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CHALLENGES FOR THE OPTIMAL USES OF WIND POWER IN BRAZIL

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Introduction

The strong economic growth that Brazil has had in recent years demands a supply of electricity in the same proportions, making it necessary to increase the development of renewable energy.

Brazil took an important step toward regulating renewable sources through the Incentive Program for Alternative Sources of Energy (PROINFA), enacting Decree No. 5,025, 2004, providing 1,422 MW of wind power. Although considered a pioneering program, prompting the deployment of equipment for wind farms utilities in Brazil, it has failed to meet the targets set[1].

The technological advancement represented by the gain scale of generating equipment led to reduced costs of industrial wind farms, which gained competitiveness. You can see this evidence analyzing the results of the Alternative Source Auction (LFA) and Reserve 2010, where contractors were 2,047.4 MW. This result indicates a greater participation of wind energy in the energy matrix in the coming years, given the average price of electricity sold in those auctions (R $ 130.86 / MWh).

Thus, this paper aims to evaluate the use of wind power in this new scenario of low wind power price, since unlike what happens with hydroelectric potential, wind potential by law. Although if it involves maps of wind potential, as the Brazilian Wind Potential Atlas[2], these maps are not intended to establish the locations of future development areas. They are derived from studies conducted for a macro-region across the board, unlike the study inventory stretches of river basins, where the location of hydroelectric dams, and its potential, are established with a precision.

[1] Up to April 2011, only 902.43 MW were in commercial operation, which represents 62.43% of the amount provided. This perspective is worse considering that all plants should have entered into commercial operation until December, 2008.

[2] http://www.cresesb.cepel.br/index.php?link=/atlas_eolico_brasil/atlas.htm

On the other hand, there are economic signs that may distort the maximum possible use of a wind farms, as the limitation of 30 MW of power plants injected into the transmission grid. As an example, law No.10,848, 2004, established 30 MW (energy injected on the grid) the upper limit for a unit to get the TUSD and TUST incentives. Because of this limitation the companies avoid constructing units with total potential of energy bigger than this limit. They will instead dividing this potential into smaller units. This is a detriment to the economy of scale, favoring the existence of gaps between the units, reducing the total exploitable potential.

Another important point presented on this paper refers to the regulation of other countries regarding the geographical location of wind farms bidding. Although the Brazilian model has been established well in the market, other models may help Brazil to improve the wind power market using the unexploitable potential, which may represent an increase supply of energy in the future.

In this way, I will present the purpose and goals of wind power generation and comment on the development of Wind Power Plants in Brazil. I will evaluate if the economic signs given to wind power generators within the regulatory issues will help to maximize the wind power generation or not, considering the concept of "optimum utilization" of the wind.

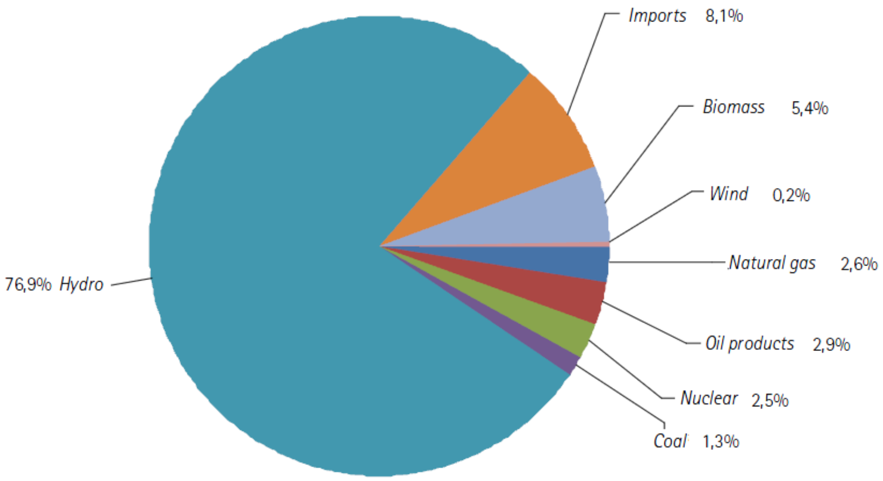
Chapter 1 - Brazilian Wind Power Potential

The purpose of this chapter is to describe the Brazilian Energy Matrix, the expansion of power generation according to the government planning, and the contribution of wind power generation in this process. I will show where wind farms are located in some regions in Brazil, associating this data with the Brazilian Wind Power Atlas (CEPEL).

1.1. Brazilian Energy Matrix

According to Energy Research Company – EPE [01], the Brazilian electricity generation matrix has predominance of renewable sources, especially hydropower which answers for more than 76% of total domestic supply, as shown in Chart 01. Adding electricity imports, which also come essentially from renewable sources, it can be stated that nearly 85% of the electricity supply in Brazil originates from renewable sources – even without taking into account that part of the thermal generation that comes from biomass.

Chart 01: Domestic Electricity Supply by Source – 2009.



Source: BRAZILIAN ENERGY BALANCE 12 2010 | year 2009, Chart 1.1.1.

The Brazilian wind potential has been the subject of studies and inventories since the 1970s. In 2001 was published by CEPEL the "Brazilian Wind Potential Atlas" [4], which is considered the first work that presented data for the survey of wind power in Brazil, with information on wind quality for use in wind generation projects in greater numbers and with greater reliability, and today is a benchmark for scholars in wind, estimating potential wind power that is available in the order of 143 GW[3], as shown in Chart 02.

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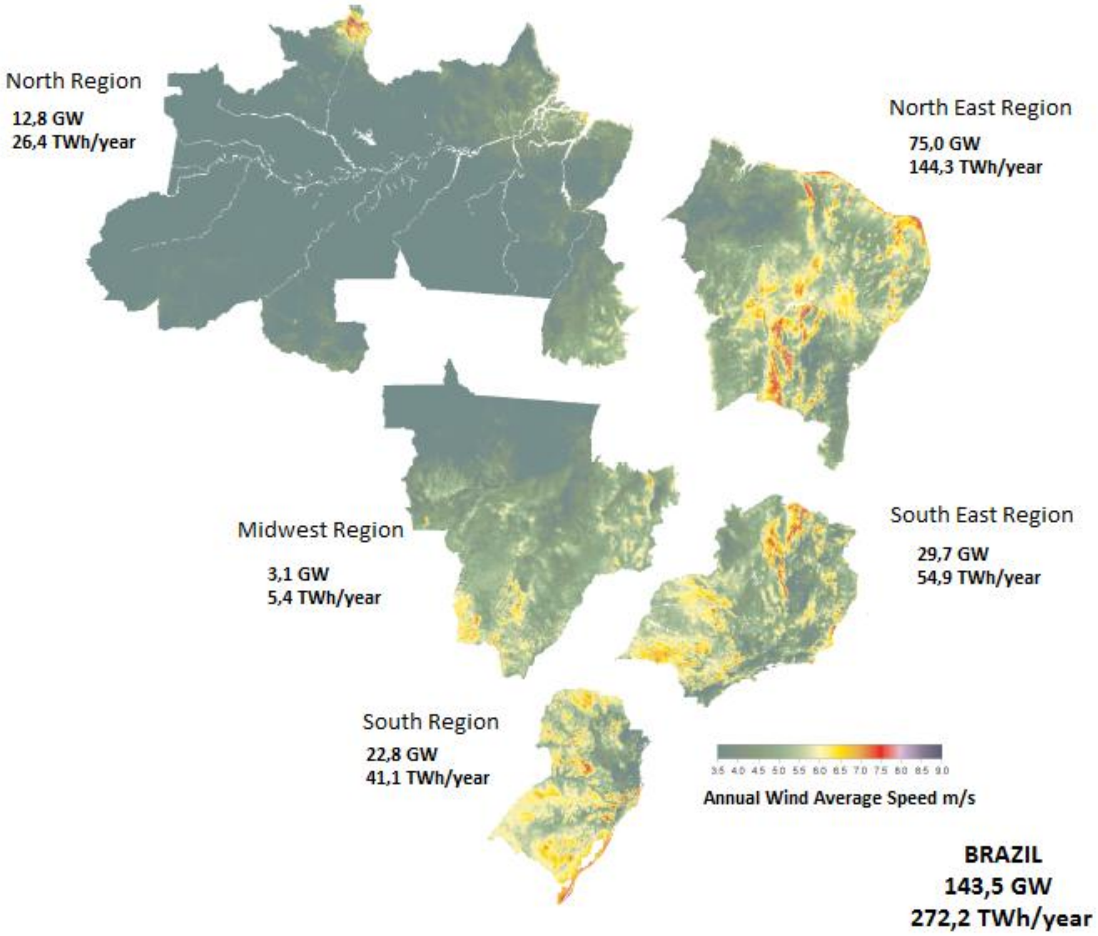
[3] This study adopted as its assumptions: i) consideration of all the areas that had annual average speeds equal to or greater than 6 m / s ii) consideration of mean performance curves of turbines 50 meters in

Chart 02: Estimated Wind Power Potential



Source: Brazilian Wind Atlas: Figure 5.1 - Potential wind estimated average annual wind less than 7.0 m/s.

1.2. Expansion of the generation of electricity and the contribution of the renewable sources.

According to the Ten Year Plan for Energy Expansion by the Energy Research Enterprise (EPE) [2], the percentage share of all renewable energy sources (hydro, wind, ethanol, biomass, etc.) will increase in the Brazilian energy matrix in the next ten years. The presence of these resources, which totaled 44.8% in 2010, will reach 46.3% in 2020, according to the most recent cycle of the Ten Year Plan for Expansion of Energy - PDE.

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height, iii) specific characteristics of roughness of ground; iv) other properties of the study presented in the wind Atlas.

The president of EPE, Mauricio Tolmasquim, said the uses of renewable sources allow Brazil to keep its position as the mother country of the cleanest energy matrix in the world. "Because of the potential oil export and the stability of its institutions, the country will increasingly be collated by the major world economies as a strategic partner for energy supply," notes Tolmasquim [2].

On the other hand, analyzing the issue in terms of demand, the installed capacity in the National Interconnected System - SIN should evolve from about 110,000 MW in December 2010 to 171,000 MW in December 2020 with the prioritization of these sources. EPE highlights that even prioritizing the expansion of supply through dams, the supply might not be sufficient to meet the demand for energy in the study's horizon (2030). This picture indicates, in a sense, a perspective of long-term depletion of the national hydroelectric potential.

Added to this framework the issues of social and environmental concerns, the natural conclusion is that there is, in fact, the current technological conditions and regulatory constraints that represents objectives for the development of Brazilian hydroelectric potential. In the present context, the social and environmental concerns related to global warming, emission of greenhouse gases and sustainable development has beginning to grow.

Thus, if the country wishes to maintain its clean energy matrix, it is necessary to promote public policies that foster a favorable environment for development projects that use alternative energy sources, assuming that other renewable sources make up this expansion. On the one hand EPE estimates the reduction in the hydroelectric share of 76% to 67%, and wind energy generation will be featured, increasing from 1% to 7%. As a result, the share of renewable sources will remain at around 83% at the end of the decade.

It is precisely here that the wind, despite its recognized potential to be explored, has not received due recognition for the strategic expansion of national generation of wind energy. The “National Energy Matrix Study 2030” [3], prepared by the Ministry of Mines and Energy (MME) noted that in the case of wind farms, it should be recognized that the effort to reduce the investment cost does not confer economic competitiveness of this alternative at the time, so that consideration would need to maintain the incentive mechanisms.

In this respect, it should be recognized that the new planning horizon EPE sees the expansion of wind generation to 7% of Brazil's energy mix.

1.3. Uses of the Brazilian Wind Power Potential

As the database of the National Electric Energy Agency – ANEEL has found, the share of generation from wind energy is 1,060 MW, representing approximately 0.90% of installed capacity in Brazil. When we consider only those enterprises that are under construction, the percentage is 6.28%, corresponding to 876 MW. When considering plants that are not yet granted their construction, this percentage rises to 10.70%, representing 4,000 MW[4].

If we consider that all the power granted was in commercial operation, the wind power already represents 3.57%, as noted in Table 01.

Units / Source	Wind Power Plants (MW)	Total Power Plants (MW)	Units	(%)
In operation	**114,573**	**1,036**	**54**	**0.90**
Under construction	**13,952**	**876**	**32**	**6.28**
Projects	**37,479**	**4,011**	**127**	**10.70**
Total	**166,004**	**5,923**	**213**	**3.57**

Source: ANEEL's database, July, 2011.

4 http://www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.asp

Observe that the great predominance of projects awarded in the northeast is justified by the fact that this region account for nearly 50% of all Brazilian wind potential (Chart 02).

As we shall see in later chapters, the development of these projects are made possible by the competitiveness of wind power generation in the current Brazilian scenario, as well as mechanisms for regulating the electricity sector, either through heavy subsidies, or by auctioning the specific sources of alternative energy.

However, through geo-referenced information of ANEEL[5], it's clear the existence of a spread of wind farms in these areas, distant from each other, is preventing the full exploitation of wind resources. For technical and regulatory issues, units must prove that they do not interfere with nearby parking lots to be granted a license, and therefore, forcing the entrepreneurs to choose distant areas to construct new units. In the long term, the current model will provide the existence of untapped areas of these units, and wind power will be wasted.

We present maps for comparison with the georeferencing of wind farms granted in various scales, from the map 1:32,000,000 "Wind Farms - Brazil up to 1:1,000,000 map" Zoom New South Wales Coast "(Annex 01). These maps show the dispersion of wind projects granted in the states of Ceará and Rio Grande do Norte (Northeast region) and Rio Grande do Sul (Southern Region), which according to the Brazilian Wind Atlas CEPEL are the regions of greatest wind potential. Remember the warning of this situation and proposals to mitigate its impact are the focus of this paper.

The location data of the units are simplified, presented through a single point for the wind farm, rather than acknowledge on show the full area. Some enterprises have hundreds of meters or even a few kilometers, but still fairly distant from each other. Thus, these maps are important to contextualize the problem.

[5] http://sigel.aneel.gov.br/

Chapter 2 - Regulatory Policy

2.1. Regulatory Framework

In 1995 the Brazilian Congress enacted the Laws No.8,987 and No.9,074, which collectively establish the procedures for concessions and permissions of public services, provided for in art. 175 of the Federal Constitution[6].These laws also establish the standards for granting licenses and extension of these concessions and permissions. This new regulatory framework has enabled the Federal Government to transfer to the private sector, public services previously provided directly by the state through concessions.

This model provided an increase in competition in the Brazilian electric sector activity mainly in power generation, since the generation activity is not characterized as a natural monopoly, unlike what occurs in the transmission and distribution activities. It was instituted the figure of the Independent Power Producer (IPP), a private entity that could provide electric utilities, whose competition through tariff is set at the lowest price, at their own risk, for a specified period established in long-term contracts.

Law No.9,427, 1996, regulated by Decree No.2,335, 1997, established the National Agency of Electric Energy (ANEEL) for the purpose of regulating and supervising the production, transmission, distribution and market electric power in accordance with the policies and guidelines of the federal government.

Law No.9,648, 1998, contributed to the restructuring and growth of the Brazilian electric sector. Among the most important points is the implementation of free negotiation market of electricity, the Wholesale Electric Energy Market (MAE), in order to facilitate the commercialization of energy in the interconnected system. This law also established the Independent System Operator (ONS), to coordinate the supervision, control and operation of the Brazilian electric system, as the centralized dispatch of large projects and monitoring the balance between supply and demand of energy.

[6] Art. 175. It is incumbency of the public power, according to the law, directly or through concession or permission, always through public tender, the provision of public services.

Law No.10,438, 2002, also contributed to the maturing of the Brazilian regulatory framework, highlighting two main points. First, this law established the Energy Development Account (CDE), with the power to confer more competitive alternative energy sources, promoting the universalization of electric services and secure resources through economic subsidies, reducing tariffs for people of low income.

Secondly the establishment of the “Program to Encourage Alternative Energy Sources” (PROINFA), considered a milestone in the expansion of renewable biomass, small hydro plants (PCH) and wind power. PROINFA was regulated on 2004, by Decree No.5,025.

On 2004, through Law 10,848, the current model of the electricity sector was put into practice. This new model established new rules for energy commercialization, defining both free and regulated markets (ACL and ACR), which is now regulated through contracts managed by the Chamber of Electrical Energy Commercialization (CCEE), which succeeded the MAE.

This law changed art. 2 of the Law No.9,478, 1997, which established the National Energy Policy and the Oil Law, signaling the need for long-term planning to determine future energy demand. With a better prediction of this demand, the bid could promote the granting of enterprises that are considered important in serving the public interest[7].

On August 16, 2004, Decree No.8,184 was published creating the Energy Research Enterprise (EPE), which aims to provide services to carry out studies and research to support the planning of the energy sector, such as electricity, oil and natural gas and its derivatives, coal, renewable energy sources and energy efficiency.

[7] Art. 10 of Law No.10,848/2004 changed the art. 2 of the Law No.9,478, 1997, including the following device: “VI - suggest the adoption of necessary acts to ensure compliance with the national demand for electricity, considering the planning of long, medium and short term and **may indicate that enterprises should have priority bidding and implementation, in view of its strategic and public interest** so that such projects will ensure the optimization of the binomial low tariffs and Electric System reliability "(emphasis added).

Within delegation of powers of the Federal Government, ANEEL should authorize the installation of generation projects in the ACL, as well as manage the authorizations of units that bid in the ACR. Specifically, for the wind power projects, the only legal instrument to regulate them after their license were given is the Normative Resolution No. 391, 2009.

Thus, the electric sector regulatory framework is established as follows: MME prepare a strategic assessment of long-term scenarios of energy supply and demand supported by studies of EPE, ensuring energy supply through auctions. These auctions are operationalized by ANEEL, permitting the private sector to generate activity through concessions or authorizations (ACR), regulated by contracts.

It is also possible that the entrepreneur sells power at your own risk in the ACL, through bilateral contracts with free buyers. In this case the generation activity is regulated by ANEEL through authorization. In both cases, the supervision, operation and control of the Brazilian electric system is carried out by the ONS.

2.2 The Constitutional conception of "optimum uses" for hydro potential and a limited comparison to wind power generation.

Art. 176 of the Brazilian Federal Constitution states that the hydraulic potential is owned by the Union, and may grant permission to the concessionaire the right to exploit this potential. In this case, the government defines the optimal potential the entrepreneurs have to generate (output), according to technical studies previously done or approved by the government (input)[8].

To regulate the proper use of this use by authorized dealers and generation, art. 5 of Law No. 9,074, 1995 introduced the concept of optimum use as: "an optimum project is considered as being all hydro-power production facilities whose global conception is defined by the best dam-line, general physical arrangements, operating water-levels, reservoir and bulk power, forming part of the alternative selected for dividing a drop in a river basin".

[8] Art. 176. Mineral deposits, under exploitation or not, and other mineral resources and the hydraulic energy potentials form, for the purpose of exploitation or utilization, a property separate from that of the soil and belong to the Union, the concessionaire being guaranteed the ownership of the mined product.

Within the energy sector, there is no other option to the Government than its available area where the hydroelectric development is located, because it is a concentrated potential in a particular location. Most importantly, potential duly recognized by the State through ANEEL, the electric energy regulation agency. Nevertheless, this potential must be properly inventoried to generate the maximum amount of potential energy as possible.

On the other hand, the exploitation of wind energy potential has not been concentrated. There is a high probability to identify another area near to the one already being studied that provides the same amount of energy, or even a larger amount. Thus, in principle, in the same region, there may be several location options. The only requirement is that the person obtains the right to the land use.

No one has a potential wind energy inventory. However, if it involves maps of wind potential, sometimes sponsored by the Government, in Brazil wind power is not considered a public good, and also these maps are not intended to establish the locations of future development areas. These maps derived from studies conducted for a macro-region across the board, unlike the study of inventory of portions of dam-lines where the location of hydroelectric dams, and its potential, are established with a minimum accuracy. Although the availability of this maps is important for business of a guide to investment, as wind is not a public good, the government doesn’t have the tools to impose enterprises to exploit the whole potential.

In fact, the energy potential of the site of a wind farm is defined by its agent in charge, without any involvement of the Government. Therefore, even if there were a proven concentrated potential, which can not be proven, the definition of their potential energy still does not have the seal of the State. In this point there is a important difference between wind energy and hydro or even petroleum. In this other cases, both are defined by the Brazilian Constitution as public goods, and the government set the rules to exploit them with specific regulatory framework.

Although Brazil has a significant potential for wind energy (143 GW), there is no law that determines the maximum use of wind resources, as in hydroelectric plants. Thus, to ensure the greatest possible use of wind power, you must create technical and legal conditions for this, giving a good regulatory framework to reduce the risk of wind power exploitation, but also promoting the maximization of this exploitation.

2.3. PROINFA – The first program for wind power sources

While hydropower accounts for most of the generation of electric power in Brazil, current international concerns are with the promotion of cleaner energy sources and environmental issues related to global warming, through the promoting of the use of renewable energy renewable in the country. This promotion is aligned to the fulfillment of the strategic planning of the government to maintain a clean energy matrix.

Thus, in 2002 the government established the PROINFA, with the aim of increasing the amount of wind energy, biomass and small hydro plants in the national interconnected system, from the Independent Power Producers (IPP), with guaranteed contracts of energy purchase. This program was designed to be deployed in two phases (PROINFA 1 and 2), but the government executed only the first phase, which was the goal of adding 1,100 MW of wind power into the Brazilian electrical system. However there was no adhesion of PCH and biomass sources expected in the program, and the equivalent power to these sources in excess was relocated to the wind farms.

Despite the fact the expected date of commercial operation of these enterprises was December, 2006 (defined in Decree No. 5,025, 2004), this schedule has been changed on several occasions, the last of which established a deadline of December, 2011 (art . 21 of Law No.12,431, 2011). Today they are enabled in PROINFA 54 wind farms with a total capacity of 1,422 MW[9].

[9] http://www.mme.gov.br/programas/proinfa/galerias/outras_imagens/tabelaproinfausinas2.bmp.

The MME stipulated that the contract price of energy from wind projects would be based on the economic value corresponding to its source, with a floor of 90% of National Average Tariff to the Final Consumer[10]. Later ANEEL regulates this average rate at R$ 162.78/MWh[11], so the floor price for wind power was set at R$ 146.50/MWh.

As it was a floor for the price, this should be the minimum value for energy contracting in the PROINFA on April, 2004. Currently this value properly adjusted corresponds to R$ 224.98[12]. The average cost of wind energy in this program is currently marketed at R$ 283.64, and in some cases the value reaches R$ 310.01[13] [05], well above the market values prevailing in recent energy auctions.

However, while the price agreed on in PROINFA is significantly high, this program has undergone many technical and legal difficulties, which caused a series of postponements. It is noteworthy at this point that there are obstacles in the grid connection, in particular in the Midwest and Northeast.

Another key point was the inability of manufacturers of equipment for wind farms in the Brazilian industry to supply demand, which has not expanded the capacity of production at the beginning of the program. Thus it was not possible to meet the demand generated by PROINFA, due to the high demand of the world market and the performance index of nationalization[14].

For this reason, a significant portion of wind farm equipment was deployed with low nominal capacity (500 kW or 1,500 kW). Additionally, after commercial operation, the actual load capacity of these projects are less than 30%, i.e., always below the estimated capacity factor[15].

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[10] Administrative Order 45, 2004.
[11] Ratifying Resolution No. 57, 2004.
[12] Value corrected to July, 2011 by the General Price Index (IGP-M) of Getúlio Vargas Foundation, Established in the contract as an economic indicator for rate adjustment.
[13] According to the Annual Plan “PROINFA PAP 2011”, the amount paid for electricity generated from some units reached R$ 310.01, as Units Coelhos II, Camurim, Presidente, Mataraca and Xavante.
[14] Through Administrative Order 86, 2007, the MME regulated the index of nationalization at a minimum of 60% for equipment and services for developments built under the PROINFA provided by law.
[15] http://www.ons.org.br/download/resultados_operacao/boletim_mensal_geracao_eolica/Boletim_Eolica_jun-2011.pdf

2.4. Other auctions for renewable sources - reserve auction and Alternative Sources auction

2.4.1 Reserve Auction - 2009:

The Auction Reserve Energy is provided in art. 1 of Decree No.6,353, 2008, which regulated the art. 3 of Law No.10,848 of March 15, 2004, and aims to purchase energy to increase the security of the supply of electricity to the National Interconnected System - SIN, from units specially contracted for this purpose, either through newly generation projects or existing projects.

The first auction for selling power exclusively dedicated to wind power by the Federal Government was held in the reservation form, which is characterized by employing an amount of energy beyond what would be needed to meet total market demand in the country. The event took place on December, 2009, purchasing 1,805.7 MW of installed capacity coming from 71 generation projects, located in five states in the Northeast and South. According to final results recorded in the CCEE data, only 4 of 71 enterprises have contracted power above 30 MW, none of them sold more than 30 MWh/h[16].

In this auction, 20-years contracts were signed, valid from July, 2012, at average price of R$ 148.39/MWh. As the price ceiling established in auction was R$ 189/MWh, the average final price represented a discount of 21.49% compared to R$ 148.39/MWh previously established.

According to the president of EPE, Mauricio Tolmasquim, "This auction shows that the price difference between the thermal and wind power is decreasing and is go so small that the energy generated through wind is an interesting alternative, economically and environmentally, as a complement to hydroelectric generation"[17] [06].

In fact, this auction can be considered a success, since the contracted price of energy was well below the price established in PROINFA. You can associate this success to several factors, among which are the technological advancement of wind

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[16] http://www.ccee.org.br/StaticFile/Arquivo/biblioteca_virtual/Leiloes/2%20Reserva/Resultado_Completo_2_LER.xls
[17] http://www.epe.gov.br/leiloes/Paginas/default.aspx?CategoriaID=6585.

turbines, financing conditions associated with increased resources provided by large public banks such as BNDES, and tax incentives.

The advancement of engineering led to the development of more powerful turbines. Previous generators were developed with towers 50 meters high, but now 100 meters towers are being utilized, resulting in much better efficiency. While in PROINFA the nominal average load factor of the projects stood at around 32%, currently that number has reached easily 45% [07].

The expected start of commercial operations of these enterprises is in 2012, and only after this date will we know if this technological evolution suggested by the entrepreneurs actually means a real increase in the load factor of wind farms.

2.4.2 Auctions for Alternative Energy Sources (A-3 e Reserve) - 2010:

The auctions for the purchase of electricity from new generation projects are planned in art. 2 of Law No.10,848, 2004, and the arts. 19 to 23 of Decree No.5,163, 2004. Such auctions are intended to supply the market demands of the distributors by selling electricity from new generation projects to be either A-5 (supply starting in 5 years) A-3 (3 years) and Auctions adjustment (1 year).

As highlighted by EPE, the auctions for alternative energy sources of 2010 (A-3 and Reserve) resulted in the purchasing of 2,892.2 MW of installed power, including 2,047.4 MW exclusively from wind farms[18]. In this context the energy was contracted from 70 wind farms (R$ 130.86/MWh), 12 biomass power plants (R$ 144.20) and seven small hydropower plants (141.93) [08].

As falling prices in these auctions were significant, EPE believes that the results of these auctions have caused a shift in paradigm in the Brazilian electric sector. The first reason is that wind power has been made among the cheapest price in the negotiation compared to the others sources of energy. Moreover, it was the competitive price of the large amount of contracted energy from alternative sources[19]. This result

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[18] http://www.epe.gov.br/imprensa/PressReleases/20100826_1.pdf
In this auction, the energy generated was hired for 70 projects, with total installed capacity of 2,047.2 MW and 899 MW average power negotiated with supply beginning on January 01, 2013 and a term of 20 years.
[19] http://www.epe.gov.br/imprensa/PressReleases/20100826_1.pdf

indicates a greater participation of wind energy in the Brazilian energy matrix in the coming years, given the average price of electricity sold in these auctions (R$ 130.86/MWh).

Unlike PROINFA, which was done through the “call for proposals” system and adopted the feed-in tariffs, the reserve and the A-3 auctions are a system based at the lowest price. Whoever offers the lowest price for the energy demanded, wins the auction. Although PROINFA has been important for the introduction of wind energy in Brazil, this program proved to be very expensive to society, with rates reaching R$ 310.01/MWh.

Thus, the regulatory framework implemented by Law No. 10,848, 2004, and the technological advancements experienced in the wind energy sector led to greater competitiveness of wind power generation. Such proven competitiveness offered by wind power at prices lower than those of PCH and biomass sources, was something not imaginable even a few years ago.

Chapter 3 - Mechanisms of incentives and subsides in foreign countries

There are several possibilities to incentivize renewable energy, and each country might choose those ones according to their own politics and economics interests. Some countries are more sensitive to environmental issues, and are driving politically to impose more aggressive laws to regulate their electric energy markets. On the other hand, there still exist countries with other concerns, avoiding this environmental discussion, applying different policies. In both cases, these countries have been changing their policies to increase the inclusion of renewable sources into their electric energy matrix.

Considering that wind power is an expanding renewable energy source, the evolution of technology provides a reduction in marginal costs of construction and operation. However it is important to ensure that competitiveness of wind power plants meet the costs of building projects of non-renewable source.

3.1 Mechanisms of incentives:

DUTRA [9] divided the incentives into two distinct lines, which has been practiced in the world, they can broadly be classified into systems based on price and quantity-based systems. The main mechanisms can be divided into three categories:

• Feed-in System (a system based on price) - used in particular by Germany, Denmark and Spain (which was the main incentive system for renewable sources by 2005 in Spain);

• Auction System (system based on the quantity) - used by the UK, Ireland and France (until 2000), this system consists of setting an amount of renewable generation to be installed on the system in the long run and, after several rounds, the projects with the lowest costs are chosen;

• Quota System / Green Certificates system (based on quantity) - used in some European countries like Austria, Denmark, Sweden, Belgium and also in thirteen American states, the quota system requires suppliers of electricity to produce or buy energy quotas from renewable generation. This system also favors the decentralized market of green certificates.

Independent of the mechanism chosen by the country, it’s important to keep in mind that the adoption of means for encouraging the commercialization of renewable generation also favors the development of technological equipment. Since these technologies initially have no economic viability to compete with the traditional sources, it is expected that the incentive mechanisms also enable technological development providing greater competitiveness of these sources. The effect of technological development directly influences the effectiveness and also the costs of mechanisms adopted.

3.1.1. Feed-in Tariffs - The German model:

In April 2000, the Renewable Sources Act (Erneuerbare Energien Gesetz—EEG) was enacted. This law established an equalization system throughout the German territory as it promoted the distribution of the costs of the reimbursements among all the electricity companies. Electricity companies had to comply with a calculation system to balance out the costs of reimbursement among the various levels of grid operators. And it also brought special support for other renewable energy technologies.

The basic principles of the EEG are: fixed payment for new installations; no compensation for inflation; and a long period for reimbursement. The Renewable Sources Act does not imply a long-term subsidy for renewable energy technologies. In order to cut generating costs and increase the efficiency, a decreasing price element for the technologies was introduced.

The EEG guarantees each plant operator a fixed tariff for electricity generated from renewable sources that is fed into the public electricity grid. The tariff paid is basically dependent on the technology used, the year the installation was put into operation and the size of the plant. Each grid system operator is obliged to pay the statutory tariff to the plant operator.

The EEG guarantees the plant operators fixed tariffs for electricity fed into the grid for a period of 20 years – plus the year it was taken into operation. The fee paid depends on the defined tariff in the year the equipment was installed. A deviation from this is micro-hydroelectric power (installations of up to 5 MW capacity), which is supported over 30 years, and ‘large’ hydroelectric power (5 to 150 MW), which is only supported over 15 years.

The legitimate interests of the plant operators are protected in accordance with their basic rights, amongst other things, in case of a future change to the Act. This principle of protection of legitimate interests extends to the fee paid, the priority given to this form of electricity and the period of 20 years guaranteed by law.

Over the past few years the costs for renewable energy source plants have been appreciably reduced. This was due, amongst other things, to mass production with high output, to increased efficiency and more efficient production, which reduced materials usage for each installation. The EEG took up this positive development in 2000 and set a degression rate for the fees paid (an annual percentage reduction). The degression for the various technologies is adjusted in each case to the technical learning curve. The amended EEG (2004) sets out the degression rates for all technologies.

In 2003/2004 the legislation was reviewed and the German parliament adopted some amendments to the EEG, which went into effect on August, 2004. The aims of these amendments included: to review the amounts reimbursed for renewable energies; to increase the share of renewables in total electricity supply to at least 12.5% by 2010 and to 20% by 2020; to improve the framework conditions for feeding electricity from renewables into the grid, and for transmitting and distributing this electricity [10].

According to Costa et al [10], besides the EEG (feed-in tariffs), the renewable energy policy has been associated to other policy instruments (investment support, soft loans and tax allowances) in public programs (federal and state level) that offer financial incentives and support programs for introducing renewable technologies in the market.

3.1.2. Auction System - the UK model:

A more competitive process is the auction system, where the regulator sets the reserves market demand for renewable sources and organizes the process of competition among generators. The concessionaires of electric energy distribution on the other hand are obliged to pay these generators the rate set at the auction for the amount of energy generated. In this case, the proposed sales are ranked in order of increasing cost until they reach the amount to be purchased. For each renewable energy generator selected during the auction, a long-term contract is signed, guaranteeing the payment for the energy generated based on the price of energy sold in its auction.

This type of competition does not provide any additional income to the generator, as in the Feed-in system. Moreover, this process automatically cancels the potential extra income from technological development. Thus, the auction system discourages the technological development that characterizes the Feed-In System, the biggest disadvantage of the auction system.

The regulatory framework in the UK has two distinct stages, initially the Non-Fossil Fuel Obligation (NFFO), which ended in 1998, followed by the Renewables Obligation (RO), which remains in effect today.

The Non-Fossil Fuel Obligation (NFFO) was implemented in 1990 in England and Wales as a mechanism for the development of a market for renewable electricity. Because it is based on an auction system, the electric power generators using renewable sources that were previously eligible to participate in the event competed for limited opportunities to generate different types of renewable energy. The advantages for the winners of the auction were the purchase agreement with regional electricity companies for a minimum period of time and a fixed price for power generated.

The UK government conducted five calls for proposals during the 1990s the last in 1998. The first two calls (NFFO-1 and NFFO-2) had eight-year contract with the regional electricity companies (REC). For other public calls, the contracts had a period of fifteen years. The price paid for energy generated was the result of the bidding process and could be configured in two components: the price in the competitive market, and technology specific to each award (the difference between the value of the outcome of the auction among energy sources with the same technology and the competitive value of conventional sources) that would come from the tax on fossil fuels (fossil fuel Levy - FFL) [09].

3.1.3. Quota System:

The basis of this system is the determination that a portion of the generation of electricity sold in a market is from a particular type of renewable generation source. In this system, utilities have the ability to purchase the amount of energy pre-defined, guaranteeing the purchase of generators whose energy source is renewable, through long-term contracts or buying certificates from an amount of clean energy specific renewable energy generator, directly from other utilities that have a surplus of this type of generation. This is the “quota regulation”.

In general, certificates are issued for renewable electricity generators that benefit from the generation of renewable electricity through two different mechanisms: selling them among the generators at the market price and the sale in a particular market of green certificates.

According to C. do Valle et al. [10], in 1997, with the change in government of the United Kingdom, legislation was revised and the adopted policy favored a greater social and environmental dimension in the government. In addition, external reasons related to the adoption of the Kyoto Protocol and the negotiations to reduce greenhouse gas emissions provided the necessary conditions for restructuring renewable energy policies in the UK. Thus, in 2000 ‘‘The Utilities Act’’ came into force, establishing a new regulatory framework for the gas and electricity markets. The most important part of this reform was the creation of the New Electricity Trading Arrangements (NETA), which began operations in March 2017 and the Renewables Obligation (RO), which only began operations in April 2002.

The new Renewables Obligation required power suppliers to derive from renewables a specified proportion of the electricity they supply to their customers. This started at 3% in 2003, rising gradually to 10% by 2010. The cost to consumers is limited by a price cap and the obligation is guaranteed in law until 2027. Eligible renewable generators receive Renewables Obligation Certificates (ROCs) for each MWh of electricity generated. These certificates can then be sold to suppliers, in order to fulfill their obligations.

3.2 Subsidies to investment:

The great advantage of subsidizing investments is the considerable reduction of the initial capital required to build a unit. This might result in a higher capacity of investments in the short term. On the other hand, we need to keep in mind that choosing as inappropriate level of subsidizing or choosing a wrong kind of technology might also harm the evolution of a more competitive marketing in the short term, even reducing the technological advancement in the long term. As these incentives are paid by all consumers, it may represent a deficiency of encouragement for the entrepreneurs [09].

Other incentives may be offered by different mechanisms. According to Dutra [09], the incentives are based on two basic guidelines: those that are applied directly to the initial investment of the project through special lines of credit and those that extend over the life of the project through tax incentives. These incentives are often used by the main markets for alternative sources of energy which, according to your goals and availability of resources, set their contributions at various levels of performance. The author also considers that the strategies used by governments in the granting of subsidies can encourage entrepreneurs not only directly, but also all its stakeholders.

Investment subsidies are a mechanism to overcome barriers to investment with a high initial cost, ideal to stimulate investments of lower economic viability. On this line, it’s reasonable to apply this kind of subsidy to emerging and immature technologies, increasing investments is these areas.

3.3 Tax Benefits

Tax relief acts in different ways to promote the generation of electricity, tax exemption for green funds, and use of specific funds for clean generation. Unlike the investment subsidies that reduce deployment costs of projects (initial phase of the project), the tax benefits reduce the cost to the entrepreneur during the period of the tax benefit. In the case of an indirect subsidy, we need to consider the same disadvantages mentioned for the subsidy for the initial investment.

Although tax incentives represent a reduction in government tax collections, they are often required for the viability of projects with high initial costs. At the same time that resources are targeted at viable projects, it can provide the fiscal resources that entrepreneurs use in the incorporation of new technologies, which somehow provides the technological development even if indirectly.

One of the important tools of the tax incentive is the depreciation of assets. This system is commonly applied to various equipment where the depreciated value of equipment for a certain amount is deducted from the calculation of income tax (voided costs), aiming to create a virtual income for future replacement of equipment. This discount in the calculation of income tax provides an extra income (which can be considered as an avoided cost), representing the best results of the internal rate of return and cash flows of the company.

Chapter 4 - Challenges to the promotion of the optimal uses of wind potential in Brazil

In this chapter, I will discuss the central objective of this study. I will comment about the most difficult challenges for the promotion of the optimal uses for wind power in Brazil, which are: aspects of regulatory policy and incentives and the ownership of the areas they will be implemented in. I will show some successful cases in other countries, which could be applied to Brazil.

4.1. Reliability of wind power generation

Considering all the renewable sources, certainly wind power is not the most reliable at all. As wind presents intermittency, wind can't be relied upon to blow all the time. Robinson [11] divided the problem of intermittency into two parts: the load factor, roughly the fraction of time the wind is blowing; and unpredictability, thus we can't predict exactly when it will no blow.

4.1.1 The load factor:

Considering the period of time during which the turbines were supposed to generate energy, the load factor measures how much a generator will deliver in relation to its capacity. Normally it is calculated by dividing total energy delivered in a year by the product of its nominal capacity and 8,760 (total hours in the year). In most cases, actual output is much shorter than the potential available, because of engineering concepts.

In this case, Robinson [11] gives good examples of load factor around the world. Average load factor achieved is 30% in UK, 21% in West Denmark, and less than 11% in Germany. As mentioned in section 3.3, load factor in Brazil is below 30%.

4.1.2 Unpredictability:

Although actual statistical tools help to predict when wind blows, its speed and directions, it's important to keep in mind that this is merely a possibility, under the confidence interval of the study. A confidence interval with particular confidence levels is intended to give the assurance that, if the statistical model and data are correct, the procedure for constructing the interval would deliver an interval that included the true value of the parameter and the proportion of the time set by the confidence level.

This confidence interval can't predict that the true value of the parameter has a particular probability of being in the confidence interval given the data actually obtained, when and how the wind will blow in the future.

According to Robinson [11], "because of the variability and unpredictable nature of its availability, additional standby generating capacity is required. Estimates of the extend of this additional capacity range from 65% to 100%. At low levels of wind penetration the cost of this standby capacity is small, but when wind power is approaching 20% of the natural power supply the costs become prohibitive".

If the wind power is unpredictable and the load factor is usually low, why should Brazil invest in this renewable source? As presented in this paper, Brazil has a huge potential unexplored, that will help keep a clean energy matrix, and is more environmentally friendly compared to non-renewable sources. Another important aspect is the government auctions results, as the price of wind power generators become extremely cheap and competitive in the last three years.

At the beginning of PRINFA, when just a few units were profitable, the fall of the prices in the last government auctions shows that most of the new projects of wind generators became profitable, otherwise they wouldn't bid. Robinson [11] highlighted that in the last few years this profit usually came from subsidies, but in the future (probably the present for Brazil) this profit may come from the attraction of power-using industries for which intermittency is not a problem. In his opinion, the increase of wind power generation should be done as efficiently as possible, not only in terms of economic costs, but also in terms of environment and of the reliability of supply.

This study is important to introduce concerns about reliability, but considering Brazil's case, in which wind power represents much less than 20% of total supply, reliability isn't already the biggest problem for wind units. Its complementarity with hydro generation is a variable that helps the grid operator (ONS) to control reliability.

On the other hand, it demonstrates the necessity to leverage wind power generators into the government planning, in a scenario that wind power increases enough to keep energy matrix clean, but not enough to harm the grid operator, in this case reducing the reliability of supply. As EPE projects that only 7% of the energy mix will come from wind units, it won't be a problem.

4.2 Brazilian Incentives for renewable sources

4.2.1 Government auctions

When Brazilian government decided to increase wind power energy generation, instituting PROINFA, the country was passing through an uncertain political and economic environment. Although investors knew the Brazilian wind potential at that time, they were supposed to import equipment, and sell energy in a market without a well-defined regulatory framework.

After all, the existence of a specific auction for renewable sources, which currently takes place in Brazil, should be considered as an incentive for wind power, as seen on section 4.1 of this paper. In the current auction's model, enterprises compete in the auction, and those who even offer the lowest price for energy win. If these enterprises can not compete at one specific auction, they have the opportunity to bid in others government auctions, as the A-3 and LFA.

When the government decides to promote auctions specifically to renewable sources, the economic signal given to the entrepreneurs is that the federal planning is decided to achieve the goals of renewable generation. It's important because the entrepreneurs have the confidence to invest in a market where there will be demand for their energy production.

EPE notes that, given its competitiveness, the current trend is to increase the participation of alternative renewable energy sources in the system, given the results of recent auctions of backup power for these specific sources. In addition, thermal power plants recently contracted at lower variable costs tend to modify the generation of units already contracted, especially the largest variable cost plants, displacing flexible plants using expensive fossil fuel, in the priority of generation. In this case these units become, in effect, a reservation system[20].

On the other hand, the performance of auctions with the same source has forced prices to fall to levels close to its marginal cost. The realization of these auctions provided reduction of the information asymmetry in relation to the actual cost of wind energy, between the costs estimated by the generators and estimated by the other market players, among them the federal government.

According to the World Bank [13], “some concerns have been expressed regarding the winning bidders’ ability to bring these projects to fruition, in light of the low prices offered and apparent cutthroat competition. This remains to be seen, although the low prices may be masked by some indirect benefits and incentives offered to bidders. Some of the incentives include tax credits, which are available for several generation sources (including renewable), and are very attractive for increasing the competitiveness of a given technology, as well as a 75 percent income tax reduction during the project’s first 10 years if it is installed in certain parts of the country. Further special financial conditions are offered by the Brazilian Bank of Development, including loans in domestic currency up to 80 percent of project investment, low spreads, and amortization periods of about 14 years”.

4.2.2 Discount applied under the tariffs of use of electric distribution and transmission (TUSD and TUST)

Due to this subsidy the Brazilian Congress passed the laws No. 10.438/2002 and No. 10,762/2003, establishing new rules on the use of transmission systems and power distribution, providing incentives to renewable sources by reducing the rates of transmission and distribution systems (TUST and TUSD). These subsidies are applied to wind power units, and also biomass, small hydro (less than 30 MW installed) and other kinds of renewable sources.

The tariffs, according to Law No. 9,427/96, are based on “service for the price” fixed in the concession agreement or in a specific document from ANEEL, which authorizes the application of new values as a result of an adjustment or revision. Tariffs

[20] Sumário Executivo do PDE 2019: http://www.epe.gov.br/PDEE/20101129_2.pdf

established by ANEEL refer to the supply to the dependent consumer and to the use of the distribution system.

The tariffs established by ANEEL are calculated by apportionment of costs associated with services transport of electricity to be paid by users of these services (also generators and consumers). Methodologically, the rates provide an economic signal that induces the rational of electrical networks (in order to avoid building of unnecessary new lines and substations) and indicate the regions lacking in energy supply or willingness to meet new consumers. As mentioned before, these tax benefits reduce the cost to the entrepreneur during the period of the tax benefit.

Small hydro power plants and generation projects that are based on alternative energy sources that produce energy for marketing purposes, which inject into the distribution or transmission network less than 30 MW of power, are entitled to at least 50% discount applied under the tariffs of use of electric distribution (TUSD) and transmission (TUST). This right was given to them by law, in accordance with policies and guidelines established by the federal government sector. The discount percentage is established in the very act of authorization of the unit.

These tariffs for the use of transmission and distribution systems have the main function of recovering the revenue of the distribution and transmission companies, and are defined by ANEEL, they should provide a correct economic signal for the rational use of distribution systems. All the generators and consumers has to pay these taxes to use the distribution and the transmission lines, and the total taxes paid have to be enough to recover the revenue of the companies, as defined in their contracts.

In this case, what happens if a generator has 50% of discount over TUSD or TUST? Considering that the distribution or the transmission company on their concession area needs to keep their profits unchanged, The difference between the fare that the generator should pay and the actual fare paid will be passed on to the final consumer, as a cross-subsidy. So it’s reasonable to conclude that the structure of this tax relief only affects generators and consumers, which facilitates the analysis.

The concerns of this paper are related to the following questions:

a. Should this be a perpetual subsidy?

b. Is the boundary of 30 MW appropriate to delimit the projects that will receive the tax benefits?

c. Does the actual structure of this tax relief promote efficiency?

What the policy makers take into account when they propose subsidies to a renewable source is that the technological improvements will reduce the costs of energy over the time. The expectation is that someday in the future this renewable source costs can compete with conventional sources.

According to A.H.I Lee et al [12], the development in wind technology has resulted in wind turbine generators that are relatively comparable to conventional units in terms of both cost and capacity ratings. Parameters like reliability, load factor, power factor, technical availability, and real availability are important factors affecting the performance of wind turbine generators. The author also explains that variation of wind speed has an impact on the economics, duration of life, and smooth running of the wind energy conversion system. With recent developments in power electronic converters, variable speed generations seem to be feasible and cost effective.

Analyzing Germany's Renewable Sources Act, the conclusion is that the feed-in-tariff in Germany does not imply a long-term subsidy for renewable energy technologies. In order to cut generating costs and increase the efficiency, a price-decreasing element for the technologies was introduced. If the German government didn't decide to decrease the tariffs over time, these tariffs would relatively increase as the real costs of the technology development decrease over time. The generators retain this extra profit, and the consumers just get a higher tariff.

But how much does the discount applied under the tariffs of use of electric distribution and transmission represent to the generators? It is a difficult question to answer, considering that the methodology used to calculate this tariff takes into account where the unit is installed. Since different units are in different places, the value isn't equal, keeping all the other variables constant.

An unit sold energy in the 2010 Reserve Auction. The total investment was about R$ 111,000,000.00, with 30 MW of total installed capacity (R$ 3,700/kW), and 14.4 MW of average energy guaranteed[21]. ANEEL calculated the nominal TUSD of the unit as R$5.048/kW.month[22]. In this example, the total of TUSD the entrepreneur will avoid is 50% of this value, which represents R$ 908,640 per year. Considering all 20 years of the contract, the amount the generator avoided is R$ 18,172,800 (16.37% of total investment).

As seen above, the total avoided costs over investment isn't high enough to prevent real competition between wind power and other conventional sources. Remembering the price of wind energy achieved in the last government auctions listed in the section 3.4, if the government decides to eliminate the TUSD and TUST discount, and the prices increase up to 20% to compensate for the losses, the final price can also be competitive.

A good study of appropriately applied incentives for renewable energy sources is presented by Mallon [16]. In this study the author considers that as the price gap between the renewable and non-renewable sources finally narrows, these technologies may be capable of migrating into the broad energy market which has carbon constraints. He also considers that in some cases, renewables sources are also cost effective in a non-carbon constrained market as is, but these cases tend to occur in niche markets.

Certainly the policy framework needs to avoid boom-bust cycles. If an incentive is bigger than necessary to stimulate the development of wind power units, the system faces an untenable boom-bust cycle. After a couple of years, the industry might be poised to fall off the investment cliff into a market and policy void. Thus, the aim of the policy driver used to provide the incentive must be to achieve the right balance to provide a steady draw on renewable industry development [16].

On the other hand, it's necessary to remember the importance of this benefit to the system, giving the entrepreneur the legal certainty necessary for the maintenance of prudent investments in the business. Thus, an alternative option would

[21] The average energy guaranteed takes into account the load factor and other variables, as outage rates of the unit, so the expected real energy production is much less than 30 MWh/h.
[22] Resolution n. 1.031, 2010.

be to eliminate the discount after the end of the contracts within the auction. Another possibility would be to gradually reduce the discount during the term of the authorized act of the enterprise.

Another important aspect of this subsidy refers to the 30MWh/h limit of instant energy injected into the transmission or distribution grid established for the enterprises. The renewable electric energy units, whose power injected into the system is below this limit, have secured a discount of at least 50% of TUSD and TUST. However, if the energy injected in the grid exceeds this value in any amount, the entrepreneur automatically loses the incentive.

The reason to limit the total units installed capacity is in order to promote an environment of competition, with the implementation of projects for small business entrepreneurs. However, this it is not what is observed, in fact. Some large companies are divided into several "special purpose societies" and participate in auctions.

This limitation has two important aspects to consider. First, the entrepreneurs are discouraged from developing larger projects. As the TUSD and TUST represent a significant value of the full project cost, entrepreneurs choose to build power plants of up to 30 MW. It is no coincidence that almost all projects that bid in the government auctions, or even those who have projects that intend to commercialize energy in the free market, have their total installed capacity limited to 30 MW (remember item 3.4.1).

Second, although few companies participate in auctions with many projects, not all are winners, depending on the expectations of entrepreneurs in relation to the rate of return on projects and the real price of energy contracted in these auctions. During the eligibility of projects, a technical criteria observed by EPE is related to the possible interference of a wind farm in other projects in the region.

Based on the literature, it’s reasonable to assume that if two different units are distant at least 20 times the maximum height of their turbines, it’s enough to ensure no interference between them[23]. Currently, the maximum height of the turbine blades of wind farms exceeds 100 meters in larger projects. Thus, as the distance criterion should

[23] ANEEL’s Resolution n. 391, 2009.

be respected, an area with a radius of 2,000 m around this park will no longer be used, which may represent a considerable waste of wind potential.

Thus, it is clear that the limits on the power injected into the system by the enterprises do not provide an environment for exploitation of wind resources in an efficient manner, something which requires correction. An alternative proposal would be a gradual reduction of the discount applied to TUSD and TUST, depending on the size of the plant, capturing economies of scale of the projects. Conceptually, the bigger the units, the less the discount applied, as in the German model. Larger enterprises will have an incentive proportionately smaller, but still have some incentive, to stimulate these economies of scale.

4.3. Economic signs related to renewable sources incentives

To keep the Brazilian energy matrix renewable, it is important that the government indicates that it intends to pursue this goal. In a way the government stimulated the development of renewable power projects through the following signs:

a) Government recognition that wind energy can be expanded to 7% of Brazil's energy mix. This expectation is based on the continuous reduction of costs of wind generation, a move that could contribute to setting targets for wind generation in the future; and

b) Auctions for specific renewable energy, such as Reserve Auctions: As mentioned before, entrepreneurs have a guaranteed purchase of electricity generated through long-term contracts, protected by adjustments for inflation.

However, for entrepreneurs to have greater confidence in the development of wind power in Brazil, other signals could be given by the government, such as:

a) Guaranteed access to properties with good potential for wind generation:

b) Ensuring infrastructure required to connect the plants to the electricity distribution and transmission:

These two proposals are complementary. Only with the delimitation of areas for wind exploitation is it possible to determine the points of the appropriate grid connection.

4.3.1 Land with high potential for wind energy generation.

Through the studies of CEPEL, much of the 143 GW of wind energy potential is inventoried in the northeast and south of the country. Regardless whether these lands are public or private, the land issue in Brazil is very problematic. In some cases the same property has more than one owner, which makes its legal status uncertainty for those wishing to explore this area.

When the entrepreneur is not the property owner, he needs to sign a rental contract to use the area. This contract includes clauses of time coincident with the contracts of energy related to the government auctions. Normally the entrepreneur pays the property owners a percentage of gross revenue generated by the plant.

Often the entrepreneur leases the property, bids in the government auctions, and when he starts to build the plant other people claim the property ownership.

In these cases the entrepreneur pays the second owner for the use of the same land, or he starts a litigation process in court. In both cases the cost of the project increases, reducing the expected pay back for the unit. This situation gives the entrepreneur uncertainty, since it will generate energy within the period specified in the Auction. The entrepreneur can turn this risk in the auction's bid, thereby increasing the price of electricity sold in the regulated market.

What could be done to mitigate this risk? The government needs to modernize the current system of property registration, which is much delayed compared to other countries. SOTO [14] has shown how the modernization of the property registries system can contribute to the development of society, but its scope is very extensive, and it will not be considered in details in this paper.

Thus, we should take into account the public interest concerning energy generation. If the entrepreneur has a legitimate title of ownership issued by a registry of real estate, the continuity in the implementation of the project should be ensured, even in court.

Now reviewing cases in which there is doubt concerning the ownership of the property, what should be done?

A good example associated with the use of property is the German case. According to SUCK [15], the federal reforms of the Building Law in 1996 granted significant regulatory competencies to the local communities: specifically, they were allowed to define construction areas for wind power installations in their zoning plans. According to the author, by actively defining these areas, the communities could define the construction of wind power plants in specific areas, and they were thereby able to exclude other areas from being used as building areas for wind energy installations.

SUCK concluded that the guarantee of the legislative power to define concentrated areas for constructing renewable energy installations gave local governments a sensible instrument for helping the local population accept such projects. As a consequence, this reform of the Federal Building Laws triggered large-scale planning activity by the local communities and municipalities, specifically to define the respective construction areas for renewable energy installations.

In the same direction, the Indian policy for renewable energy development is considering integrated national, state and regional policy-making. Since India has more than 100 GW of installed capacity, it became necessary to promote renewable energy, in order to maintain energy security, environmental and protection.

According to MALLON [16], around nine states with wind potential in India have announced attractive schemes for encouraging the private sector to generate power by harnessing wind power. The Ministry of Non-Conventional Energy Sources (MNES) issued guidelines in 1995 to all the private sector developers to ensure that the incentives and facilities provided by the central and state governments were properly utilized by the developer, and also that due emphasis was given to quality in the selection of wind power generators.

Ryan Walsh-Martel [17] considered a variety of state policies that may potentially have an effect on wind capacity in the United States. According to the author, the renewable portfolio standard (RPS), the most widespread policy in the U.S. mandates that a state must ensure that a certain percentage of its electricity is generated from renewable sources (which are usually enumerated by individual states). He also mentioned that States have varying percentage goals and timelines, ranging from relatively easy to meet to quite difficult. This paper also considers other State policies as public benefits funds, green purchasing options, and green purchasing requirements[24].

The first major law created to promote the use of renewable energy in the United States was the Public Utility Regulatory Policies Act (PURPA), passed in 1978 as a part of the National Energy Act., which was the earliest form of feed-in law. This policy required utilities to purchase power from small renewable generators and cogenerators (combined heat and power), known as “qualifying facilities.” The primary difference between PURPA and contemporary European feed-in laws is how the feed-in tariff was determined. European feed-in prices have typically been based on a specified percentage of the average retail electricity price or, more recently, fixed by law for each renewable energy technology, taking into account prevailing technology costs. The PURPA tariff was based on the projected wholesale cost of conventional (fossil-fuel) power to the utility, and was intended to approximate the “avoided costs” to the utilities [18].

According to Ryan Walsh-Martel [17], although PURPA was a federal law, the implementation and interpretation of it was left up to the individual states. Some states did nothing, while others pursued it aggressively. Once the new policy began to take effect in 1981, renewable energy developers were able to secure financing for their projects because they were guaranteed the ability to sell their electricity output in favorable circumstances. Three states that aggressively pursued PURPA were California, New York, and Maine. This paper shows that the States that most pursued the renewable sources development were the ones who promoted policies aligned with PURPA.

[24] Public benefits funds tax all consumption of electricity and then use the funding to subsidize research and development of renewable energy sources, while green purchasing options allow consumers to pay a premium for electricity that is produced from renewable energy. Green purchasing requirements require state governments to purchase a certain percentage of their energy from renewable sources.

Looking at the Brazilian case, it would be a powerful tool to help the government to define the best areas to install wind power generation efficiently. It doesn't mean that Brazil needs to decentralize the planning, as in Germany's Building Law, or to decentralize regulation as in the United States. The federal government could expand its relationship with state and local governments in order to determine the areas that could be allocated to expand the wind energy generators in Brazil.

Some Brazilian states, such as Ceará, have approved tax incentives to develop wind farms in its area of coverage[25]. Although these local incentives are effective in reducing the costs of implementation of the projects, it's not possible to correlate them with the federal government planning. The states could define the areas where projects should be designed, signaling that the tax benefits would be given in case of construction of projects in these locations. The federal government, on the other hand, could perform specific auctions for wind energy in these areas, defined by the states.

Section 3.2 presented the conceptual difference between the uses of the hydraulic and wind potential. As the hydroelectric potential belongs to the Union, the Federal Government determines where and when the dams will be installed, as well as their total installed capacity, which must be maximized. It is important to note that zoning should be done very carefully in order to avoid speculation in the areas involved. The states and municipalities should make sure that these are public areas, or if they are private areas, establish mechanisms to protect private ownership of these lands in case of no interest in wind energy exploitation.

As Brazilian law does not present any instrument requiring the developer to maximize the utilization of wind resources, the only way to maximize the wind power generation at certain sites is through public policy development of this source, as correct tax benefits.

[25] The government of Ceará state signed April 5, 2011 decree No. 30.480 approving the incentive for commercial companies registered in PROEÓLICA (Program of Development of the Productive Chain of Wind Energy Generation). This decree establishes a period of 120 months for deferral of 75% of the amount of ICMS (Tax Sale of Goods and Services) collected on a monthly basis and within the statutory period, with subsidized financing conditions in a system of regional incentives (FDI / PROVIN).

4.3.2 Grid connection.

After defining the areas for construction of wind farms, the next step is the determination of a transmission grid associated with this unit. Again, in the case of big hydro projects, the federal government put the transmission grid on auction separately[26]. Thus, it is guaranteed that the generator will be able to drain the energy generated by the project.

It is not today that the government cares about this issue. In recent auctions the government has signaled the construction of "transmission facilities of exclusive interest to Central Generation (ICG)". First the government checks the interest of entrepreneurs to participate in the auction of generation. Such facilities are under the responsibility of the concessionaire of the public electricity transmission, and are designed to enable, upon payment of specific charge, the connection of power generation from wind power, biomass or small hydro facilities.

This procedure allows the formation of groups of generators that can purchase services of power transmission and it is critical to the viability of expanding the installed generation capacity from alternative sources in regions with little or no capillary network of transmission. However, as entrepreneurs do not know how many projects will be winners in these auctions, they do not take the risk of paying the total cost of this transmission system, without an exact idea of how many generators will share the bill.

Thus, if the federal government establishes the total area to be used for wind power generation, and consequently the size of the business, and ensure construction of a reliable transmission grid, the risk would be mitigated, reflecting positively on the auction price.

[26] After bidding the hydroelectric units of Jirau and San Antonio (Madeira River Complex), the government promoted an auction exclusively to their transmission grid. In this case, the generators were confident that they could build their hydro units without concerns about the transmission line.

4.3.3 Off-shore wind generation.

Although this paper introduces some aspects of on-shore wind generation, it is also important to consider off-shore development. Brazil is bordered by the Atlantic Ocean for a distance of 7,408 km, which may represent a great potential for wind energy, even if the CEPEL atlas doesn't quantify this potential.

Because off-shore winds generally blow more strongly and consistently than on-shore winds, off-shore wind turbines operate at higher load factors than wind turbines installed on land. In addition, daily off-shore wind speed profiles tend to correspond well to periods of high electricity demand by coastal cities, such that the strongest winds (and thus highest potential energy generation) correspond to the periods of greatest electricity demand [19].

The first challenge for off-shore wind power in Brazil it the lack of a regulatory framework. The current legislation does not define important guidelines regarding the use of federal property (its use and exploitation) and access to the transmission and distribution grid. However, since the wind energy market is continually expanding, the government should address the issue.

The access to the transmission and distribution grid seems to be the easiest challenge to overcome, since the government intends to exploit well defined areas. This case is similar to land with high potential for wind energy generation on-shore (see item 5.3.1), but the problem is made simpler because there is no doubt about who owns the property. This area belongs to the Union. Considering that the government intends to promote an auction of off-shore wind power, it can also promote an auction of the off-shore transmission grid.

As for the land itself, one good example to follow is the new American regulation framework. In 2010, the U.S. Department of Energy instituted the Offshore Wind Innovation and Demonstration (OSWInD) initiative to consolidate and expand its efforts to promote and accelerate responsible commercial off-shore wind development in the U.S. The main idea is to support the development of a world-class off-shore wind industry in the United States able to achieve 54 GW of off-shore wind deployment at a cost of energy of $0.07 / kWh by the year 2030, with an interim scenario of 10 GW at $0.10 / kWh by 2020 [20].

According to the U.S. Department of State, in 2011, close collaboration and partnerships among all federal and state agencies with jurisdictional responsibility over federal and state waters will be crucial to the success of the OSWInD initiative. Federal waters in particular – those along the Outer Continental Shelf (OCS[27]) – hold tremendous promise for substantial off-shore wind development in the coming years. The OSWInD initiative will expand its ongoing efforts into a suite of seven major activities, administered through three focus areas (Technology Development, Market Barrier Removal, and Advanced Technology Demonstration). These are targeted at the critical objectives of reducing the cost of off-shore wind energy and reducing the timeline for deploying off-shore wind systems [20].

In the U.S., numerous state and federal entities have authority over siting, permitting, and installation of off-shore wind facilities, and OSWInD lists the key statutes and responsible agencies involved in the permitting of off-shore wind power projects. Several federal and state agencies need to work together to promote the off-shore development, considering all the technical, economic and environmental aspects involved.

The goal of OSWInD is to demonstrate all the stakeholders involved in this process. It assumes that coordinated and concurrent project review processes can lead to efficiency gains in the permitting of off-shore wind projects. In some cases, these opportunities for increased efficiency are already recognized and can be quickly adopted. In other cases, collaboration is needed to identify the potential efficiencies to be gained through coordinated and concurrent project review [20].

The same issues could be applied to the Brazilian case. How does Brazil seek to explore this potential for wind energy? What is the role of each institution of government? As in the U.S., it should consider the relationship between federal, states and regional governments, when it will demands environmental licenses (states and municipalities) and use of the land (federal).

[27] The OCS consists of submerged lands, subsoil, and seabed starting 3-9 nautical miles from the shore (depending on the state) and extending approximately 200 nautical miles outward.

Conclusions

The recent government auctions show that wind power generation is becoming more and more important in Brazil, in order to maintain the cleanliness of the energy matrix. Because the hydraulic power alone will not be capable of ensuring the expansion of a renewable energy supply, the government now considers wind energy in their long-term studies.

To promote a sustainable development of this source in the long-term, this paper presented some challenges that wind power generation faces, such as the need for more appropriate incentives striving for technological efficiency and cost.

Brazil also faces a difficult question regarding land ownership. In some cases it is impossible to define the real owners of these properties. It increases the risk to entrepreneurs, who in turn will be willing to reallocate this cost into the price of the energy. The entrepreneurs face today a situation in which the had already paid the owner for the use of the land, and when they start building the facilities, other people of the same land request the property of these lands. Normally the entrepreneurs stop the construction and go to court, increasing the cost of these projects and delaying the energy supply. This paper also presents some concerns about the necessity for better distribution and transmission grids associated with great wind power auctions, on-shore or off-shore.

Off-shore wind power generation is still far from reality in Brazil, although it is a reality in other countries like the United States and Great Britain. However, Brazil needs to create the regulatory framework, since the fast develop of the off-shore technology might increase its competitiveness. Certainly there is no perfect model for Brazil, but there are good examples around the world, as in the United States, in which the government consolidates all the procedures and rules to the entrepreneurs to exploit the wind off-shore potential.

Considering on-shore and off-shore wind generation, in both cases it’s important to promote the optimal uses of the wind potential in a regulatory environment. This should be coordinated by the federal government, with the collaboration of state and municipal governments. This may help to define areas of best wind resource utilization, and the most appropriate incentives for the development of renewable energy in Brazil.

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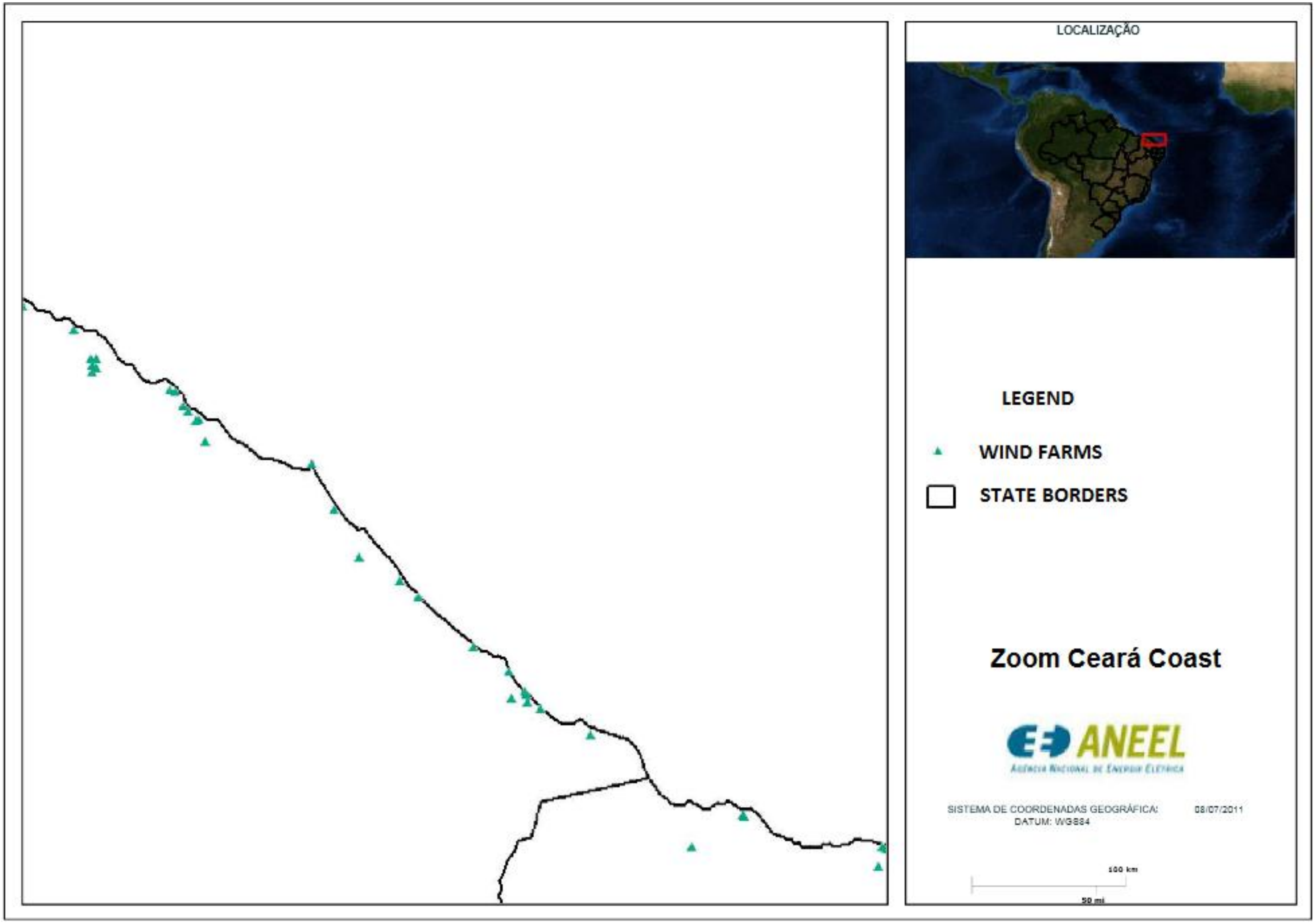
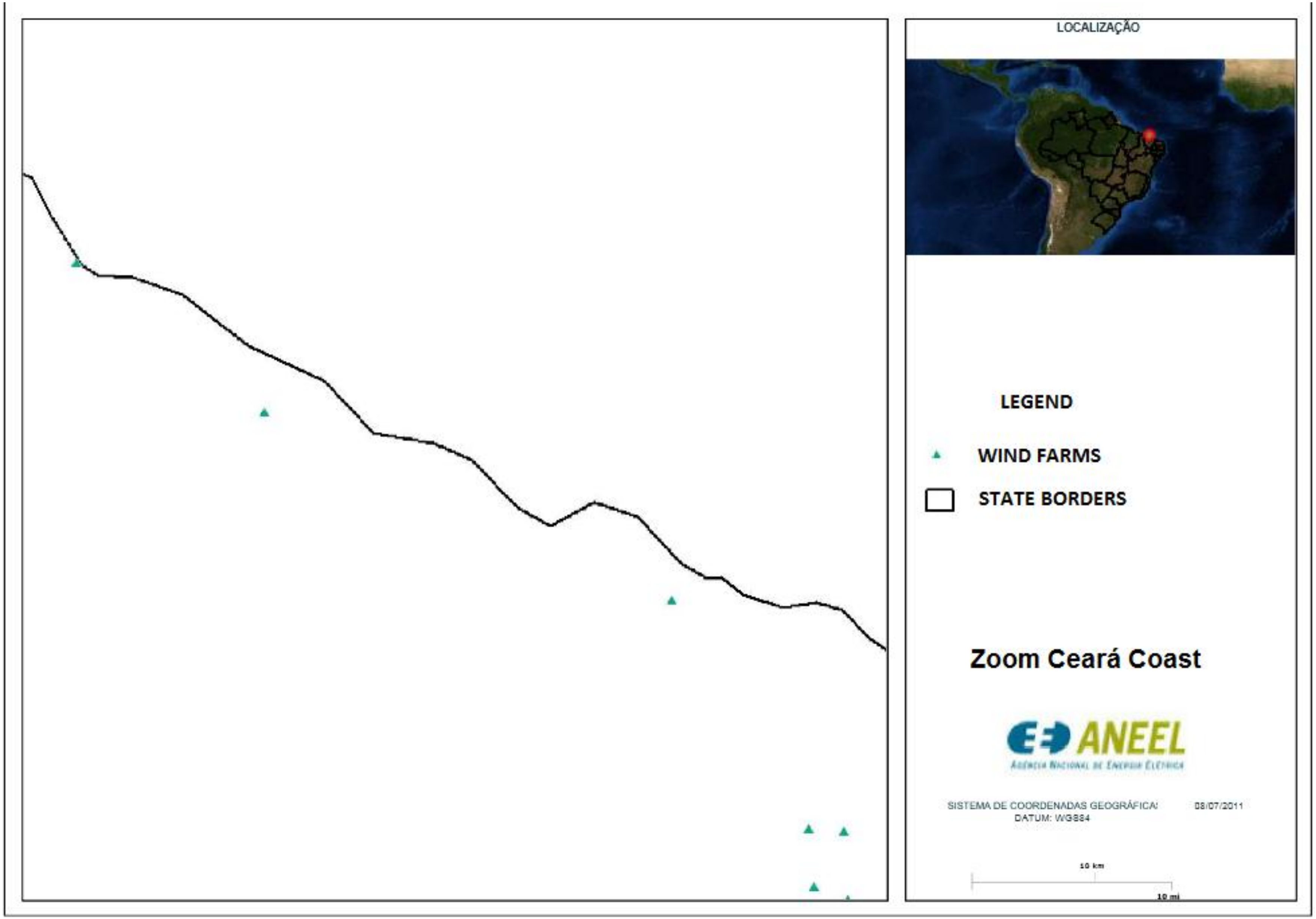
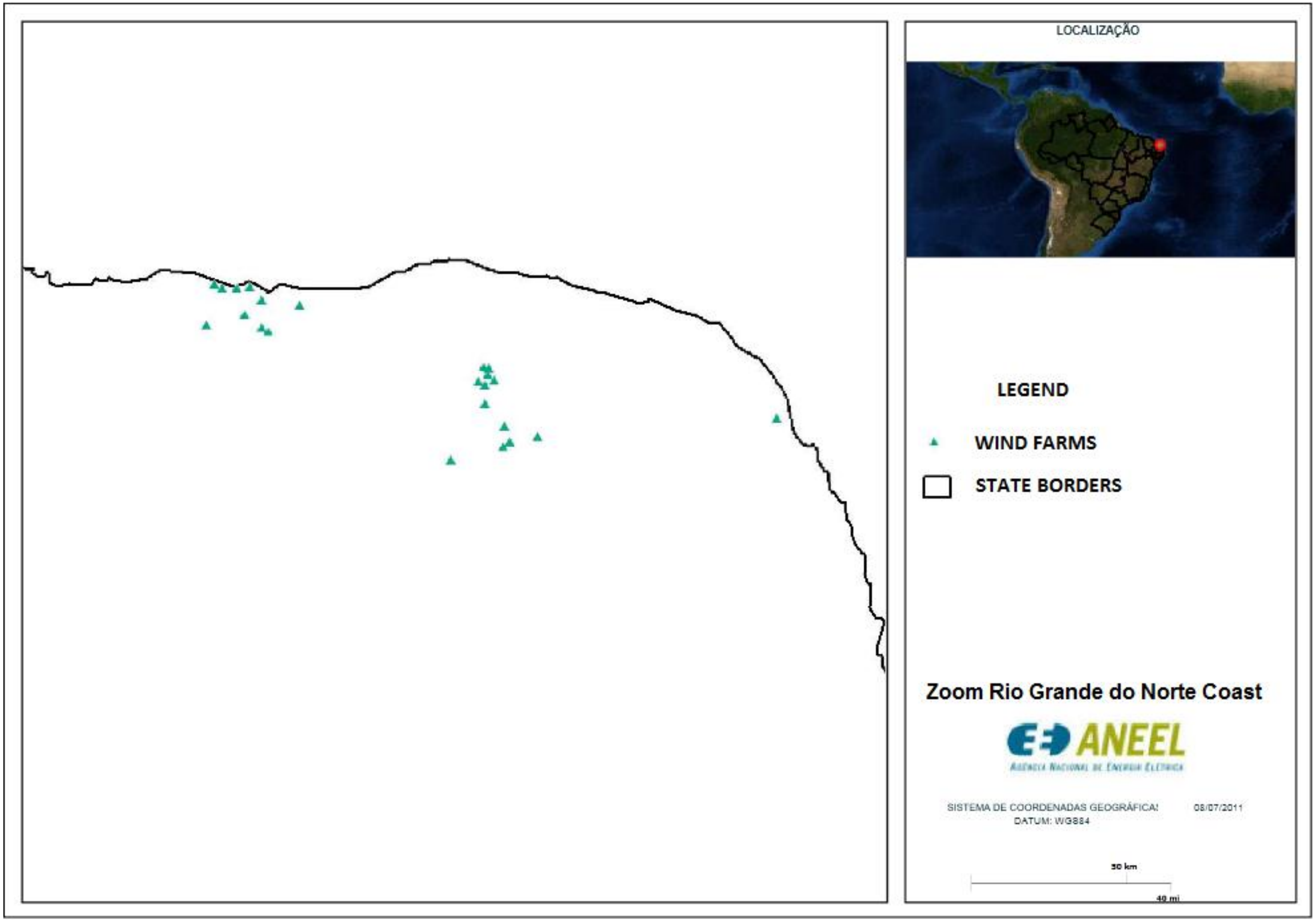
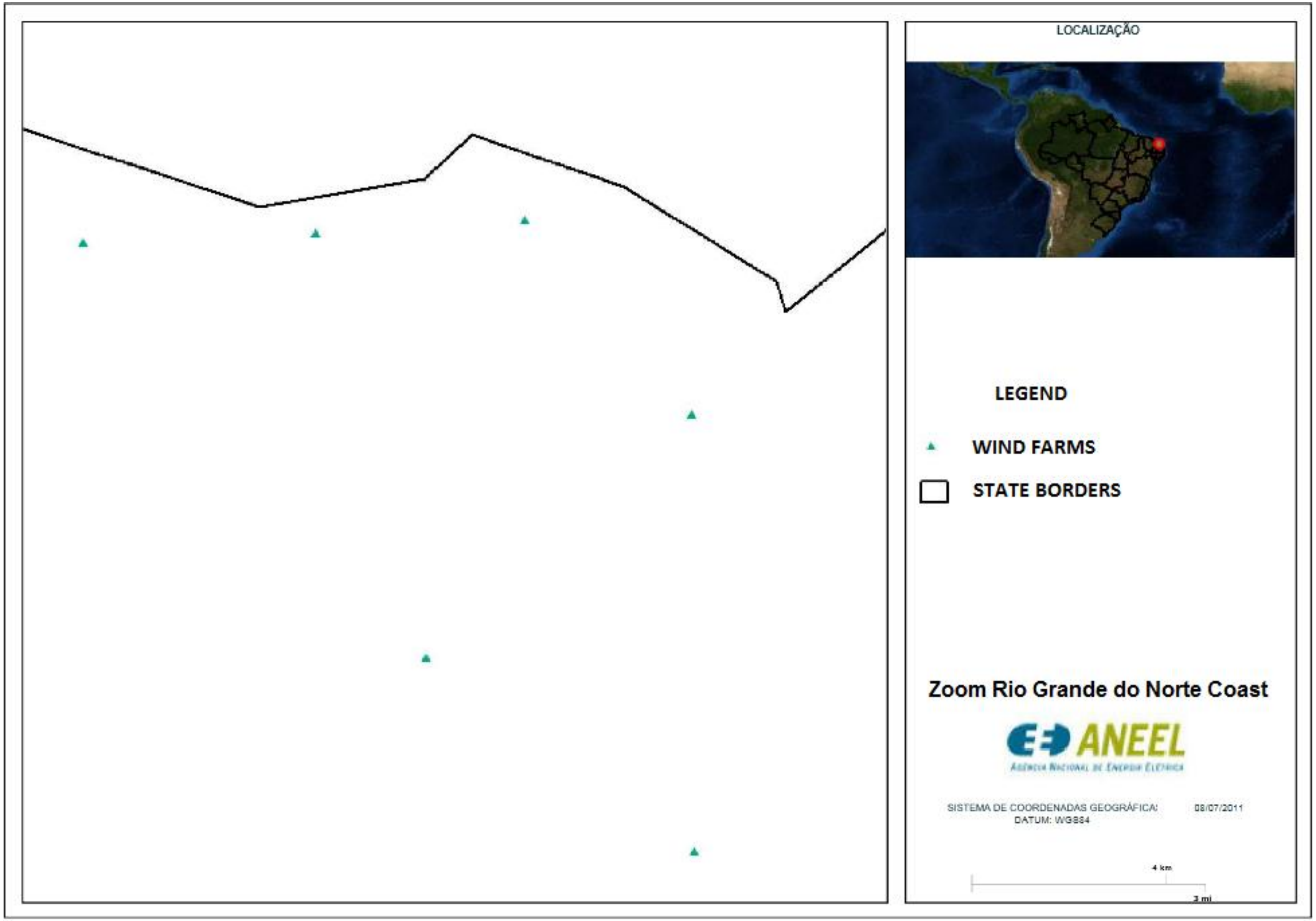
ANEXX 01 – MAPS

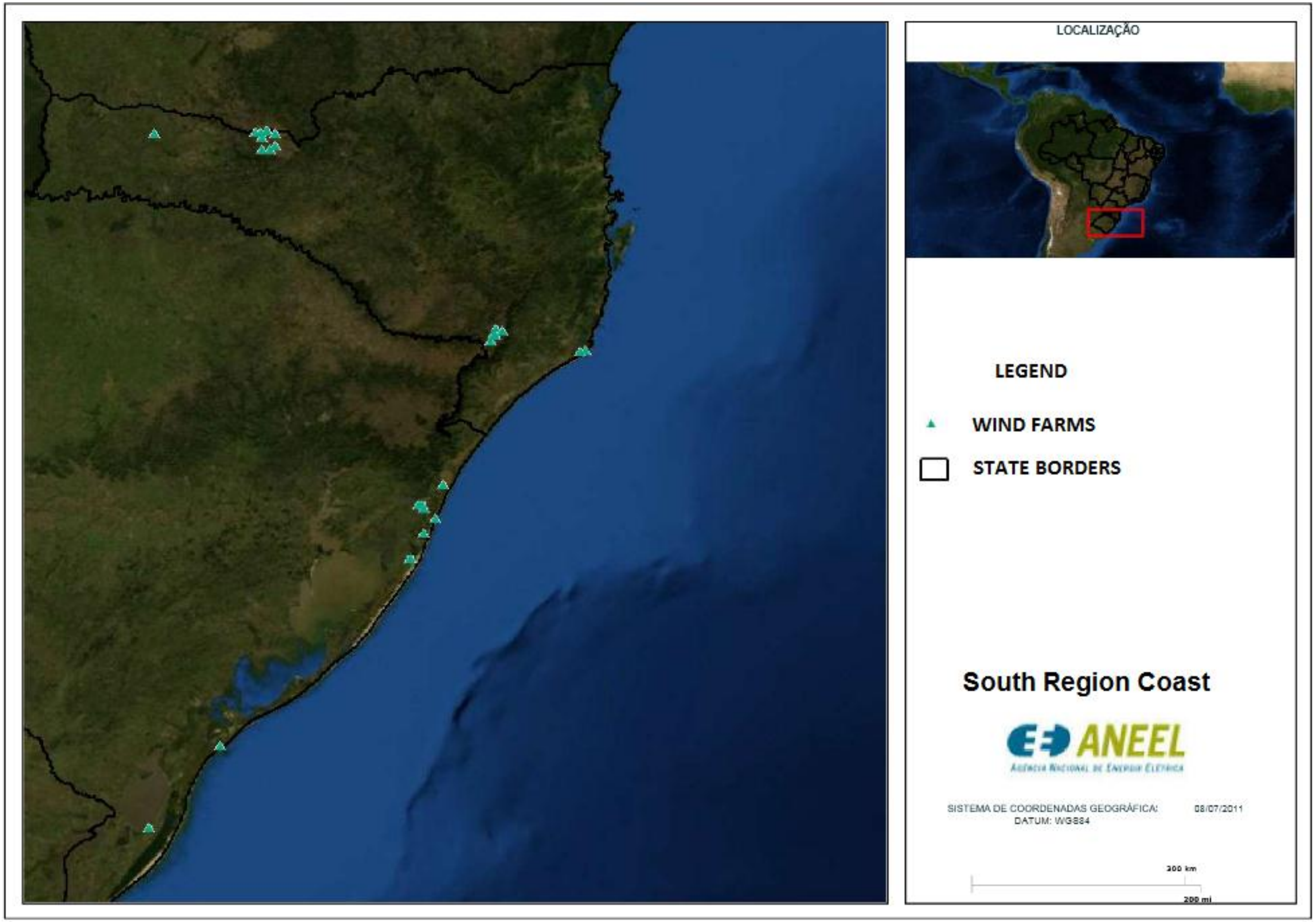

LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
North East Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICA
DATUM: WGS84
08/07/2011
500 km
300 mi

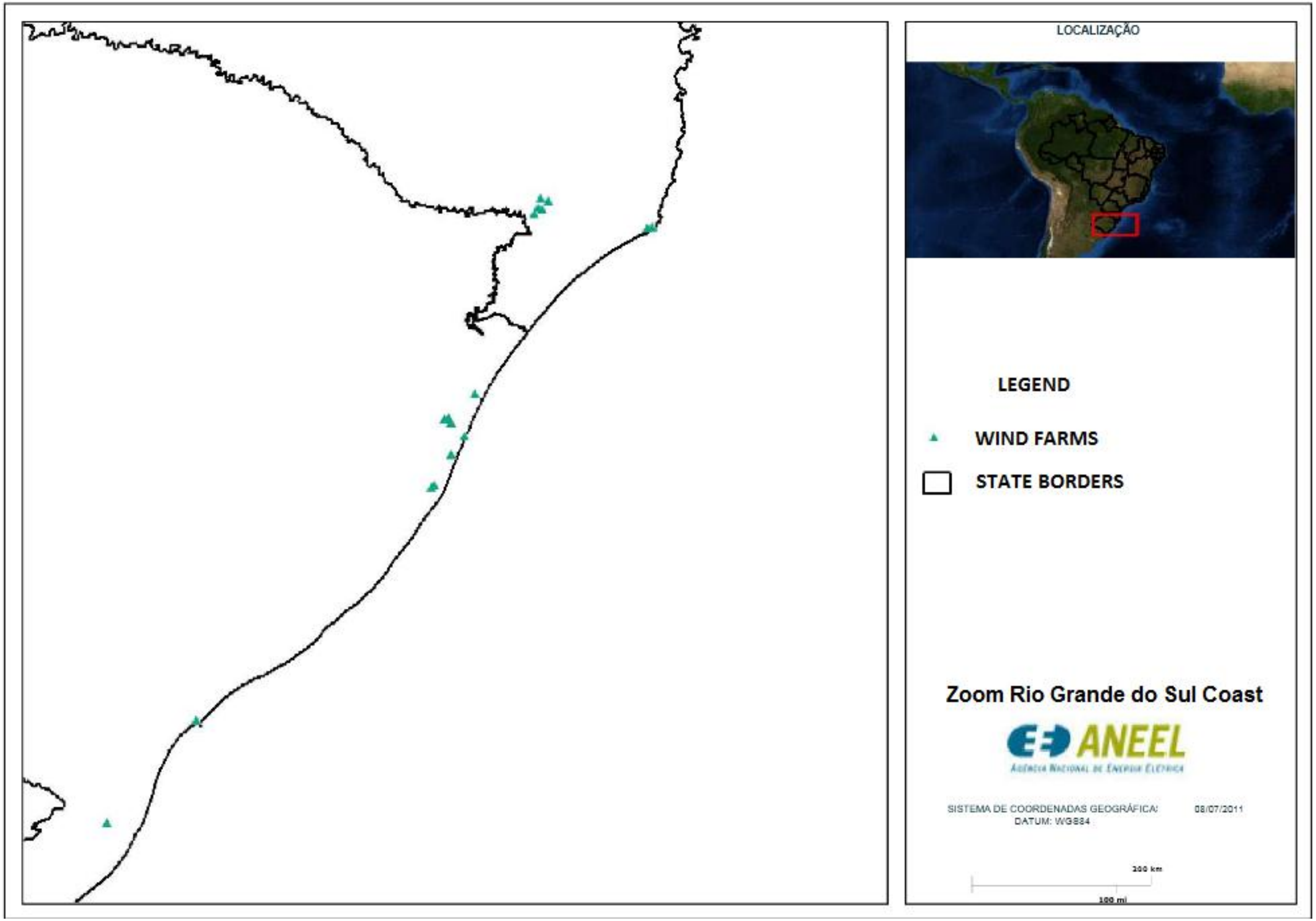

LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Ceará Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICA:
DATUM: WGS84
08/07/2011
100 km
50 mi

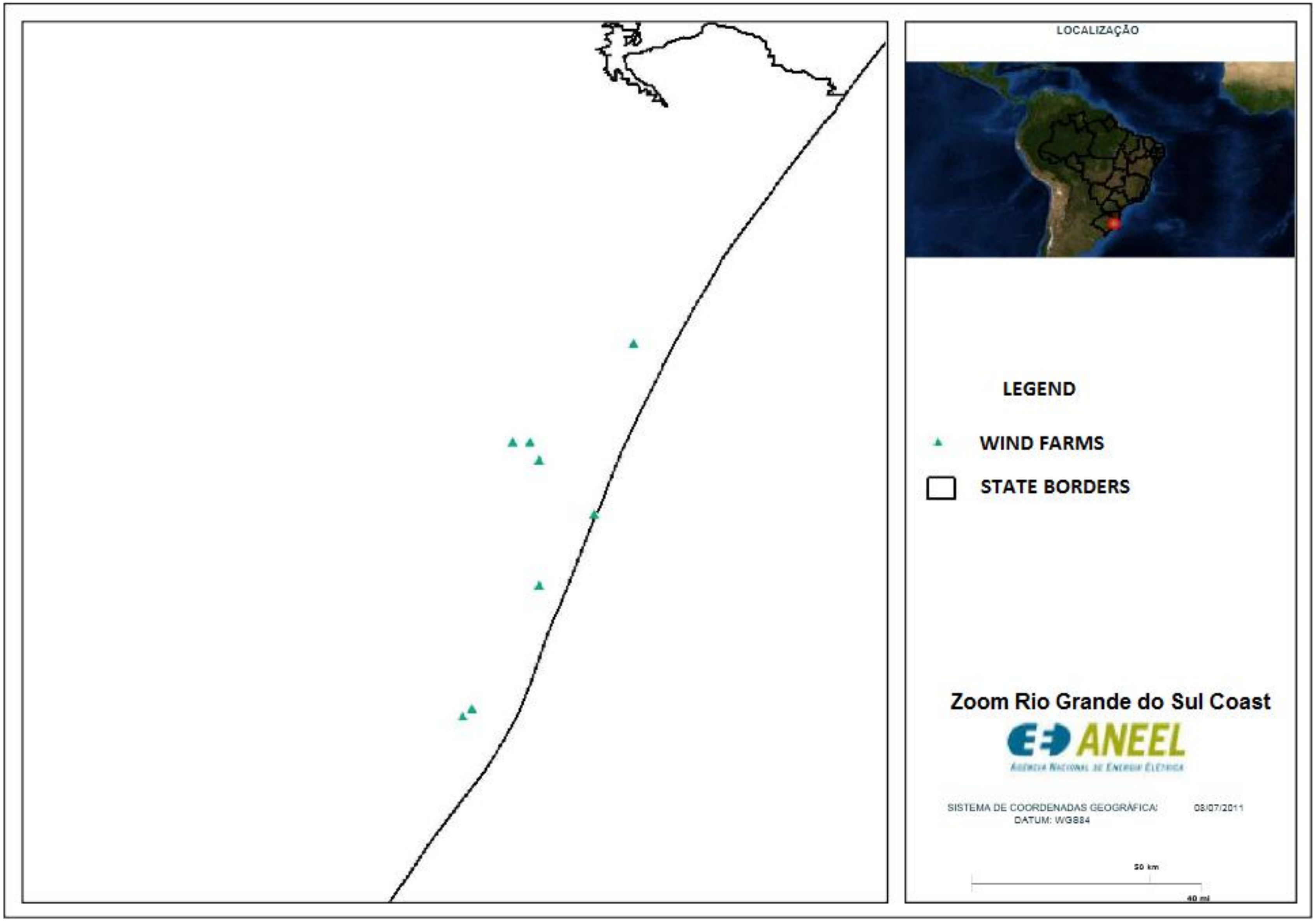

LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Ceará Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICAS
DATUM: WGS84
08/07/2011
10 km
10 mi


LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Rio Grande do Norte Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICA!
DATUM: WG884
08/07/2011
30 km
40 mi


LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Rio Grande do Norte Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICAS
DATUM: WGS84
08/07/2011
4 km
3 mi


LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
South Region Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICA:
DATUM: WGS84
08/07/2011
300 km
200 mi


LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Rio Grande do Sul Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICA:
DATUM: WGS84
08/07/2011
200 km
100 mi


LOCALIZAÇÃO
LEGEND
WIND FARMS
STATE BORDERS
Zoom Rio Grande do Sul Coast
ANEEL
SISTEMA DE COORDENADAS GEOGRÁFICAS
DATUM: WGS84
08/07/2011
50 km
40 mi