STRATEGY BASED ON THE THEORY OF REAL OPTIONS FOR A COMPETITIVE PARTICIPATION IN THE PERUVIAN RENEWABLE ENERGY RESOURCES AUCTIONS

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ABSTRACT

The structure of a Renewable Energy Resource (RER) auction in Peru is similar to the structure of a composition of financial call options and involves a sequence of similar decisions associated with the aforementioned derivative financial instrument. The perspective of the use of the Real Option Theory to evaluate the strategies of the participants in these auctions is based on their similarities and allows the use of analytical models and mathematical valuation procedures developed and used in financial derivatives markets. The objective of this study was to characterize the structure of RER auctions in Peru as a composition of call options, which involves decisions regarding the payment of premiums for the acquisition of decision rights on established dates. The chosen methodology was the case study and the selected case consists of evaluating the strategy used by ENEL GREEN POWER (EGP) in the fourth RER Auction promoted by the Peruvian Government and consequent adjudication of some of its projects. Since the auction required Bid Bonds, they were characterized as Real Option Auctions, therefore real options could be used as an analogy to understand the rationality of ENEL's strategic decisions in the process. The binomial method was used to estimate the implicit volatility, which was inserted in the Black & Scholes model to calculate the option price (premium). The premium was then compared to the amount of bid bonds presented to determine whether the Real Option on participating on the auctions was above or under the theoretical price of the option.

INTRODUCCIÓN

The structure of the RER auctions in Peru is similar to the structure of a composition of financial call option and the perspective of the use of the Real Option Theory is based on the similarity between the decision rights derived from the business investment and the rights of purchase established by financial call options. This similarity allows the use of analytical models and mathematical valuation procedures developed and used in financial derivatives markets.

The paper has the following structure: firstly, the research problem, the objectives, the justification, the proposed results, the methodology of the research and its limitations are presented. Next, the contextual framework is portraited, where the details of the Peruvian electricity market, the scheme of the RER auctions and the regulatory framework are shown. The third part discusses the conceptual framework of real options, their applications and mechanisms for their valorization. In the fourth part, the case study selected is described. Then, as a fifth part, the description of the strategy traditionally used in the auctions is presented and then, the sixth part, where the supposed strategy used by EGP is presented having the real options as a parameter, where the proposed model is developed and get the results. The conclusions and recommendations are presented in the seventh and last part.

PART ONE: RESEARCH PROBLEM

Can the use of the Real Options Theory approach, as an analogy to understand the rationality of strategic decisions, allow bidders and regulators to formulate more efficient competitive strategies for the RER auction?

OBJECTIVES

Main Objective: Characterize the structure of RER auctions in Peru as a composition of call options, which involves a sequence of decisions regarding the payment of premiums for acquisition of decision rights on established dates.

Specific Objectives: Identify if the real options approach can be used as an analogy to understand the rationality of the strategic decisions related to an RER Auction; Indicate as bidders and regulators can use this approach to formulate more efficient competitive strategies for participation in the RER auction; Determine a methodology to calculate the maximum amount of the premium to pay for the option.

JUSTIFICATION

The expansion of the renewable energy market in the last decade and its relevance in the attraction of investments and job creation make the RER investments a relevant issue[1] and the use of the Theory of Real Options allow us to understand the rationality of investing in a project with great uncertainty regarding its Net Present Value (NPV).

Another motivation to use the real option theory is indicated by Sirmans & Yavas (2005). In their experiments they discovered that, in general, the concept of real options is not intuitive or clear for the agents and they fail to identify the value of deferring an investment decision. However, the same agents, when they have to compete for the right to decide to make a future investment (auction), behave in such a way that their offers reflect the value of the option to be deferred. Even when agents are unaware of the Real Options Theory (ROT), its principles are underlying their strategic decision making.

Additionally, Cong (2016) characterizes auctions that require Bid Bonds as Real Option Auctions. Therefore, the approach of real options can be used as an analogy to understand the rationality of strategic decisions in auction processes, as described by Luehrman (1998) and by Alonso, Azofra and Fuente (2009). Therefore, it is possible to publicize a competitive strategy proposed as composed options and be able to apply it in RER auctions in Peru or in other countries. In the selected case, the strategy used by EGP Peru will be analyzed in detail.

PROPOSED RESULTS

In the present work it is proposed to achieve the following results:

1. Characterize the structure of the RER auctions in Peru as a composition of different call options;
2. Use the real options approach as an analogy to understand the rationality of the strategic decisions related to a RER Auction;
3. Indicate how bidders and regulators can use this approach to formulate more efficient competitive strategies for participation in the RER auction;

[1] Regarding the economic relevance of the RER, the data compiled by the International Renewable Energy Agency (IRENA) shows that in ten years the investments in the RER in Latin America increased by more than 250%, highlighting the recent advances of Uruguay, Chile and Mexico. Among the RER, the growth of investments in wind and solar generation stands out. In 2015, these sources concentrated more than 80% of the investments (Renewable Energy Market Analysis Latin America, IRENA, 2016).

4. Determine a methodology to identify the implied volatility of participating in the auction and calculate the maximum amount of the "premium" to be paid and therefore;
5. Propose how regulators can use the options approach to improve the definition of bid and compliance bonds and indicate useful guidelines for bidders to propose a strategy for participation in auctions that is more cost efficient and less risk, which at the same time maximize the possibilities of awarding a project and minimize the expected losses.

INVESTIGATION METHODOLOGY

The chosen methodology was the case study and the selected case consists of evaluating the strategy used by the bidders of wind projects in the fourth RER Auction promoted by the Peruvian Government and consequent adjudication of some of its projects. The strategy used by EGP Peru will be analyzed with more attention.

LIMITATIONS

The limitations indicate what aspects remain outside the coverage of that investigation, the "limits" or frontiers to which the aspirations of this research arrive are the following:

- In the characterization of the structure of the auctions as a set of options, the study will be limited to the options of deferring and abandoning the project;
- Although the other stages of the RER Auction could be characterized as options, there were not enough data to apply the selected methodology and therefore the focus of the options will be applied to modeling just the decision to participate and present a proposal;
- While it is true that agents can use the options approach to formulate more efficient strategies for their participation in the auction, the success of their projects depends on other variables;
- Considering that only part of the information necessary for the calculation of the maximum amount of the "premium" is public, some assumptions were established for the information that is private and not make available by the companies;
- Another limitation derives from the case study methodology used, since the conclusions apply only to Auctions with the same characteristics.

PART TWO: CONTEXTUAL FRAMEWORK

The institutional framework of the electricity sector is formed by the the Peruvian State, represented by the Ministry of Energy and Mines (MINEM), Free and Regulated Users of electricity, the Electric Utility Companies, the Committee for the Economic Operation of the System (COES), the Supervisory Body of Investment in Energy and Mining (OSINERGMIN), the Institute for the Defense of Competition and Intellectual Property (INDECOPI) and the Promotion Agency of Private Investment of Peru (PROINVERSIÓN).

In 2015 installed capacity was around 12,250 MW and it is worth mentioning that the RER generation reached the 5% share mark in the annual generation of electricity, an objective established by Legislative Decree No. 1002/2008. The Peruvian electricity market has grown at annual rates of 7% in the last two decades and according to the 2015 Statistical Yearbook, installed power tripled between 1995 and 2015. In 2015, the sector generated 8,764 direct jobs and had accumulated investments of USD 2,593,308,000.

The National Energy Plan (PEN) 2014-2025 considers for the considered horizon investments in the energy sector of 50 billion dollars and for the sub-sector electricity of 9 billion dollars. The goals will be to double the electricity demand requirements and reach 60% of energy production with renewable sources, as well as 100% access of Peruvian families to electricity.

The PEN 2014-2025 estimates an annual production of around 70,000 GWh / year in 2025, which implies that to maintain a 5% share of the RER it will be necessary to add approximately 1,500 GWh / year of RER generation. Taking into account the completion of the Fourth Auction in 2016, it is estimated that another auction for the acquisition of higher volume of energy should take place between 2019 and 2020.

RER AUCTION SCHEME

The requirements of quantity of electricity and types of sources are defined in terms of energy required in MWh / year distributed between different technologies: biomass, wind, solar, geothermal and tidal and plus an additional small hydroelectric power plants (less than 20 MW). Bidders must submit, together with their proposals, a Bid Bond of USD 50,000 / MW of installed capacity, which is lost if the bid is won and the bidder fails to sign the contract. The base rate (electricity Price) or "Maximum Monomic Rate" (USD / MWh) is calculated by OSINERGMIN for each type of RER generation technology. In the event of the adjudication of the Project the company must present a Performance (completion) bond (Garantía de Fiel Cumplimiento/GFC) of USD 250,000 / MW of installed capacity.

The adjudication process is carried out in four steps:

- First the Offer Envelopes are opened and the projects are ordered according to the prices from lowest to highest and those that exceed the maximum price are discarded;
- Next, it is verified whether the amount of energy offered (MWh) is less than the Required Energy, if so, the project is awarded. If the energy offered exceeds the Required Energy, it is verified if the bidder has previously agreed with the possibility of partial allocation as long as it is below the maximum price;
- Finally, maximum price is disclosed only if the Required Energy was not fully covered and if there were offers that exceeded the maximum price;
- Then the winners sign Concession Agreements that ensure them the payment of an annual income for twenty years.

REGULATORY FRAMEWORK

The legal framework for the promotion of renewable energies is included in the general regulatory framework of the electricity sector and consists of the following instruments: Legislative Decree No. 1002/2008, by Supreme Decree 012-2011-EM (March 2011) and by the Consolidated Bidding Documents of the Electricity Supply Auction with Renewable Energy Resources (RER), which are originally approved by Resolution of the Ministry of Energy and Mines (MINEM).

PART THREE: THE CONCEPTUAL FRAMEWORK

A financial call option guarantees its buyer the right to buy an asset at a certain price (strike price) at the end of a set period of time (expiration time). An investor acquires call options, paying for them an amount of money (premium). The owner of the option has the right, but is not obligated to buy. The seller of an option is obliged to sell an asset at the exercise price. The maximum loss of the investor is the value of the price paid for the option, if the buyer decides not to exercise his right to purchase the asset.

The real options are an application similar to financial options, however the underlying asset is a "real asset" such as, for example, a property, an investment project, a company, a patent, and so on. It is the right - but not the obligation - to carry out certain business initiatives, such as postponement, abandonment or expansion of a capital investment project.

THE VALUATION OF REAL OPTIONS

The main methods of valuing options are the binomial method, Black & Scholes and Monte Carlo simulation. In this research the binomial model and Black & Scholes were used.

The definition of the price of a call option by the binomial method presupposes variations for the movement of an action: its price can go up "u" or go down "d" and the values of rise and fall are always the same throughout the period of analysis of the option. The model and its components can be represented according to the following illustration:

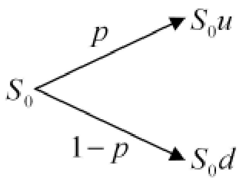

Illustration 1- Graphical representation of the binomial model

Equation 1- Components of the binomial model

$$c_u = Máx\ [S_0u - S_0,\ 0] \qquad p = \frac{e^{r\Delta t} - d}{u - d}$$

$$u = e^{\sigma\sqrt{\Delta t}}$$

$$c_d = Máx\ [S_0d - S_0, 0] \qquad d = e^{-\sigma\sqrt{\Delta t}}$$

The value of the call option in each scenario will be given by c_u and c_d and the value of the call option in the initial moment will be given by the weighted average of the values discounted by the risk free rate.

Equation 2- Value of the purchase option for the binomial model

$$C = e^{-rT}\left(pC_u + (1-p)C_d\right)$$

The Black-Scholes model determines the intrinsic price of an option based on these five factors: S_0 is the price of the underlying asset, X is the exercise price, T is the due date, σ is the variability of the underlying asset, r it is the risk-free interest rate.

Equation 3- Call Option price formulas

$$C = S_0\, e^{-qt} * N(d_1) - X\, e^{-rt} * N(d_2)$$

$$d_1 = \frac{ln(\frac{S_0}{X}) + t\,(r - q + \frac{\sigma^2}{2})}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

There is a relationship between the binomial model and the Black & Scholes model and is given by the equivalences described in Equation 4.

Equation 4 - Relationship between the binomial models and Black & Scholes

$$u = \exp\left\{\sigma\sqrt{\frac{T}{n}}\right\}$$

$$d = \exp\left\{-\sigma\sqrt{\frac{T}{n}}\right\}$$

The types of real options can be classified into three groups that can be interrelated: Defer/Learn, Investment/Growth and Divert/Reduce. For our case study, we will develop the option to defer na investment decision.

The option to defer an investment project provides its owner the right to postpone its realization during a certain period of time. It is similar to a purchase option on the NPV of the project and whose exercise price is the cost of carrying out the project on the expiration date of the option.

PART FOUR: DESCRIPTION OF THE CASE STUDY

The selected case study is the strategy used by the bidders in the fourth RER auction, a procedure called to award Energy for the Peruvian SEIN (National Interconnected Electric System), whose objective was the contracting of 1,300 GWh of wind, solar and biomass energy per year In addition, 450 GWh per year of new hydroelectric power projects were also auctioned. Then, from the investigation of the fourth RER auction, we can identify that bidders have used different types of strategies to win a project. We have focused on two types of strategies that we call Traditional Approach Strategy and Real Options Approach Strategy.

DESCRIPTION OF THE FOURTH RER AUCTION

The Auction Notice[2] of the Fourth RER Auction determined that:

[2] http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/Documentos/4taSubastaRER.AvisosConvo2015/Bases_Consolidadas_4taSubasta.pdf

a) the participation rights were to be acquired for USD 5,000.00;
b) on a specific date, companies should present two envelopes, one of qualification and another with the economic proposal;
c) preliminary information about the project, sworn statements and other documents would be included in the qualification envelope;
d) in the second envelope the bidder presents the Bid Bond (GSO), the monomic price offered (USD / MWh), the installed capacity of the power plant (MW), the annual amount of electricity offered (MWh), the minimum percentage required to obtain an award and location of bar to be connected.

In case of adjudication the auction notice determined that:

e) the bid bond would be replaced by a performance bond;
f) it would be necessary to form a Specific Purpose Company (SPC) with capital subscription equivalent to USD 100,000 / MW and;
g) Sign the concession contract with a duration of 20 years.

Once the project was awarded, the awardee would begin the preparations for the construction. In our case study, we will only focus on wind power generation technology. There were a total of 8 bidders who submitted 34 projects. It should also be noted that of the 8 bidders only 4 went to the second round.

PART FIVE: TRADITIONAL APPROACH STRATEGY

Companies interested in participating as bidders in the RER Auctions follow what we will call <u>Traditional Strategy</u>, which is subdivided into three stages: the generation of the project, the participation in the auction and implementation in case of winning the tender. <u>This strategy presupposes a one-to-one relationship between developed studies and projects presented in the auction</u>, that is, the studies and efforts made to develop a wind farm project generate only one offer, based on these studies, to be presented at the auction.

The value of projects depends on the stage of development they are in. In a study carried out annually by Deloitte[3], a multiple (€ / MW) is estimated for the valuation of wind farm assets. The projects that meet the minimum requirements for submission in the Auctions are those that

[3] "A Market Approach for Valuing Wind Farm Assets - Global Results - April 2016"

met the initial stages of the pipeline, which would be evaluated between EUR 0.2 million and EUR 0.3 million / MW of installed capacity (USD 0.21million and USD 0.31 million / MW).

In order to be able to compare the two proposed strategies, we carried out the economic and financial evaluation of one of the projects presented by ENEL, the 126MW Wind Power Plant (named Nazca Project). First, by using the Capital Asset Pricing Model (CAPM), then estimating the revenues, costs and investments. Secondly, analyzing the projected financial statements consisting of the profit and loss statement and the cash flow, to then calculate and analyze the NPV and the internal rate of return (IRR). The CAPM was used to calculate the cost of capital and results in a Ke = 8.75%. After the determination of future flows and the average cost of capital, the NPV and IRR of the economic and financial project were obtained:

Table 1 - NPV and TIR for the Nazca project in the Traditional Strategy

IRR	6.5%
NPV@WACC 4.67%	USD 29.952 million

PART SIX: STRATEGY BASED ON THE REAL OPTIONS THEORY (ROT)

The strategy based on the ROT approach is the same as the traditional strategy regarding participation in the auction process and in the implementation of the awarded projects. The difference between the strategies is that in the new strategy the one-to-one correspondence between the studies carried out to develop a wind farm project and the offers presented in the auctions ceases to be dominant.

In the traditional strategy, a study, carried out according to a Temporary Concession[4] granted by the MINEM, generates a project presented in the auction. In the proposed strategy, a study can generate several projects to offer at the bid. We will define as base configuration of the project the conditions described in the Ministerial Resolution that grants the Temporary Concession and as additional configuration any of the projects presented in the auction that can be considered as variations of the base configuration. In Table 2 we present examples of three companies that submitted projects in the fourth RER auction that we assume are variations of the base configurations.

[4] This concession allows the use of goods for public use and the right to obtain the imposition of easements for the feasibility studies of generation plants (whose installed capacity is equal to or greater than 750 MW and / or in case they require easements on third party property), substations or transmission lines (http://www.minem.gob.pe/descripcion.php?idSector=6&idTitular=6591)

Table 2 - Examples of base and additional configurations of projects presented in the 4th RER auction

Company	Basic and Original Configuration (Temporary Concession)		Additional Configuration (Projects offered in the bid process)
Grenergy	CE Parque Duna 120MW	RM N° 575-2015-MEM/DM	CE Duna 18MW CE Huambos 18MW
Cobra	CE Parque Torocco 75MW	RM N° 406-2013-MEM/DM	CE Torocco Norte 55MW CE Torocco Sur 44MW
Enel	CE Parque Nazca 120MW	RM N° 262-2015-MEM/DM	CE Parque Nazca 126.00 MW CE Parque Nazca 2 114.00 MW CE Parque Nazca 3 102.00 MW CE Parque Nazca 4 93.00 MW CE Parque Nazca 5 84.00 MW CE Parque Nazca 15 81.00 MW CE Parque Nazca 6 75.00 MW CE Parque Nazca 16 72.00 MW CE Parque Nazca 7 66.00 MW CE Parque Nazca 17 63.00 MW CE Parque Nazca 8 57.00 MW CE Parque Nazca 18 54.00 MW CE Parque Nazca 10 51.00 MW CE Parque Nazca 20 45.00 MW CE Parque Nazca 11 45.00 MW CE Parque Nazca 22 36.00 MW CE Parque Nazca 25 27.00 MW CE Parque Nazca 27 21.00 MW CE Parque Nazca 29 15.00 MW

In the Illustration 2 - Characterization of the auction as a sequence of real options, we present, according to the schedule and other guidelines of the fourth RER auction documents[5], the elements of an option (acquisition of a decision right, on a specific date through payment of a premium) for each of the stages of the bidding process.

From the perspective of the bidders, the options are as follows: in stage 4, if the bidder decides to present a proposal, the bidder must submit a Bid Bond of USD50,000 / MW. If the proposal qualifies (stage 5), the economic offer will be evaluated, if it does not qualify the project is excluded, the documents are returned and that implies a cost to the bidder that is the fees and financial cost of the bid bond presented.

In stage 10 bidders with awarded projects have the option to sign the concession contract, if by some restriction they can not sign it, or if for any reason they decide not to sign, it would cause the loss of the Bid Bond and that would be the cost of the decision of not concluding the process. Once the concession contract has been signed, the Bid Bond is returned to the bidders and they are required to submit a performance bond of USD 250,000 / MW. In other words, in stage 11, if for some reason the awardee fails to conclude or even desists from carrying out the construction, he would have the Performance Bond executed and that would be the cost of abandoning the project[6].

[5] http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/4tasubas_RER_bases.html

[6] We have not considered other possibilities, such as the sale of the SPE holding the concession contract or the inclusion of new partners in the consortium, etc.

Process flowchart RER Auction and Real Options

	Flow auction 4th RER	Date	Process	Type of Real Option	Prima
01	PARTICIPATE (NOT / YES)	03/09/2015	CALL 4th RER AUCTION		
02	BUY THE BASES	07/09/2015	BUY THE BASES	"DEFERMENT OPTIONS" Buy right to participate	US$ 5.000
03	GO (NOT)	26/11/2015	PUBLICATION OF THE MAXIMUM PRICE		Lost Bonus (US$ 5.000)
04	PRESENT THE ENVELOPES (YES)	18/12/2015	PRESENT THE ENVELOPES 1. Qualification 2. Proposal	"DEFERMENT OPTIONS" Buy the right to decide to make the investment if awarded. Today the project has VAN <0	Offer Security Warranty US$ 50.000 / MW
05	QUALIFY (NOT / YES)	21/12/2015	QUALIFY ENVELOPE N°1		Lost Fee (Offer Security Warranty US$ 50.000 / MW)
06	ADJUDGE 1°Round (YES / NO)	16/02/2016	ADJUDGE PROYECT 1°ROUND		
07	PARTICIPATE 2°Round (NOT / YES)	16/02/2016	QUALIFY ENVELOPE N°2		Lost Fee (Offer Security Warranty US$ 50.000 / MW)
08	ADJUDGE 2°Round (NOT)	16/02/2016	ADJUDGE PROYECT 2°ROUND		
09	SIGNATURE CONTRACT (NOT / YES)	17/05/2016	SIGNATURE CONTRACT		Lost Fee (Offer Security Warranty US$ 50.000 / MW)
10	SIGNED CONTRACT	17/05/2016	SIGNATURE CONTRACT	"OPTION TO ABANDON" Compra el derecho de no realizar el proyecto	Offer Security Warranty US$ 250.000 / MW
11	BUILD (NOT / YES)	18/05/2016	BUILD		Lost Fee (Offer Security Warranty US$ 250.000 / MW)
12	MAKE (NOT / YES)	31/12/2018	START OPERATIONS	"OPTION TO CALL" Buy the right to make the sale of the project	
13	EXTENSION → END		EXTENSION OPERATIONS	"OPTION TO EXPAND" Buy the right to carry out an expansion of operations in the next RER Auction	

REALIZED: OWN

Illustration 2 - Characterization of the auction as a sequence of real options

In the stage 4 of the auction, we consider that it is possible for a company to apply with different projects (additional configurations) based on the same study (base configuration). By presenting the bid bonds, the bidder "buys" the right to decide whether or not to sign the concession contract in the case of winning the tender. That is, deferring the decision to make the investment (the exercise price) only after the winning of the tender and signing of the contract. This decision right has been bought by the presentation of the Bid Bond, if it decides not to sign, it will pay USD50,000 / MW, which would be the option price (c).

DEVELOPMENT STRATEGY WITH THE FOCUS OF REAL OPTIONS

We have tried to interpret what was the strategy used by ENEL in the fourth RER auction, we support that the company used the ROT in addition to the traditional evaluation Discounted Cash Flow (DCF) to make its decision to enter and succeed in concessioning the Nazca Wind Project in the RER auction. The approach used was similar to a call option to deferred, because it gave ENEL the right to defer its decision to make the investment only after winning the tender.

We suppose that, by presenting several additional projects, ENEL tryed to maximize its chances of winning the tender. Because, other things being equal, the more projects presented, the greater the probability of success. The model we propose will be applied to stage 4, which extends from the period of presentation of the envelopes containing the projects that took place on December 18, 2015 until the closing of the process, the date of the concession and signature of the contract that is the May 17, 2016. We assume that ENEL valued its option to defer its decision (as a call option) and incorporated that data into its evaluation and thus could have more information to support its decision.

We say that the strategy is based on the ROT because, at the time before the presentation of the envelopes with the bids, the NPV of the project is less than zero, since no Power Purchase Agreement (PPA) contract has been granted and signed. However, if ENEL decided not to participate in the auction, it could sell the project to another potential bidder, since there is a project market that is very active in the periods prior to the auction. We use the multiples disclosed by Deloitte to estimate the value of the project at that time and consider it the price of the underlying asset (S_0), at the initial moment (t_0).

However, if the company decides to participate in the auction, one of the additional configurations of the project may be awarded, guaranteeing a steady cash flow through a PPA[7]. The presente value of this cash flow is equivalent to the value of the configuration of the project

[7] Power Purchase Agreement

if awarded (S_{11}). If the bid is not won, the project will have an S_{12} value, where $S_{12} < S_0$, because after the auction the market for the purchase and sale of projects slows down.

Considering that the cost of the investment to implement the wind farm is the exercise price (K), the NPV would be equivalent to ($S_{11}-K$), if the company awards the bid, or ($S_{12}-K$) if the project is not selected. If the company obtains the award and decides not to sign the concession contract, the bid bond (USD50,000 / MW) will be executed. In the real options model, the bid bon would be the option price (c).

That process of potential change in the value of the project (underlying asset) of S_0 in t_0 (presentation of the envelopes) for S_{11} in t_1 (signature of the concession contract) if the auction is awarded; or alternatively to an S_{12} value in t_1, if it is not awarded. It leads us to the conclusión that the situation is similar to buying a call option, because in any case the company would always rationally choose to make the K investment whenever $S1 > K$, or $S1-K > 0$, that is, when the NPV of the project is positive.

If $S_1-K < 0$ the company has the right to decide not to make the investment, but the bid bond would be executed. In other words, the company can pay the price (c) to not sign the contract. Then, in terms of options, after winning the bid, the company has to decide between $S_{11}-K$ or c, in other words the **Max** $(S_{11}-K, c)$.

This option to defer the decisión to do the investment would be only theoretical if it did not serve to make a decision and increase the probability of awarding a project. Therefore, by knowing how much is the price of the option, it is posible to compare it against the costs of the bid bond. If the value of the bid bond is inferior to the price of the option, it would be posible to include more additional project configurations, since increasing the number of projects presented in the auction also increases the probabilities of adjudication. The increase in the number of projects actually occurred. According to the documentation of the auction, 34 wind projects were presented, of which ENEL presented 24.

As mentioned in the strategy with the ROT approach, competing only with the base configuration of the project (Nazca Wind Farm) would generate a financial cost for presenting the bid bond to participate in the auction. The strategy is to increase the probability of award success by registering as many additional configurations of the project as possible, but the question is: **what is the optimal number of additional projects, taking into account the costs for the extra bid bond needed?**

ENEL presented eighteen additional configurations to the NAZCA base project in the RER auction, we have carried out the valuation of the base configuration of the project and of its eighteen additional configurations, taking the same assumptions and changing the elements that differentiate each additional configuration, which are: the price offered, the installed capacity and the estimated annual energy production. However, when changing these variables, important considerations in the valuation also changed, such as the number of wind turbines, plant factor, fees for associated bid bonds, CAPEX, OPEX and finally the NPV and IRR. The variables that have not been modified are capital costs (***ke***) and debt (***kd***), the percentage of debt, the construction time of the plant (even though some initial configurations are of lower installed capacity and therefore implying less wind turbines) and the unit costs of O & M. The following table shows the investment, financial NPV and economic IRR of the eighteen additional configurations:

Table 3- Results of the valuation using the Discounted Cash Flow method

Project	Installed Capacity (MW)	Offered energy (GWh/year)	Offered Price (USD/MWh)	Investment (USD 1,000)	Present Values (DCF in USD1,000)	IRR
PARQUE NAZCA	126	573.000	37.83	190,089	29,952	6.51%
PARQUE NAZCA 2	114	527.925	37.85	175,073	27,609	6.52%
PARQUE NAZCA 3	102	476.728	38.35	160,057	25,776	6.55%
PARQUE NAZCA 4	93	438.209	38.40	148,795	22,457	6.44%
PARQUE NAZCA 5	84	399.357	39.39	137,533	23,043	6.63%
PARQUE NAZCA 6	75	361.066	40.15	126,271	22,100	6.71%
PARQUE NAZCA 7	66	322.880	40.99	115,009	20,844	6.78%
PARQUE NAZCA 8	57	281.173	41.99	103,747	18,073	6.70%
PARQUE NAZCA 10	51	253.599	43.77	96,239	18,864	6.95%
PARQUE NAZCA 11	45	225.725	59.00	88,739	50,821	10.96%
PARQUE NAZCA 15	81	310.961	63.60	133,790	76,302	10.93%
PARQUE NAZCA 16	72	279.215	63.70	122,526	66,773	10.67%
PARQUE NAZCA 17	63	245.924	63.80	111,262	56,256	10.27%
PARQUE NAZCA 18	54	212.094	63.90	99,998	45,328	9.73%
PARQUE NAZCA 20	45	178.204	64.00	88,734	34,273	9.02%
PARQUE NAZCA 22	36	144.093	64.10	77,470	22,995	8.06%
PARQUE NAZCA 25	27	108.396	64.20	66,205	10,619	6.54%
PARQUE NAZCA 27	21	84.046	64.30	58,696	1,945	5.07%
PARQUE NAZCA 29	15	60.825	64.40	43,686	145	4.71%

The value of the project, estimated by the multiple of the Deloitte report, is the input for the next step, which is the valuation of the call option. This value is the price of the underlying asset S_0. For example, the price value of the underlying asset S_0, for the base configuration of the project that has a capacity of 126MW would have the value of US$ 25.2 million (126MW x US $ 0.2M).

For the case selected, we have assumed the probabilities of q_u and q_d for the posible outcomes of the call option in the binomial model and that the expected financial cost consist of two parts: the fees and interests the financial institution will charge for the issuance of the bid bond. We have assumed a cost of 1% for the period between the presentation of envelopes and the end of the bidding process.

The estimation of volatility is one of the main problems in the implementation of the valuation by real options, since in the valuation by the binomial method all the parameters within the formula are known except the volatility. That is why it was decided to estimate the implied volatility, since we know the value of the underlying asset, the exercise price, the time to exercise, the risk-free rate. We determined the volatility for the base configuration of the project using the binomial model, the result was 337%.

Binomial Method for a Call Option (Option to Defer)

S_0	= Spot price (Underlying asset value)	S_0	=	$	25,20
S_{11}	= Price in the valuation scenario	S_{11}	=	$	220,00
S_{12}	= Price in the devaluation scenario	S_{12}	=	$	2,89
k	= Strike price	k	=	$	190,00
σ	= Implied volatility	σ	=		337%
r	= risk free rate	r	=		4%
T	= Expiration time	T	=		149
n	= Number of periods	n	=		1
u	= Up factor	u	=		8,73
d	= Down factor	d	=		0,11
q_u	= Probability of asset valuation	q_u	=		0,12
q_d	= Probability of asset devaluation	q_d	=		0,88

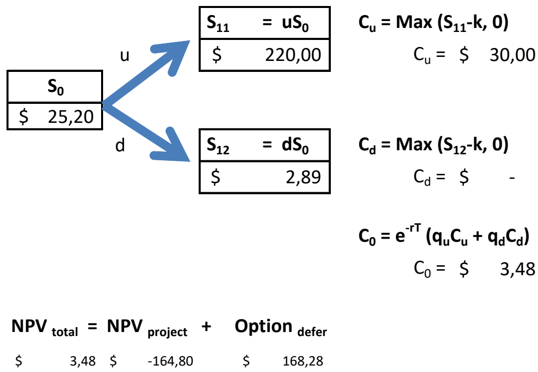

Illustration 3 - Binomial method applied for the valuation of an option to defer a project

This methodology, valuation by binomial method, has been applied to all the other additional configurations of the project, in order to determine its implied volatility, and to apply the valuation of Black & Scholes to determine the value of the call option. The following table shows the implied volatilities calculated for all the additional project configurations and that are on average above the volatility found in the base configuration of the project.

Project	Project value (USD1,000)	Present Values (DCF in USD1,000)	Up Factor and Down Factor		Probabilities		Implied volatility
	S0	S11	u	d	qu	qd	σ
PARQUE NAZCA	25,200	220,041	8.73	0.11	11%	89%	**337%**
PARQUE NAZCA 2	22,800	202,683	8.89	0.11	11%	89%	**340%**
PARQUE NAZCA 3	20,400	185,833	9.11	0.11	10%	90%	**343%**
PARQUE NAZCA 4	18,600	171,252	9.21	0.11	10%	90%	**345%**
PARQUE NAZCA 5	16,800	160,577	9.56	0.10	10%	90%	**351%**
PARQUE NAZCA 6	15,000	148,371	9.89	0.10	10%	90%	**356%**
PARQUE NAZCA 7	13,200	135,854	10.29	0.10	9%	91%	**362%**
PARQUE NAZCA 8	11,400	121,820	10.69	0.09	9%	91%	**368%**
PARQUE NAZCA 10	10,200	115,103	11.28	0.09	8%	92%	**377%**
PARQUE NAZCA 11	9,000	139,560	15.51	0.06	6%	94%	**426%**
PARQUE NAZCA 15	16,200	210,092	12.97	0.08	7%	93%	**398%**
PARQUE NAZCA 16	14,400	189,300	13.15	0.08	7%	93%	**400%**
PARQUE NAZCA 17	12,600	167,519	13.30	0.08	7%	93%	**402%**
PARQUE NAZCA 18	10,800	145,326	13.46	0.07	7%	93%	**404%**
PARQUE NAZCA 20	9,000	123,007	13.67	0.07	7%	93%	**406%**
PARQUE NAZCA 22	7,200	100,465	13.95	0.07	7%	93%	**410%**
PARQUE NAZCA 25	5,400	76,824	14.23	0.07	7%	93%	**413%**
PARQUE NAZCA 27	4,200	60,641	14.44	0.07	7%	93%	**415%**
PARQUE NAZCA 29	3,000	51,331	14.61	0.07	7%	93%	**417%**

Cuadro 1 – Determination of the implied volatilty using the Binomial Method

After finding the implied volatility by means of the binomial method, we proceed to calculate the value of the call option price for the other additional projects using the Black & Scholes model, which are shown below:

Black & Scholes Method

$$C = S_0 N(d_1) - X e^{-rT} N(d_2)$$

S_0 = *Current value of the underlying asset*	S_0 = \$ 25.2MM
X = *Strike price*	X = **\$220.0MM**
σ = *Volatility of asset*	σ = *337%*
r = *Risk free interest rate*	r = *4%*
T = *Life to expiration of the option*	T = *149 días*
$d1$ = *Probability of spot price*	$d1$ = *0.091*
$d2$ = *Probability of strike price*	$d2$ = *-2.076*
N = *Normal distribution*	$N(d1)$ = *0.536*
	$N(d2)$ = *0.019*

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} \quad 0.091$$

$$d_2 = d_1 - \sigma\sqrt{T-t} \quad -2.076$$

$$C = S_0 N(d_1) - X e^{-rT} N(d_2)$$

\$9.4MM \$13.5MM - \$4.1MM

Illustration 4 - Black & Scholes Method

Through the same method it is posible to determine the value of the call option price for all the additional configurations of the project, which are shown in table 5.

Table 4 - Black & Scholes Method - Maximum Price

Project	Project value (USD1,000)	Present Values (DCF in USD1,000)	Probabilities		Normal distribution		Premium (USD1,000)
	S0	X	d1	d2	N(d1)	N(d2)	C
PARQUE NAZCA	25,200	220,041	0.09	-2.08	0.54	0.02	9,413
PARQUE NAZCA 2	22,800	202,683	0.10	-2.08	0.54	0.02	8,612
PARQUE NAZCA 3	20,400	185,833	0.11	-2.10	0.54	0.02	7,823
PARQUE NAZCA 4	18,600	171,252	0.12	-2.10	0.55	0.02	7,179
PARQUE NAZCA 5	16,800	160,577	0.14	-2.12	0.55	0.02	6,632
PARQUE NAZCA 6	15,000	148,371	0.15	-2.14	0.56	0.02	6,043
PARQUE NAZCA 7	13,200	135,854	0.17	-2.16	0.57	0.02	5,442
PARQUE NAZCA 8	11,400	121,820	0.19	-2.18	0.58	0.01	4,801
PARQUE NAZCA 10	10,200	115,103	0.22	-2.20	0.59	0.01	4,428
PARQUE NAZCA 11	9,000	139,560	0.38	-2.36	0.65	0.01	4,582
PARQUE NAZCA 15	16,200	210,092	0.29	-2.27	0.61	0.01	7,566
PARQUE NAZCA 16	14,400	189,300	0.29	-2.28	0.62	0.01	6,772
PARQUE NAZCA 17	12,600	167,519	0.30	-2.29	0.62	0.01	5,959
PARQUE NAZCA 18	10,800	145,326	0.31	-2.29	0.62	0.01	5,138
PARQUE NAZCA 20	9,000	123,007	0.31	-2.30	0.62	0.01	4,315
PARQUE NAZCA 22	7,200	100,465	0.32	-2.31	0.63	0.01	3,487
PARQUE NAZCA 25	5,400	76,824	0.33	-2.32	0.63	0.01	2,640
PARQUE NAZCA 27	4,200	60,641	0.34	-2.33	0.63	0.01	2,068
PARQUE NAZCA 29	3,000	51,331	0.35	-2.33	0.64	0.01	1,486

The price of the call option on the basic configuration was calculated and then compared with the expected cost of the bid bond required to present this Project in the process of the fourth RER auction. The theoretical price of the call option is US $ 9,4 millions applying the Black & Scholes model and the amount of the required bid bond would be US $ 6,3 million (126MW x US $ 50 thousand), however the estimated cost would be US$ 773 thousand (regarding the interests, fees and comissions). Which leads to the conclusion that bid bond requested by the RER auction is "cheap", comparing to the call option price, and that it serves to confirm that what ENEL did by including additional configurations to the project was to increase its probability of award success, paying for all the costs of additional bid bonds a value lower than the theoretical price for the real call option to defer the decision to make the investment of the Nazca project in its basic configuration.

Within the process of the fourth RER auction, we can identify that other companies maybe have applied the same strategy, using the approach of the ROT. To exemplify the contrast between the traditional strategy and the ROT based strategy, lets compare the aproach used by ENEL and the one used by ENERSUR. ENERSUR presented the Twister Wind Farm in the auction, which was very similar to the Nazca Project, its connection also, like the Nazca Wind Farm, would be done in the electric grid in Poroma Power Line.

Table 5 - The Wind Projects with the lowest prices presented in the auction

Company	Project	Installed Capacity (MW)	Offered energy (GWh/year)	Plant Factor	Min. Partial Adjudication	Total amount of Bid Bonds	Offered Price (USD/MWh)
ENEL GREEN POWER PERÚ SA	PARQUE NAZCA	126.0	573.000	52%	92%	US$ 6.30 MM	$ 37.83
ENERSUR SA	PARQUE TWISTER	128.6	569.753	51%	0%	US$ 6.43 MM	$ 39.45

As shown in table 5, the two companies presented similar proposals. In comparison to the Project Nazca presented by ENEL, the Project Twister presented by ENERSUR had a lower plant factor, even though its installed capacity was greater. Its power generation capacity was 0.57% lower and the price offered by ENERSUR was 4.28% higher. However something very important is that ENERSUR did not accept the posibility of a partial award, meaning that ENERSUR was not willing to sign a contract to sell a lower percentage of its electricity production. ENERSUR also decide not to participate in the second round of the auction, when it would have a chance to present the project again with an even lower price.

If ENESUR had proposed a strategy based on the ROT, it could have succesed in the auction, with a partial selling of its electricity production in the second round. And since the bid bond was presented already for the first and second round, there was no additional cost in presenting the same project or a modified version of it in the second round. For example, as there were no offers for biomass energy its demand was supplied through other technologies. Thus, in the second round, the Spanish company Grenergy managed to award two projects of 18MW each. Having a focus on real options ENERSUR could have awarded part of its project and have an option to expand in the following RER auctions.

The case of Grenergy also seems to confirm the use of the ROT approach. Considering Illustration 2 - Characterization of the auction as a sequence of real options, point 10 highlights the option of abandonment, we believe that Grenergy opted for this strategy: if it did not meet the requirements to sign the contract, it would have abandoned one or both of the awarded projects. In order to sign the contract, Grenergy should, among other requirements, form an SPC and subscribe minimum capital of US$ 100,000.00 per MW, a total of US$ 3.6 millions. If Grenergy was not able to sign the contrat it would lose the bid bonds presented.

Grenergy, after the adjudication of its projects, on February 16, 2016, would have to subscribe and pay US$ 3.60 millions until May 17, 2016 to sign the contract and if not lose the bid bonds presented (2x18MW*$50,000=$1,800,000.00). During the investigation, information was found in the *Mercado Alternativo Bursátil de Madrid* that Grenergy Renovables S.A. agreed, on May 9, 2016, to increase its capital by issuing a maximum of 2,072,727 new shares with a price or issue rate of 1.90 euros per share, the effective value of this capital increase being a total of € 3,938,181.30[8].

A good analysis based on real options can lead to better strategies and better decisions. In this case, it is assumed that Grenergy analyzed its decision as a call option for the abandonment of the projects, because even if it did not have the amount to subscribe the required capital for the new SPC, its maximum loss for not signing the contract would be limited to the execution of the bid bonds.

By deferring his decision Grenergy was able to postpone the issuance of shares and do it only when there was enough certainty that the projects were awarded. Other documents illustrate the strategic use of the allocation of projects in Peru to make the issuance of shares more attractive. For example, the Presentation of the Business Plan 2016-2017 was made only on February 23, 2016 and the brochure "*DOCUMENTO DE AMPLIACIÓN REDUCIDO PARA EL MERCADO ALTERNATIVO BURSÁTIL*" where the operation of issuance of shares was made public on March 30 of 2016. Both after the award of the projects and prior to the effective increase of its capital.

PART SEVEN: CONCLUSIONS AND RECOMMENDATIONS

It was demonstrated that a company can, from a base configuration of a project, generate additional configurations and it was possible to identify the elements of a call option (acquisition of a decision right, on a specific date through the payment of a premium) for each one of the stages of the Auction process.

The decisions ENEL took in the last RER auction were modeled through the ROT, these real options were options to defer a decision, because it gave ENEL the right to defer its decision to make the investment if it awarded the project in the auction. It was pointed out that the theoretical price of this call option, from the valuation of the call option over the base

[8] https://www.bolsasymercados.es/MaB/esp/EE/Ficha/GRENERGY_RENOVABLES_ES0105079000.aspx#se_top

configuration of the Nazca Wind Farm project, was greater than the sum of the expected costs of the presentation of eighteen (18) additional configurations of the “original” Nazca Project and their respective bid bonds.

It was observed that the bid bond demanded is low, which can encourage opportunistic behaviors and encourage bidders to assume high risks, presenting projects that have no materiality, which are not robust enough. Once the projects are awarded, just after the results of the auctions, the bidders begin in fact to carry out their studies. That can generate delays and dropouts, because between a negative NPV and losing the bid bonds presented, almost always, it is cheaper to lose them.

For the bidders, the following guidelines are valid:

a) They should always use the binomial model to estimate the implicit volatility of the base configuration of the projects, for later estimation of the theoretical call option price, through the Black & Scholes model and then determine the number of additional configurations that may be presented in the auction;
b) Bidders should always consider the possibility of participating in the second round of the auction, since the price is already "paid", and for each configuration presented, a minimum feasible percentage must be determined, bearing in mind the possibility of a partial award;
c) They must consider also the possibilities of expansion implicit in the projects, especially in the wind projects. As, for example, the hybrid project (solar and wind) of ENEL in Pernambuco / Brazil[9];
d) It is always advantageous to participate in the auctions, since the expected value of the premiums to be paid for the right to decide to sign the concession contract in the case of adjudication is very low. In terms of real otpions, the price of the call option regarding buying the right to decide whether or not to do an investment is not very high.

The analysis of the selected case reveals the existence of sources of value in the business decision other than only the analysis of the expected cash flows, which allow to justify the strategy adopted. The valuation of the option ENEL choosed, to take part in the auction by presenting multiple projects, explains at least in part the rationality of the strategy employed.

[9] http://elperiodicodelaenergia.com/enel-green-power-inaugura-la-primera-central-hibrida-solar-eolica-de-brasil/

As a whole, the evidence collected and analyzed in this work contributes to increase the empirical evidence favorable to the relevance of real options as a source of value in business decisions, expanding the range of cases studied in other sectors.

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