UNIVERSITY OF PIREAUS

DEPARTMENT OF INTERNATIONAL AND EUROPEAN STUDIES

POSTGRADUATE: MASTER IN ENERGY STRATEGY, LAW AND ECONOMICS

THESIS

"FINANCING TOOLS IN RENEWABLE ENERGY TECHNOLOGIES AND PROJECTS"

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PIREAUS, DECEMBER 2018

Ο **Δεββές Ευστάθιος του Θεοδώρου** βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

ΔΕΒΒΕΣ ΕΥΣΤΑΘΙΟΣ

Abstract

The International Agenda for Renewable Finance has pointed out the importance of evaluation of finance tools, reliability of risk release mechanism and social confidence of Support Schemes for REP. All kind of actors are necessary to be informed: States, Banks, Finance Experts, Insurance Experts, RES developers, Society. The optimum leverage delivers the greater package of private financing for the minimum public funds. It is the stability of revenues, not fixing of payment prices that guarantees warranted returns of investors if they really want to receive reliable warranties regarding RE Technologies. Different RE Technologies perform different level of exposure to different risk patterns, markets and barrier formations.

In conclusion, instrument choice must correspond local actors ability to develop an effective management in RE Projects and to be modernized, in order to use the suitable instruments and local policy mechanisms, releasing barriers and risks.

Keywords: *renewable financing, support schemes, risk mitigation, energy innovation, hybrid bonds.*

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Chapter 1 Introduction

Scope

Scope of this thesis is the study of Financing Tools and further development of Renewable Energy Technologies and Projects (RET – REP). All possible choices and alternative tools for this specific energy sector will be covered. Activation of incentives, generated by these tools, for investors and stakeholders, in order to ensure best returns for them, are also to be studied.

Methodological Approach-Structure :

Methodological Approach and development of this thesis is based in 4 main pillars:
P1:**A model development for estimation of the cost of debt, equity and Weighted Average Cost of Capital (WACC).** These are the key figures for financial actors to invest in Renewable Projects and Infrastructure **(Chapter 2**).
Cost of equity indicates opportunities or threats for investors, according to Support Rules and legislation for Renewables
Cost of debt represents the major country risk. The trust of financial institutions, and smart firms that provide specialized financial services to local REP developers is tied to cost of debt, for a specific country.
WACC expresses ratio between debt and equity, level of return desired by debt creditors and level of return expected from equity holders. Creditors rank in particular company or project returns.

P2: **Identification of Key Risks and barriers in Renewable Energy Projects**. **(Chapter 3)**. Financial sector has to realize nature of REP risks and develop a rich data for specific risks caused by resource variability, nature of technology, and operational issues. Public support concerning technical maturity and engineering implementation could encourage insurance firms to innovate modern insurance products, “custom made” for RETs. Reliability of RET insurance basket could account to a significant leverage to private investments in RETs.

P3: **Availability of Financing Tools, Insurance Products and Financial Risk Management Instruments for REPs (Chapter 4). In addition, Support Scheme (Subsidies) Assessment is illustrated**. This is what is going to mitigate Investment Risks in Renewable Energy Financing.
Cash flow variations during fundamental time intervals of a REP lifetime should verify the positive and negative impacts of specific finance schemes **(Chapter 3)**, according to Risk Management solutions.
Insurance products **(Chapter 5)** offer Financial protection against any loss of income, reduction in cost of capital and relief of loss impact. This helps the liquidity of the project. Evaluation of loss events, intellectual assessment of data collection are critical elements for pricing the right insurance premiums against squeezing entrepreneurs. A rigid engineering can precisely estimate technology risks.

Uncertainties of Renewable Energy Production could be mitigated by *Financial Risk Management Instruments* **(Chapter 6)**. Modification of some mitigation services could contribute to the already adopted instruments in RE sector.
Weather insurance instruments and derivatives applied for wind, solar even hydropower used very often. Data available is an evolutionary factor for a specific derivative contract.
Credit derivatives and aggregation could be also useful to the RE Projects. Smart lending – insurance hybrids should utilize comprehensive engineering / technical data

to create these insurance products for promising RE technologies and giving them the necessary platform for finance by established financial institutions.

Comparison - evaluation of RET Supporting Schemes and a potential revision **(Chapter 7)** give us a measure of their social sustainability. Do they help payment ability of consumers? Simultaneously, investor perspectives have to be also re-considered.
Based on the stability of revenues, and not on stability of prices, a comparison between quota obligation system (including Green Certificates and FIT Scheme has a critical role in RET investor decisions.
Finally, rethinking for an effective Support Scheme has to maximize investor incentives and Social welfare

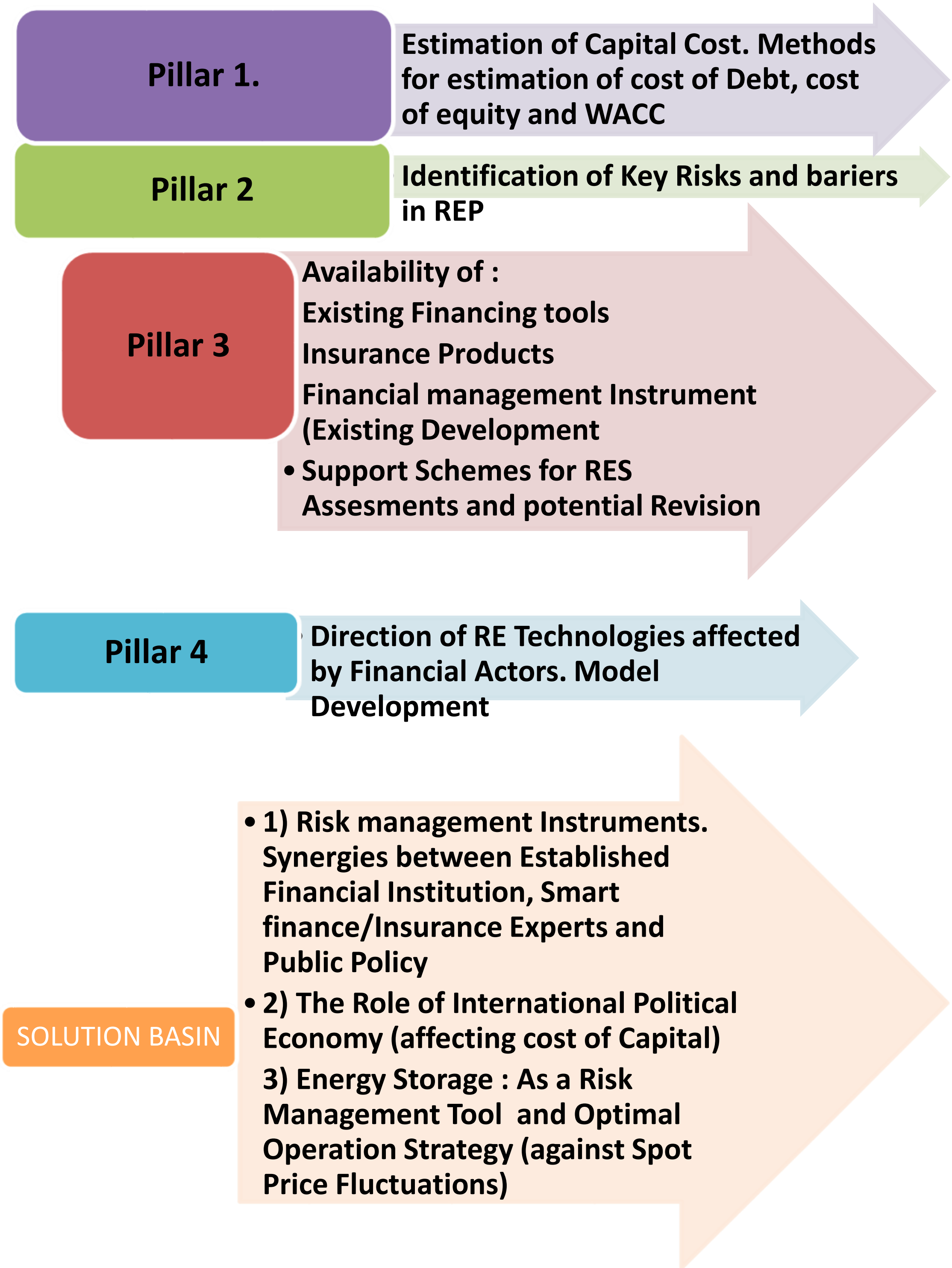
P4: **A model development that identifies how financial actors can affect directions of Renewable Energy Technology and (if necessary) Innovation.(Chapter 8**) Or else, how a proven technology can become a Commercial Scale activity, putting aside contingent market failures?
This can be achieved by measurement of technology direction of an investor-aggregated portfolio, independently of portfolio size and available to comparison throughout financial actors.

Solution Valley: Methods mentioned above, are going to establish a solution basin, that includes following 4launch pads:**1)**RES Risk Management Instruments and the combined activities of Large Financial Institutions, Smart Experienced Financial Boutiques and State Financial Policy (by means of leverage Instruments). Computational software tools for assistance in practical familiarity with modern toolkits mentioned above– An interactive web tool of World Bank. **(Chapter 9**) **2**)Review and Conclusions, taking into considerations: available and modern tools, as described in previous chapters ,the International Political Economy for Renewables, the Strong Potential of Energy Storage and Global Production Network**(Chapter 10)**.

Contribution of thesis

Contribution of this thesis is the development of a road map, which will be a rigid assistance to all participants that configure Renewable Energy Policy, in order to enable them in structured decision-making procedures, by means of suitable Toolkits. Allocation of Financial Actors affecting Investment preference (Chapter 8) enhances potential of development for Renewable Energy Technology, Innovation and Energy Storage applications, in order to ensure that RE-plants can restore energy while prices are low and respectively can sell electricity whenever prices are competitive. (Chapter 10).
After combination of suitable Support Scheme tools including quota obligation and Tradable Green Certificates in a competitive market (Chapter 7), developers and investors can ensure a friendly entrepreneur environment and guarantee revenues without charging and negative effects in social welfare (additional charge to end consumers) like in FiT existing case studies. Thus, developers can be supplied with guarantees, in order to ensure coverage and necessary modern financial tools by financiers (Chapter 4, 8). Consequently, developers can run their investment with the necessary capital inflow, especially for critical construction period, until they obtain Net Profit of Investment (Chapter 3, 4). The same is also valid for Insurance and Risk Mitigation market (Chapter 5, 6).
All these tools, including consideration of International Political Economy role to cost of capital (Chapter 10), can relief burden of WACC, capital either equity cost and interest rates, especially for specific countries and regions (Chapter 2).

Fig 1.1 Structure of Thesis



Source: The Author

Chapter 2A model development for: Cost of debt, cost of equity, Cost of Capital (WACC)

2.1 Introduction

The current chapter analyzes the basic model for capital cost estimation (Diacore, 2016)[1]of RE projects. Cost of capital is crucial for RE business cases, since it is going to be paid by project revenues. It is a kind of compensation for high-risk ranking, because upfront financial amounts have to be secured before operation and profitability runs, unlike conventional power plants. Stability in the balance between project revenues and expenditures, makes risks and capital cost lower.

2.2 Cost of equity

Despite the criticism because of its static nature, in contrast with market dynamic behavior and because of tight risk terms regarding Beta factor value and the return of a certain industry, CAPM (Graham & Harvey 2001, [2]) is the most broadly recorded method for estimation of CoE. On the contrary, the dividend growth model firstly demands a certain dividend to be paid (this is not applicable in any case) and secondly has no reference on risk assumptions. There is an obvious linear relationship between CoE, risk free rate and market risk premium:

$CoE = RfR + \beta * (MRP)$ *Eq* **(2.1)** [2]

it is essential to analyze every specific element of the above equation:

1) B, Beta factor, expresses **how a specific RE project** is more risky than **the overall market** (wind or solar projects).

It is also indicating the correlation between share and overall market portfolio returns. If the case is a combined renewable and Storage project, with new embedded technology, normally Beta factor should be higher than 1. That means a volatility of the project against entire market and higher compensations for the project shareholders, in the form of returns. Beta is very sensitive to the choice of data frequency, the time-period for this fata, all the assumption for market portfolio.

In peer review analysis [1], there is an average estimation for all companies of specific RE industry, after each company estimation for beta factor. In next equation (Hamada, 1972[3]).

$b_L = \beta_U * [1 + (1 - Tax) * \left(\frac{D}{E}\right)$**Eq. (2.2)**[3]

b_L : levered beta factor β_U : $unlevered\ beta\ factor$ D: Debt E: equity.

Unlevered beta is defined by the capital structure of the certain companies. The capital structure and tax rates for overall market is then defining the levered beta. After all, **Beta factor** moves to a range between **2.4 and 2.6**.

2) **RFR**: the level of a 10-year state bonds, with an average value over the last year. According to Deloitte [4] (2013), RFR can be referred to US or German state bonds level or to the return rate of long term state bond yields.

In **Table 2.1,** average return on 10 - year government bonds interest rates for 2013 and 2018 (June) are presented[5].

3) **Market Risk Premium (MRP)**, represents the excess return of market portfolio vs risk free interest rate. It is very crucial data for the method CAPM. This premium response to recent historical data and estimation are based to the mentality that the past represents the future value. This is not actually accurate at all. Values presented below in Table 2.2 were produced by Fernandez et al, (study of 2013) [6]. Similar recent study for 2018, March in[7], and [8].

2.3 Cost of Debt (CoD)

Cost of Debt (CoD) presents a dependence on 3 parameters, the RFR, the project spread and the Country Risk. There are 2 main methods for estimation of RFR, one linked to German State Bond and the other to the swap curve. Other 2 additional methods exist for country risk estimation. In first case credit Default swap is used (CDS), as an equal to country premium, while in next case country premium equal to the difference of 10Y bond yields. Therefore, it must be rather a range of CoD estimation than a certain value estimation. Bloomberg and Eurelectric [1] give a clear view of CoD for onshore wind power projects in EU of 28 members in Table **2.3**.

The basic relationship is given by equation **2.3** :

$CoD = RFR + Risk\ premium\ (RP)$**Eq. 2.3**

a. For wind power plants **Eurelectric** gave the equation :

$CoD = European\ RFR + CDS + PS$ **Eq. 2.4**

where : CDS is the 10 year Credit default Spread per country and

PS is the Renewable Energy Project Spread

European RFR is linked to German 10Y Bond yield rate, that was for 2013 1.57 % or 0.336 % for 2018 (as received from table **2.1**).

PS could be estimated as 3% for onshore wind projects, 4% for off shore wind, and about 3.5 % for PV projects

b. **Bloomberg** study has respectively calculated:

$CoD = TS + CR + PS$**Eq. 2.5**

TS is Term Swap, referred as a fixed payment exchange instead a floating payment linked to interest rate.

CR is the country risk, the difference between the average 10Y State bond rate and the relevant rate of German 10 Y State Bond.

2.4 Capital Structure

Capital Structure refers to Debt to Equity ratio regarding the company or the RE project. Company strategy or even industry sector define the proportion of two figures. A large proportion of debt indicates capital-intensive project and means that the activities have to be funded in an accumulative formula. Usually debt is considered to be lower than equity and this affects RE project developers in their decision. Most or researchers state that Debt to Equity ratio in RE projects used to be at a 80 : 20 before financial crisis and turned to be 70 : 30 after this.

According to NREL (2011)[9], the ratio for onshore wind energy projects, among 6 European countries during 2008 was as it seems in **Table 2.4**

According to macroeconomic parameters and liquidity of local banking market this ratio should be estimated as lower in other countries like Greece or Czech Republic, for the same period, almost performed as a ratio of 60: 40
Table **2.5** from Fraunhofer, 2013[10] and 2018[11] respectively indicates the ratio in Germany during 2013 and 2018 per RE category and
Clean Energy Pipeline, 2013 [12], implemented a short list of some offshore Wind Power plants among 3countries, funded during period 2007 - 2013, according to Table **2.6**

2.5 Conclusions: the importance of Weighted Average Cost of Capital (WACC)

The cost of capital, taken into consideration the measures of cost of debt and cost of equity and their proportional weights is summarized to the Weighted Average Cost of capital, known as **WACC**. This represents the minimum rate that a company has to be charged for satisfying its creditors, taking into consideration its assets. Creditors are seeking for higher rates if the risks are also higher. Evaluation of a project can include either company WACC or a project WACC. The risk of a project can be different than company risk that is exposed to a different debt to equity ratio. **Equation 1.6** [1] gives the calculation of WACC.

$WACC = \frac{E}{E+D} * R_E + \frac{D}{E+D} * Rd * (1 - tax)$ **Eq. 2.6**

where : E is equity share
D is Debt share
R_E is the cost of Equity and Rd is the cost of Debt

Chapter 3 Identification of Risk and barriers in Renewable Energy Projects

3. 1 Introduction

The current chapter analyzes what countries exposed to increased cost of debt, need to reconsider their RES investment policy, after recent financial crisis. Rigid insurance support must be provided. This is enhanced by identification of all risk and barriers to REP's development.

Different kinds of RE Technologies seek for a modern approach regarding pattern, size and "actuators" of financing. Their transformation to commercialized use asks for another mentality, a more aggressive risk aversion policy.

Sometimes Legislation for energy transformation erases barriers to RES development. Regulatory Authorities, Chambers and Observatories are entitled as "independent" but actually act as unaccountable actors. They arrange for a prejudiced risk premium (subsided to producers) is charged over consumers that face the energy poverty.

Finance and insurance institutions penalize innovative technologies, through premiums and conditions making them no competitive at all, instead of producing new fields of insurance potential.

3.2 Allocation between RE Technologies, Risks and Barriers

New products, technologies and process for RE could be easily risk compensated if quantification and allocation of their risks were based on better knowledge of them, as mentioned by insurance experts. Comparison between Drilling for Geothermal Hot Dry Rocks and Oil & Gas exploration need to be avoided, for example.

UNEP & SEFI[1], (2004) suggest a connection between some risk issues, RE Technologies and risk management considerations, as shown in **Table 3.1**.

Some risks related to supply stability of biomass are of great importance for financiers. The same applies for possible failures and repairs. Plenty of derivatives and insurance products cover RE source availability risks. Temperature and other weather data products are available in international level in order to promote this kind of risk management policy. Satellite technologies are spread worldwide, they are not such expensive as in the past and private risk management products can connect the weather data provided.

3.3 Risk Ranking Remarks

Risk ranking concerning construction, natural Hazards, technology/ failures, renewable source variability, regulation, banking and contracting could be represented in next two following graphs, evaluated on a scale from **No 1** to **No 5** (**Figures 3.1 &3.2**) according to March and Mc Lennan[2] , 2008. Ranking applies for both for Investors and for manufacturers.

Technology risk (machinery failure and malfunction) should be often ranked in a maximum impact level.

Proven technology reliability and efficiency is a high priority issue, in terms of developer decision making. Equipment performance testing enhance Risk mitigation associated with technology uncertainties.
The necessary data natural resources along a region or similarly could reduce contingency risks against fluctuation in sun irradiation or wind speed. As discussed on *Chapter 6*, **it is the revenue and not price stability** that should affect investor decisions.

3.4 Potential Risk Partners

Table 3.2, illustrated by KfW [3] (2005), supplies the category of risk associated with possible problem sub-categories, any potential risk partners (all of them seeking for the necessary instrument for risk mitigation).
A variety of risk categories, is difficult to be absorbed only by financial investors or lenders. There is a diversification of stakeholders that could take on some quantity / quality of risk range.
If the allocation of partners and association with risk categories is valid, it could help the risk reduction. Acknowledgement of specific assets and liabilities contributing to the risk level is also important. RE contract partner erects the rigid basement of insurance reinforcement. Engineering, Purchase & Construction Agreements, fuel supply contracts, operation, Power purchase (PPA), Joint Venture (JV) or loan Agreements are fundamental.
Any external party able to absorb the risk should be considered as a potential partner: 1) Insurance companies as primary risk absorbers, 2) state institutions responsible for legislation suitable for enhancing RE projects and social surplus, 3) Export Credit Agencies, covering part of commercial risk and 4) Development Banks, not only lending but also providing Partial Risk Guarantee (PRG) etc. They can become important players for risk allocation.
Valid and efficient risk allocation has to acknowledge tolerances and cost of risk transfer. A specific charge from the external party to the developer could be a kind of fee or penalty under negative circumstances.

3.5 Conclusions

Market pricing of conventional fuels do not include externalities like CO2 emissions etc., so expensive RE projects do not reflect the real positive impact that in fact should produce.
Real difficulties like risk of technical efficiency for some technology, availability of the energy source, high up- front costs, technical completion delays, damages credit risks etc create a "high impact" financial risk for RE projects.
An insurance or even an International Finance actor is necessary to protect all players of an energy joint venture, so the risk could be easily reduced.
A modern mentality and sense of risks concerning Technology, operation and for each individual Renewable source nature needs a smart management of data and the flexibility of public private institutions.
Although satellite and weather data technology is respectively expanded, in fact it is difficult to feed immature RE technologies with modern insurance products. It could be the public agencies useful to fund pilot products or similar projects. **Available**

studies producing applicable results and conclusion could lead insurance private sector to develop new products, properly designed for RE Technologies.
The proper risk relief tool for developers depends on **compromising between them and external risk absorbers** (like lenders etc.)

Chapter 4 Availability of Financial Tools for RE Projects and Technologies

4.1 Introduction

The current chapter explains how potential RE projects, even aggregated into a larger scale, are to be considered, and the private finance, apart from main developer's equity fund, is generated through specific groups of specialists, consulting and specialized finance vehicles. Attraction of finance requires principally risk management and minimizing the potential of a negative financial result over the total RE Project.
Thus, every potential financier should build an analysis in order to evaluate risk allocation and due diligence, in order to obtain a better sense of how applicable are RE technologies, what is their performance, what is the impact of these characteristics to the markets, the assistance of some incentives and the relevant sponsorship that provokes the investment. This is the assistance of risk allocation, as described in previous chapter.
Either groups seeking for incentives in terms of tax relief for investing their money, or local schemes that are activating in leasing of mechanical RE equipment even, finally, some attempts for aggregation of small RE projects.

4.2 The difficult combination key of attractive high returns and Short time scheme of investor expenditure

In RE Projects, it is often seems that capital costs are high and charge usually first upcoming years, where, at the same time Operation &Maintenance costs are smooth and calmly low. Thus, there is a need for long term funding of RE Project.
On the other hand, long term financing performs a necessary stand by period, until revenues become for investor, where, on the contrary the short stand by period leads to lower return rates according to IEA (2010) [1, 2]. That seem to be obvious in **Figures 4.1 & 4.2 .**
A long -term financing, associated with higher equity IRR rates, are attractive for investors that are seeking for long- period asset returns, in order to support "proportionally" produced liabilities like multi- generation funds.
Usually that is what RE Projects offer, without attraction to funds addicted to high returns in short period. **That is the peculiarity of RE Projects in terms of financing**.

4.3 Financing Barriers according to RE technology

It is very difficult to build a statistic data among different RE projects and specific conditions, however World Bank [2] provides an indication of which is the impact of several financial barriers, putting obstacles to different RE technologies.

There is a meaningful spectrum of explanations regarding above categorization. First of all, each technology performs a different scale of exposure. On the other hand, as much as larger is one RE project, the long-term funding requirement is bigger. This financing, covering also the period before task commencement, has to be proportional to project development. This predecessor factor is necessary in Hydro plants, where use of land and effects on communities living in the downstream field are something to be clarified before starting of construction tasks. This is not of the same significance whenever other technologies are concerned.

In terms of competitiveness, geothermal, small hydro and wind technology can be competitive with conventional sources of energy, but this does not happen with solar power. The availability of resource for RE is always a strong issue up to the critical moment that energy storage could be the applicable step for all kinds of RE technology.

Last, but not least, off grid projects appear a significant sensitivity to purchases for end users, individual communities, very often vulnerable to social cohesion and regional economic recession conditions.

4.4 RE finance forms

UNEP /SEFI[3] in **table 4.2** provide a table indicating special finance forms and their footprint to RE projects financial functionality.

It should be considered that small RE projects providing new technologies or carrying some kind of advanced risk issue, make investors to ask for a increased share of project equity, in order to take part in the total investment. Thus, there are some difficulties for developers of small scale projects. **There are specific terms that help finance flow to RE projects**: Long term supply of RE resources, Power Purchase agreements (PPA) assigned to reliable partners able to repay, some guarantees for sustainable revenues (sometimes this is relevant to fixed prices), construction scheduled and contracts assigned to reliable contractors with the relevant technical experience (in terms of know hoe and project management critical path task flow), warranties for energy efficiency and output performance, that have to be covered by contractors and potential sponsors (such as manufacturers of specialized equipment. These kind of contracts and insurance precautions have to be assigned to a financial commercial institution, like a bank, so the investor that lends his money or take place on an equity fund is able to take over the total project, in case of a bad performance condition, under the project developer.

Trust to the main investor reliability, *risk management* advanced *methodology* and *instruments* produced *for risk mitigation* are **key factors** for finance attraction.

If all credit and performance risks *are transferred* from developers, investors and lenders to **the insurance market**, that can enhance to a rigid and promotional finance configuration.

Revenue exposure (again Not price exposure) is a key figure for finance actors and institutions. Task progress, damage precautions, operation performance and whatever affects this kind of exposure is under the thorough view of detailed paragraphs, footnotes and parameter review formulas that included in clauses of contracts and agreements, in order to build a sustainable insurance configuration. That is the critical premise before the financial agreement.

4.5 Allocating Financial Problems, Relevant Instruments and Potential Partners

KfW[4] (2005), in table **4.3** allocates problems, instruments and partners to address all relevant issues, providing helpful solutions, but taking into consideration "laboratory conditions" regarding market maturity, ideal model of transactions, reduced risk scale for RE projects.

4.6 Allocating financial market maturity and RE financial Instruments functionality

In order to take into consideration financial market local regional or worldwide seasonal conditions and evaluate a more realistic view of financing model functionality an overall summary and application scale has been remarked in the following table **4.4**, provided by KfW[4] (2005).Then it is applicable to connect some relevant dependence on financial instruments, in relationship with financial market development scale.

4.7 Hybrid bond

4.7.1 Introduction

Even if many incentives have been worldwide introduced till now, RE projects still have to face with the great size of capital costs and a variety of sensible scenarios and instabilities. A new financial tool, known as hybrid bond, has taken place in modern markets. It includes a portfolio of RE projects and it actually mitigates a widespread of risks produced by a RE investment rather directly financing the capital cost

- It is the purchase of this hybrid bond that finance a remarkable part of initial capital cost with needs of frontward payments.
- Hybrid bond also ensures the revenues received by the operation of relevant RE projects, included in its portfolio, thus these projects are more attractive to investors, in terms of creditworthy continuity and stability of returns.
- Another advantage of hybrid bond is the ability of purchase in the secondary bond market. That is a great potential of additional income, able to compensate for any revenue loss, due to operation performance, resource fluctuation or developer weakness to fulfill his mission.

Thus, in a further view, hybrid bond is focusing to manage a variety of instabilities included in market, credit, resource, operational, technology or political risks.

4.7.2 Description

According to the principle frame of a bond, the investors (Hybrid-bondholders), after has financed the group of RE projects, will receive their planned payments from their borrowers (RE developers) through the revenues of these projects, since these revenues have been securely allocated through this hybrid bond. These payments hold both the primary payment segment, what is called par value, tied to the maturity of the bond and the secondary, the coupon rate, that is paid all along bond life.
The risk is diversified, since each RE project establishes a fracture of the total pool. So a portfolio of RE projects /Units has been established, operation risk has been accordingly diversified and a model of internal risk mitigation has been achieved.
Thus, any unpredictable electrical output, exposed to weather fluctuations, damage events or operational defaults could be smoothed by the pooling of all RE project segments. Revenues could be affected in the same way.
An important key factor is the optimization of this portfolio.
Thanks to Markowitz (1952) [5], any risk could be reduced if correlation between assets was less than value 1. The same applies supposing that correlation between revenues is also less than 1. So the fraction of each RE project will contribute accordingly, in order to optimize the total portfolio.
Lee & Zhong [6] (2013), adopted the Sharpe ratio method, as a functional approach, in order to optimize portfolio. Sharpe ratio describes the size of the returns against the risk taken, it indicates the figure of the returns per risk unit. In terms of hybrid bond scheme, they give an expression of the greatest amount of returns that are expected against the risk, as follows :

$$\max E\left[\frac{(\sum_{i=1}^{n} x_i r_i)-R_f}{\sigma_\rho}\right] \text{ (4.1)}^2 \quad \sum_{i=1}^{n} x_i r_i \text{ (4.2)}^2 \qquad x_i > 0 \text{ (4.3)}^6$$

x_i weight of capital invested in asset i, r_i return from the asset i, σ_ρ standard deviation of portfolio, R_f risk - free rate of return and E the expectation operator.
Equation 4.3 defines that the weight of capital in any RE project should not be zero, since short **selling of a RE plant is not allowed**.

4.7.3 Tranche function of hybrid bond

Further to optimization of RE projects portfolio, hybrid bond impulses the function of tranching. In that mode, additional security classes produce either rated securities against underlying assets that are unrated or else greater ratings than underlying classes of security. So a redistribution of risk is made by tranching.
Like a classic Mezzanine funding, any senior bond class has a lower credit risk than the subordinate bond class, since any potential loss of the senior class is absorbed by the subordinate class. But hybrid bond structures performs something additional: there is one (or even more) tranche, "Interest Only", (IO), produced by additional interest, since coupon rates of both senior and subordinate tranches are fixed and set below coupon rate of collateral. So this excess amount after senior and subordinated classes are paid, is going directly to IO tranche, which performs a higher but also floating coupon rate [6]. This IO tranche is not asset backed at all, and its nominal amount, equal to its par values for a 15% IO is calculated as follows :

$$Nominal\ amount\ of\ 15\%\ IO = \frac{Original\ tranche\ par\ value * Excess\ interest}{0.015}$$

(4.4) [6]

As explained, yield tied to the excess interest is floating depended on RE projects performance.
So, essentially IO tranche is **a premium edition** of original bond.

4.7.4 Remarks for Hybrid bond

Finance to RE projects and revenue /income produced by them, secured to the investors are the main characteristics of hybrid bond. Besides the main income inflows /outflows there are secondary charges and protection supply between developers and insurance services or between Investors and Management providers, for servicing the returns and the tranche payments.
Regarding protection (insurance) service, if there is any RE project that faces with a bad performance or an operation failure, the developer having been purchased a CDS earlier, will receive par value of the bond and pass the amount to the investors (bondholders).
Lee & Zhong (2013)[6] and Mitchell -Fender (2005)[7], have presented a very descriptive flowchart of income flows among all actors of hybrid bond scheme (**Fig 4.3**).
A sensitivity analysis equity cash flow against inflation rate, interest rate and currency exchange is an interesting parameter.
The decision for additional or not RE projects inside the portfolio of a RE purpose hybrid bond, is given by modern literature formulas.
The optimization of the hybrid bond should be dependent on equation condition as follows [6] :

$$\frac{E(r_{new}) - R_f}{\sigma_{new}} > \frac{E(r_p) - R_f}{\sigma_p} \, Corr(R_{new}, R_p) \quad \textbf{(4.5)}$$

Where $\mathbf{r_{new}}$ is the return produced by new portfolio, σ_{new} is the standard deviation of new portfolio, $\mathbf{r_p}$ is the return already produced by old portfolio (before adding a new REP in hybrid bond), $\boldsymbol{\sigma_p}$ is the standard deviation of the old portfolio, $\mathbf{R_f}$ is the risk free rate of return, **Corr** is the Correlation and **E()** is the expectation factor.
Senior tranches are protected from default risks of the hybrid bond asset pooling, since subordinated tranches have to absorb in a gradient mode the potential losses.
But another point of interest are the conditions of value creation of coupon rates among the different series of tranches. Since any actor of the total transaction can have realistic expectations regarding cash flow expansion, then he may issue a senior tranche, more secured from any default, willing to deal with subordinated tranches, expecting for higher coupon rates and revenues.
But all these possibilities and alternatives in tranching value creation, bring the uncertainty of who is responsible for bond portfolio redistribution in case of less performance produced
The structure of the bond is more complicated and rating agencies take the most important role in risk estimation. It is an important aspect for these agencies to have the know-how of connecting REP bond risks with energy economics, policy, market, technology, and providing proactive and dynamic tools for risk assessment and giving a potential paradigm shift for rating models, tailored made for REP assets.
In order to sum up the key points for future research of hybrid bonds are: 1) sensitivity analysis for market, political economy and energy policy parameters , 2) Dynamic asset allocation and 3) REP figured risk rating.

4.7.5 Hybrid Bond Special Application: Morris Model, a hybrid bond Supporting Solar Energy in Public Buildings, Private Public Partnership (P3), New Jersey, USA

In Jew Jersey provinces there is an innovative Financing Model that has been introduced to enhance Solal Panel Energy implementation in Public Building that belongs to local hosts. Sanders, Milford and Rittner from Clean Energy & Bond Finance Initiative (CE + BFI), (August 2013) [8], present this hybrid bond edition, giving specific the characteristics for detailed implementation. These local hosts are taking the advantage of a low cost Power Purchase Agreement (PPA),that has been assigned by Province Authority on behalf of them. These building are the first major part of assets in the total Solar Energy Portfolio. The second part of asset, is the "revenue core machine" of the project, the Solar Panel Installation. But this part belongs as an ownership to the Solar Energy Developer that supplies, installs, maintains and operates the installation.

The Developer takes the benefits of Low Cost Capital received from the Hybrid Bond, the sales of PPA purchased to the Province Authority (also Low Cost), and the accelerated depreciation that ensures to the Developer lower taxable income during early years, thus giving to the Developer tax credits, an equal cash relief that is a potential reinvestment to the shareholders or bondholders.

The bondholders receive the par value plus coupon rates, risk relief absorbed (through bond senior tranch) by subordinated tranches retained by the Public Administrator, the Province and the Solar Developer.

Public Administrator is the issuer of the bond while province gives the guaranty to the Bondholders, in case of any default. In **Figure 4.4** a detailed description is presented.

4.7.6 General Obligation Bond linked to Energy Savings Guarantee (ESCO Developer, State of Delaware case study [8])

This case represents many similarities, in comparison to the previous one but there are some particular points. Similarly to Morris model, Energy Saving Company (ESCO) is the Developer, a State or (Regional) Energy Utility (SEU/ REU) issues the Bond. Through this bond, ESCO is capital supported by qualified agencies that have assigned Installed Payment Agreement (IPA) with the major SEU Utility and also Energy Service Agreement (ESA) with ESCO.

State SEU give guarantees to Bondholders through an MOU [8]. In this case there is no asset that produces revenue, but what is revenue means that the End Consumers population pay for a fee in respect of Energy Savings and Electricity Bill reduction of payments (for less consumption, a fair enough fee compared to bill reduction)|. This is the bond revenue. End Users do not pay for the Energy Saving technical improvements, since Developer (ESCO) has ensured funding for implementing the job. The fee for the End Users is not so painful for them, since the bond gives another kind of payment (coupon rate) to the bondholders, an exemption from income tax.

In case that energy consumption improvement is not working well, the end consumers will not pay the fee and ESCO and private agency (both pre-qualified) is responsible for energy service guarantee. In this case ESCO has the highest risk subordinated tranche, in order to ensure that installation will be applicable, in terms of energy efficiency and consumption reduction for the end users. The bondholder will receive their tax relief as they belong to the senior tranche. Next following subordinated tranches (senior compared to the ESCO tranch) are for SEU and private agencies accordingly. As many bondholders have been attracted, the capital flow both for ESCO and the project is increased, so conditions for a greater project scale or a higher population of end consumers are realistic and the revenues will become greater, increasing yields for bondholders.

4 .7. 7. Carbon Financing

Carbon financing is a module that allow some available revenues before the end of RE project tasks and real productive period. Earlier revenues are produced by Certificates sales.

It not possible the rapid increase of Certificates Byers pool, unless a quota liked system should be adopted worldwide. There is a significant risk intense for the public finance institution. Implementation of accounting and precisely allocating carbon CER revenues performs a complexity, since they have to be received ahead of Project start up. Without a sustainable quota system for Carbon Certificates, revenues size is dependent to carbon prices and subjected to a wide sensitivity analysis of what is the share of Project Capital Cost that is really covered.

4.8 Conclusions

Financial tools are necessary because of the difficulty to combine both high returns and short period of upfront high investment costs, because of the challenge to erase financial barriers to Renewable technologies and the specific terms that enhance financial flow to renewable projects.

Every kind of financing toolkit needs to allocate finance flow obstacles, the suitable instruments and the partners, financial market maturity and their functionalities to renewable. As for specific bond structures, sensitivity analysis for social, economic and regulatory parameters, dynamic asset allocation and risk ranking - tailor made for renewables are the main research fields.

Chapter 5 Insurance Products

5.1 Introduction

The current chapter analyzes how Insurance products can reduce the impact of potential loss events, lower the capital cost and stabilize liquidity. All kind of creditors or equity shareholders even bondholders appreciate any back up against income loss. As mentioned in Chapter 4, some factors perform significant importance on creating added value into traditional or even modern financial tools (i.e. hybrid bonds): a) sensitivity analysis for all parameters affecting renewable perspectives, b) a certain configuration for risk ranking and c) the increased capability of one or more investors to make additional value on one or more assets. Apart from main finance tools, as described in Chapter 4, supplementary tools may improve balance sheet, capital inflow of renewable projects.

5.2 Insurance criteria for several scales of RE projects

Traditional products are applied to renewable projects and transfer the legal, regulatory, political, currency exchange and default risks. Some renewable technologies represent similar risk categories as relevant fields, i.e. offshore wind farms relevant to marine installations, or geothermal to drilling applications. Accurate estimation of possibility and impact of failures needs valid information.

Innovative renewable technologies, like offshore wind farms or Hybrid RE projects including energy storage, have to transfer their risks with specialized insurance vehicles. A specialized engineering evaluation should be necessary.

Public sector should support genuine engineering studies for accurate estimation of risk rating, supplying evolutionary material for insurance companies. It could be more effective than suppling subsidies.

5.3 Existing insurance products for RE development

SEFI – UNEP[1] supplies with 2 table formats, indicating existing insurance tools, according to risk transfer category (**Table 5.1**) and according to each RE technology type (**Table 5.2**). These are the basements for any further discussion and research.

Up to decade of '00s, wind farm developers, use to underwrite only the assets utilizing non-specialized insurance packages.

Now insurers have gradually integrated technical details validation, malfunction data collection but there is still a significant potential for a paradigm shift.

Construction Phase

Wind farm industry face an unpleasant revenue profile change if any delay or malfunction, damage is erased. About a 2% of total budget is rated for offshore wind project, compared to a 0.5% for an onshore farm.

In geothermal projects, the upfront capital cost is very high .A valid risk ranking have to be produced due to specific conditions of geothermal drilling, unlikely oil exploration.

Small hydro technology is well known and Liability cover is easily achieved. Only erections phase, combining contractor creditworthiness are to be covered under an insurance product.

Normal Operation

Precise description of control scenarios against production loss, give the capability of an accurate method of risk ranking.

Premium risk price for insurance of geothermal operation is related to the operational risks of production platform. Uncontrolled "violent" flow from the well above the surface, the restoring of the well, any leakage or even pollution.

As far as Reliability of equipment against machinery breakdown and mechanical design assurance against technical risk, there are special restriction clauses with certain requirements. Specifications for replacements of mechanical components to be replaced not before 5 years or alternative 40.000 OH (Operating Hours)[1]cover the accidental condition in case of operation failure or even a loss of efficiency, because of bad design or human factor false (during production).

Machinery tests for reliability of biomass equipment and components have been also developed.

What becomes a really rare case, is the insurance cover regarding wave /tidal energy. In this case the only possible guarantor is the wave energy developer itself. Certification of this procedure is produced by independent (free-lancer) engineers absolutely experience in offshore applications. A very district safety factor, applying for a storm impact, figured by an occurrence frequency of **once per 100 years**[1].

Design/ Technical Risk

Insurers do not use to offer great cover to the equipment editions that present new design, prototype modules, never before implemented in real operations (even if laboratory test recorded). In such a case, the manufacturer has to provide warranties to developers, in order to cove the risk of equipment defect machinery or components.

Exploration risk of a geothermal RE project is taking into consideration the amounts of flow rates regarding thermal water exploration and also improper temperatures of reservoir. Modern insurance schemes have been developed under the common sponsorship of both private and public institutions [1,2] , covered by private and public institutions.

Technical maturity risk

Wind turbine manufacturers receive a share of KWs saved, as a result of efficient design of their models. So, they offer Contractual Service Agreements (CSA), as a solution for model prototype insurance.

Insurance product against weather condition is a basic tool in wind and solar technology

Operation Feed In

Biomass purpose insurance cover in crop yield insurance module [3] is not adequate. So, there is a significant challenge for business interruption insurance [4] , not secured by long term contracts for feed in of bio mass.

HSE

Fermentation process of Biomass plant needs specified Health and Safety Risk Analysis, **Hazard and Operability** (**HAZOP**) Study, because of toxic and hazardous gases.

3rd Party Liability

For wave energy, 3rd Party Liability insurance cover regarding liability, delay in commissioning and technical construction risk, unlikely to past years. Underwriting premiums are priced to a cost level of about 0.5 % of total project liabilities [5].

5.4 Conclusions

Insurance criteria and existing products for several scales of renewable development were presented in this chapter. Two (2) useful tables are presented in **Appendix A**, indicating existing insurance tools, one for risk transfer categories and one for reference to each renewable technology.

Chapter 6 Financial Risk Instruments for RE projects

6.1 Introduction

Genuine tools for risk mitigation of RE projects can supply them with Alternative Risk Transfer solutions, Special Purpose Vehicles, Political Risk Transfer, Weather Derivatives or Credit Derivatives. Banks, Credit Agencies and International Insurers are deployed in this field.

Table 6.1 [1,3] includes some instruments for financial risk mitigation, already involved in RE projects or else capable for adaption in RE plants. Some key points are necessary to implement successful risk mitigation.

From data acquisition and expert assessment, weather and temperature derivatives can provide risk mitigation for wind (onshore - offshore), solar power. Credit Guarantees can be also deployed in RE plants financial risk.

6.2 Weather Derivatives for RE plants

Renewable production yields are dependent on variations of weather conditions like sunlight, wind speed, temperature. Protection of revenues against these weather conditions is achieved by weather derivatives. Indexes dedicated to wind speed or sunlight can support the finance package like derivatives including power or currency exchange parameters, so the risk transfer product becomes as much transparent as it should be. This should enhance the low-price tendency of commodity. It can form also a well-structured hedging policy. Any kind of technology additive, such as satellite systems and information pluralism can strengthen the risk transfer structure.

6.3 Credit Derivatives and relative instruments

RE projects are often linked to Credit structures, in order to face with credit risk exposures. Aggregation of credit quantities of small projects without liquidity, provides securities restructure under tradable mode. It could produce liquidity, attractive to potential investors. This is the same style mainly developed for Government Debt, but it should be considered also in entrepreneurial and Project linked credit products or to hardly tradable debt. It could be effective in pumping institutional investments and useful for RE projects capital inflow.

A pool of "bundled" RE plants assets could link their efficiency in terms of credit risk to the principal payment and the coupon rate of a **Credit Link Note**. That is issued by a (Special Purpose) Trust Company which sells security service to an Investor. The investor(s) receive(s) this principal payment plus coupon rate in charge of being transferred the risk of this credit security, which is embedded with a CDS (Credit Default Swap).

6.4 Risk Transfer and supplementary structures

A revenue protection is developed for a risk transfer rather than a risk financing application. The logic of a hybrid bond, including first and subordinated tranches, as explained in Ch. 4, approached the method of **Alternative Risk Transfer** for Insurance

markets, as similar to capital markets. When the risk management includes also a capital structure, contingent to fund the potential loss, it is called risk retention, on the opposite of risk transfer. These solutions are acceptable to investors and protect of renewable revenues.
Captive insurance is called for an affiliated company supplying the Group insurance or tax relief products dedicated for specified activities.
When the captives become **multi-parent**, this offers a diversification of risks facilitated by this (re)insurance company. This insurance module could supply risk mitigation facility to a **Cluster of small and scattered Renewable Developers** and projects. This could be suitable for RE developers exposed to natural disasters.
Small insurance companies can form a debt pool in a bundled CDO, in order to reduce insurance cost, fees etc. At the same time, they configure a critical mass. They can offer cover to a pool of RE developers that are funded collectively. They are called as "**Boutique insurers**", guidance or public guidance these small boutique communities and they could work for efficient risk management service to small scale RE projects under institutional association.
Securitization of renewable structures against physical disasters can be included to a diversified portfolio, a weather risk market, a disaster risk market or to capital markets with not enough maturity involving. **Risk** (or **Insurance**) **Linked Securities** have been developed, as financial instruments sold to RE (or other), developers. A **Catastrophe Bond** is a similar case, in terms of capital market.
Political Risk Insurance have been developed for years usually against currency and exchange rates.

6.5 Public Initiative Instruments

Governmental Agencies and financial Institutions act as the intermediate parts between national governments and the corporations that are willing to invest abroad, providing either loans or insurance and guarantees and remove the risks or uncertainties of investments to foreign countries. These agencies are used to be names as **Export Credit Agencies (ECA)**. **Official Bilateral Insurers (OBI)**[1] ,despite the little experience with RE projects, **are offering important chances for technology applications like RE and energy storage, including modern Renewable Projects in Europe, by resources that are not yet fully developed, like tidal energy**.
Multilateral Financial Institutions (MFI) like Development Banks help the private sector by provision of service in asset management especially for investments that are orientated in countries with a little existing package of infrastructure or, even more with lack of market liquidity. International Finance Corporation (IFC), as a part of World Bank (issued by 184 member countries of different macro-economic indexes), is such an example.
Investors can receive **Political Risk Guarantees (PRG)** or **Partial Credit Guarantees (PCG)** if they cannot face with delay of investment returns, possibility of developer default changes in legal framework or a new social condition that is hostile to the total concept.
This is not a RE orientated risk mitigation. But they can be easily applied to RE projects

6.6 Guarantee Schemes

Either States or Multilateral Institutions have developed several guarantee schemes for a further social interest category. Investment of infrastructure is such an important category of projects.

Financial guarantee gives the authority and the responsibility for the guarantee provider to fulfill the payments, in case that the borrower has lost its creditworthiness.

Credit Guarantee force the Guarantee Institution to make the payments of the loan that the borrower is obligated to pay. This could be configured in an alternative option, giving the "put option" to the creditor to sell the debt (of the borrower) that is guaranteed to the guarantor (the Guarantee Institution).

Standing guarantee makes the guarantor to pay the borrower a specific (already agreed) amount of money, in order to keep its capital share and avoid any liquidation of its properties and assets.

The State can issue **Sovereign Guarantees** in order to boost general public issue projects: a) if the borrower can produce income by the project that is granted for. b) since capital markets are still reluctant to fund large scale projects without any State agency support.

State should have a reserve fund, instead of adding burden to its Debt mechanism.

Several advantages are performed as: a) **flexibility** since the guarantee allows for the perfect match up to the borrower needs, according to its suitable maturity, amount size, interest rate and payment conditions (Because this is the developer of the project, not the guarantee institution) b)**the beneficiary** (borrower) will have the chance of **direct contact with the capital** markets, causing an interactive effect, allowing for more **access** of the borrowers **to liquid markets and** risk management **services.**.

Guarantee premium is based on **two segments**, the operational risk and the financial risk, according the size of revenues provided during total business life cycle and **subjected to a sensitivity analysis**, according to the floating parameter of specific RE industry, regulatory regime etc. The major figures for financial risk, is the ratio of income before taxes and interest obligation (divided) to this interest payments.

A Guarantee institution does not offer the same premium to all borrowers, even belonging i.e. to the same category of RE technology and project, since **one borrower can perform a higher risk rate from another.** The final (actual) credits of each borrower are produced if the offered (by the institution) guarantee is subtracted by the initial current risk credit. **Figure 6.1**[2] explains better this configuration.

6.7 Conclusions

Risk mitigation tools were analyzed in this chapter. Weather and credit derivatives, risk transfer toolkit and supplementary tools in conjunction with public initiative instruments recall these chances of hybrid structures, involving smart specialized insurers, public interest institutions and aggregation scale enterprises. Some states or multilateral institutions have build some guarantee schemes regarding renewable infrastructure.

Chapter 7 Evaluation of RET Support Schemes. Finance attraction, Cost Charging paths, Risk Mitigation and Market Strategy Alternatives

7.1 Introduction

Risk assessment of Renewable Support Schemes, in terms of Development and Technology diversification has to evaluate precisely if Feed-In-Tariff or Quota Obligation System are generating applicable mechanisms. F-i-T add a certain amount of bill expenses in End Customers (final consumers), disturbing social welfare. **In fact, no modern financial toolkit can compensate for such a doubtful Deliverable Support Scheme.** Feed in Tariff system is supposed to be the most profitable mode of supporting investments in RE-Projects, in terms of an investor returns. But after some years of experience, especially in Europe, F-i-T is not promoting any competition conditions at all, and also acts in favor of specific RE technologies, deterring some other technologies to be mature and commercially applicable. So, it is necessary to analyze if the Quota System mitigates risks, enlarging investor perspectives. Risk magnitude regarding **Demand and Price variation** is to be covered.

7.2 Risk Analysis Parameters

Risk analysis for investors in a market adopting Tradable Green Certificates (TGC) should be further investigated.

It must be mentioned that in perfect competition an equilibrium between TGS price, Long Run Marginal Cost and Electricity Price of Spot markets will be established

(TGC),pr = LRMC – SPOT MAR, pr.

This equilibrium point is affected by2 factors:

1. **Supply – Demand Curve information** that is available to all investors / developers. Investors want to evaluate correctly their future returns and existing generators want to assess correctly their Bidding Strategy.
2. **Volume Risk.** This declares the risk of variations in generation, due to weather conditions from year to year.

   It must be definitely clear that the Parameter Revenue gives a significant impact in investor perspective**, instead of price.** In other words, impact becomes when **Price is multiplied by quantity (revenues** are produced by 2 stochastic variables with negative co-variation). That is the point that makes advantages to TGC – Quota system: A very satisfying level of new investors could be achieved.

Lemming [1] produced a set of graphs and equations covering risk analysis, equilibrium points for supply & demand curve information and defining the freedom degrees of spot and forward market (both for electricity and Green Certificates) which allow to correlate the minimum revenue variation for RE producers, in relation to the number of contracts, TGC price or electricity price.

Variation and stochastic quantities due to weather conditions, in wind / solar power etc. do not guide investors to ask for risk premium in Quota System. The opposite happens in FiT.
Investor exposure in Volume Risk is created in both Quota and FiT Support Schemes and there is no re-distribution when System changes from one to the other.
On the contrary, the negative correlation between power generation and TGC price level reduces the variations in revenues, thus investors have to charge for a lower risk premium.
Summarizing, an overall diagram could allocate risk sensibility between Green investors, Companies that might transform their energy portfolio from conventional "High Carbon" to a Renewable sign, and the final consumers. Then, next optimization steps could be defined.
We can summarize also Risk Exposure and Mitigation options, according to Tables**7.1 & 7.2**:

7.3 Comparison of Existing Mechanisms under Investor Considerable

TGC price variation has a slight influence in revenue variation, due to weather fluctuation. Where weather conditions are uniform and a specific generator has produced more Certificates, the same status will have done from the rest of generators community. Finally, the TGC price will be lower. This is the case of Danish regions against Greece territorial peculiarity.
Information regarding Demand – Supply Curve is not necessary In FiT Support Scheme since investors can be paid a fix amount. In TGC Scheme, lack of information makes existing investors to become risk addicted, but they receive higher returns, since TGC prices become higher. The reason is that TGC prices are guided by LRMC of new (marginal) investor, which credits for added Risk Exposure, and sets a Risk Premium. In Long- Term mode, as technology becomes mature, TGC prices will be lower, so the competition tends to be perfect.
When the Lifetime of Green Certification validation from RE-Producer is longer than Time Interval available for Certificate Renewal for RE-Buyers, then RE-Producers have the chance to bargain for better (higher) prices, in order to sell their Certificates. In that case, Penalty Recycling Mechanism /Fund, which manages the unsold Certificates, may give zero payment to producers, in case that the Obliges manage to purchase their RE Quotas in time. Thus, the longer validate lifetime of RE-Producers Certificates may give a lower price risk for them, in terms of Purchase options but, at the same time may give a higher risk for price, in terms of reduced revenues produced by Penalty Fund. In that case, General Consumer Fund is charged, since obliges transfer by this their purchase cost.
Quota Support Mechanism provide much more flexibility in variables that define the margins of each actor (RE-Producers, Obliges, End Consumers), in order to mitigate Price /Demand Risk. End consumers to obtain lower charges from General Customer Fund, instead of being transferred from obliged cost.
A contingent system transition, from FiT to Quota System, does not proceed additional Financial Risk, but it just transfers risk from one actor to another. For lack of Supply – Demand information, risk is transferred from Regulator Authority to investor(s).
The success of quota system is up to the market design, considering that TGC prices will not be so sensitive to any incorrect estimations, during quota setting.
Energy Storage can become a buffer to the production volume fluctuations and give to Renewable Future Contracts a perspective option, helping risk-averse producers.
In random (stochastic) mode of production volume, if TGC price performs such a variation, then **the amount of future contracts have to be small** in order to perform enough **stability to revenue**, thus the amount of contracts should be **inversely** proportional to renewable volume production. On the contrary, when **weather conditions are stable**, the **optimum number of**

future contracts, in order to achieve the minimum revenue instability, have to be **proportional** to RE volume.
From **Fig 7.1** it can be seen the equilibrium price, a respective price during the lifetime of investment. Looking at **Fig 7.2**, this will represent the wrong perspectives of Equilibrium point A that investors will strongly believe, in case that this information level will be not reflect the reality.
Based to **Fig 7.3**, an increased power generation is concerned, that means that more TGC than expecting will be produced. In that case, the SRMC fracture of the bidding moves to the right space of the graph, since every generator has produced more TGC for selling. The LRMC fracture does not affected upon time, since only average revenue of the total lifetime is affecting the final decision regarding the Total Investment.

7.4 Re-thinking an effective support scheme

Finance attractiveness, should be enhanced by a green certificate system, under certain market conditions, a **strategic behavior of a Cournot competition** model[4]. This will help competition, entry barriers to be erased, new actors to enter the market and make end consumers to enjoy a significantly better surplus. The last Renewable capacity will compensate for Marginal cost when certificate price is added to the electricity price.
In **Fig 7.4,** Total Supply curve corresponds for both old and also new RE generators.
Looking at the line **0 →1**: Old actors can generate Renewable Electricity below MC, they can run of full capacity and certificate price is zero. There is no allowance for new Renewable actors for entering the market.
Also in **1→2:** Old players are producing Renewable Electricity at SRMC equal to the Sum of Electricity and Certificate Price. There is no profit for them. Certificate price should be charged to the end consumers.
2→3: Not Already existing but also new players are producing Renewable electricity at a Marginal Cost greater than Electricity price
Essentially all the area between points **2, 3, 7, 8, 4** describes a transit condition, between the old established condition provided by the already existing actors and the finally successful entrance of new players in the market. the maximum level of the revised quota obligation broad band, gives an idea of green certificates price range, which represents the difference (gap) between marginal cost and electricity price.
Feedback from economics gives an idea of how much the Nash Cournot equilibrium is "sliding" between monopoly and perfect competition condition, according to how many players are participants or retired from the total electricity (renewable) production [4].
In **Fig 7.5**, Po represents the equilibrium price of the market before a green certificate system is introduced. As green certificates are introduced, mandatory quota (meaning some renewable electricity produced by new players) expels some quantity of the old producers and according to this, old generators receive a lower **Pp** price for each unit that they can sell from now on. Thus, Pp price is the new basement, and the green certificate price for new actors will be added to this Pp value, meaning that new actors will receive (**Pp + Pgc**) price. Respectively end consumers will be charged for the sum of (**Pp + P_{TAX}**) value, where P_{TAX} is the tax value that is normally funding the green certificate. This last sum is still lower than original Po, so **Pc** price (total consumers charge equal to the sum of Pp +P_{TAX}) establishes a consumer surplus according to the difference between Po and Pc. **The new actors and consumers build up a surplus at the expense of old producers, and this represents the main concept of this model**.

Therefore, **3-4 line** represents the price difference (rise) due to certificate tax, from Pp to Pc. And respectively the line 3-5 the price difference due to certificate price, that is paid to new producers. New Renewable Producers generate an overall surplus that is corresponding to A45 triangle, where ABC triangle represents consumer surplus.
Helgesesen & Tomasgard, 2018 [1] built an innovating equilibrium market power model, including electricity and green certificate market.
Table **7.3** summarizes all gains and losses among players.

7.5 Conclusions

In conclusion, in this Chapter, a thorough viewed model proposes which could be the role of a support system introducing Green Certificate and market completion in Renewable initiatives. Since it will not relied in public subsidies, indicates solutions applied for Renewable Developers, (more desirable the new ones), in order to mitigate regulatory risks, financial uncertainties, entry barriers, insurance cover and diligence issues.

Chapter 8 Financial Actors affecting Renewable Energy Technology and Innovation

8.1 Introduction

This survey in the current chapter could develop a more specific policy instrument that gives directions to RE innovations, affected by specific financial actors.
Apart from availability of financial instruments and support scheme functionality, financial influencers could produce a strong impact in financing policy, among different renewable innovation hubs and technologies.
The reaction between public and private investments could be a useful information tool regarding different capitalizing procedures, depending on technologies and specific life cycles. Some specific data for who is doing what is necessary.

8.2 Approach

It is useful to develop a data model regarding the value of share for each investor, the distinguish i.e. either equity or loans and finally the allocation of value shares among several investors.
International experience up to now seems that low risk technologies perform a more balanced portfolio, when in high-risk technologies the expenditure level varies among investment life cycle. Most of finance actors emphasize in one or two high-risk technologies. Except from public banks, most of these actors give an impulse to some specific Renewable energy technologies.
(Mazzucato and Semienuk, 2017, pages 5-7)presented a set of 5 equations (from 8.1 to 8.5 in the present chapter) describing Risk exposure, contribution of investors among technologies, skew of investor portfolio and overall direction of total portfolio into specific technologies
Equation 8.1 describes the Risk Exposure of a specific investor for some period, by the form of weighted average

$\boldsymbol{Rit} = \frac{\boldsymbol{1}}{\boldsymbol{Xit}}\sum_{\boldsymbol{1}}^{\boldsymbol{n}}(\boldsymbol{rnt} * \boldsymbol{Xint} + \text{Cnt})$, Eq 8.1 where :

n : assets available for investment
rnt : A risk indicator for technology and time
i : investor, Xint : finance flow by investor i , Cnt : country risk by time
Equation 8.1 has a very common sense of belief: if we compare an onshore wind generator project in a country providing a steady state RE- policy environment and another offshore wind technology project in a country that is going to transform its policy and regulation, it is obvious that the second case is more risky.
Another expression defines the contribution of a specific investor in each technology sector

$\boldsymbol{g}, \boldsymbol{ijt} = \frac{\boldsymbol{Xijt} - \boldsymbol{Xij},_{(t-1)}}{\boldsymbol{Xj},_{(t-1)}}$ Eq 8.2 where

j, each technology i : investor, x : the size of investment flow by investor i and by time
The direction of converging (skew) for an investor portfolio is defined by the measure of Shannon Entropy, which is calculated as follows:

$\boldsymbol{H}_{\text{it}} = -\sum_{\boldsymbol{j=1}}^{\boldsymbol{j}} \boldsymbol{P}_{\text{ijt}} * \boldsymbol{log}(\boldsymbol{P}_{\text{ijt}})$ Eq 8.3 and $\boldsymbol{P}_{\text{ijt}} = \frac{\boldsymbol{Xijt}}{\boldsymbol{Xit}}$ Eq 8.4

From Eq 8.4 we obtain the share of the total investment that is expend to specific technology jby investor i, over period t. Finally, the Shannon Entropy H indicates an investment direction in a specific technology by a specific developer. When the Entropy is zero, that means that investment flows to one technology and, vice versa, maximum entropy means that the optimum equal share in several technologies is done, without any specific technology lagging or preceding. Entropy is not dependent from portfolio size.

Theil Index composes the overall direction of all investors inside an overall portfolio and compares several directions against time, taking into consideration portfolio size.

We have to mention again that the value of 1 in Eq 8.5 is equal to non-specific technology direction in each investor portfolio and the value of 0 indicates that all portfolios of all investor are expend to one single technology

$$T_t = -\frac{1}{H^{j}_{t}} * \sum_{i=1}^{I} P_{it} \sum_{j=1}^{J} P_{jt} P_{ijt} \log P_{ijt} \qquad \text{Eq 8.5}$$

It is very essential to understand, analyze and quantify the willingness of several types of investor concerning their participation in different special purpose vehicles and also how the corresponding financial tools affect the nature of these investment patterns.

Bloomberg New Energy Finance(BNEF)[2] has given some asset finance data of 10 years period between 2004 and 2014. We can produce some conclusion regarding technology risk classifications (**Table 8.1**) , and the share in total investment and the entropy of portfolio per each financial investor profile and of course share in total investment of each technology RE group.

8.3 Conclusions

Public actors retain a balanced preference among technologies. Energy companies have the opposite tendency to skew their portfolio. The overall data indicates that financial players prefer to guide their investment in specific sub – groups of technology.

The economic and financial crisis has obviously affected these preferences. There are only two (2) technologies that increased their share after crisis, PV (c-Si) and advanced biofuels. After crisis, public investors increased their role and scope regarding energy investment and technology maturity and encouragement. Total review of 2004-2014 period revealed that two technologies, PV (c-Si) and onshore wind production increased their share

Chapter 9 Modern tools for Financial Risk Management and RE Projects evaluation

9.1 Introduction

The current chapter is referred to further ideas that can configure a more effective framework consisted of financial institutions, investors and developments should be implemented in RE project field.

A far as public finance resourced are deteriorated, the best solution is to manipulate these sources to the most efficient method of leverage and promotion of sustainable RE technology projects.

In addition, energy poverty including emerging even medium scale developed economies minimizes energy access to millions of families worldwide. It is not a matter of prosperity, but it is a matter of health, education, culture, sustainable growth and social injustice relief.

9.2 Carbon Finance

Only a few projects have used worldwide carbon finance tool. Set up of tradable carbon certificates and capability for production of new risk management products, corresponding to the needs of guaranteed values for emission reductions were inefficient. Regulatory aspects were too complex, as well. Nevertheless, new and modern insurance products can be developed to fit carbon finance needs, under a further optimization of regulation frameworks.

9.3 Perspectives for new instruments for RE boost

Modern finance companies, smart and specialized, called as "boutique" can develop strong relationship with corresponding smart RE developers, in order to expand small - scale RE projects. But they are unable to capitalize large amounts and cause a strong impact in RE investments. Large size institutions have to compensate for their inflexibility and inertia, responding to the flexibility and urgent reaction of the expert small actors.

Public sector and the multilateral institutions with a strong balance sheet could be the catalyst of this interaction, acting as an intermediate player.

This Trilateral interaction could find risk management solutions in RE Projects.

Innovative energy technologies, or energy storage should be secured by new risk management models, produced by detailed engineering studies. Multinational organizations like E.U. could organize tenders that bidders should competitively offer this kind of studies. This necessary data can arm both expert "boutiques", that implement the underwriting procedure and the strong institutions that fulfill the lending procedures.

Business development incentive, quota obligations and Green Certificates (not over end customer expenses but over pollutant producers or wholesale "prosumers") and guarantees for RE technologies can create further demand conditions.

The core business of this interaction could be an “exercise” to produce a total spectrum, scaled in detail regarding Risk management and finance instruments, specifically for RE projects, instead of just financing occasionally them.

What is modern innovative and impulsive to the RE development, is the creation of Special Purpose Underwriting Vehicles (SPUV). In first step, they develop the engineering data from RET, supplying all the necessary details for support of risk management. Secondly, a Group of Insurers has a representative that accepts or rejects the risks, on behalf of Total Group. Thirdly, the Group is awarding the risk management practices that reducing the premiums. Then the Group starts to develop insurance cover for production yields i.e. in biomass crops, in weather / wind speed etc..

9.4 A paradigm shift for Special Purpose Underwitng Vehicles (SPUV)

9.4.1 Introduction

Marsh and Ascot Renewco, 2008[1], has presented a feasibility study for a new SPUV in China, dedicated to RE projects, especially for wind power plants and for the establishment of relevant reinsurance facility. The main characteristics of this study are : a) an overall framework enhancing Credit rating b) new forms and structure of risk management market c) multilateral scheme of lending and guarantee players giving them the role of last resort capital sources and last but not least, d) the advanced engineering services and consultancy regarding specific characteristics and needs of wind power industry.

A Pilot Study is to establish allocation of all possible players contributing to this scheme.

The main concept is based to make the facility able to leverage reinsurance markets, in order to cover a wider spectrum of insurance and guarantee, technical validation that is dedicated to specific technology and to connect local insurance that are seeking for a dedicated reinsurance field instead of making continual insurance contracts, not designed for RE projects with international players who had no incentives for entrance in the specific local market and, from now on, they will have the ability to overcome local barriers in terms of regulatory regime.

9.4.2 Current Conditions to be remedied

Foreign Developers in China had also to overcome difficulties related to the exchange currency policy that is intended to strengthen local currency and capital inflows. In addition, Clean Development Mechanism is forcing to the configuration of joint ventures ensuring a 51% majority of local partners.

On the other hand, Foreign OEMs consider the fact that the local manufacturers are able to manufacture lower power levels of wind turbines, up to 1.5 MW and to expand their research and Development field. So when Chinese companies are purchasing foreign mechanical equipment, have a focusing on implementation of the relevant technology and strength their competitiveness advantage against foreign manufacturers.

From the view of local insurers, their local market presents high level of competition with too low prices and a significant fluctuation in premiums among each one project, not tailor made to wind farm projects. That is what to be remedied by international project financed schemes: the fact that wind farm projects had to be rated as there included other kind of physical assets, not Wind Power Projects. Some specific possible malfunctions like the sand particles in wind turbine blades or in gear boxes were not able to be predicted in the insurance package. And many local insurers had no technical awareness of wind power industry and the necessary technical compliance to be cover. Local insurers are not even familiar with wind farm technology or with risk management products like Delayed Start Up or Business Interruption coverage.

It is also necessary to be considered that 3 different alternative schemes, foreign companies, joint ventures and local companies, have fundamentally different requirements, in terms of insurance configuration.

Thus in the proposed facility configuration, the international insurers should supply more confidence to international developers of wind RE industry, enhancing the chance for more activities and, at the same time, local insurers will develop an expansion of contact channels, authorized by institutions.

9.4.3 Facility Configuration

A thorough view at the stakeholders of the facility should point the combined advantages of the configuration.

Facilitator

First of all, facility manager has to focus on technical requirements, communicate these in other stakeholders and build an insurance submission with specified architecture of best fit and legal compliance proposals. It has also to deliver the concept and the new options of the facility to all stakeholders, developers, international potential insurers and local underwriters and agencies that will help the marketing of facility fundamentals. Another service of facilitator is to issue invoices, collect payments, and be responsible for the deliveries of payment obligations to the players and the commitments to the reinsurance panel.

Facilitator should supply to the players with the most important risk management services, specified for the RE project such as benchmarking regarding risk assessment, in comparison with other similar projects, Inspections and Audit , made on site, data record for accidents , malfunctions etc, Project monitoring and workshops regarding consolidation of all players actions to promote the facility concept.

Reinsurers

The body of reinsurers has to build the precise best fit proposals, according facilitator architecture configuration, taking into consideration specific knowledge regarding topography of the project place, installation methods, exposure to natural disasters, reliability of wind farm electro - mechanical equipment, predictive maintenance aspects, Health & Safety (HSE) precautions, technology design, maintenance records configuration, warranties, capital and revenue inflows in timeframe. In other words, reinsurers have to configure a respected tool for reliability and willingness of investors to finance within the best fit premiums limits in the RE project. Finally they will provide high rates of risk management premiums and security rates, like Standard 7 Poor "A-grade", expert design, enough capacity for RE projects and new products, such as Credit Guarantees or others.

Local Insurers

The segment of local insurers should develop a co-operation with the facilitator regarding the assurance of the valid information collected by the client or the intermediate broker dealing with the technical aspects, progress and all other on site information of the RE project, that might contribute to final risk benchmarking of the project. They have also the responsibility to promote the insurance products to the final RE developers, that are the end customers of the SPUV, and to establish the most expanded distribution channels among local market actors. They will become the major local developers and messengers of the SPUV.

The overall SPUV facility should cover several varieties of risk like : Construction All risks, Delays in Start Up, marine transits, Operation All Risks, machinery Breakdown, Business Interruption and 3rd Party Liabilities.

Figure 9.1, recommends the working framework including all possible participants.
Table 9.1 includes the main monitoring fields, that cover the SPUV control, associated with special committed responsibilities and Service location.

9.6 An interactive RE finance web tool from World Bank

World bank has performed a **special software**[2] for RE projects and available finance tool. The toolbox is structured according to relevant principals that have been presented in previous chapters regarding potential financial instruments, risk assessment for RE projects, insurance instruments and risk mitigation forms.
The software firstly gives to the choice of either an advice of financing tools or an identification or risk and barriers addressed to an instrument.
In **Appendix C**, after a description of a specific instrument, there are some case studies that are presented. Case studies for Central & Eastern Europe, Central America and FYROM are available.

- In case of Central & Eastern Europe[3], lending programs for Energy Efficiency were developed in Hungary, Czech Republic, Estonia, Latvia, Lithuania and Slovakia. the concept was based to the fact that Local Financial Intermediate actors were lending the RE projects or energy efficiency projects. International Financial Corporation provided portfolio partial guarantees for these loans. Global Environmental Facility (GEF) granted for funding the IFC, in order to cover first loss and mitigate risk of local Financial Intermediate actors by backing their guarantee liabilities and funding technical consultancy, operation of the plan and structure configuration procedures.

  What made the difference, was the fact the FI little experience in RE sector and high credit risks were remedied by guarantees and risk mitigations serviced by ESCO companies (smart and experts) and GEF - IFC (finance - insurance capacity aggregators). Thus, a very effective commercialization of RE project initiatives was achieved.
- In case of Central America [4], there was an effort to overcome difficulties regarding high amount of collateral and project equity liabilities to the banks implementing the loans. CAREC, Central American Renewable Energy Clean production facility, provided mezzanine finance for RE projects in 7 countries of Latin America and Caribbean. This produced adequate finance access to RE developers. As explained in Chapter 3, mezzanine financing is serviced by the form of subordinated debt or by share and equity options. CAREC supplied up to 25% of RE capital cost. Revenue streams produced by RE project operation ensures senior debt service. In addition, profit share, ownership share and green certificate credits enhance the structure coverage.
- Next case study is referred to Bank for Development Promotion of FYROM[5] which launched a double guarantee and also lending facility program to RE and energy efficiency programs. Thus, if an ESCO company runs a business plan for RE and Saving energy facility, it will receive partial credit guarantee by MBDP in order to cover 50-70 % of loan obligations taken by commercial banking sector. Loans will be built in a subordinated debt structure.

9.7 Conclusions

Engineering studies are absolutely necessary in fields where insurance of RE technologies is absent or technology proven innovations have not yet obtained commercial maturity. This is the basement for SPUV creation. When public sector support is dedicated to fund these studies and fees for these risk management development, suitable for specific SPUVs, then the leverage is maximized and public sector will have minimized its financial obligations, making the optimum allocation of its expenses and spending.

Research field and further proceeding of RE development should be based in the following next steps:

- A new generation of applicable and RE- technology proven risk management / transfer product should be generated.
- As a result of Trilateral Groups core business a pilot scheme offering small scale RE projects in combination with large scale commercial involvement, should be implemented.
- Bundling occasionally spread small RE applications, insurance, risk transfer and financial services should be precisely modeled.

A more closed correlation and co – variance clarification should be developed between RE resources potential, forecast and risk ratings. The software of World Bank gives to the choice of either an advice of financing tools or an identification or risk and barriers addressed to an instrument. In **Appendix C** there are some case studies that are presented.

Chapter 10 Review and Conclusions

10.1 Road map produced by currently available and modern ambitious toolkit

Trilateral interaction between smart, expertized finance –technical renewable developers, multi–national strong balance sheet institutions and public interest sector could generate advanced risk mitigation tools.

Multi-national entities like European Union could publish a series of tenders and award the studies which can reinforce smart developers, in order to underwrite their activities, where strong (but not flexible institutions can lend the experts. In that way, a critical mass of business cases in renewable sector could be expanded.

Based on a reliable and competitive support scheme, not due to guarantee tariffs, but generated by the competition between new renewable actors, producers willing to transform their pollutant production to a renewable one, even partially, or even "energy prosumers". So, renewable projects could create a new demand.

An overall spectrum of renewable projects, thoroughly studied, in terms of risk ranking and finance instrument scale, can lead to a financing road map, instead of just an occasional finance eligibility, based on doubtful assessment.

A shown in Chapter 9, **World Bank** has developed a special **software tool**, giving the choice of a specific finance tool or allocation of risks and barriers that the suitable instrument should erase.

Renewable funding attractiveness is based on risk mitigation instruments, tailor made risk management methodology and investor reliability, especially in terms of technical implementation.

Financiers and relevant institutions are seeking for key figures in terms of revenue exposure (not Prices exposure"). This is very important for a thorough assessment procedure.

Considering all types of fiancé, Hybrid bonds perform the best fit solution for renewable developers. They can cover a significant part of upfront capital cost, make the projects more attractive to investors, due to revenues guaranteed from operation profit, and they can add a potential income generated from the secondary bond market, in order to compensate for any revenue loss. So they can manage a variety of risks and instabilities.

Project of Tilos island, which is the first autonomous renewable island in Mediterranean, has become the most symbolic and remarkable paradigm shift.

Renewable innovation and storage of this project enhances the European Agenda for 2020 targets. It is actually an Horizon 2020 project, performing a total budget of **13,7 M €,** including a *European grant* of **11 M€**[1].

Many islands in Southern Europe have a limited grid connection to the mainland [1]. So, this projects corresponds as a hybrid system with a smart micro –grid coordinating a wind turbine, a PV park and a battery storage system.

But TILOS project is not only referred in the specific Greek island. Additional 3 islands, from Germany, Spain and France (Corsica) are also participants, supporting a platform helping technology know – how interaction between 4 locations and building case studies in order to encourage similar actions in other regions.

Tilos consortium is consisting of 4 industrial partners, 7 academic and independent researchers, 2 Electrical System Operators, 1 NGO, coming from 7 European countries[1,2].
The coordinator is the Technological Educational Institute of Pireaus, from Greece

10.2 Technology direction of renewable funders

What is concluded from **Chapter 8,** is that Maximum Shannon Entropy (equal shares of investments) is a measure of assessment for the best diversification regarding technologies portfolio and under specific constraints on each investment.
Some public finance utilities skew towards offshore wind production projects. It is the technical nature aspect and difficulties that create the necessity of specific finance patterns
At the same time, some other investors use to distribute their portfolio in a wide range of competitive technologies, creating a RE technology direction.
In addition, public finance utilities, not only invest in high risk project and affect risk direction, but also contribute to an increasing share of total expenditures, so at the same time encourage both mature and immature technologies.
In a similar way, Venture Capitals help to solving problems in asymmetries of information in "Valley Death phase", where there is a need for a proven technology innovation to be transformed into commercial scale technology activity.
In that way, Public funds and Venture Capitals are compensating for possible market failures

10.3 Energy Storage: A strong potential for funding due diligence

Storage application gives the opportunity to renewables to become independent of Support Schemes based on a guarantee tariff. They can make renewables more attractive both for funding tools and innovation strategy
Lund, Salgi et al, 2009[3] have studied a strategy road map for a CAES application, order to deal with a 80-90% earning level, compared to the optimal result, due to decision making upon projection of forward spot prices.
Modification of renewables applies the chance to restore energy when electricity demand is off - peak (so do the prices) and, in next steps, to expand and produce electricity, whenever demand (and price) is on peak.
According to dynamic programming of technical process, there are four operation modes possible, supposing that the reservoir is not close to either full or empty condition: either net income is negative, then compressor is in operation and storage level becomes increased or net income is positive, turbine is in operation, in other words electricity supply is taking place. In case that net income is zero, (electricity price minus cost) and the storage level remains the same, no one operation is taking place. With net income positive and operation for both turbine and compressor at the same time, storage level remains the same.
The basic concept is that profit is due to an electricity selling price that is higher than Marginal Cost of 1 (one) unit generation - production.
It must be: $\mathbf{Psell} > MC\mathbf{prod}$
Optimal operation strategy should verify: the time of maximum electricity spot price and the storage limit around this time, marginal operating cost based on minimum

price, which is the minimum price within storage limits, storage margins in comparison with turbine or storage capacity, operation of turbine during maximum electricity price and operation of compressor storage during minimum price time[6]) operation of turbine during Maximum electricity price time and operation of compressor during minimum electricity price time.

Two (2) approaches are possible: In first case, historical strategy is based on average price due to price values recorded during recent 24 hours, where in second case prognostic strategy is based on average price due to value prognosis.

10.4 International Political Economy for Renewables: Block-chain, devaluation of high costs and funding needs

Political Economy of Renewables is settled not only by a struggle between renewable players against fossil investments, but also by a struggle between Renewable actors, trying to dominate their home region or to enter in international fields[2].

Global Production Network (GPN) and universal supply chain prove that every country is a dynamic participant in renewable international work allocation instead of 1 or 2 dominant players establishment.

Massive job creation and added value will succeed in downstream activity like renewable plants instead of upstream manufacturing. But the downstream needs to devaluate the extremely high costs, artificially produced by revenue buffer, guarantee payments, tariffs etc. The same factors that squeeze the renewables access to poor people and to reliable replacement of fossils.

There are peculiarities in some Renewable technologies, like PV manufacturing2, that have to be taken into account, when environmental and social issues are considered. And these issues generate the question of the overall environmental balance of these technologies.

Looking at some European countries like **Denmark**[4]**,** after a serious public debate, 30 years before, people became the energy owners, as called "prosumers", with the chance of ownership of large scale offshore wind or PV energy plants.

In **Germany**, a balance between corporation forces and green movement was established and consumers took a significant role in electricity industry and transmission.

It has to be concluded that Energy and Renewable funding policy makers need to adjust the right policy package to the recently captured knowledge. In addition, alternatives and innovation could create radical changes if democracy is in power, and equal distribution of all participants, political, social, economic and industry are considered. In that way transition modes are effective, erase the inequalities and encourage knowledge adoption.

APPENDICES

A. TABLES
B. FIGURES
C. TOOLKIT SOFTWARE DEMONSTRATION
D. LIST OF REFERENCE

APPENDIX A. TABLES

Chapter 2: A model development for : Cost of debt, cost of equity, Cost of Capital (WACC)

Table 2.1 Average Interest rates % per EUMS countries for 2013 and 2018

EU Countries	10-year Gov Bond I.R %, 2013	10-year Gov Bond I.R %, 2018
Austria	2.01	0.625
Belgium	2.41	0.732
Bulgaria	3.47	1.12
Croatia	4.68	2.266
Cyprus	6.50	2.54
Czech Republic	2.11	2.216
Denmark	1.75	0.366
Finland	1.86	0.566
France	2.20	0.708
Germany	1.57	0.336
Greece	10.05	4.152
Hungary	5.92	3.610
Ireland	3.79	0.864
Italy	4.32	2.726
Lithuania	3.83	1.050
Malta	3.36	1.318
Netherlands	1.96	0.498
Poland	4.03	3.203
Portugal	6.29	1.817
Romania	5.41	5.12
Slovakia	3.19	0.72
Slovenia	5.81	1.064
Spain	4.56	1.362
Sweeden	2.12	0.500
U.K	2.03	1.322

Source: Deloitte [4], 2013

Table 2.2 MRP used across EUMS countries for 2013 and 2018

EU Countries	MRP %, 2013 [6]	MRP %, 2018 [7-8]
Austria	5.70	6.2
Belgium	6.00	6.2
Bulgaria	8.30	7.5
Croatia	7.80	-
Cyprus	7.90	-
Czech Republic	6.80	5.9
Denmark	5.50	6.0
Finland	6.00	5.9

France	5.90	5.9
Germany	5.50	5.3
Greece	9.60	8.30
Hungary	7.40	7.9
Ireland	6.60	6.50
Italy	5.60	6.1
Lithuania	7.90	-
Malta	6.60	-
Netherlands	5.40	5.8
Poland	6.40	6.0
Portugal	7.20	7.2
Romania	7.70	7.0
Slovakia	6.90	6.6
Slovenia	6.50	7.2
Spain	6.00	6.7
Sweden	5.90	7.1
U.K	5.50	5.5

Source: Fernandez et al, study of 2013 [6], Fernandez et al, study of 2013 [7], Market Risk Premia .com (2018)

Table 2.3 Cost of Debt of onshore wind poer plants, among EU members, valid for 2012, according Eurelectric and Bloomberg methods [1]

EU Countries	CoD % , Eurelectric method	CoD % , Bloomberg method
Austria	5.8	6.0
Belgium	5.9	6.1
Bulgaria	6.2	7.8
Croatia	8.2	9.0
Cyprus	4.2	8.5
Czech Republic	5.8	6.0
Denmark	5.8	6.0
Finland	5.7	6.0
France	6.0	6.1
Germany	5.5	5.8
Greece	9.5	14.0
Hungary	8.0	10.0
Ireland	7.0	8.0
Italy	8.0	8.1
Lithuania	6.2	8.0
Malta	7.5	8.0
Netherlands	5.8	6.0
Poland	6.0	8.0
Portugal	10.0	10.2
Romania	7.0	9.8
Slovakia	6.0	7.0

Slovenia	8.0	10.0
Spain	8	8.9
Sweeden	5.7	6.1
U.K	5.8	6.0

Source: Diacore, (2016)[1]

Table 2.4 Debt to Equity Ratio for onshore wind energy in 6 European Countries

Country	Debt to Equity Ratio
Denmark	80 : 20
Germany	70 : 30
Netherlands	80 : 20
Spain	80 : 20
Sweden	87 : 13
Switzerland	70 : 30

Source: Market Risk Premia .com (2018)[8]

Table 2.5 Debt to Equity Ratio for Renewable Technlogies in Germany, for 2013 [10] and 2018

Technology	Debt to Equity Ratio 2013 [9]	Debt to Equity Ratio 2018 [10]
Onshore Wind	70 : 30	80 : 20
Offshore Wind	60 : 40	70 : 30
PV	80 : 20	80 : 20

Source: Fraunhofer (2018) [11]

Table 2.6 Debt to Equity Ratio for several Offshore wind RE projects, during 2013, among 4 countries

Offshore Wind Project	Country	Financing date	Debt to Equity Ratio
Butendiek 288 MW	Germany	1/2/2013	65 : 35
Lincs 270 MW	UK	1/6/2012	43 : 57
Northwind 216 MW	Belgium	1/6/2012	70 : 30
Baltic 1 48.3 MW	Germany	1/12/2011	69 : 31
Meerwind 288 MW	Germany	11/8/2011	69 : 31
Global Tech 1 400 MW	Germany	11/7/2011	60 : 40
Thorton Bank (C Power Phase 2-3 295.2 MW	Belgium	1/12/2010	67 : 33
Borkum West II 200 MW	Germany	1/12/2010	64 : 36
Bligh Bank 165 MW	Belgium	1/7/2009	89 : 11
Thorton Bank (C Power Phase 1 30 MW	Belgium	1/5/2007	80 : 20

Source: Clean Energy Pipeline (2013) [12]

Chapter 3 Identification of Risk and barriers in Renewable Energy Projects

Table 3.1Risks and barriers related to different Renewable Energy Technologies

RE Technology	Risk issues	Risk Management Considerations
Geothermal	• Expenses for drilling and associated risk • Exploration risk concerning non suitable water temperature and flow rates • Equipment failures (i.e. pumps etc) • Long lead times for planning permissions etc	• Limited population of human experience and capability for drilling operation. Limited places worldwide that are familiar with several drilling technology aspects • Limited measured data and lack of experienced technicians who will seize this kind of data • Stimulation technology (boosting for productivity) still unproven • Project Planning could be not easy for approval
Large PV	• Equipment malfunctions (short circuits etc) • Damages due to weather conditions • Violence actions against equipment	• Performance guarantee up to 25 years • Standard components, spare parts easy to be replaced by universal technology • Maintenance can be neglected, moreover if the operator is not interested in (installation far away installed or a developing country place)
Solarthermal	By increasing project scale and by combination with other RE Technology like solar towers, technology risk is increasing also	• Data records for normal operation and failure modes • Maintenance could be neglected
Small Hydropower	• Flooding • Fluctuations according seasonality. Variations in flow rates or reservoir capacity • Equipment failures with long delivery time for spare parts	• Long-term proven technology, low operational failure risks and maintenance expenses
Wind Power	• Long Time necessary for permits and task amendment, capital cost intense in the very first steps of technical implementation • Failures / damages for basic components of the equipment (garbox, bearings , blades etc) • Fluctuations in production due to weather condition (wind speed) • Sub-sea installation of main supply cable in off shore wind farms	• Optimization of wind turbine models and manufacturing • Suppliers should support a rigid guarantee procedure, technically reliable • Wind resource data reliable, smart personnel and institutional structure, in order to seize technical and weather data • Management of power loss or urgent accident or HSE aspect (fire fighting issues, reliable and applicable installation and configuration philosophy, especially in difficult remote control management (i.e. offshore wind farms)
Biomass power	• Fluctuation of fuel source or even full loss of availability • Fluctuation in the prices of primary waste material • Waste material (actually the fuel) storage and handling needs special treatment that	• **Long term contracts can be proved applicable if only production estimations are reliable and realistic in comparison to population characteristics** • Proper management of fuel costs

	generates environmental liabilities	• Emission control procedure, dedicated to specific technology, in order to erase any potential environmental risk
Biogas power	• Fuel supply risk. When organic feedstock is reduced, the same happens in biogas production • **Environmental and Urban Planning restrictions can be fairly opposed to the bad design, low budget mentality and counter social business orientation**(unsolved odour problems that undermine urban life).	• Operational and HSE procedure should be tough, in order to be in standards of reliable management of any service loss or accident condition (fire-fighting and other Hazardous Potential Safety Treatment) • There is no risk relief and mitigation if legal contracts are just reproducing manufacturer statements that normal wear or equipment depreciation is not covered by any warranty. Risk relief conditions are generated by specific high rate values for wear and tear. Thus, risk mitigation will not just help the "market". **But it will mainly serve production, Research and Development**
Tidal / wave power	• Technical restriction in difficult marine environments • Technology risk with no leader enterprising, for the time being. • Long time necessary for permits and construction amendment.	• Further progress to demonstrate and implement relevant concepts, generating the next projects • Development of resource data and smart analysis.

Source: UNEP / SEFI, (2004)[1]

Table 3.2 Risk Allocation and Partners, RE Projects

			Potential Risk Partner						
Risk Category	Risk Sub-Category	Project Developer	Contractor / Supplier	Grid / Power Distributor	Commercial Lender	JV partner	Official Financing Aid Institution	ECA / PRG	Commercial Insurance
Country Risk	Expropriation						●		
	Contract validation						●		
	Foreign Exchange						●		
	RE policy & Legislation						●		
Resource exploration		●							
Development		●							
Technology Maturity		●							
Construction	Delay		●						
	Cost Overrun		●						
Operation	Resource Supply	●							●
	Damages / violent actions / robberies								●
	Technical Performance		●						
	Management	●				●			
Commercial	Operating Cost	●				●			
	Price /Tariff			●		●			
	Demand			●		●			
	Payment			●		●			
Financial	Debt accumulation		●		●	●	●		
	Loans	●			●	●			
	Interest Rate				●				
	Exchange Rate				●		●		
	Maturity				●		●		
Force Majeure							●		

Source: KfW, (2005)[3]

Chapter 4 Availability of Finance Tools for RE Projects and Technologies

Table 4.1Financing Barriers according to RE technologies

	Financing Barriers				
	Lack of Long Term Finance	**Lack of Project Financing**	**High exposure to Project Development Cost Level**	**High exposure to Project Development Cost Fluctuation**	**Lack of Equity Finance**
On grid					
Wind farms	High	Medium	Low	Low	Low
Solar energy	High	Medium	Low	Low	Medium
Small Hydro	High	Medium	Medium	Medium	Medium
Biomass	High	Medium	Low	Low	Low
Geothermal	Medium	Medium	High	High	Medium
Off grid					
Solar	Medium	Low	Medium	Medium	High
Micro-Hydro	Medium	Low	Medium	Medium	High

Source: World Bank, Climate Investment Funds (2011)[2]

Table 4.2 RE Finance Forms

Finance Type	Design	Impact on RE Development Frame
Private	Personal savings or bank loans with private asset securing	It could be last resort for small scale project finance
Grants	When the developer wants to finance early stage of the project grants given by public sector could be a solution	It could be the key to bring commercial adequacy - maturity to already technically proven RE technologies (storage, offshore wind farms, wave/tidal energy etc)
Risk capital	Equity investment becoming from venture Capitals (VC), private equity funds or strategic investors, such as equipment manufacturers	Risk capital could be the only additional finance option , apart from developer own equity
Mezzanine	It is a hybrid form between Debt and equity Financing. it gives the Lender the rights to convert an ownership or to an Equity Interest in the company (in case of default) after Venture capitals are paid. It is considered as Equity, when a Balance Sheet is built. It needs a further survey from the investor regarding due diligence of the developer. Returns rates are higher, but Mezzanine type is positioned between increased returns equity position with high risks and fixed debt position with low risks.	Giving a good scope for RE (even publicly or privately) financing in Developing countries.
Corporate	If assets stated on the balance sheet of the company, are used as a collateral, in order to be provided debt by banks, then a corporate finance is structured. In this case, a sponsor is accepting risk and a potential reward of a project in its entirety	Mature companies based to strong asset properties, adequate cash flow and debt capacity should be benefited by this finance structure
Project	Distinct, single purpose companies could be provided such a debt mode. Power Purchase Agreements (PPA) usually guarantee future revenues.	A helpful tool. Long term PPAs. On the other hand, any discounts in PPAs and regulatory risk reduce lenders incentive. But it could be a fine tool for RE projects orientated to off grid applications
	This is a kind of **Non Resource Finance.** It is actually a loan, but the lender is **only** entitled to repayment **from the profits**, produced from this specific project. Lender is **not** going to be paid **from other assets** of the borrower(s).	
Participation	It is similar to Project Finance, but the lender could be a group of investors, a cooperative fund for wind farms. These are going to receive benefits in the option of fiscal or tax relief incentives	It could be provided with the absence of PPAs, or with existence of proactive hedging and management of regulatory risks
Risk/Insurance Structure	They use to transfer specific risks through commercial insurance companies that reduce exposure and damp revenue fluctuations	A very added value tool for countries with well implemented insurance markets
	Credit Enhancement : A method whereby a company attempts to improve its debt or credit worthiness. Lender is provided with reinsurance that the borrower will honor the obligation. How this insurance is being provided ? Through insurance 3rd party guarantee and Additional collateral. Thus, if Credit Enhancement provided, then Default Risk is reduced, credit rating is increased and interest rates are going down.	
Consumer	Regarding individual clients of specific projects or for off grid installation, if the client is proven to be reliable in credit, installation profits can be used as a collateral for financing	Micro credit structure for home solar systems, or off grid RE installations
3rd Party	An independent party is financing many individual RE systems. Fee for service and leasing structures similar to Consumer Finance	An asset backed model, feed in cash flows produced by RE project itself. Supplying some flexibility and possible tax reliefs for smaller RE systems, engaged to a collective vehicle.

Source: UNEP /SEFI (2004)[3]

Table 4.3 Allocation between Problems, Instrument and relevant financial partners

Problem Factor	Kind of Problem	Potential instrument	Partner Institution to address the proble,				
			Commercial banks	Venture Capitals	Institutional Investors	Equipment Supplier	Promotional S Institutions
Type of fund	"weak capital"	Sufficient outside equity		●	●	●	Specialized equ Promotional Insti
Amounts	Low amount	Household credit					Micro finance Ins
	Medium	Company Credit				●	Promotional Insti
	High	Project Finance	●	●	●	●	Promotional Insti
External share for Financing	Limited own capital	Outside equity by 3rd party		●	●	●	Specialized equit
Technology Immaturity	Very Long Term profits	Long term credit or equity	●		●		Promotional Insti
Interest rates	Interest Rates in the lower range of the market due to limited return of investment	Risk management tool for compensation in debt finance low flow					Insurance w experience, Pr Institution
		Sub-ordinated Debt (mezzanine model) for compensation of senior debt risk					Promotional Insti
		Market use for getting efficient conditions	●				
	Limited funds seeking for interest rates	HIgh level of outside equity		●	●		Specialized equit
Security & Collateral	Limited capacity for collateral, on base of cash flow	HIgh level of outside equity		●	●		Specialized equit
		Use of leasing, or sell and lease back model	●			●	Specialized instit

Source: KfW, 2005[4]

Table 4.4 Allocating Financial Market Maturity and instruments functionality

Financial Markets	**Equity**	**Credits**	**Bonds**	**Mezzanine**	**Leasing**
Mature	Yes	Yes, but presenting difficulties within the segment of extra-long maturities	Difficult, High Level of transaction cost	Yes	Some financial institutes provide leasing options but limited in amounts
Advanced Emerging	No capital scarcity, but there is a need for formalization and accessibility of venture capitals	Yes , but with only mid to long-term maturity (max 8 years). Only very limited schemes with RET efficient extra long maturities	Difficult to be available. High Level of transaction cost. Investors behavior with risk aversion	Available with some schemes, but with semi-commercial institutions	Some financial institutes provide leasing options but limited in amounts
Emerging		Yes, but with limited amounts and only mid-term maturity (max 5 years). No schemes with RET efficient extra long maturities	Not practically available due to high transaction cost, risk aversion by investors and volatile markets	Available with some schemes, but with semi-commercial institutions	Some financial institutes provide leasing options but limited in amounts
Basic		Only limited amounts with mid term maturities	Not available, apart from some state bonds	Basic instruments are absent, so do the hybrid like mezzanine	Limited to international supplier of leasing options

Source: KfW, 2005[4]

Chapter 5 Insurance Products

Table 5.1 Existing insurance tools for RE projects			
Risk transfer product	**Risk impact**	**Insurance remediation**	**Special Underwritng concerns**
Construction /Erection Risks	Damages or equioment / installation losses during construction phase	For all risks for any, 3rd party liabilities loss or damage from procurement up to commissioning phase	Quality control procedure for contractors. Problems erased due to power cable laying installation for offshore wind projects
Delay of Start UP and Loss of Profit	Delays causing capital inflow loss during erection phase	For loss of revenue during Construction phase	Energy Transformation loss Milestones leading the project
Operation Risks and Physical Damage	Damages, shutdown of production	"All risks" package	Explosion hazardous impacts for biogas and geothermal plants Losses due to fire in wind farms Quality control, maintenance check lists
Machinery Breakdown	Unexpected shutdown of E/M equipment, malfunctions, long period necessary for repair	Defect elimination in machinery components, detail design for erection and commissioning, preventive maintenance procedures	Errors in design, component defects, human factor interference Technology risk Equipment warranties End of life cycle for materials, spare parts
Business interruption	Loss / damage causing interruption of business	Loss of revenues insured under Operation All Risks package	Losses for power cable and transformers. Key milestones for necessary replacements Exposure of developer to waste supply for biomass Wind speed / conditions for wind turbine farms Solar radiation for solar power system
Operators Extra Expense for Geothermal Projects	Uncontrolled flow from the wells	Expenses related to control of the well, drilling, possible leakages, pollution	Further limits for losses in geothermal systems Well depths, basins, reliability of driiling contractors
3rd Party Liabilities	Liabilities by the law, contractual liabilities for damage or human injury	Charters / cargoes liabilities, cover for machinery , maritime accidents	3rd party liabilities and issues related to toxic gases, explosive enviroments for biomass / geothermal plants

Source: UNEP /SEFI (2004)[1]

Table5. 2 Risk transfer for each RE technology and Risk Category[1]

Risk category	Construction All Risks	Resource Supply / Exploration	Property Damage	Machinery Breakdown	Business Interruption	Delay in Start up, Profit Losses	Defective components / Technology Risk	Contractors Overall Risk	3rd Party Liabilities
Onshore wind	High cover			Almost High Cover			No cover		
Offshore wind	Medium Cover	Low Cover							
Solar PV				n/a					
Wave/ tidal									
Geothermal									
Biogass									
Small Hydro				n/a					
Biomass									

Source: UNEP /SEFI (2004)[1]

Color Symbol		Cover available
		Highly expanded and competitive cover with decreasing rates
		Almost High Cover, availability of insurance product and standard rates, possible high premiums
		Medium cover, increasing availability in the insurance market, limited capacity, high premiums
		Low Cover, limited markets, district terms, a lot of exclusions
		No cover available in the insurance markets, as existing

Chapter 6 Financial Risk Instruments for RE projects

Table 6.1 Financial Risk Instruments for RE Projects

Type	Mechanism	What is mitigating ?	Issues to specific RE Technology
Hybrid form of reinsurance and derivative	Contract and OTC derivatives with weather linked finance (wind speed, temperature etc). Risk transfer from developers to insurance and capital markets	Resource fluctuations affecting revenues	Big data is necessary in combination with smart data acquisition. Satellite technology is obviously helpful
Alternative Risk Transfer (ART)	When an operational malfunction (1rst problem) causes (potentially) a spike in electricity price (2nd event)and reinsurers cover these business interruption risks, then an ART structure is made	Contigent risks (as a sequel event) can affect revenue inflows	Since a sequence of events is assumed, it must be studied very carefully for all potential scenarios
Debt & Equity combination finance	Policy under the module of hybrid securities, debt or equity shares provided by the reinsurer, in order to support / protect capital that otherwise should be found in the capital markets, upon a high level interests	For any contingent event that could cause a rapid default / damage to the project / asset equipment	A very careful study for all possible scenarios is proposed. the product could be applicable under a **S**pecial **P**urpose **U**nderwriting **V**ehicle
Risk Finance	Long term contracts , including premiums based on probability of malfunction and following impacts. It can make dampening to a chain of events (with relevant variances) that affect revenues. potentially, it could spread losses of high cash flows over time.	Known as Timing risk effect, where losses happen faster than expected	A very careful study for all possible technical scenarios is proposed. Often based on strong credit profile
A variety of asset backed Securities	Securitization of finance risk with Insurance Linked Securities or Catastrophe Bonds and Collateralized Debt Obligations, issued by several tranches with gradual credit risk exposure (major and subordinated tranches). Credit graduations create risk transfer and therefore a finance path	Bundling of Credit Default, liability, credit risk, weather / natural disaster risks	A pool function, bundling risks produced by weather fluctuations, resource variations, emerging markets. A SPUV potential
Risk finance or ART	Self - insurance by a company that establishes its own insurance affiliate company, in order to achieve in-house risk management and lower costs, comparing to outsourcing solution. Protected Cell structures can diverify the risks among several projects	A property insurance. Could be transformed to finance risks insurance	Pooling mechanism, requiring similar risk profiles. Requires initial capitalization.
Insurance	Products provided by insurers against future delivery of credit or money to purchase credits in spot markets. Therefore they will be able to honor the obligation of the contract. Risk transfer from developers and investors to insurers	Risks associated with TGC or emission reductions, technical performance, and political risks	A regulatory framework is necessary. Long term policy for RE support scheme is obviously included in this requirement.
Grant, Loan, Guarantee	Contingent or performance grant or loan, Partial Credit Guarantees, investment and reserve funds, by GEF, in combination with Implementing Agencies. Project Risk transfer	Soft funding for public interest projects with high risk level	Slow and complex process progress. Limited sources.
Guarantee (Credit Enhancement)	Donor capitals used by funds, in order to leverage commercial loans	Political and credits risks in emerging markets	Suitable for projects of large scale infrastructure, with further potential applications
Guarantee (Credit Enhancement)	Partial Risk Guarantee that covers both creditors and equity investors, and Partial Credit Guarantee that covers creditors, issued by i.e. World Bank or Regional Development Banks. Flexible structures are preferred, not including Sovereign Counter- Guarantees or at least	Credit Default or Political risks, like a government default on contract obligations	Partial Credit Guarantees and Credit Enhancement forms for RE projects available

	sovereign guarantees that not increasing sovereign debt (based to an existing reserve)		
Guarantee, Export Credit, Insurance	Guarantee, Export Credit, Insurance, provided by ECAs (Export Credit Agencies, and Official Bilateral Institutes (OBIs)	Political , currency exchange risks associated with private investments abroad	A strong demand for RE Technology data, in order to validate the underwriting methods

Source: UNEP /SEFI - KWF, (2004-2005) [1,3]

Chapter 7 Evaluation of RET Support Schemes. Finance attraction, Cost Charging paths, Risk Mitigation and Market Strategy Alternatives

Table 7.1 Revenue Risk Exposure

Revenue Risk Exposure	Lack Of Information for Supply – Demand Curve	Volume of Electricity Generation
Support Scheme		
FiT (etc Subsidies)	Low Risk	Increased Risk
Quota System	Increased Risk	Low Risk

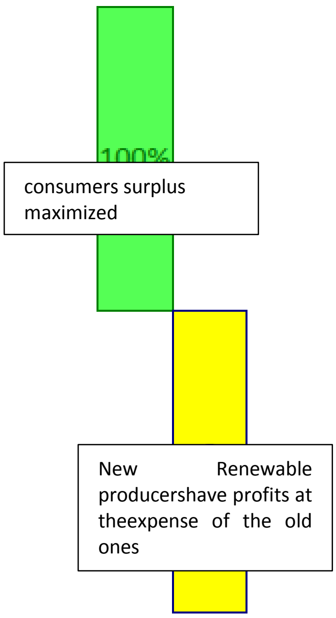
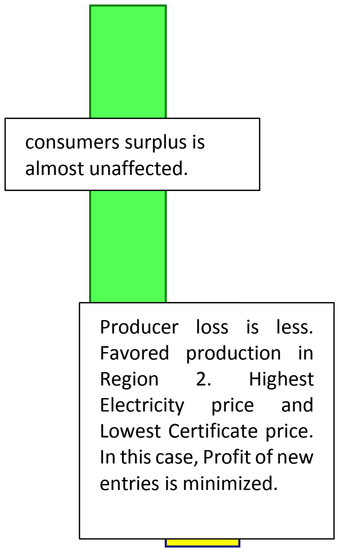
Source: The Author

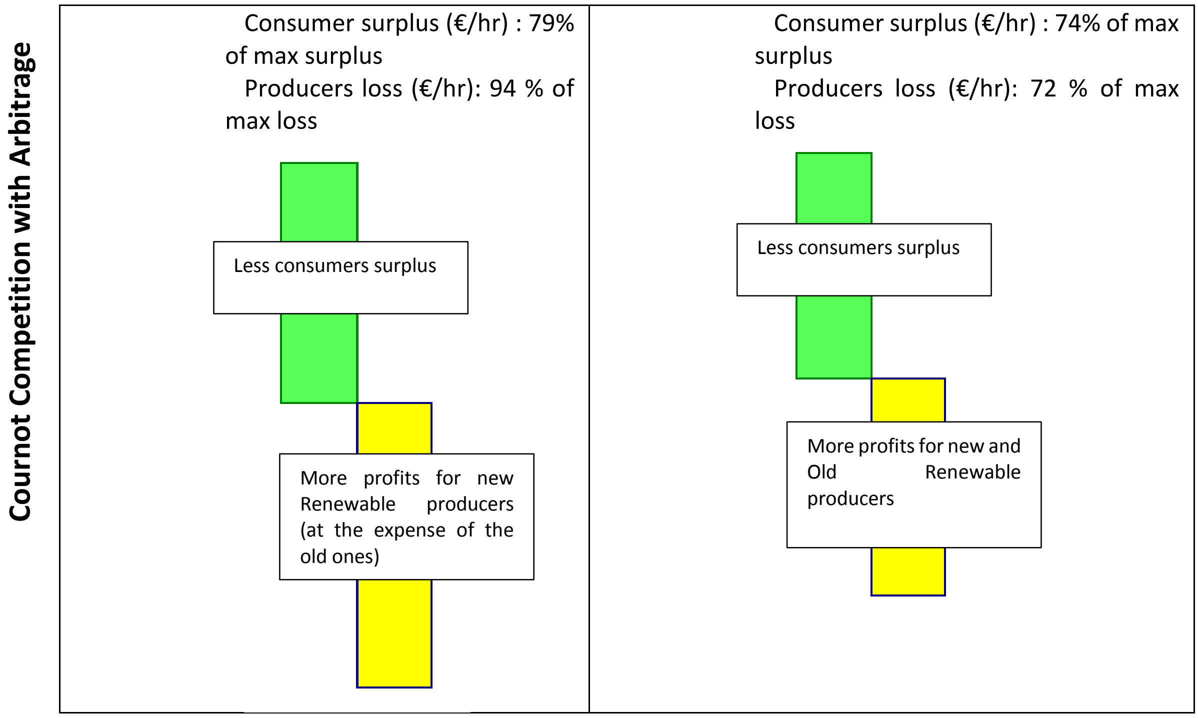
Table 7.2 Revenue Risk Mitigation

Revenue Risk Mitigation	Lack Of Information for Supply – Demand Curve	Volume of Electricity Generation
Support Scheme		
FiT (etc Subsidies)	**Subsidy**	**Subsidy**
Quota System	Increased price of TGC	-(Low Risk)

Source: The Author

Table 7.3 Games and loses among players

	Infinite transmission capacity	**Finite capacity (i.e. 25MW) 2 ways direction energy exchange between regions**
Cournot Competition, No Arbitrage	Consumer surplus (€/hr) : max surplus Producers loss (€/hr): max loss 	Consumer surplus (€/hr) : 98% of max surplus Producers loss (€/hr): 81 % of max losS 



Source: Helgesen, Tomasgard (January 2018)[4]

Chapter 8: Financial Actors affecting Renewable Technology and Innovation

Table 8.1 Technology Risk Classifications 2004 - 2014

	Technology	Technology Sub-Group	Risk Level
Wind			
1	Onshore		Low
2	Offshore		High
Solar			
3	Crystalline Silicon PV		High (2004-2006)
			Medium (2007-2009)
			Low (2010-2014)
4	Other PV	Thin film PV	High (2004-2009)
			Medium (2010-2014)
		Concentrator PV (CPV)	High
5	Concentrated Solar Power (CSP)		High
Biofuels			
6	1rst Generation fuels		Low
7	2nd Generation Fuels		High
Other Technologies			
8	Biomass & waste	Incineration	Low
		Other Biomass Technologies	Medium
9	Geotermal		Medium
10	Marine		High
11	Small Hydro		Low

Source: Bloomberg New Energy Finance(BNEF), 2014-2015[2]

Chapter 9 Modern Toolsfor Financial Risk Management and RE Projects evaluation

Table 9.1SPUV Main Monitoring Fields and Responsibilities

Main Monitoring Fields	Special Responsibilities	Service Location
Senior Consultancy		
Technical Consultancy	Relationship management & technical advice on major risk issues	Home or Regional
Technical Consultancy	Co-ordination between local and foreign participants upon certain issues arises, through facilitator	Abroad
Business Consultancy	Strategic advice t the core service team. Performance audit with SPUV progress tracking and quality assurance	Home or Regional
Business Consultancy	Reinsurance broking and wholesales progress. Technical advice on major insurance issues	Abroad
Core Service Group		
Key Account Manager	Overview of all aspects of service deliverables	Home
Connection between specialists in the service team	Insurance & reinsurance broking and technical advice on insurance aspects	Home
Service Management	Monitoring and securing daily service deliverables. Focal points of contact and operational aspects	Home
Local service placement	Insurance and reinsurance broking & placement	Home
Insurance consultancy	Supervision and implementation of daily service	Home
Risk Control		
Senior Risk Consultancy	Risk control consultancy, in terms of property risks	Home
Junior Risk Consultancy	Daily Administration and CO-ordination, in terms of loss control and risk management facility	Home
Claims Management		
Senior Claims Consultancy	Supervision and co-ordination of all insurance claims issues	Home
Client Consultancy	Advices and negotiation procedure supply to clients	Home
Junior claims consultancy	Monitoring of negotiation issues in insurance claims	Home

Source: Marsh and Mc Lennan, 2008[1]

APPENDIX B. FIGURES

Chapter 3 Identification of Risk and barriers in Renewable Energy Projects

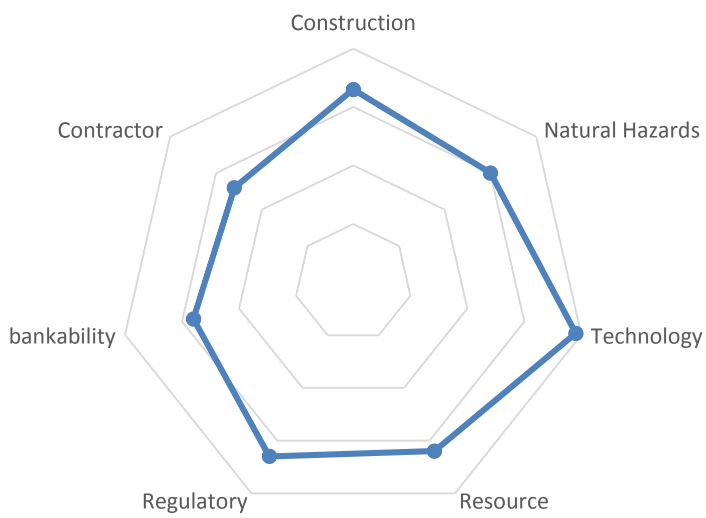
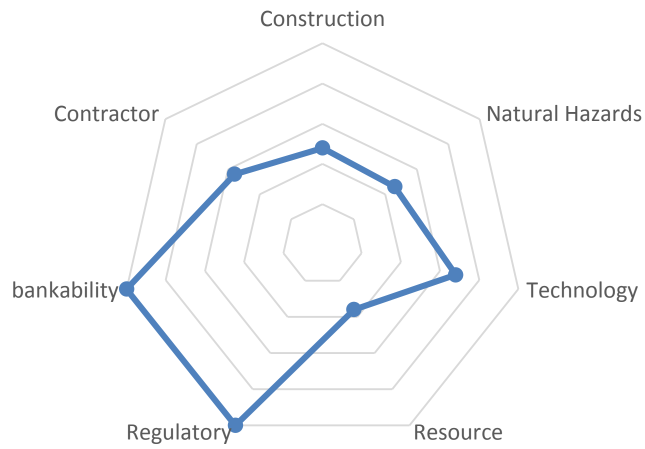


Figure 3.1 Developer Risk Ranking

Source: Marsh and Mc Lennan, (2008)[2]

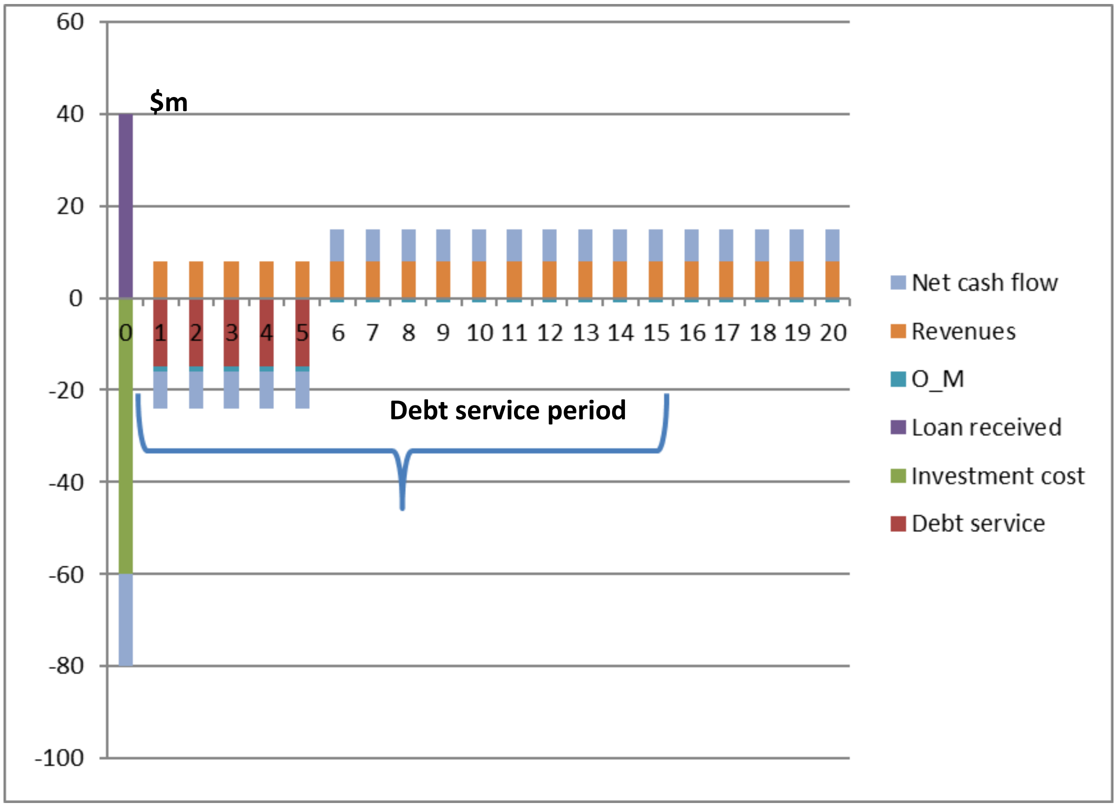
Figure 3.2 Manufacturer Risk Ranking[2]



Source: Marsh and Mc Lennan, (2008)[2]

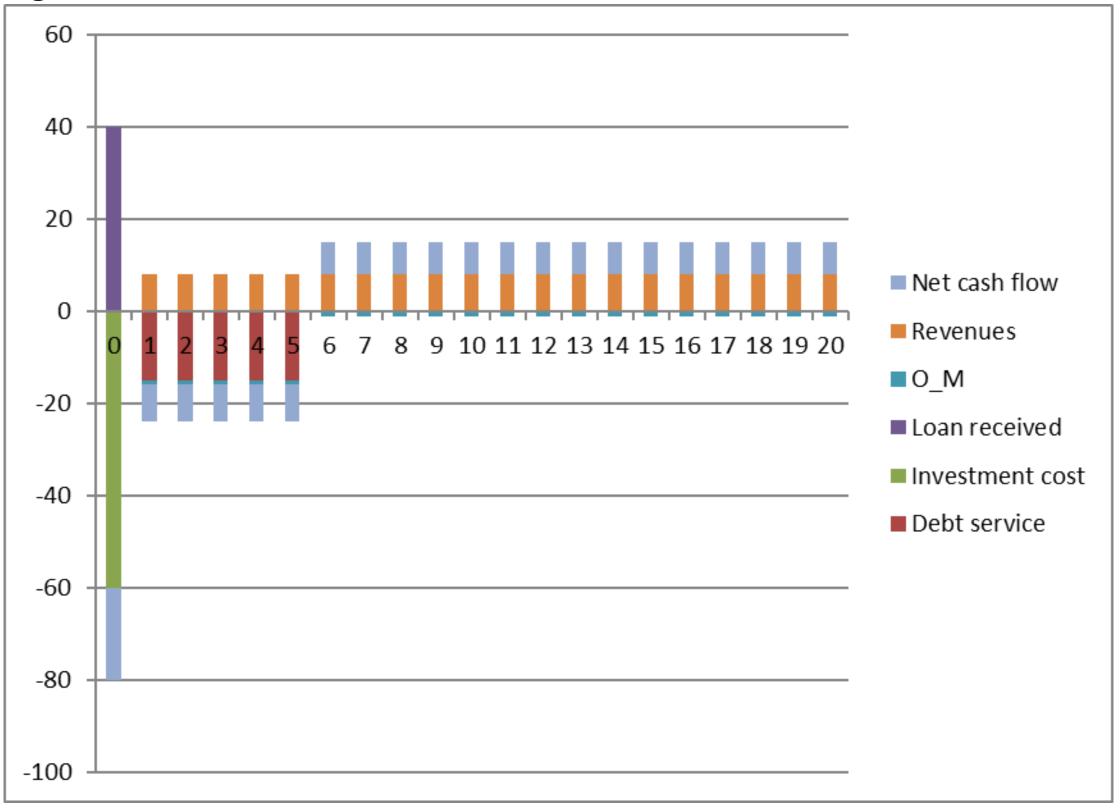
Chapter 4 Availability of Finance Tools for RE Projects and Technologies

Figure 4.1 **15 - year Debt ServiceEquity IRR : 15.8 %**



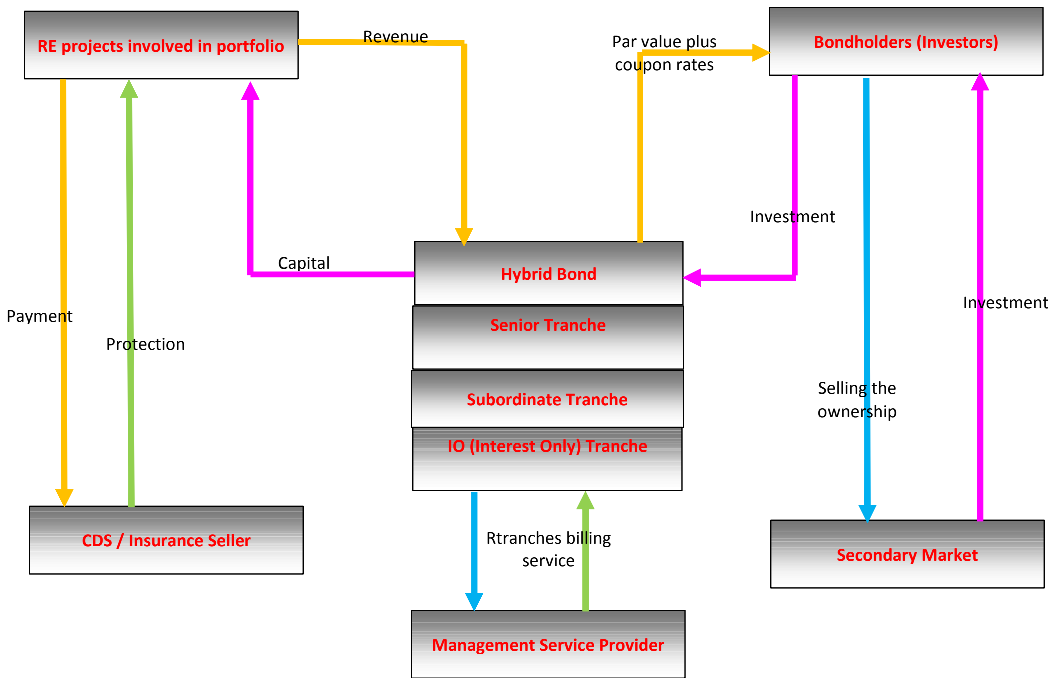
Source: IEA - World Bank, Climate Investment Funds (2010 – 2011)[1, 2]

Figure 4.25 - year Debt Service' Equity IRR : 12.5 %



Source : IEA - World Bank, Climate Investment Funds (2010 – 2011)[1, 2]

Fig 4.3 Hybrid Bond scheme



Source: Lee & Zhong (2015)[6]

Figure 4.4 Morris Model: Public Private Partnership (P3) Hybrid Bond (New Jersey Province, USA)

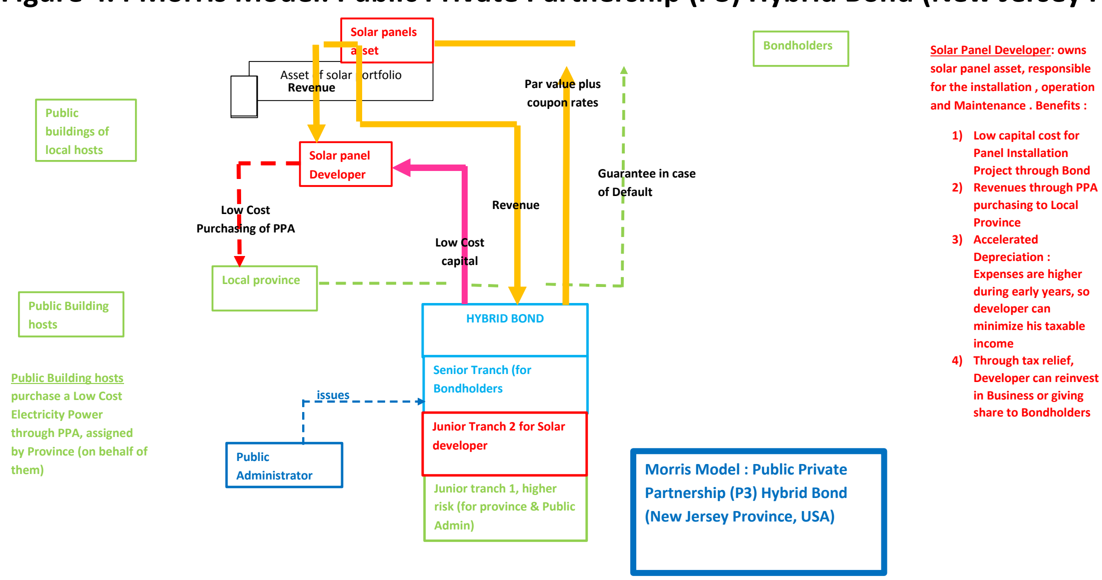
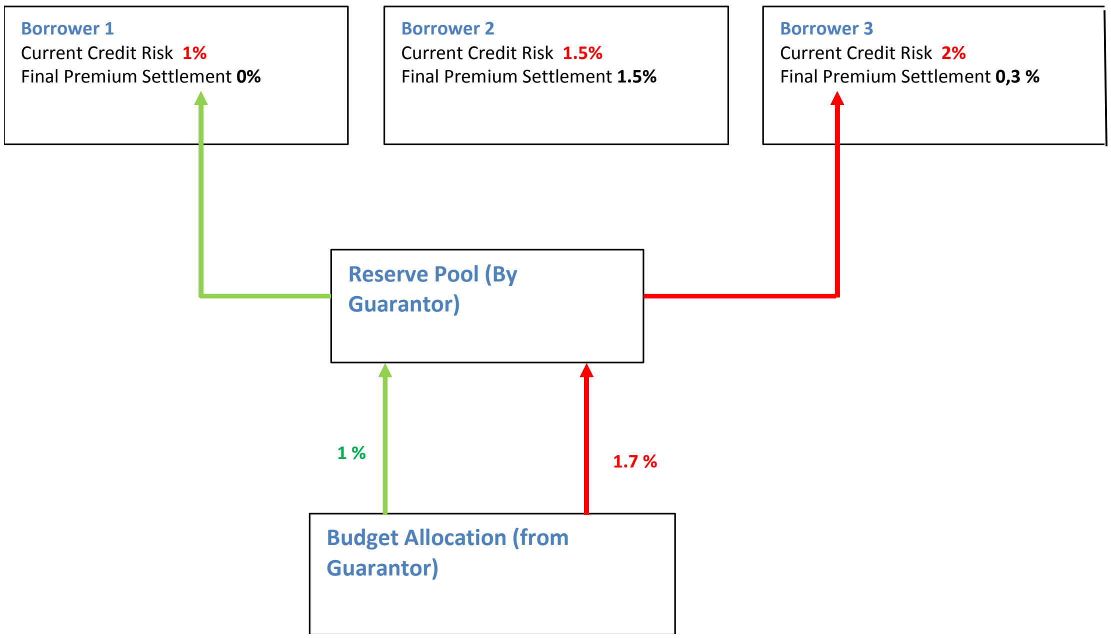


Figure 3.4

Source: Sanders, Milford and Rittner from Clean Energy & Bond Finance Initiative (CE + BFI), August 2013 [8]

Chapter 6 Financial Risk Instruments for RE projects

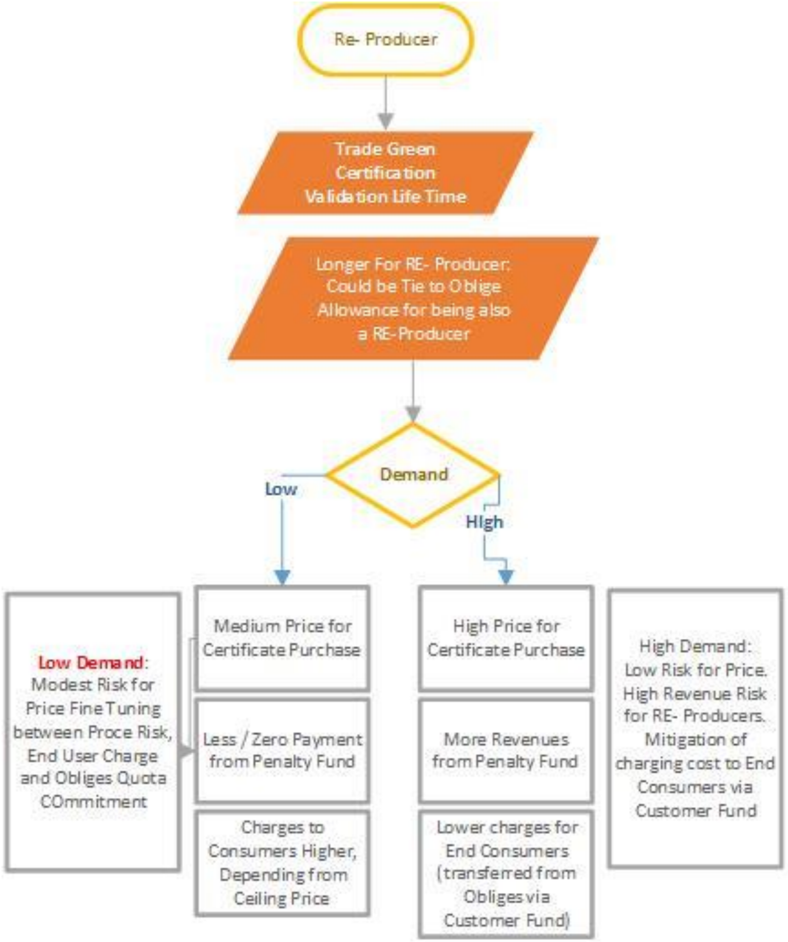
Figure 6.1 Guarantee Allocation from Guarantor to Borrowers, as a discount (percentage of outstanding amounts) to the current credit risk figures

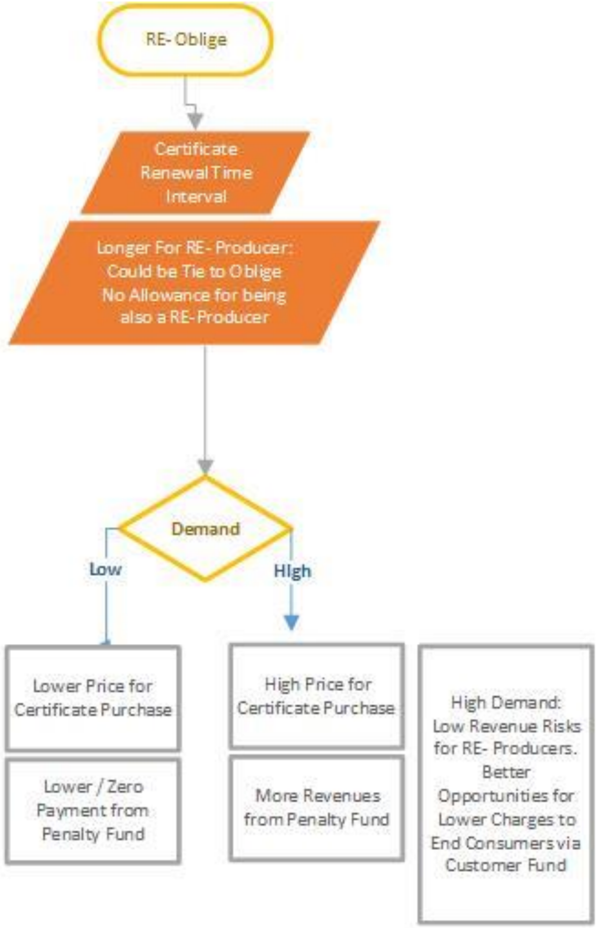


Source: World Bank (1999)[2]

Chapter 7 Evaluation of RET Support Schemes. Finance attraction, Cost Charging paths, Risk Mitigation and Market Strategy Alternatives

Diagram 7.1Road map for risk assessment of Quota Obligation Support System



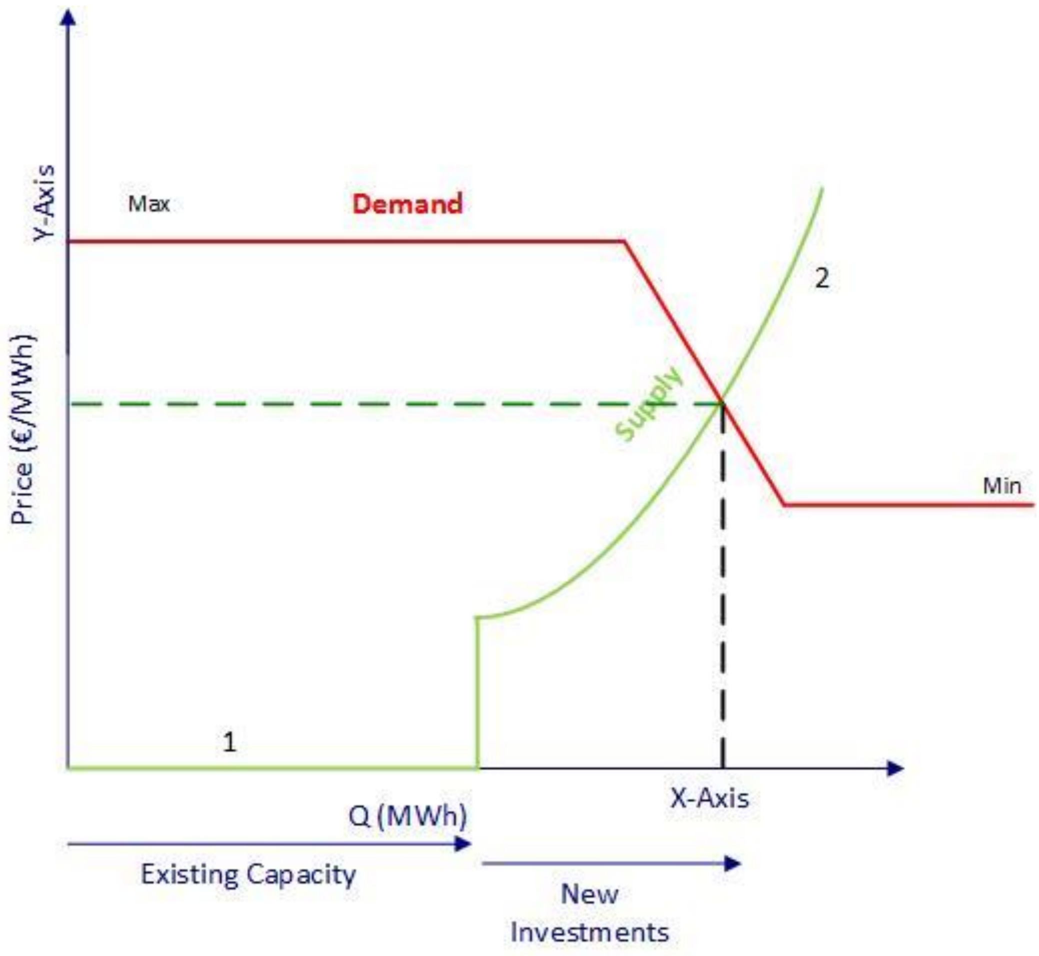


Source: The Author

Fig 7.1 Equilibrium for TGC market for a perfect competition

Part No 1 of supply curve: The Maximum value between 0 and SPMC for existing capacity minus (-) expected electricity price

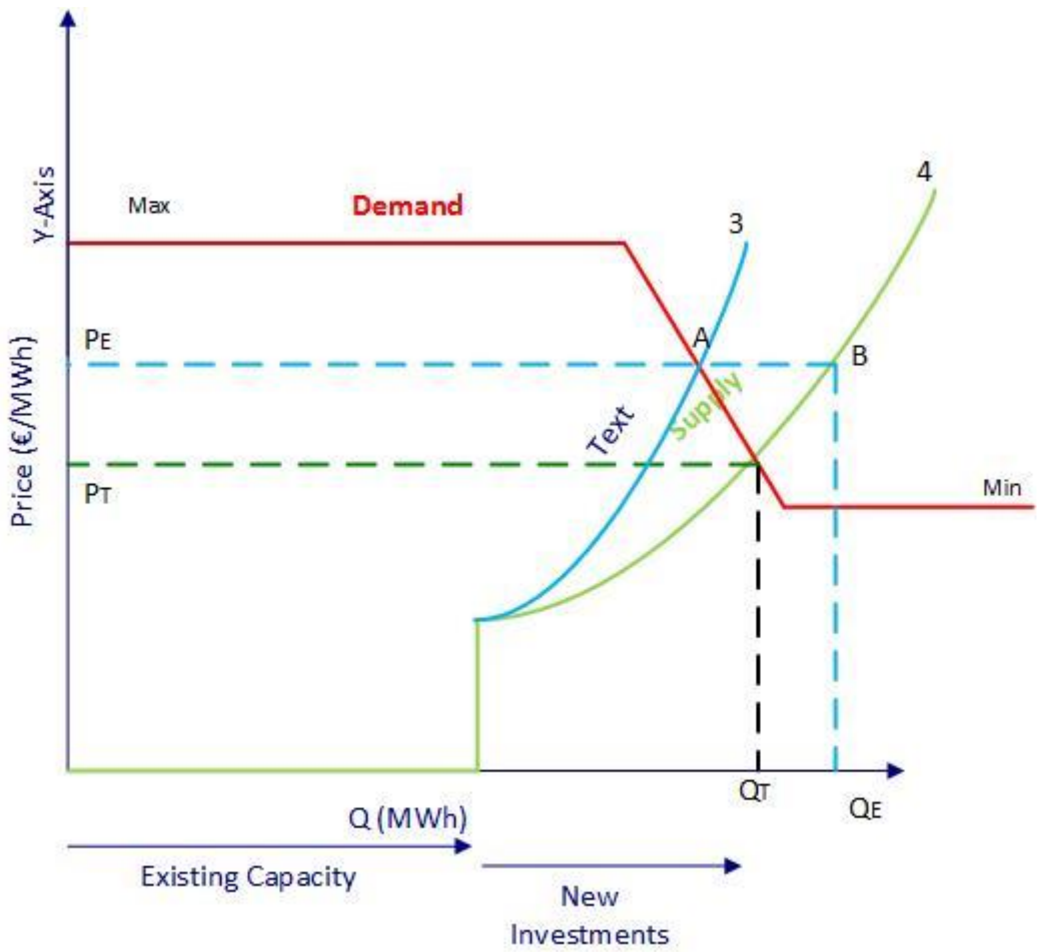
Part No 2 of supply curve: LPMC for new investors minus (-) expected electricity price



Source: Lemming, 2003 [1]

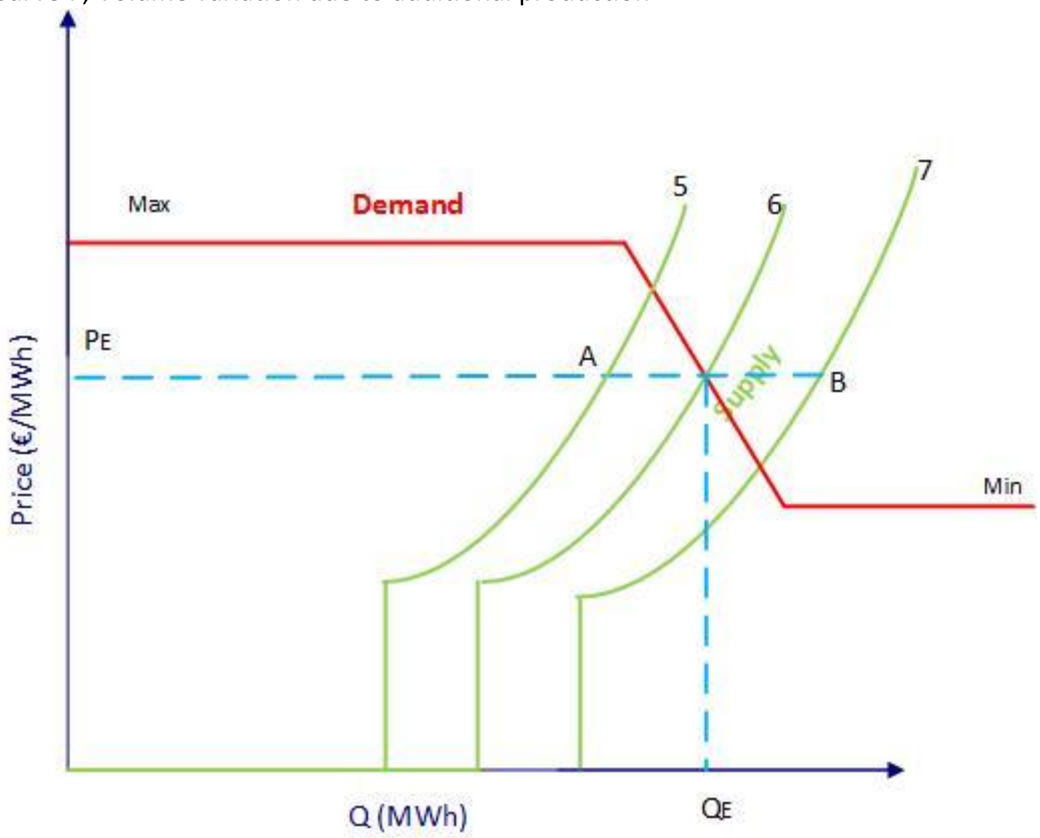
Fig 7.2Removal of marginal unit from A to B. Additional capacity due to Information Lack

Curve 3 expected LRMC, Curve 4 Actual LRMC



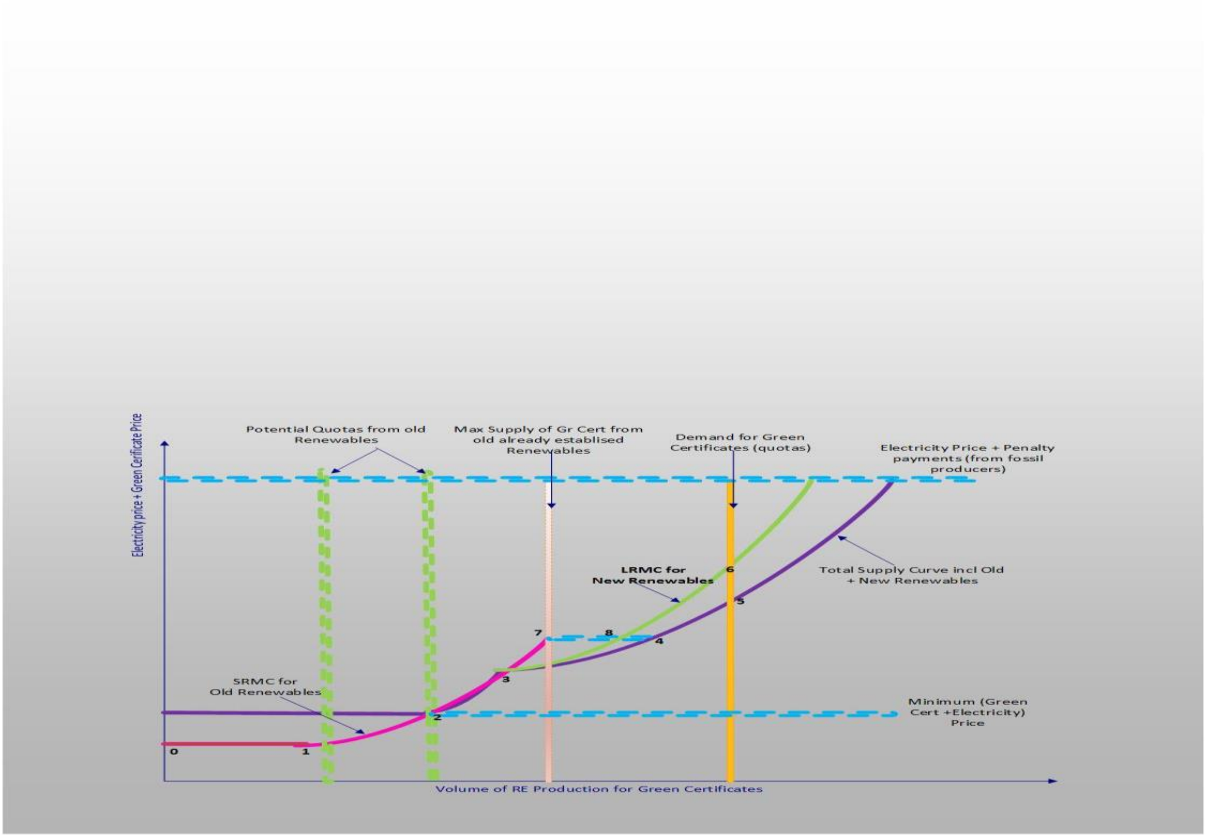
Source: Lemming, 2003 [1]

Fig 7.3Removal of Equilibrium due to volume (weather) fluctuations
Curve 5, Weather not proceed RE Production (absence of wind or sun radiation)
Curve 6, Normal Supply Curve
Curve 7, Volume variation due to additional production



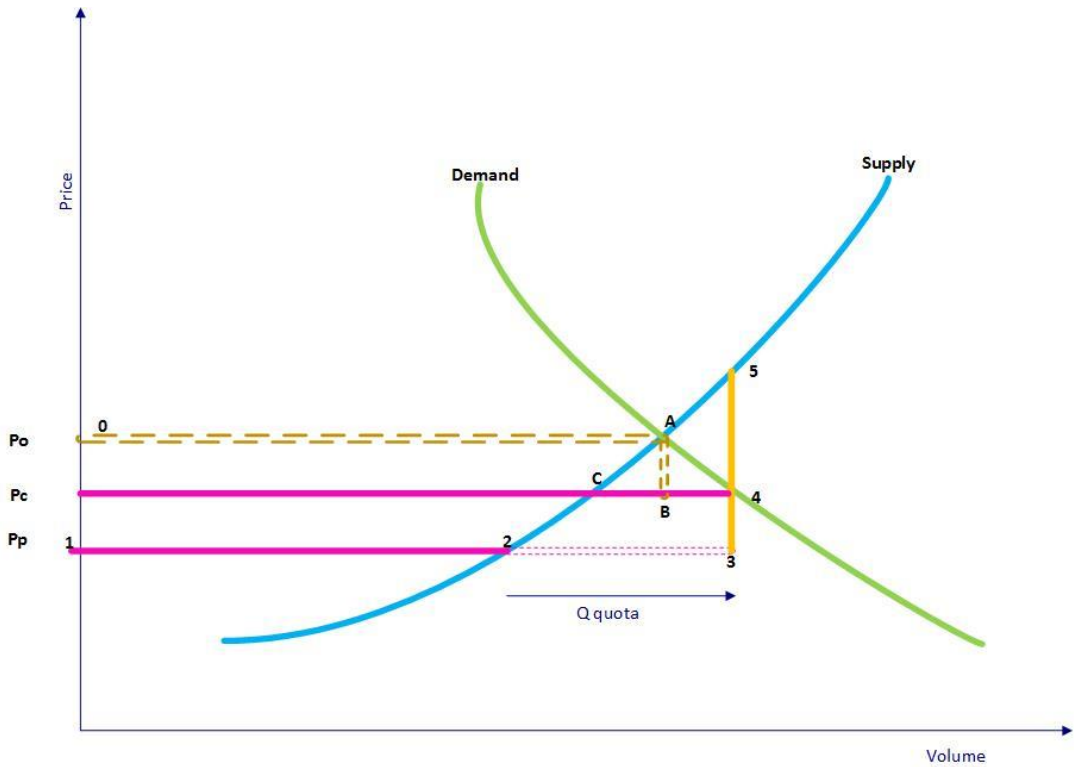
Source: Lemming, 2003 [1]

Fig 7.4 Total Supply curve, corresponding for old and new RE generators.



Source: Helgesen, Tomasgard (January 2018)[4]

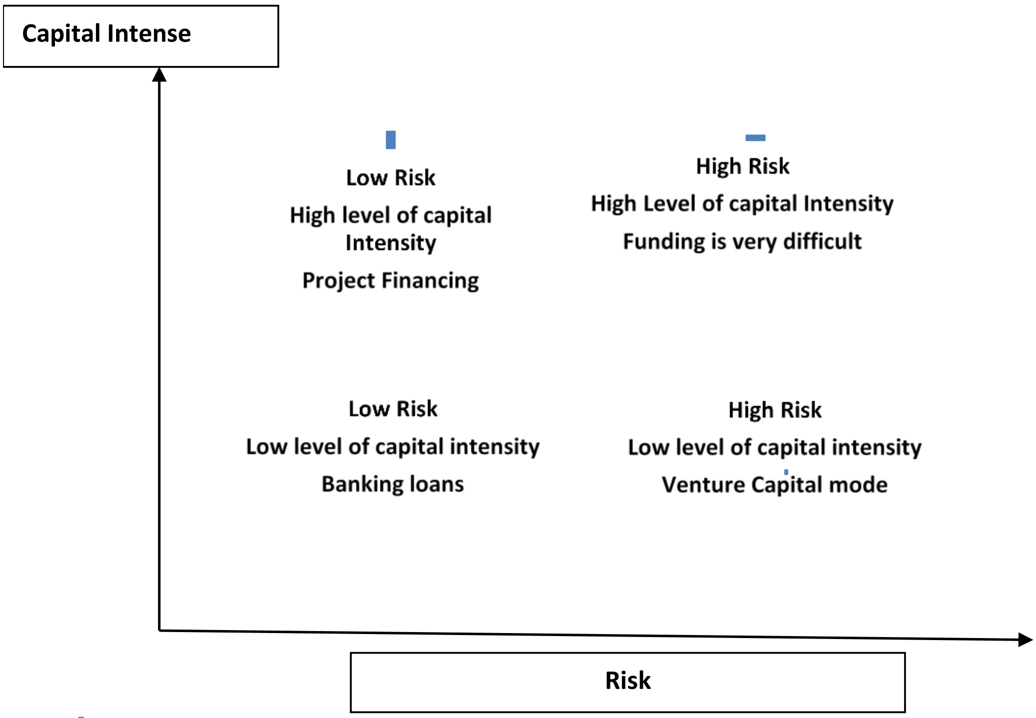
Fig 7.5price equilibrium, deficits and surplus, Old –new actors and Consumers



Source: Helgesen, Tomasgard (January 2018)[4]

Chapter 8: Financial Actors affecting Renewable Technology and Innovation

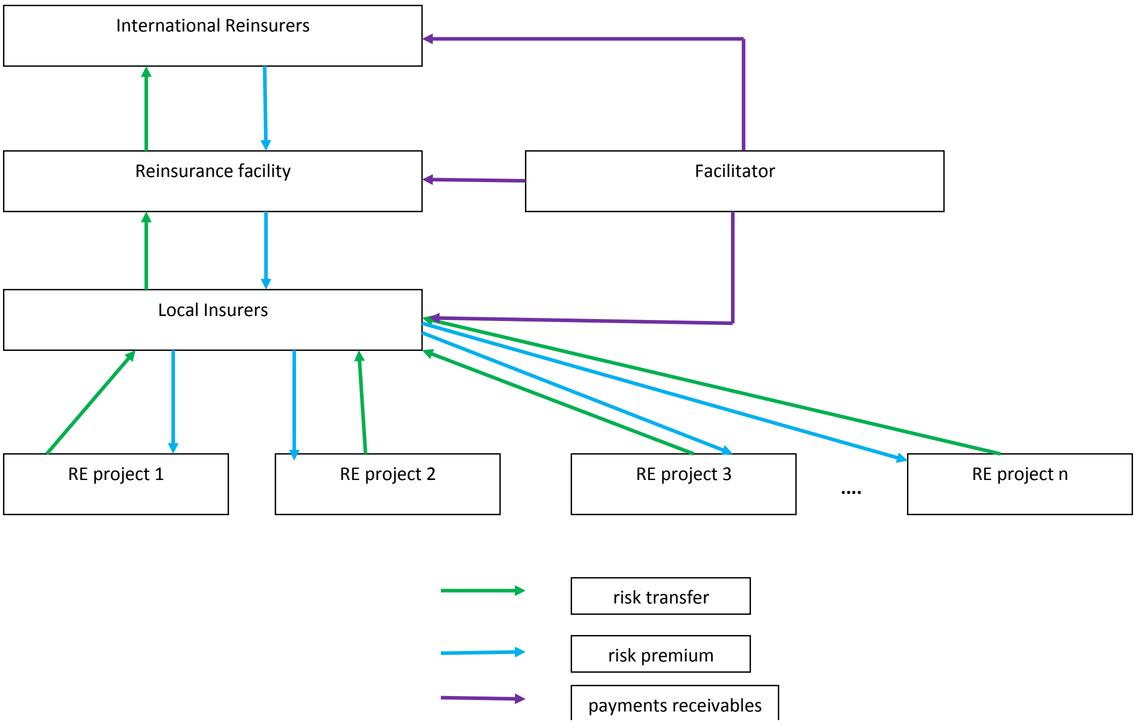
Fig 8.1 Classification of RE Finance



Source: Mazzucato, (2017)

Chapter 9. Modern Toolsfor Financial Risk Management and RE Projects evaluation

Figure 9.1 SPUV Participants



Source: Marsh and Mc Lennan, 2008[1]

C. TOOLKIT SOFTWARE DEMONSTRATION

(Source World Bank)[2]


Web tool - Renewable E
www-esd.worldbank.org/refine/
THE WORLD BANK
Renewable Energy Financial Instrument Tool (REFINe) - Beta Version
REFINe | Knowledge Center | Case Studies | Glossary
About
REFINe is an interactive Web tool that helps users better understand experiences with financial instruments to scale up renewable energy technologies.
The tool can be used to identify financial instruments that can be used to overcome user specified project risks and barriers, or to identify project risks and barriers that have been addressed by a specific financial instrument in the past. REFINe is intended to assist policymakers in low-income countries (LICs) in identifying how to apply financial instruments funded from public and concessionary sources to support the scaling-up of commercially proven Renewable Energy Technologies (RETs). It does not pretend to be a comprehensive guide to the incommodividual instruments described or to the full range of infrastructure project and RET financing issues.
This work benefited from support provided by the Climate Investment Funds, through the Scaling-Up Renewable Energy Program in Low Income Countries (SREP).
Get Started
THE WORLD BANK GROUP
IBRD IDA IFC MIGA ICSID
© 2017 The World Bank Group, All Rights Reserved. Terms and Conditions |IFC Disclaimer | Privacy Policy | Disclaimer
EN
8:10 μμ
18/9/2017


Web tool - Renewable E
www-esd.worldbank.org/refine/index.cfm?Page=REFine&rmode=1
REFINe | Knowledge Center | Case Studies | Glossary
Web tool
The basic instructions below are augmented by the glossary and help on pop-up screens that can be generated by selecting table entries.
STEP 1: Select the Web Tool Application
I want to get advice on financial instrument(s)
OR
I want to identify project risks and barriers adressed by an instrument
STEP 2: Select Renewable Energy Technology
Grid
Off-Grid
Biomass
Geothermal
Hydro
Solar
Wind
Hybrid
Other
STEP 3: Select Project Risks and Barriers, and Status of Banking Sector
Clear All
Project Risks
High costs of resource assessments
High exposure to regulatory risks
High financial cost relative to other technologies
High operational risk
Uncertainties over resource adequacy
Financing Barriers
High and uncertain project development costs
Lack of equity finance
Lack of long term financing
Lack of project financing
Small scale of projects
Banking Sector
Weak banking sector
Suggest Relevant Financial Instrument
EN
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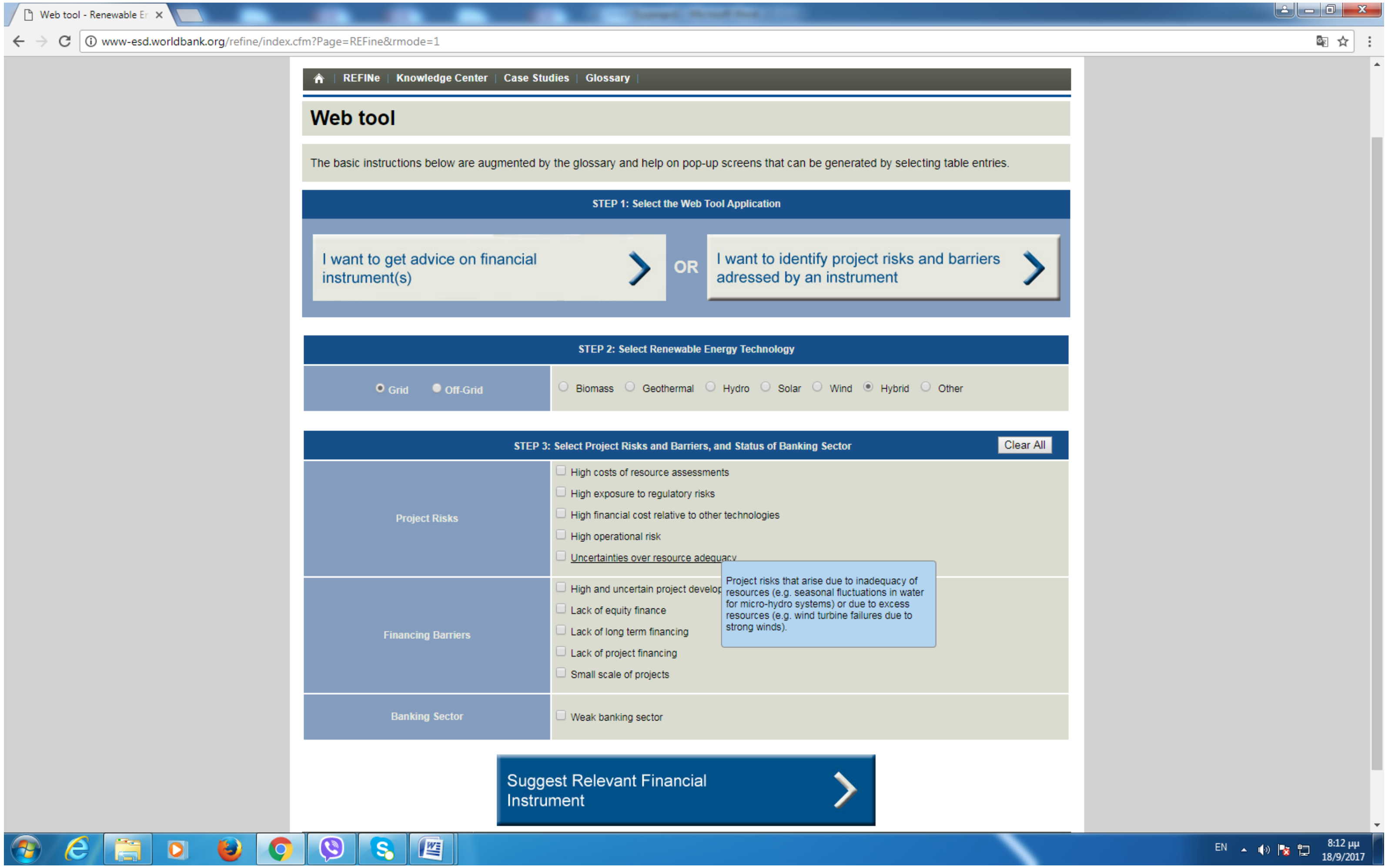
18/9/2017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REFINe
Knowledge Center
Case Studies
Glossary
Web tool
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Other
STEP 3: Select Project Risks and Barriers, and Status of Banking Sector
Clear All
Project Risks
High costs of resource assessments
High exposure to regulatory risks
High financial cost relative to other technologies
High operational risk
Uncertainties over resource adequacy
Financing Barriers
High and uncertain project develop
Lack of equity finance
Lack of long term financing
Lack of project financing
Small scale of projects
Project risks that arise due to inadequacy of resources (e.g. seasonal fluctuations in water for micro-hydro systems) or due to excess resources (e.g. wind turbine failures due to strong winds).
Banking Sector
Weak banking sector
Suggest Relevant Financial Instrument
EN
8:12 μμ
18/9/2017


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www-esd.worldbank.org/refine/index.cfm?Page=REFine&rmode=1
REFINe | Knowledge Center | Case Studies | Glossary
Web tool
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Geothermal
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Hybrid
Other
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Clear All
Project Risks
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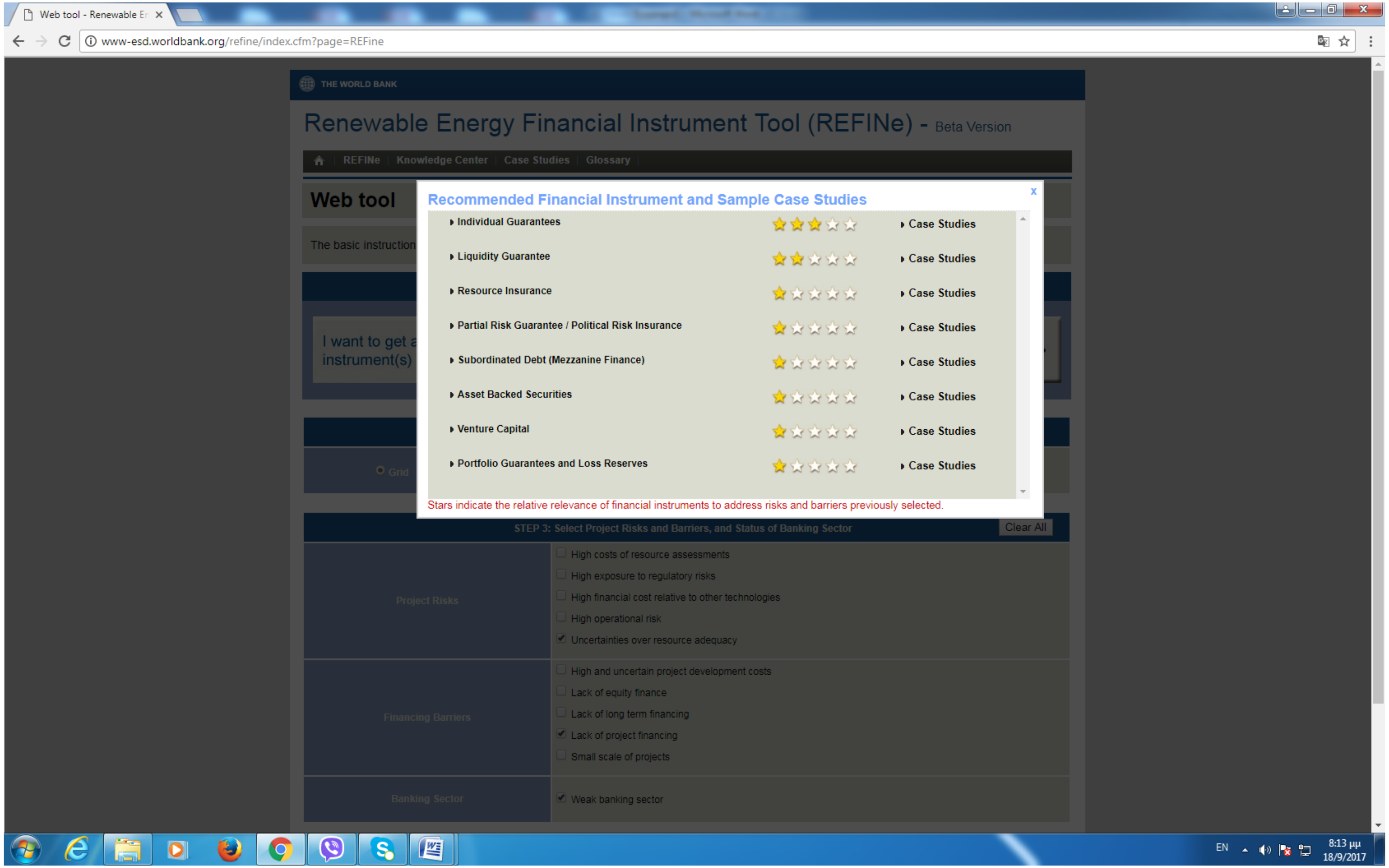
High financial cost relative to other technologies
High operational risk
Uncertainties over resource adequacy
Financing Barriers
High and uncertain project development costs
Lack of equity finance
Lack of long term financing
Lack of project financing
Banking Sector
In a project finance basis, the security for the loan comes from future project cashflows and where little or no up-front collateral is required, although there will still be a need for a share of the project to be funded from equity. RET projects are more exposed to the limited availability of project financing than most conventional technologies, as the share of capital costs in their total cost is much greater.
Suggest
Instrument
EN
8:12 μμ
18/9/2017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REFINe
Knowledge Center
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Web tool
The basic instruction
I want to get a
instrument(s)
Grid
Recommended Financial Instrument and Sample Case Studies
Individual Guarantees
Case Studies
Liquidity Guarantee
Case Studies
Resource Insurance
Case Studies
Partial Risk Guarantee / Political Risk Insurance
Case Studies
Subordinated Debt (Mezzanine Finance)
Case Studies
Asset Backed Securities
Case Studies
Venture Capital
Case Studies
Portfolio Guarantees and Loss Reserves
Case Studies
Stars indicate the relative relevance of financial instruments to address risks and barriers previously selected.
STEP 3: Select Project Risks and Barriers, and Status of Banking Sector
Clear All
Project Risks
High costs of resource assessments
High exposure to regulatory risks
High financial cost relative to other technologies
High operational risk
Uncertainties over resource adequacy
Financing Barriers
High and uncertain project development costs
Lack of equity finance
Lack of long term financing
Lack of project financing
Small scale of projects
Banking Sector
Weak banking sector
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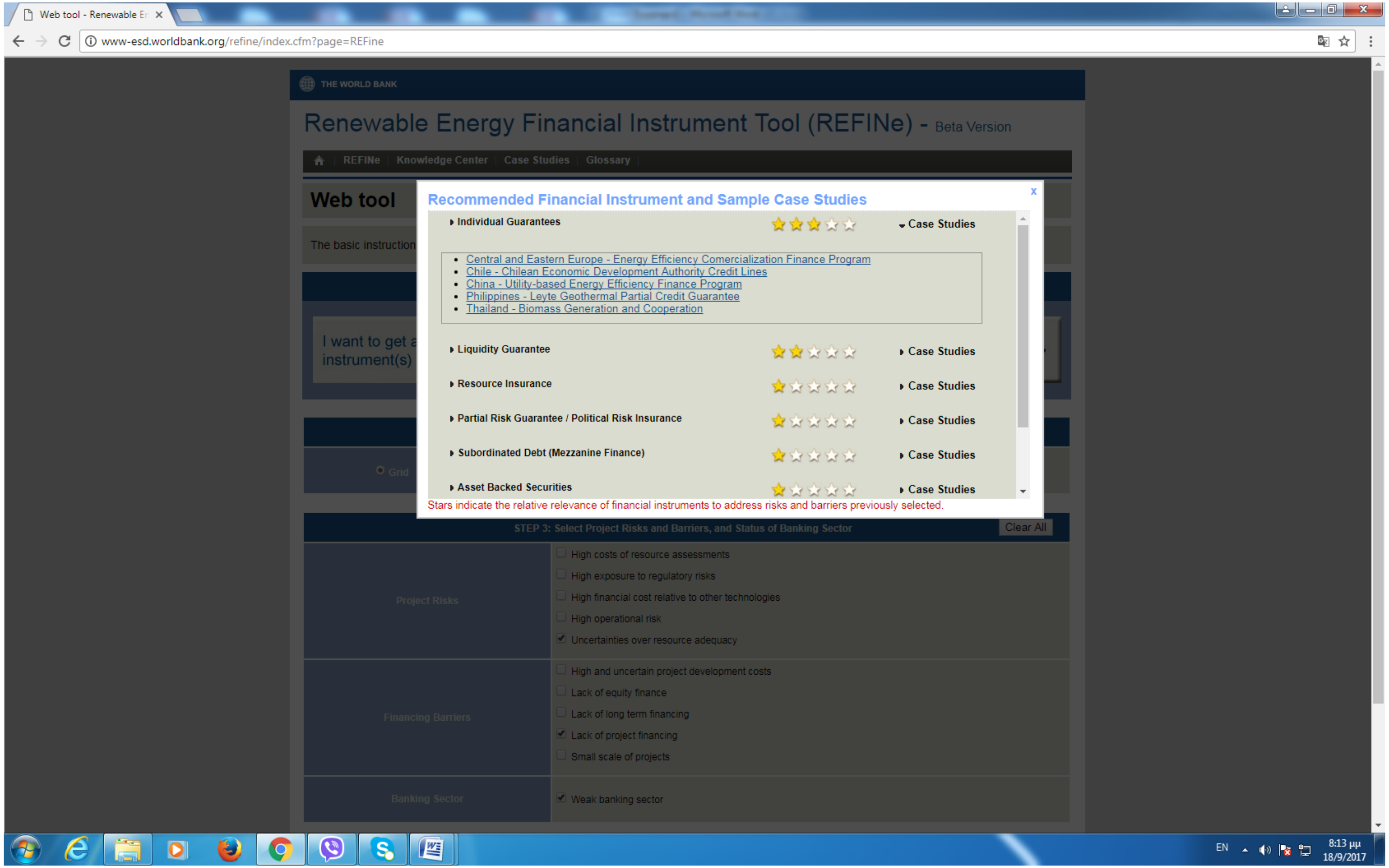
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Web tool
The basic instruction
I want to get a
instrument(s)
Recommended Financial Instrument and Sample Case Studies
Individual Guarantees
Case Studies
Central and Eastern Europe - Energy Efficiency Comercialization Finance Program
Chile - Chilean Economic Development Authority Credit Lines
China - Utility-based Energy Efficiency Finance Program
Philippines - Leyte Geothermal Partial Credit Guarantee
Thailand - Biomass Generation and Cooperation
Liquidity Guarantee
Case Studies
Resource Insurance
Case Studies
Partial Risk Guarantee / Political Risk Insurance
Case Studies
Subordinated Debt (Mezzanine Finance)
Case Studies
Asset Backed Securities
Case Studies
Stars indicate the relative relevance of financial instruments to address risks and barriers previously selected.
Grid
STEP 3: Select Project Risks and Barriers, and Status of Banking Sector
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Banking Sector
Weak banking sector
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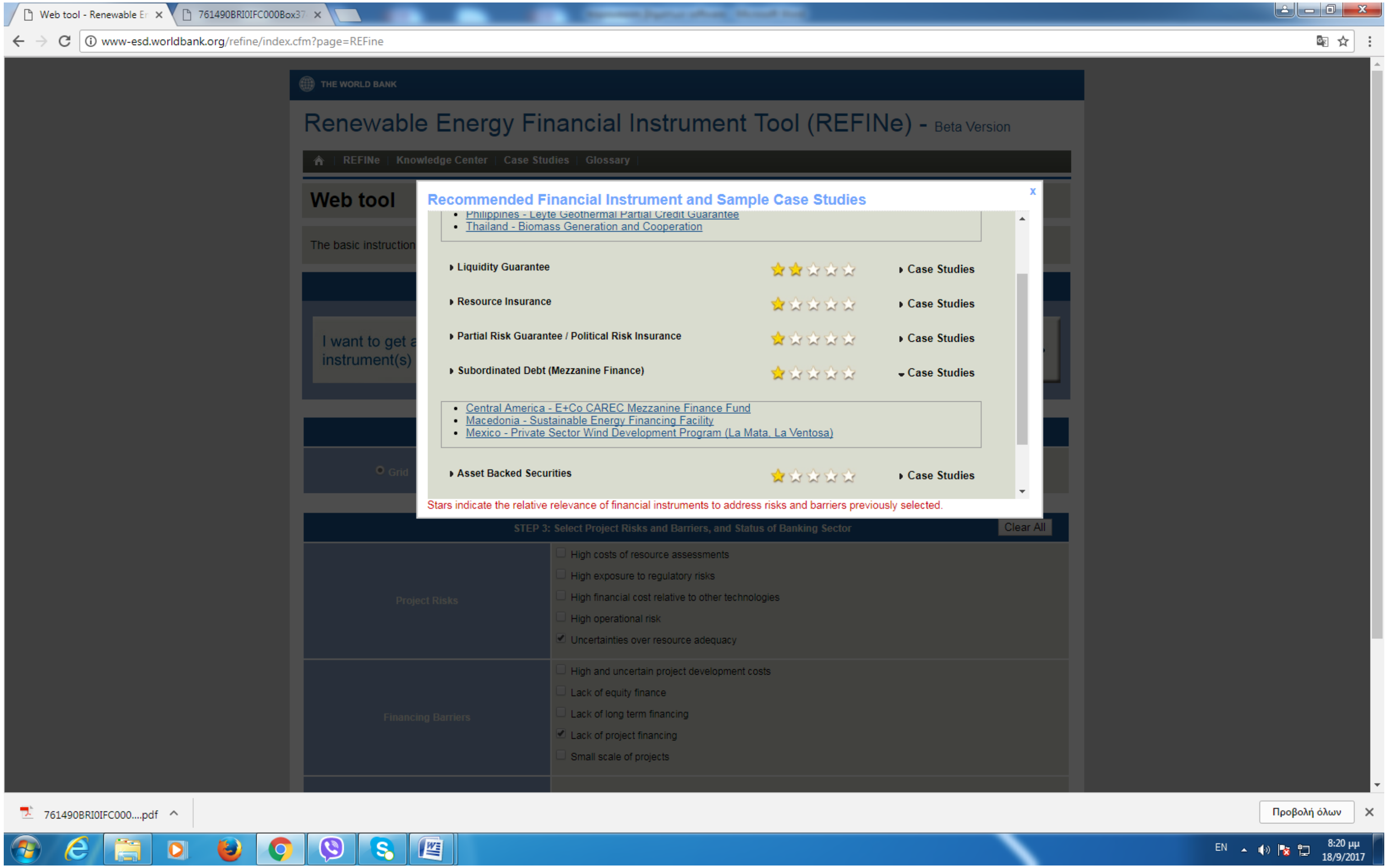
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THE WORLD BANK
Renewable Energy Financial Instrument Tool (REFINe) - Beta Version
REFINe
Knowledge Center
Case Studies
Glossary
Web tool
The basic instruction
I want to get a
instrument(s)
Recommended Financial Instrument and Sample Case Studies
Philippines - Leyte Geothermal Partial Credit Guarantee
Thailand - Biomass Generation and Cooperation
Liquidity Guarantee
Case Studies
Resource Insurance
Case Studies
Partial Risk Guarantee / Political Risk Insurance
Case Studies
Subordinated Debt (Mezzanine Finance)
Case Studies
Central America - E+Co CAREC Mezzanine Finance Fund
Macedonia - Sustainable Energy Financing Facility
Mexico - Private Sector Wind Development Program (La Mata, La Ventosa)
Asset Backed Securities
Case Studies
Stars indicate the relative relevance of financial instruments to address risks and barriers previously selected.
STEP 3: Select Project Risks and Barriers, and Status of Banking Sector
Clear All
Project Risks
High costs of resource assessments
High exposure to regulatory risks
High financial cost relative to other technologies
High operational risk
Uncertainties over resource adequacy
Financing Barriers
High and uncertain project development costs
Lack of equity finance
Lack of long term financing
Lack of project financing
Small scale of projects
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