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SYSTEMATIC SEARCH OF THE PRODUCTION CHAIN IN TECHNOLOGY FOR MANUFACTURERS OF WIND TURBINES IN BRAZIL

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Abstract.*.Only in 2014, it was installed 51,448.0 MW, more than twice the largest hydroelectric in the world, Tree Gorges, which took 15 years to have installed the 22,500.0 MW. Between 2012 and 2014 Brazil went from 2092.0 MW of installed power to 5939.0 MW, ranking among the top 10 countries in installed wind power. Many foreign companies, experts in their countries of origin and wind generator manufacturers are settling in Brazil, bringing the manufacturing technology of large wind generators. However, the Brazilian market items and sub-items need to be enhanced and enabled to meet the demand of these companies assemblers. In some areas such as towers and blades, Brazil has become a major supplier, including for export. The objective of this study was to investigate the behavior of industrial production chain of some important items for subassemblies and meet demand from automakers. Furthermore, the concept will be introduced the standard plant to normalize scaling in terms of installed capacity. Some industrialized parts in the country, mailing steel towers, were checked for the domestic market attention due to the design and implementation of major parts. The conclusions have indicated that there is discontinuity in certain items such as plates and forged flanges for steel tower.*

Keywords: *Wind energy, Wind Turbines, Steel towers, Forged flanges.*

1. INTRODUCTION

Wind energy is one of the energy sources that fastest growing in the world. Its use as renewable energy in the use of a natural source along with hydropower and solar ones, put these forms of energy as excellent choices for electricity generation.

Wind power is a clean energy and offers the possibility of using one of the most abundant resources in nature, the wind. The total potential available in wind energy worldwide could reach 1.5 TW.

In almost 24 years of facilities within modern wind turbine designs, it has already installed a total of 370.0 GW, almost one third of all installed hydraulic power in over a century, which came at the end of 2013 in about 1100.0 GW (GWEC, 2014; IEA, 2014). This increase grew in 2014 at 51,5 GW, approximately 2.3 hydroelectric of three gorges, which took 15 years to reach the 22.4 GW (author's note).

The evolution of the penetration of wind farms, in the contest of electricity generation, exceeds the progress of implantation of hydroelectric in the early twentieth century.

Although the working principle of wind power is known long ago, with the old windmills installed mainly in the Netherlands, with the same principle of these old mills, only in 1888 came the first windmill to generate electricity. It was effectively with the Danish school, headed by Pou La Cour, the first step in using the new concept of electricity generation by wind turbines began (HAMSEN, 2003).

In 1941, during World War II, an American team led by Palmer Putnam Cosslett and with funding from the Central Vermont Public Service Corporation, designed a wind turbine with 1,2 kW capacity, a major challenge for the season. The project was called Smith-Putnam Wind Turbine. The turbine ran for nearly three years, but because of the failures and disruption of one of the blades, for lack of appropriate materials of their manufacturing at that time, the manufacturing project, on a large scale, was abandoned (KOEPPL, 1982).

Only in the late 70's which appeared effectively to market, a wind turbine with a capacity above 1000 kW (author's note).

This increase went through several attempts to use various types and forms of turbines. For example, horizontal axis turbine (HAWT), which has assumed the current shape with three blades, had the attempted use of two blades until a blade. The two-bladed, mainly developed in the 80s, Sweden and Germany, have reached a capacity of 3,000.0 kW (Gasch, 2001).

The use of this source for electricity generation on a commercial scale began in the 1970s, when it stressed the international oil crisis. The USA and some European countries were interested in the development of alternative sources for the production of electricity, seeking to decrease dependence on oil and coal. Table 1 shows the countries with the largest installed potential.

Table 1. Main countries with wind power plant in the world

Country	Installed Capacity (MW)		
	2012	**2013**	**2014**
China	75,564	91,412	114,763
United States	60,007	61,091	66,879
Germany	31,332	34,259	39,165
Spain	22,796	22,959	22,987
India	18,421	20,150	22,485
United Kingdom	8,845	10,531	12,440
Italy	8,144	8,552	8,663
France	7,196	8,254	9,285
Canada	6,200	7,803	9,694
Brazil	2,508	3,461	5,939
Sweden	3,746	4,470	5,425
Portugal	4,525	4,724	4,914
Denmark	4,162	4,772	4,845
Poland	2,496	3,390	3,834
Australia	2,584	3,239	3,806
(rest of the world)	24,357	29,038	34,429
Total worldwide	**282,883**	**318.105**	**369,553**

Source. GWEC, 2015; WWEA , 2014.

As can be seen in Table 1, Brazil went from 2,.508.0 MW in 2012 to 5,939.0 MW in 2014, going from 14th place to 10th place, ahead of Denmark, Sweden, Australia and Portugal.

1.2 Evolution of the wind market in brazil

Brazil is a country with great wind potential and which offers favorable conditions for the installation of wind turbines, especially on the northeast coast and the southeast region.

When the first "Atlas of the Brazilian Wind Potential" was completed in 2001, the technology of the towers was quite different from that used in the construction of the equipment installed today in wind farms. The work, commissioned by the Ministry of Mines and Energy, has estimated for the country a power of 140.0 GW of wind power, however, it has been considered wind turbines of 600.0 kilowatts and 48 meters high. Today, wind turbines installed in wind farms built from 2009 have 100 meters high with power between 1.6 MW and 3 MW. If these data are revised the wind potential in Brazil will rise to approximately 300.0 GW, and regions that do not concentrated the wind potential will be considered in future projects (ABEEÓLICA, 2012).

Brazil has left an installed capacity of 20 MW, 14 years ago, for a total of 5,939.0 MW, corresponding to 4.47% of all electric power in the country as shown in Fig. 1, which represents the share of energy sources in generation of electricity.

The Brazilian Association of Wind Energy launched the Industry Data Monthly Bulletin Wind, on a monthly basis, in February 2015, showing some of the main data on wind power in the country. Brazil accounted in early 2015, 242 wind farms in operation, with an installed capacity of 6,080.0 MW. Geographically, the parks are concentrated in the Northeast and South. In terms of installed capacity, the state of Rio Grande do Norte has the greatest potential, with 2,092.0 MW in operation, divided among 74 parks. The state also has 92 of the 415 parks under construction and procurement currently in the country, totaling 2,400.2 MW.

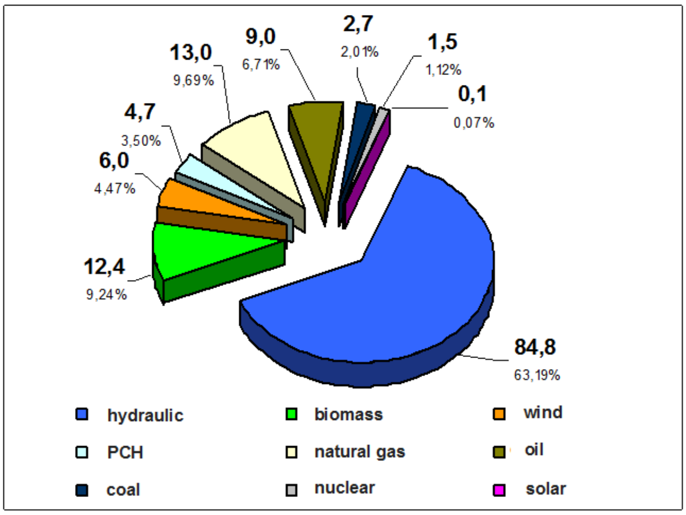

Figure 1 - Share of energy sources in electricity generation.
Source: ABEEólica / ANEEL (01/05/2015). Redesigned.

2 OBJECTIVES

The objectives are to map the productive chain of the Brazilian wind industry with respect to one of its main components, tubular towers in steel structures, identifying bottlenecks productive supply, imported equipment, and industry-leading manufacturers and their service to potential expansion plan wind energy.

The specific objectives should take into account the availability and accessibility to the various sectors of the installed infrastructure in the country and the service the government targets the expansion of the national wind farm.

3 MAJOR MANUFACTURERS POTENTIALLY INSTALLED IN BRAZIL

Table 2 shows the relationship of the leading manufacturers solidly already installed in Brazil and the capacity of wind turbines wishing to produce in new ventures.

Table 2 - List of major suppliers installed in Brazil

Manufacturer /fitter	Type of Wind Turbine	location	Operation
ACCIONA	AW-3,0 MW	Simões Filho- BA	Cubes and nacelles
GE	ECO100-3.0 MW; ECO110-3.0 MW ECO122-2.7–3.0 MW	Campinas - SP	Mounting cubes and nacelle
SIEMENS	SWT-2.3-101	Guarulhos/Jundiaí SP	New turbine deployment
WEG (without reduction gearbox)	AGW110/2.1 e 110/2.0, AGW100/2.2 e AGW93/2.3	Jaraguá do Sul SC	Generators manufacturing for Ibiapina Park in Ceará
GAMESA	G114-2.5 MW G106-2.5 MW IA e II	Camaçari - BA	Manufactures cubes and towers (Torrebrás) in operation
ALSTOM	ECO100-3.0 MW; ECO110-3.0 MW ECO122-2.7–3.0 MW	Camaçari - BA	Manufactures nacelle and cubes
WOBBEN (without reduction gearbox)	E82 -2,0 a 3,0 MW E92 – 2,3 MW	Sorocaba- SP	First to install a wind turbine in Brazil

Sources: Own Preparation and information of text quotes: ACCIONA, 2014. Wobben, 2012. GEIMPRENSA, 2014. SIEMENS, 2011. WEG, 2014. ABBEOLICA, 2013. GAMESA, 2013.

4 THE CHOICE OF A STANDARD TURBINE

Inside the insertion in the market of major powers offered by Brazilian manufacturers turbines, as shown in Tab.2, for every study of this work was taken as standard a turbine of 2,500.0 MW.

It is a turbine that will govern all production in terms of major assemblies used in manufacturing, assembly and installation of the turbine. Thus, for example, if the annual production of towers is 1,100 towers of 100 meters high, the power in terms of standard turbine installation in wind farms will be 2 ,750.0 MW.

5 TOWERS

The towers are structural components that support the whole wind turbine. They may have different construction types; tubular steel structure, lattice and prestressed concrete structure. In Brazil, the two most widely used types are metal and concrete.

5.1 Tubular steel towers

Table 3 presents a list of the leading manufacturers of towers installed in Brazil, both steel and concrete.

Table 3 List of major towers manufacturers in Brazil

Manufacturer	**Location**	**State**	**Production Tower/year**	**Note**
RM eólica (GESTAMP)	Cabo Sto. . Agostinho	PE	400	May reach 600 towers/year
Tecnomaq	Fortaleza	CE	120	Added more 120
Engebasa	Cubatão	SP	160	
Intecnial	Erechim	RS	80	
Torrebras	Camaçari	BA	220	
Máquinas Piratininga	Recife	PE	200	It can add more 50
Alstom	Camaçari	BA	120	
Total			**1300**	
Torres de Concreto				
Wobben	Gravataí	RS	300	
Wobben	Pecém	CE	220	
Wobben	Parazinho	RN	200	
Acciona	Fábrica móvel		96	
Total			**816**	

Source: own elaboration based on: Engebasa, 2013. TECNOMAC, 2010. GRANDIN, 2013. (Regarding TORREBRAS). Wobben, 2014. HAWK, 2010. (Refer to PIRATININGA MACHINES). TRIBUNE OF BAHIA, 2014. (Regarding ALSTOM). RMEÓLICA, 2010.

For wind turbines 2,000.0-3,000.0 kW, it may have height varying from 80 to 110 m, a diameter of between 3.5 / 4.5 m in the base where is placed the fixing flange and between 3.5 / 2.8 m on top where the assembly is mounted on the nacelle.

The wall thickness can vary from 4 to 5 cm at the base and 1.5 to 2.0 cm at the top. They are made of special steel, manufactured in Brazil and supplied by USIMINAS.

Still part of the group of towers: the flanges, the mounting screws at the base and between the various sections, the hatch, stairs and platforms, etc.

The towers are built in segments that soldered form the passages, which are shipped mounted and screwed in the construction site.

Each tower may comprise 3 to 4 passages, between 20 and 30 m each range from 5 to 8 segments, depending on the manufacturer and the height of the tower and also make the transportation easier.

The welds between the various segments, both longitudinally as circumferential is done through the submerged arc process which provides speed to be an automated and good finishing.

The tubular steel towers represent approximately 50 to 60% of the total weight of the wind generator. The table 3. shows the distribution of the total amount of steel towers between domestic manufacturers.

One of the main elements in the assembly of the towers is the foundation, which must be prepared to receive the first stretch and must have waiting risers where the flange of the first section must be perfectly seated.

If it was only analyzed the manufacture of steel towers, when taken standard 2,500.0 MW turbine, the production capacity of 1300 towers would meet approximately 3250 MW year wind turbine installation.

But this production would be subject to much of imported plate and forged flanges at a level not manufactured in Brazil. The sum of the steel towers and concrete perfectly meets an annual installed power of about 5,000 MW, taking as reference the standard turbine to the study of 2,500 kW. There is, therefore, in this comparison an excess of towers to meet the demand for wind turbines. Of course, many parks also will require less power turbines.

5.2 Flanges

The flanges are essential elements for the union sections of the towers and the tower base connection with the foundation.

Basically they are constructed of forged rims or rolled square ingots or rectangular laminates subsequently calendared and soldered, forming a ring that will undergo machining turning and drilling.

Each tower at the height ranging from 80 to 100 I comprises 3 to 4 passages requires 6 to 8 pieces of flanges and rings.

The first manufactures flanges installed in Brazil was the IRAETA , linked to the Spanish group Gonvarri. The unit of 5.5 million square meters has a production capacity of 6,000 flanges per year, which would serve approximately 800 wind towers, 80% of the total required for the market for wind turbine assemblers (Iraeta, 2012).

The UNIFORJA in Diadema, São Paulo, also has the capacity to meet manufacturing flanges of metal towers (ABID, 2014).

A concept that could become interesting for the domestic industry would be the manufacture welded flanges for use circle sectors obtained from previously specified steel plates, which would undergo subsequent heat treatment and final machining of turning and drilling.

Figure 2 shows the sequence of manufacturing to assembly of metal steel towers, varying little between each manufacturer, depending on the equipment used.

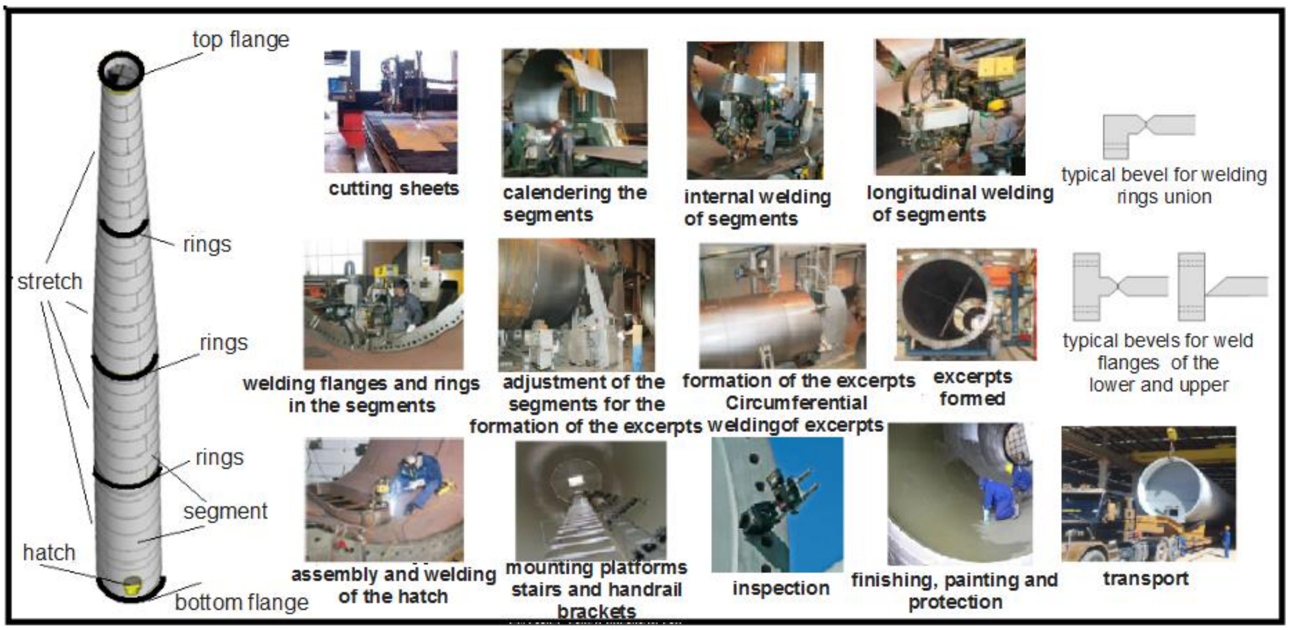

Figure 2 Sequence of manufacturing a wind tower tubular steel
Sources: TECNOMAQ, 2014. ESAB, 2014. WAHLEN 2011

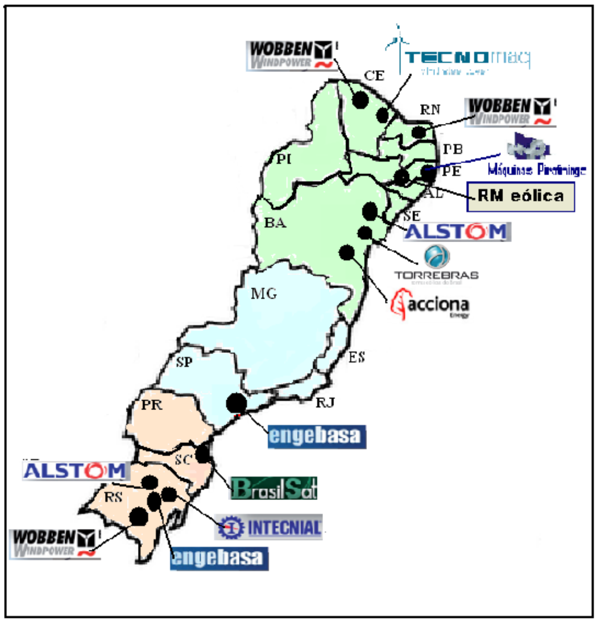

Figure 3 Main towers manufacturers.
Source: ABID, 2014. Authors´ drawing.

5.3 Screws and fasteners

This is a market that has had great investment for over 15 years and focused part of its efforts in meeting the wind market. The German company FRIEDBERG has subsidiary in Monte Mor, State of São Paulo. Currently, the company is developing two products for export: one HV screw, high strength M36 and M42, intended exclusively for the wind in Europe and USA (SCREW MAGAZINE, 2009).

Another company that is a leader in the market and manufactures fasteners, bolts and nuts of quality required in the construction and erection of wind towers is CISER, located in Joenville, Santa Catarina, with a monthly output of 6,000 tons (ABID, 2014).

On the raw material for making fasteners straps and screws, GERDAU also developed the 42CrMo4 steel modified, created especially for the production of fasteners for aero generators towers (CIMM, 2012).

5.4 Structural part

Regarding the structural part, stairs, platforms, doors and hatches there are no problems for the supply, and the market served by various boiler shops and welding workshops accredited in the domestic market.

The manufacture and supply of stairs are currently run by companies: ATLANTA, city of Sorocaba, São Paulo; HAILO, city of Jaguariúna, São Paulo and also the KATHREIN in the city of São Paulo, São Paulo, both with the possibility to meet 100% of the needs of the towers.

Regarding the elevators companies: AVANTI, in the city of Fortaleza, BARAN in the city of Sapucaia do Sul, Rio Grande do Sul and the MONTARTE in the city of Santa Isabel, São Paulo, meet the demand of Towers manufacturers.

Platforms, supports, handrails, guardrails are available from Hailo, ATLANTA, and BARDELLA, this last located in the city of Guarulhos, Sao Paulo.

Power cables and transmission passing through the tower, from the top to the bottom, are provided by traditional companies of manufacturer of cables, such as PIRELLI, with its new subsidiary, PRYSMIAN in the city of Sorocaba, São Paulo and NEXANS, located in the city of Americana, São Paulo and in the city of Rio de Janeiro (ABID, 2014).

5.5 Consumables and machinery

It is understood by consumables used for the preparation of welding processes and machines for preparing segments.

Regarding the welding material consumption as flow, wire and electrodes can be provided by national industries such as: ESAB, White Martins, Lincoln. The welding process used to make most often is the submerged arc welding (SAW).

6 THE BOTTLENECK ON PRODUCTION OF STEEL TOWERS

The only supplier of special plates for the production of steel towers is USIMINAS.

The plate used is a special one: SYNC WHS 500 M, plate the same line of USI SAR-50 BN, but with increased strength, better weldability and toughness (USIMINAS, 2013).

The 9.5 million tons produced by USIMINAS in 2013, only 120,000 tons were directed for use in wind towers.

Taking into account that for a wind turbine with tower 100 m needs approximately 160.0 t, the supply would meet 750 towers for turbines of 2,500.0 kW (authors´ note).

While the production of USIMINAS not increase for this type plate, which is expected to double by 2016, the solution is to import this material from Chinese steelmakers.

Another bottleneck is to manufacture the flanges, taking into account that the flanges are fabricated to process rolled bars and that the forged welded, although meet specifications for use in wind towers. The main supplier of raw materials for the production of flanges is GERDAU (CIMM, 2012).

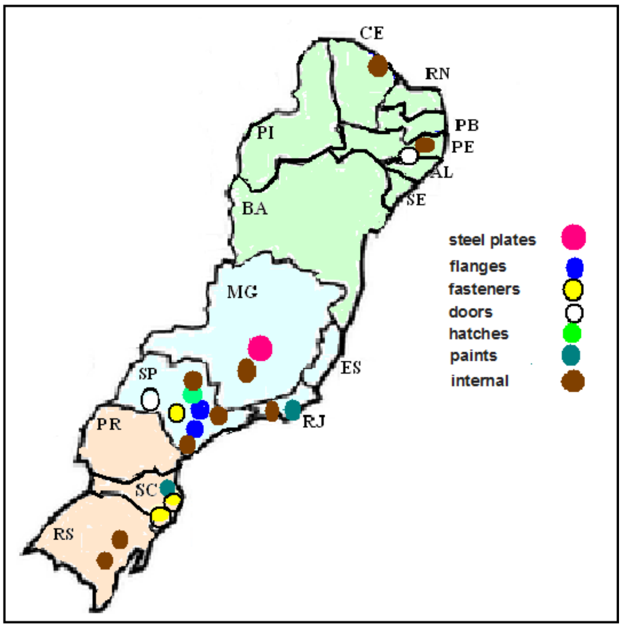

Figure 4 production chain of towers manufacturers.
Source: ABID, 2014. Authors` drawing.

7. MAPPING THE TOWERS PRODUCTION CHAIN IN BRAZIL

The maps shown in Fig.1 and Fig.2 show the distribution of the main towers manufacturers for the erection of wind turbines in Brazil.

As can be seen, particularly in Fig. 2, there is a concentration of component manufacturers in the south and southeast, away from the building center of large wind farms that are concentrated in the Northeast.

This geographical situation requires a lot of efforts into planning and logistics to meet the manufacturing needs of towers and complete assembly of them in these parks.

8 CONCLUSIONS

Wind power has been explored at levels that have never been explored before checked for any source of energy in the world.

Brazil is ranked among the top 10 countries in the exploration of electric energy in the world, a position achieved through government programs such as PROINFA and BNDES.

Major automakers companies in Brazil depend on a number of inputs that still need to be developed by several national companies or representatives of foreign companies.

It has been reached a self-sufficiency, that may reflect export focus, in two important segments such as towers and blades.

An item worth mentioning is the lack of a manufacturer of flanges and forged rings, which would contribute to meet the connections of the towers, the large gears and tracks of the drive Yaw bearings. This would imply the installations of ovens, special presses and, if the rings are machined offered, specific machine tools.

Some items of raw materials for manufacture of blades and composite glass fiber, carbon fiber and binders need to solidify domestic production, reducing dependence on international suppliers.

With the balanced production, compliance with the goals to be achieved by major vendors such as USIMINAS, Robrasa, SKF, ROMI, VOITH, BARDELLA and others, and especially the incentives of main Government agencies involved in renewable energy, an increase of 2,500 MW it will be possible to 3,000 MW per year, with reference to the standard turbine of 2.5 MW.

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10 RESPONSIBILITY NOTICE

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