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THE GROWTH WIND ENERGY, ENVIRONMENT AND SUSTAINABILITY IN BRAZIL.

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Abstract. *Wind energy has been developing rapidly in the last decade in Brazil due to several factors, such as crisis in the electricity sector, because it is an almost clean source of energy and for improving environmental, economic and social sustainability, also covering the region of the communities where wind farms are installed. The environmental problems exist, mainly due to the lack of inefficiency and deviations in the governmental organisms of licensing and inspection responsible by the nature. The environmental impacts of wind power are small compared to other non-renewable energy sources. One of the problems that will be addressed is the recycling of materials from the wind turbines propeller since the parks are recent and not yet have so many problems with these materials and how to reuse the in a cost-effective way, contributing to society and the environment.*

Key words: Wind Energy; Environment and Recycling; Sustainability; Wind Potential.

1. INTRODUCTION

In the last decade, the exponential growth of Wind energy has been driven directly by rising prices of fóssil fuels and conventional energy. With the aggravation of the various damages caused to the environment and also greater government incentives that have been given to production of renewable energies (SOUZA et al, 2014, KENNEDY, 2005, BERRY, 2009 and LEWIS, 2010).

Due to the oil crisis of the 1970's, global economies felt the need to incorporate new energy sources into their energy matrix. Until 1985, wind energy inventors in Denmark received 30% of the purchase value of the units as government subsidy. In 1978, in the United States, wind energy turbines were legally authorized to connect to the grid and there was an expansion of credit lines for those who installed wind turbines (PINTO, 2013, LIRA et l, 2017).

"The concern about climate changes and efforts to reduce emissions of greenhouse gases (GHG) since the KYOTO Protocol assignment in 1997 led to the search for alternatives that could meet economic needs and at the same time, generate less environmental impacts. Among the measures, one of the most popular was the increasing investment in renewable energy sources, such as wind power. According to the Intergovernmental Panel on Climate Change (IPCC), this energy source has great potential for reducing GHG emissions. Globally, although distributed in a non-uniform way across countries, the technical potential of wind energy is greater than the world's electricity production, since the social and environmental dimensions are dimensions are dependent on the ability of this mode of energy to compete with others. Considering political, economic and technological barriers, it is estimated that wind power can supply up to 20% of the world's electric energy demand by 2050" (IPCC, 2011; BIRTH; MENDONÇA; CUNHA, 2012; SIMAS; PACCA, 2013).

The effects f these patterns of production and consumption have led partnerships, companies and institutions to think more intensively about issues related to sustainability from different perspectives, such as economic, social and environmental, in search of a new form of development, based on for sustainable development, as established by the Brundtland Commission (BARBIERI, 2007; BLACKBURN, 2007; ELKINGTON, 2012).

It is agreed that the insertion of renewable energy leads to the mitigation of GHG emissions. Other environmental pollutants in the life cycle of energy generation technologies, changes in land use and biodiversity have been widely studied. However, the in-depth discussion of the socio-economic impacts of these technologies is still

scarce. This discussion becomes even more important in periods of low economic gowth (FRANKHAUSES et al., LEHR et al., 2008).

Despite the potential to bring various benefits to local and regional development, the encouragement of renewable energy sources should not be as a development policy, but rather a practice that if applied in conjunction with other social policies that will be able to bring great collaboration for development of these communities (RIO; BURGUILLO, 2009).

Considering the great potential of wind energy, this article aims to show how wind energy is growing and what it has to provide in terms of sustainability for people from regions where wind farms are being installed, including to know How it affects the environment and what can be done in order to try reducing the environmental impacts with the recycling of some materials that are used in its manufacture.

2. Wind energy and its potential in Brazil

Brazil was the pioneer in Latin America to install a wind turbine in the early 1990's. Over the next ten years, little progress has been made in consolidating wind power as an alternative of generation in the country, partly because of the lack of policies, but especially because of the high cost of technology. In 2001, the Atlas of Brazilian Wind Potential was launched, which estimated the technical feasibility of Brazil (CEPEL, 2001) at 143 GQ.

According to EPE (2011), Proinfa, established in 2002, was the main engine to boost the development of the wind energy market in Brazil. As there was a creation of the first effective public policy focused on the sector, provided an environment with few risks for investment in technology still little known in the country. The program showed that wind energy is technically feasible, and served as a gain of experience for the various activities that involved this sector.

Eletrobras' long-term purchase agreements at a rate that reflected capital costs, BNDES financing conditions of up to 80% of the project and generation flexibility resulted in an attractive environment for investors. The entry of wind energy into the regulated energy market as of 2009, as part of the policy diversification policy of the electricity matrix and priority contracting of renewable sources, resulted in a new milestone for the insertion of this technology in Brazilian electricity sector (EPE, 2011).

Since then, wind farms have accounted for 50% of the contracted electricity generation capacity, in average MW, with increasingly competitive energy sales prices, approaching the average value of conventional thermoelectric plants. With the commissioning of projects contracted in the regulated market, installed wind power capacity will reach 8.1 GW in 2016, with an estimated participation in 5.5% of the Brazilian electricity matrix projected in the 2020 Energy Expansion Plan (EPE), 2011, SIMCA, PACCA, 2013).

Wind energy has experience exponential and virtuous growth in Brazil. From 2009 to 1012, in the sic auctions where the wind power source participated, 7 GW were contracted in the projects. These projects will increase the volume of wind energy facilities in the country to more than 8.4 GW by 2017, 3.5 times larger than current capacity, and attract more 21 billion reais in investments (MELO, 2010, MELO, 2013).

The year 2012 was marked by the commemoration of the insertion of 2 GW of installed power of wind in the national electric system, so that Brazil electricity grid. This capacity installed represents, in fact, the effective insertion of the wind industry in the country. In 2012 alone 40 new wind farms were installed, totalizing 108 projects and adding 1 GW in the system. This same volume was previously injected over a period of 13 years, from 1998 to 2011 demonstrating a virtuous leap in source participation in the matrix. The current installed capacity of 2.5 GW enables the supply of power to four million homes (MELO, 2010).

2.1. INSTALLED CAACITY IN 2017

In 2017, 79 new wind farms were installed, totalizing 2,027.00 MW. The states contemplated with the new enterprises were Piauí, Bahia, Rio Grande do Norte, Maranhão, Ceará, Pernambuco, Rio Grande do Sul and Paraíba. With 508 plants in total, the year 2017 ended with 12.77 GW of installed Wind power, which represented na increase of 18.87% in power compared to December 2016, when the installed capacity was 10.74 GW. Considering all the sources of electricity generation, in 2017, 6.84 GW of power were installed, whose growth was led mainly by hydroelectric and wind power sources, which represented 47.86% and 29.63%, respectively. In addition to 2.03 GW of new installed capacity, the total wind power allowed for the source an 8.10% share of the Brazilian electricity matrix, (ABEeólica, 2017).

Table 1- Power and Plant data installed in 2017. Source: ABEeólica, 2017.

NEW CAPACITY INSTALLED (MW)		
State	No. of factories	Potential
PI	19	528,20
BA	20	517,10
RN	10	259,30
MA	8	220,8
CE	6	147
PE	5	131,10
RS	8	129,00
PB	3	94,5
Total	79	2.027,00

3. SUSTAINABILITY WITHIN WIND ENERGY

The principle of sustainability arises in the context of globalization as a stop to reorient the civilizing process of humanity. The environmental crisis came to question the rationality and theoretical paradigms that propelled and legitimized economic growth, denying nature. Sustainability appears as a process for the reconstruction of the economic order, as a condition for human survival and as a support to reach a lasting development, questioning the very bases of production (LEFF, 2001; MORREIRA et al, 2013).

The problem arises intrinsically from the industrial expansion of wind energy and the need to implement an economy of scale in the sector, where the main technical barriers to the growth of wind power to higher levels within the energy matrix are associated with the operational and structural properties of the system energy. In addition, the factors of production, storage and distribution are not only linked to the improvement of wind technology, but to an entire interconnected group of variables (LeWis & Wiser, 2007; GÖRANSSON & JOHNSSON, 2011; MILLS, WISER, & PORTER, 2012).

The presence of renewable energy projects in rural areas, especially in areas that lack economic development, can bring several benefits to the community. Socioeconomic characteristics of many regions, such as high unemployment, lack of economic development alternatives and high rates of migration of the economically active population, make it advantageous to invest in these technologies. Renewable energy generation plants are often smaller

and more dispersed than traditional power plants, and for this reason are often located in rural areas of low population density. Due to this characteristic, the construction of these plants requires a greater quantity of labor and generates potential for the training and employment of rural populations in different localities (NGUYEN, 2007).

Another important aspect is the leasing of land, especially by wind farms, due to the fact that the wind farms occupy only a small fraction of the area, the money raised by the rent of the area can be invested for other productive activities in the property, besides contributing substantially to achieve climate protection objectives (RIO, BURGUILLO, 2008, SCHUSTER, BULLING, KÖPPEL, 2015, SIGH and FEHRS, 2001).

4. ENVIRONMENT AND RECYCLING OF MATERIALS OF WIND TURBINES

The discussion about the environment involves diverse dimensions such as social, economic, cultural and political, as well as the notion of development is imbricated (MORREIRA et al, 2013, SACHS, 1986, p.10).

The demand for raw materials and energy will continue to grow and bring a civilizational stalemate in this process: either the consumer society faces the challenge of sustainability or we will have less fresh and clean water, less forests, less fertile soils and other side effects of this suicide model of development (TRIGUEIRO, 2005).

Wind and solar energy bring less risk and less natural disruption by using renewable sources in their natural form. Wind power generation has been successful in countries such as Denmark, the United Kingdom, Germany, the United States and the Netherlands for many years without any problems with society and nature. It has been shown by studies in Denmark that the negative factors that could have an impact on the environment and that are discussed in the aero generators are the maximum permissible noise levels, the aesthetic landscape of nature and the death of the birds by collisions (DANISH WIND INDUSTRY ASSOCIATION, 2004).

For Kennedy (2005) and Gökçek and Genç (2009), wind energy has a great social benefit because it reduces environmental costs and energy costs, as well as avoided fuel costs and minimizing tax rates. Thus, wind energy could be represented only by the variable costs multiplied by the quantity of energy produced and added to the fixed costs. Basically of the total social costs, the wind system only has capacity costs (SOUZA et al, 2014).

Associated with the Wind Energy growth, there is also an increase in the amount of waste generated in the manufacture of the blades, as well as in the disposal of old blades after the end of their useful life. It is estimated that the useful life of a wind turbine will be 20 years and that in 2020 approximately 50 thousand tons of used blades will be generated worldwide and that this number only tends to increase, reaching in 2034 around 200 thousand tonnes. (BRAHMS et al, apud GUERRERO, MANCINI; TOUBIA, 2011, p 148)

One solution to this problem would be to recycle waste from the manufacture of wind turbines. However, because it has a fixed-term polymer, conventional recycling via melting is not possible. In this way, the recycling through pyrolysis presents itself as an alternative to the use of these residues, mainly the fiberglass they contain, which can be reused in the manufacture of swimming pools, bathtubs, bus and subway seats, water boxes, reinforcement of polymers and even in the manufacture of the blades themselves for wind turbines (De PAOLI, 2008).

The chemical recycling consists of a depolymerization, with the formation of monomers or other useful intermediates from planned degradations that result in the decrease of the molecular weight of the products (LA MANTIA, 2002). It can be divided into two types: Thermolysis and solvolysis, the solvolysis being based on the use mainly of solvents for the occurrence of depolymerization. In the thermolysis the chemical structure of the polymer is degraded through the use of heat, and can occur through three processes: pyrolysis, gasification and hydrogenation (ZANIN et al., 2002).

Pyrolysis is the thermal degradation of organic products, usually in the absence of oxygen to prevent loss of reactants by combustion, reducing coal, oil and combustible gases, leaving a solid residue in which metals and other contained solid materials can be recovered, as well as solids, liquids and gases resulting from degradation. Pyrolysis has been applied to a variety of wastes, including tires, plastics, biomass, municipal solid waste etc. Generally, high temperatures are used, typically in the range of 400 to 700 ° C (WILLIAMS, 2010). Product yields of any pyrolytic process depend on a variety of factors, such as residence time, temperature, particle size of the residue and the atmosphere used. Depending on the combination of the chosen conditions, varying amounts of gases, liquids and solids can be produced (BISIO et al., 1994).

5. METHODOLOGY

This is a systematic review based on the search for critical evaluation and the synthesis of scientific evidence that can guide future research. The review was guided by the technological advance of wind energy, its potential and sustainability and environment with focus on the solution for the problem related to the great quantity of material that could be generated in the future coming from the wind turbine propellers.

The CAPES platform was consulted to obtain the reference articles, using the key words as follows: Wind Energy; Wind Energy and Environment; Wind and Potential Energy; Wind Energy and Sustainability. At first, 994,054 titles were identified and separated in detail.

The research was conducted in the periodical portal of CAPES and the entire research process was carried out by a single researcher. When articles were considered relevant, they were included in the study and when they were not, they were excluded. The following forms were used with parameters for choosing the articles for inclusion and exclusion criteria contained in the relevance test I (Applied to the title and abstracts of articles) and relevance test II (Applied to articles in full) (Table 1).

Relevance test application form I	Yes	No
Inclusion criteria		
Is the article in Portuguese, English or Spanish?		
The article was published in the period from 2000 to 2017		
Does the study address the key aspects of wind power?		
Exclusion Criteria		
Is it editorial, letter and/or thesis?		
Relevance test application form II		
Inclusion Criteria	Yes	No
Does the article describe the growing demand for wind power?		
Does the study address the potential, sustainability and/or environment?		
Exclusion Criteria		
Does the article have no major focus on wind power?		

The inclusion criteria for selection of articles were: (a) Articles that were written in Portuguese, English or Spanish; (b) Articles published in the period 2000 to 2017; (c) Researches describing the main aspects of wind energy; (d) Wind energy growth; (e) Study of potential, sustainability and environment taking into account wind energy. The

definition of the last 17 years occurred because of this period being the space of time that more wind energy took impulse in its growth in the commercial market and for being an ample and current time. The following were excluded: (a) Articles that did not address the main aspects of wind energy; (b) Repeated articles; and (c) editorials, letters, dissertations or theses.

The articles were submitted to the relevance test I through the reading of the titles and abstracts. The application of the relevance test I resulted in 25 articles excluding 994,019 (as it is a very self-value number, it was not possible to verify all the articles in the reading) and afterwards the 25 articles were submitted to the relevance test II, all articles being in full.

6. RESULTS

According to the analysis that was based on the search for critical evaluation and synthesis of scientific evidence, the review was based on the great technological progress of wind energy, its potential and sustainability and the environment, focusing on a solution for recycling materials from wind turbines.

The expansion of wind energy in Brazil has come from the need to diversify energy sources so that there is a decrease in the chances of a crisis in the electric sector, due to development factors and technological growth, and there is a vast territory with great potential wind. In the year of 2017 there was an increase that represented an increase of 18.87% of power compared to December 2016, when the installed capacity was of 10.74 GW. In wind power generation in Brazil, this expansion has attracted large international companies that believe in the growth of this sector. With the rapid development of the wind power source and the government's attention to the relevance of this source that are consolidated in the 2012-2021 Ten Year Plan, the wind power source could reach 9% of this matrix in 2021, with a total of 16 GW installed. The affluence of this industry is presented by the decrease in the average value of investment that has been decreasing considerably when compared to other sources of energy.

In terms of sustainability, wind energy is renewable, has a low environmental impact and contributes to Brazil fulfilling its objectives in climate agreements, generates income and improved life for landowners with leases and allows the landowner to continue with plantations.

The facilities of these wind farms will generate large amounts of waste in the future, the life expectancy of a wind turbine is estimated to be 20 years, and in 2020 around 50 thousand tons of used blades can be generated worldwide by 2034 and can reach 200 a thousand tons. When dealing with wind turbines, the material generated is epoxy resin and fiberglass, together they are a thermosetting material that will need an appropriate destination. Recycling by pyrolysis promotes the separation of this material and is an alternative for the reuse of these residues, in the case of glass fibers, which can be reused for the manufacture of swimming pools, bathtubs, bus and subway seats, water boxes, reinforcement of polymers and even of the blades themselves for new wind turbines.

7. CONCLUSION

Our findings allow us to infer that the data surveyed reflect the importance of wind power to reduce the environmental impact in the present scenario and that if there is not an investment in research for the future in relation to what to do with the large amount of waste that will be generated, this environmental problems with the large accumulation of waste.

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