EVALUATION OF THE NEW BRAZILIAN REGULATION CONCERNING LOW VOLTAGE DISTRIBUTION NETWORK: AN OPPORTUNITY FOR SMALL WIND TURBINES

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Sumary

The Brazilian Electric Energy Agency (Aneel) published the Normative Resolution #482/2012 in order to reduce barriers to the installation of distributed generation from renewable resources (wind, photovoltaic, hydro, biomass and cogeneration) connected at the distribution grid and to encourage the development of these technologies in Brazil. This article presents the rules of the new regulation and also presents small wind turbines as a feasible option for the Northeast Region of Brazil

1. Introduction

Despite the fact that the wind energy market in Brazil is going through a rapid growth in the generation of large size wind farms, the same is not observed for small wind turbines. The growth of large size wind generation is based on the Brazilian electric sector model, which is composed by three pillars: low tariffs, supply security and legal stability. To reach low tariffs, the government organized energy auctions. The energy auctions take place in the so-called regulated environment of electricity contracting, where electricity utilities bid on a certain amount of installed capacity under offer. In this environment, large wind energy projects have undergone major changes since 2009. Several projects have been contracted and reached tariff values that are competitive with traditional sources such as thermal generation with natural gas. Figure 1 shows the evolution of wind power installed in Brazil and a forecast of its evolution until 2020. Brazil´s current wind power installed capacity is about 2 GW [1], and it is expected to reach 11.5 GW by the end of 2020 with 6.7 GW contracted to be in operation until 2016 [2].

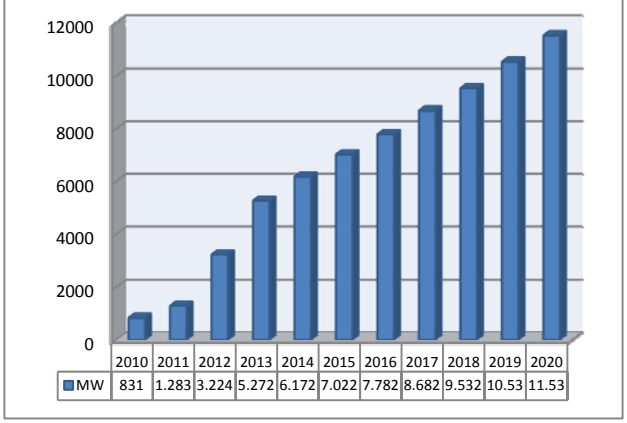

Figure 1 – Wind power installed in Brazil and forecast [2]

In order to reduce barriers to the installation of distributed generation from renewable sources connected at the distribution grid and to encourage the development of these technologies in Brazil, the National Electric Energy Agency (ANEEL) issued the Normative Resolution # 482/2012. This resolution establishes the general conditions for access of distributed minigeneration (up to 100 kW) and microgeneration (from 100 kW to 1 MW) for the electricity distribution grid and compensation mechanisms for the energy generated by the consumer. This resolution helps the consumer to participate as a small electricity generator.
Distributed microgeneration is classified as an electric power generating plant that uses fonts based on hydropower, solar, wind, biomass or cogeneration. That small plant will be connected to the distribution network with installed capacity up tp 100 kW; and the distributed minigeneration is classified for an installed capacity greater than 100 kW to 1 MW.
This resolution is a great opportunity for the development of small wind turbines, promoting incentives through the reduction of legal obligations and provision of an energetic compensation for the excess of energy production. Although the incentive is not a program exclusively for small wind turbines, this technology presents several advantages, especially considering the Brazilian wind resource.

2. Normative Resolution #482/2012

The Brazilian Electric Energy Agency (Aneel) published the Normative Resolution #482/2012 in order to reduce barriers to the installation of distributed generation from renewable resources (wind, photovoltaic, hydro, biomass and cogeneration) connected at distribution grid and to encourage the development of these technologies in Brazil. This regulation establishes the general conditions for access of distributed minigeneration (up to 100 kW) and microgeneration (from 100 kW to 1 MW) and the electric compensation rules.

2.1 – Distribution Sistem Access

The access to the system of electricity distribution is based on the Procedures of National Electrical Distribution in Electric Energy System - PRODIST. This set of standards has as goal to homogenize the

methods of access to the distribution grid concerning the specific characteristics of the local electricity company.
In order to facilitate access to the distribution grid, Normative Resolution # 482/2012 amended the connection procedures (Chapter 3 of PRODIST) so there is no need to sign contract of use and connection of the generating unit that is participant in the energetic compensation system. It is worth simply signing the Operating Agreement between participants (distributed minigeneration and / or microgeneration).
The acceptance of the Operating Agreement allows to the renewable energy generator participant of the energetic compensation system, greater flexibility as regarding the energy dispatch. There is no contract between the generator and the utility that determines the amount of energy to be generated and dispatched. Thus, the generator has only the responsibility for the operation of a plant and for the quality of energy generated by it. The costs of adequacy of the connection and of the power measurements are also responsibility of the generator so that he can participate in the energetic compensation system.

2.2 – Electric Power Compensation Rules

The energetic compensation system provides rules for the accounting of the balance of generation / consumption of energy that will be the basis for the economic feasibility calculation of a project regarding the distributed generation.
It is important to mention that, unlike the Feed-In system, the tariff proposed by the energetic compensation system is not a premium gained by generating electricity but it's a compensation for the energy generated that will be discounted from the energy consumption through payment of the electricity bill. As Brazil has one of the most expensive electricity bills in the world, by using this comparative cost basis, it is possible to prove that small wind generation is viable in some parts of Brazil.
In general ways, the energetic compensation system has the following characteristics:

- If the generated energy is lesser than the energy consumed, the energy bill value will be the difference between consumption and generation;
- If the generated energy is greater than the energy consumed, the difference should be used preferentially for reducing the value of the energy bill of other units within the same billing cycle;
- If the amount of generated energy has not been used by the compensation system in its own consumer unit, it may be used to offset the consumption of other units of the same consumer;
- Surpluses credits generated within the compensation system will be valid for 36 months after the billing.

The direct effect of the compensation system will be realized in reducing the electricity bills of consumers who may use the surplus credits to offset the electricity bill of other consuming units of the same owner. This effect will be realized to a single consuming unit too. In general, the system must have a size that is compatible with the total energy consumption (one or more consuming units) since the excess credit is valid for 3 years.

3. Residential Electric Power Bill in Brazil

Despite the generation costs of electricity in Brazil being one of the cheapest in the world, the electricity bill for the consumer is one of the most expensive in the world mainly by the incidence of taxes [4] [5]. As the energetic compensation system comes only from the difference between power generated and consumed, the taxes are only applied on the difference. As there is no income, the generator does not pay taxes on the energy generated. Thus, it is necessary to consider the tariff and the taxes together to make the economic viability assessment.
Figure 2 shows the tariffs, taxes and charges paid by residential consumers throughout Brazil.

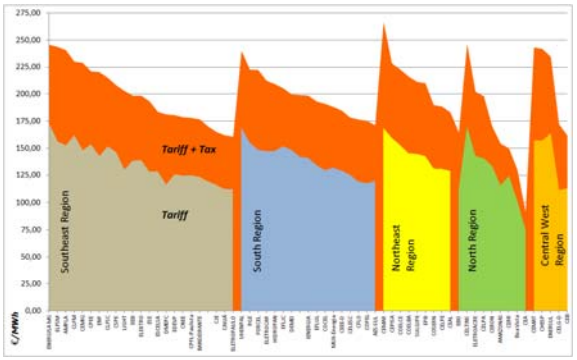

Figure 2 – Final price of energy for brazilian residential consumers [6]

Taxes and charges represent, on average, 30.7% increase in the tariff for residential consumers. The final values of the fare to the final consumer in Brazil range from € 268.60/MWh (Northeast) until € 91.88/MWh (Northern Region). Considering all regions, the change in tariffs and the minimum tariff is practiced in the state of Amapá (Northern Region) (€ 91.71/MWh), which can be considered a special case. In order to conduct the evaluation of the economic viability, this article indicates reference values for small wind generation in order to identify concession areas which present fees equal to or above these values.

4. The small wind turbine industry and the Brazilian wind power resources

The small wind industry in Brazil is still incipient. Despite the existence of several representatives of foreign companies [7], in Brazil there are only three companies that manufacture wind turbines with models designed in Brazil [8] [9] [10]. The market remains in the beginning mainly due to the non-existence of a specific program for the development of the market for small wind turbines. Even with applications focused on isolated systems, government programs for rural electrification have not given differentiated incentives for the use of wind

technology and resulted in rural electrification by the use of only photovoltaic systems and extension of the conventional network.
Despite the market being developed exclusively by its own resources, without government incentives, the small wind industry in Brazil has developed technology in their products that range from a few Watts up to 24 kW. Table 1 presents the models developed by Brazilian manufacturers.

Table 1 - Wind turbines developed and manufactured in Brazil [8][9][10]

Company	Model	Power
Enersud	Notus138	350 W
Enersud	Gerar 246	1 kW
Enersud	Verne 555	6 kW
Canoas Eólica	TC5	4.8 kW
Canoas Eólica	TC24	24 kW
Eletrovento	Turbo500	500 W
Eletrovento	Turbo 2000	2 kW
Eletrovento	Turbo 5000	5 kW

The Atlas of Brazilian Wind Potential [11], published to a height of 50m was used to identify the potential for small wind generation. The logarithmic law was used to identify wind power to a height of 20m by using GIS tools and crossing layers of annual average wind speed and roughness of the terrain.
The Northeast Region was chosen to evaluate the potential for small wind generation considering the quality of the winds and the amount of large projects already in operation in the region. Figure 3a and 3b show, respectively, the wind potential for 50m and 20m for part of the Northeast Region.
The wind potential to a height of 20m shows favorable areas both in the inner part and on the coast of the State of Rio Grande do Norte that could be exploited for decentralized generation through small wind turbines. The state of Ceará has also a significant wind potential along its coast and also in some countryside areas. The tariffs for residential consumers in the State of Ceará (€ 222.71/MWh) and the State of Rio Grande do Norte (€ 189.88/MWh) will be used as constraints to economic viability.

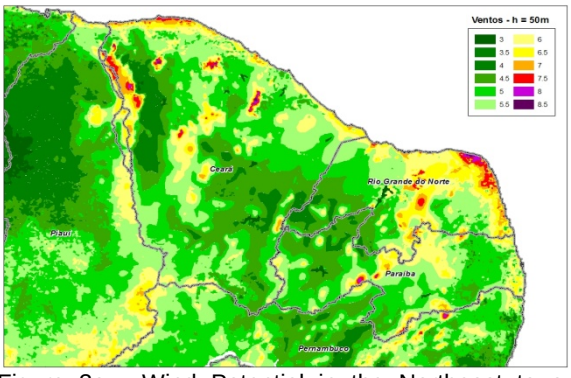

Figure 3a - Wind Potential in the Northeast to a height of 50m. [12]

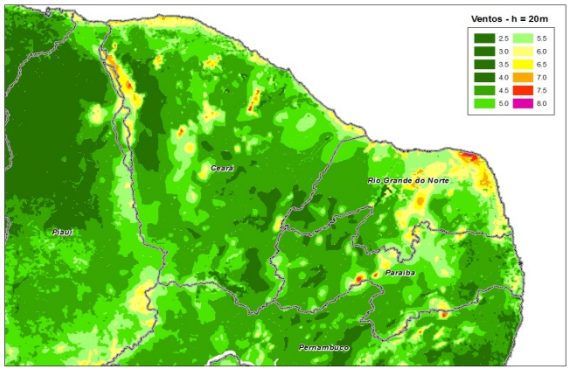

Figure 3b - Wind Potential in the Northeast to a height of 20m. [12]

5. Availability Case

In economic feasibility study, three levels of possible Capacity Factors (CF=25%, 30% and 40%) in the Northeast Region were adopted (Figure 3b)
Since it is an energetic compensation, it is important that the energy generated by the wind turbine is equal to or less than the average residential consumption. For the case of the Northeast, the average monthly residential consumption is 97 kWh/month [13]. Whereas residential consumption of upper-middle class can reach three or four times more than the average, the best option for this consumer would be a wind turbine of 1 kW.
An interest rate consistent with the rate used by the most popular investment in Brazil that reached 7.5% in 2011 was considered. The leveled costs of the investment concerning a 1 kW wind turbine for the period of 20 years with an interest rate of 7.5% has been calculated. The maintenance cost of 3% of the investment to be applied every year has also been added to the calculation. Considering only the states of the Northeast Region shown in Figure 3b, the residential tariffs prevailing on the region (Figure 2) and the leveled cost of energy generated by the small wind turbine, it is possible to find points of technical and economic viability in various concession areas for the three levels of generation shown in Table 2.
Figure 4 shows the cost of wind generation for the three levels of CF and the residential tariffs charged by electric utilities in the Northeast.

Table 2 – Project hypotheses

Investiment [8][9][10]	€3802,28[1]
Period	20 anos
Interest rate	7,5%aa
Leveled annual cost	€ 372.97[1]
Maintenence	€ 114.07[1]
Total Annual	€ 487.04[1]
Power	1000 W
Energy production (CF=25%)	2.19 MWh.y
Energy production (CF=30%)	2.63 MWh.y
Energy production (CF=40%)	3.50 MWh.y
Energy cost (CF=25%)	€ 222,39/MWh
Energy cost (CF=30%)	€ 185,33/MWh
Energy cost (CF=40%)	€ 139,00/MWh

1 - R$/€ = 2,63 (September/2012)

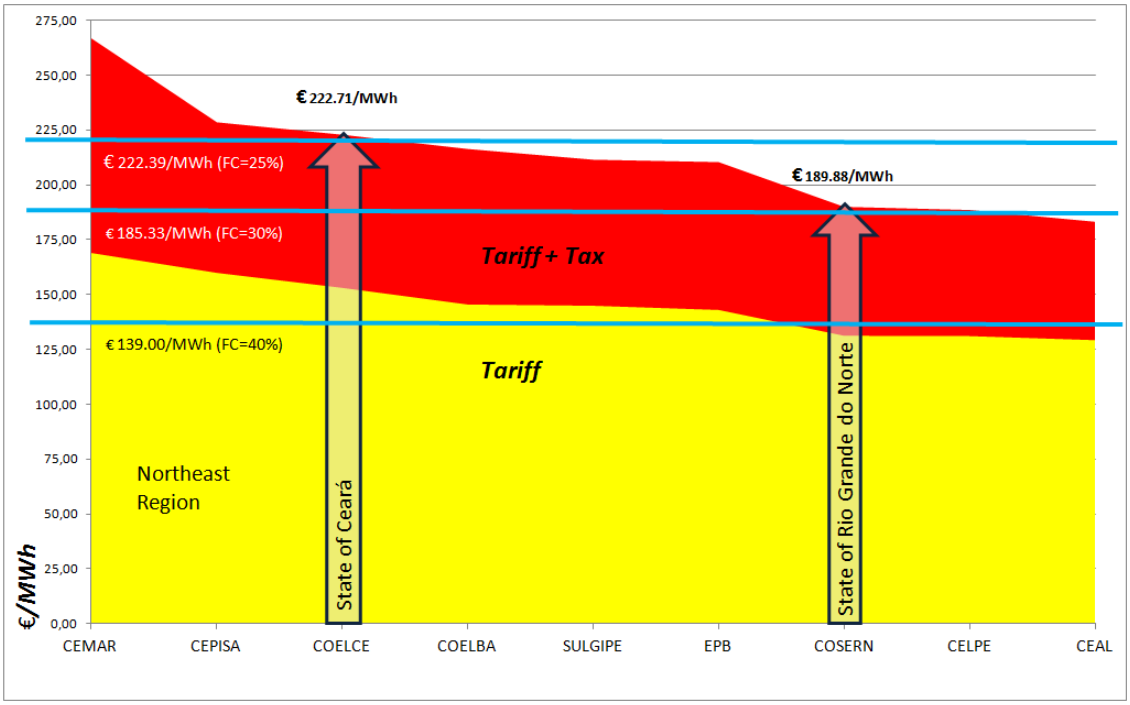

Figure 4 - Cost of wind generation and residential tariffs in the Northeast Region[6]

6. Conclusion

The State of Ceará, by having a higher residential tariff, has advantages for wind generation with CF = 25% (equivalent tariff) which covers a larger area of utilization of wind resource as presented in Figure 3b. Because State of Rio Grande do Norte has better wind potential, It has a better potential of utilization of the energetic compensation system even with a lower residential tariff.

The presented results show that there is technical and economic feasibility for decentralized wind generation and other regions in Brazil must be addressed in order to enable the growing of the market, the utilization of international models of wind turbines and the reduction of prices of equipment.

7. References

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