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The Brazilian electricity market: a study on the economic viability of electricity generation in wind farms

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Abstract— **This paper presents a overview on the Brazilian electricity market in recent years and a discussion on the development of renewable energy. We discuss the relevance and economic viability of wind farms to generate electric energy. In order to study the economic viability of Brazilian wind farms, well known for having one of the highest capacity factors in the world, we used the Net Present Value (NPV), Internal Rate of Return (IRR) and Payback calculation methods. The results, considering the sale of carbon credits, indicate a NPV of US$ 42.86 and a IRR of 26.74% with negotiation in the Certified Emission Reductions in the California Carbon Dashboard and indicate a NPV of US$30.50 and a IRR of 21.68% with negotiation the Certified Emission Reductions in the European Emission Allowances, higher than the reference value 13.03%. The Payback calculation indicated the recovery of the invested capital in approximately six to eight years.**

Index Terms— **Renewable energy, Hydropower energy, Wind energy, Biomass energy, Solar energy, Economic viability of wind energy.**

I. INTRODUCTION

The importance of producing increasingly more energy in a society can be explained in the face of constant expansion of world economies and population growth. According to Ban Ki-moom [1], energy allows for economic growth, increasing social equality and promoting prosperity and comfort. Ban Ki-moom also states that access to energy is a necessary pre-condition for achieving development goals and should go beyond the energy sector, to also encompass food security, the drinking water supply, poverty eradication, climate change prevention, health improvement and placing the social, economic and environmental pillars of sustainable development more equally at the center of the decision-making process.

Energy is one of the main inputs to the socio-economic development of a country, and its availability in sufficient quantities and at competitive prices, is a challenge. The global energy matrix is mainly based upon burning fossil fuels such as coal, oil and natural gas. These fuels have been the climate system due to their CO2 emissions.

As a result of the decreasing price of oil in recent years, the energy generated by its combustion became cheaper. However, due to the energy crisis, environmental, economic, political, market, social issues and environmental problems have motivated governments and researchers to develop sources of sustainable and renewable energies to secure energy consumption, protect the environment, and to promote regional development since the global demand for electricity is expected to grow by more than a third by 2035 [2] [3]. In fact, a great effort to reduce the use of fossil fuels, avoiding the increase of global warming and its impacts on climate change took place this last decade [4]. Taking into account the undesirable environmental impacts of the utilization of fossil fuels for electricity generation, the generation of energy from clean, and renewable sources has received special attention, especially water, biomass, wind and solar sources, which are gaining ground worldwide [5], progressively taking a bigger share in the energy matrix. The transition from conventional energy to sustainable systems is an imperative prospect of the 21st century, where industrialized countries must accelerate the transition to low-carbon technologies and developing countries have the opportunity to abandon conventional energy options in favor of clean alternative energy sources that will drive growth and promote economic and social development [1].

The Brazilian energy matrix is predominantly based on renewable sources, mainly hydroelectric plants. Brazil has one of the largest potential for hydroelectric generation in the world, accounting for more than 61% of electricity generation in the country in 2015 [6]. This feature led the country to establish an energy matrix among the cleanest in the world. However, the unfavorable hydrology scenario (due to lack of rain) and environmental and socioeconomic constraints of hydroelectric projects, coupled with technological advances in the use of new renewable sources, have led the Brazilian government to seek to increase the share of non-conventional sources of energy such as wind, biomass and photovoltaics, in planning the expansion of the electricity sector. Figure 1 illustrates the insertion of each source of electricity generation in the country.

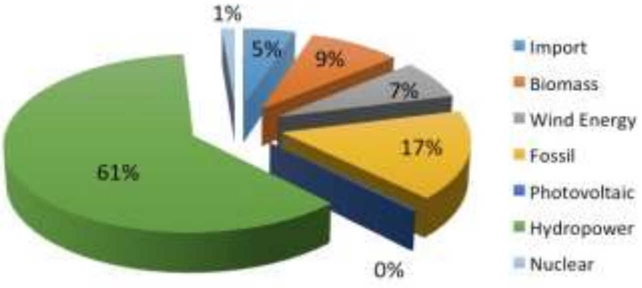

Figure 1. Electrical Power Installed in Brazil. Source: [6].

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The main objective of this paper is to present an economic feasibility analysis of energy generation in a wind farm. For this purpose, the article is organized as follows: in Section 2, we present a brief overview on the Brazilian electricity market, followed by a discussion on the development of renewable energy such as hydropower, wind, biomass and photovoltaics, in Section 3. Section 4 presents the main indicators that influence the economic viability of the project. Section 5 describes the method and presents the results of an economic analysis based on data from an existing wind farm. Section 6 concludes the paper.

II. THE BRAZILIAN ELECTRICITY MARKET

Brazil has 4.752 plants in operation, amounting to 155.561 MW of energy generation capacity connected to the national grid in November 2017. Approximately 61% of the total comes from hydroelectric plants. An additional amount of 21.549 MW of energy generation capacity will soon be available in the country from the 240 plants currently under construction and another 548 ongoing projects with construction not started but planned for the near future [6]. In April of 2017 the Brazilian consumption for energy was 39.167 MWh, have a decline of 2.3% over 2016. This decrease was primarily verified by a drop in industrial and residential consumption due to the unfavorable scenario of industrial activities and influenced by high rates throughout the year. This represents the lowest growth rate since 2009 [7]. Figure 2 shows the growth rates in the Brazilian electric energy consumption in the 2009 - 2015 period.

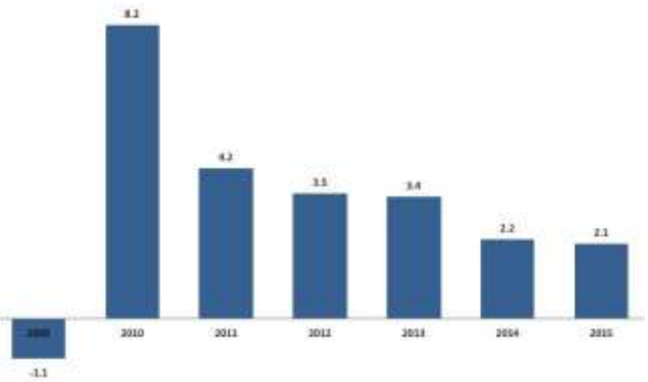

Figure 2. Growth rates of the Brazilian Electric Energy Consumption in the period of 2009–2015. Source: [7], [8], [9].

In the current context, in which countries around the world are seeking alternatives to reduce emissions of greenhouse gases, Brazil will face the challenge to both increase the electricity supply to meet demand and reduce the environmental impacts of energy production. According to the Generation Information Bank (BIG) [6], about 18,4% of the total installed capacity of electric energy generation is based on alternative renewable energy sources such as wind, photovoltaics, biomass and small hydroelectric plants (PCHs). Conventional sources such as hydroelectric, nuclear and thermoelectric – powered by natural gas, diesel oil, charcoal and fuel oil – correspond to 81,6%. Figure 3 illustrates the installed capacity for different generation sources in 2013 and projections for 2017 and 2023 [6].

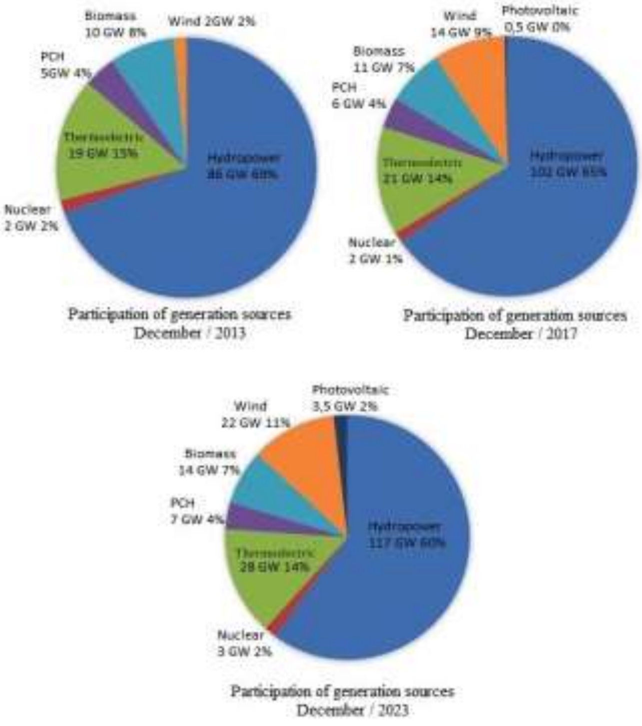

Figure 3. Evolution of installed capacity per power generation in Brazil. Source: [10].

The planned expansion is composed of indicative projects whose studies are being concluded. According to ANEEL [6], the planned expansion will only be achieved by obtaining environmental licenses, which would enable the participation of the plants listed in the power purchase auctions originating from new enterprises, provided by law. Considering the planned expansion scenario and the energy that has already been hired, as shown in Figure 4, we can observe that it is mainly based on renewable sources with complementary power plants powered by natural gas.

Figure 4. Annual increase of installed capacity, by source, in Brazil. Source: [10]

This complementation depends on the availability of natural gas, its viability and the competitiveness of the enterprises. If the natural gas is not available or cannot fulfill the total demand, other energy sources such as coal can be used to meet the quota.

III. RENEWABLE ENERGY PRODUCTION IN BRAZIL

Following a worldwide trend, due to concerns with the environment and issues such as the inevitable scarcity of fossil fuels such as coal, natural gas and oil, Brazil has, in recent years, diversified its energy matrix by investing in new electric power sources.

The Brazilian electric system is mainly comprised of renewable energy sources, but has been experiencing serious energy problems due to the lack of water in hydroelectric plants. Some reservoirs are at such a low volume level that energy production is made impossible, which requires the activation of thermoelectric plants, that, in 2014 and mid 2015, operated at their maximum capacity to compensate for the problems in hydroelectric plants. Today, the thermoelectric plants serve as a complementary source to hydroelectric plants. They are activated to ensure the supply when the water tanks are at a low level, thus increasing the use of fossil fuels. In addition to the negative environmental aspect, the cost of heat energy can be significantly higher, depending on the efficiency of the thermal unit. A solution for Brazil is to develop additional offer alternatives that are, preferably, based upon clean generation sources. Investments are being made on wind farms, biomass – particularly on cogeneration with sugarcane bagasse (bioelectricity) – and photovoltaics as complementary sources to hydropower.

A. *Hydropower energy*

The participation of hydropower in the world energy matrix is not significant – between 1973 and 2012, the share of hydropower in the total energy production in the world increased from 1,8% to 2,4% [11].

In Brazil, hydroelectric was the source with the highest installed capacity in the energy matrix, however, its participation has retreated due to the construction of power plants based on other sources of energy such as wind and thermal power plants fueled by natural gas and biomass, as they perform at a higher rate than that observed in hydroelectric plants.

In March 2015, according to data [12], hydroelectric plants produced 44.504 MW, demonstrating a decrease of 13% compared to the same month in 2014. In 2016 hydroelectric plants grew 9,4% compared to March 2015. Put together, hydroelectric and small hydroelectric plants (PCHs) recovered their representation, generating 80.2% of power in the country in the early days of March, but this is still 4,43% lower than the index recorded in 2014. This decrease was matched by an increase in thermal generation, especially derived from natural gas, which expanded to 25,59 % in March 2015, recording an increase in its participation in the energy matrix and an increase in wind generation. In 2016, data shows a 37% increase in electric generation by wind plants and 21% by biomass plants [6], [12], [13].

According to [6], the electric energy production from water stems from 430 Small Hydropower Plants with 4.969 MW of installed capacity, 620 Hydropower Generating Plants with 463.107 MW of installed capacity and 219 Hydroelectric Plants with 101.188 MW of generating capacity.

It is important to mention that the reductions in the energy sector took place due to problems like the climate, but also to the decrease verified in Brazilian industrial production last year [14].

B. *Biomass energy*

The Brazilian government has adopted incentive policies towards thermal production fueled by biomass (which utilizes the waste derived from sugar cane, black liquor and others) as an alternative for the expansion of renewable energy sources in the energy matrix, in order to meet the future energy demand in Brazil. According to the Generation Information Bank (BIG) [6], the thermal production fueled by biomass had a significant growth in the energy matrix; its installed capacity is about 9%, deriving from 537 plants. However, according to the InfoMercado Semanal, a weekly newsletter published by the Electricity Trading Chamber (CCEE) [13], the electricity production from biomass registered, in January 2017, a 35% growth in comparison to the previous year. Table 1 presents installed capacity by fuel type.

Table 1. Installed power Biomass. Source: [6].

Fuel	Number of plants	Power MW	(%)
Bagasse Sugar Cane	397	11.111.035	75.29
Biogas-AGR	3	1.822	0.01
Elephant Grass	3	65.700	0.45
Rice husk	12	45.333	0.31
Ethanol	1	320	2.17
Vegetable Oils	2	4.350	0.03
Vegetable Coal	7	41.197	0.28
Biomass	10	114.265	0.77
Firewood	3	15.650	0.11
Black Liquor	18	2.542.616	17.18
Forest Residues	50	404.270	2.73
Biogas - RA	13	4.439	0.03
Biogas - RU	17	122.250	0.83
Coal - RU	1	2.700	0.02
Total	537	14.795.627	100.0

C. *Biomass energy*

Wind energy is expanding rapidly in Brazil. For the past eight years, it has been the fastest growing energy source in participation in energy auctions, contributing to approximately 6,03% of all electric energy capacity in the country. It accounts for 482 wind farms with 11.880 MW of acknowledged power, 136 wind farms under construction with 3.086 MW of acknowledged power and other 126 wind farms with 2.743 MW of acknowledged power whose construction has not yet started [6]. Low prices in auctions grants wind energy with a great competitive edge, contributing to its successful insertion, consolidation and sustainability in the Brazilian energy matrix. Figure 6 shows the price of wind energy hired in auctions in the 2009 - 2015 period (with reference to the Central Bank of Brazil exchange rate on April 18th, 2012, of 1US$ = 3.5972 BRL).

According to the Generation Information Bank (BIG) [6], Brazil has 418.325 (MW) of installed capacity for electricity generation, wherein photovoltaic generation is equivalent to 0.25% of the total, but with prospects of growth.

In December 2013, the State of Pernambuco held an auction regarding solar energy. Six projects were hired with 122 MW of total power, with an average price of US$ 108.35 MWh. It is also worth mentioning the Reserve Energy Auction 2014 (LER 2014), which included a specific product for solar energy, meaning this source did not compete with others. The LER 2014 registered 400 photovoltaic generation projects that corresponded to 10.790 MW of power. Thirty-one enterprises were hired, which amounted to 889,7 MW of power and a 202,3 MW average of assured power, at an average price of US$ 101.95 MWh [15].

In 2015, 30 solar photovoltaic power generation projects were hired, totaling an installed capacity of 1.043 MW, hired on the 1st Reserve Energy Auction in 2015, with an average price of US$ 143.03 MWh [16] and 32 projects hired on the 2nd Reserve Energy Auction, representing 929,3 MW of enabled power. The average selling price of photovoltaics on the 2nd LER/2015 was US$ 141.11 MWh, ranging from US$ 137.44 to US$ 143.55 MWh, representing, on average, a discount of 21,9 % compared to the upper limit price of US$ 180.57 MWh [17]. Figure 5 shows the photovoltaic projects that succeeded at the LER/2014, 1st LER/2015 and 2nd LER/2015 auctions.

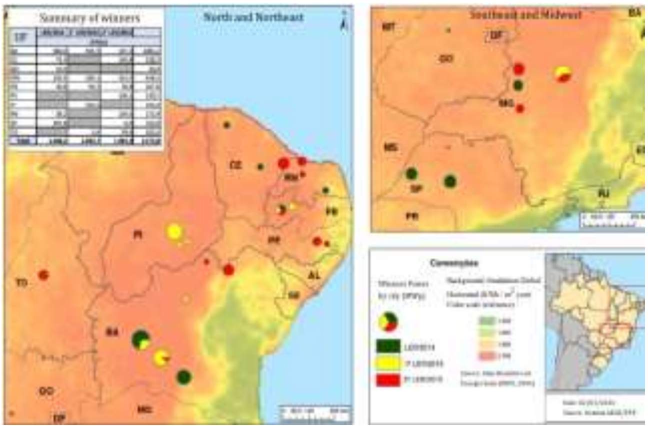

Figure 5. Photovoltaic projects winners on the 2nd LER/2015. Source: [17].

Even though the photovoltaic energy market in Brazil does not emerge as a competitive energy source, it is expected that auctions (beginning in 2013 and more strongly in 2014) will signal towards hiring the photovoltaic energy, as a means to diversify the national energy matrix.

According to [18], there is an estimate that the Brazilian market will reach more than 1 GW of installed capacity in the near futuro, being propelled by regulatory mechanisms such as ANEEL's normative Resolution No. 482, since the country presents an increasing demand for electricity and presents elevated levels of solar irradiance.

D. *Wind energy*

Wind energy is expanding rapidly in Brazil. For the past eight years, it has been the fastest growing energy source in participation in energy auctions, contributing to approximately 6,03% of all electric energy capacity in the country. It accounts for 482 wind farms with 11.880 MW of acknowledged power, 136 wind farms under construction with 3.086 MW of acknowledged power and other 126 wind farms with 2.743 MW of acknowledged power whose construction has not yet started [6]. Low prices in auctions grants wind energy with a great competitive edge, contributing to its successful insertion, consolidation and sustainability in the Brazilian energy matrix. Figure 6 shows the price of wind energy hired in auctions in the 2009 - 2015 period (with reference to the Central Bank of Brazil exchange rate on April 18th, 2012, of 1US$ = 3.5972 BRL).

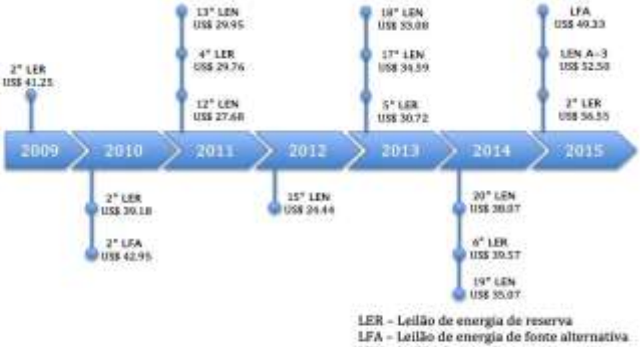

Figure 6. MWh price for wind energy contracted in auctions between 2009 and 2015. Source: [19].

In 2016, the Energy Research Enterprise (EPE) approved 802 projects for the A-5 Auction 2016, scheduled for the month of April, which will hire electric energy to be supplied from 2021 forward. In total, there will be 29.628 MW of installed capacity offered from various sources – wind being the main generating source, with 17.131 MW stemming from 693 projects. According to [20], Brazil produces the most competitive wind energy in the world and the Brazilian market is the second most competitive source, only behind grand hydroelectric endeavors.

IV. ECONOMIC FEASIBILITY ANALYSIS OF WIND ENERGY GENERATION

An analysis of the economic feasibility is essential to determine whether the installation project for a wind farm is economically viable. The investigated scenario refers to the Santana do Livramento Wind Farm Complex, which encompasses 5 wind energy generation units with 39 wind turbines (WTs). Altogether, the generation units have a nominal installation capacity of 78 MW. Table 2 presents the characteristics of the investigated scenario.

Table 2. Investigated wind farm scenario.

Characteristics	
2 MW generation units	39 WTs
Installed capacity [MW]	78
Capacity factor [%]	46.8
Annual energy generation [MWh]	319.771

A. *Input data*

The wind farm data was obtained through the Project Design Document and Validation Report, issued by the United Nations Framework Convention on Climate Change (UNFCCC, 2012) [21], as well as the Brazilian Development Bank (BNDS), in Brazilian currency (R$ or BRL), with reference to the Central Bank of Brazil exchange rate on December 3rd, 2012, of 1US$ = 2.11 BRL.

The project's investment costs include the supply of goods and services, land lease, topography study, execution of civil works, substation construction, transportation and installation of turbines, transmission lines, tax payments, among others. The main indicators that influence the economic feasibility of a wind farm are the investment costs, the price of electricity, the cost of transmission and the costs of operation and maintenance.

The price of electricity considered in the analysis originates from the results of the 2011 A-3 Energy Auction [22]. Considering the average of the whole complex of the wind farm, the price of electricity is equivalent to US$ 45.79 / MWh, and adjusted annually by the Extended National Consumer Price Index (IPCA). The Transmission System Usage Rate (TUST) cost, which refers to costs in the transmission of energy in the network, were obtained from the Approval Resolution No. 1.179, issued on July 18th 2011 [23]. The fee is charged over the installed power. Due to the fact that the project complies with law No. 9.427 (December 26th 1996) [24], which states that the power inserted in the transmission network should be inferior or equal to 30 MW, ANEEL will apply a reduction percentage not inferior to 50% to be applied to the TUST.

It is noteworthy that the facilities of the Santa do Livramento wind complex, our object of study, are comprised of five plants with 10, 12, 24, 8 and 24 MW, totaling 78 MW of installed capacity, in accordance with the aforementioned law.

As for the operation and maintenance costs (O&M), the costs are different – in the first five years of the project execution, with new equipment, the O&M costs for this project are 8.524 US$/MW/year. For the next five years, the 6th to 10th years, the cost amounts to 39.111 US$/MW/year. For the next 10 years, the O&M costs add up to 43.022 US$/MW/year [21]. Table 3 details the investments on the wind farm.

Table 3. Total investment for the scenarios.

Category	Scenario investment [US$]
Generation units	87.295.169
Extended warranty - 5 years	3.509.353
Supply of goods and services	28.323.999
TOTAL	119.128.522

To conduct the economic simulation and to calculate the Deterministic cash flow, other inputs are needed, as well as the ones obtained from [21] and presented on Table 4.

Table 4. Common input data for scenarios.

Input	Value
Credit [%]	63.50
Equity [%]	36.50
Land rent cost [% of income]	1.0
Electricity sales price [US$/MWh]	45.79
PIS/PASEP, COFINS [% of income]	3.65
Interest rate [% a.a.]	5.5
Financing years	16
TUST (2012) [US$//kW]	3.157
TUST (2013) [US$//kW]	3.157
TUST (2014) [US$//kW]	3.061
TUST (2015) [US$//kW]	2.966
TUST (2016) [US$//kW]	2.870
TUST (2017) [US$//kW]	2.775
TUST (2018) [US$//kW]	2.680
TUST (2019) [US$//kW]	2.585
Inflation rate [%]	6.5

The viability analysis assumes that the project's annual inflation is constantly at 6,5% year. The acronyms PIS/PASEP and COFINS are national taxes, and TUST stands for the Transmission System Usage Rate for electric energy. The construction period for this project is three years. After this period, the project will last 20 years.

V. METHODS

Deterministically, a project's economic viability is determined by its capacity to generate benefits, that is, after a period of time, the project's cash flow must present a positive amount. That is one of the conditions for the project's execution. Amongst the usual deterministic assessment techniques, we utilized the following: Net Present Value (NPV), Internal Rate of Return (IRR) and Payback.

The NPV is the most employed method to analyze the economic viability of an investment, for it considers the value of the investment by measuring the present value of cash flows during the lifetime of the project. The criterion for project acceptance is a positive NPV. In this case, the invested capital can be recovered and remunerated to an interest rate higher than the cost of the capital. The project's value is calculated according to equation 1.

$$VPL = \sum_{t=1}^{T} \frac{E[FC_t]}{(1+k)^t} - I \qquad (1)$$

Where:

FC is the net cash flow for each time period t,
I is total initial investment costs
T is the total number of periods,
k is the discount rate (rate of return that could be obtained with the investment), 233 **t = 1**, **2**, . . . , **20** number of time periods.

The internal rate of return method (IRR) displays the expectation of return of the invested capital; it is the rate which relates the invested amount with the redeemed amount in the end of the investment. This method will be compared with the reference value (Benchmark). To calculate the benchmark in energy sector companies, we used the Capital Assets Pricing Model (CAPM), developed by [25] and widely utilized in the financial area. The (k_e) was calculated according to equation 2.

$$k_e = R_f + \beta(R_m - R_f) \qquad (2)$$

$\mathbf{k_e}$ is the expected return of the asset i.
$\mathbf{R_f}$ is the return of the risk-free asset.
β is the investment risk of an asset compared to the market, that is, the variance of the return of the asset i with the market return divided by the variance of the market return.
$\mathbf{R_m} - \mathbf{R_f}$ is the expected return on a risky asset (Market Return) less the rate of return on risk-free asset (risk premium).

Taking into account the presented input data, the reference analysis results are shown in Table 5, the resulting rate of return being k_e = 13.03 % a.a. We will use this value as reference to assess the project's additionality for the studied wind plant scenario. If the calculated IRR is inferior to the reference value, the project should be rejected.

We also used the Payback method in the analysis, because it can provide the investor with an idea of when the value of the investment will be recovered. When analyzing the performance of a wind farm, one should design the project's future cash flow that, in this case, will be considered discounted cash flow.

Table 5. Benchmark analysis.

Year	R_f(%)	Months	β	R_m %	R_m -R_f
2014 Jan/Feb	6.76	2	0.35	30.08	23.32
2013Jan–Dec	5.07	12		-22.10	- 27.18
2012Jan–Dec	4.60	12		-4.07	-8.67
2011Jan–Dec	5.84	12		69.05	63.20
2010Jan–Dec	6.13	12		8.91	2.78
2009 MarDec	6.60	5		90.73	84.12
Average	5.65	–		–	20.83
ke	13.03 %				
We	36.50 %				
Wd	63.50 %				

VI. RESULTS

In conducting an economic simulation with annual resolution, we have analyzed the probability of the NPV to be lower than zero and the IRR to be less than the reference value. The results are presented in Table 6. By the rule of NPV, the project would be accepted, as the net present value is positive. By analyzing the IRR on equity, it can be concluded that the wind plant project, has an indicator of IRR = 12.79% per year, less favorable than the reference value of 13.03 % per year.

The analysis is also based upon the sale of carbon credits. The purchase of carbon credit generated by alternative sources – such as wind power, biomass, photovoltaics and others – is utilized by developed countries to meet specific CO2 emission reduction targets. It is also a means to ensure economic visibility of Brazilian projects.

The analysis results, considering the sale of carbon credits, increased the NPV to 42.86 US$ and the IRR to 26.74% per year with the marketing in the California Carbon Dashboard with a Payback of six years and seven months, increasing the NPV to 30.50 US$ and the IRR to 21.68% per year with the marketing in the European Emission Allowances with a payback period of eight years and six months.

Table 6. Feasibility analysis using the net present value, internal rate of return and payback period.

Criterion	Method of economic simulation		
	NPV(US$)	IRR %	Payback
Feasibility analysis without the carbon credit negotiation	3.05	12.79	20.2
Feasibility analysis with carbon credit negotiation - California Carbon in January 05 of 2016 (US$ 13.20)	42.86	26.74	6.7
Feasibility analysis with carbon credit negotiation - European Emission Allowances in January 05 of 2016 (EUR 8.00)	30.5	21.68	8.6

We have concluded that the investment analysis provides valid arguments in favor of the project's additionality, since the project's activity with the sale of carbon credit is likely to be economically or financially attractive. This conclusion is supported by:

- The project's IRR without CER incentives is lower than the reference index (13.03% per year); therefore, the project is not attractive;
- The higher the CER incentive (price), the larger the impact on the project's NPV and IRR. Table 7 presents the negotiated CER prices between 2012 and 2016.
- In the analysis, the variables that have the most impact on the project's IRR were the CER prices in the years of 2013 and 2012, when the IRR increased to, respectively, 30.83% per year and 29.54% per year, negotiated in the California Carbon Dashboard. In 2016, the IRR remained at 21.86%, negotiated in the European Emission Allowances. Table 8 presents the complete IRR analysis for each year.

Table 7. Price in US$/EUR/tCO2.

Year	2012	2013	2014	2015	2016
CaliforniaCarbon Bashboard (Price in 05 January)	15.30	16.25	12.08	13.02	13.20
European Emission Allowances (Price in 05 January)	6.50	4.59	4.73	6.91	8.00

Table 8. Internal Rate Of Return (%) with negotiation the Certified Emission Reductions.

Year	2012	2013	2014	2015	2016
California Carbon Dashboard	15.30	16.25	12.08	13.02	13.20
Internal Rate Of Return (%)	29.54	30.83	25.30	26.51	26.74
European Emission Allowances	6.50	4.59	4.73	6.91	8.00
Internal Rate Of Return (%)	19.75	17.47	17.63	20.27	21.68

VII. CONCLUSION

Brazil has aimed to expand its energetic matrix through energy generation stemming from non-conventional sources. In recent years, energy sources such as wind power, biomass and photovoltaics have presented an expressive growth in the energy system expansion, resulting in technological development advancements. The investments in such sources were propelled by the implantation of energy auctions. In an economic analysis, the obtained results agree with the results of various projects that are registered in the Clean Development Mechanism (CDM), a specific method for electric energy generation projects connected to the net through renewable sources. According to the tool for the demonstration and assessment of additionality, the project would not be economically viable without the sale of carbon credit. Although, when the carbon credit is negotiated along with the energy sales, the project becomes economically attractive. It is believed that part of the environmental impacts due to the use of fossil fuels will be mitigated through the use of renewable sources and that, in the future, CO2 emissions will be monetized. On the results of the analysis of economic viability, it is worth noticing that the bigger the amount of carbon credit negotiated, the more attractive is the project.

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