INVESTMENT ANALYSIS UNDER UNCERTAINTY IN FAST-GROWING HYDRO-THERMAL ELECTRICITY MARKETS

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1. Overview

The conceptual design of the power sector model in any country is to allocate different sources of risks among different agents (generators, traders and consumers) through a set of (market) rules such that the tariff for the final consumer is the least possible.

Two alternatives for selling the electricity are usually available for generators: spot and contract sales. Each one presents opportunities and risks. For example, contract sales are good mechanisms to mitigate energy spot prices volatilities. But contract sales can also bring hydrological risks for hydro generators, associated with the inability to deliver the contracted amount during the dry periods. The objective is then to devise a competitive pricing strategy that is sufficient to remunerate investment, cover operating costs and hedge the project against the different sources of risks. For spot sales, the challenge is to verify if forecasted energy spot prices can recover investment and operational costs. Risks may be understood as the uncertainties associated with project returns caused by hydrology, market prices, costs overruns, construction delays, fuel prices, and others. A proper assessment of the diverse types of risks associated to the project is extremely important when managing their economical impacts by the investors.

An interesting aspect is the relative effect of the risks among the projects when analyzing investment alternatives. Projects using different technologies may have the same competitiveness in terms of expected returns, but diverse risks due to the existence of uncertainties in only one of the technologies, or even greater exposure to similar risks. This aspect is important because the Internal Rate of Return (IRR) required by the agents for a given project depends on its risk level. Agents will normally require larger return for projects presenting higher risk levels.

This work proposes a methodology and a computational model to identify and price the risks of each alternative for generation investment, comparing them on the same basis. The objective is to assist agents in their investment decisions. It is proposed to utilize an efficient risk-return frontier to compare the projects.

2. Methods

The methodology may be divided into three parts:

(i) Mapping of risk factors and project pricing is performed: the major risk factors of each generation technology –market prices, hydrology, environment, construction, technological, exchange rate and fuel risk are identified. For each of these items, it is proposed to translate the risk factors into *scenarios* with their respective probabilities. For example, environmental risks may be translated into scenarios of plant operation delay and increase of non-transferable environmental costs. Uncertainties on market prices and hydrology can be produced by scheduling model, in a fundamental approach. In turn, regulatory risks can be translated into scenarios of non-transferable costs increase;

(ii) Evaluation of new investments in generation under uncertainty, where the different risks (market prices, hydrological, fuel costs, delays etc.) associated to the implementation of each project are quantified and priced in accordance to the agent's risk-aversion profile. For contract sales, the price that assures an intended IRR with given confidence level considering the risks involved is established.

(iii) Comparison of distinct generation investment technologies considering their uncertainties and intrinsic risks is proposed, demonstrating how to calculate the risk premium for each investment alternative, and verifying the impact of each intrinsic uncertainty of the project upon the variance of its expected return.

This methodology can be extended to define the portfolio of generation assets investments in face of the projects considered by each investor.

Scenarios of the uncertain variables which will compose the project cash flows are obtained through a fundamental approach. Hydro-thermal optimization model, such as SDDP and market rules simulation models are utilized. Once a vector of scenarios for the key variables is obtained, a complete cash flow for a

given project can be calculated for the realization of each scenario. The cash-flow's IRR for each scenario is then calculated, representing the project's attractiveness. Different IRR are obtained by different cash flow scenarios, thus enabling one to characterize the empirical probability distribution, of the IRRs. Hence the project's IRR with desired confidence level can be selected with indices such as VaR or CVaR. Figs. 1 and 2 show an example of IRR probability functions (density and cumulative) and the related α-VaR percentile.

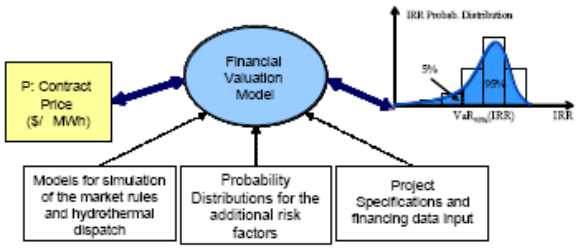

Fig. 1 – General outlook of the methodology

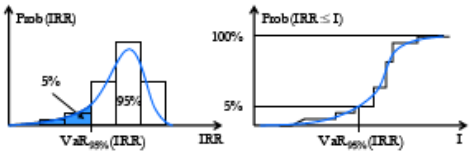

Fig. 2 – Project's estimated VaR_{α}(IRR)

Another option of the proposed model is to calculate the resulting IRR when the market price is a fixed parameter. In this case, IRR VaR or CVaR and its complete distribution may be accessed so as to compose part of subsequent models for comparing technologies and selecting projects.

3. Results

Examples and realistic case studies from the Brazilian power sector will be shown, so as to demonstrate how this methodology can widen the view of investors when selecting their projects. Likewise Turkey, Brazil is a fast-growing market which presents similar environment, and demanding significant investments every year which attract private players to the market.

4. Conclusions

The analysis, representation and correct pricing of the risks are of extreme importance in the evaluation of new generation investments in the competitive electricity markets elsewhere. This is most demanding for fast-growing markets such as the Turkish and Latin American ones. The paper contributes with an analytical approach to carry out investment analysis under uncertainty, aiming at pricing risks faced by long-term investments in power projects. Correct risk management provides investors guidelines to support their choices among investment opportunities of different generation options.

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Luiz Augusto Barroso has a BSc in Math and a PhD in operations research. He is a technical director at PSR, where he has been providing consulting services and researching on power systems economics, planning and operation, focusing on hydrothermal systems in Brazil and abroad. He has been a speaker on these subjects in Latin America, Europe and US/Canada.