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Wind Power as an Opportunity to Diversify the Brazil's Electricity System

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INTRODUCTION

The two oil shocks that occurred in the 70s were a watershed in relation to the concepts of developing nations that are now questioning the way the energy matrix was predominant in the majority of the countries.

Given the high successive oil price increases, the world economy begins to prioritize the replacement of oil by other energy sources and having as main objective the energy security.

This time permitted the resumption of investment in alternative energy which was strengthened by environmental pressures directed to the sector of power generation that were stronger after the accident in the reactors at Three Mile Island in 1979, in the United States, and later in 1986 in the city of Chernobyl ,former Soviet Union. These accidents forced the world community to seek safe and reliable sources that have less environmental risk in the supply of electricity. Within the new paradigms for sources with lower environmental risk, prevalent in the eighties and nineties, a favorable and highly promising environment was created for the development of renewable energy sources.

In parallel, the global scientific community presented to the planet very serious indicators on environmental catastrophes, caused by the emission of greenhouse gases, which were released into the atmosphere by the current thermal energy matrix based on fossil fuels such as oil and coal. These emissions were as well considered responsible for the gradual warming of planet earth that gave start to the melting of the north and south poles. This configuration corroborated in global warming, responsible for many disasters that are occurring on regular and growing bases. With these alarming results, at the end of the 90s (1997), United Nations created the Kyoto Protocol, imposing regulations on developed countries that should take the lead in fighting the global warming, and return, around the year 2000, to their anthropogenic emissions of greenhouse gases to levels prior 1990.

Faced with this whole issue arises, more specifically in Europe, a movement towards alternative sources of renewable energy, seeking sustainable development, a concept that combines the expansion of supply, consumer awareness, environmental preservation and improvement of life quality . It is the development able to meet the needs of the present generation without compromising the ability to meet the needs of future generations. It is the development that does not exhaust the resources for the future. In other words, the challenge is to reduce the environmental impact and at the same time be able to support economic growth.

Thus, through the development of many scientific researches, ways to obtain energy in a sustainable and clean way as from wind power and biomass were implanted. But despite the growth seen, these sources have little participation in the global energy matrix.

Due to the high cost of production while the technology is not yet consolidated, the group's expansion of renewable energies is due in large part to government support through public programs that include variables such as compulsory acquisition by the local electric power companies, subsidies, special rates, tax relief or direct input of resources.

The main focus of the current research project will be the presentation of using wind power to diversify the Brazilian electricity industry.

Besides the introduction, this paper is structured in six chapters. Chapter 1 briefly shows the world's wind potencial and the international trends in the use of wind energy. This chapter also presents the numbers of the evolution of this renewable energy around the world.

Chapter two presents characteristics of the Electricity Industry in Brazil. It will show that Brazil' electricity matrix is dominated by hydroelectric plants but this share tends to be reduced due to environmental and geographical issues.

Chapter 3 shows the development in using alternatives energy sources in Brazil and the contribuition of the Brazilian Government in this journey.

Chapter 4 shows the wind's potential and the main advantages of its use in Brazil.

Chapter 5 shows the favorable forecasts for expansion of the wind energy in Brazil and, finally, the conclusion summarizes the main issues discussed throughout this paper.

GLOBAL SCENARIO

1.1. WORLD'S WIND RESOURCES

According to researches, as of 1993[1] , usable world's wind power potencial was estimated at aproximately 48,500 TWh/year and it's well distributed around the globe[2] as presented in the table below.

Considering the technological standarts of 1993, the mentioned research takes in to account only locations with wind speeds greater or equal 7 to 8 m/s at 50 meters of altitude .

Region/ Continent	Usable Potencial (TWh/year)
Africa	10,600
Australia	3,000
North America	14,000
Latin America	5,400
Western Europe	4,800
Russia	5,800
Asia	4,900
World (3)	48,500

[1] Resource: Grubb, M.J e Meyer, N.I.Wind Energy:resources, systems and regional strategies.In.JO-HANSSON, T.B. et.al.Renewable ebergy: sources fou fuel and electricity. Washington,D.C.: Inslands Press, 1993

[2] Excluding Greenland, Antartic, most islands and offshore resources.

Most recently , according to a research, as of 2005 Stanford University's Global Climate and Energy Project, the study found the potencial of wind power on land and near shore to be 72,000 TWh/year, equivalent to 54.000 MToE (millions tons of oil equivalent) per year, or over six times the world's energy use in all forms in 2008. Even if only 20% of this power could be captured, it could satisfy 100% of the world energy demand for all purposes (8.428 MToE, according to datas of International Energy Agency- IEA for 2008) and over seven times the world electricity needs (1450 MToE, according to datas of International Energy Agency- IEA for 2008).

The last mentioned potencial takes into account only locations with mean annual wind speeds greater ou equal to 6.9 m/s but considered an altitude of 80 meters since the turbines are higher than were before and this new condition can be considered suitable for low-cost wind power generation. The stydy assumes six 1.5 megawatt, 77 meters diameter turbines per square Kilometer on roughly 13% of the total Global land area.

2.1. INTERNATIONAL OVERVIEW

Renewable energy policy is the principal driver of the growth in renewable energy use.

The most common policy is the feed-in law[3]. There are also many other forms of policy support for renewable power generation, including investment subsidies or rebates, tax incentives and credits, sales tax exemptions, direct production payments (tax credits per kWh), green certificate trading, and net metering.

Among the renewable and alternative electrical energy sources that are being promoted in the world, wind energy has a growing and prominent relevance. This trend is due to the fact that wind is an abundant resource distributed all over the world. Furthermore, it is gradually becoming more competitive relative to other renewable energy sources. In this sense, considering the increasing demand for electrical energy and the need to increase the share of renewable sources in the world matrix, consistent programs for promoting wind energy have been created in the last years. These policies have permitted the installed capacity of wind turbines around the world to grow from 24.322 MW in 2001 to 159.213 MW in the end of 2009.

This expansion was mainly based in renewable energy policies with two main goals as mentioned in the introduction of this paper: reduction the dependence in the use of petroleum due to the increase in its price in the international market and the reduction of greenhouse effect gases emissions to the atmosphere and consequently limitation to global warming.

The wind capacity worldwide showed a 554, 6 % increase between 2001 e 2009 and reached and overall size of 159.213 MW in 2009, according to the World Wind Energy Association (WWEA) information's, as presented below:

[3] The Feed-In's system consists in a more advantageous tariff for generating plants that use renewable sources of energy if compared to a tariff for a convencional sources of energy. The goal is to enable the implementation of such plants which have higher costs of production. These tariffs are guaranteed for a determined period of time , from 10 to 20 years, which would be the estimated time for the development of alternative sources with consequent cost reduction.Resource: Aneel,Technical Note 0043/2010.

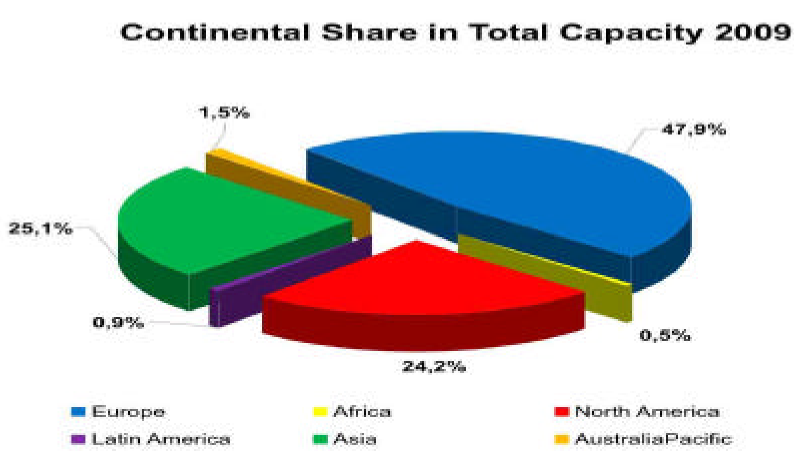
World Total Installed Capacity - 2001/2009

Year	Installed Capacity (MW)	Growth %
2001	24,322	
2002	31,181	28.2
2003	39,295	26.0
2004	47,693	21.4
2005	59,024	23.8
2006	74,122	25.6
2007	93,930	26.7
2008	120,903	28.7
2009	159,213	31.7
		554.6

Source: World Wind Energy Report 2009

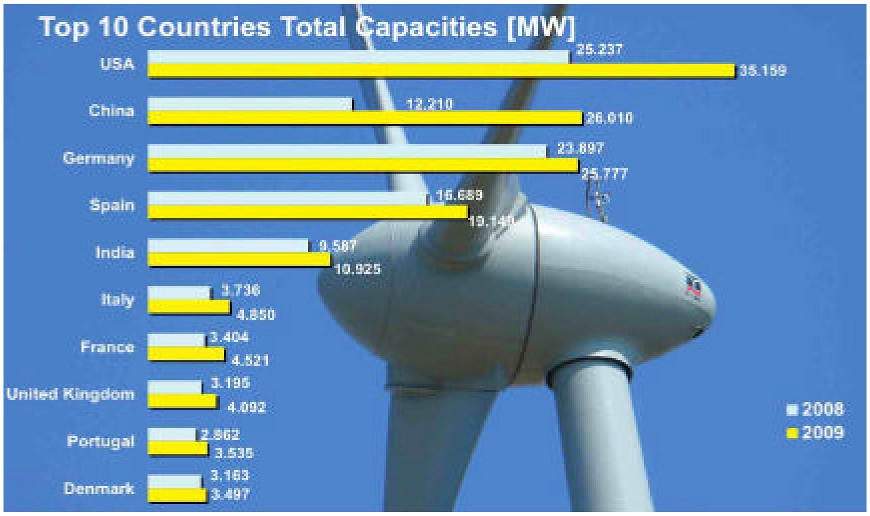
The annual growth rate continued to increase since 2004, reaching 31,7% in 2009 - the highest rate since 2001.It can be seen that the installed wind capacity is more than doubling every third year.

Europe accounts for almost half of the total capacity (47,9%) followed by Asia (25,1%) and North America (24,2%). Although, the most dynamic progress of the wind industry took place in Asia, mainly due to the two large markets China and India. In 2009, China was the leader in new capacity adding 13.800 MW within one year, more than doubling the installations for the fourth year in a row.



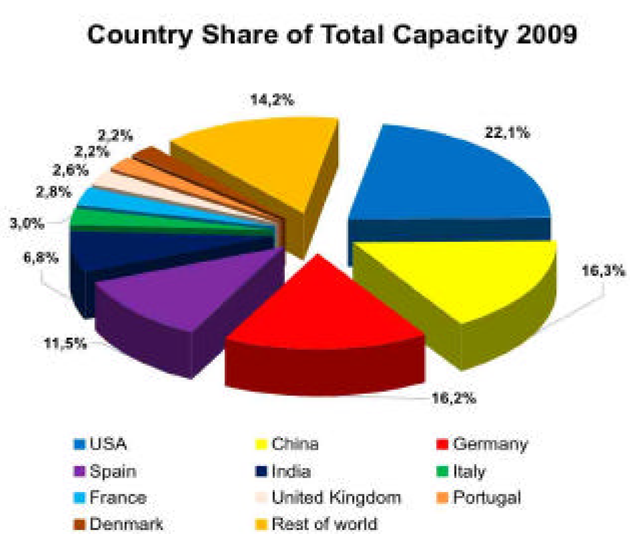
Source: World Wind Energy Report 2009

Among the ten (10) leading producers of wind power in the world, the USA maintained its number one position in terms of total installed capacity (35,159 MW) and China became number two in total capacity (26,010 MW) , only slightly ahead of Germany(25,777MW).



Source: World Wind Energy Report 2009

The USA and China together represented 38.4% of the global wind capacity. The top five countries (USA, China, Germany, Spain and India) represented 72.9% of the worldwide wind capacity, slightly more than 72.4% in the year 2008.



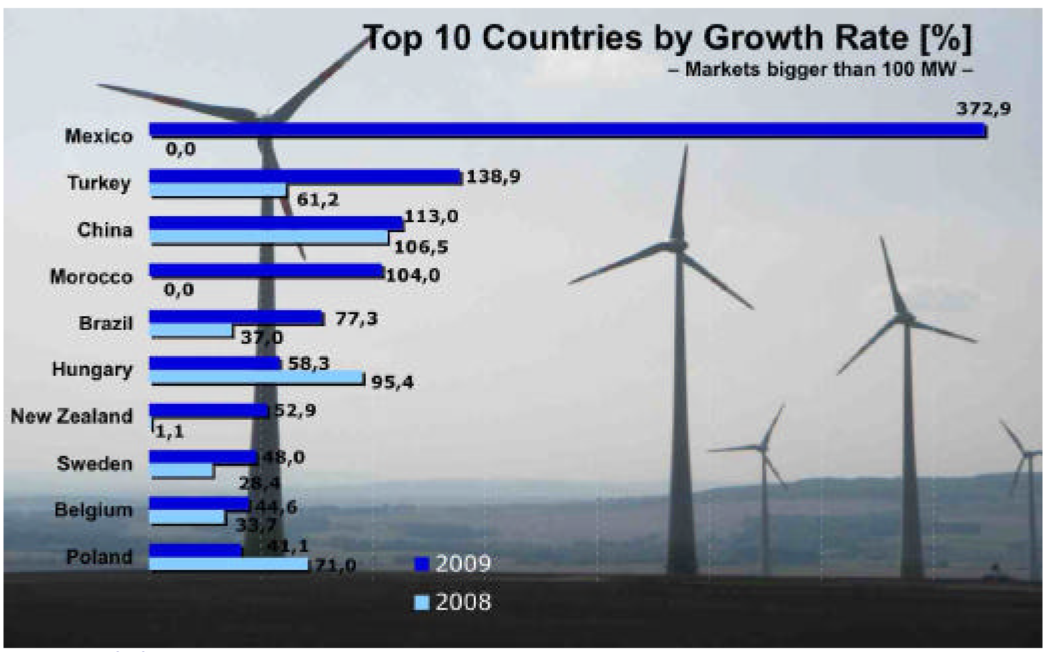
Source: World Wind Energy Report 2009

Although mainly due to the strong performance of China and the USA the top 5 markets could increase their share, still it could be observed that the diversification continued as well and that more and more countries were deploying wind energy on a larger scale.

In the year 2009, altogether 82 countries used wind energy on a commercial basis, out of which 49 countries increased their installed capacity.

Brazil responded with only 0.38% of total installed capacity of wind energy worldwide, standing at 21st in the ranking of global industry.

The highest growth rates of the year 2009 with more than 100% could be found in México which quadrupled its installed capacity, once again in Turkey (132%) which had the highest rate in the previous year, in China (113%) as well as in Marrocos (104%).



Source: Wind Energy Report 2009

It is encouraging to see that three of these five of the most dynamic markets can be found in Africa and in Latin America, both regions which are still lagging behind the rest of the world in the commercial use of wind power.

Amongst the major markets, also the USA (39.3%), Canada (40,1%) and France (32.8%) showed growth rates above the average.

All wind turbines installed globally by the end of the year 2009 contributed with 340 watt-hours to the world wide electricity supply which represents 2% of the global electricity demand.

This energy amount equals the electricity needs of Italy, an industrialized country with 60 million inhabitants and the seventh largest economy of the world.

In some countries and regions wind has become one of the largest electricity sources, the highest shares being:

Denmark: 20%

Portugal: 15%

Spain: 14%

Germany: 9%.

Based on accelerated development and further improved policies, WWEA increases its predictions and sees a global capacity of 1,900,000 Megawatt as possible by the year 2020.

According to Global Wind Energy Council (GWEC), wind energy is already making a significant contribuition to saving CO2 emissions. The global wind capacity in place at the end of 2009 will save 204 millions tons of CO2 every year.

GWEC also estimates that by the end of 2009, half a million people were employed worldwide directly and indirectly in the various branches of the wind sector.

2. NACIONAL OVERVIEW

2.1. THE CHARACTERISTICS OF BRAZILIAN ELECTRICITY INDUSTRY

The renewable sources of energy have a relevant participation in the Brazilian electricity matrix although this is dominated by hydroelectric plants, which account for about 80% of total installed capacity , considering only the brazilian portion of the power plant of ITAIPU.

Electric Energy Matrix

Enterprises in Operation							
Type		**Installed Capacity**		**%**	**Total**		**%**
		Nr of Plants	**(kW)**		**Nr of Plants**	**(kW)**	
Hydro		852	79,182,326	67..50	852	79,182,326	67.50
Gas	Natural	94	11,055,618	9.42	127	12,331,101	10.51
	Process	33	1,275,483	1.09			
Artigo I. Oil	Diesel	808	3,901,271	3.33	837	6,345,274	5.41
	Residual	29	2,444,003	2.08			
Biomass	Sugar Cane Bagasse	299	5,233,977	4.46	367	6,878,622	5.86
	Black Sap	14	1,240,798	1.06			
	Wood	38	327,767	0.28			
	Biogás	9	44,672	0.04			
	Rice Husk	7	31,408	0.03			
Nuclear		2	2,007,000	1.71	2	2,007,000	1.71
Mineral Coal	Mineral Coal	9	1,594,054	1.36	9	1,594,054	1.36
Eolian		45	794,334	0.68	45	794,334	0.68
Importation	Paraguai		5,650,000	5.46		8,170,000	6.96
	Argentina		2,250,000	2.17			
	Venezuela		200,000	0.19			
	Uruguai		70.000	0,07			
Total		**2,239**	**117,302,711**	**100**	**2,239**	**117,302,711**	**100**

Source: ANEEL (2010)

This water system, as it depends on rainfall, presents problems related to the lack of predictability of rainfall. In an average year, hydropower flowing through rivers for energetic use (known as the Natural Affluent Energy -ENA) is even greater than the load, but it refers to energy distributed throughout the year in an uneven manner and subject to high levels of uncertainty [4].

ENA is greater than the load during the humid season between the months of December through April, but the opposite occurs predominantly during the dry season, which runs from May to November.

In order to minimize the impact of uncertainty and seasonality of inflows, the Brazilian Electrical System is based on hydroelectric plants with large reservoirs that accumulate water in the humid period of the year which permits its conversion into electricity in the dry period. Dams store water during the wet season, when the turnout is high, so that the accumulated water can be fueled in dry, keeping the electric power generation stable throughout the year.

Aiming to make good use of inputs of diversity and storage capacity between the hydrographic basins in Brazil, was built, and has been enlarged, the SIN-Interconnected National System, which allows the exchange of electricity among regions through high voltage transmission lines. This network reduces, in regionally level, the risks associated with seasonality in energy availability and the total amount of natural energy affluent. For example, in its humid season Subsystem North exports surplus of power from Tucuruí Hydroelectric to Northeast and Southeast / Midwest Subsystems. Differently, starting in June, the North Subsystem, which has a long dry season and lacks reservoirs able to satisfactorily regulate inputs, starts to import energy, above all from Southeast, that has large storage capacity .These operations are coordinated by the ONS -National System Operator.

This reliance on abundant hydroelectric resources is beneficial to Brazil as it reduces the overall generation costs. However, this large dependence on hydropower makes the country especially vulnerable to supply shortages in low-rainfall years.

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[4] (1) In 2008, for example, there was an existing hydroelectric energy potential average of 54,830 MW, with inflows in the long-term historical average. And in that same year, the burden of SIN was a little lower- 50, 998 MW at medium. Data compiled by Gesel-IE-UFRJ from the historical database available on the website of the National System Operator, ONS.

Furthermore, even though there are more than 150 GW of hydrological resources to be exploited, most of this potential is located in the Northern Region of the country that is geographically flat. This physical characteristic limits the construction of large reservoirs and as a result reduction of the capacity of regulating electrical energy offer. This reduction associated with growing electricity demand calls for the diversification of the Brazilian energy matrix through the insertion of other sources, especially those that can operate in the base during the dry period of the year.

Nowadays, apart from biomass, which accounts for about 5,86% of total generation capacity, no other renewable energy source besides hydroelectricity plays a relevant role in the energy mix.

The participation of wind energy in the Brazilian electrical matrix is below 1%.

3. BRAZIL'S WIND POWER DEVELOPMENT

3.1. GOVERNMENT SUPPORT

The presence of a specific legislation for the development of alternative energy sources appears to be critical to the growth of these technologies usage.

The Brazilian government, like that seen in a significant number of countries, is encouraging, since 2002, in a more significant way, investments in renewable energy sources.

3.1.1 THE ALTERNATIVE ENERGY SOURCES INCENTIVE PROGRAM- PROINFA

The interest in alternative sources in Brazil began in the early 90s, particularly after the Meeting on Environment issues held in Rio de Janeiro in 1992 – ECO/1992. This event allowed the initiation of several pilot projects on alternative sources in Brazil, particularly in solar energy, photovoltaic and in wind power, as well. Partnerships and agreements signed between the U.S. and Germany have enabled projects for alternative energy sources.

The first regulatory frameworks which record efforts to promote renewable energy sources in Brazil date respectively from 1995 and 1996 with the publication of Law nº 9.074 and Decree nº 2.003 by which it was created and regulated the Independent Producer of Energy–PIE and Autonomous Independent Producer- AIP. However, the delay and uncertainty involved in the drafting and implementation of laws, decrees and resolutions brought about a decline in investments.

Only in 2001, with the severe crisis of energy supply in Brazil, caused by the drought that cut water to the country's hydroelectric dams and led to electricity rationing from June 2001 to February 2002, the encouragement of alternative sources of energy gained strength in Brazil.

The rationing boasted several laws and resolutions aiming at encourage the expansion of generation and energy saving, such as Law 10.438, of April 26th , 2002, which, inspired in successful legislation in Germany and Denmark, consolidates the

Brazilian institutional support to the development of renewable energy through the creation of The Alternative Energy Sources Incentives Program- PROINFA.

The Alternative Energy Sources Incentive Program -PROINFA, created on April 26th, 2002 by publication of the Federal Law 10,438, being later revised and adjusted through Laws: 10,762 of (November 11, 2003), 10,889 (June 25 2004), 11,943 (May 28, 2009) and 12,212 (January 20, 2010) and regulated by decrees: 4,541/2002 and 5,025/2004, is one of the most important programs for the development of alternative energy sources in Brazil with the following strategic objectives:

• Brazilian energy matrix diversification, increasing supply's security;

• Appreciation of the characteristics of regional and local potential, creating jobs, capacitating and training of manpower;

• Reducing greenhouse gases emissions.

The program was divided into two stages: the first for project implementation in short term and the second for implementation in medium terms.

The program's main goal is to fund, in financial attractive conditions supported by the Developing, Economic and Social Bank-BNDES, energy generation projects from wind (wind power), small hydropower (SHP) and biomass .

The purchase of energy generated is guaranteed by ELETROBRAS for 20 years.

PROINFA consolidates Brazilian institutional option support to the development of renewable energy through a hybrid system of policy support for renewable power generation that includes the *Feed-in*[5] remuneration system since it sets a price for electricity produced from renewable sources and the Quota System[6][7] which initially establishes quotas of initial power to be contracted.

[5] The Feed-In's system consists in a more advantageous tariff for generating plants that use renewable sources of energy if compared to a tariff for a convencional sources of energy. The goal is to enable the implementation of such plants which have higher costs of production. These tariffs are guaranteed for a determined period of time , from 10 to 20 years, which would be the estimated time for the development of alternative sources with consequent cost reduction.Resource: Aneel,Technical Note 0043/2010.

[6]

[7] In the quota system is established a quota of energy to be compulsorily acquired by the power distribution companies for each energy source that is meant to encourage, transferring the costs of buying more expensive energy for consumers. .Resource: Aneel,Technical Note 0043/2010.

According to the Ministry and Energy's Ordinance 45 , of March 30 th, 2004, the minimum price purchase for each type of the enabled energy source was as follows:

Type of Energy Source	**Minimum Price Range - R$/WWh**
Small Hydroplants	117.02
Wind Power	150.45 to 204.35 (a)
Biomass	83.58 to 169.08 (b)

(a)Depending on the productivity of the enterprise.
(b)Depending on the fuel used .

The program provides for acquisition of 3,300 MW in projects equally distributed to energy sources such as wind, biomass and Small Hydroelectric. However, as the biomass projects have not reached that amount, the remainder was transferred to the eolian and small hydroelectric projects.

Thus, as a result of hiring power, the program provides for the construction of 144 plants, totaling 3,299.4 MW of installed capacity distributed as follows: 1,191. 24 MW from small hydro's plants, 1,422. 92 of 54 MW wind farms, and 685.24 MW of 27 power plants based on biomass. The deadline for early operation of the project was December 2006 and was subsequently extended (Ordinance 452/2005 from Ministry of Mines and Energy) to December 2008 and later (Law 11,943) postponed to December 2010.

The percentage of 43% of the projects contracted by PROINFA was based on wind and are located in the northeast region of the country, according to the table below:

State	**Region**	**Contracted Power(MW)**	**Participation %**
Ceará	NE	500.53	35.18
Rio Grande do Sul	S	227.56	15.99
Santa Catarina	S	226.73	15.93
Rio Grande do Norte	NE	201.10	14.13
Paraíba	NE	64.85	4.56
Pernambuco	NE	21.25	1.49
Piauí	NE	17.85	1.25
Rio de Janeiro	SE	163.05	11.46
Total		1,422.92	100.00

Since the inception of Proinfa, Brazil's wind energy production has escalated from 22 MW in 2003 to nearly 600 MW in December of 2009, registering in this last year an increase of 77.7% over the previous year (341 MW). Brazil accounts for nearly half of installed capacity in Latin America, but represents only 0.38% of the world. These data, released by the Global Wind Energy Council (GWEC), show that Brazil has grown more than twice the world average: 31%.

In 2009, the Brazilian growth was higher, for example, than the United States, which had an increase of 39%, India (13%) and Europe (16%) but lower than China's, whose generation capacity has expanded to 107%. However, Brazil grew less than the average in Latin America, where the increase was 95%, driven largely by the capacity expansions in Mexico (137%), Chile (740%), Costa Rica (67%) and Nicaragua (which went from zero to 40 MW).

3.1.2. ENERGY AUCTIONS

In December 2009, the Brazilian government in order to facilitate the continued integration of wind energy generation in the Brazilian matrix enhanced the stimulation to the eolians with the completion of the first auction of this type of energy.

The Auction of Reserve Energy Power, exclusively for wind power, held in December 2009, was considered a success and confirmed the expectations of the Ministry of Mines and Energy (MME) for the amounts contracted and selling prices.

The contracting of reserve power was made possible through reserve energy auctions covered in paragraph 3 and in Article 3 of Law 10,848, of 15/03/2004, which were regulated by Decree 6,353/2008. This mode of procurement under the "reserve" (above market demand) is designed to increase security on supply of electricity to the National Interconnected System-SIN from plants specially hired for this purpose.

The contracts traded at the auction totaled 1,805.7 MW, with an average selling price of R $ 148.39 / MWh, a discount of more then 20% over the initial price of R $ 189.00. The amount transacted as a result of the event will reach R$ 19.59 billion at the end of the duration of contracts-20 years.

It is assigned to the following factors the discount found in the auction:

• Reduction of Industrialized Products Tax (IPI, the acronym in Portuguese) for wind turbines and equipment;

• Belief in remission of Tax on Sale of Goods and Services (ICMS the acronym in Portuguese) , which represents 17% of the value of some equipment from a wind farm, including the wind turbine that is 70% of the total investment of a plant, which was later done;

• Inclusion of enterprises in the Accelerate Growth Program (PAC, the acronym in Portuguese) with the guarantee of the Special Incentives for the Development of Infrastructure(REIDI, the acronym in Portuguese) with the exemption of charges(Social Integration Program/ PIS / and Contribution to Social Security Financing/COFINS) on the billing of companies for five years;

• 50% discount on tariffs for the use of the Transmission System (developments of power below 30 MW).T

The projects from the said auction will be installed mainly in northeastern of Brazil, notably the states of Ceará and Rio Grande do Norte which together account for 62% of the 71 contracted projects. Of the total 71 hired plants, 23 are in the state of Rio Grande do Norte, 21 in Ceará, 18 in Bahia, 8 in Rio Grande do Sul and one in Sergipe.

According to the perception of the Electric Energy Trading Chamber's President (CCEE) -, Antonio Carlos Fraga Machado, the results obtained in this auction showed the competitiveness of wind energy that fights for space with the thermal and other renewable sources in the complementarity of the water system.

According to the chairman of the Energy Research Company, EPE, Maurício Tolmasquim, the significant contracting of wind projects, added to the decision of canceling the power plant auction that would occur on 21/12/2009, showed the government's commitment to maintaining the high percentage of renewable sources in the Brazilian energy matrix.

To Hamilton Moss, director at Energy and Mines Ministry -MME, the auction was the begining of a new phase of alternative energy in Brazil, which has reached a point where it no longer needs government incentives. "By the time you have become a competitive source to the point where entrepreneurs are fighting for the price and causing this price to fall, this is the best of worlds," said Moss.

To continue the process of integrating alternative sources in the matrix, the government promoted, on August , 2010 an auction adressed to wind, biomass and small hydroelectric plants.

The contracts traded at this lastest auction had the folowing results:

TYPE OF ENERGY	NUMBERS OF CONTRACTS	INSTALLED CAPACITY(MW)	TRADED ENERGY(MEDIUM MW)	AVERAGE PRICE (R$/MWH)
WIND	**70**	**2,047.8**	**899.0**	**130.86**
BIOMASS	**12**	**712.9**	**190.6**	**144.2**
SMALL HYDROELECTRIC PLANTS	**7**	**131.5**	**69.8**	**141.93**
TOTAL	**87**	**2,892.2**	**1,159.4**	**133.56**

According to the chairman of Energy Research Company, EPE, Maurício Tolmasquim, the results os this auction represented a paradigm shift for the Brazil's electrical system. First because the wind energy had appeared as the cheapest type among the energies that were traded .Second becauseof it's price that shows it can be competitive with other energy sources.

Tolmasquim also said the New Energy Auction A-5, planned for the end of 2010, could result in hiring only from renewable sources, including large hydropower plants. If this occurs, the total volume of electricity traded in 2010 would only be from renewable sources.

4. WIND ENERGY AS AN OPPORTUNITY TO DIVERSIFY THE ELECTRIC MATRIZ

4.1. ADVANTAGES OF USING WIND ENERGY IN BRAZIL

Wind power besides being renewable, presents at least three simultaneous factors that warrant special attention in order to make it effective as an additional source of hydroelectric generation in Brazil's generating park: (i) the vast national wind potential, (ii) the Wind complementation possibility of the energy produced by hydroelectric generation and (iii) reduction on the Greenhouse Gas (GHG) Emissions.

4.1.1. WIND'S POTENTIAL

Brazil is favored in terms of winds, which are characterized by being present in twice the world's average amount and the volatility of 5% (swing speed), which gives greater predictability to the volume being produced.

Brazil's huge territorial extension led to many difficulties in monitoring the national wind potential. Only with the development of the MesoMap system (Surface Wind's Modeling Software) it was possible to develop the 2001 Brazilian's Wind Power Potential Atlas (last survey about the issue).

According to information/data presented by the 2001 Brazilian's Wind Potential Atlas, and without regarding the maritime zone, the gross potential installable power is estimated in 143 GW in areas where annual average wind speed is greater than 7.0 m / s.

Table - Cumulative Integration -BRAZIL

Wind (m/s)	(Cumulative) Área-Km²	Installable Potencial (GW)	Anual Energy (TWh/year)
> 6,0	667,391	1,334	1,711.6
> 6,5	231,746	463	739.2
> 7,0	71,735	143	272.2
> 7,5	21,676	43	100.3
> 8,0	6,679	13	35.9
> 8,5	1,775	3	10.7

Source: CEPEL, 2001

Table - Integration by Region - Range Speed >7.0 m/s.

Region	(Cumulative) Area - Km²	Installable Potencial (GW)	Anual Energy (TWh/year)
Northeast	37,526	75.1	144.2
North	6,420	12.8	26.3
Mid-west	1,541	3.1	5.53
Southeast	14,869	29.8	54.9
South	11,379	22.7	41.1
Total	71,735	143.5	272.03

Source: CEPEL, 2001

The Wind's Atlas shows that, except for the Amazon region, the wind's potential is distributed throughout the country, being more intense during the months from June to December, coinciding with the months of lowest rainfall.

The best wind resources in terms of wind speed and capacity factor are in the Northeast (52.3%), Southeast (20.7%) and Southern (15.9%) Regions.

A new national wind map is expected to be issued until the end of 2010. Based on calculations made by CEPEL (Energy Research Center), the potential is bigger than 250,000 MW. This is almost two times more than the calculations made in 2001 with the potential prognoses of 143,000 MW. In that time, the technology was limited by the use of wind in 30 – 40 meters above the surface.

The researchers say that the new calculation will be based on the wind potential in the altitude of 90-100 meters above the surface, due there are some equipments operating in those altitudes.

4.1.2. COMPLEMENTARY TO HYDROLOGICAL SOURCES

The Brazilian hydroelectric generation system undergoes a transition in their evolution pattern. The trend is to expand the installed generating capacity without new large reservoirs, which will reduce the ability to regulate the energy availability. This trend will occur by the combination of two factors. On one hand, the construction of dams with large reservoirs began to suffer restrictions from environmental agencies, who condemn and prevent exploitations with high flow between the wetland and the installed capacity. Moreover, the remaining hydro potential is concentrated in the northern region, dominated by rivers that cross the great plains.

The gentle topography of the region and the low slopes result in dams flooding vast areas to store relatively small amounts of energy, making the construction of reservoirs regularization difficult to justify.

This is a situation different from that which prevailed in the main basins already explored where it was possible to build dams that fill deep valleys and accumulate volumes that result in large energy stocks.

Therefore, the remaining hydro potential is located in a region that was badly suited for the construction of a hydroelectric generation system fully regularized and the opportunities for construction of large reservoirs that by chance could be constructed in such areas will hardly exist to increasing environmental restrictions. The consequence is that new dams in the northern region of the country - called water string – will have large capacity, but little actual generation during the dry season.

Nowadays, the most emblematic and paradigmatic example among large plants now in operation is the Tucuruí Project which recently expanded its installed capacity to 8,340 MW. This capability can be fully used during the wet season, but the generation is limited to little more than 2,000 MW in the dry season, as a consequence of the waters of the Tocantins basin and the absence of reservoirs capable to lead the seasonal nature of natural flow.

Another example of this trend is the future Belo Monte's Hydroelectric Power Plant. This is the only utilization provided for the Xingu River to be built at one point of the river where the average flow is almost 18,000 m^3 / s at the best of the wet season (between March and May). But the flow falls to less than 1,100 m^3 / s at the peak of dry season (between September and November). And there are no projects of reservoirs able to regularize the flow of this river, just like there are no plans for the construction of reservoirs capable of adequately regulating the flow of Madeira, Tapajós and Teles Pires rivers, which are the main front advance of the dam in the Amazon.

In this sense, compared to the seasonal availability of new power generation and the lack of water reserves capable of storing this energy, it can be concluded that the

Brazilian Electric System will increasingly need alternative sources of generation during the dry season.

In this scenery, comes the growing necessity for substantial additional generation in all the dry seasons. Among the existing possibilities, wind energy appears as a good alternative to be incorporated into the matrix having as advantage the complementarily of the wind (this means that in Brazil it is just during the period of low inflow of the rivers that there is a high intensity of winds) and the fast construction of projects that can last from six (6) to 12 (twelve) months.

Furthermore, despite the wind energy's production being uncertain as the winds vary in intensity during the days, months and years, its complementarily with the water resources is a major benefit to the Brazilian's energy matrix.

The country's wind potential is very large and a large-scale introduction of wind generation may be an attractive and efficient alternative with the idea of reducing construction costs of wind farms due to gains of scale and learning.

4.1.3. THE EMISSIONS REDUCTIONS OF GHG

The Brazilian rank as one of the five largest GHG emissions with an annual emission of 2.2 Gt of Co2 [8]. It is due essentially to change in soil use where foresting is responsible for 60% of the Brazilian emissions. So, it is evident that the GHG emissions reduction policy should be focused on restraining deforesting.

Nevertheless it is necessary an integration of Brazilian energy police in the strategies for reducing climate change. The accommodation of both policies is necessary so that Brazil can maintain and even improve the energy matrix with reduced carbon intensity aiming at changing to a green economy.

The following table presents data about the Brazilian emissions profile as compared to those of other countries and of the world average value.

[8] Resource: Ministry of Science and Tecnology of Brazil , 2009.

Comparison of GHG Emissions by Group of Countries and Type of Activity(*)

(in %)

Region/Country	Energy	Transport	Industrial Process	Agriculture	Change in Soil Use	Waste	Total
World	48.8	11.8	3.4	13.8	18.6	3.6	100
Annex I	63.3	18.6	3.6	8.2	-	6.2	100
Non Annex I	36.9	6.1	3.2	15.6	35.1	3.0	100
China	64.6	4.6	7.9	21.4	-1.0	2.5	100
India	52.3	6.8	3.5	34.8	-2.2	4.8	100
Indonesia	7.9	2.0	0.5	4.0	83.6	1.9	100
South Korea	68.8	17.5	9.2	2.8	0.2	1.6	100
Brazil	8.8	5.7	1.5	20.1	62.0	1.8	100
Mexico	50.5	16.6	3.5	8.2	15.8	5.3	100
South Africa	73.7	9.6	2.7	10.7	0.5	2.9	100

Source: SOUZA (2006)

(*) Brazilian data are those from the inventory published in 2004 relative to the 1990/1994 period.

The Copenhagen Agreement reported the intention of several countries to reduce their carbon emissions. In the Brazilian case, the presented target is a voluntary reduction of 36% to 39% of emissions projected for 2020.

In this sense, the proposed actions were divided into four main groups:

Deforestation Reduction: with an 80% reduction in the Amazon deforestation and 40% in the Savannah deforestation (reduction of 24. 8% in CO_2 emissions);

Agriculture: actions to recover pastures, agriculture-cattle breeding integration, tillage and nitrogen fixation (the reduction ranges from 4.9% to 6.1% in CO_2 emissions);

Energy: actions with a focus on energy efficiency, increased use of biofuels, expansion of energy supply by hydroelectric plants and alternative sources like, for example, wind power and bioelectricity (reduction varying from 6.1% to 7.7% in emissions of CO_2);

Metallurgy: deforestation done for coal production is replaced by planted trees (reduction varying from 0.3% to 0.4% in CO2 emissions).

The largest participation of wind energy in the Brazilian electricity matrix, especially on replacing fossil fuels, is highly beneficial in the strategy of reducing CO2 emissions, as be seen in the table below:

CO2 Emissions From Different Sources (Kg per MWh)

Energy Source	CO2 Emissions
Natural Gas (open Cycle)	440
Natural Gas (combined Cycle)	400
Oil	550
Coal	800
Hydroelectricity	25
Wind Energy	28

Source: European Union (2007).

4.1.4. ADICIONAL BENEFITS

a)The emergency demand by generation in the Brazilian Electric System, can be largely met by the fast development of wind farms in the gig watt scale, because for such plants the environmental authorizations are uncomplicated, and the leasing of small areas needed is done without any prejudice to the existing economic and environmental activities;

An eolian plant of 100MW, for example, can be constructed in less than 1 year, differently to the construction of a small hydroelectric and/or thermoelectric plant of the same capacity which would take from 3 to 5 years.

b)Much of this potential is found in areas with low industrial and residential development, therefore, in low power consumption regions, and these regions are in the vast majority poorly served by weak networks or may even have no access to electricity;

c) The total absence of environmental risks for large-scale wind generation in the country;

d) Generation of direct jobs in industrial production and technological corresponding fixation;

5. FUTURE PERSPECTIVES

5.1. INCREASING WIND ENERGY'S PARTICIPATION IN THE BRAZILIAN ENERGY MATRIX

According to data released by the Energetic Research Company - EPE, contained in the Ten Year Plan for Energy of 2019 - PDE 2019, there will be an additional 63,482 MW of power in the Brazilian energy matrix in the period of 2010 to 2019.

The share of alternative energies in this growth will be of 14,655 MW representing 23.1% of the total increase. In this participation 5.3 MW (36%) will come from wind, 5.4 MW (37%) of biomass and 3.9 MW (27%) from small hydroelectric plants.

These data indicates that the Brazilian energy matrix is becoming increasingly clean, with a clear prioritization of the projects of renewable energy and with increasing participation of the alternative sources to replace fossil fuels.

The market follows the government signs in the trend of these alternative sources growth, especially in regard to the generation of wind energy, as can be seen on the results of alternative energy auctions conducted by the federal government, the first, in December 2009, specific for wind energy, and the second dedicated to the three alternative sources, wind, biomass and small hydro, in August 2010, where it was found, in both, the predominance of the supply of wind energy.

5.2. ECONOMIC AND SOCIAL DEVELOPMENTS

The amounts of wind power contracted by the government in alternative energy auctions conducted in 2009 and 2010 will directly impact on the sectors related to this activity, especially the manufacturing of wind turbines, and electrical metallurgy, glass and resin industries with the manufacture of the blades of wind towers.

The Government's signals towards a firmer commitment in hiring minimum annual quantities of wind power in medium and long terms are attracting manufacturers of wind turbines and other components of the production chain of this sector (towers and blades) and will enable the growth of wind capacity in the country and the decrease in the production costs, due to the higher competitiveness.

Today, only the WPE multinational - Argentine subsidiary of Impsa - and Wobben, linked to the German Enercon produces wind turbines in Brazilian territory. However, the outcome of the exclusively auction for wind power in December 2009 is already having an effect on domestic industry, as is the case in which Alstom announced on December 18th ,2009, having signed a protocol of understanding with the government of Bahia for installing a wind turbine industry in Brazil. Just like Alstom, other companies such as General Electric and Vestas are already contractually committed to the national production in 2011 according to data obtained from the Brazilian Aeolian Energy Association (Associação Brasileira de Energia Eólica-ABEEólica, acronym in Portuguese), after the specific wind energy reserve auction held on December 14th , 2009, as presented in the table below:

Brazil's Annual Production Capacity (in MW)

Manufacturers	2009	2010	2011	2012
WOBBEN	500	500	500	750
IMPSA	450	460	600	600
GE			600	600
ALSTOM			300	500
VESTAS			120	300
TOTAL	950	960	2.120	2.750

The expectation is that other companies such as Siemens and Suzlon, install plants with that same focus in the country.

The great Brazilian wind potential and incentives for the expansion of wind power generation in the Brazilian energy matrix should encourage, in Brazil, the installation of international investors who own the technology and the needed knowledge to contribute for the development of wind energy in Brazil.

This transfer of technology will be crucial for the development of wind energy in Brazil, so this may have reduced costs and become more competitive.

Therefore, besides supplying the demand for electricity, the expansion of the wind system, opens up new technological opportunities for the country, encourages the establishment of manufactures and suppliers, generates employment and income, these vectors are fundamental for national and regional economic development. In Brazil, with only 600MW installed, there are about 10,000 jobs among manufacturers, suppliers and various service providers in the wind field.

5.3. COST REDUCTION

Although the cost varies between different countries , the trend everywhere is the same – wind energy is getting cheaper. The cost is coming down for various reasons. The turbines themselves are getting cheaper as technology improves and the components can be made more economically. The productivity of these newer designs is also better, so more electricity is produced from most cost-effective turbines. There is also a trend towards larger machines. This reduces infrastructure costs, as fewer turbines are needed for the same output.

The cost of financing is also falling as lenders gain confidence in the technology.

According to national data from the last auction, the commercial value of wind energy (R$ 130,86 MWh at the auction in August 2010) was above the cost of hydropower (R$ 77.97 MWh, the auction Belo Monte in April 2010), but was lower than thermal (R $ 145.23 MWh in the last auction in September 2009) and biomass (R$ 144.20 MWh in the auction of August 2010), and small hydro plants (R$ 141.93 MWh in the auction of August 2010). Those number shows that wind power can be competitive in Brazil.

The higher wind energy cost in Brazil , until now, could be attributed to the limited number of domestic wind turbine producers, associated with restrictions on imports of such equipment.

Until 2010, in Brazil, the supply of wind turbines, representing approximately 70% of the costs of setting up a plant of this type, was limited to two enterprises that have additional competitive advantages: 14% tax on imports of wind turbines, only wind turbines with power above 1.5 MW can be imported and the fact that the BNDES only provides financing to domestic manufacturers.

Therefore, these two companies were able to charge prices well above those that would be competitive because the market presented significant barriers of entry.

The technological advances associated with large scale production enable, the worldwide reduction in the cost of wind energy. In 2005 the cost of energy was about one-fifth of what it cost in the late 1990s and this fall should continue with the rise of the technology production and large wind turbines.

The training and absorption of new technologies are arising from the entry of new wind power equipment manufacturers in Brazil and the increments of demand allowing economies of scale should be reflected in the cheapening of costs of deployment of these plants and consequently reduce the cost of generating this energy in Brazil, as we can see in the table below:

Modality	Year of Agreement	Average Selling Price of Wind Energy – R$/MWh	% of reduction
PROINFA	2004	177.40	-
Wind Energy Auction	2009	148,39	16
Renewable Energy Auction	2010	130,86	12

The economics of wind energy are already strong, despite the relative youth of the industry. The downward trend in costs is predicted to continue . The strong influence will be exercet by the downward trend in wind turbines prices.

CONCLUSIONS

Worldwide, the use of wind energy in the generation of additional power has been widely disseminated and is expected to significantly increase during the coming years.

Brazil should also follow this international trend in line with the direction by the government that is encouraging the generation of alternativesources of energy in the country.

The creation of the Alternative Energy Sources Incentive Program -PROINFA was the first step towards the development of wind energy generation in the country. Since the creation of PROINFA, the installed capacity of wind power in Brazil increased from 22MW in 2003 to 700 MW in 2010, reaching 1400 MW in early 2011.

With the results of the exclusive wind energy auction, held in December 2009, the installed capacity of wind power will increase to 3400 MW in 2012 already, which means quadruple the current capacity installed in the country.

Besides the strategic importance of energy supply security and also its clean and renewable aspect of the source, other factors, quoted below and already discussed in this work, contribute to increase the participation of wind energy in the Brazilian energy matrix:

• Difficulties for environmental permission to build new hydroelectric plants;

• The feature of new hydroelectric plants with the edge of water, with the consequent reduction of the ability for multi-annual regulation;

• The enormous wind potential target (143,000MW);

• The seasonal hydro - eolian complementarily;

• Commitment to reduce CO_2 emissions.

The cost presented for wind energy in Brazil, as evidenced in recent auctions, shows itself to be competitive with the small hydro and heat derived from biomass and fossil fuels.

The maintenance of government incentives is still essential to attract investment not only in generation but also in manufacturing equipment and might enhance the competitiveness of this segment accelerating the participation of wind energy in the Brazilian energy matrix.

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