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Real Options versus Traditional Methods to assess Renewable Energy Projects

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ABSTRACT

Several methods can be employed to evaluate investment in energy production. On one hand, traditional methods (Net Present Value (NPV) or Internal Rate of Return (IRR), for example) ignore certain project characteristics that may influence its evaluation, such as irreversibility, uncertainty and management flexibility. Nevertheless, the Real Option Approach (ROA) has an advantage over the application of traditional methods, since the prior uncertainties are taken into account. Thus, the main objective of this study is to apply ROA to a case-study (mini-hydro plant) through the use of the binomial tree developed by Cox, Ross and Rubinstein in 1979. This study concludes that the value of ROA is higher than the value of NPV because the investor can get better information and uncertainty is reduced when he has the option to defer the investment. In addition to providing a deep analysis on the major gaps in energy investment evaluation, this work contributes to a better understanding of the usefulness of ROA.

1. Introduction

In the last few decades, the liberalization of electricity markets has significantly influenced investment decisions in regards to electricity generation. Furthermore, electricity generation projects have specific characteristics, such as irreversibility and high levels of uncertainty that influence the choice of the best method to evaluate energy investments.

The Net Present Value (NPV) is commonly used to evaluate these investments. However, this method underestimates the value of investment when flexibility is one of the project characteristics because some management options are not taken into account, such as contraction or expansion actions [1]. Thus, this method is unsuitable for evaluating power generation investments.

The Real Option Approach (ROA) overcomes these shortcomings. When uncertainty and irreversibility are present in energy investments, ROA evaluates those investments considering that the investor's choice is subject to flexibility, i.e., the investor has the option whether to postpone his decision on irreversible investments [2].

Having this in mind, the main purpose of this article is to evaluate a renewable energy investment through ROA and traditional methodologies. The methodology used was the following: after a literature survey focused on the characterization of different methodologies and their main applications to energy investments, ROA will be presented in more detail. Subsequently, the study will analyze an investment in a mini-hydro plant through the application of traditional methods. Finally, ROA is applied to the same case study and the results are obtained and compared.

The article proceeds as follows: Section 2 makes a literature survey on the traditional methods used to evaluate energy investments; Section 3 presents the Real Option Approach; Section 4 evaluates an investment of a mini-hydro and presents the main results; and the last section presents conclusions.

2. The economic evaluation of energy investments

Energy investments have specific characteristics that distinguish them from other types of investments. First, this kind of investments is partially or completely irreversible because the capital of the industry cannot be used in other sectors or by different companies [3]. Second, investors have to assess their options under high levels of uncertainty associated with the liberalized electricity market [2]. Third, investments may occur in a flexible time, i.e., the investor can invest today or postpone his decision in order to obtain better

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information. Finally, investors have several generation technologies at their disposal that can be chosen when the project is defined. However, these technologies are associated with different uncertainty levels that should be considered. Therefore, investors should adopt a methodology to evaluate energy investments that takes into account risks and uncertainties regarding the investment.

Many authors have applied several methodologies to analyze the viability of these projects. Table 1 systematizes the different methods used to make that evaluation and presents some examples of application on energy investments.

As can be seen by Table 1, there are several methods applicable to evaluating energy investments, yet some of these are more appropriate than others. Thus, a question arises: What is the best method to evaluate energy investments?

According to Bracher [68], traditional methods include project risk but ignore management actions. Moreover, if those actions were considered, risk could be mitigated, maintaining or even increasing the project value. On the other hand, the Real Option Approach (ROA) combines uncertainty and risk with flexibility, taking into account the volatility associated with the evaluation process as a potential positive factor, which gives value to the project.

As mentioned previously, energy investments have specific characteristics, particularly in regards to uncertainty and irreversibility. The application of traditional methods with their static evaluation tools fails to regard flexibility and undervalues investments [42]. Therefore, according to Pindyck [69] the use of traditional methodologies can be inconsistent, supporting the application of ROA.

Mainly used to evaluate real assets, ROA factors in operational and managerial flexibilities over the project lifetime, differentiating itself from traditional methods (like Net Present Value (NPV)). Indeed, real options give flexibility to investors when making decisions about real assets, revealing uncertainty associated with cash-flows and allowing investors to make decisions that positively influence the final project value.

It can be concluded that traditional methods assess the risk but cannot study all uncertainties and flexibilities associated with the project. ROA overcomes these shortcomings since it considers management flexibility. Thus, investors of a renewable generation project can make informed decisions because better information on the project is obtained. For these reasons and since the evaluation of a renewable generation project is the main objective rather than to make a portfolio evaluation, traditional methods will not be applied, instead the application of ROA seems more suitable. Hence, the next chapter will present the real option approach as it is applied to this specific project.

3. Towards a new approach: real options as a suitable method for evaluating energy investments

ROA is claimed as the only asset evaluation method that considers the interaction between three main characteristics which define energy investments: irreversibility, uncertainty, and time flexibility [70].

Nevertheless, before starting the presentation of ROA, the difference between *financial options* and *real options* must be defined. A *financial option* is an asset where the holder has the right to but not the obligation of buying (call option) or selling (put option) a quantity of a specific asset (underlying asset), at a fixed price (exercise price) during a pre-established period or date. A *real option* gives to its holder the right but not the obligation of taking a share that affects a real physical asset, at a pre-determined cost during a pre-established time [71]. Table 2 shows the analogy between these two concepts.

Although the evaluation of real options is more complicated than that of financial options, the application of methodologies underlying the evaluation of financial options constitutes a good approximation to evaluate real options. Thus, the main models used to evaluate financial options will be presented: the Black–Scholes

Table 1
Assessment methods used in energy investment projects.

Methods	Definition	Numerical solution[a]	Decision Criterion to implement the Project	Applications	References
Net present value	Sum of the present value of all cash flows produced by the project, net of the necessary investments to implement the project.	$NPV = -\sum_{t=0}^{n-1} I_t/(1+i)^t + \sum_{t=1}^{n} NR_t/(1+i)^t$	$NPV > 0$	Oil and Gas industries. Renewable energy investments/projects.	[4–14]
Internal Rate of Return	Represents the discount rate that equalizes the NPV to zero.	$0 = -\sum_{t=0}^{n-1} I_t/(1+\mathrm{IRR})^t + \sum_{t=1}^{n} \mathrm{NR}_t/(1+\mathrm{IRR})^t$	$IRR > k$	Renewable energy investments/projects.	[10,11,14,15]
Return on Investment	Measures the relation between the present value of cash flows and the necessary investments to implement the project.	$ROI = [\sum_{t=1}^{n} \mathrm{NR}_t/(1+i)^t]/[\sum_{t=0}^{n-1} I_t/(1+i)^t]$	$ROI > 1$ ($NPV > 0$)		
Payback Period	Period of time required to recover the investments.	$P = [\sum_{t=0}^{n-1} I_t/(1+i)^t]/[\sum_{t=1}^{n} \mathrm{NR}_t/[(1+i)^t/n]]$	$P < n$	Renewable energy investments/projects.	[10,14,16]
Benefit-Cost Ratio	Identify, quantify and weigh the benefits and costs of the investment projects.	$B/C = [\sum_t (R_t - C_t)/(1+i)^t]/[\sum_t I_t/(1+i)^t]$	$B/C > 1$	Renewable energy investments/projects.	[10,14,16–20]
Levelized Costs	Compare the energy generation technologies with different characteristics and lifetimes.	$LC = (C_I + C_{O\&M} + C_c + C_d)/E_{act}$	Lowest levelized cost	Energy investments/ projects Energy Market. Power Generation.	[13,16,21–32]
Real Options	Reformulates the NPV so that the scenarios of great uncertainty, which compose the investments, are considered.	$NPV_{expanded} = NPV_{traditional\ or\ static} + Value_{management\ flexibility}$	$NPV_{expanded} > 0$	Oil and Gas industries. Renewable energy investments/projects. Energy market. Power generation.	[6–8,33–67]

[a] Terminology: I_t: Investment Cash- Flows in period t; NR_t: Net Revenue in period t; i: Discount Rate; IRR: Internal Rate of Return; k: the reference interest rate or the opportunity cost of capital; n: number of years; $R_t - C_t$: Operation Cash-Flows in period t; C_I: Present Investment Cost; $C_{O\&M}$: Present Value of Operation & Maintenance Costs; C_c: Present Value of Fuel Costs; C_d: Present Value of Various Annual Costs; E_{act}: Present Cumulative Value of Energy Production.