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Wind energy in Brazil

Energia eólica no Brasil

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ABSTRACT
The study sought to position the economic feasibility of energy generation through wind turbines. Wind turbines are used to convert part of the kinetic energy of winds into electrical energy, therefore, they are useful to know what is the upper limit of extractable energy, which requires that they be placed in an ideal situation in which processes are carried out in search of maximum perfection. As it turned out, there are opportunities to significantly increase the supply of wind energy through the use of wind turbines, but they are already sufficient to raise a number of points where it would be necessary to invest in the acquisition of knowledge, and in technological development. The study was developed through a literature review.

Keywords: Feasibility, Energy, Wind, Wind Turbines.

1 INTRODUCTION

Brazil is a country with 210 million inhabitants, according to estimates by the Brazilian Institute of Geography and Statistics (IBGE), and stands out as the fifth most populous nation in the world. In 2022 National Electric Energy Agency (Aneel), about 95% of the population had access to the electricity grid. (ANEEL 2023).

In 2001 Brazil had the problem that consisted of the greater demand for energy than there was in terms of generation, which was being circumvented in every way by the current government so that it would not emerge before the entire population and without exceptions. Quickly, overnight the country had a nightmare of the "blackout", which led to a crisis that deeply shook the economy as well as greatly altering the habits of Brazilian citizens and all the movements of the economy that are managed by Industries, Commerce and Financial Markets.

In this context, the country seeks to increase the production of electricity, so that the effects of rationing as occurred at the beginning of this decade are not repeated.

From a structural point of view, this study sought to position the economic feasibility of power generation through wind turbines.

Wind turbines are used to convert part of the kinetic energy of winds into electrical energy.

Consequently, in the wind turbine it is necessary to eliminate all dissipative effects of energy, due to the viscosity of the air, contributing to inefficiency. A wind turbine is never able to capture 100% of this power, and the wind is so bad that the power captured by the rotor of the machine is much lower.

The power coefficient of a wind turbine is how efficiently it works and expresses how much of the total power possessed by the incident wind is actually captured by the wind turbine rotor. In addition, it should be noted that the coefficient of power with the operation of a wind turbine is usually not constant, it varies depending on the operating conditions of the machine.

This study aims to analyze aero calculation strategies based on the combination of wind turbines and studies of the theory of the amount of motion, where you have to apply the equations of continuity, momentum and energy, and the theory of the porous disk in which it replaces the rotor, which is composed of an infinite number of blades that rotate, by a fully porous disc of the same radius as the rotor replaces.

Theories used in studies and research of wind turbines and wind turbines were used.

The area of renewable energy in Brazil has grown a lot in recent years due to the availability of these resources in the country. This increase has made individuals and companies increasingly value its use, due to the economic return and low CO2 emissions.

2 THEORETICAL BACKGROUND

Wind turbines draw energy from the wind, decreasing the amount of current movement, so it be useful to know what the upper limit of extractable energy is. This requires placing in an ideal situation where processes are done with the utmost perfection. Consequently it is necessary to eliminate all energy dissipative effects due to the viscosity of the air contributing to inefficiencies.

A wind turbine seeks, in a simplified way, to generate electricity through the wind and as Maia (2011, p. 05) indicates:

> The first wind turbine topology to be consolidated in the market was characterized by constant speed, which consists of an induction generator solidly connected to the grid. This system began to give way due to its operational limitations and power quality issues. The parallel evolution of power electronics devices and the consequent reduction of their costs, allowed a control of the operation of induction generators, enabling their connection to the electrical grid, eliminating most of the problems of their predecessor. On the other hand, the system operates with higher speed excursion and greater operating stability and with minimal switching transients.

According to Gomes (2015), wind is an energy source that man has known about since very ancient times, although, curiously, he has turned to the use of less healthy energies. Harnessing the wind today can replace fossil fuel, prevent overheating, and stop the massive emission of millions of tons of carbon dioxide.

The burning of fossil fuels is the main supplier of carbon dioxide, a gas that accentuates the so-called "greenhouse effect", as this gas accumulates in the atmosphere, the energy of the sun's rays converted into temperature is maintained as in greenhouses for flowers and vegetables, not being able to release in its entirety into space, progressively increasing the temperature of the planet. (CASTRO, 2015)

Today's wind turbines are the result of a long evolution, with wind power first being used in Egypt around 3000 BC to power sailboats, in Hammurabi windmills for irrigation in 2000 BC. The earliest known factories are Seistan, the seventh century. In the 1400s, Pope Celestine III claimed wind possession: mills could use for a fee. Halladay in 1854 introduced a light mill, which stands as one of the symbols of American farms. In 1888 it was believed that the first wind turbine could be used for power generation, improved in the following years by Poul La Cour. The first large mill to generate electricity, the Smith-Putnam turbine was built in Vermont in 1945. In 2005, there are generators producing more than 5 MW, and large wind farms installed at sea.

In the year 1888 the first operational automatic wind turbine for electricity generation (wind turbine) appeared. It had a rotor diameter of 17 m and 144 blades made of cedar wood. Despite the size of the turbine, the generator was only 12 kW, and American-type slow-spinning wind turbines have low average efficiency, and it was later discovered that fast-spinning wind turbines with few rotor blades are more efficient for producing electricity than slow. The turbine was used for 20 years acting as a battery charger. The Windmill in Cleveland (12 kW, 17 meters) Poul la Cour (1846-1908), is considered the pioneer of modern electrically powered wind turbines, was also one of the pioneers of modern aerodynamics, and built its own wind tunnel for experiments. By 1918, about 120 local public companies had a wind turbine, usually the size of 20 to 35 kW.

Wind turbines are usually defined, depending on the position of their axis of rotation, in relation to the wind direction. So, they are divided into:

- With shaft parallel to the wind direction.
- With the axis perpendicular to the direction of the wind.
- horizontal-shaft turbines.
- Vertical eixo of wind turbines.

- the wind turbines, using the displacement of a piece of furniture (only mentioned as a souvenir).
- Static recovery systems, wind energy.

Horizontal-axis wind turbines with parallel axis to the wind direction are currently the most widespread and more yielding machines than the other existing one, something very important when starting a project.

In this group those with 1,2,3 or 4 blades, in addition to the typical multi-blades for pumping water are included.

Between these machines, those that have blades positioned "face the wind" and those that have the "back to the wind" stand out.

Wind turbines in general are equipped with three-blade or double-blade rotors facing the wind.

According to Branco (2008), in the various activities of production or in the distribution of consumption of goods and services, it is necessary to use energy more and more as a result of a growing material development.

Certainly, the use of energy is indispensable for daily survival, for it provides "essential services" to human life – heat for heating, cooking and manufacturing activities, or power for transport and mechanical work.

Energy is part of sustaining the development of a nation and should evaluate the availability of energy, its access to the population and especially the level of sustainability of energy generation.

According to Branco (2008), the energy sources that are represented by fuels and the supply of energy inputs are diverse and poorly distributed throughout the national territory.

Currently, the energy needed for these services comes from fuels – natural gas, oil, coal, peat and conventional nuclear power, which are non-renewable energy sources. There are other primary energy sources, such as: solar, wind, tidal and wave or hydraulic energy, wood, vegetables, manure, waterfalls, geoterminal springs, as well as human and animal muscle power. These are renewable energy sources. (WHITE, 2008)

Renewable energy systems are still at a relatively early stage of development. (WHITE, 2008)

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3 MATERIALS AND METHODS

The study was developed through a literature review, carried out through systematic readings and the production of files of books, articles and electronic sources that address the proposed theme. The review of the literature on the subject is presented as a basis for acquiring prior knowledge about what has been dealt with in previous research on the subject to be investigated.

4 RESULTS AND DISCUSSION

Wind energy has become a real and commercially attractive option for electricity generation and, therefore, one of the fastest growing. This growth was mainly driven by the adoption of energy policies that seek to favor and establish clear objectives. with regard to the production of renewable energies, as well as innovation processes in wind turbine manufacturing companies to reduce their costs and improve their performance.

This study, applied in a company, will promote an assessment of physical and economic feasibility in order to reduce the environmental impacts caused by the use of non-clean energy, reduce monthly costs with electricity and insert the company among the pioneers in the use of renewable energy.

With the objective of expanding renewable energy, there are incentives and appreciation for its implementation, such as financing, exemption from PIS and COFINS for the purchase of materials and services in accordance with the Special Incentive Regime for Infrastructure Development, receipt of the Renewable Energy Certificate and Seal according to the Brazilian Wind Energy Association and, also, the reduction in standard energy expenditures.

From the feasibility study in the company, it is also possible to influence other companies to adopt this type of energy in their work bases, seeking a clean and innovative method of energy production.

An energy market like Brazil, where electricity is mainly produced by hydroelectric plants, is required to have firm power generation plants that meet energy demand in case of droughts.

According to Martinho (2020, p. 01):

> The survey carried out by the Ministry of Mines and Energy (MME), "Wind Energy in Brazil and the World", points out that the country was fourth in the world ranking of wind power expansion in 2014, with 2,686 megawatts (MW), being surpassed by China (23,149 megawatts), Germany (6,184 megawatts) and the United States (4,854 megawatts). In the Ten-Year Energy Expansion Plan (PDE 2022), the government estimates that Brazil's installed wind capacity will reach around 24 thousand MW. Of this total, 21 thousand MW should be generated in the Northeast region, which will represent 45% of the total produced in the region.

The choice of the location of wind generation projects is essential for their optimal development. Planning a wind generation project is very complex, given the number of variables to be taken into account when selecting a suitable area for your settlement. As in any project, the environmental impacts that may be generated must be evaluated, as well as the technical requirements that the area where it will be installed must meet. The ultimate goal is to determine an area where economic profitability is maximum and environmental impacts are minimal, which presents a challenge for today's planners. However, the planning of this type of projects can be optimized through a spatial assessment, through the integration of geographic information systems (GIS) and multicriteria decision methods (MCMC). GIS and MDMC are tools that complement each other. GIS offers the possibility of acquiring, storing, visualizing, and analyzing georeferenced information. Based on this information, the MDMC provides the techniques and procedures for structuring a decision problem and evaluating possible alternatives. Given the use of GIS, the quality of the results depends on the quality of the input data used, in terms of resolution or scale, provenance, spatial distribution, temporal agreement, and logical consistency.

The first challenge was to establish the criteria for restricting and evaluating areas with wind potential and to set the limit values for them. Restriction criteria correspond to those that limit the development of wind projects, while evaluation criteria define the suitability of an area for the development of these projects.

Wind energy is one of the most important renewable energy sources in the world and one of the fastest growing renewables in installed capacity in the last decade. With the implementation of wind energy projects, the goal is to reduce greenhouse gas emissions and thus combat climate change. However, wind projects generate environmental impacts whose mitigation measures start from the choice of their location. The objective of this research work was to outline a methodology for the identification and evaluation of areas with wind potential in which GIS are integrated with the MDMC, technical, economic and environmental criteria are taken into account and, based on this methodology, the feasibility of the areas for the development of wind generation projects is established. The integration of GIS with MDMC in the planning of renewable energy projects has recently been used in the literature as a new methodology to identify and evaluate areas with wind potential. This is to promote the study and use of this type of energy, which in countries like Brazil has been little studied and is just beginning to be promoted. In this sense, this work contributes to the study of wind potential. This is to promote the study and use of this type of energy, which in countries like Brazil has been little studied and is just beginning to be promoted. In this sense, this

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Average wind speed is the most important criterion of relative importance in the classification of an area. From the literature review, it is clear that the most commonly used method to assign weights to the criteria is AHP. The advantages that this method offers, such as the presentation of a mathematical support, the possibility of verifying the consistency of judgments or allowing the participation of experts, make it one of the preferred methods for solving a decision problem. The application of this type of methodology is concentrated in European and Asian countries, where there is an established legislative framework for renewable energy. In addition, there are clear targets for the future participation of renewables in the energy market. In the Brazilian case, there is no defined regulatory framework regarding the positioning of wind farms. Therefore, the criteria for restriction and evaluation of the zones were defined based on a review of the literature and the corresponding Brazilian legislation. As the presentation of a mathematical support, the possibility of checking the consistency of judgments or allowing the participation of experts, become one of the preferred methods for solving a decision problem.

According to Martinho (2020, p. 01):

> The first step in an analysis and determining the use of the wind resource is the assessment of a region's wind potential. The relief influences the wind speed in a given location, as well as its distribution and frequency (SILVA et al. 2006). Due to the immense territorial extension, Brazil has several regions with characteristics that favor the use of wind energy, and it is essential to know and the behavior of the wind, especially its speed and direction so as not to waste this natural and renewable resource. In these studies, the Northeast region is found, as it presents exceptional characteristics, with an air flow free of natural obstacles, high intensity and continuity of the Trade Winds, also counting on the complementation of the hydrological regime with the wind regime (National Energy Plan _PNE, 2030).
> According to geographer Telmo Amand Ribeiro of UnB, not all regions have these characteristics. The plateaus of the Brazilian hinterland do not allow the trade winds that fall on the coast to go to the interior of the country. He explains that these winds blow from the Equator to the tropics and only reach the northeastern coast, from Maranhão to Rio Grande do Norte, mainly in Ceará (PORTAL BRASIL, 2015).
> The Atlas of Brazilian Wind Potential was created from a system called MesoMap, where it presents, in a resolution of 1km x 1km, the average annual wind conditions throughout the Brazilian territory. The analysis of these estimates shows that the windiest months are the months with the lowest rainfall, which means that from June to December we have the greatest potential for wind energy in Brazil. It was concluded that the use of wind energy is excellent against the low rainfall and geographical distribution of the existing water resources in the country, and it is possible to preserve the hydrographic basins minimizing the use of hydroelectric plants. This fact confirms that wind is a great supplementary source to the energy generated by hydroelectric plants, today the largest source of electricity in the country.

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5 CONCLUSION

As verified, there are opportunities to significantly increase the supply of wind energy, through the use of wind turbines, which must still seek ways to reduce costs in the implementation of systems, which must still go through the formulation of public policies to encourage their implementation.

In this way, any wind energy production unit in the various parts of Brazil must work on a generation plan interconnected to grids, in the search for cost reduction, increasing its productive gain, and realizing means to increase the Brazilian energy capacity, both for homes and for the interconnected system.

In this way, they are considered to have achieved the objectives and also to have contributed to the literature on the subject, presenting subsidies that may indicate the use of wind turbines in wind energy.

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Finally, it should be noted that the study did not seek to fully determine the results and exhaust the topic discussed. On the contrary, it sought to encourage further studies on the topics discussed.

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