Project evaluation for small hydro power investments in Portugal

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ABSTRACT

Due to the increasing concern with sustainable development, renewable energy sources (RES) emerge as an important alternative for electricity production. In this context, for countries like Portugal, hydropower plants assume an important role and several incentives have been granted by the government to promote hydroelectric production. However, due to the deep economic and financial crisis of the last years, a change in the energy paradigm is taking place increasing the perceived risk factors for RES electricity producers. Therefore, this paper focus on identifying and assessing the impact of those risks associated with an investment in a small hydropower (SHP). Although the independent analysis of each risk variable showed that the project is worthwhile, the possibility of having a negative outcome was evident for the investment costs, discount rate and feed-in-tariffs variables. On the other hand, the results of the combined analysis are much less optimistic demonstrating that even under regulated tariffs the probability of having a negative NPV largely surpasses the probability of obtaining a positive value.

KEYWORDS

Renewable energy; Small-hydropower plants; Investment appraisal; Investment risk; Probabilistic methods

INTRODUCTION

The European Union (EU) policies for the energy sector point to the objective of achieving a sustainable society resting in large extent on reducing energy consumption through energy efficiency measures, and on raising the share of EU energy consumption produced from renewable energy sources (RES). The Portuguese electricity system is strongly supported on RES, mainly wind and hydro power. In fact, these technologies have been implemented in the last ten years contributing to achieve greater flexibility in power management and decreased emissions of CO_2, when compared with a system entirely dependent on fossil energy [1].

Focusing on hydroelectric production, it should be noted that small hydropower (SHP) production started in the late 1980s with the publication of legislation on the establishment of the special arrangements for the production of electricity in SHP plants with installed power up to 10

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MW [1]. Nowadays, hydroelectric production can represent almost 30% of the total electricity consumption. However, in dry years its contribution to total electricity production can be much weaker [2], which means that Portugal remains heavily dependent on imported energy sources (e.g. oil, coal and natural gas). Therefore, the continued use of RES emerges as a priority in the energy policy contributing to improve the trade balance and to reduce energy dependence. Moreover, the hydropower technology, particularly where reservoir capacity regularization is possible, has value added to the national grid operation, given its high availability, reliability and flexibility of operation [1].

However, the deep economic and financial crisis of the last four years can lead to a different energy paradigm, changing the government incentives and creating what are perceived to be additional risk factors for the RES electricity producers.

Previous works (e.g. [3]) have already concluded that decision-making in the electricity sector is influenced by three factors: social acceptance, the technical aspects and the risk of the activity. The political uncertainty significantly influences the risk in this type of projects but other aspects must be considered also as major risk factors for these investments, namely: construction/completion, technological, geological, hydrological, economic, financial, political, environmental, other external events, and sociocultural. From the point of view of a RES investor, the project evaluation must go beyond the traditional discounted cash-flow analysis and the importance of risk factors must be evaluated and included in the project evaluation.

This paper addresses the particular case of small hydro power (SHP) investments in Portugal. Departing from a real case study, the economic evaluation of a project is described under the present market conditions. Taking into account the energy market instability, the interest rate uncertainty and the value of tariffs charged, a risk analysis is presented. The study focus then on the political risk relating it to the future of feed-in tariffs and market tariffs; country and financial risk, relating this to the cost of capital; and economic and operational risk, associated with investment and operational costs. The work resorts firstly to qualitative approach to identify risk sources, impacts and mitigation measures. Then a quantitative analysis is conducted in order to examine how the risk and uncertainty affect the interest of the project and its expected profitability.

The remainder of the paper is organized as follows. Section 2 describes the characteristics of the investment project under analysis, namely the forecasted production, capital and operational expenditures and the results of the investment appraisal. In Section 3 the major potential risks associated with investments in SHP plants are identified. Section 4 corresponds to the quantitative assessment of risk and uncertainty based on probabilistic methods. Finally, section 5 drawn the main conclusions of the paper and highlights future avenues of research.

PROJECT INVESTMENT APPRAISAL

The characteristics of the project under analysis regarding the forecasted production, capital and operational expenditures, as well as the results of the investment project evaluation, are shown in this section.

Production and revenues forecasts

The project investment analysed is based in a real case study and regards a SHP plant, although minor adjustments have been made for the purpose of the present paper. Based on the technical and engineering studies performed, the best alternative was a small weir with an adjacent central that has the advantage of allowing some regularization capacity. To support the analysis of production and their economic valuation a study was conducted based on hydrological series of daily average flows recorded at several hydrological stations in the region, allowing estimating the average daily flow of the tributaries to the SHP Bayou. Therefore, the forecasted annual production is 6,124 MWh/year, ensured by a single generator of 1.90 MW. The electricity is expected to be sold at a feed-in-tariff of 91 €/MWh, determined in accordance with the currently average values, which means that the energy produced is received in full by the grid operator and there is a fixed payment per MWh.

Investment cost and operation and maintenance (O&M) costs

Regarding investment costs, the amounts considered in this study were provided by manufacturers and installers of major equipment and construction costs were based on average market prices. The forecasted investment costs are summarised in table 1.

Table 1. Summary of investment costs

Description	Value (thousand €)	Depreciation
Buildings	1,350	30 years
Equipment	2,089.5	16 years
Electricity grid	62.5	20 years
Land	169	-
Intangible assets	298.6	3 years

Although O&M costs of a SHP plant represent a small portion of the total costs they should be properly identified and taken into account for a correct investment evaluation. Those costs were identified and estimated by comparing the known costs of similar facilities and are shown in Table 2 grouped in main categories.

Table 2. Summary of O&M costs

Description	Value (thousand €/year)
General and administrative	11
Operation and maintenance	21.5
Insurance	10
Contingencies	1.5

Besides these O&M costs, it is expected to incur, after fifteen years, in major maintenance costs, namely the revision of the turbine and alternator amounting to 25 thousand euros and the review and partial replacement of equipment in the amount of 60 thousand euros.

Investment appraisal

The analysis of the viability of the project was undertaken considering an investment horizon of 25 years, nominal cash flows, a nominal discount rate of 10.3%, and an income tax rate of 25%. For simplicity it was assumed that investments values were paid completely at time zero. The analysis was conducted in the context of a regulated feed-in tariff. A conservative approach was assumed regarding revenues and expenditures' growth over the investment horizon. Through the consumer price index (excluding housing) of the last five years, it was possible to calculate an estimate for the tariff's value growth rate of 1.92%. On the other hand, given that in the last two years the average rate of inflation was slightly more than 3%, it was assumed that operational expenditures increased at this rate.

Based on these assumptions, one concludes that the investment is recovered in 15 years (considering the discounted payback period, DPBP), with a positive net present value (NPV) of € 984,240 and an internal rate of return (IRR) of 13.2% (higher than the discount rate of 10.3%). Therefore, the investment project in a SHP plant is an economically viable investment under the baseline scenario.

However, a SHP plant investment is subject to a number of risks that may restrict its profitability. As emphasised by [4], project risk involve the likelihood and degree of unacceptable deviations from predicted characteristics that are the basis for the investment decision. Therefore, it is important to identify the main sources of uncertainty and risk associated with such investments.

RISK AND UNCERTAINTY OF SHP PLANT INVESTMENTS

To identify the major sources of risk associated with an investment in a SHP plant a brief review of the literature was undertaken based on the following references: [5], [6], [7], [8], [9], [10], and [11]. This review allowed identifying the following types of risks: construction/completion, technological, geological, hydrological, economic, financial, political, environmental, other external events, and sociocultural.

Table 3 summarises the relevant information about these risks, namely in terms of its definition, source of risk, impact, and mitigation measures.

Table 3. Summary of categories of risks, their impact and mitigation measures

Type of risk	Definition	Source of risk	Impact on the project	Mitigation measures
Construction or Completion	Possibility of the project is not timely concluded/completed	Unexpected delays in the schedule Underestimation of construction costs Inaccuracies in the initial project design Failure in supplies Contractual problems Unexpected rise in inflation	Unfeasibility of the project Increased costs Increased time to complete the project	Detailed budgeting Efficient management of the project Stipulation of deadlines with penalty clauses for non-compliance
Technological	Technology becomes obsolete very soon or performs below their specifications throughout the project life	Early obsolescence of equipment Equipment performance below expectations	Reduced yields Capital loss for the company	Implementation of appropriate maintenance plans
Geological	Dependent on the construction site of the dam	Uncertainties in the impact of sediment in the reservoir Geological conditions of the surface Seismic activity	Delay in construction period Increased costs	Detailed geological study
Hydrological	Energy production will depend on the river water supplied	Meteorological and hydrological instability	Decrease in the amount of energy produced Decrease in revenue generated	Detailed hydrological study Careful analysis of the historical local meteorological conditions
Economic	Arises from the possibility of a poor economic performance of the project, even if the project is underpinned in good technology and operating at normal load	Rising costs of operation Variation in market price of electricity Changes in demand Delays in receiving money from clients	Cash flow problems Not fully recovery of investment expenses Increased operating costs	Use of contracts that allow the transfer of risk with penalties for non-compliance Efficient management of the project Implementation of policies and processes for measuring and managing risk

Financial	Arises from external factors to the project and can significantly affect its financial condition	Poor project management Difficulties in obtaining financing Changes in exchange rates Changes in interest rates	Cash flow problems	Use of derivative financial instruments that allow the transfer of risk
Political or Legal	Is related to changes in legislation about the energy sector	Unexpected changes in current legislation Political instability	Increased uncertainty among potential investors Uncertainty about the viability of the project Cost overruns	Study of the political environment
Environmental	Occurs when the effects of the project on the environment cause delays in their development or even a change in the initial design	Misinterpretation of environmental legislation Changes in legislation Legal obstacles raised by environmental groups	Increased costs Changes to the initial project Delays in project implementation	Detailed environmental impact study Study of the environmental legislation Strict monitoring of environmental requirements
Other external events	Is characterized by the occurrence of a particular event that prevents the normal operation of the project	Technical failures Fires Strikes Earthquakes Other natural disasters	Increased costs Preventing the normal operation of the project Reduction in revenue	Insurance policy
Socio-cultural	Arises from social and cultural differences between the promoters of the project, local authorities and workers	Complaints and grievances of the populations concerned with the implementation of the project	Increased costs Abandonment of the project Reputation damage of promoters and investors Loss of revenue Consumer boycott	Studies on the social impacts Looking for a good public image Promote social acceptance of the project since its inception Establish local forms of compensation

ASSESSING THE IMPACT OF RISK AND UNCERTAINTY

In the previous section the major types of risks associated with the investment in a SHP plant were identified. The project evaluation must now proceed with a quantitative analyses of those risks based on probabilistic methods, specifically the Monte Carlo simulation.

In a previous paper from the authors [12], the sensitivity analysis demonstrated that the project viability can be very much sensitive to variations of variables related to investment, tariffs and discount rate. This previous study was based on a deterministic approach and each variable was analysed independently, evaluating its impact on the project viability. Following this initial approach, probabilistic risk analysis techniques will now be used to randomly generate cash-flows and to calculate the return of the investment, the expected NPV value and the chances of this value being negative. Software @Risk was used for the distribution fitting of the data and for the Monte Carlo simulations.

Table 4 summarizes the variables considered for the risk simulations, the assumed distribution and the parameters used.

Table 4. Summary about the variables considered for the risk simulations

Variable	Distribution	Assumptions
Investment cost	Triangular	Maximum value = 226% × Mean Minimum value = 54% × Mean
O&M cost	Triangular	Maximum value = 195% × Mean Minimum value = 62% × Mean
Discount rate	Triangular	Maximum value = 171% × Mean Minimum value = 76% × Mean
Tariffs (market values)	Normal	Expected value = 46.96 €/MWh Standard deviation = 14.80 €/MWh
Tariffs (feed in values)	Normal	Expected value = 91.00 €/MWh Standard deviation = 28.68 €/MWh

Investment and O&M costs

For the investment costs, the mean value of each category was assumed equal to the base case scenario. The maximum and minimum values were based on the expected investment costs range for large dams in Portugal computed against the mean. This information was obtained from the technical document [13]. The same goes for the O&M costs. Figures 1 and 2 present the results of these two simulations for the NPV computation.

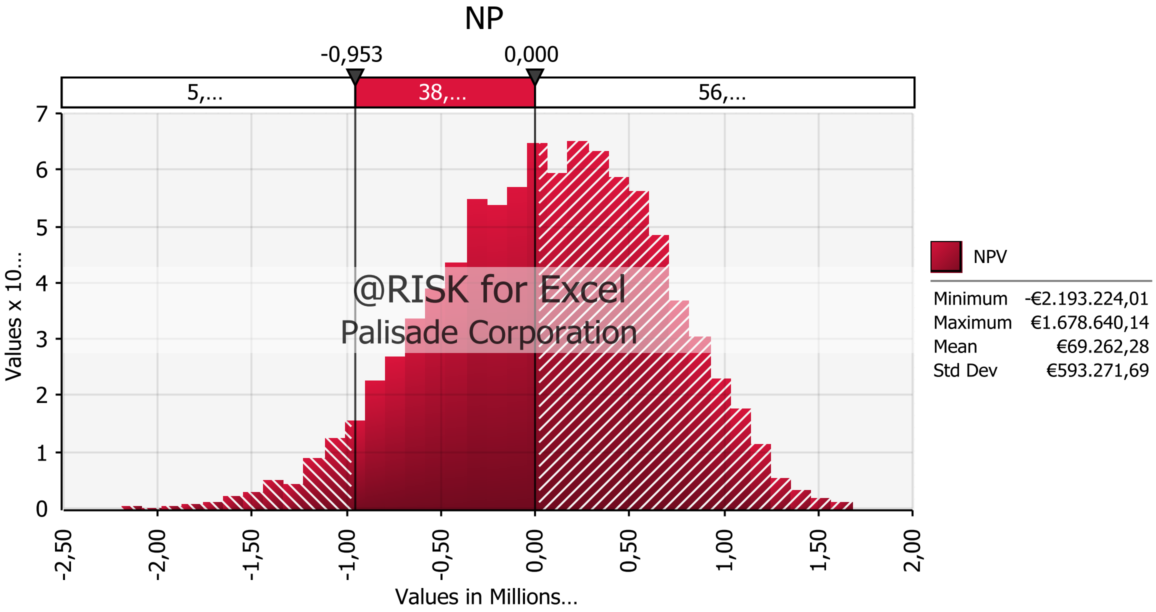

Figure 1. Probability density graph for investment risk.

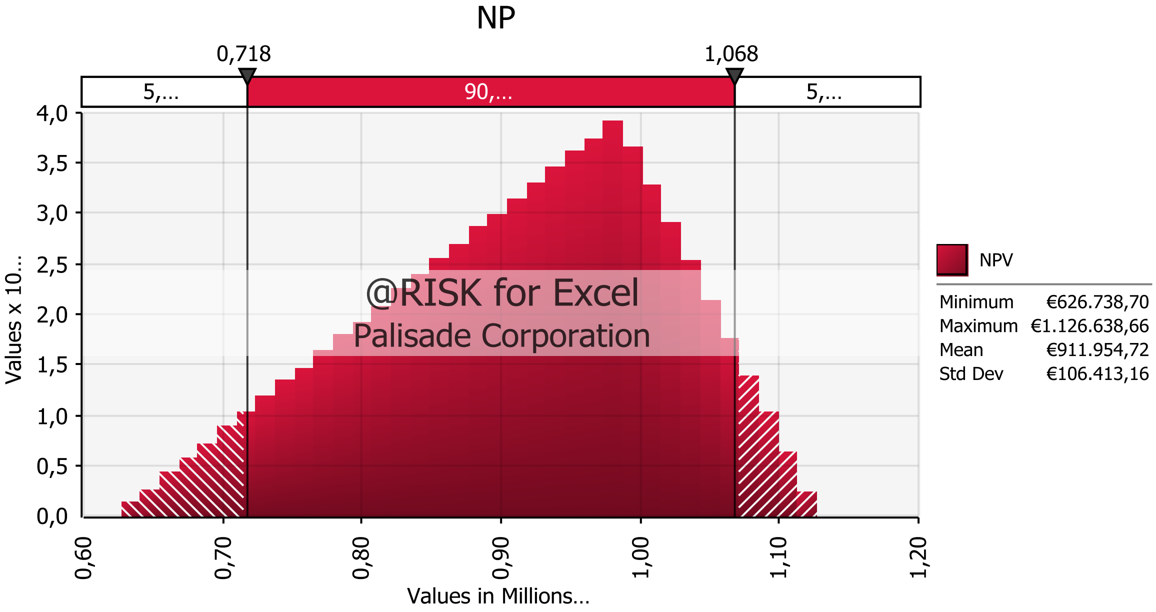

Figure 2. Probability density graph for O&M cost risk.

For both cases, although the NPV mean is lower than the base case scenario (especially for the investment risk), it is still positive and the probability of having a positive NPV is around 56% even for the investment simulation.

Discount rate

The discount rate maximum and minimum variations were obtained according to the yield to maturity rate of the 10 years Portuguese Treasury bonds. A daily serious (2008-2013) was used to compute the mean value and to check the maximum and minimum variations against the mean. The same variation range was used for the project under analysis, assuming the base case scenario as the expected discount rate. Figure 3 presents the results of this simulation for the NPV computation.

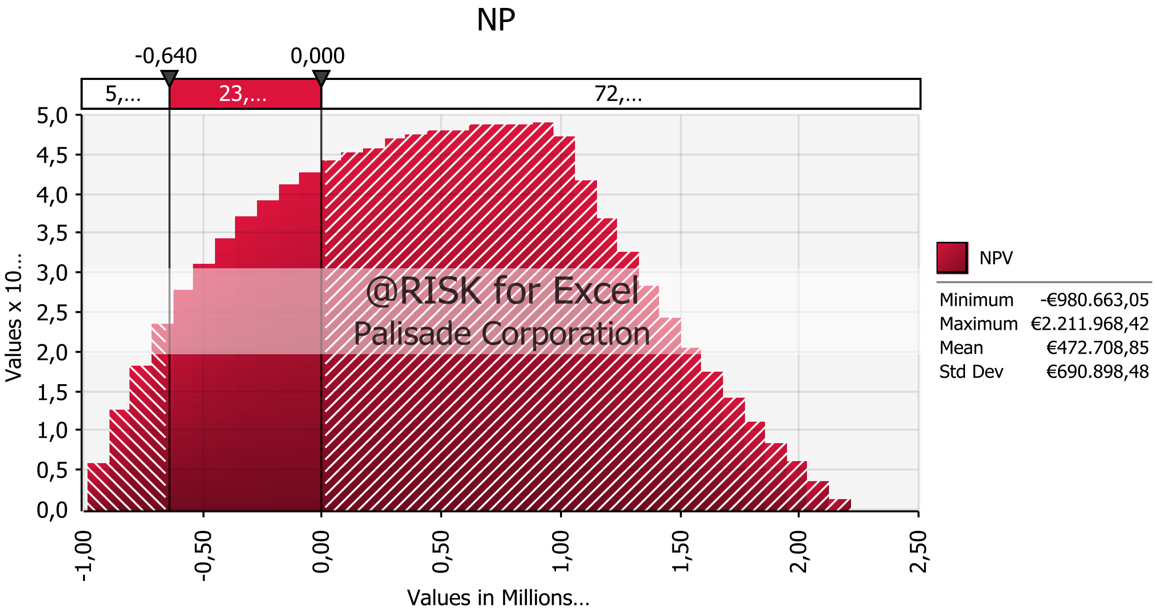

Figure 3. Probability density graph for discount rate risk.

Also for the discount rate, the NPV mean is much lower than the base case scenario but it is still positive. The probability of having a positive NPV is 72% but a negative NPV is possible if an increase of the discount rate is experienced.

Electricity tariffs

Finally, for the values of the tariffs, market values were used according to the MIBEL spot prices for the period 2010-2013. A normal distribution was assumed with the expected value and standard deviation directly obtained from the time series. Recognizing that this can severely threaten the return of the project, in a second approach the time series were corrected according to the feed-in-tariff assumed under the base case scenario. This would mean that the investor return would still depend on the market variations but an average higher tariff would be ensured. Figures 4 and 5 present the results of these two simulations for the NPV computation.

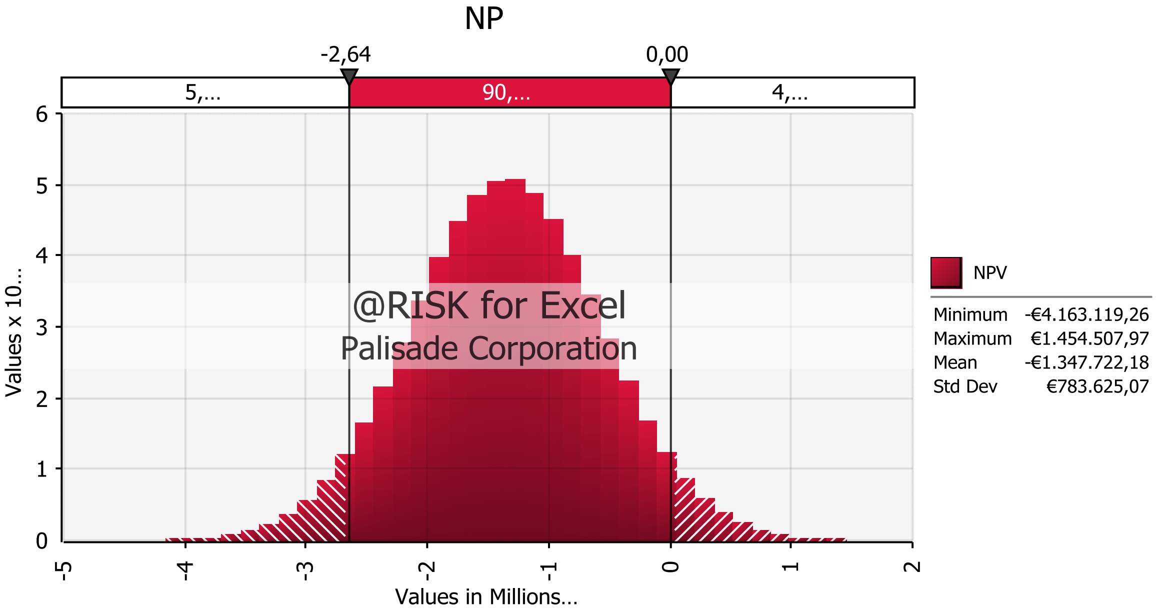

Figure 4. Probability density graph for market tariffs.

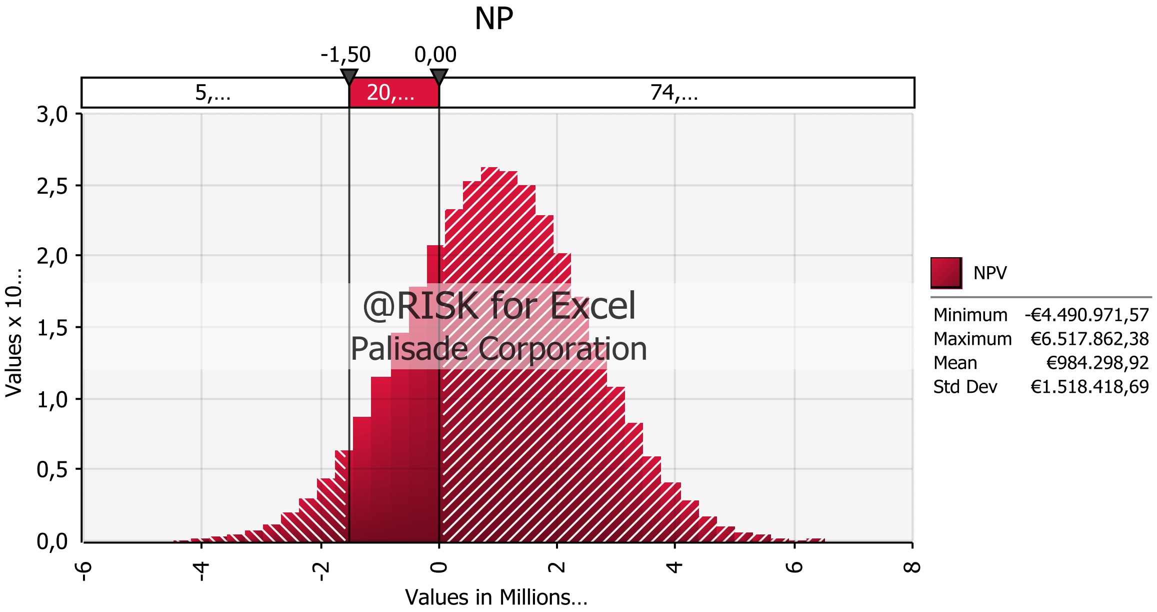

Figure 5. Probability density graph for feed-in-tariffs.

The obtained results demonstrate the importance of the feed-in-tariffs for these projects. In fact, if the project is operating under market conditions the viability of the investment is much doubtful as the possibility of having a positive NPV only slightly surpasses 3%. On the other hand, under the assumed feed-in-tariff regime the mean is positive and the probability of having a positive NPV is more than 74%.

Combined risk analysis

The risk evaluation must go beyond the analysis of each variable independently. In fact, much of the uncertainty of the NPV output comes from the combination of several random events. The final and fundamental simulation combines now the different variables distributions giving rise to the expected NPV at risk. Figures 6 and 7 present the results of this simulation for the NPV computation, assuming a feed-in-tariff scenario.

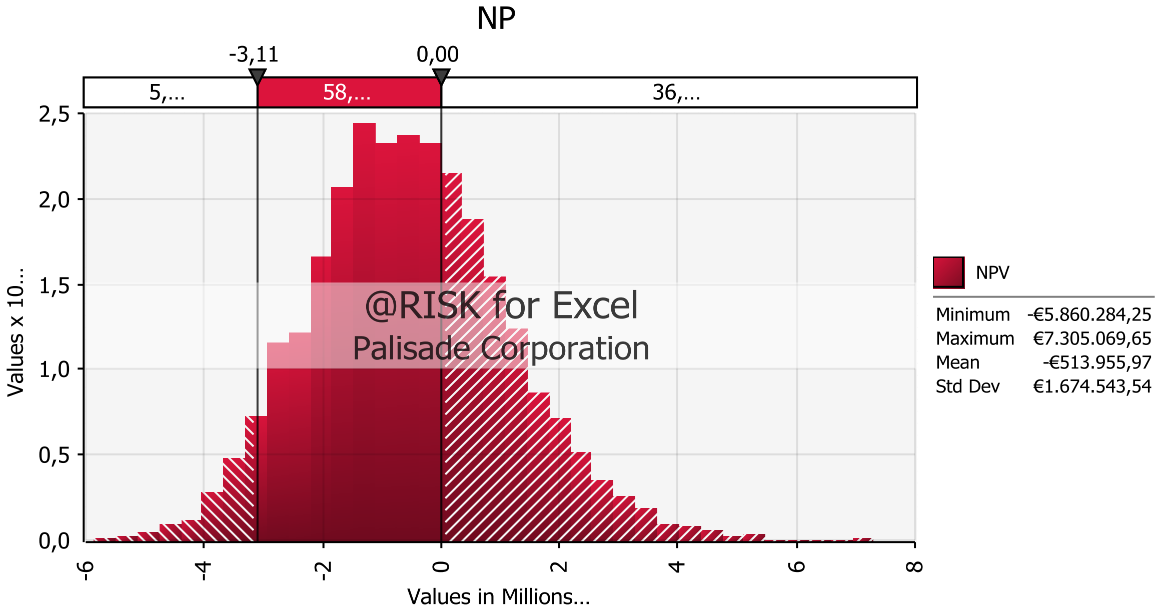

Figure 6. Combined probability density graph

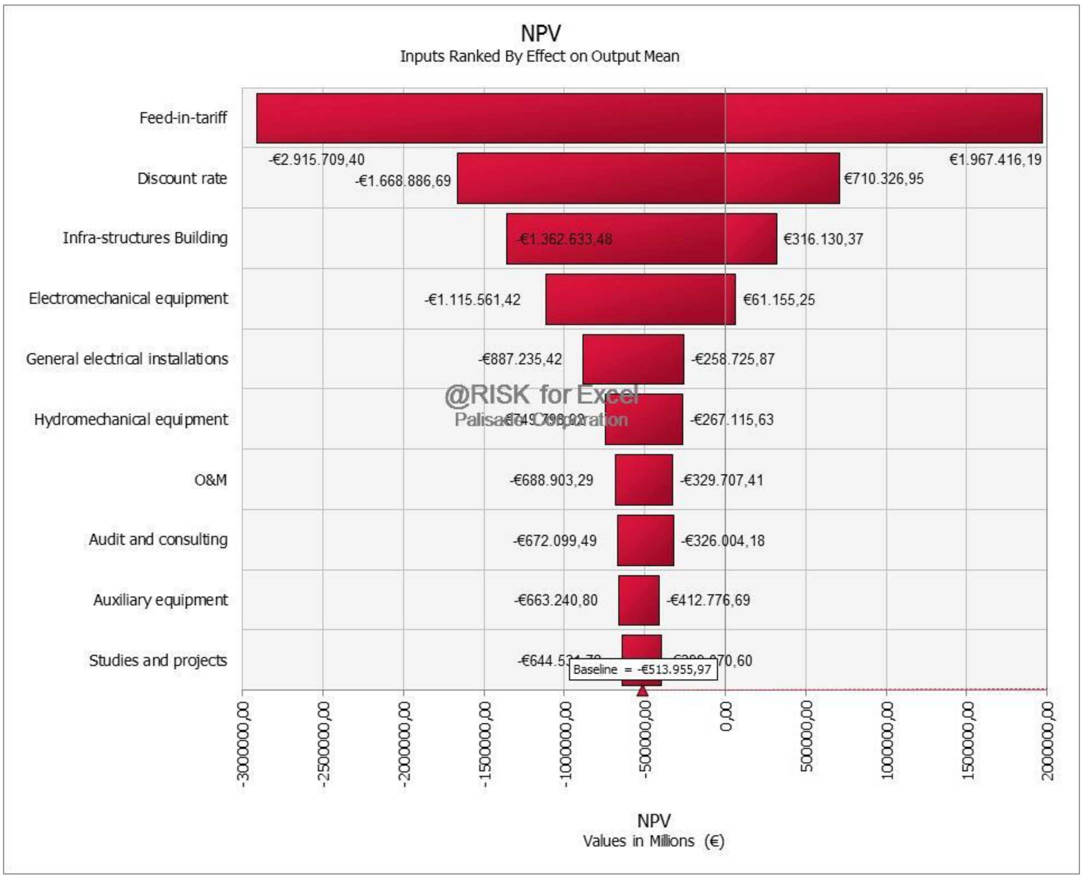

Figure 7. Tornado chart for NPV

The combined risk evaluation leads to a less positive view of the project return. The possibility of having a positive NPV is only 36% and the expected value is negative. The tornado chart puts in evidence the importance of the feed-in-tariffs, the discount rate and the initial investment.

CONCLUSION

Given the growing concerns with sustainable electricity production, small hydroelectric power plants emerge as an interesting alternative, especially as it refers to renewable energy sources. However, it is advisable to develop a thorough identification of the risks associated with this investment, since they range from completion to technological risk, from hydrologic to environmental impact, and from political to sociocultural risk.

In this paper, departing from a real case study, the investment appraisal of a SHP project was described under the present market conditions followed by a probabilistic risk analysis in order to identify and evaluate the main sources of risk.

Although the independent analysis of each variable showed that the project could be interesting with positive mean values, the possibility of having a negative outcome was evident for the investment costs, discount rate and feed-in-tariffs variables. On the other hand, the results of the combined analysis are much less optimistic demonstrating that even under regulated tariffs the probability of having a negative NPV largely surpasses the probability of obtaining a positive value.

The results obtained showed that in the context of a regulated tariff, as was the case-base scenario, the project could be worthwhile due to a positive NPV. However, if electricity had to be sold at market prices, the project becomes unprofitable. This is an important issue because the perspectives for the future is a reduction of incentives (especially feed-in tariffs) and increased difficulties of network access for producers of electricity from renewable sources.

The risk analysis puts also in evidence the vulnerability of an investment of this kind to an adverse change in interest rates. This is not an unexpected outcome given the nature of RES projects, characterized by large investment values and reduced O&M costs. In fact the present market conditions giving rise to high capital costs along with the liberalization trend of the tariffs represent important risk elements that can easily lead to a reduction of the investors' interest on these projects.

Future research is expected to address the use of different tools able to incorporate a formal risk analysis procedure on project evaluation, namely the application of real options approach and multi-criteria decision methods in order to take into account different perspectives on the decision-making process and cost/benefit analysis for the economic valuation of the externalities.

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