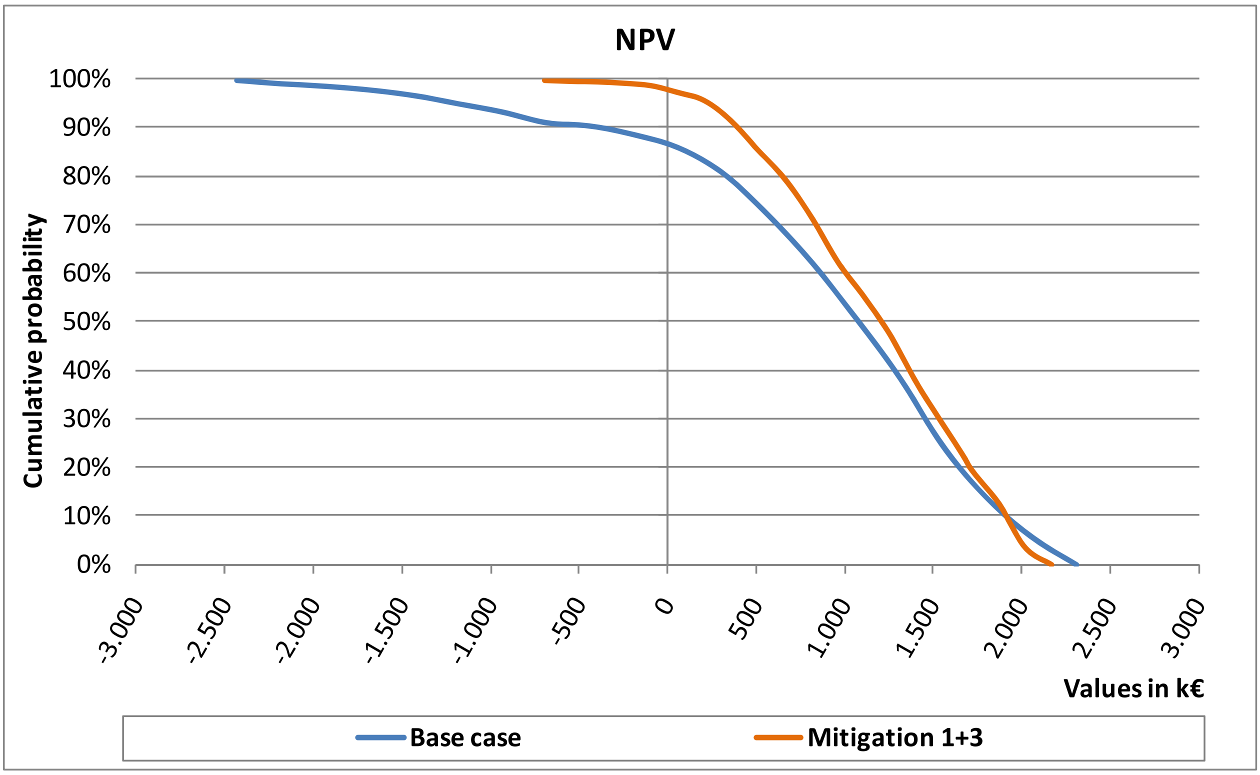


Figure 51 Distribution of the payback time for the base case and after the implementation of the three control actions (taken separately).



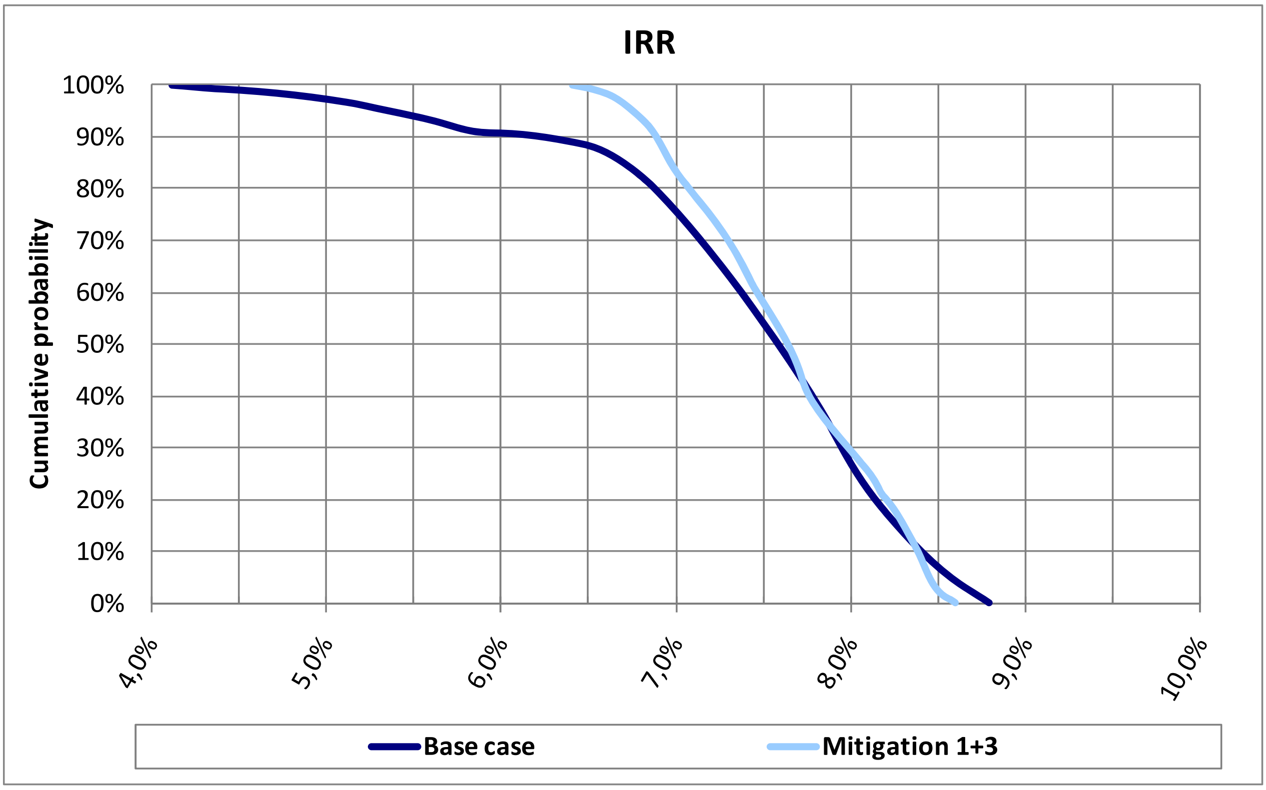
The combination of the two more relevant control actions (1 and 3) allows to decrease the overall uncertainty of the project (gap among P10 and P90), reducing the probability to incur in a loss to 3% and limiting the maximum undesired loss to 750 k€ (instead of 2500 k€).

Figure 52 Cumulative probability of the NPV of the project for the base case and after the implementation of the control actions number 1 and 3.



The IRR (Internal Rate of Return of the project) is presented in the graph below: the implementation of the mitigations actions will reduce considerably the uncertainty, increasing the minimum IRR from 4.2% to 6.4%, but slightly reducing the maximum IRR from 8.75% to 8.65%.

Figure 53 Cumulative probability of the IRR (Internal rate of return) of the project for the base case and after the implementation of the control actions number 1 and 3.



Feedback from the participants

The project and the Risk Methodology developed by Altran & ADL were presented to the workshop participants. The participants had some comments on the methodology, the feedback is given below:

1. There should be a fundamental discussion about the objectives of the project before risk assessment starts
2. Depending on the objective of the project the priorities might be set differently; for instance for a demonstrator project the performance is more important than build time and hence delay might be acceptable, whereas in commercial projects with significant loss due to production delay or damage claims, timely delivery supersedes overall performance. This issue will impact the risk assessment.
3. There is the need to assess which risks are manageable and which ones are inherent in the project e.g. which risks can be managed and mitigated; and which have to be monitored only. The risk maturity levels identified by this project (e.g. evolving, latent, and mature) do not cover this aspect. An additional criterion on the “Manageability” should be developed.
4. The perspective of the final customer is missing in the risk assessment approach, but plays a major role as stakeholder.
5. The final customer has to be identified before risk assessment starts. Several constructions are possible, from build and operate in the same hand to build and commission to third party.
6. There are specialized companies acting in the whole value chain from R&D, through site selection, build and operate, to decommissioning. Depending on how much of the value chain is covered by the risk assessment methodology the assessment has a different scope.

7. Risk assessment methodology seems to be very much focused on project realization, but some companies already start risk management in the R&D phase. An important question is the extent this risk can be captured by the given methodology. Emerging technologies need a broader range for risk assessment, e.g. R&D pipeline risk
8. Typically project developers look at a pipeline of 3 yrs. with minimum requirements. This limitation needs to be considered when developing risk management approaches.
9. As of now supply and demand are not yet balanced, thus the market is not yet fully developed; this introduces additional risks
10. The pre-project-phase starts whenever a company is dedicating significant resources in the development of a new site/location/market. How can prices (e.g. for lobbying) be factored into the risk assessment strategy? Since also policy makers are target audience for the study, new locations/markets seem to be within the scope of the work.
11. Currently many RES projects are still demonstrators. These projects follow a very different logic than purely commercial projects.
12. It is necessary to specify when risk management activities should start
13. There are two key questions in the mind of a project developer from the commercial point of view:
    a. What are the tariffs in the future?
    b. How can financing be obtained?
14. The final go/no go of a project is more or less given by the bank, through granting financing or not.
15. Policy risks should be evaluated qualitatively, while technical aspects can be assessed in a quantitative way.
16. Not the actual risk but the perceived risk is important for financing
17. How is the risk on the cost of debt accounted for
18. How does the model deal with multiple perspectives

The participants provided feedback on the methodology and the suitability of the method through a questionnaire. The result is given below:

Table 22 Results of the survey

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree	Comments
The overall risk management approach presented today is useful for our RES projects	3	6				- Very clear exposure details of all the potential risks in the potential projects - Agree: PV, less agree: other RES - It should be possible to assign several issues which are affected by some risk
The Risk breakdown structure is useful for identifying issues we may not have otherwise considered	3	5				- I traditionally focus on major big risks and do not focus on smaller but still relevant issues
The use of quantitative and qualitative assessment is important for managing risks	6	3				- It is critical

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree	Comments
We could use this approach to facilitate financing	2	4	2	1		- Better and easier way to expose risks will help banks to understand every single risk - By having banks accept this method - Define like a standard model approved by all parties involved - By educating banks - It should be validated by banks previously, anyway it helps to reconsider aspects of interest for the bank - This supports the financial request to the banks - Standardizing a model may help - Banks have their own technical advisors with their own criteria - As banks use advisors I would only use this model for innovative technologies
We could use this approach to facilitate permitting/authorizations		4	4		1	- Define like a standard model approved by all parties involved - The method helps to discover risks impacting the permitting that can be forecasted from the beginning - Standardizing a model may help - I would use this analysis for lobbying
We could use this approach to facilitate tendering/contracts	1	6	1			- It would make easier finance modelling - Will force a more homogeneous offer-to-offer comparison - The method helps to discover risks impacting the permitting that can be forecasted from the beginning - Contracts depend on a good risk analysis - Standardizing a model may help - It is a way to show risk evaluation of the EPC contract that may impact on the price in EPC or risk in the sponsor - To show the strengths of our analysis
We already apply similar methodologies for risk identification	1	2	4			- Due diligence questionnaire prior to acquisitions - We use different models - Managing projects involves risk management
We already apply similar methodologies for qualitative assessment	1	3	3			- RBS and brainstorming - Less structured - We use different models - Managing projects involves risk management
We already apply similar methodologies for quantitative assessment	1	2	4			- Pre-acquisition financial modelling - We use different models - Managing projects involves risk management

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree	Comments
We already apply similar methodologies for control/monitoring/feedback		2	2	3		- Struct. Monitoring of post acquisition performance - We have the data research but not the evaluation tools - Once the project is in operation we don't give further feedback about risk analysis
We do not use this approach at present, but we see it applicable in our current organization	1	3	1		1	- During the DD process to evaluate "true" value of assets - In order to develop more accurate DD in the financing side - If a good model is developed we will surely use it - The more mature the market gets many risks are transferred from the EPC contractor to the sponsor in order to adjust prices
This approach to risk management will assist in developing innovative support mechanisms for RES projects	2	5	2			- This approach will be extremely useful for regulators - Can allow define objective criteria for project qualification to receive subsidies/other support measure - It should be used by promoters in order to give success warranties to banks and policy makers Previously the model should be - Statistics tools are key for those studies explained to them in order do feel confident about it - I see that assessment correct for exploring new markets, due to new countries or new technologies not assumed at that moment as strategic

Appendix 1b: Offshore Wind Case study

The second case-study involved the risk assessment methodology being trialled on a realistic offshore wind project. The aim of this exercise was to involve experts to demonstrate and refine the methodology and obtain further feedback.
The exercise took place in Amsterdam during July 2010 and involved a cross section of key project players: project sponsors, equipment manufacturers, project managers, technical experts.

The following participants were involved in this study:

Table 23 List of the involved players in the risk analysis

Organization
Eneco
EWT
EZ (regulator)
Nuon/Weom
Green Giraffe
Altran (Germany)
Altran (Italy)
Altran (NL)

Step 1: Project Definition and Requirements

The main characteristics of the Wind Case study as presented below were presented and shared with key players involved in the exercise:

Table 24 Main characteristics of the Offshore Wind case study

Name	Organization
Plant size (MWp):	400 MWp
Total Investment	€ 1,312,000,000
Location:	Offshore, Netherlands
Short description of site:	• 15 m depth, 25 km offshore
Authorisations	• Permit to build from the Regional Authority confirmed • Permit for connection to grid not assigned (pending) • FiP (Feed in Premium) not assigned (pending)
Financing	70% project finance / 30% equity
Partnership	50%/50% with other operator
Timing:	Expected start of works: March, 2012 Execution time: 4 years (Approx.)
Operations & Maintenance Cost	55 M€/y
Maintenance & Repair	25 M€/y
Insurance:	21 M€/y
Others (transports, control,..)	9 M€/y
Market price subsidized electricity	0,184 €/kWh

Step 2: Risk identification

Risks were identified through a Delphi process; this allowed the methodology to be tested where it was not possible to bring all key stakeholders to a single brainstorming session.

An initial risk register was produced through individual interviews. This risk register was then consolidated in an internal Altran workshop in Amsterdam on June 18th. The results were sent back to all participants via email, requesting their individual evaluation on any single risk issue, using the evaluation matrix. Further email exchanges were made to refine the results by highlighting the discrepancies in order to reach a common understanding on every single issue. Where significant discrepancies remained, related differences were modelled in the variables of the quantitative model (step 3 in the approach presented in chapter 5), to take in consideration experts opinions plurality.

Email exchanges requested by the Delphi method were also used to define mitigation measures and to have a feedback from RES professionals on the proposed risks assessment approach. Detailed results are presented in the following paragraphs.

Risk Identification was done according to the classification developed in the Risk Methodology based on the Risk Breakdown Structure (RBS). The list of 25 risks identified is presented below.

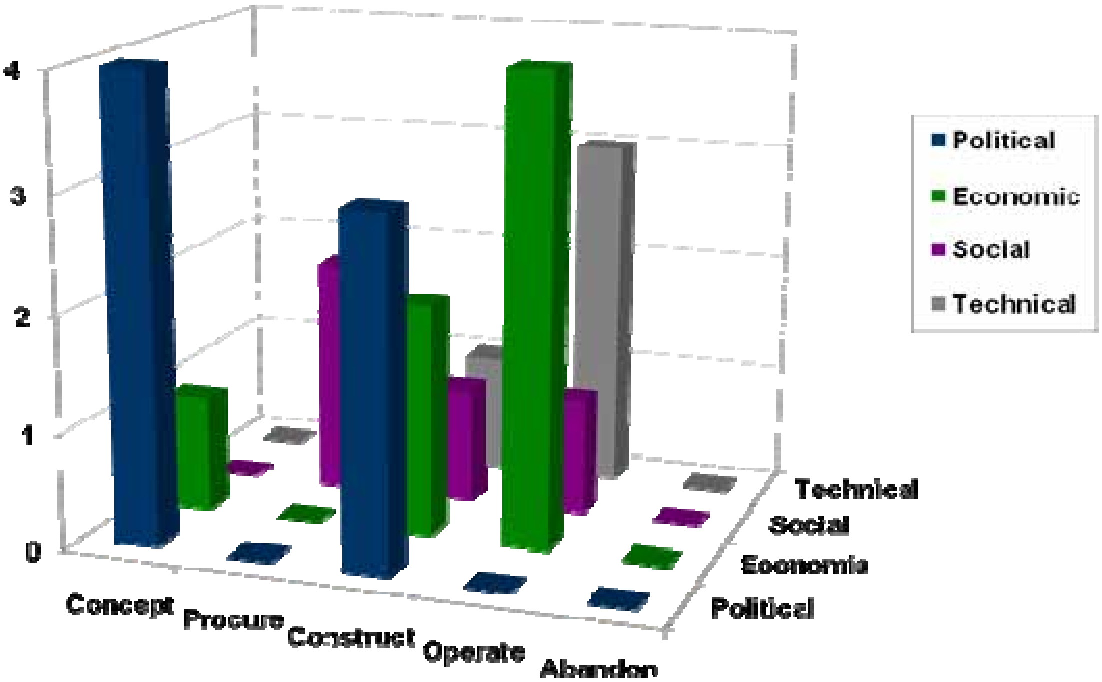
Table 25 List of the risks identified by case-study participants

			In which phase(s) does the risk cause concern?					
Nb.	**Category***	**Risk**	**Concept**	**Procure**	**Construct**	**Operate**	**Abandon**	**Risk Phase**
1	P	Cancellation of the FIT for new projects	x					Emergent
2	P	Opportunity: Higher renewable energy percentage: FIT granted for all project life	x					Emergent
3	P	Taxation benefits cancelled	x					Emergent
4	P	Port infrastructure availability. Possible delay in the construction.			x			Mature
5	P	Delay of permits by 2 years (both national and local)			x			Mature
6	P	Strict regulation on security (e.g. Increase numbers of buoy)	x					Mature
7	P	Facilitation of permitting by 1 years			x			Latent
8	P	Reduction of the FIT from 10% to 15% before commissioning	x					Emergent
9	E	Uncertainty on interest rates variation due to market conditions				x		Latent
10	E	Increase of 0.5% in interest rates due to bank bankruptcy				x		Latent
11	E	Damage to turbines during construction, installation and commissioning			x			Mature
12	E	Uncertainty on electricity prices indexation (+/-1%)				x		Latent
13	E	Long term wind regularity (-10% / +10% on load hours)				x		Mature
14	E	EPC contractor not able to deliver on time and on quality			x			Mature
15	E	Critical failure of turbines during operations (higher OPEX)				x		Mature
16	E	Partner bankruptcy: need to find another partner or take all the liabilities	x					Latent
17	S	Damage to fishing industry: possible public opposition			x			Mature
18	S	Gearbox oil spill: cleanup cost				x		Mature
19	S	Skilled labour unavailability		x				Emergent
20	S	Delay of 6 months of the projects due to local communities opposition		x				Mature
21	T	5% lower yield				x		Mature
22	T	Higher failure rate: increase of 5% OPEX				x		Mature
23	T	Difficult access to the site due to bad weather conditions. Higher operation cost and performance reduction.				x		Mature
24	T	Bad weather condition during the construction phase: possible delays and increase in CAPEX			x			Mature
25	T	Turbine prices uncertainty (-5% / +20%)		x				Mature

* P=Political, E=Economic, S=Social, T=Technical

The coverage of the risks was summarised according to project phase and risk category (Political, Economic, Social, and Technical) and is presented below. The risks were quite evenly spread throughout the Project phases (except for the Abandon where the participants did not highlight any particular risk) and the different PEST categories.

Figure 54 Graphical representation of the risk coverage



Step 3: Risk Evaluation

The risks were assessed in terms of probability, impact and affected parameter (CAPEX, OPEX, revenues, etc.). The results are reported in the following table (Risk Register).

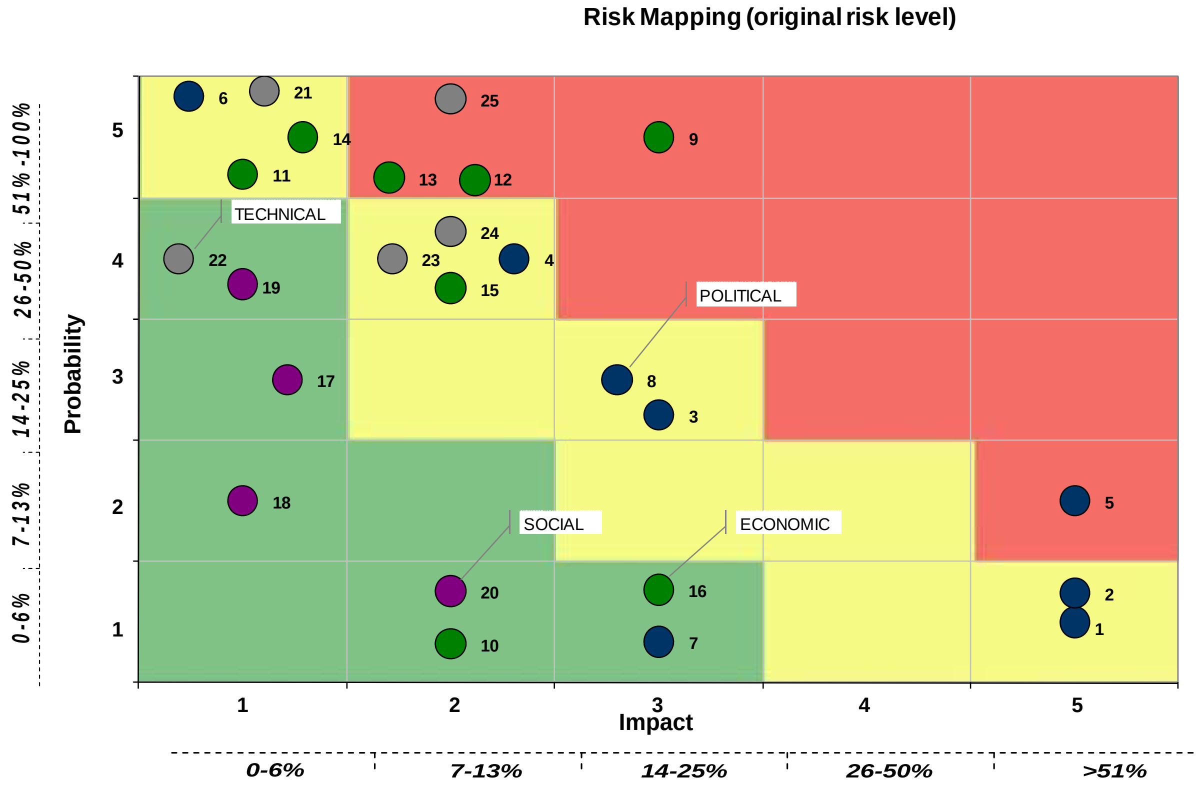
Table 26 Risk Register

Nb.	Risk	Probability	Affects	Distribution	Absolute/ Percentage	IMPACT MIN	IMPACT MOST LIKELY	IMPACT MAX	Risk Level
1	Cancellation of the FIT for new projects	5%	Revenue	Discrete	Absolute		233.000.000 €		M
2	Opportunity: Higher renewable energy percentage: FIT granted for all project life	2%	Revenue	Discrete	Absolute		233.000.000 €		M
3	Taxation benefits cancelled	20%	Tax	Discrete	Absolute		5,0%		M
4	Port infrastructure availability. Possible delay in the construction.	40%	Schedule	Triangular	Absolute	90 days	180 days	240 days	M
5	Delay of permits by 2 years (both national and local)	10%	Schedule	Uniform	Absolute	372 days		720 days	H
6	Strict regulation on security (e.g. Increase numbers of Buoy)	50%	Capex	Triangular	Percentage	1%	2%	3%	M
7	Facilitation of permitting by 1 years	2%	Schedule	Uniform	Absolute	180 days		360 days	L
8	Reduction of the FIT from 10% to 15% before commissioning	20%	Revenue	Uniform	Percentage	10%		15%	M
9	Uncertainty on interest rates variation due to market conditions	100%	Interest	Triangular	Absolute	-0,5%	0%	2,5%	H
10	Increase of 0,5% in interest rates due to bank bankruptcy	2%	Interest	Discrete	Absolute		0,5%		L
11	Damage to turbines during construction, installation and commissioning	50%	Capex	Triangular	Absolute	5.000.000 €	6.000.000 €	10.000.000 €	M
12	Uncertainty on electricity prices indexation (+/-1%)	100%	Revenue	Uniform	Absolute	3,00%		5,00%	H
13	Long term wind regularity (-10% / +10% on load hours)	100%	Revenue	Uniform	Percentage	-10%		10%	H
14	EPC contractor not able to deliver on time and on quality	50%	Schedule	Triangular	Absolute	60 days	90 days	180 days	M
15	Critical failure of turbines during operations (higher OPEX)	30%	Opex	Triangular	Percentage	10%	12%	20%	M
16	Partner bankruptcy: need	1%	Interest	Discrete	Percentage		1%		L

Nb.	Risk	Probability	Affects	Distribution	Absolute/ Percentage	IMPACT MIN	IMPACT MOST LIKELY	IMPACT MAX	Risk Level
	to find another partner or take all the liabilities								
17	Damage to fishing industry: possible public opposition	20%	Schedule	Uniform	Absolute	30 days		90 days	L
18	Gearbox oil spill: clean up cost	10%	Opex	Uniform	Absolute	2.500.000 €		5.000.000 €	L
19	Skilled labour unavailability	30%	Capex	Uniform	Percentage	5%		10%	L
20	Delay of 6 months of the projects due to local communities opposition	5%	Schedule	Uniform	Absolute	120 days		180 days	L
21	5% lower yield	70%	Revenue	Triangular	Percentage	4%	5%	6%	M
22	Higher failure rate: increase of 5% OPEX	30%	Opex	Discrete	Percentage		5%		L
23	Difficult access to the site due to bad weather conditions. Higher operating cost and performance reduction.	30%	Opex	Triangular	Percentage	10%	12%	20%	M
24	Bad weather condition during the construction phase: possible delays and increase in CAPEX	30%	Capex	Triangular	Percentage	10%	12%	20%	M
25	Turbine prices uncertainty (-5% / +20%)	100%	Capex	Triangular	Percentage	-5%	0%	20%	H

The risks are mapped according to probability, impact and category (Political, Economic, Social, and Technical) and reported in the chart of Figure 55.

Figure 55 Risk Mapping



The most critical issues were either economic issues, (e.g. uncertainty on finance conditions, electricity price indexation and purchase price of the turbines), or political issues, (e.g. possibility of permitting delays due to national or local opposition). From the technical point of view, the stakeholders highlighted the possible increase in the CAPEX and OPEX due to bad weather conditions during the construction and the maintenance phase as a critical issue.

From the quantitative point of view, the risks were linked to the relevant element of the discounted cash flow (DCF). Furthermore two types of correlations were considered within the model:

- Correlation among different risks, in order to reflect the dependency of one risk to another (e.g. the Risk Number 11 has an higher probability of occurrence if the Risk Number 23 and 24 happen);
- Correlation on the impact of some risks all over the DCF sequence. In fact these risks will have constant impact on the project life (e.g. Risk Numbers. 1, 8, 9, 10, 12, 21). Instead other risks are not correlated, because they can occur on the project casually year after year.

The cumulative distribution of the NPV of the project (calculated with capital costs of 6.6%) is reported in Figure 56. The probability that the project will be profitable (NPV>0) is around 85%, but the spread among the minimum NPV (-720 M€) and the maximum (520 M€) is high. In particular the gap between the P90 (NPV at 90% confidence) and the minimum is significant, due to technical risks with a low probability of occurrence, but significant CAPEX impact. This can be observed on the cumulative curve for CAPEX that levels off after P90 (CAPEX at 90% of confidence).

Figure 56 Cumulative probability of the NPV of the project (calculated with a 6.6% cost of capital)

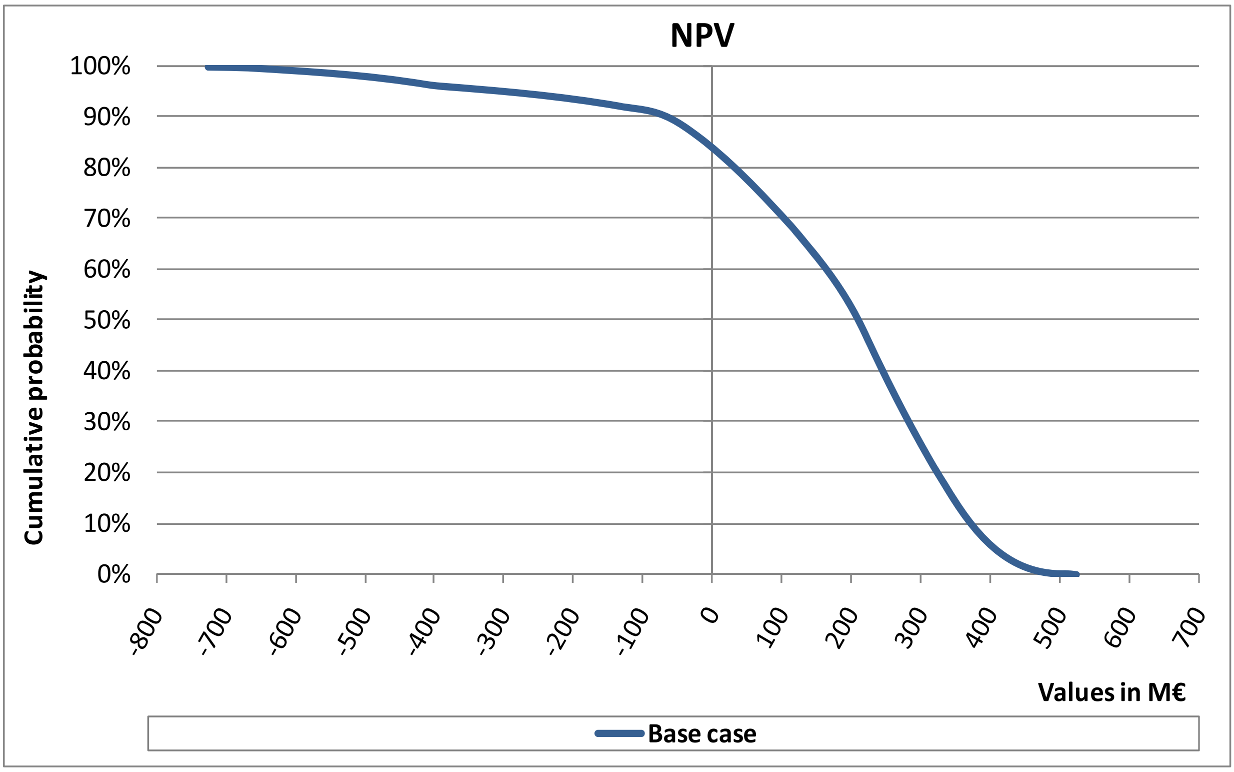
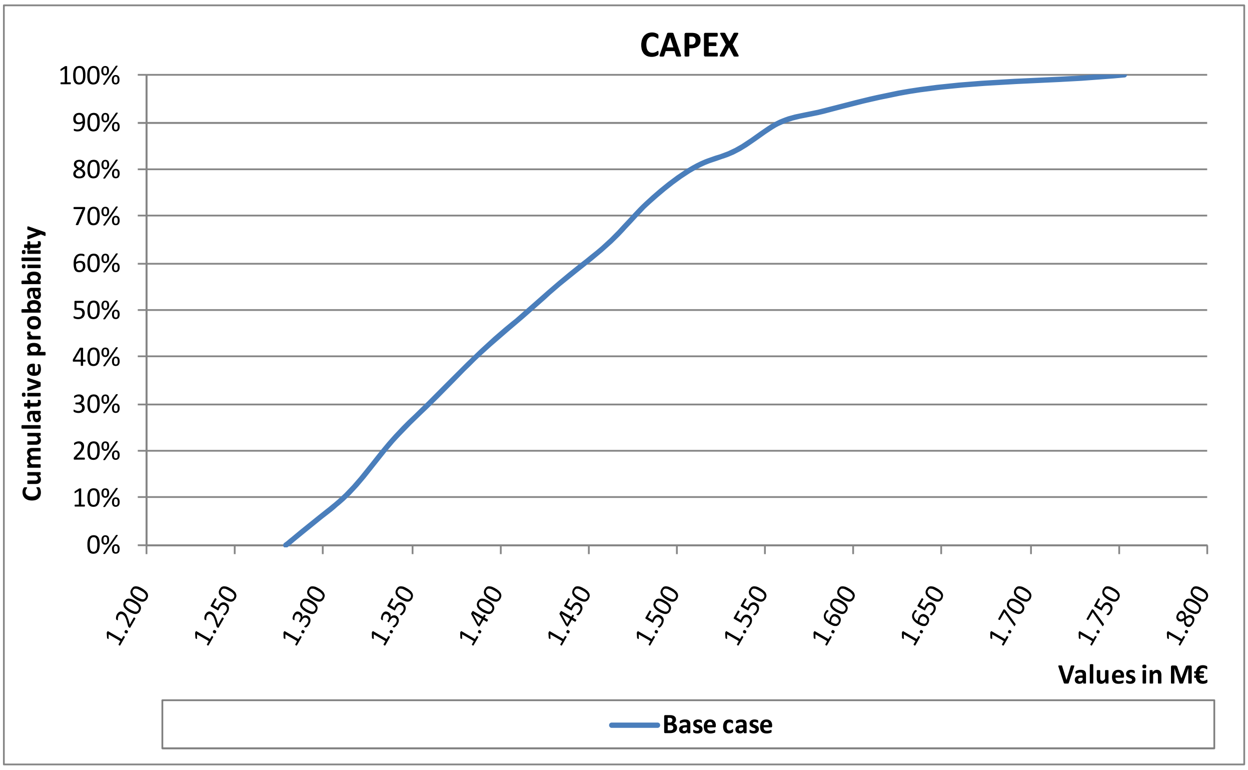
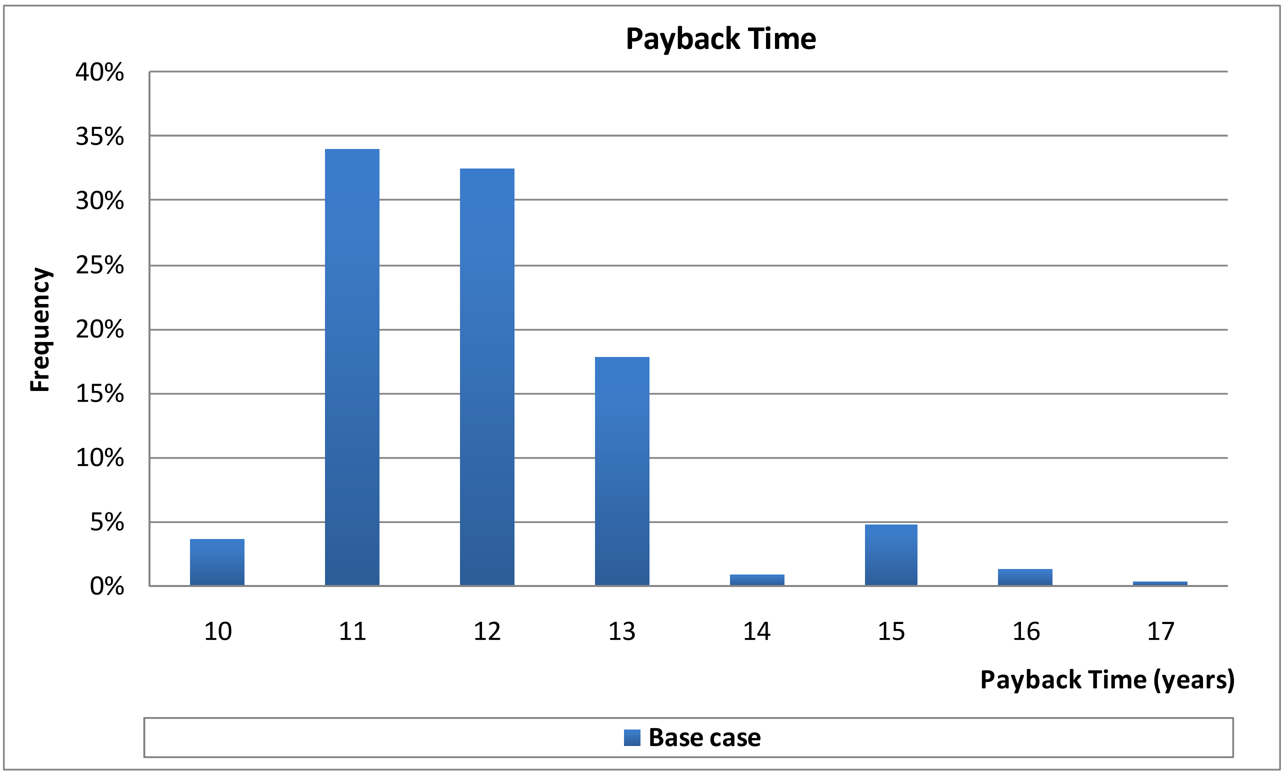


Figure 57 Cumulative probability of the CAPEX of the project



The distribution of the payback time is presented in Figure 58: the range of the payback is between 10 and 17 years, but the most likely value is around 11 years, with more than 35% of probability of occurrence. The probability that the payback time will be over 13 years is less than 20%.

Figure 58 Distribution of the payback of the investment



Step 4: Risk Control

The risk control step of the risk management process was limited to the discussion of three mitigation actions for this case study. This allowed participants to understand and see examples of how the qualitative and quantitative approach would function. Therefore while some risks with a high level of criticality (in the red area of the matrix) were not mitigated, in a real project further management measures would have been identified.

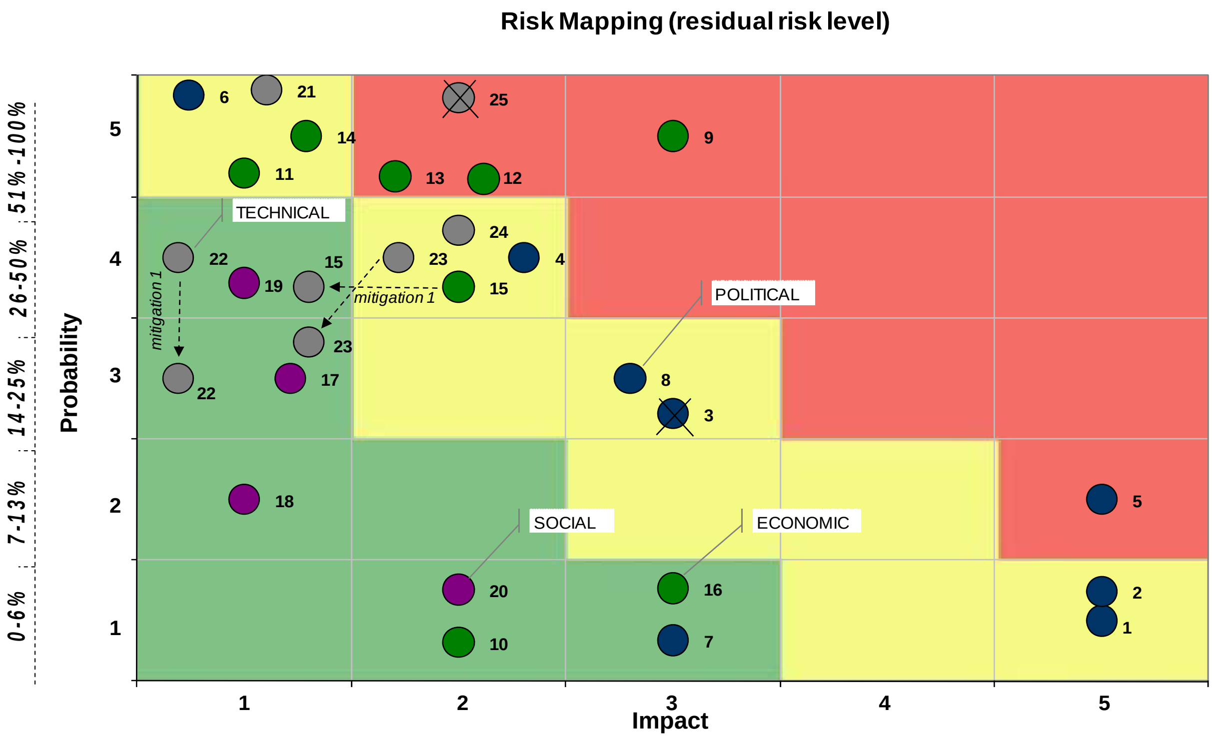
Each control action is described in terms of the control strategy involved and specific details of the measure (Table 26):

Table 27 – List of control actions

Nb.	Control Action	Control strategy	Description
1	Development of a well qualified pool of maintenance contractors in a competitive market	Mitigate	Reduction of the consequence of the risk no. 15, 22 and 23 (-50% impact) thanks to the better performance of the maintenance contractors. This element reduces also the probability (-50%) to have the risk no. 15 and 22. The probability of the risk no. 23 is not affected by this control strategy.
2	Turbine anticipated procurement	Avoid	Reduction of the uncertainty on the turbine price from -5% / +20% to a fixed +2,5% (Risk no. 25)
3	Fixed interest rate guarantee over one year negotiation time (+1% fixed)	Transfer	Reduction of the uncertainty on the interest rates from 7%-10% to a fixed 7,5% (Risk no. 9).

From a qualitative perspective, the impact of the control strategies on the risk map is reported in the following graph Figure 59.

Figure 59 Residual risk mapping



The impact of each control strategy was also analyzed separately within the quantitative risk model. The results are displayed in Figure 60:

- The control action number 1 has a positive impact both on the NPV and the Payback Time. It increases the probability to have an NPV>0 up to 88%. Moreover, the implementation of this measure, allows to gain 50 M€ of NPV at the same confidence level (the gap between the "base case" curve and the "mitigation 1" curve, readable directly on the curve). As a consequence the payback period is slightly lower than in the base case, with a higher probability to have a breakeven in 10, 11 or 12 years;
- The anticipated procurement of the turbines (control action number 2) allows a reduction in the overall uncertainty of the project. As a consequence the probability to have an NPV>0 increases to 87%. The payback time is concentrated within year 11 and 13, in comparison to the base case the payback is widespread;
- The control action number. 3 has the same impact as the previous mitigation action. The confidence that the project will have a positive NPV is equal to 87% and the payback time is concentrated within year 11 and 13.

Figure 60 Cumulative probability of the NPV of the project for the base case and after the implementation of the three control actions (taken separately).

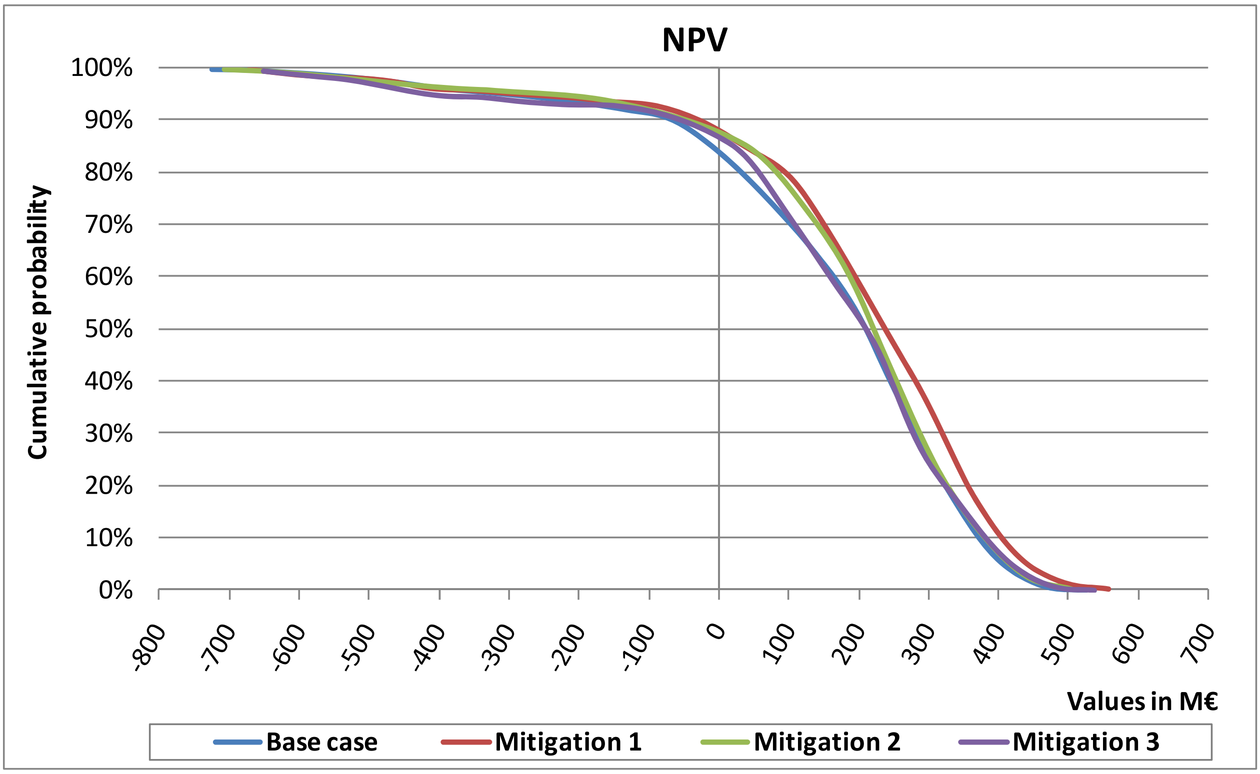
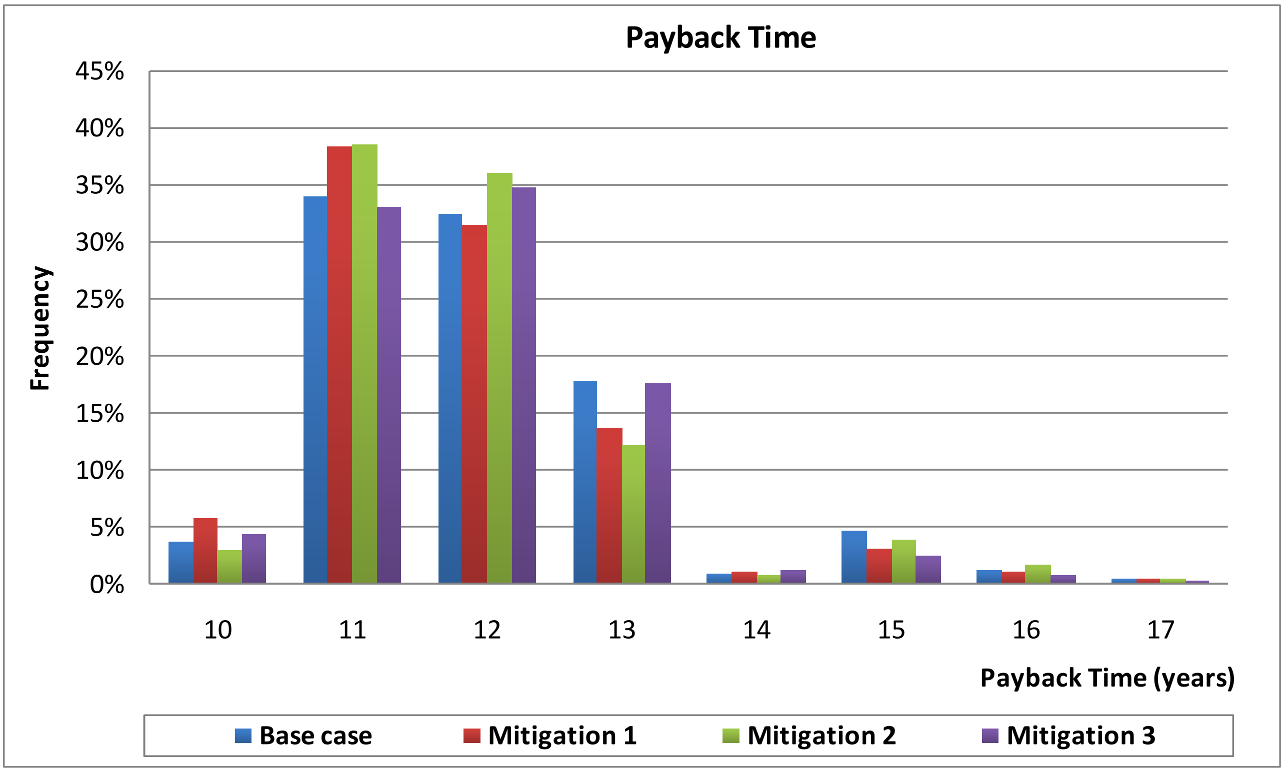


Figure 61 Distribution of the payback time for the base case and after the implementation of the three control actions (taken separately).



The combination of all the control strategies presented above increases the probability of an NPV>0 from 84% to 90%, without reducing the overall uncertainty of the project. This last element is visible also in the graph of the IRR (Internal Rate of Return), where the implementation of the mitigation measure allows a 1% increase in IRR, but the spread among the P10 and the P90 remains the same.

Figure 62 Cumulative probability of the NPV of the project for the base case and after the implementation of the control actions number 1, 2 and 3.

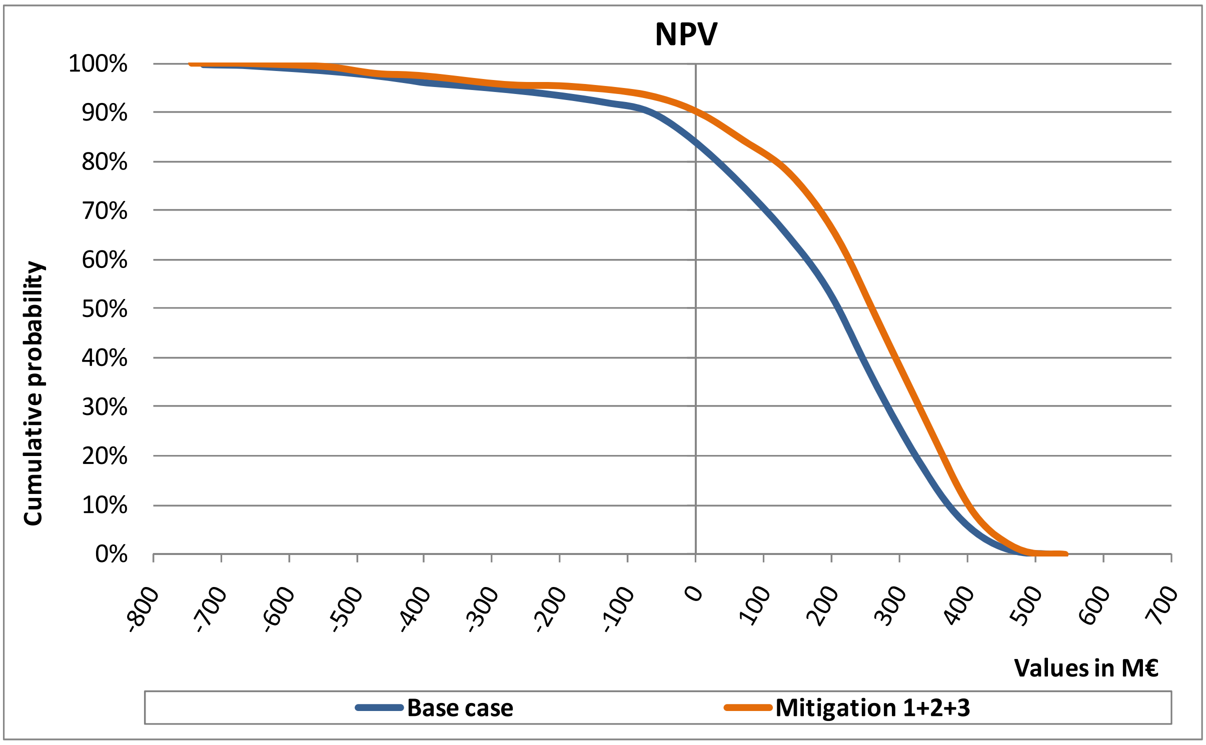
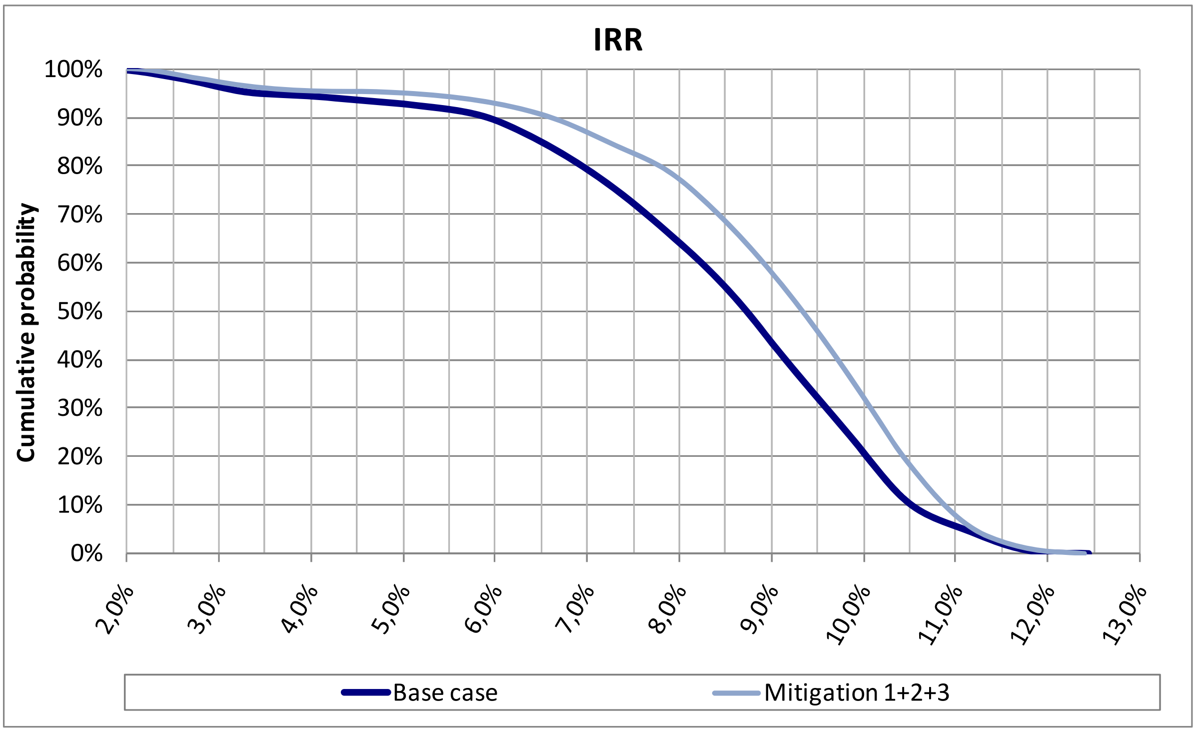


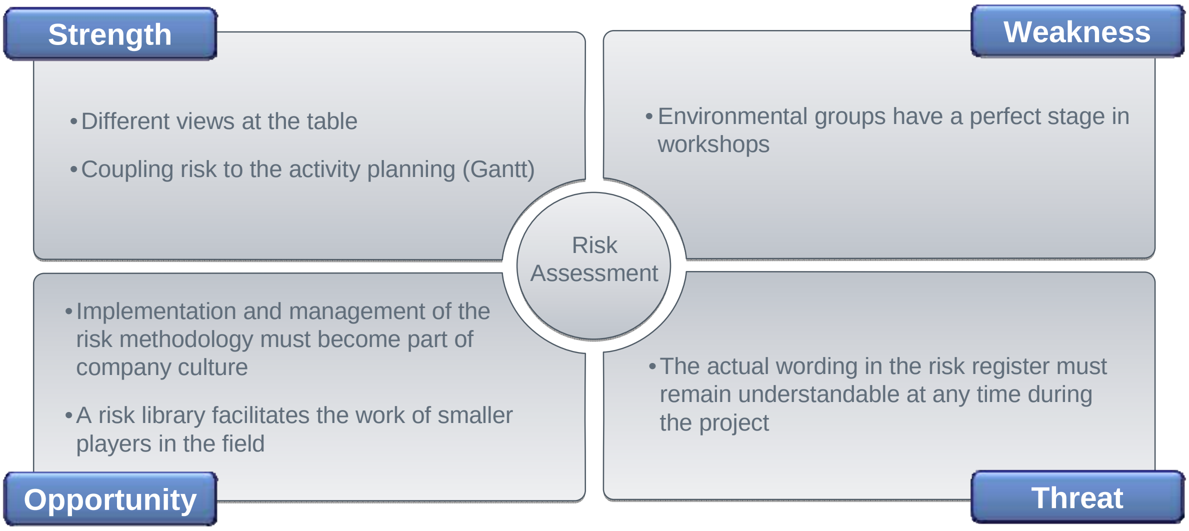
Figure 63 Cumulative probability of the IRR (Internal rate of return) of the project for the base case and after the implementation of the control actions number 1 and 3.



Feedback from the participants

A number of interviews with case-study participants based across the value chain were held; these included government, project finance, project development and operation stakeholders.
While the method was overall accepted and welcome, there were remarks on the classification of risks, and the applicability for smaller players in the market. The figure 64 below shows strengths, weaknesses, threats and opportunities for the developed risk assessment methodology as seen by the interviewed stakeholders from the wind energy sector.

Figure 64 Strengths, weaknesses, threats and opportunities as seen by the interviewed players of the wind energy sector.



The following remarks were also given during the interviews by the stakeholders:

Current risk assessment:

- Safety risks are always be assessed separately. Putting them into the PEST structure is insufficient.
- A dedicated "lender engineer" representing the view of the investors is appointed during project planning.
- Risk assessment is done according to the graduation "practical, technical, contractual" -> Does it work in practice? Does it work technically? Does it work contractually?
- A lessons learned register is crucial for project improvements. This includes a list of events "gone wrong" and "nearly gone wrong", where some random event has prevented the undesired outcome.
- The risk register is typically kept on highest level of detail (nuts & bolts) but not all events are taken into account in the Monte-Carlo simulation.

Other remarks/information:
The approach should also consider how it can further contribute to critical issues within the industry:
- Availability of sufficient capital to fully exploit the potential for offshore wind (200 billion euro investment till 2020 in the North Sea area alone)
- Difficulty in obtaining equity finance. To attract sufficient equity, profitability needs to be reached earlier in the project, while it is crucial to obtain sufficient equity funding to keep debt parties on board.
- Many projects need refinancing after commissioning. The risk assessment should be done accordingly.

- The risk/benefit ratio is the leading indicator, which imposes to take some risks rather than mitigate them.
- Differences between oil & gas and renewable energy: "O&G problems can usually be solved with capital effort. Since the margins in renewable energy are much lower, this strategy does not work."
- The scale of equipment for O&G and offshore wind is different, i.e. the equipment cannot just be used for either one or the other. Hence dedicated equipment for offshore wind development is (currently) hard to get.

Annex 2 Background to Altran, Arthur D. Little and RETD

About IEA – RETD

The RETD Implementing Agreement is one of the key outcomes from the International Conference for Renewable Energies in Germany in June 2004. Members of the RETD are countries that want to encourage the international deployment of renewable energy through improved policies. While the other IEA implementing agreements on renewable energy focus on specific technologies, the RETD is crosscutting from a technological point of view and intends to complement these.
The RETD wants to significantly increase the use of renewable energy (RES) technologies in the RETD member countries. To obtain this ambition, the RETD aims to:

- Improve the cooperation between the participating countries on deployment issues.
- Launch projects that encourage technology deployment by public-private partnership.
- Inform and facilitate ongoing international dialogue and public awareness of renewable energy.

About Altran and Arthur D. Little

Created in 1982, ***Altran*** is today a European leader in innovation consulting. Our added value is the ability of our consultants to manage our customer's projects that deliver tomorrow's solutions today. Built on an original model, then decentralised to give free rein to initiative, Altran assists its clients at every stage of the innovation cycle in three business lines:

In 2009, the Group's turnover reached 1.8 billion Euros, with over 18.000 employees in 26 countries. Consulting services include: technology and innovation, organisation & information systems and strategy & management consultancy.

Arthur D. Little, founded in 1886, is a global leader in management consultancy with 800 employees worldwide, linking strategy, innovation and technology with deep industry knowledge. We offer our clients sustainable solutions to their most complex business problems. Arthur D. Little has a collaborative client engagement style, exceptional people and a firm-wide commitment to quality and integrity.

Altran and Arthur D.Little created a dedicated workgroup (later mentioned as "Workgroup") for this study, gathering the most competent resources among its affiliates, also representing a wide range of cultural and regional references in risk management and REN projects. Thus, Altran and Arthur D. Little affiliates from Germany, Italy, Spain, UK, Netherland and France were involved on this study.

10 Glossary

This glossary of terms is derived within the context of how terms are used in the guide.

Activity: An element of work performed during the course of a project. An activity normally has an expected duration, an expected cost, and expected resource requirement.

Actual Cost: The costs actually incurred and recorded in accomplishing work performed.

Assumptions: Factors used for planning purposes that are considered true, real or certain. Assumptions affect all aspects of the planning process and of the progression of the project activities. (Generally, the assumptions will contain an element of risk.)

Asset finance: All money invested in renewable energy generation projects, whether from internal company balance sheets, from debt finance, or from equity finance. This excludes re-financings. The asset finance numbers represent investment raised in each year – i.e., equity that is committed, or debt that is provided (sometimes in tranches). The plant or project may not be commissioned in the same year.

Baseline: A quantitative definition of cost, schedule, and technical performance that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field program(s), project(s), task(s), or subtask(s) are measured, assessed, and controlled.

Bias: A repeated or systematic distortion of a statistic or value, imbalanced about its mean.

Brainstorming: Interactive technique designed for developing new ideas with a group of people.

Capital Expenditure – CAPEX: Funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. Some investment will translate into capacity in the following year.

Change Control: A process that ensures changes to the approved baseline are properly identified, reviewed, approved, implemented and tested, and documented.

Communication Planning or Plan: Process and plan for determining the information and communication needs of the project/program stakeholders. Identifies who needs what information, when they will need the information, and how it should be presented, tracked, and documented.

Consequence: Outcome of an event. (Normally includes scope, schedule, and cost.)

Correlation: Relationship between variables such that changes in one (or more) variable(s) is generally associated with changes in another. Correlation is caused by one or more dependency relationships. Measure of a statistical or dependence relationship existing between two items estimated for accurate quantitative risk analysis.

DCF: Discounted Cash Flow is a method of valuing a project, company, or asset using the concepts of the time value of money. All future cash flows are estimated and discounted to give their present values (PVs) – the sum of all future cash flows, both incoming and outgoing, is the net present value (NPV), which is taken as the value or price of the cash flows in question.

Decision Analysis: Process for assisting decision makers in capturing judgments about risks as probability distributions, having single value measure, and putting these together with expected value calculations.

Delphi Technique: Technique used to gather information used to reach consensus within a group of subject matter experts on a particular item. Generally a questionnaire is used on an agreed set of items regarding the matter to be decided. Responses are summarized, further comments elicited. The process is often repeated several times. Technique is used to reduce bias in the data and to reduce the bias of one person, one voice.

Estimate: Assessment of the most likely quantitative result. (Generally, it is applied to costs and durations with a confidence percentage indication of likelihood of its accuracy.)

EPC contract: Engineering, Procurement and Construction contract

Expert Interviews: Process of seeking opinions or assistance on the project from subject matter experts (SMEs).

External Risks: Risks outside the project control or global risks inherent in any project such as global economic downturns, trade difficulties affecting deliverables such as construction materials or political actions that are beyond the direct control of the project.

Feedback: System concept where a portion of the output is fed back to the input.

Feed-in tariff: A premium rate paid for electricity fed back into the electricity grid from a designated renewable electricity generation source.

Fishbone Diagram: Technique often referred to as cause and effect diagramming. Technique often used during brainstorming and other similar sessions to help identify root causes of an issue or risk. Structure used to diagram resembles that of a fish bone.

Impact Scores: Convergence of the probability and consequence scores.

Initiation: Authorization of the project or phase of the project.

Internal Risks: Risks that the project has direct control over, such as organizational behavior and dynamics, organizational structure, resources, performance, financing, and management support.

IRR: Internal Rate of Return is the interest rate at which the net present value of costs (negative cash flows) of the investment equal the net present value of the benefits (positive cash flows) of the investment.

Key Risk: Key risks are a set of risks considered to be of particular interest to the project team. These key risks are those estimated to have the most impact on cost and schedule and could include project, technical, internal, external, and other sub-categories of risk. For example on a nuclear design project, the risks identified using the “Risk and Opportunity Assessment” process may be considered a set of key risks on the project.

Lessons Learned: Formal or informal set of “learnings” collected from project or program experience that can be applied to future projects or programs after a risk evaluation. Can be gathered at any point during the life of the project or program.

Mitigate: To eliminate or lessen the likelihood and/or consequence of a risk.

Non-recourse project finance:

Debt and equity provided directly to projects rather than to the company developing them. The lender is only entitled to repayment from the profits of the project and has no access to the borrower's other assets in the event of default.

O&M: Operation & Maintenance

Opportunity: Risk with positive benefits.

NPV: Net Present Value is defined as the sum of the present values (PVs) of the individual cash flows. Each cash inflow/outflow is discounted back to its present value.

Primary Risk: Initial risk entry in the risk register. A residual or secondary risk can become a primary risk if in the case of a residual risk the primary risk is closed and the Federal Project Director and/or Contractor Project Manager determines the residual risk should be made the primary risk or the risk entry in the risk register. The secondary risk can become the primary risk in the risk register if the Federal Project Director and/or Contractor Project Manager determine that it should become the risk entry based upon the realization of the trigger metric or other determining factor.

Probability: Likelihood of an event occurring, expressed as a qualitative and/or quantitative metric.

Program: A portfolio of projects and/or other related work efforts managed in a coordinated way to achieve a specific business objective.

Project Risk: Risks that are captured within the scope, cost, or schedule of the project.

Qualitative Risk Analysis: Involves assessing the probability and impact of project risks using a variety of subjective and judgmental techniques to rank or prioritize the risks.

Quantitative Risk Analysis: Involves assessing the probability and impact of project risks and using more numerically based techniques, such as simulation and decision tree analysis for determining risk implications.

RES: Renewable Energies are energies which come from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished).

Residual Risk: Risk that remains after risk strategies have been implemented.

Risk: Factor, element, constraint, or course of action that introduces an uncertainty of outcome, either positively or negatively that could impact project objectives. This definition for risk is strictly limited for risk as it pertains to project management applications in the development of the overall risk management plan and its related documentation and reports.

Risk Acceptance: An informed and deliberate decision to accept consequences and the likelihood of a particular risk.

Risk Analysis: Process by which risks are examined in further detail to determine the extent of the risks, how they relate to each other, and which ones are the highest risks.

Risk Assessment: Identification and analysis of project and program risks to ensure an understanding of each risk in terms of probability and consequences.

Risk Assumption: Any assumptions pertaining to the risk itself.

Risk Breakdown Structure: Methodology that allows risks to be categorized according to their source, revealing common causes of risk on a project.

Risk Category: A method of categorizing the various risks on the project to allow grouping for various analysis techniques such as Risk Breakdown Structure or Network Diagram.

Risk Communication: An exchange or sharing of information about risk between the decision-maker(s), stakeholders, and project team. (The information can relate to various information sources such as the existence, nature, form, probability, severity, acceptability, treatment, or other aspects of risk.)

Risk Documentation: The recording, maintaining, and reporting assessments, handling analysis and plans, and monitoring results.

Risk Handling Strategy: Process that identifies, evaluates, selects, and implements options in order to set risk at acceptable levels given project constraints and objectives. Includes specific actions, when they should be accomplished, who is the owner, and what is the cost and schedule.
Risk Identification: Process to find, list and characterize elements of risk.

Risk Management: The handling of risks through specific methods and techniques.

Risk Management Plan: Documents how the risk processes will be carried out during the project/program.

Risk Mitigation: Process to reduce the consequence and/or probability of a risk.

Risk Monitoring and Tracking: Process of systematically watching over time the evolution of the project risks and evaluating the effectiveness of risk strategies against established metrics.

Risk Owner: The individual responsible for managing a specified risk and ensuring effective treatment plans are developed and implemented.

Risk Planning: Process of developing and documenting an organized, comprehensive, and interactive strategy and methods for identifying and tracking risk, performing continuous risk assessments to determine how risks have changed, developing risk handling plans, monitoring the performance of risk handling actions, and assigning adequate resources.

Risk Register: Database for risks associated with the project. (Also known as risk database or risk log.)

Risk Threshold: Defined or agreed level of acceptable risk that risk handling strategies are expected to meet.

Risk Transfer: Movement of the risk ownership to another organizational element. (However, to be successfully and fully transferred, the risk should be accepted by the organization to which the risk is being transferred.)

Secondary Risk: Risk arising as a direct result of implementing a risk handling strategy.

Simulation, (Monte Carlo): Process for modeling the behavior of a stochastic (probabilistic) system. (A sampling technique is used to obtain trial values for key uncertain model input variables. By repeating the process for many trials, a frequency distribution is built up, which approximates the true probability distribution for the system's output. This random sampling process, averaged over many trials, is effectively the same as integrating what is usually a very difficult or impossible equation.)

String Diagram: Technique used to analyze the physical or proximity connections within a process. Technique is often used to find latent risks.

Technical Risk: Risks that include disciplines such as mechanical, electrical, chemical engineering, safety, safeguards and security, chemistry, biology, etc.

Threat: Risk with negative consequences.

Trigger Metric: Event, occurrence or sequence of events that indicates the risk may be about to occur, or the pre-step for the risk indicating that the risk will be initiated.

Venture capital and private equity (VC/PE):
All money invested by venture capital and private equity funds in the equity of companies developing renewable energy technology. Similar investment in companies setting up generating capacity through special purpose vehicles is counted in the asset financing figure.