WINDPOWER IN BRAZIL – A TRANSITION USING THE GERMAN EXPERIENCE

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The development of the installed capacity of wind energy converters in Germany shows that a significant increase of its contribution to the energy supply is possible, depending on the measures introduced by the state. In contrast to Germany, Brazil did not think much about its greenhouse gas emissions, as 95% of the electricity is generated by hydropower. However, due to the current energy crisis Brazil has to search for new alternatives for stabilizing the energy matrix and diminishing the dependence on precipitation, especially as a new capacity of 4 GW has to be installed each year. The intention of the authors is to present the German regulations that led to the actual favorable situation for wind energy and to compare these to Brazilian conditions of climate and legislation that exist for an extended application of this energy source.

The German Energy Sector

The German electric power generation is dominated by fossil fuels, as shown in table 1.

Table 1: German Electric Power Generation [1]

Energy Source	Share [%]
Nuclear	31
Hard Coal	25
Lignite	24
Natural Gas	11
Water Power	5
Petroleum	1
Wind Power	1 (3*)
Others	2
	(* new data 2002)

With the intention to diminish the greenhouse gas emissions, mainly caused by the burning of fossil fuels, as well as to guarantee a reliable energy supply, the German Government has set the objective of at least doubling the percentage share of renewable energy sources in total energy supply by 2010. In order to attain this objective, it seems necessary to mobilize a wider utilization of alternative energy sources, like solar and wind energy, small hydrodynamic power, etc.

The German electricity sector is totally privatized. More competition causes the effect that companies are investing in cheap technologies with a rapid return of investment such as gas turbines. No company will invest in renewable energies that are still quite expensive compared to conventional technologies, i.e. depreciated coal power stations. Besides this, the previous monopoly enjoyed by the electricity utilities made it more difficult for companies not associated with the utilities – particularly for operators of renewable energy projects – to obtain access to the grid owned by the utilities.

In order to overcome these difficulties, the German Government decided to intervene in the market by regulating in favor of renewable energies. There are basically two ways to intervene in the market: (a) To fix quantities or market shares and in principle to leave the price to be set by competition, as is the case, for example, with the tender models in the UK or with quota models like in the Netherlands. (b) To fix or steer prices and to leave the quantity open in principle. Germany took the second course in its Electricity Feed Law (in effect since 1 January 1991), amended and expanded by the Act on Granting Priority to Renewable Energy Sources, which went into force on 1 April 2000. According to this Act, grid operators are obliged to connect to their grids electricity generation installations based

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on renewable energy sources, to purchase preferably electricity available from these installations, and to compensate the suppliers of the electricity with a minimum price.

Wind Power in Germany

Germany is a small country of 357.022 km^2 with 82 million people, which corresponds to 230 inhabitants per km^2. This fact shows that it is a very densely populated country, which turns the erection of wind turbines difficult. As shown in figure 1 the highest average wind velocities – between 5 and 6 m/s - may be found in the northern coastal line. Although these velocities are not very high, compared to sites in other countries, 13 billions of kWh were generated by wind turbines in 2000.

In June of 2001, an estimate of the use of wind energy in Germany resulted in a number of 10.033 installed turbines with a rated power of 6.916 MW.

As shown in figures 2 and 3, since 1991 the installed power of wind turbines has climbed up quickly.

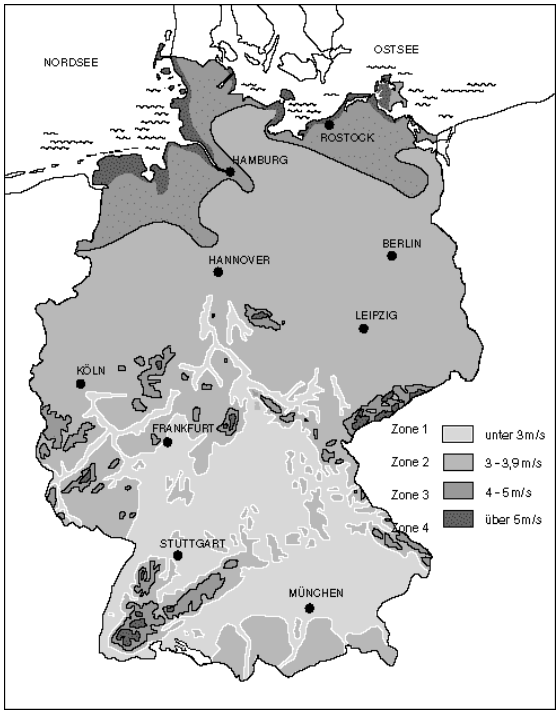

Fig.1: Average wind velocities [Source: HEW]

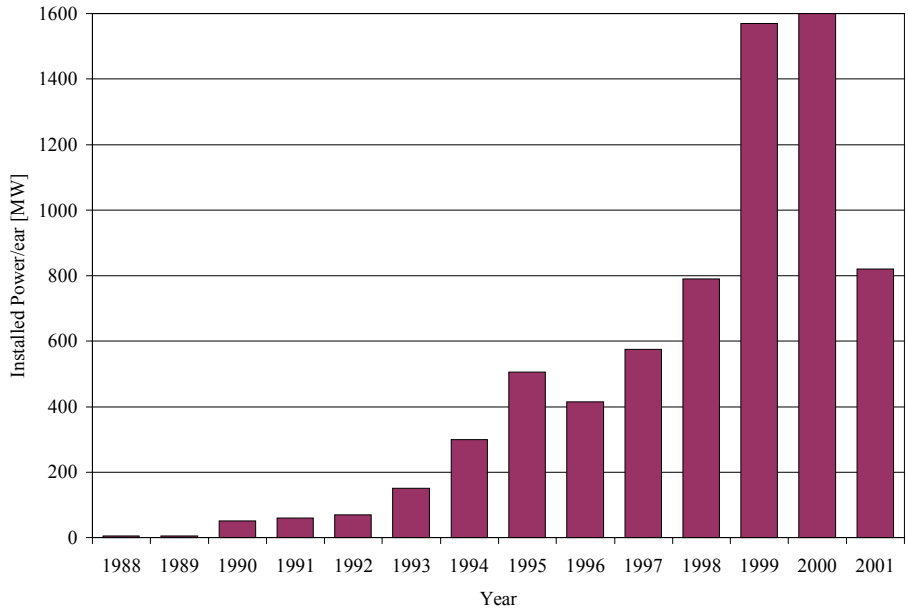

Fig. 2: Development of the yearly installed power [2]

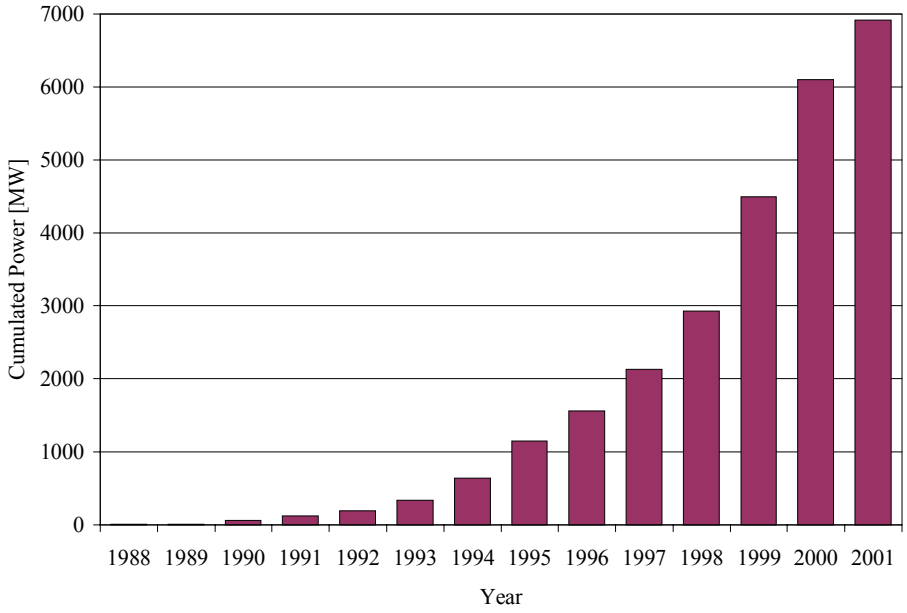

Fig. 3: Development of the cumulated installed power [2]

This development was enabled by the enactment of the Electricity Feed Law (Stromeinspeisungs-gesetz)[3], effected since 1st of January 1991, which was amended and expanded by the Act on Granting Priority to Renewable Energy Sources [4], which was enforced on 1st of April 2000. These regulations oblige the grid operator to purchase power from renewable sources at a percentage or a minimum price if it does not originate from a public sector power provider. The Electricity Feed Law arranged that a minimum fee has been reset nationwide each year as a specific percentage of the average revenues earned by the grid operators from sales to all final electricity consumers in the year before. These fees varied depending on the energy source and the size of the facility. In particular, for electricity from solar and wind power from any size of facility they paid 1999 0.1652 DM/kWh[1] = US$ 0.0938 in 1999. The following Act on Granting Priority to Renewable Energy Sources works without percentages and defines a fixed minimum price. In the case of wind power the compensation to be paid has to be at least 0.08 US$/kWh for a period of five years starting from the date of commissioning, after this period at least 0.06 US$/kWh (US$ 2002). As of 1st of January 2002, the minimum compensation is to be reduced by 1.5 percent annually.

The Brazilian Energy Sector

Since the early 1990s, the Brazilian electricity market is passing through a complete process of change. From an original state monopoly in generation, transmission and distribution, an almost privatized, liberalized and competitive service sector is to follow. Until now, only the distribution and transmission sectors have been privatized.

Actually, electric power generation in Brazil is dominated by hydrodynamic power, more than 90% of the installed capacity and production; the rest is based on thermoelectric plants. Compared to Germany, Brazil's energy supply is mostly based on renewable energy resources. So the first question in the Brazilian case is not the substitution of fossil fuels, but how to cover the rising energy demand (ca. 4 GW p.a.) in the future. The utilization of wind energy can contribute to reach this objective.

[1] One DM (Deutsche Mark) corresponds approximately with 1 Brazilian Real.

Wind Power in Brazil

Brazil has an area of ca. 169.6 million km^2. With 19.9 inhabitants/km^2 Brazil is very sparsely populated, with a high concentration in the urban centers (81.2%) [5]. This area is equivalent to the continental US; therefore it is not inconceivable that good wind resources can be found in the country.

Actually there exist 20.5 MW of installed wind power capacity in Brazil. In 1999 was finished the first Brazilian Wind Energy Atlas. Simulations, performed by CEPEL (Electric Energy Research Center), estimate a Brazilian wind potential of 143.5 GW.[2] [6] The Wind Atlas shows very good potentials in the coastal line of Northeast, in the South and Southeast of Brazil. Until now, most focus has been put on the state of Ceará mainly because it was the first one to carry out precise and reliable wind data collection. The first anemometers installed in the Island of Fernando de Noronha (Pernambuco) and the coast of Ceará revealed a yearly average wind speed of about 8 m/s, much higher than in Germany. The analysis of wind data in the last years from several sites in the Northeast coast confirmed the characteristics of the southeast trade-winds: uniformity of wind speed and direction during the whole year, exceptionally high Weibull shape factor when compared to sites in US or Europe, low turbulence intensity and low variability of wind directions (almost uni-directional wind) [7].

Moreover, it was not only at the coast of the Northeast region that windy sites were identified. In Minas Gerais, 1000 km from the coast, a 1 MW wind farm is located on a 7 m/s site. In the southern part of Brazil, state of Paraná, annual averages of 7.5 m/s have been reported [7].

Up to now, there did not exist any important favorable incentives for alternative energies in Brazil, and therefore it was difficult for operators of small renewable energy projects to become established in the Brazilian energy sector. With the enactment of the resolution No. 24 of the 5th of July 2001 (Emergency Program of Wind Energy – PROEÓLICA) [8], Brazil decided to intervene in the market by a price regulation model, similar to the German model. The three main objectives of this program are: (a) to make the implantation of 1050 MW of electric power from wind energy resources possible until December 2003, integrated into the national electric grid system; (b) to promote the use of wind energy resources as an alternative for the energetic, economic, social and environmental development and (c) to promote the seasonal complementary of the hydraulic fluxes to the storage lakes of the national grid system. To execute PROEÓLICA, Eletrobrás shall contract, directly or indirectly via its member companies, the purchase of generated wind energy for a minimum period of 15 years until a limit of 1050 MW. The value of these purchased quantities will be equivalent to the transfer values of the tariffs related to the wind resource and established according to the regulations of ANEEL (National Agency of Electric Energy). According to this, wind energy receives an additional bonus to the already increased reimbursement for the kWh generated by wind, depending on the date of commissioning of the wind farm. In February 2001, ANEEL set the rate for wind power at R$ 112/MWh (US$ 43/MWh). According to PROEÓLICA, the purchase price increases to about US$ 52/MWh for projects implemented until December 31st, 2001, but will fall to about US$ 47,30/MWh for projects approved by the end of 2002.

The German as well as the Brazilian model of governmental market intervention in favor of wind energy are based on a price regulation for generated electricity. But, in contrast to Germany, Brazil does not allow a respective free adjustment of the wind power to be installed, but at the same time fixes the maximum power that can be installed (1050 MW until 2003). Another difference is the fact that there is a lack of long term purchase contracts for wind energy between the wind turbine operators and any “buyer” of this energy, like grid operators, distribution companies, etc. The obligation, like it was introduced in Germany, to purchase the energy from small renewable energy sources lacks in Brazil until now. It remains to be seen to what extent the fixed price will be appropriate to promote a development like in the German case.

[2] This value is based on the following assumptions: average wind velocities of more than 7m/s, only on-shore, using wind turbines of 600 kW.

According to a study of Brazilian Center of Wind Energy (CBEE), the cost of wind power generation in Brazil (between US$ 0.039 and US$ 0.084 per kWh) is already competitive to thermoelectric, nuclear and new hydroelectric projects. Above all, the construction of new large hydroelectric plants is limited by its absence of suitable places and the high socioeconomic costs. Table 2 shows the generation cost of various energy sources of new projects in Brazil [7].

Another important problem of PROEÓLICA can be seen in its short-term design that does not promote a long-term establishment of wind industry in Brazil, but creates an incentive for importation of wind turbines. Actually, there is only one Wind Company dominating the Brazilian market. With Wobben Windpower as a subsidiary of the German company Enercon exists a local turbine manufacturer and independent supplier of wind energy technology.

One characteristic of the Brazilian electric power generation is its domination by hydrodynamic power. One important challenge by planning the interconnected electrical system is the seasonal stabilization of the energy supply due to the stochastic nature of the hydro resources. One objective of PROEÓLICA is the promotion of the wind/hydro seasonal complementarity. This fact is given in several areas of Brazil. The wind regimes in the South and the Northeast are complementary to the seasonal hydro regime.

PROEÓLICA is a step into the right direction, but in order to promote a sustainable social and industrial development, a more long-term project is necessary. It remains to hope that the development of the installed wind capacity will continue after 2003.

Table 2: Cost comparison of energy sources [7]

Energy Source	Generation Cost [US$/MWh]
Biomass	38 to 78
Wind	39 to 84
Coal	50 to 65
Natural Gas	38
Imported Coal	49
Imported Natural Gas	47

Conclusions

Brazil shows good conditions of geography for promoting a large use of wind energy. There exist high wind average velocities with a low variation of wind directions. Up to now, it was difficult for operators of small renewable energy projects to become established in the privatized Brazilian market. With the enactment of the resolution No. 24 of the 5th of July 2001 (PROEÓLICA), there is a first concrete market intervention to promote the utilization of wind energy. According to this, wind energy receives an additional bonus to the already increased reimburse tax for kWh generated. Unfortunately, the success of this program cannot be expected to be the same than in Germany, because of its lack of long-term purchase contracts for wind energy and is short-term character that does not give a strong incentive to establish a wind industry in an insecure market.

In the future, the tendency of investment in the Brazilian energy sector will move away from large hydro plants and towards gas, nuclear and small renewable energy source projects Although gas plants use a clean technology and gas is still abundant, it is a limited resource. Further there is the most recent problem of a shortage of gas turbines in the world market. Nuclear plants are expensive and have the problem of worst consequences if an accident takes place, as well as the absent solution for the final storage of radioactive waste. Small renewable energy plants cannot resolve the energy crisis in Brazil, but simultaneously with an appropriate politic of energy conservation they can contribute a lot to relax the situation.

Among the security of electric energy supply, wind energy could also be used to solve the problem of water usage (electricity generation against irrigation) in various regions of Brazil. In addition to that, many isolated communities have not any access to the public electricity network and use diesel generators for the electric energy production. Wind turbines could couple to the existing diesel systems and promote savings with respect to fuel, transportation, storage, operation and maintenance costs of the diesel, not to mention the environmental pollution reduction.

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