University of Twente
Enschede - The Netherlands

Green light for renewable energy investments

A Risk Analysis Tool for Renewable Energy Project Development

Graduate thesis for the study Industrial Engineering & Management

School of Management and Governance
Department of Finance and Accounting
University of Twente
Enschede, The Netherlands

July 29, 2008

Erik Jan Rodenhuis

Supervisors:
Ir. H. Kroon
Ir. G.J. de Leeuw

Acknowledgements

During a previously executed feasibility study on a biomass energy project the question became apparent, what makes a renewable energy attractive for investment or moreover: why are some renewable energy projects unable to attract financing? This caused my personal interest in the motives and requirements of project developers and investors to participate in renewable energy projects. The risks attached to these kind of projects in the first stages of development seem to be very critical, before a project can reach the stage of maturity successfully. I hope my thesis provides an interesting instrument for project developers to create project risks awareness, to communicate these risks to potential investors and find ways to effectively manage the project risks.

I would like to acknowledge the following people for their support, assistance and guidance:

Winfried Rijssenbeek of RR Energy BV for giving me the opportunity to take a look into the practice of a renewable energy consultancy.

Kökan Dulda of Falanj Energy AS for providing an excellent case study to test the instrument.

Frank Hoiting and Jorn Leeuwendal of Koop Duurzame Energie BV and Fred Bruin and Ids Auke Boersma of Econvert Climate & Energy BV for giving their time for interviews, their useful comments regarding their own project development procedures and feedback on the proposed instrument.

Fatma Ben Fadhl, manager of the project "Financial Risk Management Instruments for Renewable Energy Projects" of the United Nations Environment Programme for her interest and helpful comments.

My supervisors Henk Kroon and Rianne de Leeuw of the University of Twente for coaching, helpful comments and stimulating and guiding me in the right direction during writing this thesis.

Last but not least, I would like to thank friends and family and especially my girl Maaike for her love and support.

Heerenveen, 29 July 2008

Erik Jan Rodenhuis

Samenvatting

De huidige stijging van de prijzen van fossiele brandstoffen en energieprijzen stimuleren een grotere interesse in de aanwending van duurzame energiebronnen. Bovendien is er middels het verdrag van Kyoto overeengekomen dat er maatregelen genomen moeten worden om de wereldwijde uitstoot van broeikasgassen te reduceren. Zodoende zou men verwachten dat alle lichten 'op groen' staan voor duurzame energie. Ondanks de huidige ontwikkeling van de sector, zijn er nog diverse barrières voor energieprojecten om financiering te vinden. Een belangrijk probleem is dat de technologieën over het algemeen worden geassocieerd met onbekende, hoge en onduidelijke risico's. Daarnaast zijn project ontwikkelaar in deze sector regelmatig relatief onervaren en is er in de financiële sector weinig expertise ten aanzien van duurzame energie. Dit was de aanleiding tot de doelstelling van het onderzoek, namelijk het ontwikkelen van een instrument, dat inzicht verschaft in de risico's ten aanzien van duurzame energie projecten. Het instrument dient als hulpmiddel om projectrisico's inzichtelijk te maken voor projectontwikkelaars, de projectrisico's beter te kunnen communiceren naar potentiële investeerders en om zodoende methoden te vinden om deze risico's beter te kunnen beheersen.

Het ontwikkelde instrument bestaat uit drie stappen, waarin het project ontwikkelaars en investeerders een leidraad biedt voor de evaluatie van de project risico's. In de eerste stap worden vijf categorieën geïntroduceerd, namelijk bestuurlijke, bouw-, operationele, markt- en financiële risico's. Voor elke categorie wordt een procedure geboden, waarmee de projectrisico's kunnen worden geïdentificeerd.
In de tweede stap worden de geïdentificeerde risico's gescoord op basis van de *kans van optreden* en de *gevolgen van optreden* van het risico. Immers, risico is het product van kans maal gevolg. Het instrument neemt de lezer aan de hand bij het vaststellen van kans en gevolg, wat resulteert in een 'stoplichtmatrix' die per categorie de aanwezige projectrisico's weergeeft.
In de derde stap van het instrument wordt een risicoscore toegewezen aan de categorie en deze scores worden weergegeven in een 'risicospin', welke een overzicht geeft van het totale project risico.

Het instrument is voorgelegd aan vier ervaren projectontwikkelaars en geïllustreerd met praktijkvoorbeelden om het instrument te evalueren. Het instrument sluit aan op de praktijk van project ontwikkeling van duurzame energie projecten en is toepasbaar in de verschillende stadia van projectontwikkeling. De projectontwikkelaars beschouwen de tool als potentiële toevoeging op de alreeds gebruikte procedures. Het ontwerp van het instrument maakt het mogelijk om het instrument naar eigen behoefte en inzicht te wijzigen.
Volgens de projectontwikkelaars is het gebruik van subjectieve beoordelingen van de risico analist een beperking voor communicatie van risico's. Verder geeft het instrument geen expliciete oplossingsrichtingen voor de geanalyseerde risico's.

Naar aanleiding van de evaluatie zijn twee aanbevelingen gemaakt. Ten eerste, de ontwikkeling van risico reducerende maatregelen is gebaat bij meer inzicht in de aanleidingen en gevolgen van project risico's. Ten tweede, representatieve kwantitatieve cijfers ten aanzien van successen en mislukkingen in projectontwikkeling van duurzame energie, kan een meer genuanceerde risico perceptie van projectontwikkelaars en investeerders teweeg brengen.

Abstract

The currently escalating fossil fuels and energy prices contribute to a growing interest in renewable energy sources. Moreover, international agreements are established to lower the emissions of greenhouse gases globally. Therefore one would expect that renewable energy technologies would be receiving 'green light'. Although the sector is maturing fast, still the technologies are experiencing some hurdles to come to financial closure of actual projects. A prominent problem is that the technologies are generally associated with unfamiliar, high risks and unclear risks. Furthermore project developers are often rather inexperienced and within the financial sector there lack of understanding concerning renewable energy. Therefore the objective of the research was to develop a tool, that provides insights in the risks present in renewable energy projects, assists to communicate these risks and helps finding ways to effectively manage the project risks.

The developed tool consists out of three steps, whereby it assists project developers and investors to assess the project's risk. In the Step 1 five risk categories are introduced, namely regulatory, construction, operation, revenue and financial risks. For each of the categories a procedure is presented that enables to identify the risks present in the project.
In Step 2 the identified risks are rated upon their *probability of occurrence* and the *severity of the consequences*. After all, risk can be expressed by combining the probability and the impact by multiplication. The tool guides the reader in assessing probability and impact, which ultimately leads to a visualization of the risk per category in the traffic-light matrix. After compiling the traffic-light matrix the risk priority becomes visual.
In the third step the category risk scores can be made up from the individual risks within the category and are rendered to the risk spider, which gives an overview upon total project risk.

The tool was presented to four experienced project developers, tested with actual cases and evaluated. The tool fits to the practice of project evaluation and is applicable in various stages of project development. The project developers identify it as a practical and complimentary tool to their existing procedures. The design of the tool provides project developers and investors the ability to modify the tool at their own discretion. The project developers see the input of subjective judgments of the risk assessor as a limitation for the communication of risks. Furthermore the tool does not give direction to risk mitigation measures.

Therefore two recommendations were made to comply with these limitations. Firstly, the development of risk mitigating measures will benefit from more insight in the causes and consequences of project risks. Secondly, representative quantitative probability figures on project development successes and failures can improve the project developers' and investors' risk perceptions.

Contents

Acknowledgements i
Samenvatting ii
Abstract iii
Contents iv
List of figures v
List of tables vi
List of equations vi
List of used abbreviations vi
1 Introduction 1
2 Problem statement and design of the study 3
2.1 Problem statement 3
2.2 Research objective and strategy 7
2.3 Research questions and design 9
3 Project and Risk Assessment 13
3.1 Project evaluation 13
3.2 Risk 14
3.3 Risk assessment 14
3.4 Risk Management 17
4 Risk analysis tool for renewable energy projects 19
4.1 Model assumptions 19
4.2 Structure of the risk tool 19
5 Step 1: Identification of project risks 21
5.1 Identification of regulatory risks 22
5.2 Identification of development & construction risks 23
5.3 Identification of operational risks 24
5.4 Revenue risks 25
5.5 Financial risks 26
5.6 Outcomes of the first step and follow-up 27
6 Step 2: compiling the traffic-light matrix 29
6.1 Traffic-light matrix 29
6.2 Step 2A: Assessing probability of occurrence 32
6.2.1 Probability of occurrence for regulatory risks 32
6.2.2 Probability of occurrence of construction risks 34
6.2.3 Probability of occurrence of operational risks 37
6.2.4 Probability of occurrence of revenue risks 42
6.2.5 Probability of occurrence of financial risks 45
6.2.6 Conclusion and follow-up 46
6.3 Step 2B - Assessing the severity of consequences 47
6.3.1 Financial performance indicators 47
6.3.2 Composition of IRR and DSCR 48
6.3.3 Assessing the severity of consequences 51
6.3.4 Conclusions & follow-up 52
6.4 Step 2C - compiling the traffic-light matrix 53
6.4.1 Risk priority and assigning 53
6.4.2 Category risk scores 53
7 Step 3: Compiling the risk-spider 55
8 Evaluation & Recommendations 57
8.1 Evaluation of the tool 57
8.2 Recommendations 60
9 Conclusions 63
References 65

List of figures

Figure 1: The conventional energy project development cycle (CD4CDM 2007) 3
Figure 2: Renewable Energy Project Development Finance Continuum (Makinson 2005) 6
Figure 3: Investment cost in euros and risk for different types of renewable energy (Lindlein 2005) ... 7
Figure 4: The process of exploratory research (Routio 2007).. 8
Figure 5: Design of the research... 10
Figure 6: Process of project evaluation (Sonntag-O'Brien 2004) 13
Figure 7: Project risks over time for a renewable energy as an emissions reductions project 15
Figure 8: Basic form risk matrix 16
Figure 9: Outline of the stochastic risk model as applied by Marsh (2007)... 16
Figure 10: Flow diagram for risk assessment and treatment (Sadgrove 2005) 18
Figure 11: Flow diagram of application of the tool.. 20
Figure 12: Regulatory issues during the project lifecycle 22
Figure 13: Stakeholder approach to identify project construction risks 23
Figure 14: Stakeholder approach to identify project operational risks.. 24
Figure 15: Identification of revenue risks by analyzing supplied markets 25
Figure 16: Standard project finance cash flow model (CD4CDM 2007).. 26
Figure 17: Basic appearance of the traffic-light matrix.. 29
Figure 18: Example on compiling risks 31
Figure 19: Probability of occurrence of changing legislation and regulations.................................... 32
Figure 20: Probability of occurrence of rejection or withdrawal of permits and licenses.................... 33
Figure 21: Probability of occurrence of adverse changes in emissions reductions regulations 33
Figure 22: Probability of occurrence of co-developers risks.. 34
Figure 23: Risk probability of occurrence in advisory contracts... 35
Figure 24: Risk probability of occurrence in EPC contracts 36
Figure 25: Risk probability of occurrence of project company's default with respect to construction loan 36
Figure 26: Probability of occurrence of (fuel) supply risks 37
Figure 27: Probability of occurrence of operation interruptions or O&M cost escalation.................. 38
Figure 28: Probability of occurrence of employee underperformance.. 38
Figure 29: Probability of occurrence of temporarily grid inaccessibility.. 39
Figure 30: Probability of occurrence of non- disbursement of the suffered damage 39
Figure 31: Probability of occurrence of short falling assigned emissions reductions or certification delays... 40
Figure 32: Probability of occurrence of fraud or erroneous employee actions 40
Figure 33: Risk probability of occurrence of losing creditor support 41
Figure 34: Probability of occurrence of inability to sell produced energy and energy price risks........ 42
Figure 35: Probability of occurrence of REC market risks exposure.. 43
Figure 36: CDM project risk profile and it's impact on negotiated CER prices 44
Figure 37: Probability of occurrence of emission reductions price decreases or short falling project delivery.. 44
Figure 38: Risk probability of occurrence of currency risks 45
Figure 39: Probability of occurrence of base interest rate risks 46
Figure 40: Dupont chart for the IRR and the DSCR 48
Figure 41: Risk priority 53
Figure 42: Spider diagram for visualization of category scores... 55
Figure 43: Observed approach to project risks in current applied project assessments 58
Figure 44: Stage-gating in renewable energy project development 59
Figure 45: Bow-tie diagram for delay of equipment delivery risk... 61
Figure 46: Risk treatment strategies within the traffic-light matrix 62

List of tables

Table 1: Hurdles for renewable energy projects in the steps to financial closure (Lindlein 2005) 5
Table 2: Description of items in the Dupont chart with 49
Table 3: Severity of consequences ordinal scale 52

List of equations

Equation 1: Relation Net Present Value and Internal Rate of Return 47
Equation 2: Debt Service Coverage Ratio 47

List of used abbreviations

CDM	Clean Development Mechanism
CER	Certified Emission Reduction
DNA	Designated National Authority
DOE	Designated Operational Entity
EB UNFCCC	Executive Board UNFCCC
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortization
EPC contract	Engineering, Procurement and Construction contract
ERPA	Emissions Reductions Purchase Agreement
EU-ETS	European Union Emissions Trading System
IRR	Internal Rate of Return
JI	Joint Implementation
LDC’s	lesser developed countries
NPV	Net Present Value
O&M	Operation & Maintenance
PDD	Project Design Document
PPA	Power Purchase Agreement
RE	renewable energy
RECs	Renewable Energy Certificates
UNFCCC	United Nations Framework Convention on Climate Change
VER	Verified Emission Reduction (preliminary CER)
VER	Voluntary Emission Reduction

1 Introduction

The depletion of fossil reserves and the impact the use of fossil fuels has on the climate impose an urgency to apply more alternative power sources in the currently fossil fuels dominated energy markets. Several countries therefore adopted ambitious goals to reduce greenhouse gas emissions during the coming decades or even to become 'carbon neutral' by mid century. The transition to a low carbon economy will be one of the biggest challenges of this century. Therefore, governments and policy makers are introducing legislation and support mechanisms to accelerate the development of the sector.

The above mentioned developments combined with rising fossil fuel price are assumed to clear the path for investment in renewable energy technologies. But due to their scale, availability, high investment costs and relative immaturity these technologies are not yet applied on a large scale. Furthermore, these technologies are associated with high or unfamiliar risk. The limited understanding of project risks are generally imposing hurdles in the project development of renewable energy projects. Therefore a tool was developed that assists project developers to create a bigger awareness in the nature of the project risks, to communicate these risks to potential investors and to develop measures that make it possible to manage these risks effectively.

Chapter 2 discusses the problem statement in greater detail. Furthermore the research objectives and methodology are given. Chapter 3 reports upon project evaluation and the role of the risk assessment in this process. Chapter 4 presents the risk assessment tool, which consists out of three steps: identifying project risks (chapter 5), assessing project risks (chapter 6) and compiling the individual project risks into one final overview (chapter 7). Sheets for application of the tool are available in Annex 1. Chapter 8 reports upon the evaluation of the tool. This evaluation is done by having expert interviews and delivers recommendations for further research. Chapter 9 concludes on the answering of the problem statement and recommendations for further research.

2 Problem statement and design of the study

This chapter presents the problem statements, which in turn leads to defining the research objectives, research questions and methodology. The first paragraph deals with the problem statement and introduces the reader to the barriers in renewable energy project development. In this paragraph the problem statement will be formulated. The second paragraph addresses the research strategy and methodology, that lead to the formulation of the research questions in paragraph 3.

2.1 Problem statement

Investments in renewable energy projects face a varied palette of risks that endanger the project to reach successful implementation. Project developers face several hurdles to get from a project idea to a running project. As in any business start-up, feasibility studies and a business plan have to be developed. Furthermore the project needs operating permissions, long-term power purchase contracts, environmental impact assessments and contracts that mitigate risks in the construction and operational phase. Figure 1 below illustrates the steps in the development cycle.

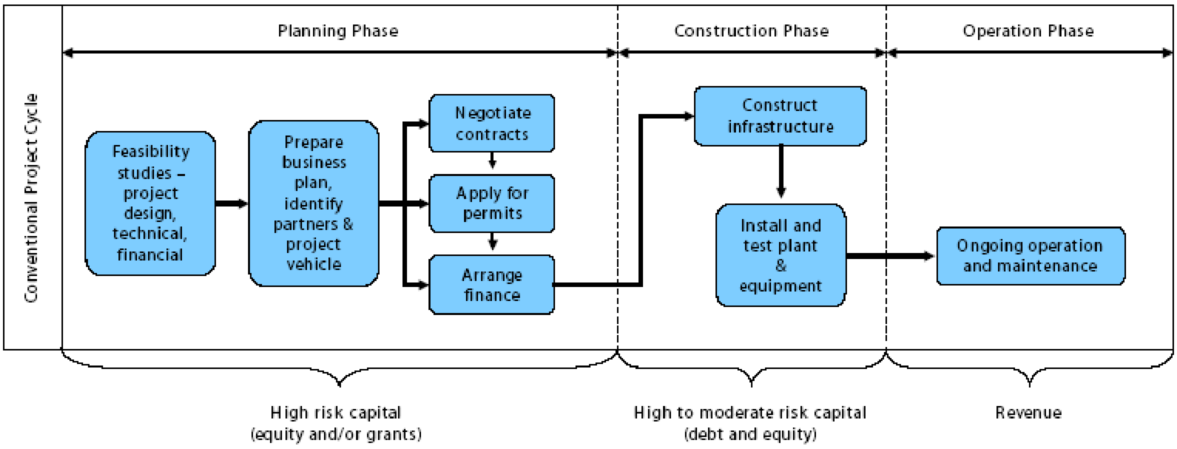


Figure 1: The conventional energy project development cycle (CD4CDM 2007)

In this process of project engineering the conclusion might be that it is not possible to implement the project, because the expected hurdles are too difficult to overcome. If the project is taken into development, these hurdles complicate the process of obtaining adequate financing. Because of relatively young technologies, renewable energy projects are seen as having a high-risk profile, and therefore these type of technologies and projects generally face some financing gaps. As a result, the project planning has to be executed with the developers own funds.
Lindlein and Mostert (2005) identify a number of hurdles that have to be taken throughout the process to come to a financial closure of the project. These are: inherent barriers of renewable energy, inherent hurdles of project sponsors, external hurdles in the energy sector and barriers in the financial sector. These hurdles are described in more detail below.

A. Inherent barriers of renewable energy

- **Capital cost intensive structure**: because of the high investment cost and low operational costs during the project lifetime, the Net Present Value is very sensitive to deviancies in the total cost of the commissioning and construction of the project. Projects typically have a high ratio of capital costs to operational costs.

- **Gaps in project analysis**: often there might be insufficient data for a prudent project analysis. It might be difficult to acquire certitude over the available renewable resources, good figures on the performance of the equipment and good future estimates on power prices and operational costs. In combination with the smaller project sizes than conventional energy technology the transaction costs are relatively high.
- **High and unclear risks** in construction and operational phase. This includes difficulties in guaranteeing a certain cash flow and the absence of enforceable securities. Operational risks are high due to young technologies with lack of proven commercial business models.

B. Inherent hurdles of project sponsors

- **Inexperienced project developers**: project developers often lack project experience or have a limited project portfolio to work with.
- **Limited financial and/or managerial capacity**: project sponsors often work from a technical oriented project idea or possess a suitable project-site. The do not necessarily have adequate financial or managerial capacities / skills.
- **Limited credit-worthiness**: due to the high investment and often small sponsors and developers there is lack of supplementary own funds.

C. External hurdles in the energy sector

- **Regulatory issues and policies** can favor conventional energy technologies or hamper introductions of renewable energy. Politically inducted policy changes concerning the energy sector create insecurity in the long-term legal framework. Power grid operators might be reluctant to deal with decentralized suppliers of energy.
- The energy market can be facing **imperfections of the market mechanism** for instance price regulations in order to stimulate economical growth. Furthermore deficiencies in the financial, legal or institutional framework may occur. Renewable energy generation cost might be higher than prevailing tariffs. Furthermore the market often does not value the public benefits of renewable energy.
- **Absence or lack of reliable partners** for take-off contract. And risk of change of instable feed-in laws or even absence of a feed-in law.

D. Barriers in the financial sector (especially in least developed countries)

- **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.

The hurdles for renewable energy projects in the steps to financial closure are summed up in Table 1. Here, three aspects are encircled. These encircled aspects show that there is a generally limited understanding of technology risks and also a lack of understanding of the risk exposure of both project developers and potential investors. This research will focus on these aspects in order to improve understanding of renewable energy project risks.

Table 1: Hurdles for renewable energy projects in the steps to financial closure (Lindlein 2005)

Inherent barriers of **renewable energy**	Inherent hurdles of RE **project sponsors**	External hurdles in the **energy sector**	Barriers in the **financial sector** especially in **LDCs**
Cost: Capital cost intensive structure; Analysis: insufficient data for prudent project analysis. Risk: High or unclear risk, incl. 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	Politics: Regulatory and policy issues which favor conventinal energy types or hamper RE; 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 take off contracts/ feed-in laws	Lack of funds and/or improper financial conditions, Lack of instruments and shortcomings of local financial institutions, Lack of sector know-how and willingness to invest in RE, low level of awareness and understanding of the RE as well as insufficient information for prudent investment analysis. High collateral requirements.

The identified barriers impede the implementation of renewable energy projects and create financing gaps in two major areas. Firstly, in the project preparatory phase projects often lack development capital to cover the transaction cost of obtaining a prudent business plan and sound project structuring. Secondly, problems may arise when there is a need to widen the debt-equity gap to provide investors with a proper return on investment. Due to the likely absence of adequate risk management instruments, it might be difficult to create financial leverage and thus a relatively high portion of equity is needed. Of course, this depends heavily on local financial, regulatory and technology contexts. In general renewable energy projects have high up-front capital costs and therefore long-term financing requirements; small overall project sizes compared to conventional energy projects; high transaction costs and a general lack of familiarity with renewable energy on the part of investors and lenders.

As for the first gap, the financing gap in the preparation phase, there is a need for soft loans and/or contingent grants to cover the development costs. The second financing gap, namely the debt/equity gap, needs to be overcome with third party finance (such as from technology suppliers) and innovative financing products like mezzanine finance and a proper risk management package. Figure 2 illustrates the financing gaps and the blue boxes and arrows visualize the existing and proposed innovative finance mechanisms (Makinson 2005).

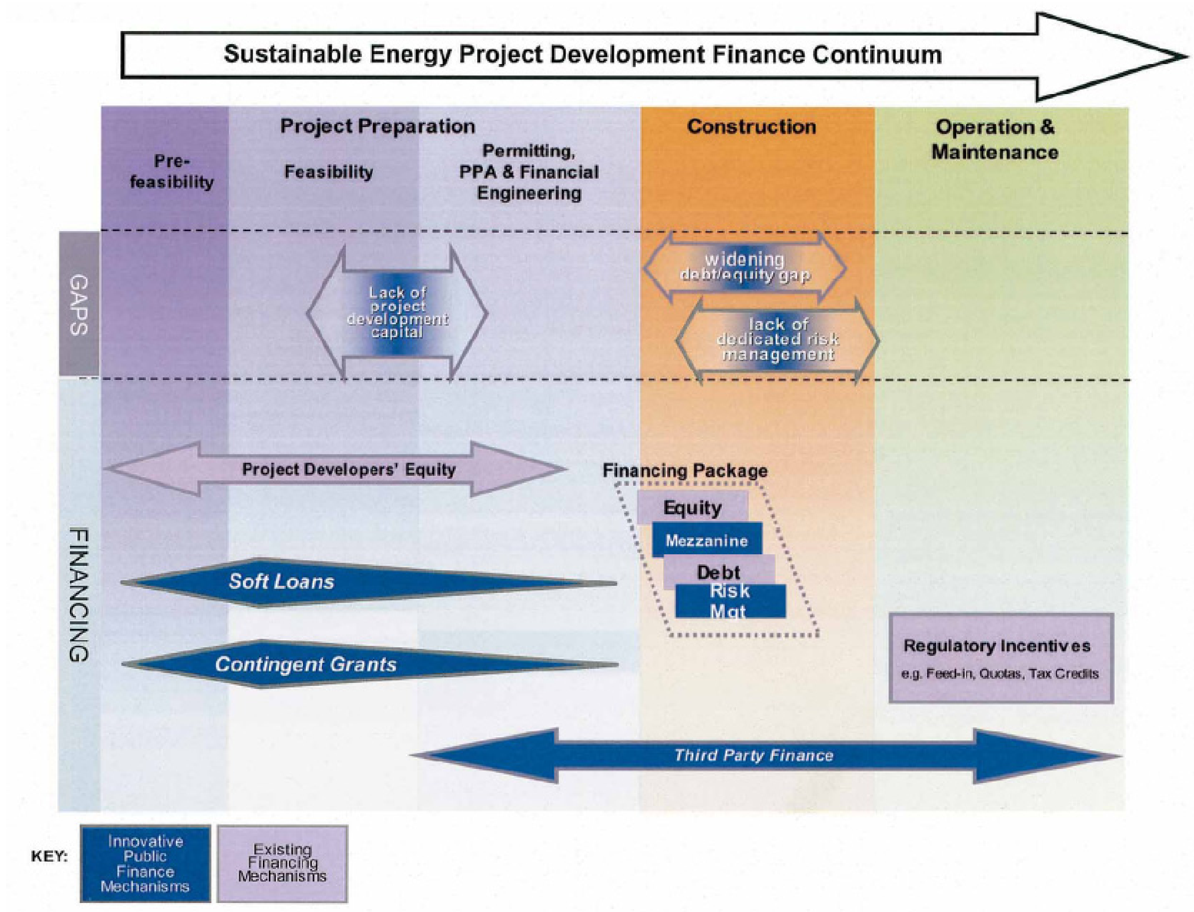


Figure 2: Renewable Energy Project Development Finance Continuum (Makinson 2005)

As renewable energy can be applied on different scales and in very different contexts the relevance of different financial sources and options for financial structuring will diverge. Lindlein (2005) illustrated the prevailing investment structure according to the total investment cost (see Figure 3). On one hand pico-hydro, biogas application for cooking purposes and small solar photovoltaic power will depend on consumer- and micro credits. Investments in the range from 30 thousand to 20 million euro will be mostly in the field of corporate financing. For large projects with investment sums greater than 20 million euro advanced financial engineering of projects with project finance makes sense. Also the figure displays on the vertical axis the perceived risk, whereby only low to medium risk technologies are included. New Energy Finance Research (2007) observes that financial solutions for the renewable energy sector are evolving and that this is leading to more finance deals.

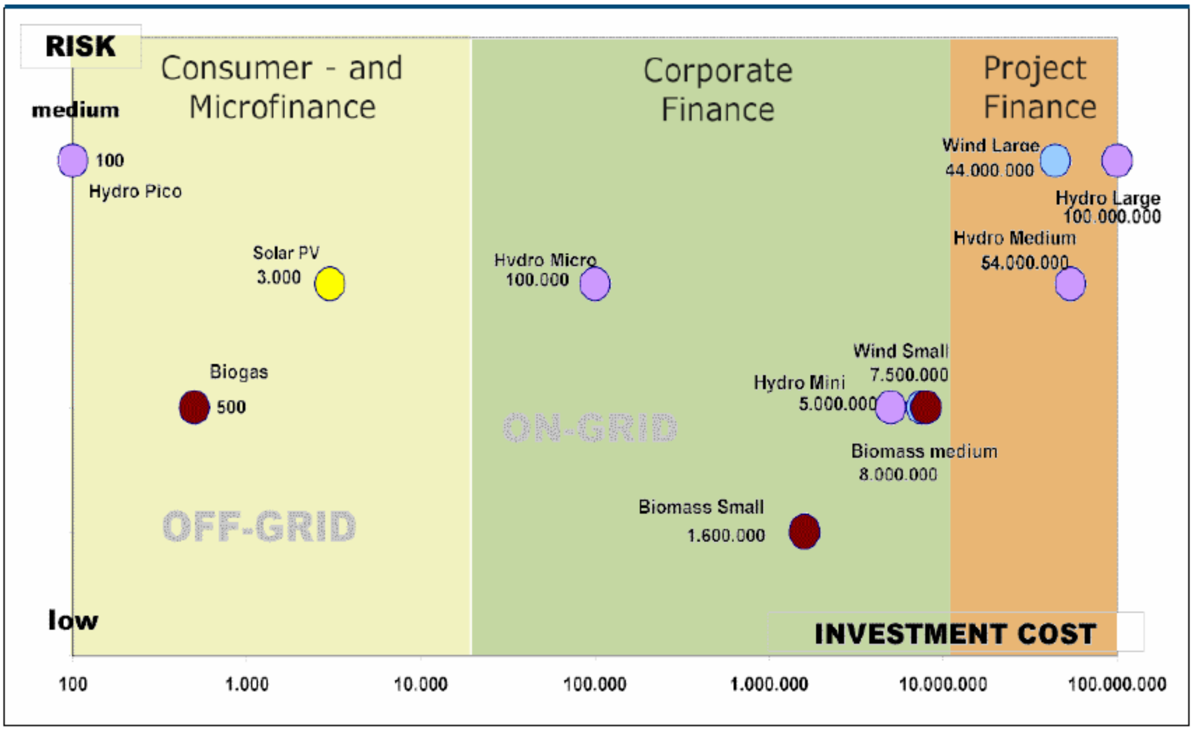


Figure 3: Investment cost in euros and risk for different types of renewable energy (Lindlein 2005)

Makinson (2005) concludes that if more suitable risk management instruments and risk transfer tools existed, this would lead to a better finance availability for project developers. This conclusion, when combined with the hurdles identified by Lindlein (2005), outlines the general problem faced by renewable energy projects: general uncertainty concerning the risk exposure of these projects. Because of limited risk awareness, there is a need for sound risk assessment procedures that make it possible to introduce risk management strategies and instruments. Furthermore, a better understanding of the risk exposure helps project developers to communicate risks to potential investors. The problem statement of this research is therefore:

In order to come to final closure of a renewable energy project, there is lack of understanding of the nature of project risks, which limits clear communication of project risks to potential investors and complicates effective risk management.

In order to provide a solution for the stated problem, the objective of this research is to develop a risk analysis procedure that serves as a tool to identify, value, communicate and manage project risks. The next paragraph describes the applied research methodology for the development of the tool and states the research objectives and strategy.

2.2 Research objective and strategy

This paragraph describes the approach to develop a risk analysis tool that resolves the formulated problem statement in the previous paragraph. In order to structure the problem further and provide an adequate solution qualitative research methods are chosen. The research objective is based on the problem statement and reads:

The research objective is the development of a tool, that increases risk awareness for renewable energy project developers, improves the ability to communicate risks to potential investors and gives direction to effective ways to manage these project risks.

The research objective aims to create a tool to improve the risk assessment of renewable energy projects, as well as to increase theory on renewable energy project risks. The study aims to design an instrument that has a proper fit with the current practice and benefits from methods already available in other disciplines. Therefore the research displays characteristics of *exploratory normative research* and *grounded theory*. In a process of continuous comparison of the current risk assessment practice and available procedures, a tool is designed.

In 'normative research', models are used to describe the existing problems and to define improvements to the object of study. Exploratory research can also be applied on normative studies, in the situation where the desirable improvement of the object of study is unclear. The goal of exploratory research is to 'unearth' theory from the empirical situation. This theory should be valid in all, or at least most cases, which can be done by abstraction and generalization of the empirical object. A general strategy is to apply different viewpoints to the object. Figure 4 illustrates the practice of exploratory research, in which viewpoints or existing theories are applied to the object of study. The outcome of the research can be both new theoretical concepts and an improved object of study. Important in a normative study is to define the normative point of view for evaluation of the proposed improvement. In order to reach an acceptable result it is quite usual, that the sequence is repeated several times (Routio 2007).

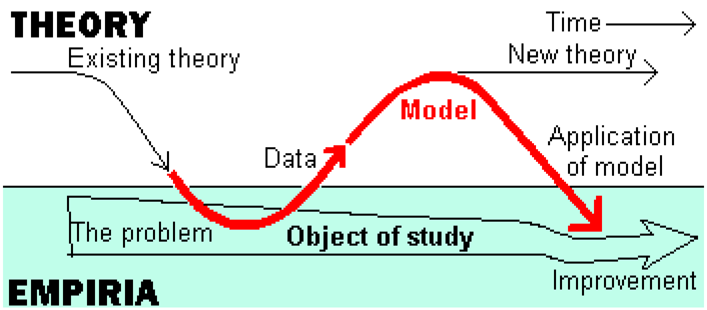


Figure 4: The process of exploratory research (Routio 2007)

Grounded theory (Verschuren 2003) is a general method of comparative analysis, in which observations in the empirical world are compared with theoretical concepts. Main characteristics of this research method are:

1. the researcher uses a seeking 'hermeneutic' approach;
2. a continuous comparison of empirical and theoretical concepts is executed;
3. the careful application of a coding technique in order to enable other researchers to scrutinize the results.

Grounded theory as well as exploratory research work through a number of cycles in order to generalize the empirical world into theories and test the theory to practical situation. Analogous to the criteria of grounded theory, the objective needs to meet the following requirements:

- Fit: the concept needs to fit closely with the objective it is representing;
- Relevance: the study deals with a real concern of holders of a problem and is not only of academic interest;

- Workability: the theory also explains how the problem is being solved with much variation;
- Modifiability: the theoretical concept can be altered when there is relevant new data.

Based on the requirements of *exploratory normative research* and *grounded theory* the research objective needs:

1. evaluation of the proposed tool by members of the interest group, namely project developers in renewable energy;
2. to meet the requirements of grounded theory, namely fit, relevance, workability and modifiability.

2.3 Research questions and design

The research design for this research results from the research objective and strategy, as described in the previous paragraph. Figure 5 visualizes the application of the aforementioned research strategies on the research object, which is the risk assessment of renewable energy projects. The red arrow describes the process of exploratory research and the continuous comparison of the empirical world with theoretical concepts.
Exploratory techniques are used, such as informal conversations and taking cognizance of a broad range of written information sources. Informal conversations were held with project owners, project developers, carbon developers and brokers. Written information sources include academic literature, industry magazines, renewable energy market surveys, carbon market surveys and digital newsletters.
In continuous comparison with the observed patterns in risk assessment practice and actual projects in various stages of development, appropriate theories were sought to describe the phenomenon (selective coding). Also the model and tool were evaluated in expert evaluations.
The delivered risk assessment model aims to improve understanding of renewable energy project risks. The model can be used as a tool for project and allows the assessor to insert its financial performance indicator, that acts as a benchmark.

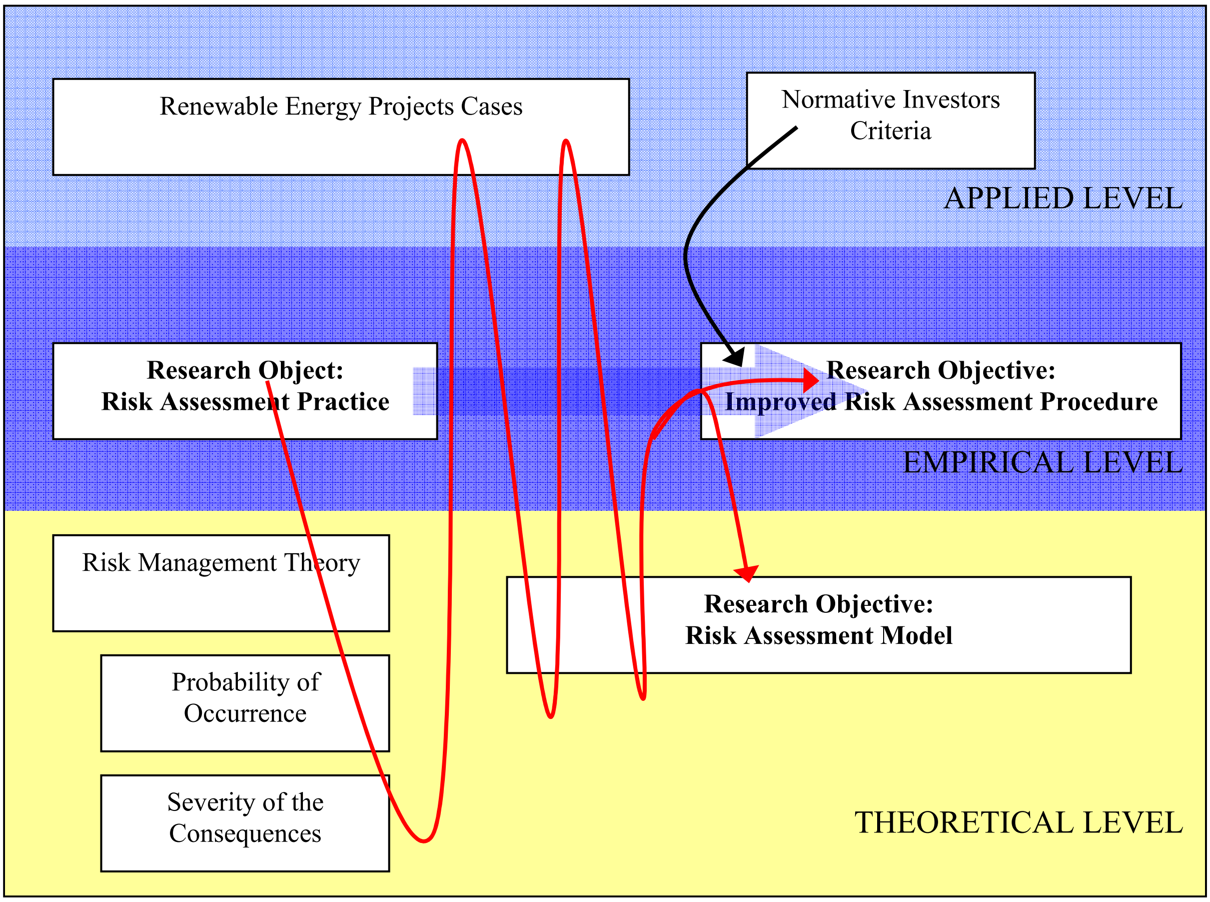


Figure 5: Design of the research

According to the research objective a tool is needed that assists project developers in increasing their risk awareness, that makes it possible to communicate the risks effectively to potential investors and that gives direction to possible risk management strategies. The main research question is therefore:

How can risks in renewable energy projects be assessed in order to provide project developers and potential investors with a broader understanding in the nature of these risks?

In order to conduct exploratory research on the risk assessment of renewable energy projects, the following sub questions were defined:

1. How is risk assessment done by professionals in the renewable energy sector?
    a. What other project aspects, besides the project risks, are taken into consideration in project evaluation?
    b. Do they classify the risks in categories?
    c. What are the characteristics of renewable energy projects that manage to reach the construction and operational stage? And why?

In order to gain more insight in the nature of the object, research was applied on the concept ‘risk’, with use of the following questions:

2. What existing risk structuring methods could fit to the risks present in renewable energy project development?
    a. What is risk? What are the central themes in risk terminology?
    b. What mechanisms influence the probability of occurrence?

c. How can the severity of consequences be expressed?
d. How do ‘probability of occurrence’ and ‘severity of consequences’ relate to risk perception?
e. What methods are available from other disciplines risk assessments done in other applications, such as risk assessments related to safety and health issues?

Observations of the process of risk assessment are normative for the development of the risk model. Continuous comparison of existing theories, observations and actual cases is executed in which is focused on the criteria: fit, relevance, workability and modifiability. Therefore critical reflection is needed on the taken actions. In order to evaluate the model and tool, experienced project developers have been asked to evaluate the tool on the aforementioned criteria. The questions for evaluation are:

3. Does the tool provide the project developers with an additional understanding of project risks?
   a. Does the model fit with the practice of project assessment?
   b. Is the risk assessment tool supplementary to the procedures already in use?
   c. Is the risk assessment tool practical and workable?
   d. Is the risk assessment tool modifiable when new data is available?

The next chapter answers the exploratory questions 1 and 2. Chapter 8 discusses the evaluation of the risk assessment tool and therefore answers question 3.

3 Project and Risk Assessment

This chapter introduces the reader with the major themes in project evaluation and the relation with risks and how these risks are assessed. The first paragraph discusses the process of project evaluation and the role of risk within project evaluation. The second paragraph deals with the concept ‘risk’. Paragraph 3 describes risk assessment approaches. Based on this risk assessment a risk treatment is needed, which is discussed in the fourth paragraph.

3.1 Project evaluation

“Risk – let’s get it straight upfront – is good! The point of risk management isn’t to eliminate it; that would eliminate reward. The point is to manage it – that is, to choose where to place bets, and where to avoid betting altogether.”

The lines above from Thomas Stewart (2000) provide a good understanding of the relation between risk and return. The two are strongly linked. An investor will typically look for better than average investments that make a good trade-off between the risk associated and the expected return, thus lying above the efficient market line. Figure 6 visualizes the process of project evaluation, where the investor takes both risk and return into consideration (Sonntag-O’Brien 2004). In this process the investors aim is to maximize the trade-off between risk and return, which means that an investor will strive for:

- Maximization of the expected return, given the risk;
- Minimization of the risk, given the expected return.

This investor’s behavior is visualized with the yield curve, which draws a line between investments that meet the investor’s expected trade-off and those that are unable to meet this trade-off (Dorsman 1999).

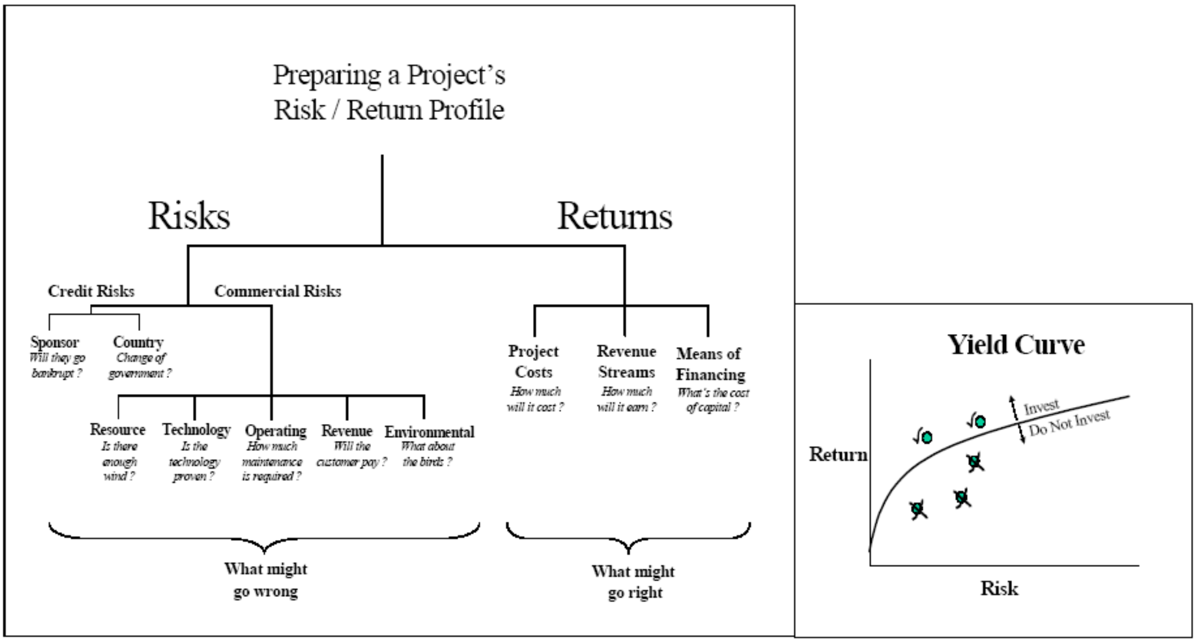


Figure 6: Process of project evaluation (Sonntag-O’Brien 2004)

In informal conversations held at the Carbon Expo 2007 the majority of interviewed carbon investors stated that they assess projects on a case-to-case basis. Besides the trade-off between risk and return, the carbon investors mentioned other considerations that are of interest in project evaluation, such as:

- Portfolio requirements (size, need for diversification in portfolio)
- Minimum project size in order to compensate transaction costs
- Access to a bigger portfolio of similar projects
- Specific country or technology focus or exclusions
- Local representation in project country

From a utility perspective these considerations aim to maximize the risk-return trade-off within the total project portfolio.

3.2 Risk

A project proposal will make assumptions for the expected uncertainties and risks. Knight (1921) defined risk as an uncertainty with a probability that is known through past experience. Uncertainty refers, according to Knight, to a situation where there is no objective way to place a probability on an event. Under the definitions of Knight, risk is associated with mathematical assumptions and can be quantitatively assessed. Conversely, uncertainty lacks a probability function and cannot be quantitatively assessed.
In risk-return theories the risk is defined as the expected variance of the expected return. In this approach ‘risk’ is a neutral term to describe uncertainties. The dictionary’s definition tends to be more subjective, because it focuses on the potential negative impact of an undesirable event, whether or not it actually takes place. Risk is therefore the multiplication of the probability of an undesired event and the impact of this event.

$$\text{Risk} = (\text{probability of occurence}) \bullet (\text{severity of the consequences})$$

Because risk is defined as an equation, it can be mathematically assessed if the parameters ‘probability of occurrence’ and ‘severity of the consequences’ are known. In cases where there is lack of a realistic probability distribution the risks have to be assessed qualitatively.
The maximal amount of damage that could be suffered due to an undesirable event is the Value-at-Risk or the risk exposure. Risk exposure is a measure for a worst case rather unlikely event to occur.
Volatility gives an indicator of the events and impacts to occur on a higher probability level, because it uses a confidence interval for the range between best- and worst-case scenario’s. Risk volatility is the variability in possible outcomes within a certain confidence level. Risk volatility can be derived from a dataset of scenario projections or data on past events. Risk severity is another definition on risk, which addresses the amount of damage that is likely to be suffered (Lam 2003). In this study the term risk is applied to uncertain events that can have a negative impact on a project, whether or not an objective probability is known.

3.3 Risk assessment

The previous paragraph briefly presented the different concepts that are relevant when assessing project risks. This paragraph describes available risk assessment methods.
Renewable energy project face a number of risks, especially when the project also serves as an emission reductions project. In this case an additional cash flow, but also a new set of risks are brought into the project. Figure 7 presents the risks in an renewable energy project, that also serves as an emissions reductions project (CD4CDM 2007). During the different stages the project is exposed to different risks. The inclusion of the absolute risks accentuates that the absolute perceived risk declines after testing and commissioning of the project.

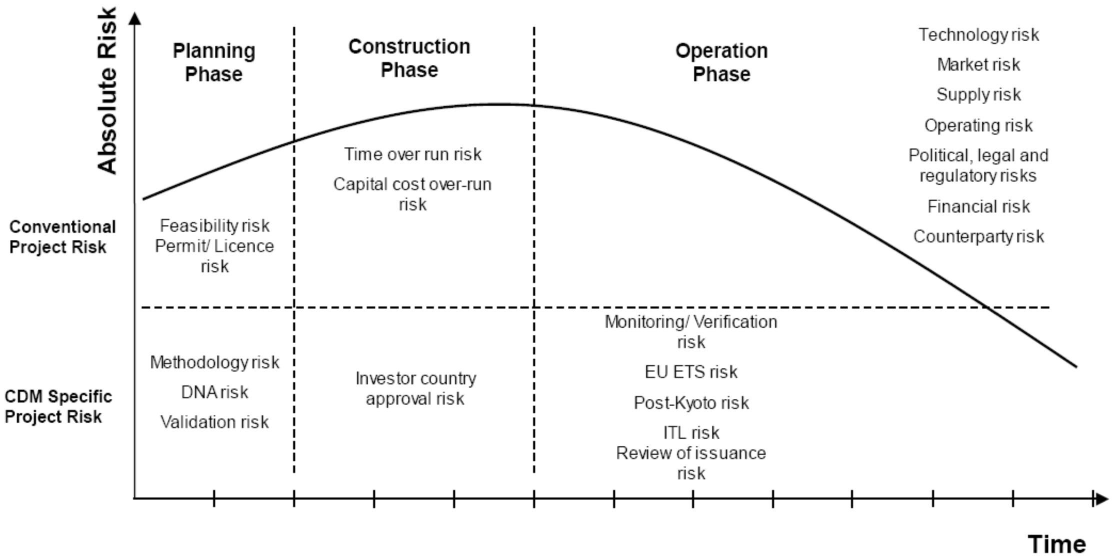


Figure 7: Project risks over time for a renewable energy as an emissions reductions project

Usually these risks are categorized by the phase of the lifecycle and a chronological approach to the risk assessment is applied. Beidleman (1990) and UNEP (2006) group the individual risks in four categories: development, construction, operation and ongoing risks. Others simply distinguish pre-completion and post-completion risks (Fieldstone Private Capital Group 1993). Other approaches aim to group the individual risks into more general classifications of risk (Marsh 2007, De Waal 2007, Bishop 2007).
Beidleman (1990) describes risks in project finance qualitatively and proposes risk allocation amongst the project stakeholders in order to reduce the probability of a risk to occur. The proposed risk sharing and assigning methods could be described with agency theory. The structure of the project company’s contracts should assign risks to stakeholders that are well able to bear the specific risk and give incentives that compensate for bearing the risk. Also other authors suggest mechanisms that can apply these principles in contracts of the project company and its stakeholders (Fieldstone Private Capital Group 1993, UNEP 2006, Marsh 2007, Bishop 2007). UNEP (2006) and Marsh (2007) focus on financial instruments to restructure and transfer risks.
UNEP (2006) uses an ordinal scale to rate the probability and impact of individual risks, an approach that is also practiced in related risk literature on health, physical hazard or environmental risks. From these sources practical risk visualizations methods are available that provide a risk score to specific risks. Figure 8 displays a risk matrix in its most simplest form. Both likelihood and consequences can be rated on an ordinal scale. Qualitative or quantitative measures can be applied to one or both ordinal scales and the number can vary. Risk increases along the diagonal from the lower left hand corner to the upper right hand corner. Each color represents a zone of roughly equal amounts of risks. Risk scores can be applied in order to distinct between cells within each zone (Barringer 2004, Aerospace Institute 2003). With these methods risk scores can be applied and can be compared with a benchmark for an acceptable risk level.

Likeli-hood					
	high	4	6	8	10
	medium	2	4	6	8
	low	1	2	4	6
		minor	significant	critical	catastrophic
		Consequence			

Figure 8: Basic form risk matrix

Marsh (2007) applies probability distributions to a number of the project risks, in order to calculate the probability distribution of the project return by applying Monte Carlo simulations[1]. The advantage of Monte Carlo simulations is that it can deliver the return of a project within a level of confidence. As this approach needs objective probability distributions, it has limitations.

Figure 9 outlines the project model as applied by Marsh. In this model some parameters are assumed to be static, while other have a continuous distribution. The calibration of the model is based on several sources, among other sources a web survey among 31 experts, historical meteorological and market data. The model applies to a Chinese wind project, that also generates income from emissions reduction under the CDM. The research of Marsh was conducted in order to value financial risk instruments. This limits the reproducibility for other renewable energy projects, because the used probability distributions might not hold true in another context. The respondents in the survey executed by Marsh (2007) ranked ‘contract bankability’ as the most significant risk, which is described as “Risk of being unable to secure a bankable off taker or fuel supply contracts”. The probability of this risk was determined by the survey, which makes this kind of approach impractical for an individual project developer.

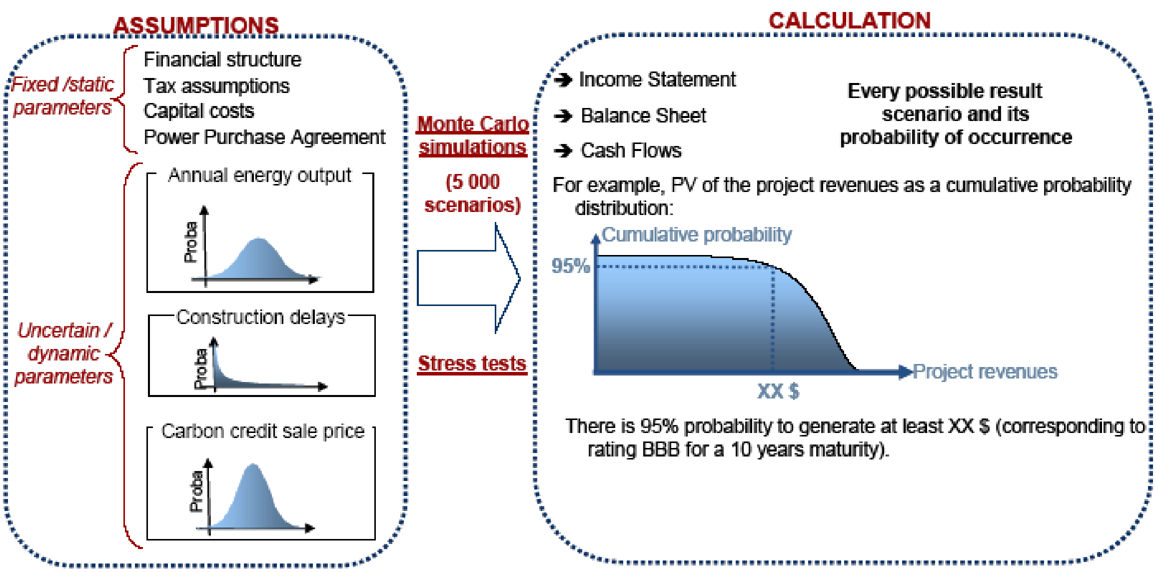


Figure 9: Outline of the stochastic risk model as applied by Marsh (2007)

[1] Commercial Excel Add-ins that can execute these tasks are amongst others Palisade’s @Risk and Oracle’s Crystal Ball.

The renewable energy project analysis software Retscreen[2] enables users to perform a sensitivity analysis on a number of parameters, namely energy price, annual generated energy, initial project costs, annual operational costs, debt ratio, debt interest rate, debt term, the emission reduction credit price and/or the renewable energy production credit. The user can also apply normal distributions to these parameters to perform Monte Carlo simulations. The normal distributions are based on the variance range of the parameter as provided by the user. The Retscreen model is practical for the majority of risks that have a known influence on the aforementioned parameters. It provides project developers with a broad understanding about the influence of risk on the financial parameters.

3.4 Risk Management

Risk management starts with risk awareness by executing a risk assessment, which gives an overview and prioritization of risks. Based on the risks identified, there are different ways to treat the risks (Sadgrove 2005) :

- Avoidance: choosing to not accept the risk. This implies that the investor chooses not to invest or looks for an exit strategy in order to have no risk exposure from the project or operations.
- Minimization: reducing or controlling the risk, by implementing increased monitoring, changing or implementing procedures or changing characteristics of the project. Risk minimization will come with extra costs to control the risk.
- Transferring (also known as spreading or sharing the risk): this can be done by portfolio diversification, sub-contracting, outsourcing, joint venturing, market hedges or insurance products. Transferring risk causes an opportunity cost for lowering the risk to an acceptable level.
- Acceptance: deciding that the risk is within agreed acceptable risk tolerances and manageable.

If risks are accepted it is of great importance to monitor the accepted risks. This can be done by setting key performance indicators and keeping an eye on trends that indicate a growing risk or variances from the norm. The general risk management line of action is visualized in Figure 10.

[2] The freeware RETScreen Clean Energy Project Analysis Software is also attributed with a simple sensitivity and risk analysis using Monte Carlo simulations. Software and documentation is available at: http://www.retscreen.net/

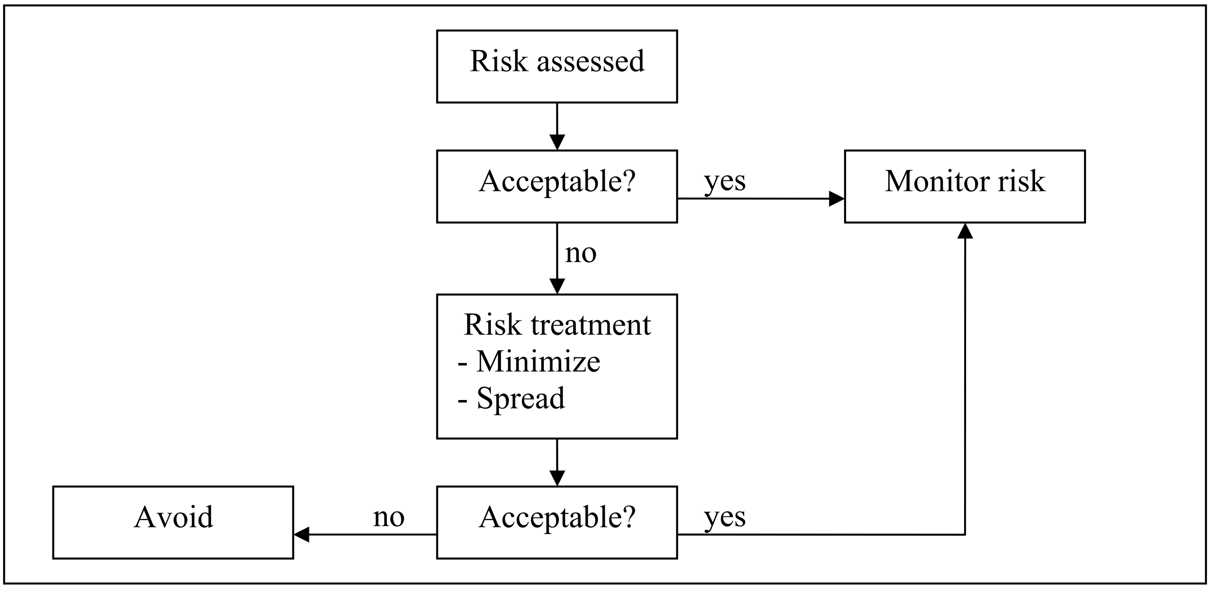


Figure 10: Flow diagram for risk assessment and treatment (Sadgrove 2005)

4 Risk analysis tool for renewable energy projects

The previous chapter described the observations of the exploratory research on the current practice of risk assessment and the analytical tools available for risk assessment. The continuous comparison of observations of the empirical world and available risk assessment approaches led to the design of a risk tool.

With a model one tries to 'catch' the empirical world as best as possible, but is also a simplification of the mechanisms taking place. The model describes rational behaviour based on a number of assumptions, which are discussed in the first paragraph. Hereafter the second paragraph presents the basic structure of the tool. In the next chapters the different steps of the tool will be discussed more extensively.

4.1 Model assumptions

The model has a number of underlying assumptions, which are:

- Absolute quantification of the probability of occurrence of project risks is impractical for individual project developers or investors. An ordinal score based on qualitative criteria would provide a more practical solution.
- Project developers and investors apply rational decisions based on financial criteria. The severity of the consequences is therefore evaluated with financial parameters. To limit the number of calculated scenario's the impact is also rated on an ordinal scale.
- In order to obtain a better overview of the risks, the risks are categorized in categories. The individual risks within a category share similar distributions and/or similar triggering mechanisms. In order to assign a score to a risk category, the most significant risks prevail.
- Evaluation of the categories' risk scores needs a proper benchmark, which relates the developer's or investor's risk perception.

4.2 Structure of the risk tool

Based on the assumptions stated above, and in line with the research objective, a risk analysis procedure is developed which has the purpose to assist project developers of renewable energy projects in:

1. identify occurring risks during the project lifecycle of a renewable energy project;
2. give insight in the severity of the consequences and probability of occurrence of a specific risk: the risk exposure and prioritize the different risks for risk mitigation measures;
3. give an overview of the total risk exposure of a project and the implication for the financability of the project.

Figure 11 shows the structure of the risk tool. Based on the outcomes project owners and developers can choose to restructure the project characteristics with available instruments in order to improve the project. The model assists in uncovering of the risk exposure of a renewable energy project. Based on this assessment project developers can:

- decide to avoid the risk, in other words choose to refrain from further restructuring of the project;
- implement instruments to minimize certain risks;
- look for ways to transfer risks to other stakeholders in the project;
- accept the risk exposure of the project if the risks are at an acceptable level.

This is visualized with the 'project restructuring loop' in Figure 11, in which risks are mitigated or transferred if a project owner is reluctant to accept the risk. The model does not give explicit direction to instruments that can change the risk exposure, by:

4. appointing stakeholders that have influence over the identified risks;
5. restructuring the project.

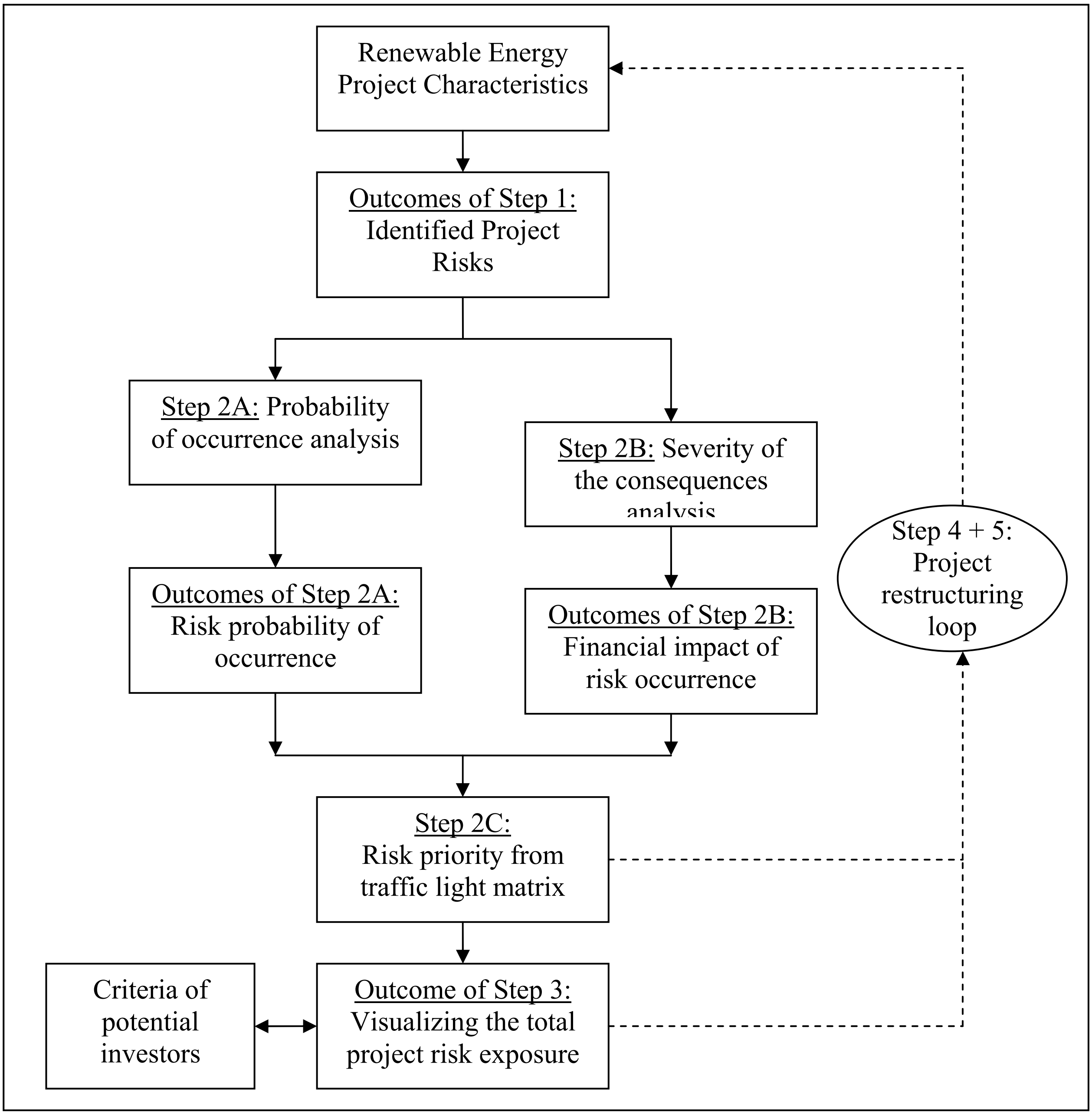


Figure 11: Flow diagram of application of the tool

The following three chapters describe the risk identification step, the risk analysis step and the compiling of a total project risk overview in more detail.

5 Step 1: Identification of project risks

The first step of analyzing risks, starts with the identification of all the risks present in the project. Based on the applied technology, location, local policies and supplied markets several risks can be identified. In this chapter five categories are defined and accompanying approaches are presented to identify all possible risks. In this stage it is not necessary to estimate the magnitude of a risk, nor its severity of consequences. This will be done in the following second steps.

The latter strategy is applied and therefore five categories are identified, namely:

- Regulatory risks: risks that are influenced by actions from governments or other authorities and tend to be outside the project company's sphere of influence;
- Development & Construction risks: risks that are influenced by the stakeholders in the projects during set-up and construction of the project and can be managed by sound contractual arrangements;
- Operational risks: risks that are influenced by the stakeholders in the project during the exploitation of the project and can be managed by sound contractual arrangements;
- Revenue risks: risks that arise from the market on which the project sells it's products;
- Financial risks: risks that arise from other market mechanisms than the primary markets the project sell it's products on.

In the following subparagraphs the identification of the risks will be discussed per category.

5.1 Identification of regulatory risks

For project development, construction and operation several licenses and permits are needed. Usually the availability and conditions of obtaining the permits are assessed in an early project stage. During the project regulations and legislation might be subject to change, which imposes risks on the project. Secondly the regulations concerning foreign investment and repatriation of capital is of importance to finance providers. In order to get a complete listing of all the risks involved, the lifecycle of the project is observed and assessed on the legal issues related to (foreign) investment, construction, operation, sales and expatriation of capital. The regulatory issues are visualized in Figure 12 and provide a listing of legal and regulatory risks present in the project. Different risks can become manifest during the period of investment in the project. The latter is visualized with the arrow. When the ownership of the project changes, refinancing is executed or major refurbishment is taking place the investment cycle recurs.

The needed permits and licenses are essential for project implementation, others factors such as taxation and repatriation of capital can lower the expected net return of the project.

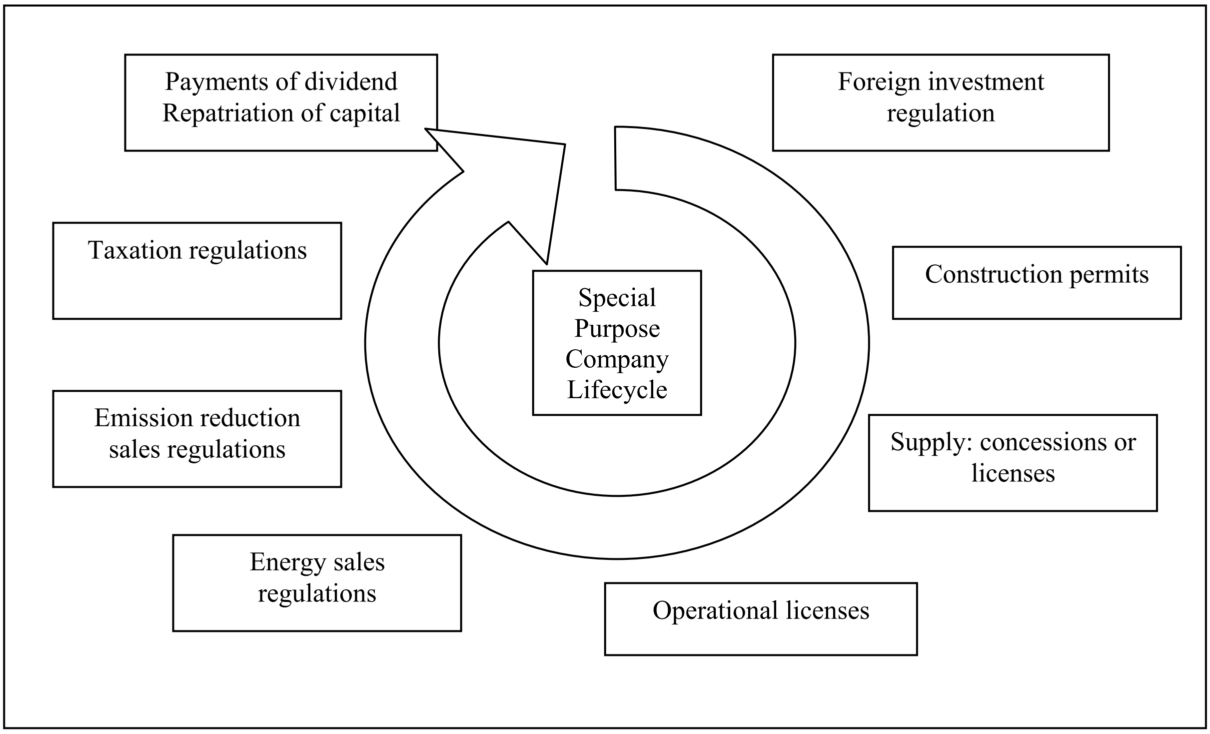


Figure 12: Regulatory issues during the project lifecycle

5.2 Identification of development & construction risks

This paragraph discusses the procedure for identification of risks from initial development through testing and commissioning of the project. In order to start with the civil works contracts are closed for engineering, procurement and construction. The terms of the contracts distribute the various risks among the principal and the contracted parties. Assessment of the contracts is needed in order to list all the risks related to the development & construction phase assessment of the contracts is needed. A stakeholder-approach is used in order to identify the project risks, whereby the relevant contracts are listed in Figure 13. Based on the terms of the contracts and the trustworthiness of the contracted parties a overview of the risk allocation between principal and contracted parties can be given. The arrow visualizes the risk balance for generally occurring cost and time overruns risks during development, engineering, procurement and construction.

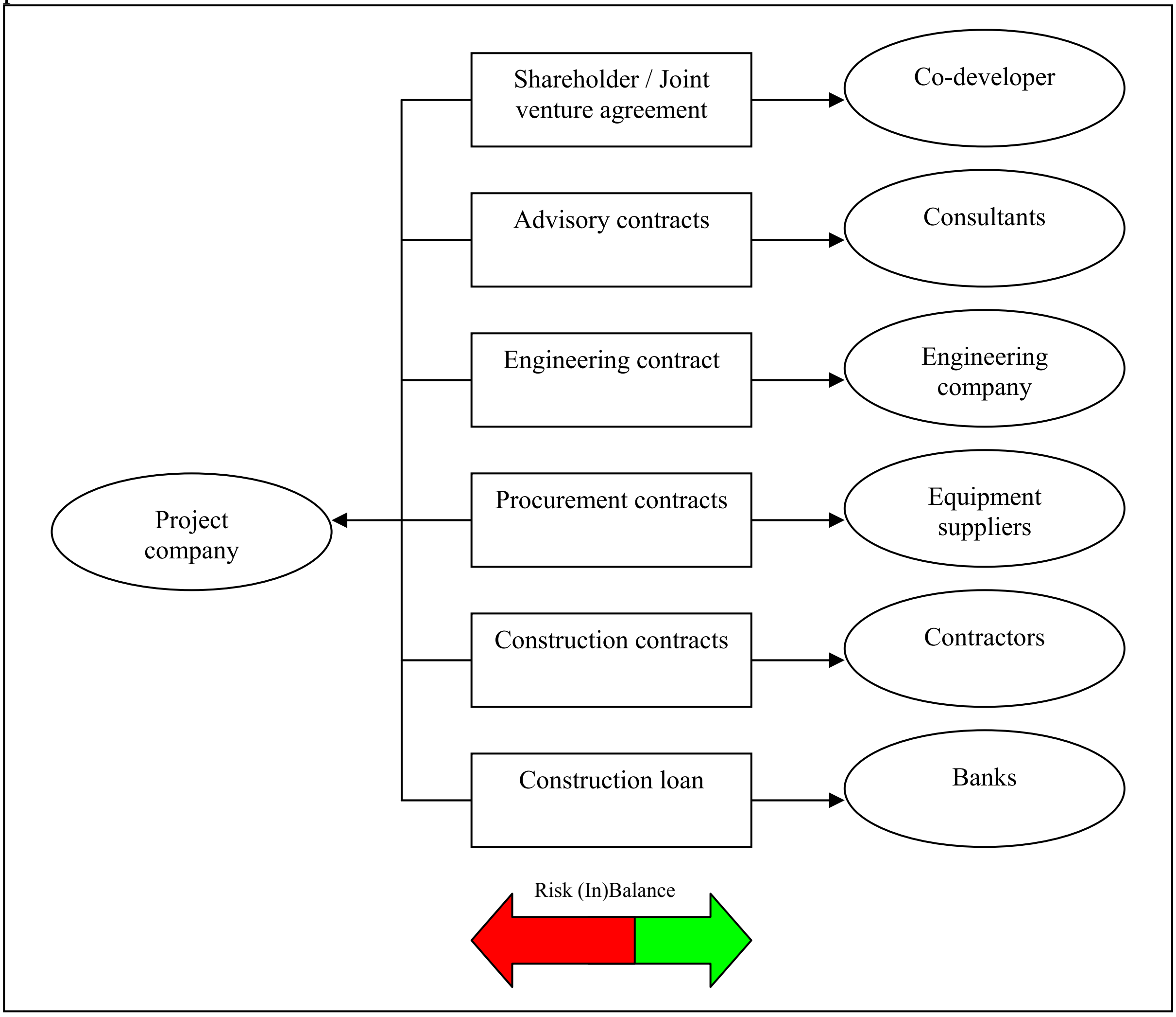


Figure 13: Stakeholder approach to identify project construction risks

5.3 Identification of operational risks

Several contracts are closed in order to secure supplies, operation and sales. Again the terms of the contracts decide the allocating of the project risks among the project stakeholders. Analog to the identification of construction risks, a stakeholder-approach on the productive inputs is executed by analyzing the relevant contracts during exploitation of the project. For practical purposes the risks associated to the sale of the project products are categorized under revenue risks. In Figure 14 the several possible contractual arrangements are given which arrange the risk allocation between the contracting parties. Also, the company's procedures to control internal risks are assessed on their quality. Procedures aim to prevent unwanted events, such as jeopardies due to operator errors or financial losses due to fraud.

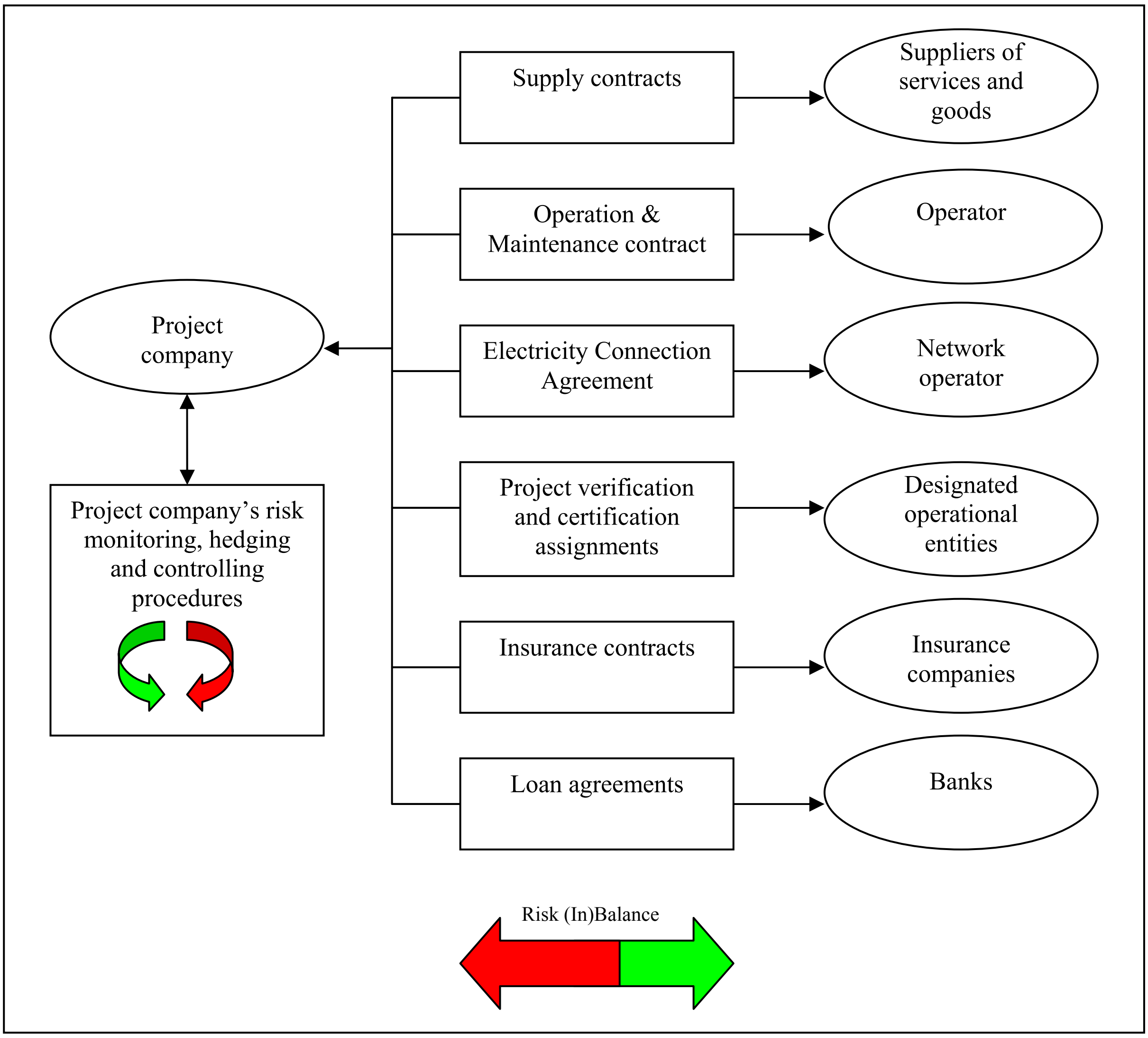


Figure 14: Stakeholder approach to identify project operational risks

5.4 Revenue risks

Future market developments influence the price of the projects deliverables. The project company can enter purchase contracts, but can also decide to have an exposure to the market developments. A PPA is a contract with a long duration, whereas spot market sales are immediately effective and have a short duration. Renewable Energy Certificates (RECs) and emission reductions credits are commodities that are representing the social and environmental benefits of the usage of renewable energy sources. These commodities are both traded under different standards and demanded by both compliance and voluntary markets. RECs and emission reduction credits are sold on a forward base or by spot-market trades.
The relevant purchase contracts are visualized in Figure 15.

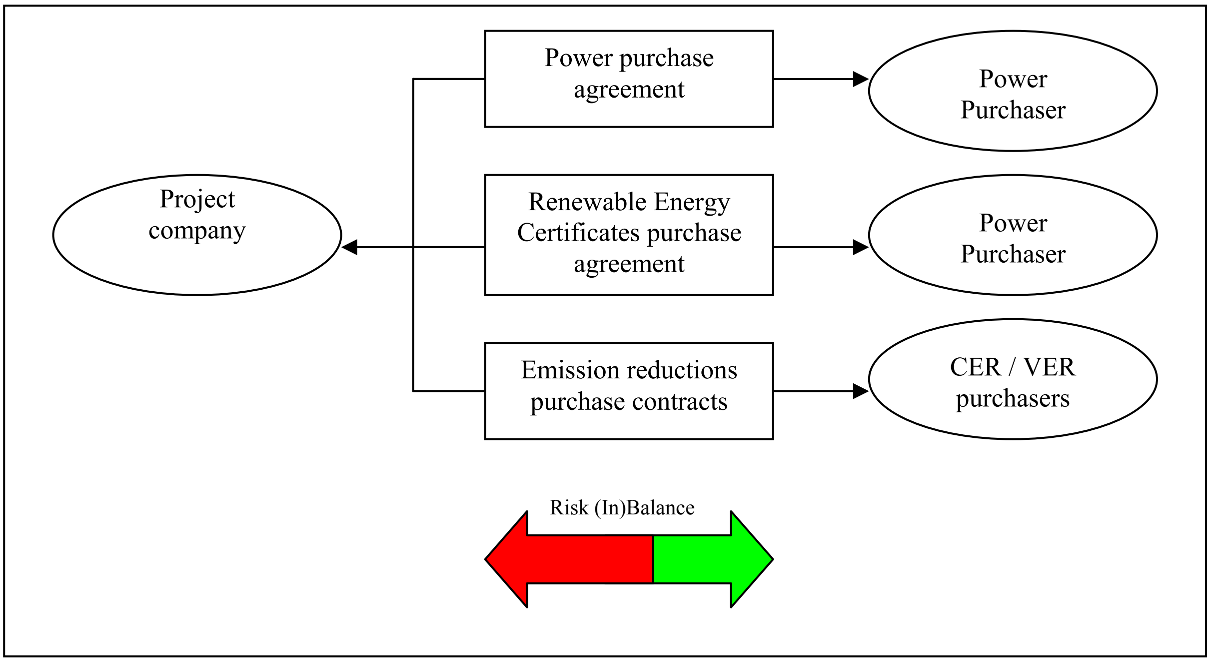


Figure 15: Identification of revenue risks by analyzing supplied markets

5.5 Financial risks

For all expenses and revenues of the project company there are financial risks due to changing currency and interest rates. By assessing the currency and terms of contracts the financial risks become apparent. By looking at the project's cash flow the different cash streams can be assessed on the articulated currencies. For instance a debt loan is in dollars or euro's, whereas the tariff mentioned in the Power Purchase Agreement is in a rather instable local currency. Figure 16 visualizes the different cash flows for a project finance model, whereby the risks can be identified by analyzing the matching over time of the different cash flows.
Cash flows are classified into:

1. Financing cash flows, which represent incomes or expenditures resulting from financing activities. This consist out of received equity and debt, dividends, interest payments, loan and equity repayments.
2. Investment cash flows, which consists out of expenditures on the acquisition of long-term assets and incomes received from sales of long-term assets.
3. Operational cash flows, which consists out of incomes and expenditures as a result of the company's business activities.

The "statement of cash flows" shows the amount of cash generated and used by the project company in a given period. When incomes and expenditures are contractual established in different currencies, currency risks are present.

Secondly loan agreements can include provisions concerning a floating base rate, which exposes the project company to interest rate risks induced by inflation of the currency.

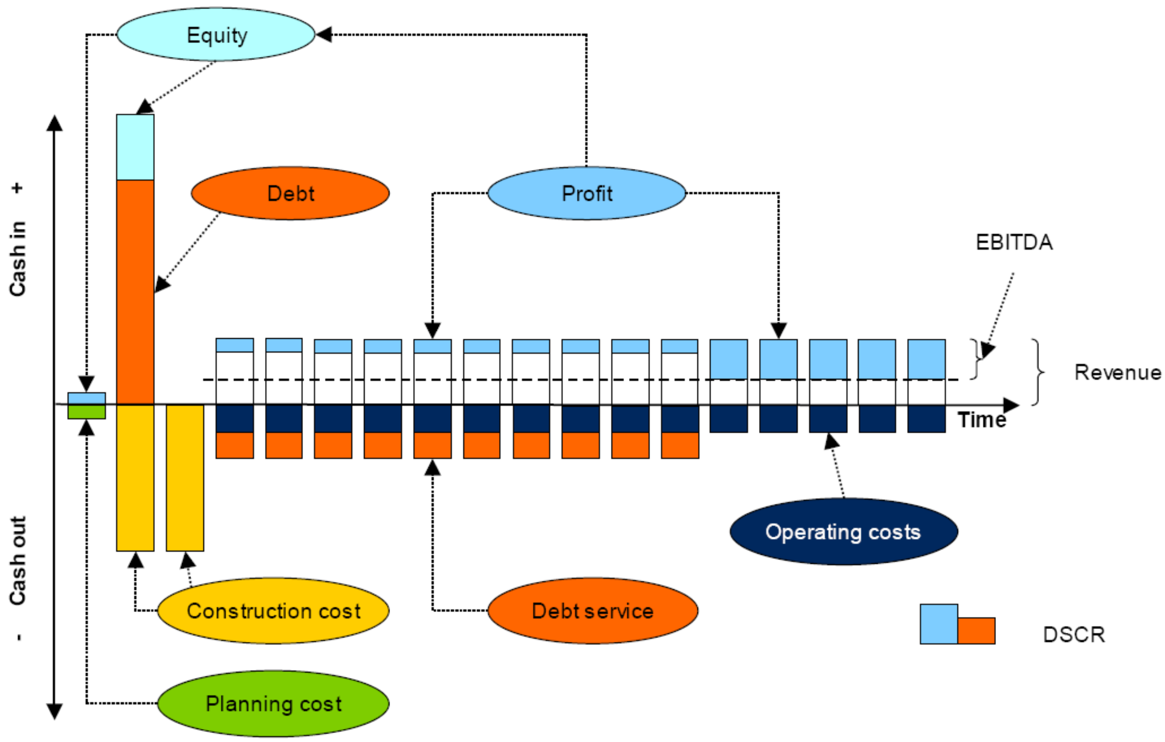


Figure 16: Standard project finance cash flow model (CD4CDM 2007)

5.6 Outcomes of the first step and follow-up

During this first step risks are identified, without rating their impact and their probability of occurrence. Thus, the outcome of this first step is a gross list of risks. In order to extract the vital risks from the many possible risks, the magnitude of these risks needs to be assessed. This is done by assessing the probability of occurrence and the severity of the consequences, as is described in the next chapter.

6 Step 2: compiling the traffic-light matrix

In order to distinct the vital risks from the gross list of risks, a magnitude will be assigned to the identified risks. The first paragraph explains the design of the traffic-light matrix that is used for this purpose. The assessment of the dimensions of this matrix, the probability of occurrence and the severity of the consequences, are presented in paragraphs 0 and 0. The final paragraph discusses the ranking of the risks per category and appointing a score to every category of risks.

6.1 Traffic-light matrix

The traffic-light matrix is based on the idea that risk is the product of the probability of occurrence and the expected severity of the consequences when the risk occurs. In order to assess the identified risks in the first step, the individual risks need to be rated on their possible impact and their probability of occurrence. The procedures for rating the probability of occurrence and the impact of an identified risk are clarified in the in paragraphs 0 and 0. These procedures make it possible to position the individual risks in the traffic-light matrix.
Figure 17 shows the basic appearance of the traffic-light matrix, with on the horizontal axis the severity of the consequences and on the vertical axis the probability of occurrence. Per category from the individual risks are positioned in this matrix.

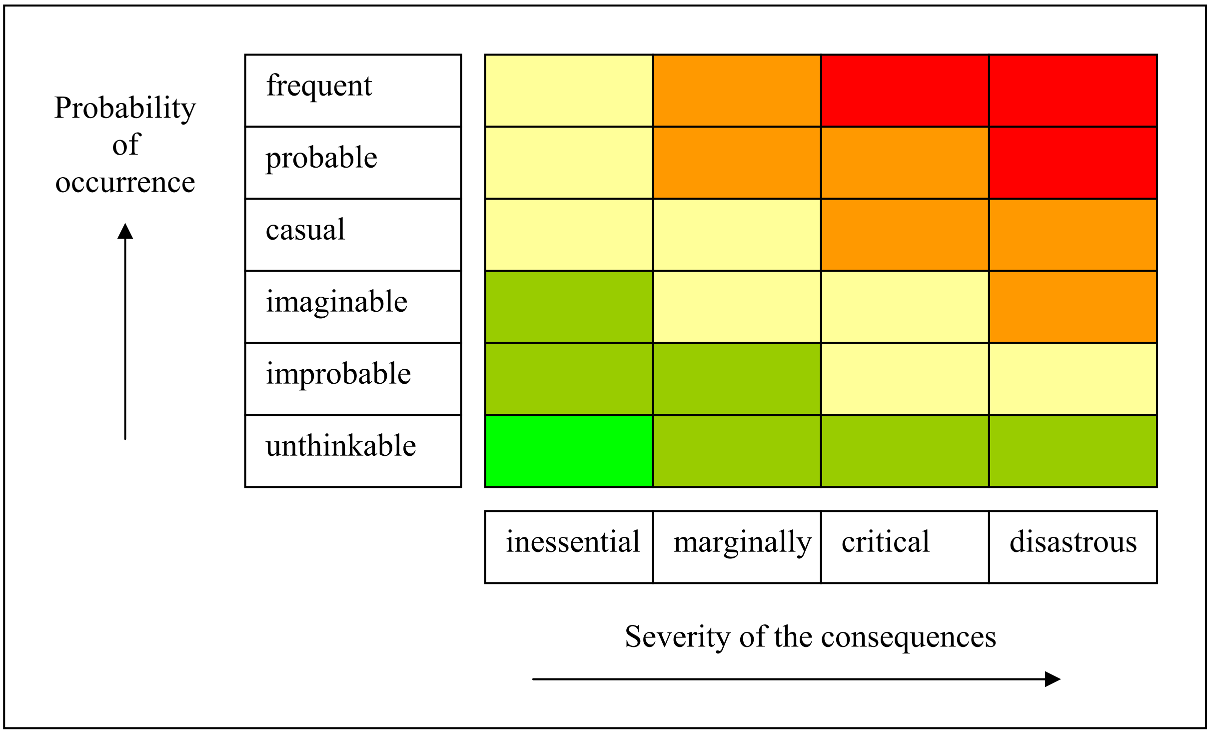


Figure 17: Basic appearance of the traffic-light matrix

To compile the traffic-light matrix we use two approaches to identify respectively the *probability of occurrence* and the *severity of the consequences*.

A. The **probability of occurrence** is addressed with the approaches already presented in Step 1, namely the **lifecycle approach** for the regulatory risks, the **stakeholder approach** for the construction, operational and revenue risks and the **cash flow approach** for the financial risks. In this approach per category the probability of the risks are assessed. The probability is expressed on a six point scale, ranging from *unthinkable* to *frequent*.

B. The **severity of the consequences** is assessed with the a **sensitivity analysis** based on the Dupont chart. The rationale behind this approach is that it provides insights in the composition of the financial parameters Internal Rate of Return (IRR) and Debt Service Coverage Ratio (DSCR). Uncertainties and variations in the projects revenue and cost structure are easily accessed. Because the cash flow approach deals with deviancies from the assumed scenario the *impact* of these deviancies becomes apparent. The severity of the consequences is expressed on a four point scale, on which the spectrum ranges from *inessential* to *disastrous*.

Thus, the probability of occurrence is qualitatively assessed based on the (expected) outline of the regulation, contracts and cash-flow planning. The severity of consequences is semi-quantitatively assessed, based on the impact of the risk on the financial parameters of the contract.

Based on the score of the probability of the consequences and the severity of the consequences, the individual risk is positioned in the traffic-light matrix. This leads to a magnitude scale of the risk on an ordinal scale. The score is linked to a color code, where:

- - extremely risky (red);
- unacceptable risky (orange);
0 ALARP (as low as reasonable practicable)(yellow);
+ acceptable risk (olive);
++ ideal risk (green).

Ideally an individual risk is positioned in a single cell of the matrix, which should be realistic in the more advanced stages of development. If this is not completely possible in the more preliminary stages, the matrix offers some flexibility. This can be illustrated with an example, were is assumed that a law enforced feed-in tariff will be available for the economic life of the project. The price for the emission reductions In an improbable worst-case scenario the price of the emission reductions is virtually nil, but it would be rather casual that prices are fluctuating with a marginal impact. The revenue risks to this example are visualized in Figure 18.

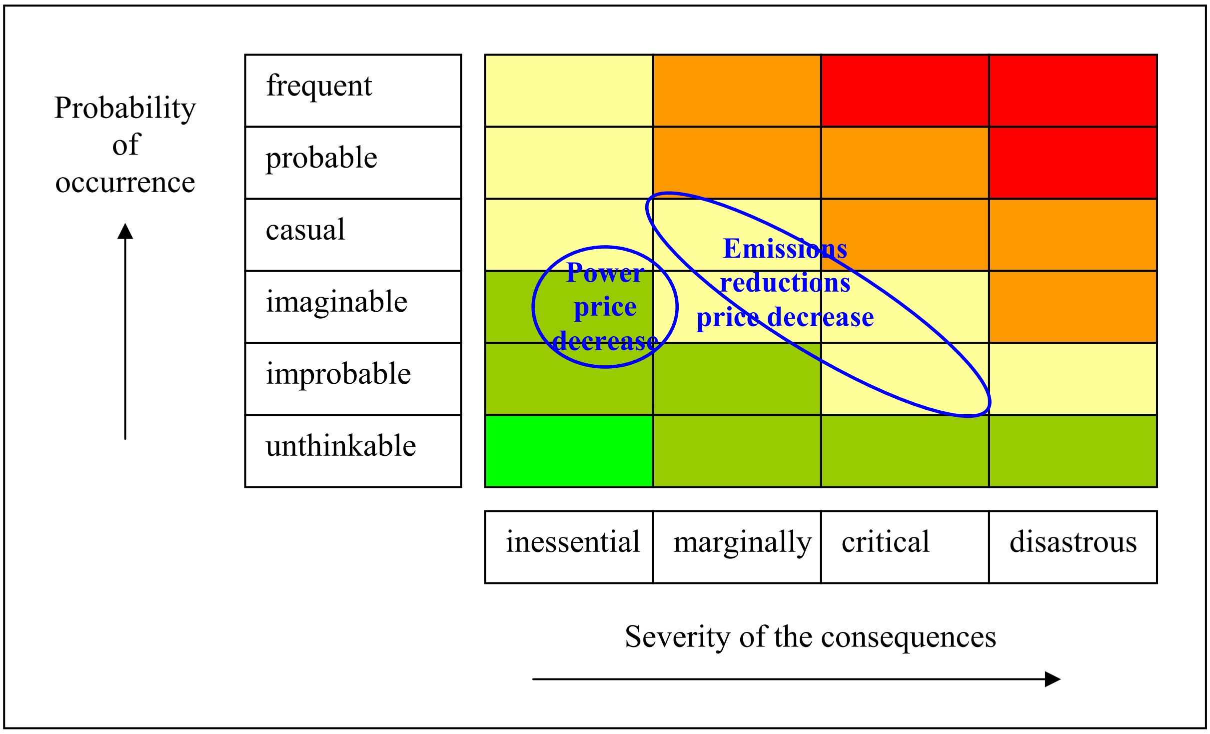


Figure 18: Example on compiling risks

The next chapter discusses the assessment of the probability of occurrence, which is followed by the assessment of the severity of the consequences in paragraph 6.3.

6.2 Step 2A: Assessing probability of occurrence

In this step the probability of occurrence is assessed with the approaches already introduced in Step 1. In the first paragraph the identified relevant regulations and legislations are used to assess them on their nature and likeliness to change. In the second paragraph the probability of occurrence of the identified construction risks are assessed with the stakeholder approach on their nature, terms and ability to enforce compliance of the made agreements. Also the stakeholder approach is used in a similar way to assess the operational and revenue risks, which is explained in respectively paragraph 5.3 and 5.4. In the fifth paragraph we will assess the probability of occurrence for the financial risks.

6.2.1 Probability of occurrence for regulatory risks

By application of Step 1 several risks are identified. To assess these risks on their probability of occurrence the relevant legislation and regulations have to be examined in bigger detail. The main regulatory risks have to do with the probability of changing regulations or with the rejection or withdrawal of permits and licenses.

Relevant legislation & regulations

In order to assess the probability that legislations and regulations will change adversely for the project it is of importance to examine the expected duration of the legislations and regulations. If long-term durations of the regulations are explicitly stated, this will lower the probability of occurrence. If the authority has a track-record of often changing policies, this increases the probability of occurrence. If the political situation is rather unstable, this increases the likeliness that regulations might be subject to change. The range of possible situations are rendered in Figure 19. Transitional arrangements can be expected for changing regulations.

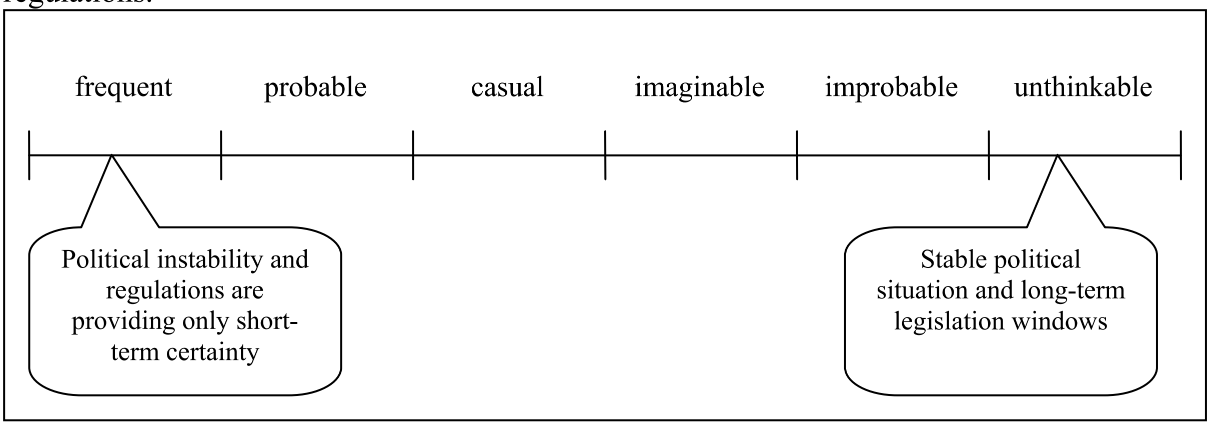


Figure 19: Probability of occurrence of changing legislation and regulations

Permits & licenses

For construction and operation different licenses have to obtained. Some countries proof to be more willing to enable implementation of renewable energy. The willingness of authorities and the adequacy of handling of permit & licenses request will lower the perceived regulatory risks. In order to obtain an operating license authorities might have additional requirements and demand for instance a bank guarantee. Possible situations with respect to permits and licenses are given in Figure 20. The lack of essential permits and licenses can act as real project killers, but also additional requirements can bring the project to a (temporary) standstill.

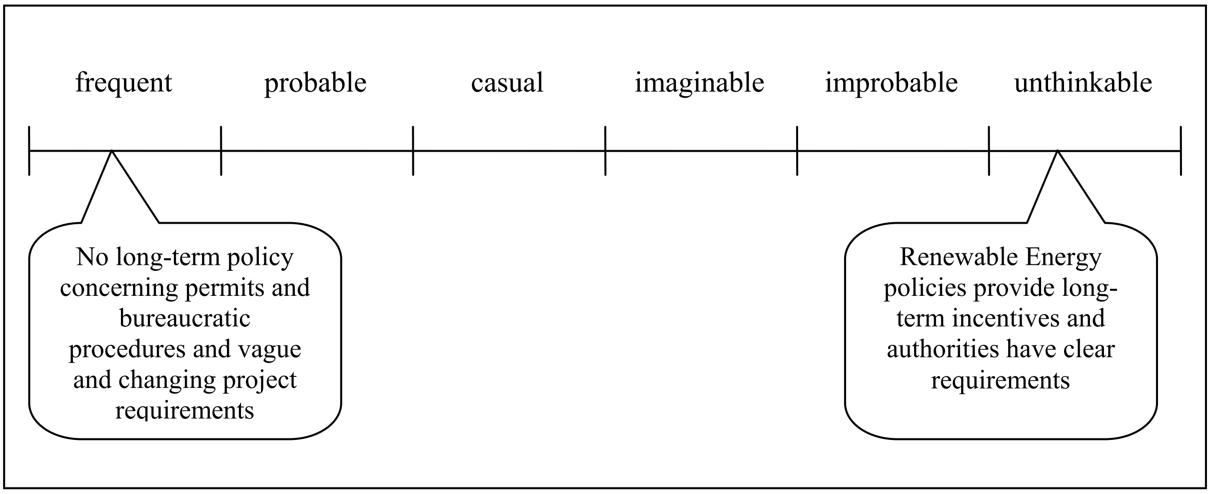


Figure 20: Probability of occurrence of rejection or withdrawal of permits and licenses

Emissions reductions regulatory issues

The UNFCCC regulates the Kyoto markets through approval of methodologies and Project Design Documents (PDD's). Furthermore it certifies the emission reductions after verification by a Designated Operational Entity (DOE). Because the mechanisms are relatively young, methodologies are expected to change. Also the UNFCCC's Executive Board tends to put stricter requirements on the PDD's, methodologies and verification reports. The current absence of a post-2012 successor for the current protocol imposes uncertainties with respect to the Kyoto framework.

For the voluntary market there is no official regulation, but to ensure integrity of the system the sector tends to work more intensively with Kyoto-alike standards.

A large number of uncertainties and potential risks can be identified with respect to the Kyoto-markets. Dependent upon the host country there might be more or less problems to get host country approval. The applied technology and used methodology might be of major importance to get approval of the project. Furthermore delays of approval are often occurring.

For voluntary markets there is no real regulation, but to be able to fulfill the market's self-imposed requirements, Kyoto-alike project development, monitoring and verification is favored. In Figure 21 indicative probabilities of occurrence of emission reductions regulatory risks are displayed.

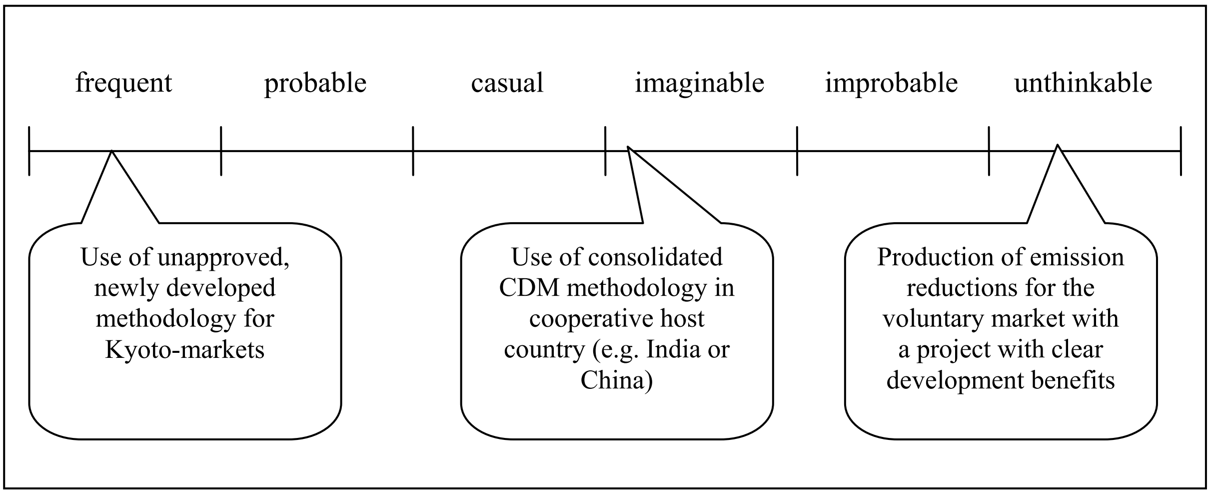


Figure 21: Probability of occurrence of adverse changes in emissions reductions regulations

6.2.2 Probability of occurrence of construction risks

In Step 1 several risks are identified that are connected to the development, engineering, procurement and construction of the project. By assessing the tenor and detailed terms in the contracts the risk allocation becomes apparent. In this phases initial risk-bearing capital has to brought in and several services and equipment are bought in from third parties and the principal's interest can conflict with those of the contracted parties.

Shareholders agreement

The shareholders agreement governs the relationship between the project company and their shareholders. But also it structures the relationship between joint venture partners. Hereby the agreement regulates the ownership and voting rights in the joint venture. Also it arranges the control and management and makes provisions for the resolutions of any future disputes between the shareholders. Furthermore it states the initial and future capital contributions of the shareholders and possible third parties. It ensures that there is sufficient capital for the project, but also ensures limited or non-recourse on the other assets of the shareholders (in case of default of the joint venture). Shareholders can control the management of the firm and can intervene in case of underperformance or opportunistic actions of the management. It basic function is to mitigate the risk that there is lack of capital to proceed to full operation and during the operation of the project. Therefore it can also include provisions concerning equity resale. Specific funding obligations could require shareholders to commit funds on a contingent basis for the future.
Absence of solid shareholder agreement increases the risks of the future shareholders not meeting their promised obligations. In order to rate the likelihood that the credit risk becomes reality and the shareholders or co-developers will not meet their obligations, the quality of the agreement has to be assessed. Figure 22 indicates the probability of occurrence based on the quality of the agreement between the project company's stakeholders.

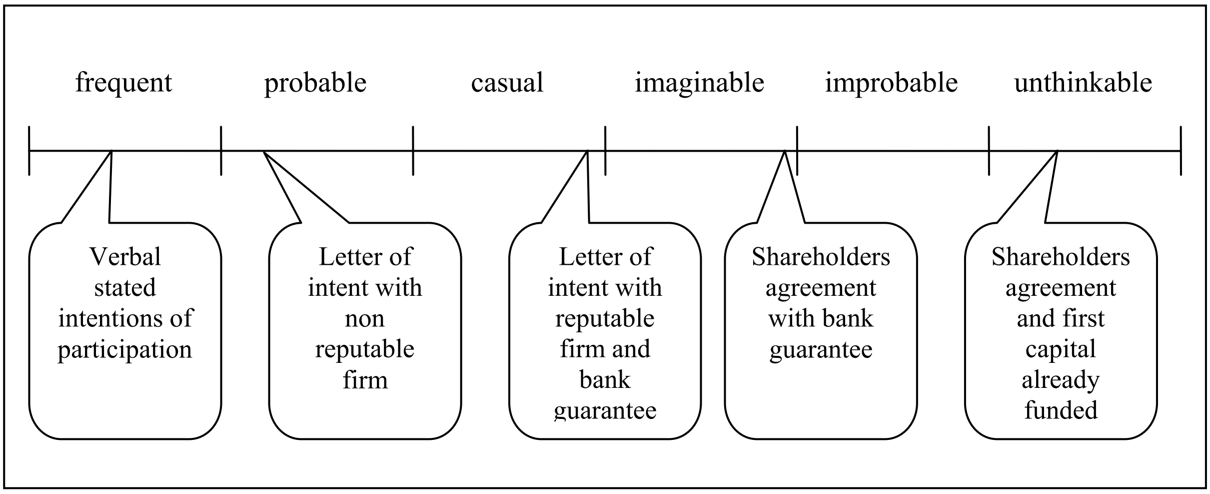


Figure 22: Probability of occurrence of co-developers risks

Advisory contracts

In the planning phase several experts will be consulted for technical, legal and financial advise. This can also include services as investment intermediation or contract negotiation support. Usually consultants and advisors are only liable up to their fee for advise. Therefore most developers will choose for a known consultant, or one with a decent track-record and

well-known reputation. Also contracts can include success-fees or designed on a no-cure-no-pay basis. When working on a no-cure-no-pay basis the bid risk is partially transferred to the advisors, because they will receive no remuneration, when the project does not reach successful implementation. The probability scale concerning advisory contracts is illustrated with Figure 23.
Developers with a certain focus might choose to obtain in-house expertise on specific subjects. Also due-diligence or peer review by an independent consultant could improve the outcomes of the advisory services.

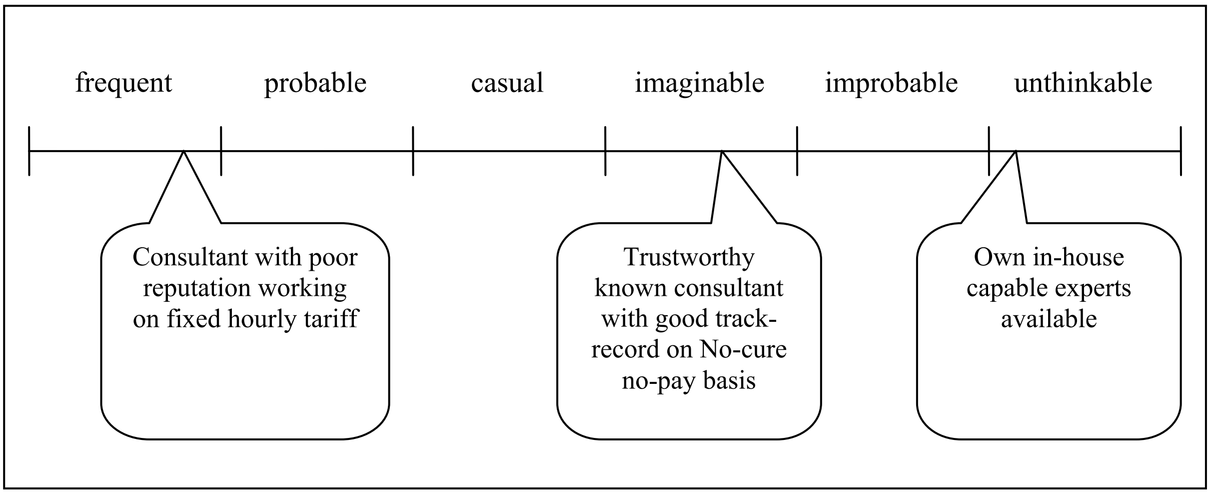


Figure 23: Risk probability of occurrence in advisory contracts

Engineering, procurement and construction contracts

In engineering, procurement and construction (EPC) contracts there is a large risk of cost and time overrun. Different instruments are available to give performance incentives, such as an additional payment for work completed before the contractual deadline and/or penalties for exceeding the deadline. This prevents the project from monetary damages due to delay. Also there are insurances available for certain delay risks. In Figure 24 typical contract structure are displayed and their relation to probability of occurrence of the most common EPC risks.
To mitigate the risk of cost overrun a fixed-price is preferred, usually through a turnkey contract. Also for the energy equipment normally the contract contains specifications for the performance of the equipment.
In cost-plus contracts the principal bears all the risk of cost overrun. In design & construct or construction only contracts the principal has to describe very accurate the works to be completed in a design brief. The primary risks associated with the EPC contract are delays, cost-overruns and credit risks.

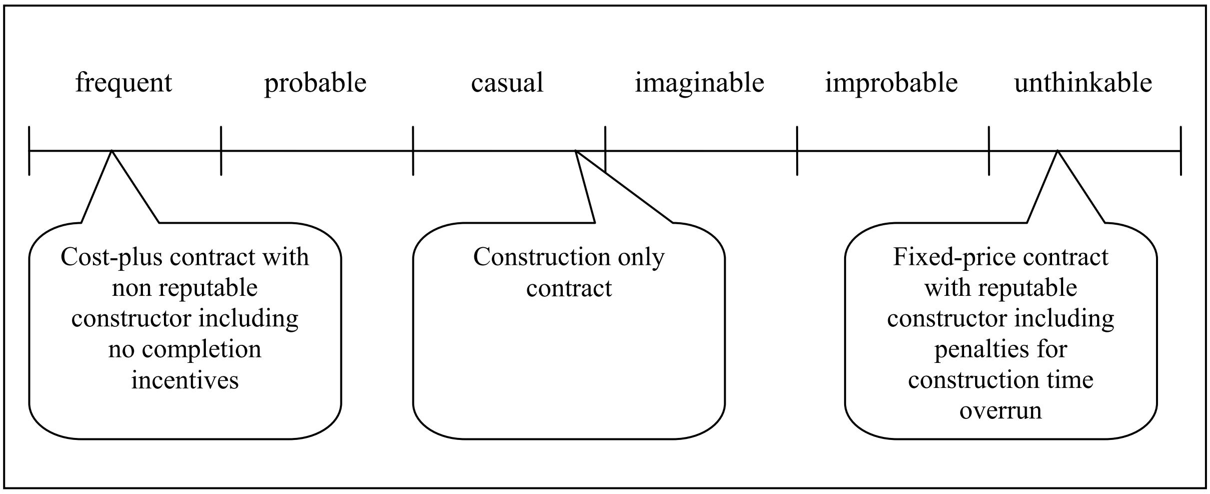


Figure 24: Risk probability of occurrence in EPC contracts

Construction loans

The debt provided for construction is usually on different terms than the debt available during exploitation of the project. As already visualized in Figure 7 the absolute project risks decrease after testing and commissioning of the installation. Therefore, the conditions can negotiated more favorable, interest rate can decrease and gearing can increase after the project demonstrates to operate successfully.

Due to the inability to fulfill too tight loan conditions, financial penalties might be imposed or loan renegotiations might be needed, which can be considered as a consequential damage. Construction loans that do not provide enough flexibility for the debtor, increase the probability of construction loan defaults. In Figure 25 the range that indicates the probability of occurrence that the project company fails to meet all construction loan conditions.

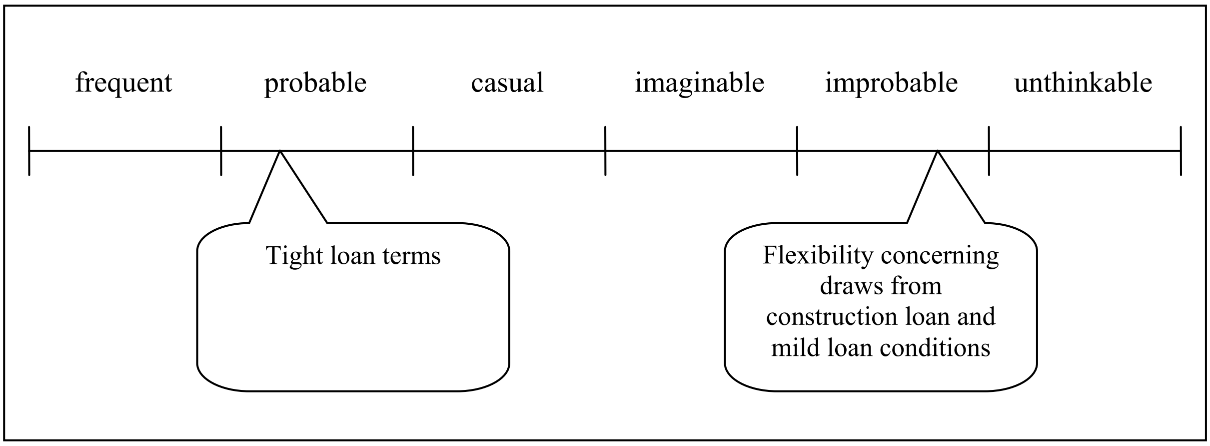


Figure 25: Risk probability of occurrence of project company's default with respect to construction loan

6.2.3 Probability of occurrence of operational risks

During project exploitation several service have to be bought in and furthermore interruptions in operation might occur. The identified risks in Step 1 need to be examined more carefully to judge upon the risk allocation between the project company and it's stakeholders. Furthermore internal company procedures might be practiced in order to control internal company risks.

(Fuel) Supply contracts

Supply contracts for biomass, fossil fuels, lubricating oils or other goods can be obtained against the actual market prices during operation or on a long-term supply contract. The reliability of the contract partner, the duration of the contract and incentives for delivery on time and in conformance with the requirements are factors that improve the stability of the costs of the physical inputs needed. Especially in absence of a mature market (such as a local biomass market) a long-term and enforceable supply contract with stable suppliers is of major importance. The probability of occurrence of supply risks is illustrated in Figure 26. In biomass contracts also energetic value, moisture content, contaminations or physical characteristics are of major importance. The risk of business interruption become rather high due to the absence of good supply contracts in combination with an immature local market for biomass.

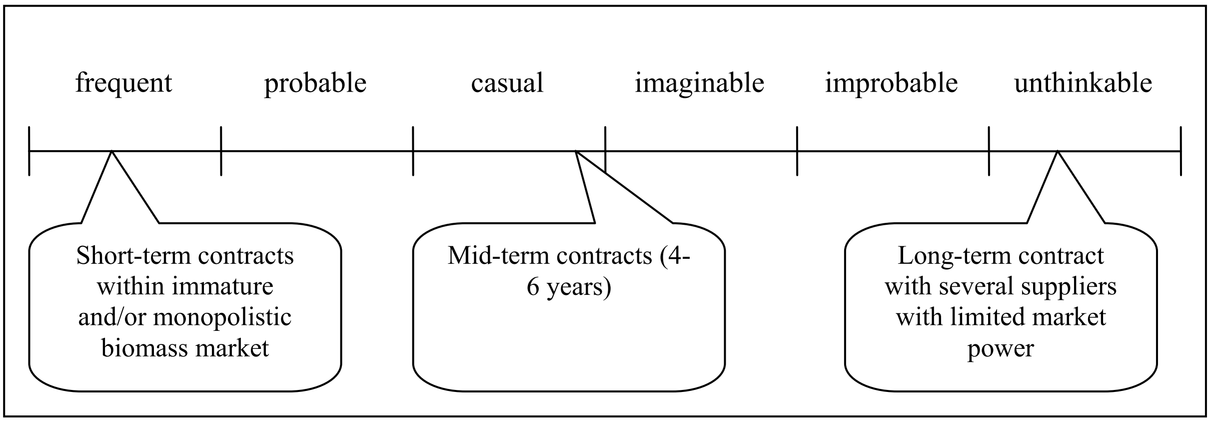


Figure 26: Probability of occurrence of (fuel) supply risks

Operation & maintenance contract

In order to prevent cost overruns during operation, the project company could go into a contract with a guaranteed minimum performance level. The amount of risk for cost overrun during operation can be placed upon the principal when the contract is on a cost-plus fee base or placed upon the contractor with a fixed-price contract with full responsibility for deliverables. In between all kinds of arrangements and performance incentives are possible. In Figure 27 the probability of occurrence for operation interruptions or O&M cost escalation are visualized.

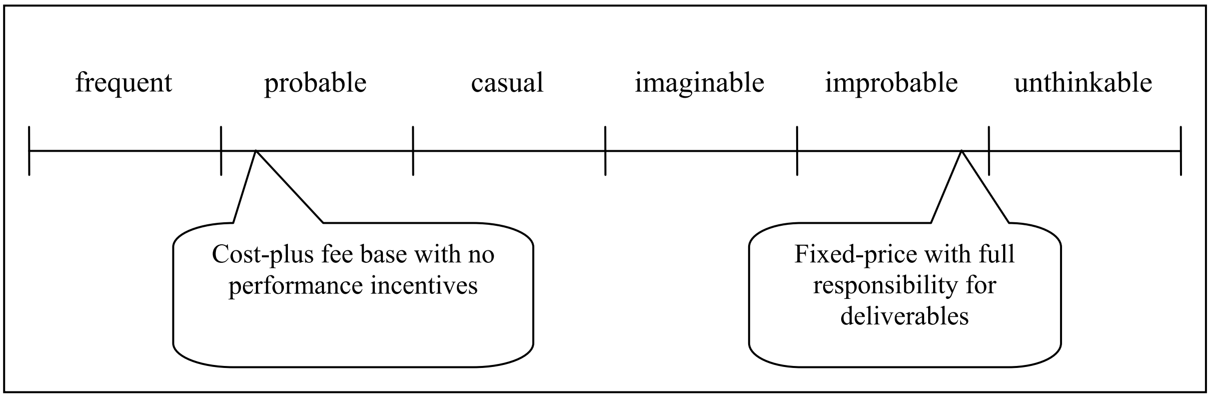


Figure 27: Probability of occurrence of operation interruptions or O&M cost escalation

Employment contracts

In employment contracts performance incentives can improve the dedication of its personnel. This can be done through bonuses or equity participation. A capable management lowers the probability of management failure and needed intervention by shareholders. The probability of occurrence of employee underperformance is qualitatively rated in Figure 28.

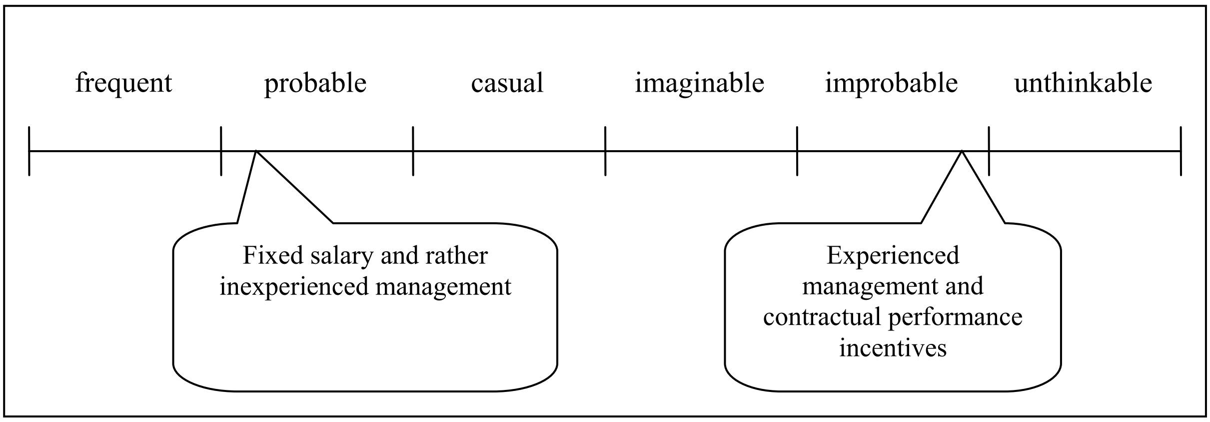


Figure 28: Probability of occurrence of employee underperformance

Electricity Connection agreement

In order to deliver the energy to the buyer of the energy, the electricity connection agreement is of major importance. Regulator fees can be due to change which will be in most cases determined by national governmental boards. Because of the scale of independent renewable power producers and power availability depends on resource availability (wind, run-of-river hydro), the ability to influence tariffs will increase with industry grouping. In some countries electricity wholesalers might have obligations concerning the quantity of renewable energy in their energy mix, which gives the energy producer a relative bigger bargaining power or priority on the grid. Indications on the probability of occurrence of temporarily grid inaccessibility in visualized in Figure 29.

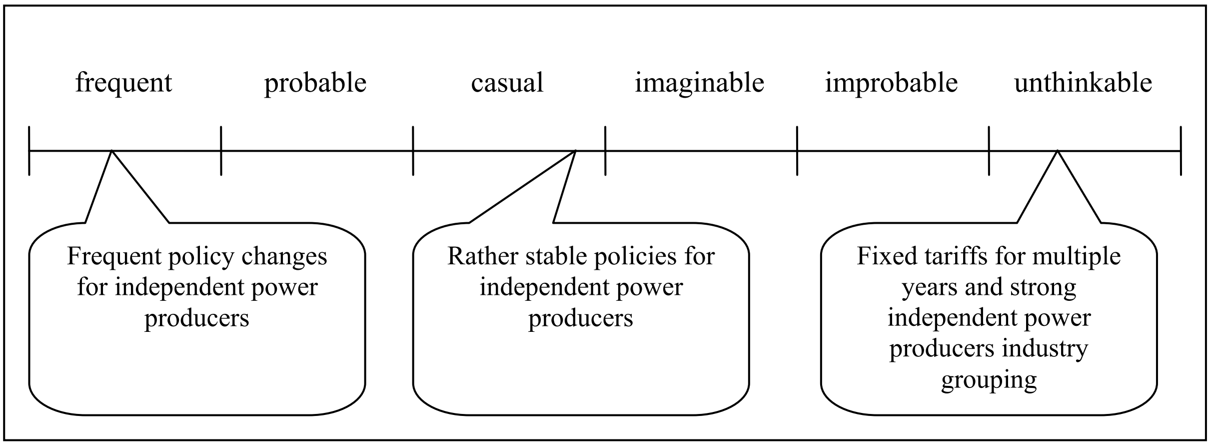


Figure 29: Probability of occurrence of temporarily grid inaccessibility

Insurance contracts

Several residual risks that are not covered by the projects contracts can be transferred by insurance and financial instruments. Typical risks are country political risks, changing weather patterns and physical hazards. A limited cover insurance is available in some countries and for some technologies (UNEP 2004, UNEP 2005, Marsh 2006). Therefore, it should be taken into consideration that insurance is relatively new and that the coverage is not available in most countries. Insurance does not have an influence of the probability of occurrence of for instance physical hazards to occur, but changes the severity of consequences. In case of physical hazard insurers will make sure that the project company cannot be reproached for negligence. This implicates a risk of partially or non-disbursement of the suffered damage, which depends on the provisions of the insurance. In Figure 30 the risk probability of occurrence is given for non-disbursement of suffered damage.

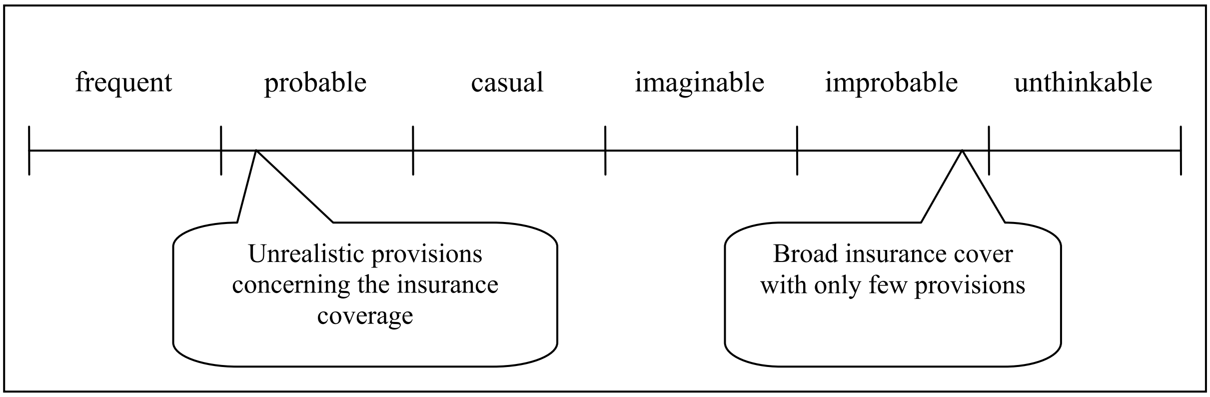


Figure 30: Probability of occurrence of non- disbursement of the suffered damage

Contracted project validation and verification services

Project validation and verification has to be executed by a Designated Operational Entity, which places another additional burden on the project. Because of the limited number of DOEs, these parties have a rather big power in their tariff structure. In order to stimulate competition it is expected that the UNFCCC will accredit more DOE's. Because of the current limited DOE capacity there is also a risk of time-delay.

Also the event can occur that the project developer cannot address requests of review for validation or verification of the project. This can occur when the projects documents are not transparent, contain inconsistencies or mistakes. This can lead to time-delay as well as outright rejection of the projects or the requested VER registration. Indicative probabilities of occurrence for risks associated to project validation and verification services are given in Figure 31.

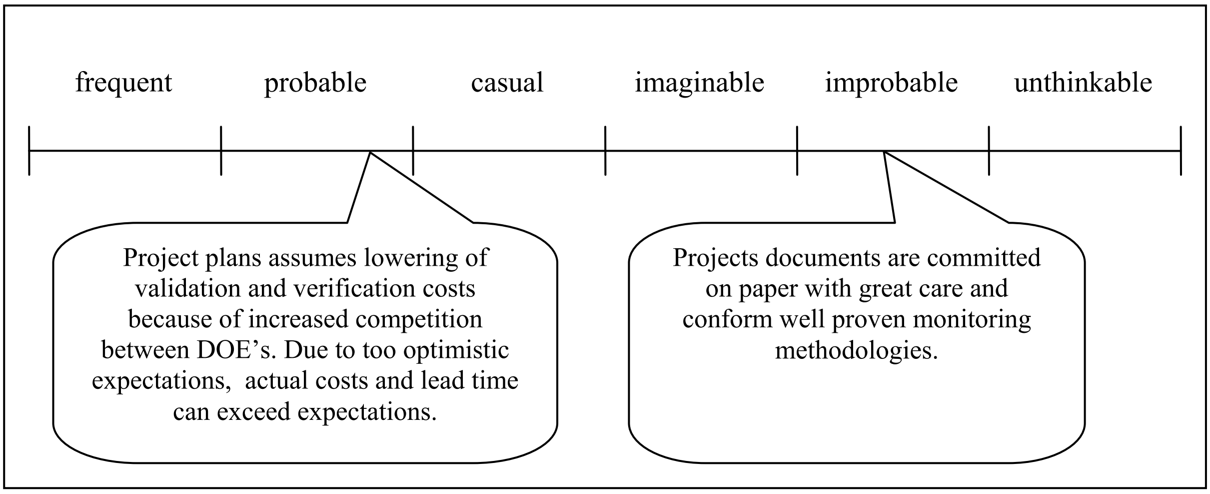


Figure 31: Probability of occurrence of short falling assigned emissions reductions or certification delays

Project company's risk monitoring and controlling procedures

In order to control residual risks in an effective manner, the project company needs to set up monitoring administrative and safety procedures that minimize the probability of negative events to happen. Procedures can be needed for scheduling maintenance, bring plants to standstill in dangerous situations and prevent white-collar crimes. Figure 32 illustrates the probability of occurrence of fraud or erroneous employee actions.

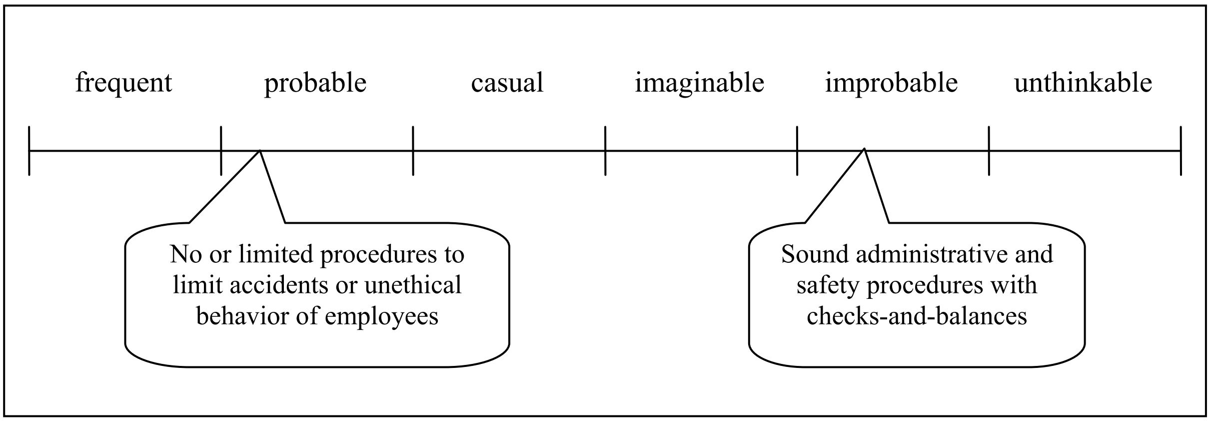


Figure 32: Probability of occurrence of fraud or erroneous employee actions

Loan agreement

Senior lenders will require full repayment of the loan within the period of the major contracts, in particular the Power Purchase Agreement (and preferably fuel/waste supply contracts for waste-to-energy projects; for landfill gas projects also the ERPA would be of importance). In project finance there is no or limited recourse over the balance sheet of the sponsor for repayment. Therefore lenders will demand a stable and predictable stream of cash flow to ensure repayment of their loans. In adverse situations the lenders can take security over the project assets and in this case repayment has to come from the cash flow of the project (not sale of assets). The interest rate can be either a fixed interest rate or a floating debt rate, consisting of a base rate plus a risk premium. The base interest rate risk is discussed in paragraph 6.2.5.

Changing market situations or increasing operational costs might impose tensions on the ability to fulfill the debt service obligations. This might urge the debtor to increase the interest premium, withdraw bank guarantees or threaten to take security over the project company. The probability of occurrence of losing creditor support is illustrated in Figure 33.

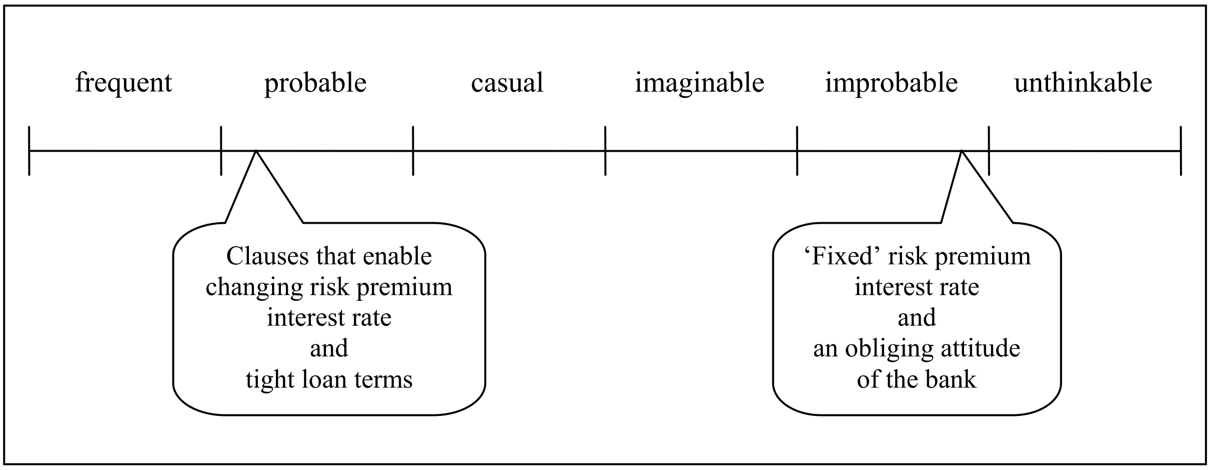


Figure 33: Risk probability of occurrence of losing creditor support

6.2.4 Probability of occurrence of revenue risks

The revenue risks identified in Step 1 depend largely on the availability or absence of off-take agreements of the project's deliverables. Between a fixed tariff and sale of deliverables on spot market, several arrangements are possible in order to be able to profit from upward price movements. Income can be generated from the sale of energy, renewable energy certificates or emission reductions.

Power purchase agreement (PPA)

Electricity or heat prices will depend largely depend on prevailing fossil fuel prices and weather characteristics. A fixed tariff will ensure the energy price over time, but also the price can be coupled to fossil fuel tariffs or be delivered against the spot prices at time of delivery. In the first case there is rather more certainty upon the project income over the project life and this secures a firm cash flow during operation. In several countries there is special legislation concerning renewable energy producers, that has the objective to stimulate renewable energy by guaranteed minimum tariffs or guaranteed delivery on the grid.
In case of delivery of thermal energy (for process steam or district heating) the trustworthiness of the off taker will be the most important issue, because the ability to transport thermal energy is limited.
Because of the nature of renewable energy technologies usually no penalties are applied when a facility is not able to meet the expected output. When technologies mature and its contribution to the energy portfolio increases the timing of available capacity will become more important. The probability of occurrence of inability to sell produced energy and energy price risks is illustrated in Figure 34.

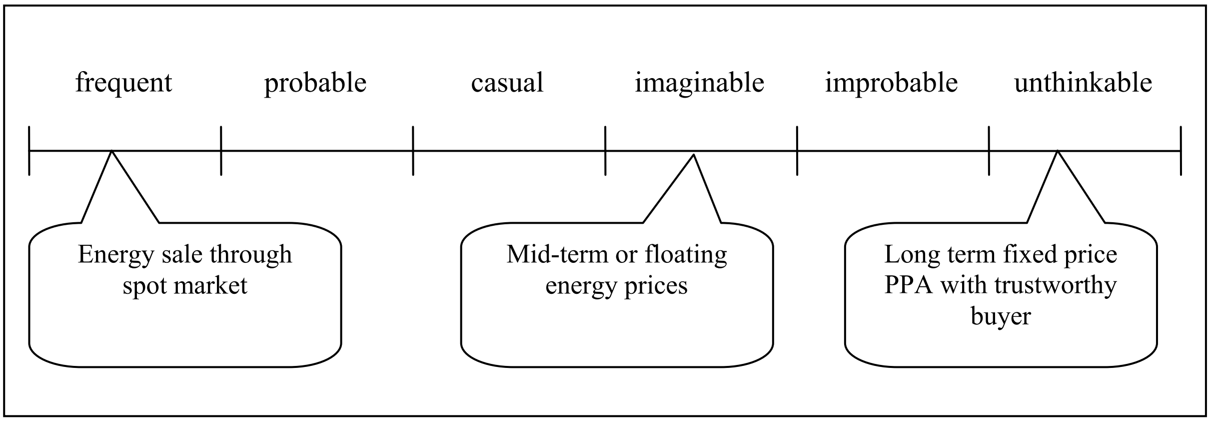


Figure 34: Probability of occurrence of inability to sell produced energy and energy price risks

Renewable Energy Certificates purchase agreement

RECs represent the social and environmental benefits of energy generation by generating energy from renewable sources. By unbundling these merits from the energy that is delivered through the electrical grid a separate product becomes available. These green attributes can be unbundled and sold separately. RECs market usually have geographic boundaries due to the many different standards. RECs are used for voluntary or mandatory purposes, where the latter are imposed by renewable energy regulations. Market transactions are usually traded over-the-counter and on forward basis and price disclosure is usually not available (Eckhart 2006, Bayon 2007). Figure 35 visualizes the risk of shortfalls on the expected revenues from RECs sales. A fixed price ensures a stable income from RECs, although in a bullish market the project company might be unable to profit from higher market prices. A fixed price lowers the exposure to price risks and therefore decreases the risk.

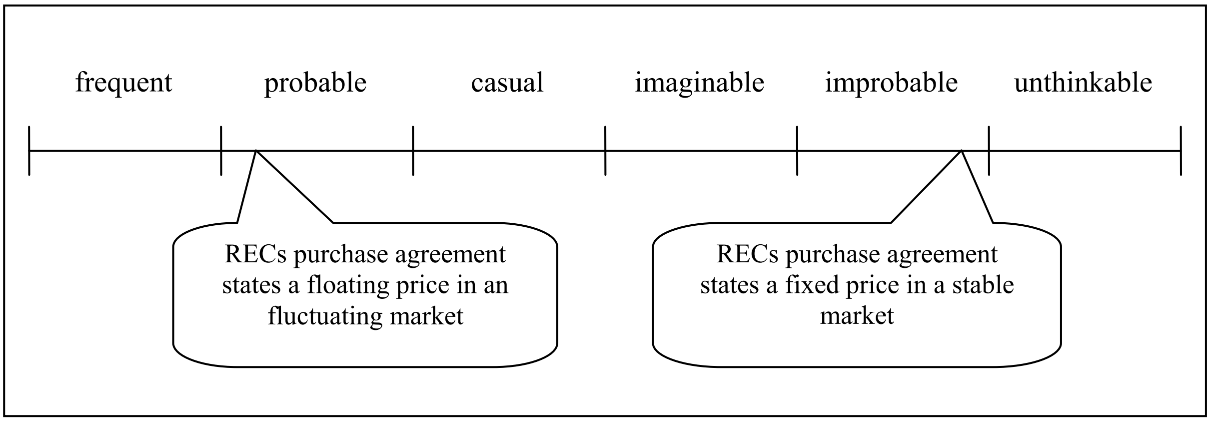


Figure 35: Probability of occurrence of REC market risks exposure

Emissions reductions purchase agreement (ERPA)

An ERPA can be structured in several ways to increase the risk exposure of the young emission reductions markets. The price and demand for these intangibles depends heavily on political decisions made by UNFCCC and regulations within the major mandatory carbon markets, such as the EU-ETS. Apart from the price risk, the CDM/JI procedure introduces a whole set of additional risks to the project.

Upfront payment (also referred to as Carbon Finance) and fixed-price contracts lower market risk exposure. Contracts can state fixed amounts and thereby introducing performance risk, because the shortfalls have to bought in on the market. Other contracts allow deviations from estimated annual values. Also contracts for sale of Verified Emissions Reductions are possible in order to transfer the review of issuance risk to the buyer. Because the risk transfer and carbon finance has its price, the buyer will negotiate a lower emissions reductions price. The risk adjusted price with full exposure to the various Kyoto-risks is considerable lower than the risk-free value of a CER, as is visualized in Figure 36.

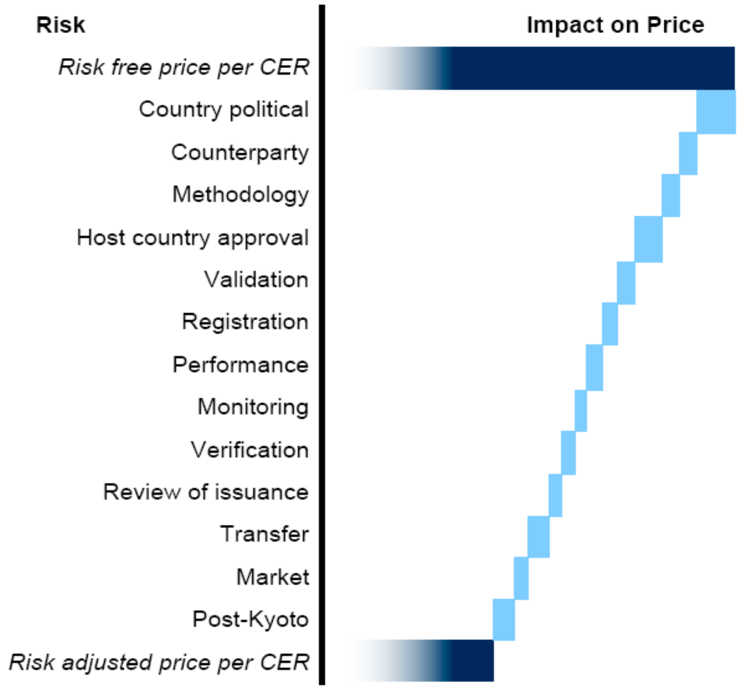


Figure 36: CDM project risk profile and it's impact on negotiated CER prices (CD4CDM 2007)

In Figure 37 a few possible CER transaction structures are given and rated on their probability of occurrence of emission reductions price decreases or short falling project delivery. Carbon finance is interesting for developers who lack the necessary funds to prepare the documentation for registration at UNFCCC (UNDP/BDP 2003, WADE 2006).

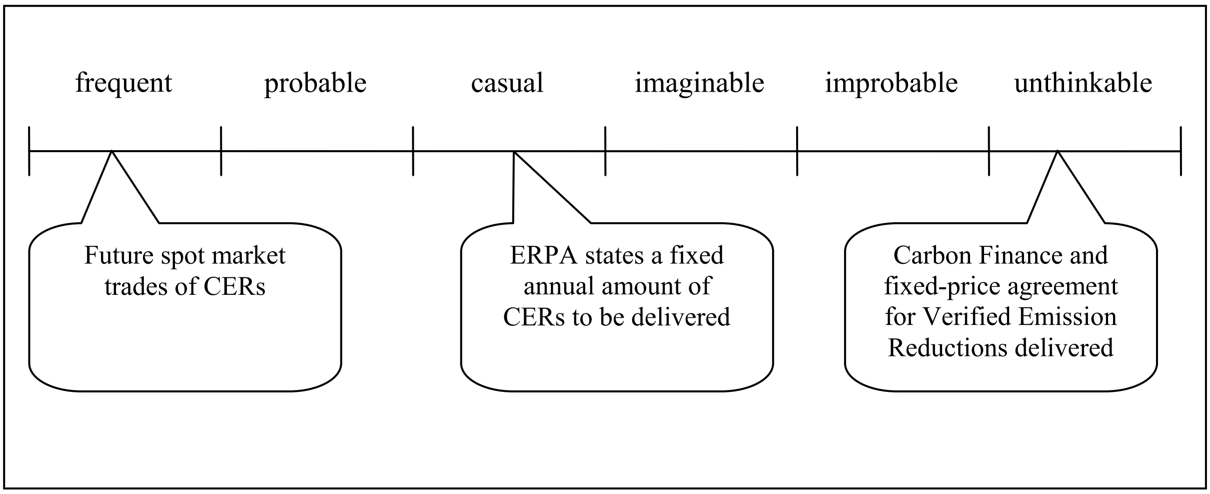


Figure 37: Probability of occurrence of emission reductions price decreases or short falling project delivery

6.2.5 Probability of occurrence of financial risks

Currency and base interest rate risks, need to be rated on their probability of occurrence. These risks can usually be hedged, but might be very present if no carefully financial engineering is executed.

Currency risks

By observing the project's annual cash flow statement mismatches between incoming and outgoing cash flows can become apparent. If the procured equipment has to be paid in dollars, currency risks can be mitigated by obtaining a construction loan in the similar currency.
Similarly the project finance loan is in the same currency as the incomes from the project's deliverables, because the debt service has to be fulfilled in the same currency. In Figure 38 the probability of occurrence of currency risks is visualized.

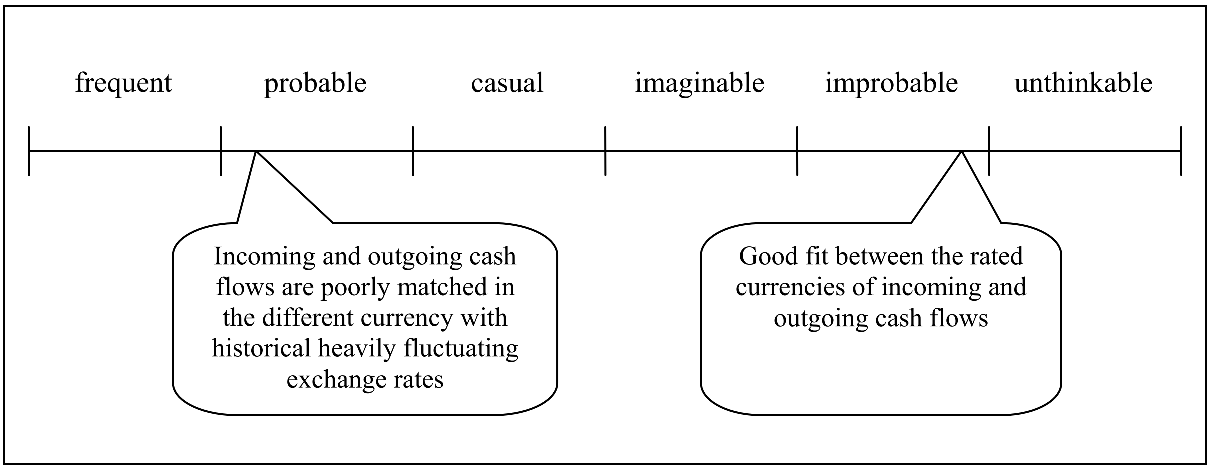


Figure 38: Risk probability of occurrence of currency risks

Base interest rate risks

As discussed in 6.2.3 the interest rate can be either a fixed interest rate or a floating debt rate, consisting of a base rate plus a risk premium. In the later case there might be exposure to the risk of changing base interest rate. The interbank interest rates are strongly determined by the actual inflation. By purchasing financial instruments (such as interest rate swaps) from banks, interest rates can be maintained at a fixed level. The probability of occurrence of base interest rate risks is illustrated in Figure 39.

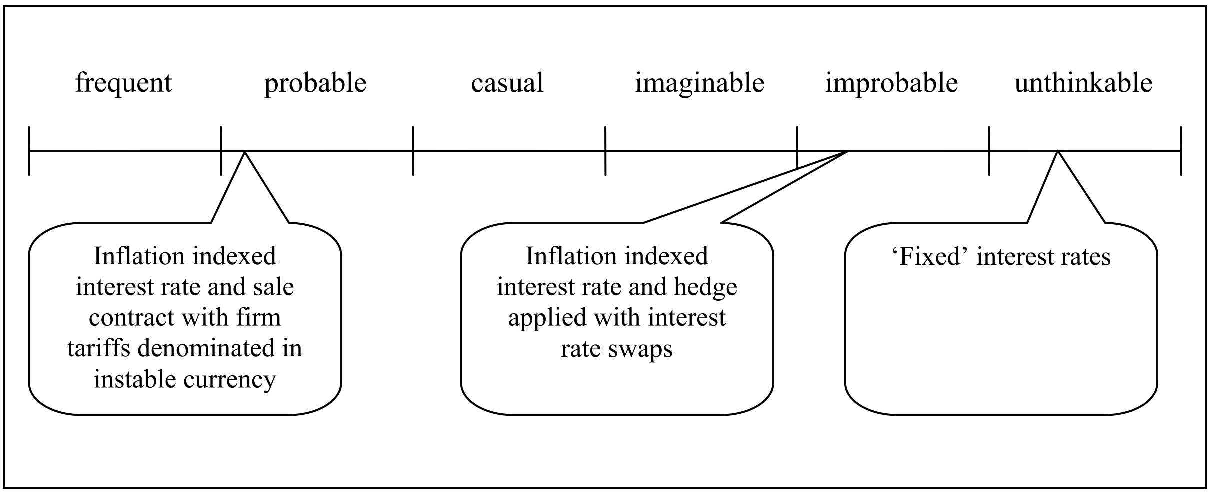


Figure 39: Probability of occurrence of base interest rate risks

6.2.6 Conclusion and follow-up

This paragraph discussed the assessment of the probability of occurrence of the identified risks. After this step the position on the vertical axis of the traffic-light matrix is known and Step 2A is finished. The position of the individual risks on the horizontal axis is assessed in Step 2B, which is described in the next paragraph. After this the traffic-light matrix can be filled in.

6.3 Step 2B - Assessing the severity of consequences

After rating the identified risks on their probability of occurrence in the previous paragraph, the other dimension of the risk - the severity of consequences - will be discussed in this paragraph. In the first subparagraph the indicators of the project's financial performance are discussed. The second subparagraph deals with the composition of the discussed financial indicators. The third subparagraph discusses the assessing of the severity of consequences.

6.3.1 Financial performance indicators

Equity investors address the project's performance amongst others with the Internal Rate of Return (IRR). Other common used indicators are Payback period and Net Present Value. The **Internal Rate of Return** (IRR) is an indicator for the profitability of an investment and it can be seen as the annualized effective compounded return rate. If the internal rate of return of the project is equal to or greater than the required rate of return of the organization, then the project will likely be considered financially acceptable (assuming equal risk). If it is less than the required rate of return, the project is typically rejected. An organization may have multiple required rates of return that will vary according to the perceived risk of the projects. The most obvious advantage of using the internal rate of return for project evaluation, is that the outcome applies on the project and can be easily compared with individual investors' required return. The relation between the Net Present Value and the Internal Rate of Return is given in Equation 1.

Equation 1: Relation Net Present Value and Internal Rate of Return

$$\mathrm{NPV} = \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} \qquad \text{if } \mathrm{NPV} = 0 \quad \text{then} \quad r = \mathrm{IRR}$$

Where NPV – the net present value of the project (here assumed zero for deriving IRR)
t – the time of the cash flow
T – the project economic life
C_t – the net cash flow at time t
r – the investor's required rate of return
IRR – the internal rate of return

Debt investors are interested in the ability of the project to meet its debt obligations and can use the performance indicator **Debt Service Coverage Ratio** to judge financial risk. It is the ratio of the operating benefits of the project over the debt payments. This value reflects the capacity of the project to generate the cash liquidity required to meet the debt payments. It is calculated by dividing net operation income or savings (net cash flows before depreciation, debt payments and income taxes) by debt payments (loan repayment and interest). In Equation 2 the composition of the Debt Service Coverage Ratio is given.

Equation 2: Debt Service Coverage Ratio

$$\mathrm{DSCR} = \frac{\mathrm{EBITDA}}{\text{debt service}} = \frac{\mathrm{EBITDA}}{\text{interest} + \text{loan repayments}}$$

Where DSCR – the Debt Service Coverage Ratio
EBITDA – Earnings Before Interest, Tax, Depreciation and Amortization

6.3.2 Composition of IRR and DSCR

The Internal Rate of Return and Debt Service Coverage Ratio are composed out of a large amount of factors, but not all factors have a severe impact. The composition of the IRR and DSCR are visualized in Figure 40 as a Dupont chart.

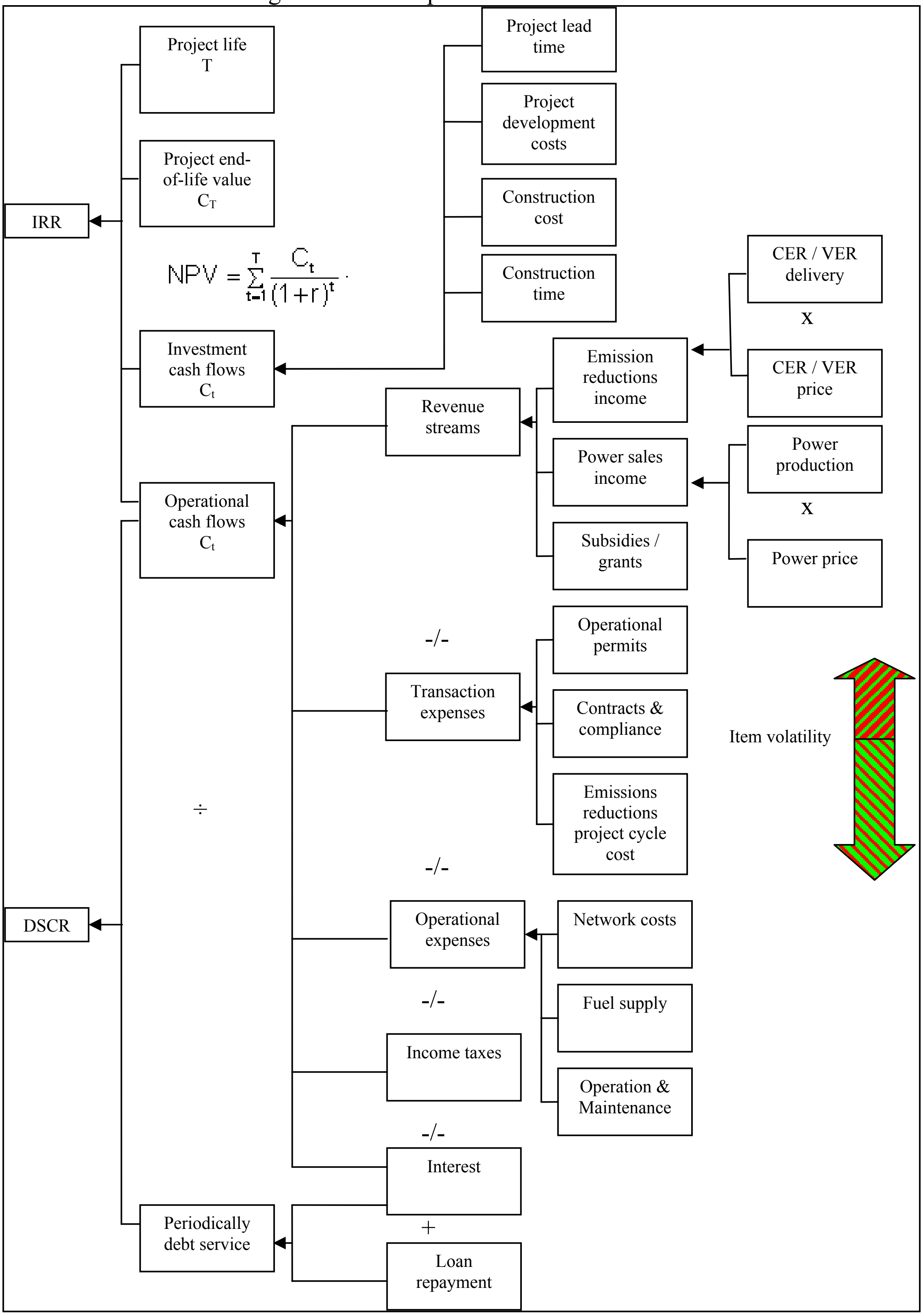


Figure 40: Dupont chart for the IRR and the DSCR

The Dupont chart illustrates the relationship between the various financial variables. When a risk comes apparent it has an effect on one or more end-branches in the chart. The end-branches are described in Table 2, which also explains the mechanisms that cause a change in the individual items.

Table 2: Description of items in the Dupont chart with

Item	Description	Mechanisms
Project life	The time over which the financial feasibility of the project is evaluated. Depending on circumstances, it can correspond to the life expectancy of the energy equipment, the term of the debt, or the duration of a power purchase agreement.	- reduced demand for power - reduced technical lifetime of the equipment - revocation of operating permits
Project end-of-life value	The salvage value (or disposal value) at end-of-life. It is the remaining value of an asset after it has been fully depreciated.	- increased cost of disposal - decreased financial feasibility for project overhaul
Project lead time	The time span needed to execute feasibility studies, get the needed permits and do the financial structuring of the project. Also the procedure to get the project registered as an emissions reductions project can be part of the project lead time.	- increased efforts needed to obtain contracts and/or permits - delivery of necessary permits and licenses delayed - decreased capacity to executing feasibility studies
Project development costs	These costs typically represents the sum of the costs incurred to bring a project to the detailed design and construction stage. This includes feasibility studies, initial financial structuring of the project, the obtaining of permits and basic engineering.	- increased cost of technical, legal or financial advise - increased cost of application of permits and licenses - additional requirements for obtaining permit or license
Construction costs	These costs represents the sum of the purchasing and installation costs of the energy equipment, civil works and other construction expenses.	- missing items in design brief - increased costs of equipment, materials and labour
Construction time	Time needed for tendering, detail engineering and construction of the installation.	- increased time needed to obtain suitable offer - delay in construction planning - delay in delivery of equipment

Item	Description	Mechanisms
CER/VER delivery	The actual amount of emissions reductions which need to be verified by an Designated Official Entity (DOE) and in case of CERs: certified by the Executive Board of the UNFCCC.	- emissions baseline subject to change from PDD - shortfalls of resource availability - reduced availability of equipment due to technology malfunction - other interruptions due to strikes, force majeure or terrorist action - lower than expected equipment performance
CER/VER price	The price for every CER or VER delivered on a forward-contract basis or directly to the market.	- lesser market demand - increased taxation of emission reductions revenues
Power production	The actual annual power delivered to the grid.	- shortfalls of resource availability - reduced availability of equipment due to technology malfunction - other interruptions due to strikes, force majeure or terrorist action - lower than expected equipment performance
Power price	The price received for every MWh as negotiated in a Power Purchase Agreement (PPA) or according to the prices on the spot market.	- increased supply of competitors - reduced cost of production of competitors or other power generation technologies
Subsidies and grants	Contributions, grants, subsidies, etc. that is paid for the initial cost or during operation of the project	- changing requirements for grant or subsidy eligibility - reduced amount of subsidy - project shortfalls expectations or reporting
Operational permits	All permits needed to act as an independent power producer, company registration, electricity connection agreement, etc.	- increased cost of application and/or prolonging permits and licenses - increased requirements, such as safety or environmental issues
Costs of contracts	All costs made for negotiating and securing compliance of all contracts made (Advisory services, Engineering and construction contracts, procurement contracts, employment contracts, (fuel) supply contracts, PPA, ERPA and insurance contracts.	- renegotiation of contracts needed - conflict over contracts and additional cost of legal support - contract party default

Item	Description	Mechanisms
Emissions reductions project cycle cost	All transaction costs needed to meet all requirements of registration, monitoring of the project and the verification and certification of the emissions reductions.	- PDD needs corrections - new UNFCCC methodology needed - increased UNFCCC Executive Board fees - increased cost of monitoring - monitoring equipment default - review of issuance of CERs - increased cost of DOE tariffs
Network costs	Costs of being connected to the grid and transporting energy through the grid.	- changing tariff
Fuel supply	Costs of obtaining biomass or fossil fuels for power generation.	- changing market prices - market shortages - supplier default - lower than expected quality of fuel (for instance lower organic fraction in landfill or higher moisture content of biomass)
Operation and maintenance costs	All costs of labour, additional supplies and planned maintenance.	- increased wages - unforeseen costs - compensations for physical damages of others, injuries or death of process operators
Income taxes	Income taxes is a tax levied on the financial income of the project. In some tax regimes business losses can be deducted against business tax by carrying forward the loss to later taxation years.	- change of tariff - abolition of income tax exemptions, tax holidays or loss carry-forward.
Interest rate	The compensations made to the debt investors for providing debt capital to the project. This does not include the principal repayments of the loan.	- changing base interest rates - changing requirements of debtors
Currency exchange rates	All cash flows might be affected by changing foreign exchange rates between contract closure and payments	- currency exchange rate fluctuations

6.3.3 Assessing the severity of consequences

For every identified risk a worst-case scenario can be added to the original financial assessment. This can be done by duplicating the original financial spreadsheet and changing the relevant values. By recalculating the value for the IRR and the DSCR for variations in the different units, a change in IRR and DSCR have to be scored on a ordinal four-point scale ranging from *inessential* to *disastrous*. Because different investors will define different hurdle rates based on the project characteristics and investment policy, general absolute values for the project financial indicators cannot be given. The project developer can set individual norms for the different scores by taking it's own return requirements into consideration, where the description of the developer perception should match the descriptions given in Table 3.

Table 3: Severity of consequences ordinal scale

Severity	Description
Inessential	It is very difficult to measure the impact of a variation of the parameter on the major financial indicators of the project, as it has a negligible impact on the project. Assuming that the risk will occur, this does not lead to a change in perception upon the attractiveness and financability of the project.
Marginally	Variations of the project parameters lead to minor changes in the primary financial indicators of the project. The project is still able to meet the hurdle rates for IRR and DSCR to a great extent. Assuming that the individual risk would occur, this would lead to carefully reconsidering of the project on other potential risks.
Critical	Variations of the project parameters have a big effect on the profitability of the project and liquidity of the project. Although risk occurrence does not jeopardize the continuing exploitation, the project is not able to meet the investors hurdle rates on IRR and DSCR.
Disastrous	Variations of the project parameters would lead to default of the project, when the risk would occur.

6.3.4 Conclusions & follow-up

In this paragraph Step 2B was explained, which is an approach to assess the severity of consequences. For every individual risk the position on the horizontal axis is determined. This delivers a risk matrix per category. The next paragraph deals with Step 2C in which a risk priority is determined and a risk score is assigned to every risk category.

6.4 Step 2C - compiling the traffic-light matrix

In Step 2A en 2B scores for respectively the *probability of occurrence* and the *severity of consequences* are assigned. In the first subparagraph the ranking of the risks per category is discussed in order to determine the risk priority. The second subparagraph explains the assignment of a risk category score in order to render the project risks in one overview.

6.4.1 Risk priority and assigning

After running through Step 2A and 2B the individual risks can be positioned in the traffic-light matrix per category. As a result the risk are rated on an ordinal scale, where:

- - extremely risky (red);
- unacceptable risky (orange);
0 ALARP (as low as reasonable practicable)(yellow);
+ acceptable risk (olive);
++ ideal risk (green).

These scale makes it possible to rank the individual risks on their priority. The arrow in Figure 41 shows the magnitude of the risks. Therefore risks within the green category are of a lower magnitude than the risks positioned in the upper-left red corner.

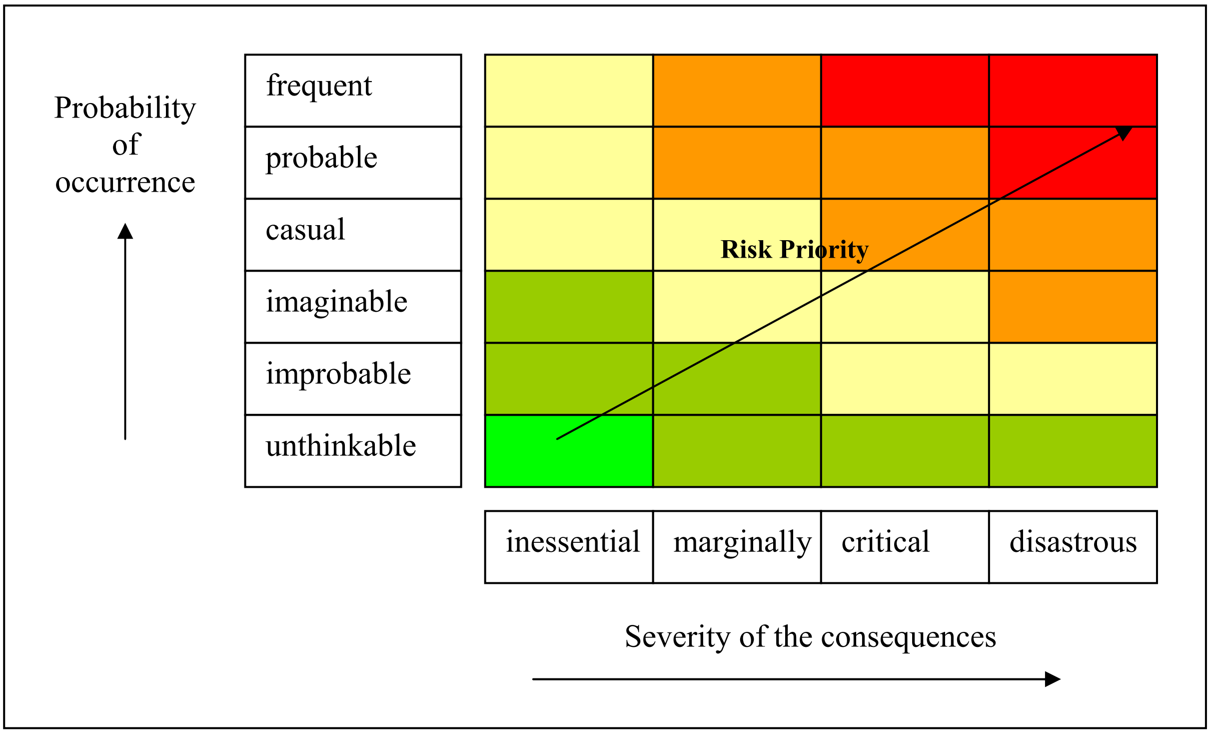


Figure 41: Risk priority

6.4.2 Category risk scores

In order to compile a risk profile in one overview category scores are needed. The risk priority rendered from the traffic-light matrix identifies which of the individual risks are most critical within the risk categories. Because the vital risks are determinative for the category risk, the category score is equal to the worst individual score within the category. This category risk scores serve as the input for Step 3, which is discussed in the next chapter.

7 Step 3: Compiling the risk-spider

The result of the preceding Step 2C is a traffic-light matrix for every risk category and a score on every risk category based on the worst individual score within each category. Therefore a category risk score is available, which is on a five point ordinal scale:

- - extremely risky;
- unacceptable risky;
0 ALARP (as low as reasonable practicable);
+ acceptable risk
++ ideal risk.

In Step 3 all categories risk scores are brought together in one spider diagram as is visualized in Figure 42. This risk-spider aims to provide an overview of all the project risks. It allows project developers and potential investors to set maximum risk levels given the expected return. The green area represents the assumed acceptable region for a project to be viable for financial closure. Based on the total overview and the investor's risk seeking or risk avoiding behavior the project can be judged on it's financability. Also the risk spider makes it possible to compare multiple projects.

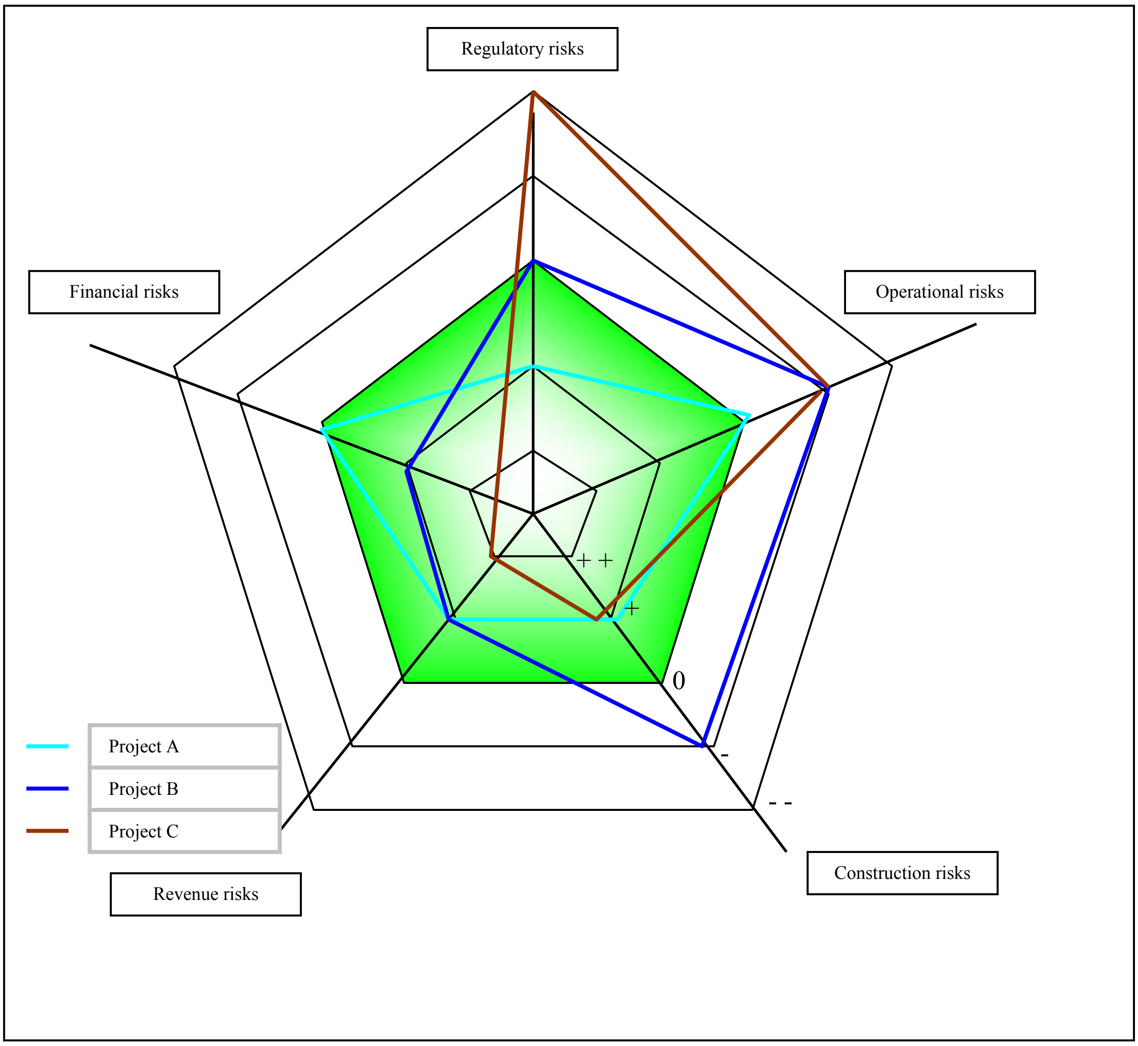


Figure 42: Spider diagram for visualization of category scores

8 Evaluation & Recommendations

Evaluation of the tool is done with interviews with experienced project developers, which is reported upon in the first paragraph. Based on the interviews recommendations for further research are made in the second paragraph.

8.1 Evaluation of the tool

The tool has been presented to experts of two experienced project development companies, which are active in wind, hydro, landfill gas and biomass energy for several years. By implementing the tool on a number of cases the tool was evaluated on the fit, relevance, workability and modifiability.

Fit

Both project developers use 'stage gating' which cut the development project into different stages and provides clear points of project evaluation coupled to a go/no-go decisions. By using general or case-specific checklists the decision is made either to proceed with a next stage of development or to stop further development of the project. In the more advanced stages of development the checklists become more comprehensive.
Although there is no formal risk assessment procedure, the identification and analysis of risks is carefully interwoven in the feasibility analyses. Also there are parallels in the approach towards risks. Both companies scan the project for 'showstoppers', which could be addressed as risks with a *disastrous* to *critical* impact on the project. For these 'showstoppers' mitigation measures are searched and otherwise the project is avoided.
Another parallel is that both companies use conservative figures for risks with a *imaginable* to *frequent* probability of occurrence and an *inessential* or *marginally* severity of consequences, whereby they thus assume that the risk will occur. If the risk somehow does not occur, this is delivering the project an 'upside potential'. The considerations concerning risk analysis and management of the respondents are visualized in the traffic-light matrix in Figure 43.

The experts agreed upon the method of scoring the category risks by attributing the worst score of the individual risk within the category to the whole category. Compensation of good individual scores with high risks within the category is not seen as a real option.
Concerning the spider diagram one of the experts commented that probably not all the categories would have the same magnitude or weight in the decision upon project feasibility. Further was mentioned that an extremely risky score (- -) should lead to outright rejection of the project. The rationale behind this could be that the experts think that for some categories and individual risks adequate risk mitigation measures could be available. Because weighting of the risks is executed by the application of Step 2A and 2B, weighing should not be executed again in Step 3. A logical explanation for this is that risks, that are of comparable minor importance, would not be assigned with attribute *extremely risky (- -)* or *unacceptable risky (-)*.

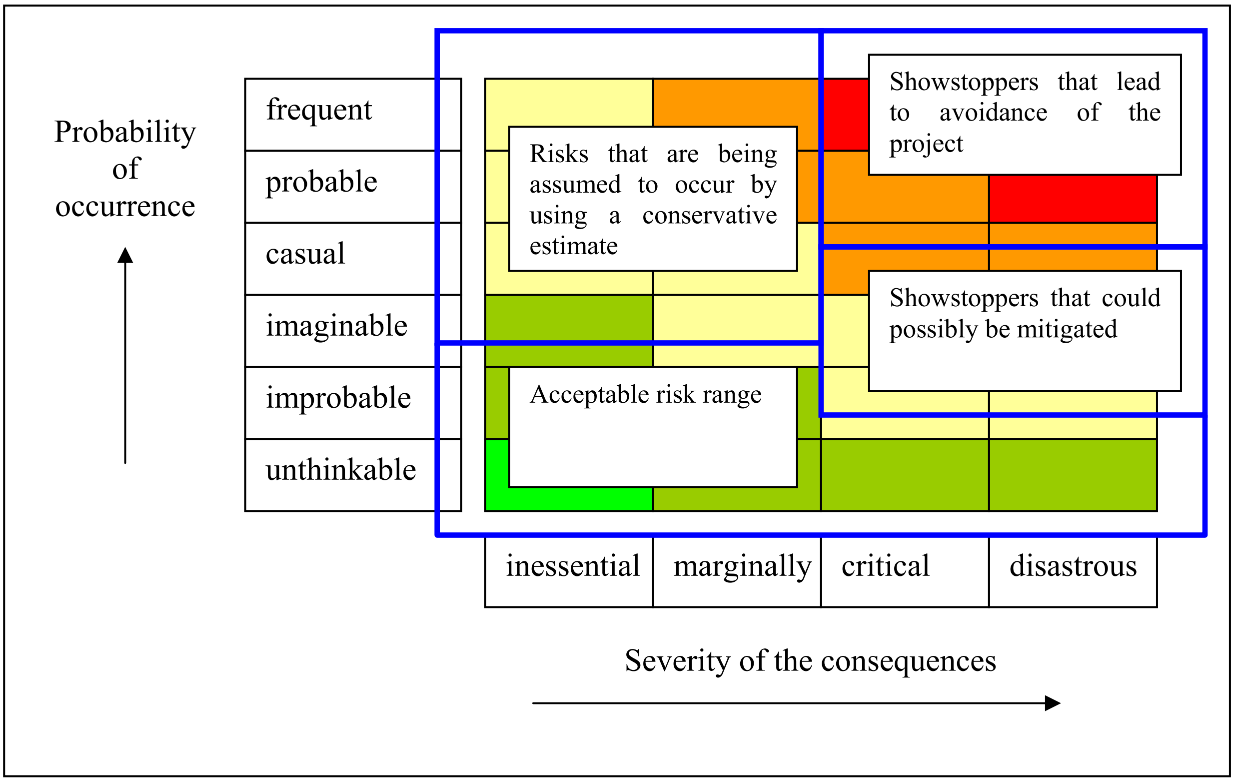


Figure 43: Observed approach to project risks in current applied project assessments

Relevance

In both interviews scenario analyses have been discussed and the general consistent problem is that a scenario with multiple risks causing worst case scenario's, no project will remain erect. They are aware that there is software available that can execute Monte Carlo simulations based on assumed risk distributions. The objection against using this type of tools is that risk distributions of all risks are often not known and that this reduces the meaning and reliability of the outcomes. Also there might be variance or co-variance between different risks, which is of importance for accurate modeling of the assumptions for the Monte Carlo simulation.

In order to limit the loss of development costs, the development is cut in stages. In these stages funds are spend to clear technical, financial and legal uncertainties. Between the stages gates are created, which serve as a decision point for initiating funding for the subsequent stage and moving forward with the project. This process of stage-gating is visualized in Figure 44.

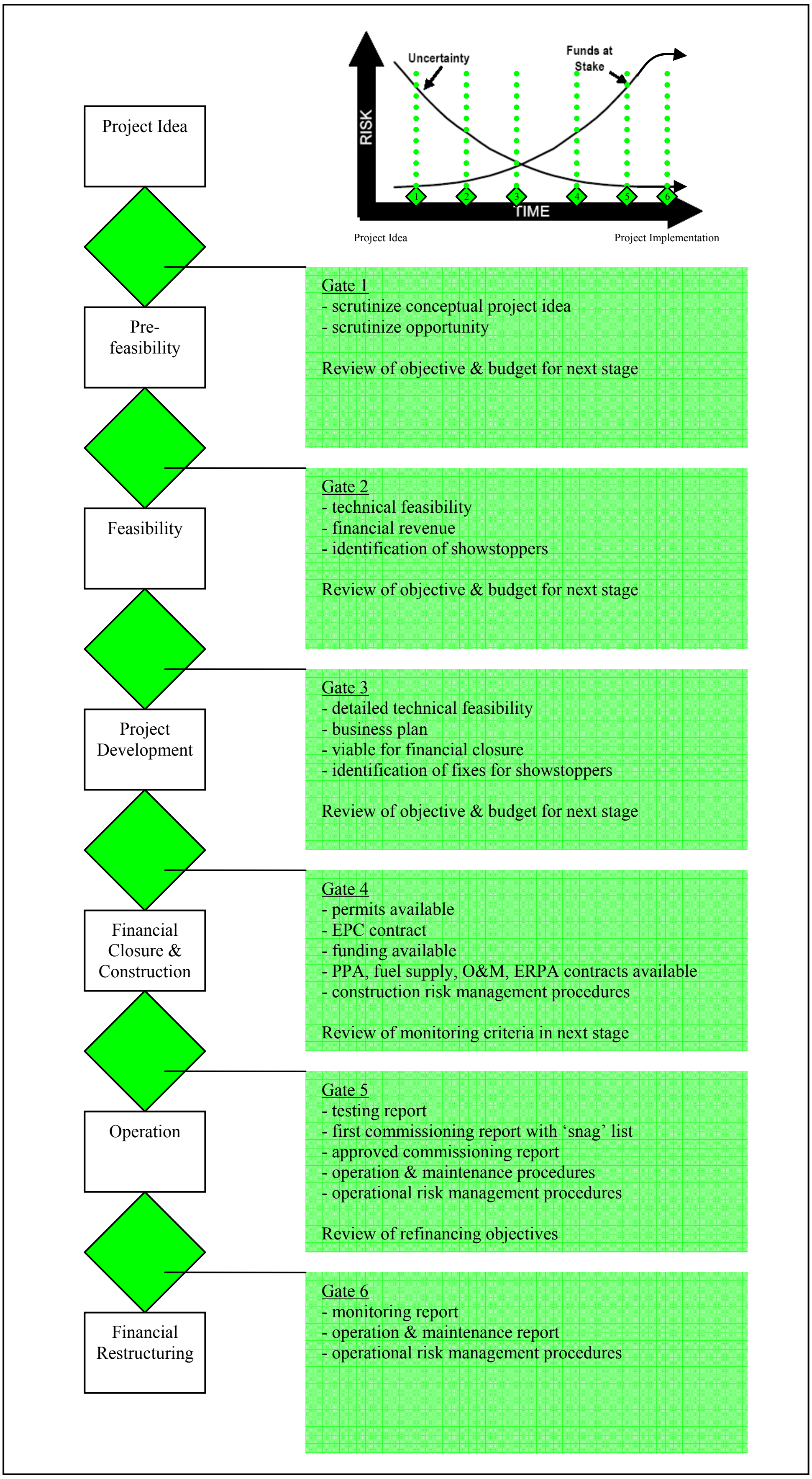


Figure 44: Stage-gating in renewable energy project development

Workability

Because the tool does not rely on exact probability distributions, the tool can be applied in all stages of project development. The qualitative approach to the *probability of occurrence* and semi-quantitative approach to the *severity of the consequences* makes it practical. The project developers see the input of subjective judgments of the risk assessor as a limitation for the communication of risks. Therefore a more quantitative approach with Monte Carlo simulations are appealing. It should be taken into account that probability distributions provide an impression of being *objective*, but include underlying assumptions based on historical data on a more aggregate level and *subjective* interpretations.
This does not mean that data on a more aggregate level does not provide useful information for project developers. Quite the contrary, it provides a good point of reference for project developers and investors to prevent under- or overestimating the project chances of success or failure. The availability of probability distributions, based on a representative dataset, enables project developers and investors to calibrate their risk perception.

Modifiability

The design of the tool provides project developers and investors the ability to modify the tool at their own discretion. For instance: the approach to identify risks can be extended, the number of cells in the risk matrix can be changed and a semi-quantitative approach can be applied to the assessment of the *probability of occurrence*. One project developer mentioned that in some project decisions the payback time is an important financial performance indicator. Although the tool uses other financial parameters, there are no objections to modify the tool and express the *severity of consequences* in terms of payback time. The merits of the tool is that it provides a systematic approach to the risk assessment process.

8.2 Recommendations

Two recommendations can be distilled from the tool evaluation in the previous paragraph. Firstly, the development of risk mitigating measures will benefit from more insight in the causes and consequences of project risks. Secondly, representative quantitative probability figures on project development successes and failures can improve the project developers' and investors' risk perceptions.

Causes and consequences of risks

The tool provides limited understanding in the causes of risks. The assessment of the probability of occurrence is done in an intuitive and qualitative manner, which does not give clear direction to risk mitigating measures. Also the occurrence of a risk can be due to different causes. Also the consequences of the risks can induce other risks. More insight in the mechanisms that cause risks provides a better insight in measures that mitigate these risks. Because the projects are usually rather complex, it is rather difficult to provide a ready-made answer for the present risk. Therefore it might be helpful to structure the causes and consequences of risks. A practical tool that structures risks is a bow-tie diagram (Lewis 2005). In a bow-tie diagram includes the event, its causes and consequences, and the measures to mitigate the risk.
As an example a bow-tie diagram for delayed delivery of equipment risk is given in Figure 45. In this example there a number of causes given of the occurrence of the unwanted event. In order to minimize the probability of occurrence of delayed delivery due to market shortages two prevention barriers are available. Nevertheless, the risk is not completely prevented, because delay could also be caused by underperformance of the contractor that

constructs the access road. The diagram indicates the need for a prevention measure that mitigates the consequences of a preceding risk.
Furthermore, the unwanted event can have multiple consequences, which also need mitigation measures. For instance an insurance for delay in start-up does not change the probability of occurrence, but it provides an instrument to reduce the severity of the consequences.

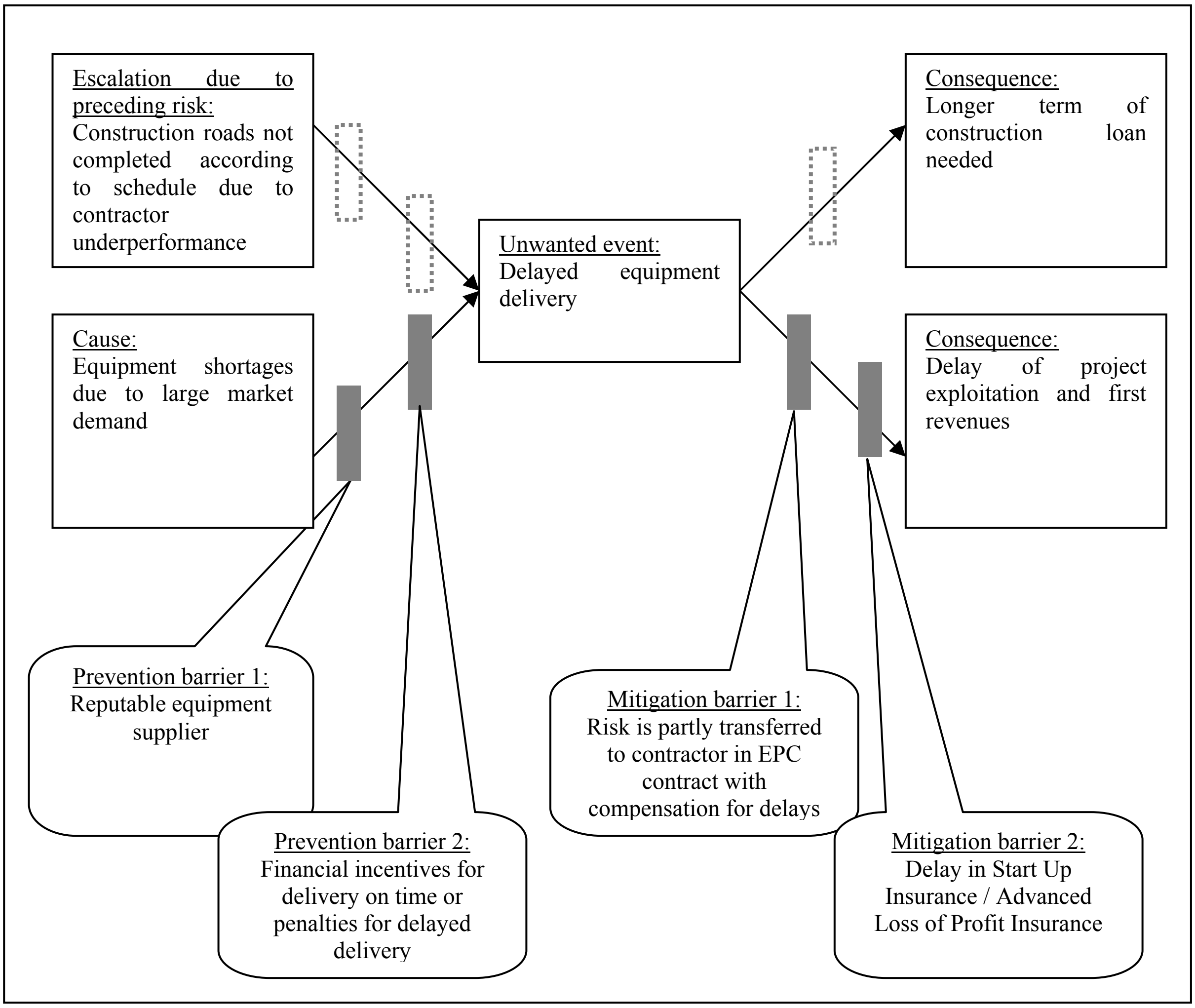


Figure 45: Bow-tie diagram for delay of equipment delivery risk

Thus, one treatment to lower the risk is preventing a risk to occur: i.e. lowering the probability of occurrence of the risk. Another strategy is to reduce the severity of the risk by transferring risks. Figure 46 shows the analogy with the traffic-light matrix, where the directions for risk treatment options are positioned. Research on worst- and best-practice cases should provide more insight in respectively risk mechanisms and mitigating measures.

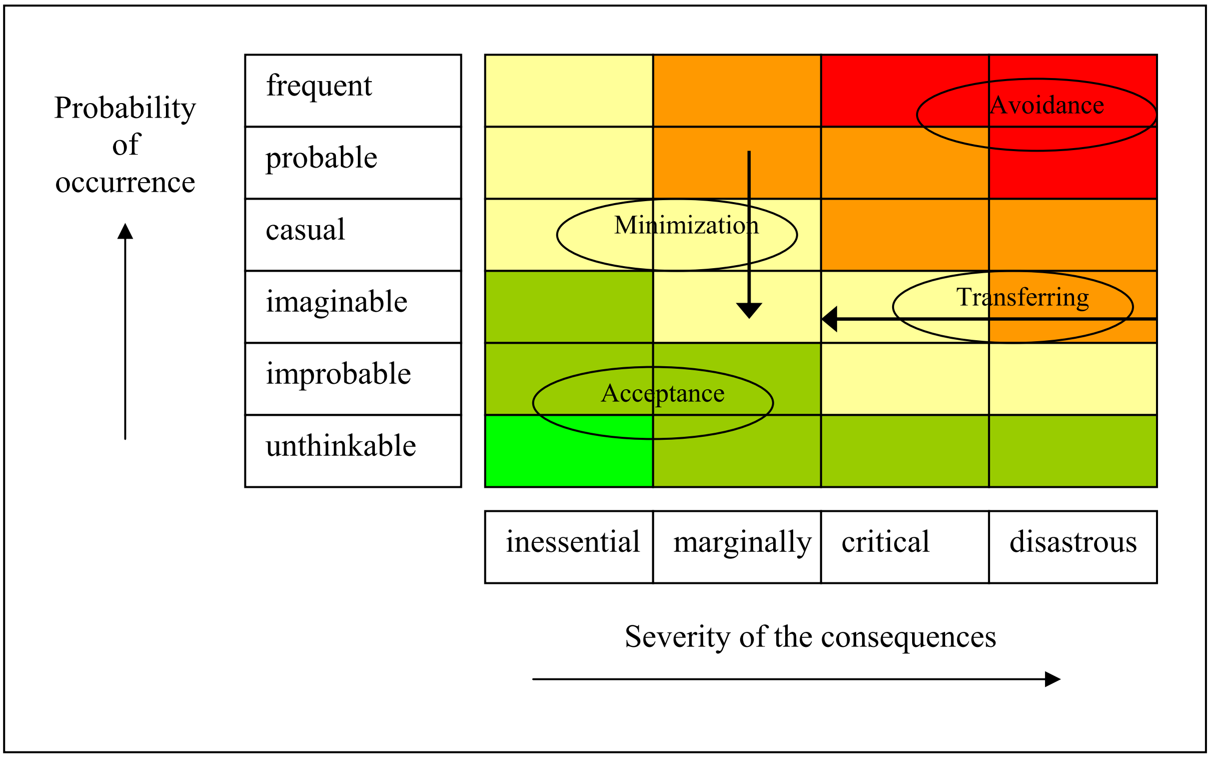


Figure 46: Risk treatment strategies within the traffic-light matrix

Quantification of probability distributions

The tool provides a systematic risk assessment approach, that enables to communicate the risks. Because it uses a qualitative approach in the assessment of the probability of occurrence contains a subjective judgment of the risk assessor. Therefore the outcome can be unconvincing for project developers or investors, that hold a positive or negative bias towards renewable energy projects. The availability of probability distributions derived from a representative sample of projects can calibrate the risk perception, whether it is overestimating or underestimating the prevent risks. Furthermore it enables a semi-quantitative approach in the assessment of the probability of occurrence.

9 Conclusions

Lindlein (2005) identified several hurdles for renewable energy projects in order to come to financial closure. A prominent problem is that the technologies are generally associated with unfamiliar, high risks and unclear risks. Furthermore project developers are often rather inexperienced and within the financial sector there lack of understanding concerning renewable energy. Therefore the objective of the research was to develop a tool, that provides insights in the risks present in renewable energy projects, assists to communicate these risks and helps finding ways to effectively manage the project risks. Therefore the main research question was:

How can risks in renewable energy projects be assessed in order to provide project developers and potential investors with a broader understanding in the nature of these risks?

This main research question was split up into two exploratory questions that provided input for the design process. One research question aimed to evaluate the designed tool.

1. **How is risk assessment done by professionals in the renewable energy sector?**

Project developers and investors state that they assess projects on a case-to-case basis. The main criteria is a good risk-return trade-off, but also other criteria can be of importance, such as portfolio spread, minimum project size, access to bigger portfolio of similar projects, specific country or technology focus or exclusions and having local representation in the project country. Similar criteria are applied by project developers in renewable energy. Different approaches are available to group individual risks into broader categories.

2. **What existing risk structuring methods could fit to the risks present in renewable energy development?**

Although other definitions are available, risk is defined as: the potential negative impact of an uncertain and undesirable event, whether or not it actually takes place. Risk is therefore the multiplication of the probability of an undesired event and the impact of this event. Probabilities of occurrence can be assessed quantitatively if probability distributions are known. If no probability distributions are available, assessment can be applied on a semi-quantitative or qualitative basis. Historical information and agency theory can act as input for this qualitative assessment. The severity of consequences can be assessed semi-quantitative by taking financial performance indicators into consideration. Risk matrixes are available for semi-quantitative and qualitative assessments. Monte Carlo simulations allow a more quantitative approach, provided that objective probability distributions are available.

Based on the previous two exploratory research question a tool was designed by applying the grounded theory approach. The tool was evaluated with the following question:

3. **Does the tool provide the project developers with an additional understanding of project risks?**

The tool fits to the practice of project evaluation and is applicable in various stages of project development. The project developers identify it as a practical and complimentary tool to their existing procedures. The design of the tool provides project developers and investors the ability to modify the tool at their own discretion. The project developers see the input of subjective judgments of the risk assessor as a limitation for the communication of risks. Furthermore the tool does not give direction to risk mitigation measures.

Therefore two recommendations were made to comply with these limitations. Firstly, the development of risk mitigating measures will benefit from more insight in the causes and consequences of project risks. Secondly, representative quantitative probability figures on project development successes and failures can improve the project developers' and investors' risk perceptions.

References

Aerospace Corporation, *Risk Management Quick Reference Card*, The Aerospace Institute, 2003, available at: http://www.aero.org/education/tai/materials.html

Barringer, Paul, *Risk-Based Decisions*, Barringer & Associates, November 2004, available at: http://www.barringer1.com/nov04prb.htm

Bayon, Ricardo et.al, *Voluntary Carbon Markets, An Internacional Business Guide to What They Are and How They Work*, Earthscan, James and James (Science Publishers) Ltd., 2007.

Beidleman, C.R., D. Fletcher, D. Veshosky, "On allocating risk: the essence of project finance", *Sloan Management Review*, Spring 1990, p.47-55

Bishop, V., *Improving Price Equity in CDM projects, Strategies for Maximizing Carbon Value*, in: Hodes, G. & S. Kamel (Ed.), *Determining a Fair Price for Carbon*, CD4CDM Project, UNEP Risø Centre, 2007, p. 37 – 55, available at: http://www.cd4cdm.org/Publications/Perspectives/FairPriceCarbon.pdf

Capacity Development for the Clean Development Mechanism (CD4CDM), *Guidebook to Financing CDM Projects*, ISBN 978-87-550-3594-2, CD4CDM Project, UNEP Risø Centre, Roskilde Denmark, May 2007, available at: http://www.cd4cdm.org/Publications/FinanceCDMprojectsGuidebook.pdf

Dick, Bob, "Grounded theory: a thumbnail sketch", *Action Research Resources*, 2005 available at: http://www.scu.edu.au/schools/gcm/ar/arp/grounded.html

Dorsman, A.B., *Vlottend Financieel Management, Analyse en Planning*, fourth revised edition, Kluwer Bedrijfsinformatie, 1999

Eckhart, Michael and Tom Weirich, "Moving Renewable Energy Into the Mainstream", *Worldpower*, 2006 edition, p. 119-121.

Fieldstone Private Capital Group Limited, *Financing Renewable Energy Projects; A guide for developers*, Prepared for the Department of Trade and Industry, Revised by ETSU, ETSU K/FR/00028/REP, February 2000, available at http://www.berr.gov/files/file15118.pdf

Knight, F.H., *Risk, Uncertainty, and Profit. Boston*, MA: Hart, Schaffner & Marx; Houghton Mifflin Company, 1921, available at: http://www.econlib.org/LIBRARY/Knight/knRUP.html

Lam, James, *Enterprise Risk Management, From Incentives to Controls*, John Wiley and Sons, 2003, p.24-25

Lettner, Friedrich, et.al., *Gasification Guide, Deliverable 9: Report on possible health, safety and environmental hazard from biomass gasification plants*, Institute of Thermal Engineering, Graz University of Technology, Intelligent Energy Europe Program, Austria, December 2007, available at: http://www.gasification-guide.eu/

Lewis, Steve & Sheryl Hurst, "Bow-Tie, An elegant solution?", *Strategic Risk*, 8 November 2005

Lindlein, Peter & Wolfgang Mostert, *Financing Renewable Energy, Instruments, Strategies, Practise Approaches*, Discussion Paper 38, KfW Development Bank, Frankfurt December 2005, available at: http://www.kfw-entwicklungsbank.de/DE_Home/Service/Online_Bibliothek/PDF-Dokumente_Diskussionsbeitraege/38_AMD_Renewable_Energy.pdf

Makinson, Sandra, et. al., *Catalyzing sustainable energy sector growth*, UNEP Sefi, ISBN 92-807-2592-0, 2005, available at : http://sefi.unep.org/fileadmin/media/sefi/docs/publications/SEFI_Public_Finance_Report.pdf

Marsh Ltd., *Survey of Insurance Availability for Renewable Energy Projects*, UNEP, March 2006, available at: http://sefi.unep.org/fileadmin/media/sefi/docs/industry_reports/Marsh_Risk.pdf

Marsh Ltd., *Assessment of Financial Risk Management Instruments for Renewable Energy Projects*, UNEP Working Group 1 Study Report, UNEP, 2007, available at: http://www.unep.fr/energy/projects/frm/doc/UNEP%20WorkingGroup1Report2007.pdf

New Energy Finance Research, *Global Trends in Sustainable Energy Investment 2007, Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency in OECD and Developing Countries*, UNEP Sefi and New Energy Finance, 2007, available at http://www.unep.org/pdf/SEFI_report-GlobalTrendsInSustainableEnergyInverstment07.pdf

Routio, Pentti, *The Science of artifacts, Guide to research and development*, 2007, available at: http://www2.uiah.fi/projects/metodi/

Sadgrove, Kit, *The Complete Guide To Business Risk Management*, Gower Publishing Ltd, 2005

Sonntag-O'Brien, Virginia & Eric Usher, Mobilizing Finance for Renewable Energies, thematic background paper, Basel Agency for Sustainable Energy / United Nations Environment Programme, Internationale Konferenz für Erneuerbare Energien, Bonn, January 2004, available at: http://www.renewables2004.de/pdf/tbp/TBP05-financing.pdf

Stewart, Thomas A., "Managing Risk in the 21st century", *Fortune* (February 7th 2000): 202

Treasury Board of Canada, *Applied Risk Management, Examples form Federal Departments and Agencies*, ISBN 0-662-69023-0, 2005, available at: http://www.tbs-sct.gc.ca/rm-gr/arm-pgr/exfed_e.pdf

UNDP/BDP Energy and Environment Group, *The Clean Development Mechanism: A users guide*, UNDP, 2003, available at: http://www.undp.org/climatechange/mitigat.htm

UNEP, *Scoping Study on Financial Risk Management Instruments for Renewable Energy Projects, reference document*, United Nations Environment Programme, 2004, available at: http://www.uneptie.org/energy/projects/frmi/doc/Reference%20doc-RE%20risk%20study.pdf

UNEP, *Public Finance mechanisms to Catalyze Sustainable Energy Sector Growth*, United United Nations Environment Programme, Division of Technology, Industry and Economics, Basel Agency for Sustainable Energy, 2005, available at: http://sefi.unep.org/fileadmin/media/sefi/docs/publications/SEFI_Public_Finance_Report.pdf

UNEP, *Assessment of Financial Risk Management Instruments for RE projects in Developing Countries*, UNEP/GEF Project, United Nations Environment Programme, April 2006, available at: http://www.uneptie.org/energy/projects/frmi/doc/Background%20study-%20final.pdf

Verschuren, P. & Hans Doorewaard, *Het ontwerpen van een onderzoek*, Uitgeverij Lemma BV, Utrecht, 2003

Waal, P. de, *Financing with Carbon Assets*, Fortis, Presentation held at Carbon Expo 2007, Cologne, available at: http://www.mc-cgn.de/km/carbonexpo/conference/download_presentations_2007/pdf/thurs_11-12_es_PeterdeWaal.pdf

World Alliance for Decentralized Energy (WADE), *Clean Development through co-generation; Combined Heat and Power Projects in the Clean Development Mechanism*, October 2006, p. 14, available at: http://www.localpower.org/documents/report_chp-cdm.pdf

Annex - Risk assessment forms

For practical application of the tool the chapters 4 through 7 serve as guidance. The tool consist out of 3 steps: identification of risks (Step 1), assessment of the risks (Step 2) and generating an overview of the risks (Step 3).

For identification and assessment five risk categories are used, namely:

1. Regulatory risks
2. Development & Construction risks
3. Operational risks
4. Revenue risks
5. Financial risks

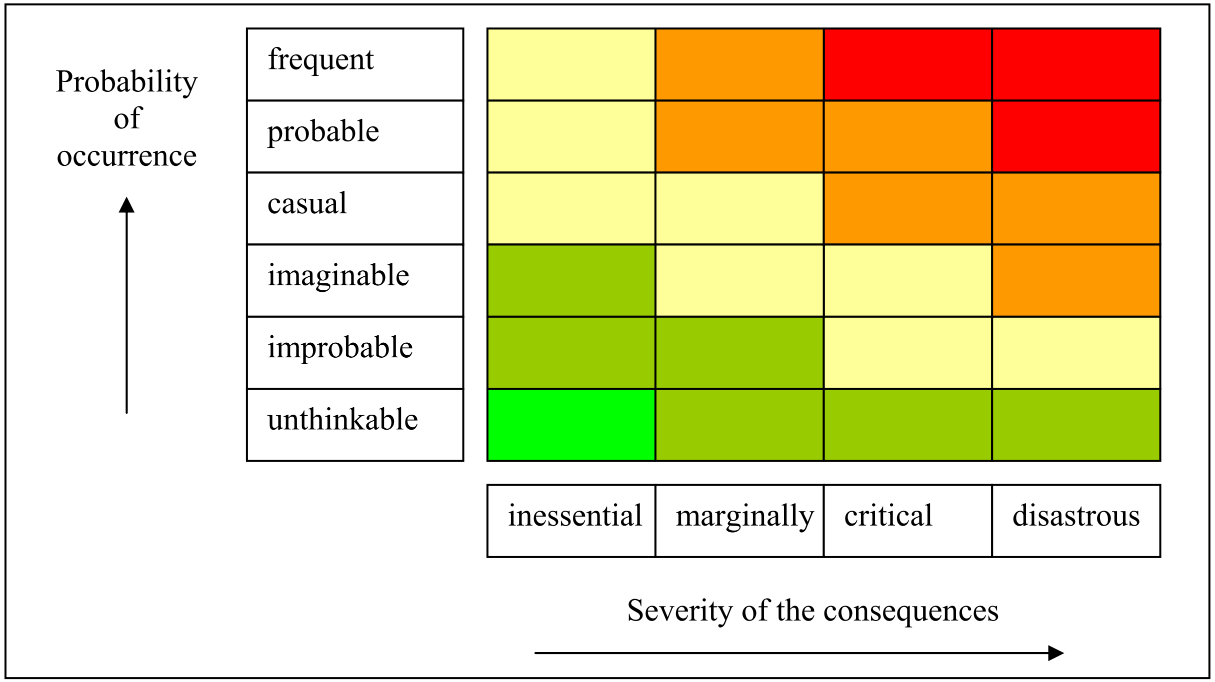
For every risk category one form is available for identification (Step 1) and risk assessment (Step 2). The risk-spider in Step 3 assists in compiling the category risks into one overview.

For Step 2B the assessor needs to define his requirements considering the financial performance indicators of the project.

Severity	Description	Financial indicator
Inessential	It is very difficult to measure the impact of a variation of the parameter on the major financial indicators of the project, as it has a negligible impact on the project. Assuming that the risk will occur, this does not lead to a change in perception upon the attractiveness and financability of the project.	…. < IRR < …. …. < DSCR < ….
Marginally	Variations of the project parameters lead to minor changes in the primary financial indicators of the project. The project is still able to meet the hurdle rates for IRR and DSCR to a great extent. Assuming that the individual risk would occur, this would lead to carefully reconsidering of the project on other potential risks.	…. < IRR < …. …. < DSCR < ….
Critical	Variations of the project parameters have a big effect on the profitability of the project and liquidity of the project. Although risk occurrence does not jeopardize the continuing exploitation, the project is not able to meet the investors hurdle rates on IRR and DSCR.	…. < IRR < …. …. < DSCR < ….
Disastrous	Variations of the project parameters would lead to default of the project, when the risk would occur.	…. < IRR < …. …. < DSCR < ….

Regulatory risks

	Identified Risks (Step 1)	Probability of occurrence considerations (Step 2A)	Probability score	Severity of the Consequences (Step 2B)	Severity Score	Priority (Step 2C)
A.						
B.						
C.						
D.						
E.						



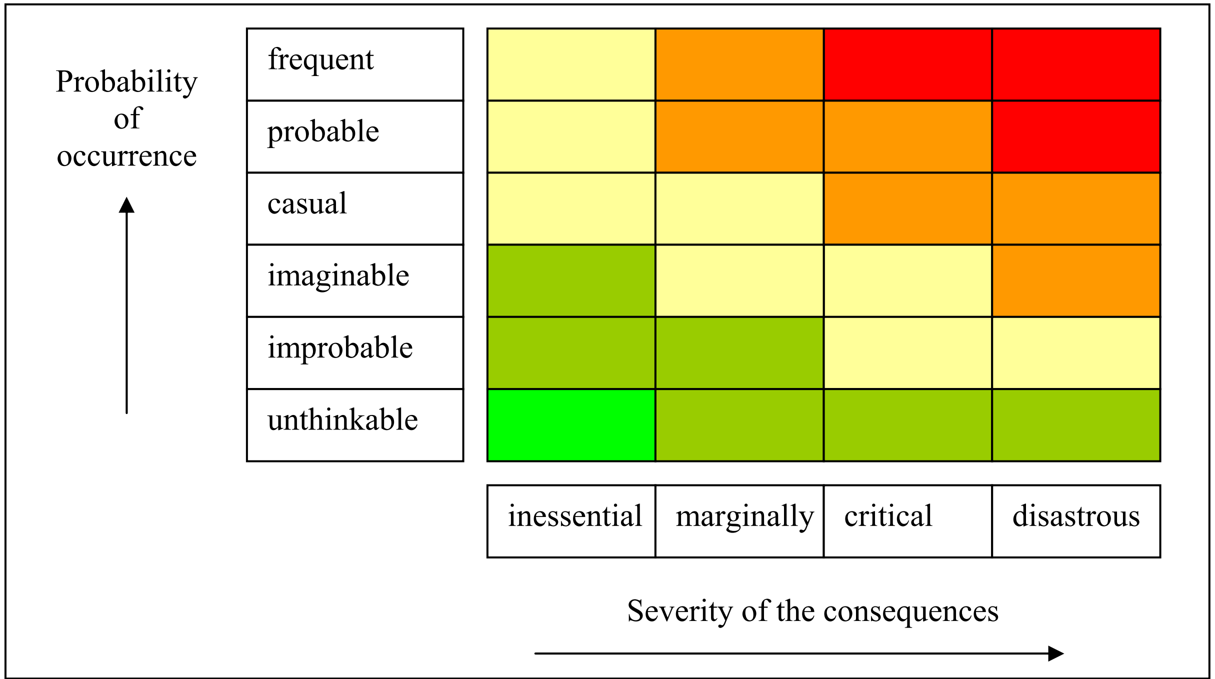
Category score:

- - / - / 0 / + / ++

B

Development & construction risks

	Identified Risks (Step 1)	Probability of occurrence considerations (Step 2A)	Probability score	Severity of the Consequences (Step 2B)	Severity Score	Priority (Step 2C)
A.						
B.						
C.						
D.						
E.						



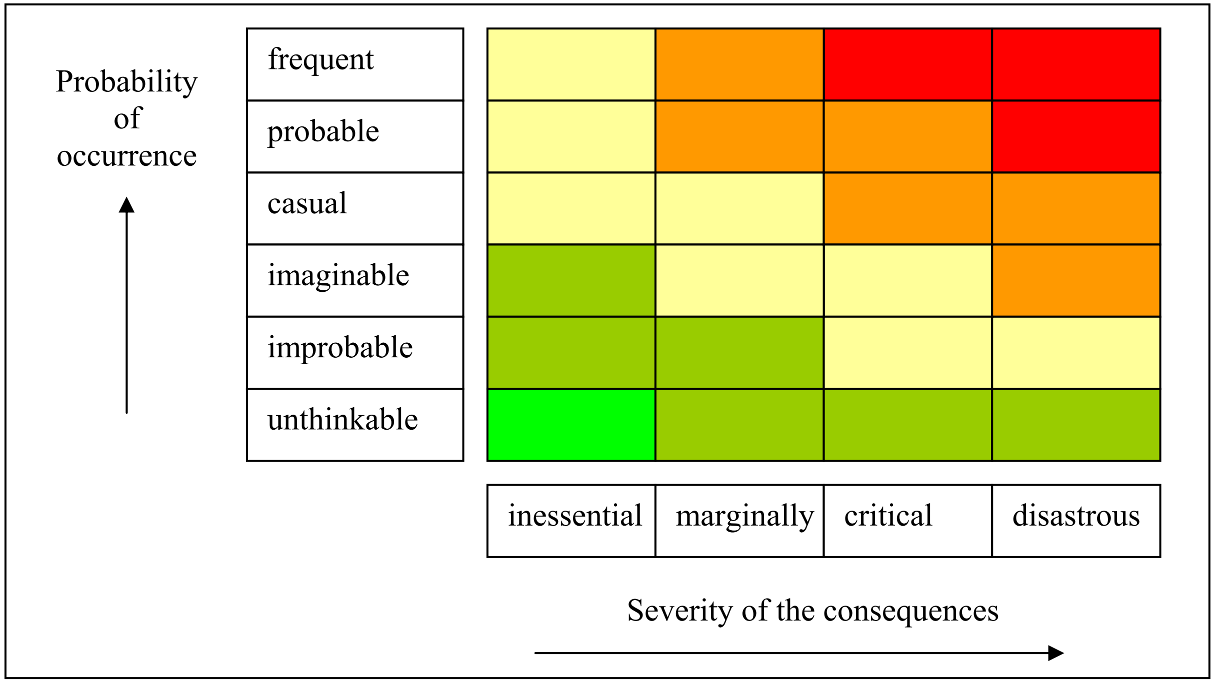
Category score:

- - / - / 0 / + / ++

C

Operational risks

	Identified Risks (Step 1)	Probability of occurrence considerations (Step 2A)	Probability score	Severity of the Consequences (Step 2B)	Severity Score	Priority (Step 2C)
A.						
B.						
C.						
D.						
E.						



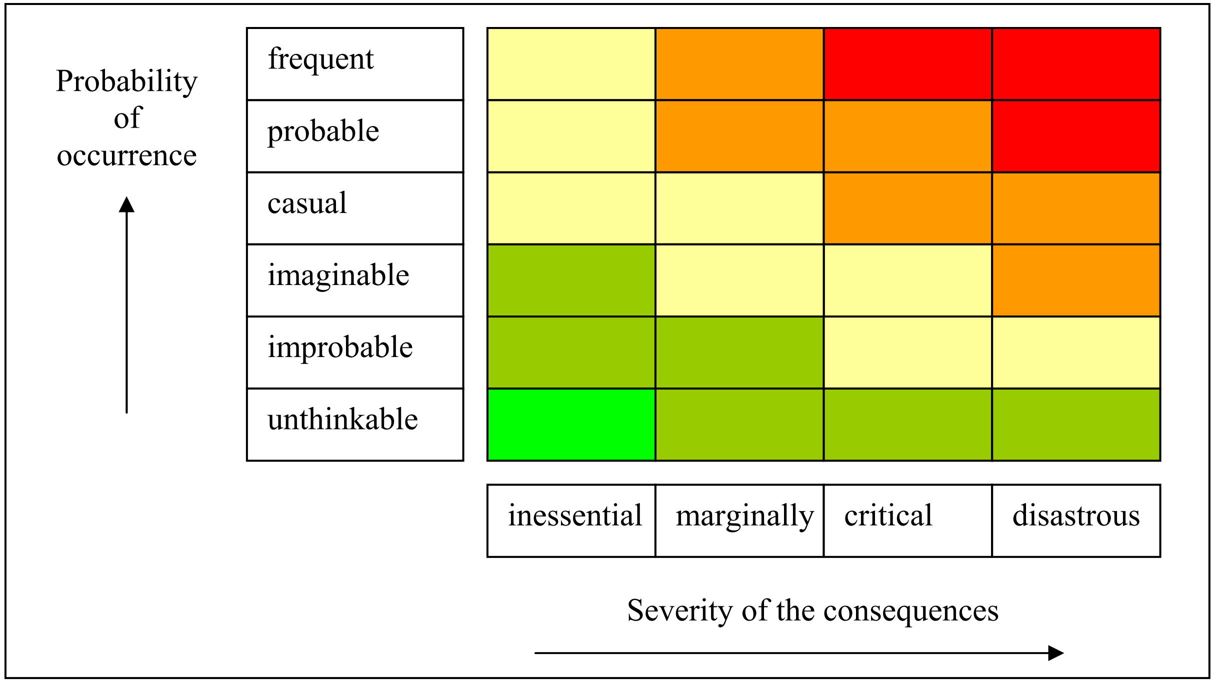
Category score:

- - / - / 0 / + / ++

D

Revenue risks

	Identified Risks (Step 1)	Probability of occurrence considerations (Step 2A)	Probability score	Severity of the Consequences (Step 2B)	Severity Score	Priority (Step 2C)
A.						
B.						
C.						
D.						
E.						



Category score:

- - / - / 0 / + / ++

E

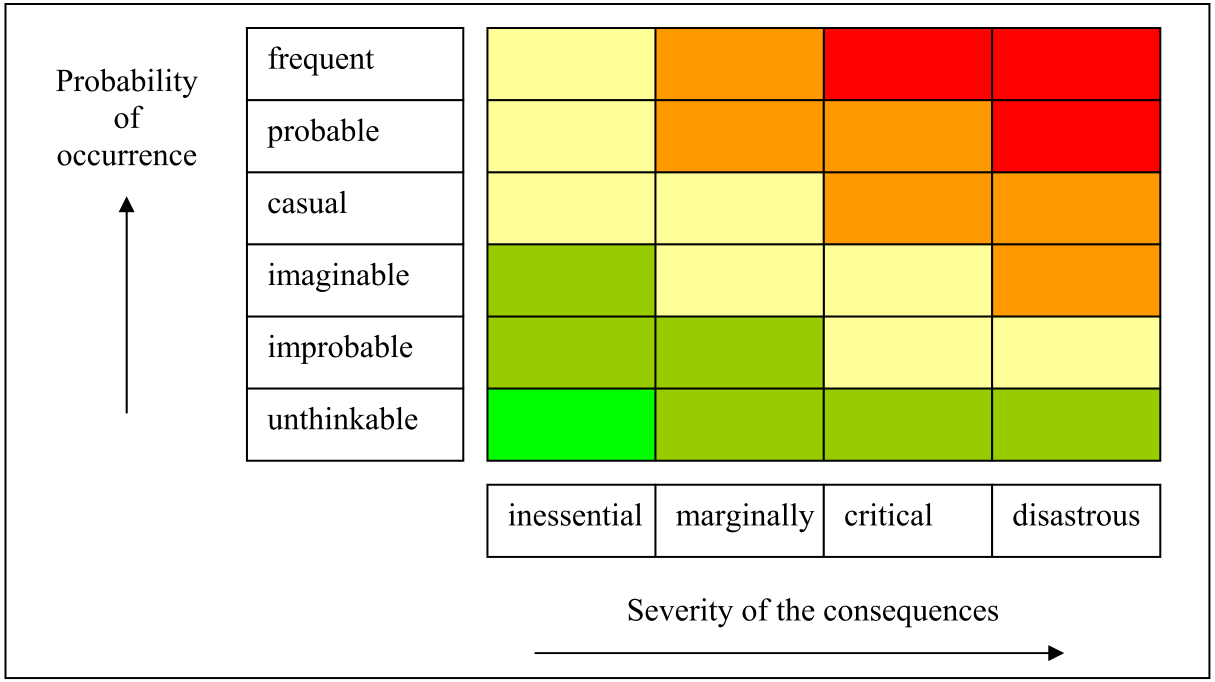
Financial risks

	Identified Risks (Step 1)
A.	
B.	
C.	
D.	
E.	

Probability of occurrence considerations (Step 2A)	Probability score

Severity of the Consequences (Step 2B)	Severity Score

Priority (Step 2C)

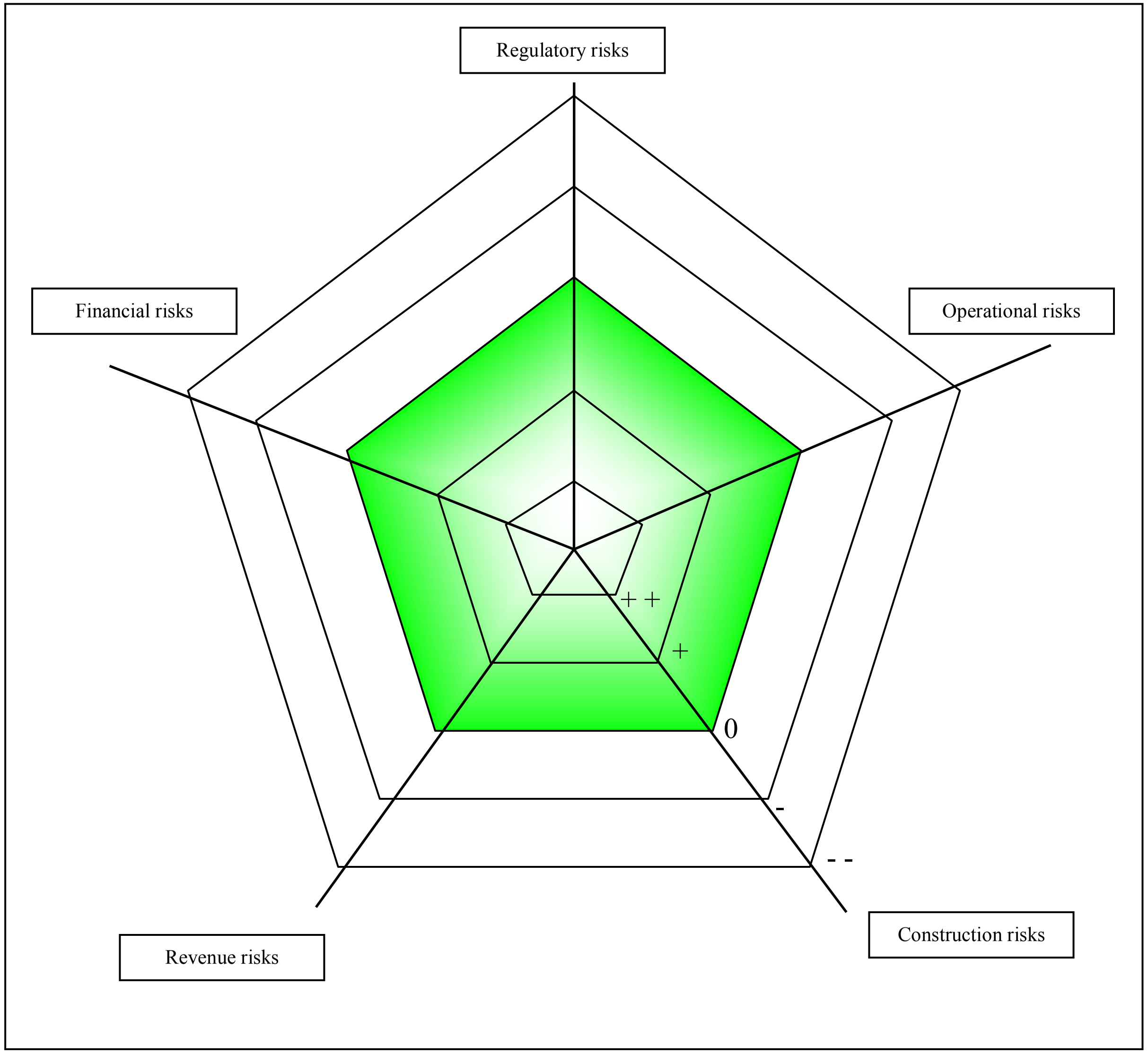


Category score:

- - / - / 0 / + / ++

F

Risk Spider (Step 3)



Category	Score
Regulatory risks	
Development & Construction risks	
Operational risks	
Revenue risks	
Financial risks	