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# A SOFTWARE FOR CALCULATION OF COSTS AND OPERATION OF A SMALL WIND POWER PLANT

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**Abstract.** *In this project was made a survey of the wind conditions in the state of Ceará and a market research to establish approximate values for the creation of a software for consulting costs and profitability of a small wind power plant. This computer program will help the consumer get a sense of what they will spend and how long that financial return will take. The program is customizable and can be used to generate estimates not only in the state of Ceará, but throughout the country. The methodology used was a bibliographical research related to the behavior of the winds and a market research, and from this information, software in the Python language was created to allow easier access to this type of information. In addition, the electricity distribution companies were also consulted and provided important information regarding concessions and incentives for energy production autonomously. To bring all this knowledge closer to the population, we have created a website with useful information, where we offer the link to download the program in a totally free way, allowing anyone who has an interest to carry out this query and get an idea more obvious how the entire system works, from budgeting to energy production. From this it will be possible to make the potential investors better informed of the ecological and financial advantages and disadvantages to install small wind energy plants.*

**Keywords:** *power plant, software, low-cost energy, alternative energy, wind turbine, python*

## 1. INTRODUCTION

According to ANEEL (National Agency for Electric Energy), in the last 15 years the situation of electric consumption in Brazil has become increasingly complicated, as the significant increase in consumption associated with reductions in rainfall rates recorded by INMET (National Institute of Meteorology). This caused a productive insufficiency in these plants, because the supply did not cover the demand, therewith, the thermoelectric plants were used to supply this input. This resulted in an increase in the consumption rate for the population. Another important point to be mentioned is the Northeast, a region where there is not much hydroelectric potential to be explored, different when we talk about the winds.

Wind energy applies to diversified energy markets. Small power plants are capable of servicing isolated systems in locations far from urban centers, where there is still no universal access to electric power (Farias, L. M. and Sellito, M.A., 2011).

In view of the growing need and the constant search for ecologically and economically viable alternatives for the generation of electric energy, and taking advantage of the great wind potential of the states of the Northeast, specifically Ceará, we made a survey about the energy production potential using the energy of the wind as a source of energy.

In this article we will focus on the production of energy at the domestic level, so that it can serve as a research factor and source of information to encourage and facilitate the creation of new small power plants with energy mini generation. This will address environmental, economic, legislative and structural factors.

## 2. WIND ENERGY

It is the kinetic energy from the winds, it is used to propel sailing boats and can be used as a source of alternative energy to the burning of fossil fuels, because it is clean and does not emit polluting gases during the energy conversion process. For this, it requires a small amount of ground for the installation of the wind turbines and the environmental impact is much smaller than the other forms of energy generation.

Wind farms are groups of wind turbines gathered in each location and connected to a power transmission network or to energy storage devices, such as isolated systems. These wind farms may be small in isolated or large-scale areas with large production and generally located along the coastal strip where there is less turbulence in the wind.

The low environmental impact generated by this means of generation and the possibility of having an inexhaustible source of energy culminated in the interest of several countries and in a considerable growth of the use of the strength of the winds as a source of energy production. This fact has generated interest in several countries in the world, such as Denmark, Germany, the United States and China.

## 2.1 Wind Energy in Brazil

At the beginning of the 21st century Brazil suffered a great drought that caused the water level in the dams to drop and generated a serious energy crisis in the country. This event created the need to establish energy rationing throughout the nation, which culminated in an economic crisis of considerable proportions. It was from this point on that Brazilians concluded that the need to seek alternative sources of energy had become critically important.

Brazil has more than 75% of its energy matrix from hydroelectricity, which reveals such dependence on this energy source, while renewables still have a small share of this total.

Thus, in 2002, the Brazilian government created the Program for Incentives to Alternative Sources of Electric Energy (Proinfa) to encourage the use of the most varied sources of energy, such as wind, solar, biomass, among others. The impact caused by the creation of Proinfa was notorious in a short time, since its creation the wind energy production has increased considerably. According to the National Electric Energy Agency (ANEEL), in 2003 there was a production of 22 MW, and only 6 years later, in 2009, this generation grew to 602 MW and to 1000 MW in 2011. With this it is possible to observe that the growth of this alternative means of obtaining electricity has great potential and this continuous advance will extend over the coming years to ever greater levels.

All this potential, despite being present throughout the Brazilian territory, is not homogeneous, according to the Energy Research Company, the regions with the greatest potential for generating wind energy are the Southeast and Northeast regions, the latter being, in turn, responsible for most of current production, as it has the largest amount of wind farms.



Figure 1. Brazilian Wind Potential by Region

According to Figure 1, from the Energy Research Company, one can note the total superiority of the Northeast with respect to the wind potential. Despite this, this potential still has much to take advantage of, since, according to ANEEL, the current production in the Northeast is around 5GW, while the generation capacity is around 75GW, that is, the production currently represents approximately 6.7% of the total to be exploited.

All this progress, growth and incentive to the generation of wind energy in Brazil is positively impacting the economic and energy development process in the country, since these changes have already been responsible for transforming the lives of thousands of Brazilians through the generation of jobs and the preservation of the environment through the choice of clean sources of energy. All this is combined with the vision of these changes as a way of escape from the energy and economic crisis experienced by the Brazilian population today.

## 2.2 Wind Energy in Ceará

Regarding the state of Ceará, it can be said that this is one of the states of Brazil with the greatest potential for wind power generation. According to ANEEL (National Electric Energy Agency), Ceará produces 1,323 MW of power from the 48 wind farms currently in operation, with 25 more parks under construction, which puts the wind as the second largest source of energy in the state, second only to thermal plants, which produce 1,953 MW of power.

Through these data, it is noted that Ceará is not yet the main producer of this type of energy, but this is not repeated when it comes to distributed microgeneration, that is, the small electric generation, carried out by the consumer himself from renewable sources or high energy efficiency. There are 20 wind power generating units or units with a power of 53.1 KW, which corresponds to 26.2% of the distributed generation power installed throughout Brazil, and this places the state as the Brazilian leader in energy production by distributed generation (National Agency of Electric Energy, 2012).

Such information reveals the attractive economic possibilities of investment in the wind sector within the state of Ceará. Given that large companies are already adhering to this means of making a profit, why not install your own small wind farm for a micro energy generation?

The great potential of microgeneration of existing energy in Ceará is a factor that can and should be explored so that there is an improvement in the economic, social and sustainable development of the place, always considering the investment factors, the geomorphological analysis and the local conditions.

## 2.3 Environmental Impacts

The generation of wind energy, in general, represents a minimal impact on the environment. Regarding large aerogenerators, care must be taken with the migration of the birds and with the local fauna, because the noise caused by this equipment can harm the animals of the region because they are of great intensity.

It is worth mentioning that there are also the materials used to produce the components of the wind turbine, these can represent significant damages if they require a process of obtaining or manufacturing aggressive to nature.

Another factor of extreme importance are the shadows that the blades produce on houses, because there are reports that families got psychological problems caused by the shadows in periodic movement during the day.

As far as small wind turbines are concerned, the environmental impact is almost non-existent, since they are small equipment installed at a much lower level than the others and, in addition, they produce much less noise, especially vertical axis wind turbines, more present in urban environments.

Using wind energy as a source of electricity for a system with 220 kW of power, the generated clean energy ceases to deposit, every month, about 13 tons of harmful waste in nature. What makes the wind power system become one of the means of generating energy with less environmental damage. (Pioli, M.B., 2010).

## 2.4 Energy Demand

The energy demand consists of the amount of energy that must be generated to supply the consumption of the analyzed place, a residence, for example.

The calculation of this amount of energy is simple and requires little information, which are: the power of each appliance and the time that these appliances stay on during the day. From this, one can arrive at an estimate of the monthly consumption.

This step is of great importance because it will establish the amount of wind turbines to be installed, as well as the power of each one, and this will have a direct impact on the investment to be made.

## 2.5 Wind Analysis

The study of the local wind is of fundamental importance for a successful installation, since it is through this analysis that the type and power of each wind turbine will be chosen, besides the place of installation and the calculation of the monthly savings that that regime of winds can generate.

This process consists in using data from the Atlas of the region, and after that, a more detailed analysis using anemometers. This data is processed and produces charts that show how the wind behaves throughout the year at that location. From this, the appropriate wind turbines are chosen, and the overall budget is realized.

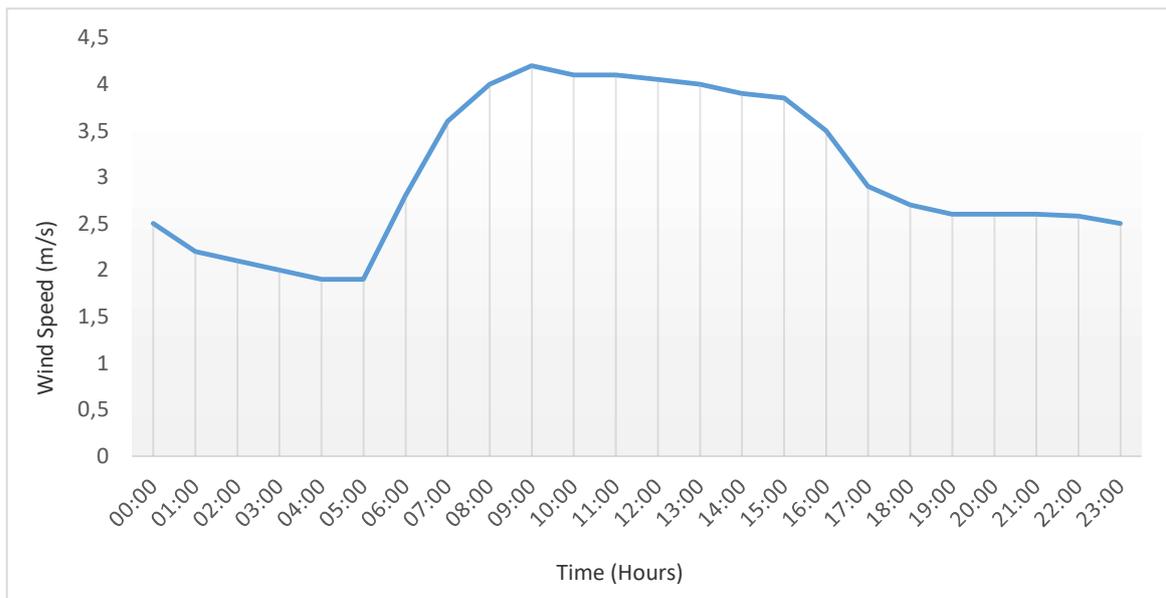


Figure 2. Wind Speed Throughout the Day (Height: 10m)

The variation in the velocity of the Ceará winds between day and night is noticeable due to the difference between the absorption of heat in the sea and in the continent, since the air moves from the colder to the hotter regions. During the day the continent has a higher temperature, and for this reason it receives air masses coming from the ocean at night is the opposite. This fact occurs due to the high specific heat of the water, which causes it to retain more thermal energy, leaving the ocean cooler than the mainland during the day and warmer at night. An exception to this rule occurs in inland and mountain regions, which do not have maritime influence.

### 3. SOFTWIND

Given the difficulty in defining the energy demand and the type of wind turbine to be installed, such as how many units should be purchased to supply that consumption, the calculation of the costs of installing a wind farm with distributed generation needed to become simpler and fast, and should be accessible to anyone, even if it does not have technical expertise in that area. It was with this need that came up the idea of creating the Softwind.

Figure 3 shows the software in operation, it was created with the use of the Python language and has the function of assisting ordinary users in the query of demand and equipment necessary for the installation of a power plant for mini generation of wind energy.

To use it is simple: just enter the power of each device in your home, the power of each and the average hours that each is turned on during the day. After that, it will show on screen the demand that the user has, the amount of wind turbines he will need, along with the power of each and the total energy produced monthly by these wind turbines.

SoftWind

Preencha a Tabela Com os Dados Pedidos (Somente Números)

|                       | Quantidade | Potência(em watts) | Horas/Dia |
|-----------------------|------------|--------------------|-----------|
| Lâmpadas              | 20         | 20                 | 10        |
| TVs                   | 4          | 120                | 7         |
| Ventiladores          | 4          | 150                | 15        |
| Condicionadores de Ar | 1          | 800                | 6         |
| Computadores          | 1          | 100                | 8         |
| Geladeiras            | 1          | 200                | 10        |
| Chuveiros Elétricos   | 0          | 0                  | 0         |
| Máquinas de Lavar     | 1          | 1500               | 2         |
| Outros                | 0          | 0                  | 0         |

CALCULAR

Demanda: 808.8 Kw.h/mês  
Gasto\_Mensal: 647.03 Reais

OPÇÕES\_DE\_INVESTIMENTO

|   |  |
|---|--|
| QUANTIDADE_NECESSÁRIA_DE_AEROGERADORES_DE_2000w: 2.0<br>GERAÇÃO_DE_ENERGIA_APROXIMADA: 1200.0 Kw.h/mês<br>****VALOR_INVESTIDO: 26000.0 Reais<br>****RETORNO_DO_INVESTIMENTO: 40.0 meses | QUANTIDADE_NECESSÁRIA_DE_AEROGERADORES_DE_1000w: 3.0<br>GERAÇÃO_DE_ENERGIA_APROXIMADA: 900.0 Kw.h/mês<br>****VALOR_INVESTIDO: 14700.0 Reais<br>****RETORNO_DO_INVESTIMENTO: 22.0 meses |
| QUANTIDADE_NECESSÁRIA_DE_AEROGERADORES_DE_1600w: 2.0<br>GERAÇÃO_DE_ENERGIA_APROXIMADA: 900.0 Kw.h/mês<br>****VALOR_INVESTIDO: 12000.0 Reais<br>****RETORNO_DO_INVESTIMENTO: 18.0 meses  | QUANTIDADE_NECESSÁRIA_DE_AEROGERADORES_DE_800w: 4.0<br>GERAÇÃO_DE_ENERGIA_APROXIMADA: 920.0 Kw.h/mês<br>****VALOR_INVESTIDO: 17600.0 Reais<br>****RETORNO_DO_INVESTIMENTO: 27.0 meses  |
| QUANTIDADE_NECESSÁRIA_DE_AEROGERADORES_DE_600w: 7.0<br>GERAÇÃO_DE_ENERGIA_APROXIMADA: 910.0 Kw.h/mês<br>****VALOR_INVESTIDO: 23100.0 Reais<br>****RETORNO_DO_INVESTIMENTO: 35.0 meses   |  |

Figure 3. Softwind's printscreen

#### 4. RETURN ON INVESTMENT

The autonomous power generation system presents a significant investment and this factor may generate insecurity or fear on the part of citizens who do not yet have prior knowledge. Is it even a profitable investment? How can it be attractive to the consumer?

The current tariff for each Kwh consumed in the electricity bill is around R\$ 0.74, with 27% of taxes related to ICMS and 6.4% for PIS and COFINS, giving a total of more than R\$ 0.90 per kwh consumed. The following table shows the data referring to 3 beacons of three residences in Ceará.

Table 1. Detailing of Energy Accounts for Profitability Analysis

| TARIFAS                  | BILL 1            | BILL 2            | BILL 3            |
|--------------------------|-------------------|-------------------|-------------------|
| <b>CONSUMPTION</b>       | 316 Kwh           | 323 Kwh           | 379 Kwh           |
| <b>TAX OF ICMS</b>       | R\$ 63.40         | R\$ 62.25         | R\$ 73.04         |
| <b>TAX OF PIS/COFINS</b> | R\$ 16.08         | R\$ 14.08         | R\$ 17.36         |
| <b>TOTAL</b>             | <b>R\$ 234.85</b> | <b>R\$ 230.56</b> | <b>R\$ 329.52</b> |

Looking at the data in Table 1, we can see the impact of taxes on the electric energy bill, which makes the autonomous generation system even more attractive from a financial point of view.

To simulate a distributed generation system in operation, one can take as an example a residence where a 1000w power wind turbine was installed, which, based on table 2, has an average cost of R\$ 4,900.00 and, to install and let ready for use, one owner spent another R\$ 4,000.00 referring to the purchase of installation material, complementary devices and labor, totaling an investment of R\$ 8,900.00. According to the manufacturer, this wind turbine model has the capacity to generate, on average, 300 Kwh/month and, considering the local consumption tariff of R\$ 0.74 for each Kwh consumed, there is a production equivalent to about R\$ 222.00 each month. In terms of profitability, it can be estimated that, based on this production and on this consumption, the time of return of the investment, that is, the time necessary for the monthly economy to equal the amount invested is about 40 months, or 3 years and 4 months. In comparison with the photovoltaic generation system, the wind system has a higher profitability, since the estimated return time using solar energy is about 7 to 8 years.

Because it is a relatively financially attractive investment that generates positive impacts both in the social as well as in the environmental sphere, it is natural that there should be an incentive from the regulatory and financing agencies. This began with the tax exemption requested by ANEEL and spread with the creation of a line of financing for the micro and distributed mini generation of renewable electricity by Banco do Nordeste (BNB), destined to companies of all sizes and sectors, producers and rural enterprises, cooperatives and associations. This financing line uses resources from the Northeastern Constitutional Financing Fund and has a payment term of up to 12 years, with a grace period of one year. The investment can be financed up to 100% and there is a 15% payout bonus.

Given the time of return of the amount invested in the purchase and installation of a wind energy mini generation system, it can be said that this financing is a very adequate option for those who intend to use the wind as their source of energy and consequently of money.

## 5. CONCLUSION

According to the data analyzed, organized and grouped it was possible to establish a good cost-benefit ratio so that investment in the domestic wind sector is possible and quite attractive.

Through the project is expected to gain acceptance by the population, as well as encourage the use of alternative energy sources for social, financial and ecological benefits. The program will be made available through a web page so that anyone can have simple and objective access to this type of information and generate energy for themselves and the world.

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