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CONNECTING RENEWABLE POWER PLANT TO THE BRAZILIAN TRANSMISSION POWER SYSTEM

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1. INTRODUCTION

The transmission utilities are the ones that enable nationwide power trading and better access to all sources of energy. This fact is true in every country. In the United States of America, “one environmental expert linked this to force America to live under the Aluminum Sky” [34].

Comparing the transmissions lines to highways, they are the necessary infrastructure to ensure that the product (energy) achieves it consumer. Therefore, it is the paper of the State to create the regulatory framework to guarantee the development of necessary infrastructure, so that the final consumers can reach their product. In the case under study, the infrastructure needed is the construction of transmission lines to carry alternative sources to energy finals consumers in Brazil.

It is a priority of the Brazilian government to increase the participation of renewable source of energy in the country energetic matrix. According to EPE (Brazilian’s Company of Energetic Research) the participation of small hydro power plant, wind power and Biomass in the Brazilian electric energetic matrix will increase from 8% to 16% in ten years.

Usually, sources like biomass and wind are usually small plants and fully concentrated in and specific geographic area. All this energy must be connected to the Brazilian power transmission system to be transported to energy consumers all over Brazil, which bring the following challenges: To provide access for small, remote located, alternative source power station to the Brazilian transmission system, in reasonable price to all the society.

This work proposes to evaluate if the actual regulation framework is providing the right conditions to develop transmission utilities connect the renewable power plant to Brazilian Interconnected Electric System.

It proposes improvement on the regulations on the subject connection of the renewable power plants to the Brazilian's transmission system. Therefore, guarantee that the energy from renewable sources may be available to final consumers.

Chapter 2 will show an overview on Brazilian Electric Sector: history, relation among the institutions and the structure of the transmission system In Chapter 3 will present policy, development and description of the main sources of alternative energy used in the Brazilian Electric industry. In Chapter 4 will be show the actual regulation over the subject: access of the alternatives source to the interconnected system. Chapter 5 discuss the issues involved in the development of the transmission system, in order to provide access to the "green energy". Chapter 6 will present the conclusions on the subject.

2. BRAZILIAN ENERGY SECTOR

2.1. HISTORY OF BRAZILIAN ELETRIC SECTOR

In the last 20 years, the Brazilian Electric Sector has been completely reformed, changing from a sector in which all the companies were state-owned to a sector in which private and public companies compete in equal condition for new enterprises in auctions.

In the early 1990`s, the Brazilian electric sector was having problems financing its expansion. In response the Brazilian Government reduced the presence of the state in the sector

by privatizing most of the state-owned companies. This allowed the private sector to invest in the expansion of the electric system.

To achieve this goal the government needed to reform the sector and one of the pre-conditions was to divide the activities of the production chain in Generation, Transmission, Distribution and Commercialization.[1]

The Laws n$^{os.}$8,987 [2] and 9,074[3], both from 1995, promoted most of the necessary changes in the sector. These Changes included the necessity to auction new power stations, the creation of an independent producer of electric energy and freedom of access to the transmission and distribution system. Another change was the creation of free consumers; those consumers can choose from whom they buy electric energy supply through bilateral contracts negotiated freely. [1]

Continuing these reforms, the Law n$^{o.}$9.427[4], of January 8th 1997, established the Brazilian Electricity Regulatory Agency in order to regulate and audit electric energy production, transmission, distribution and retail markets according to guidelines instituted by Brazilian Federal Government. [1]

The Law n$^{o.}$9,648 [5], of May 27th of 1998, created the Wholesale Electric Energy Market (MAE), which became responsible for all electric energy trade transactions in the interconnected system. It also established the National Grid Operator (ONS), which became responsible for coordinating and controlling generators and the transmission system.[1]

In 2001, Brazil faced an electric energy crisis caused by a lack of power supply[1]. This event showed the necessity of investment in the electric energy sector. Also, it showed the[2] necessity to diversify the electric energy matrix.[1]

Therefore, in 2002, the Law n°.10,438, April, 29th of 2002, [12] was approved, and created incentives for alternative sources of energy, in order to provide a diversified energy matrix.

In 2004, the Brazilian Congress approved the Laws n°. 10,848 [6] and 10,847 [7]. These new reforms' main was goal to guarantee the electrical energy supply, to promote reasonable tariffs and to also promote social inclusion in the Brazilian Electric Sector.[8]

It created two environments in which to trade energy, one called the Free Trade Environment (ACL), in which only free consumers can participate, and as before, they can negotiate directly from whom they will buy their energy supply. [8]

The second environment created was the Regulated Trade Environment (ACR), in this environment the electric energy supply is sold through auctions promoted by ANEEL. The distribution companies are only allowed to purchase their electric energy supply in this environment. [8]

[1] The drougt in to 2001 prevented the hydroreletric power stations work in full capacity, causing the shortage of power supply.

[2]

Another change that the reforms promoted was that the Ministry of Mines and Energy (MME) become responsible for the planning and development of policies to the Electric Energy Sector.

From the institutional perspective, these reforms created the Company of Energetic Research (EPE) that is responsible for promoting studies and research to support the long term planning of the power sector in Brazil, including the electric power, petroleum, natural gas and renewable energy sources. These also created the Brazilian Electric Sector Monitoring Committee, which became responsible for evaluating the stability and security of the electric energy supply. Another institution that was created was the Chamber of Electric Energy Trade – CCEE, which succeed MAE.[8]

2.2. THE RELANTIOSHIP AMONG THE INSTITUITIONS

The main institutions in the Brazilian electric sector are the following:

a) Brazilian Committee of Energetic Policies – CNPE
b) Ministry of Mines and Energy – MME
c) Brazilian Electric Sector Monitoring Committee –CMSE
d) Company of Energetic Research – EPE
e) Brazilian Electric Energy Regulatory Agency – ANEEL
f) Chamber of Electric Energy Trade – CCEE
g) National Grid Operator – ONS

The MME is responsible to develop policy and guidelines to the mines, petroleum, electric energy, including nuclear energy. In the Electric Energy sector is also responsible for planning of the system.

Under the MME responsibility is the CMSE and the EPE, the first one is responsible constantly evaluate the reliability and continuity of the electric energy supply. EPE is responsible to do studies and research to subsidies the planning of the electric sector.

Also, under the MME responsibility is Eletrobrás, a mixed capital company, which plays an important paper in the Brazilian Electric industry.

The CNPE is linked to the Republic President office, it is presided for Th Minister of Mines and Energy and it main responsibility is to propose national politicizes to the sector.

Although, ANEEL is the regulatory agency responsible to regulate the sector, although is linked to MME, it keeps the political independency. ANEEL is also responsible to regulate and audit the CCEE and ONS.The Figure 2.1 presents the Hierarchy in the electric sector among the institutions.

Figure - 2.1 – Hierarchy between institutions [8]

2.3. INTERCONNECTED TRANSMISSION SYSTEM

The Brazilian Interconnected System (SIN) is a complex hydro-thermal system that is connected by a long transmission grid. It connects the south, southeast, mid-west, the northeast and part of north of Brazil. Only 3.4 % of electricity production is not part of the SIN, these are isolated systems located mostly in the Amazonia area [9].

The transmission grid is the part of the system that carries large amounts of electric power from generation stations to consumption areas. According to the ANEEL Resolution n$^{o.}$67, 2004, [10] the transmission power line and substations equipment equal or over 230 kV are called the basic grid, except for the ones that are exclusively used by generators and consumers. In the end of 2020, the basic grid will have 142,202 km of power line and almost 300,000 MVA in transformers equipment [11]. The Figure 2.2 shows a map from the SIN.

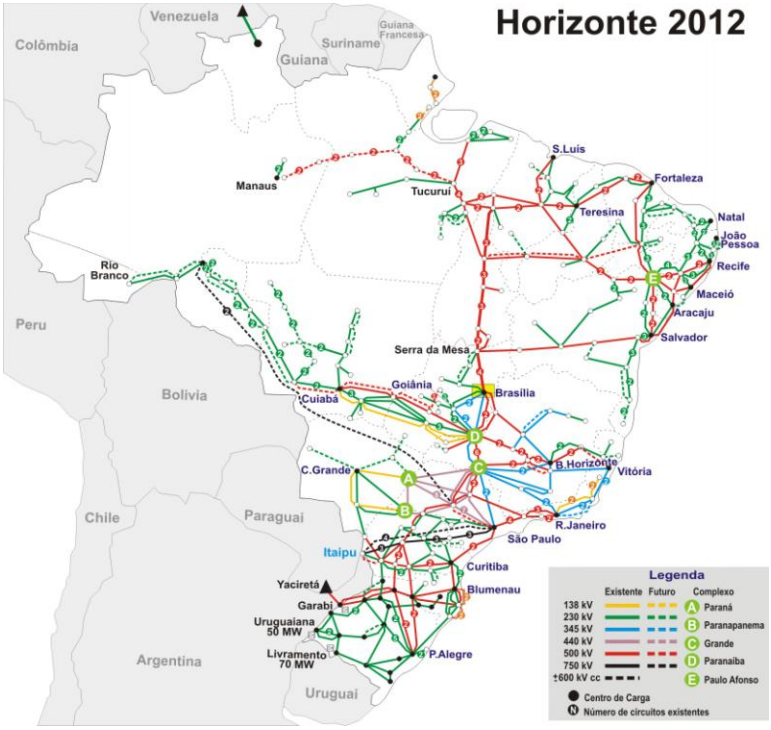


Figure 2.2 – Brazilian Interconnected System [9]

According to Law n°.9,074 [3], from 1995, the power lines and substations classified as part of the basic grid are objects of concession. The expansion of the basic grid can be made by auctions of new concessions or by the authorization of reinforcement in the existent facility. The auctions' rules and the authorization regulation are defined by ANEEL.

2.3.1. PLANNING THE TRANSMISSION SYSTEM

The decisions about which power lines and substations are going to be constructed starts in studies developed by EPE and ONS. The Research Company analyzes the electricity market, the power station program. Focusing on the minimum global cost to the system, EPE publishes an annual Program to Expand the Transmission System (PET), which shows what power lines and substations need to be built in a 5 year period in order to maintain the standards and the security of SIN.[9]

ONS also studies the transmission system evolution. ONS uses the help of generators, transmissions, distributions and free-consumers agents to develop the expansion and reinforcement plan (PAR). PAR considers proposals of new reinforcements to the transmission system, proposals for new access to the transmission system, the load variations, the delay in the new generation and in the transmission enterprises. PAR proposes what need to be done in the system in the next 3 years.[9]

The Minister of Mines and Energy is responsible for analyzing PAR and PET and deciding which transmission enterprises are going to be built, which are going to auction or are going to be authorized. Every year MME publishes the Consolidated Enterprise of the Basic Grid, which shows all the enterprises that must be authorized or go to auction in the next three years.[11]

After that ANEEL prepared the bidding documents to the enterprises that go to auction, including the technical specifications, the conditions to participate and contract drafts.

The auction is based on the Minimum Permitted Annual Revenue (RAP); the company that bids the lowest permitted annual revenue, wins the auction. The transmission company is entitle of the revenue after have constructed the entire project. It will have the right to exploit the service for 30 years.

Since the first transmission auction in 1999 until the first semester of 2010, it was auctioned a total of 38,800 km of power lines and 60,600 MVA in transformers equipments. [16].

When it is decided one a new reinforcement in an existent facility are authorized by ANEEL that analyzes the project and calculate the annual revenue. In this case, the company also is entitling to the revenue after the equipment is operating.

2.3.2. ACCESSING THE TRANSMISSION SYSTEM

The basic grid access is free, which means that any agent in the industry may require the access the basic grid. This requirement is analyzed by the ONS, if it is not necessary to expand the system, the agent can do at anytime.

The Access to the transmission system is considered a deep connection, this mean that the agent that wants to connect facilities need construct their one power line until a facility. In order to connect the transmission system, agent must sign to contracts: one with the transmission owner called connection contract and the other with ONS called the transmission use contract. The access Regulation is disposed in ANEEL Resolution n$^{o.}$ 281/99. [17]

2.3.3. ALOCATION COST

The transmission owners are paid for a Revenue-CAP that is collected through the Transmission System Use Tariff TUST. The revenue is updated every year in June; the idea is apply a monetary correction. The Table 2.1 shows the growth of the basic grid revenue.

Table 2.1 – The Growth of the Permitted Annual Revenue [20]

YEAR	Annual Permited ($)[a]	Infaltion Index	Real Revenue ($)	Variation
1999/2000	1,109,563,958.49	2,908266	3,226,907,642.00	0,00%
2000/2001	1,330,309,738.99	2,554002	3,397,613,220.12	5,30%
2001/2002	1,535,966,718.87	2,299831	3,532,463,820.03	9,50%
2002/2003	2,120,986,679.87	2,112246	4,480,046,633.55	38,80%
2003/2004	3,108,571,018.87	1,605922	4,992,121,710.87	54,70%
2004/2005	3,718,015,478.62	1,500268	5,578,018,198.72	72,90%
2005/2006	4,552,753,141.67	1,375443	6,262,052,554.41	94,10%
2006/2007	4,970,121,098.04	1,379987	6,858,703,733.12	112,50%
2007/2008	5,154,721,265,03	1,321831	6,813,671,116.85	111,20%
2008/2009	5,961,968,045.01	1,185228	7,066,290,991.64	119,00%
2009/2010	5,821,646,328.60	1,143593	6,657,596,310.53	106,30%
2010/2011	6,550,541,354.57	1,097729	7,190,721,417.92	122,80%
2011/2012	7,759,013,781.15	1	7,759,013,781.15	140,40%

Note: a- Exchange Rate: 1,59 R$/$[19]

The Law 10,848/2004 established that the tariff should be calculated based on the nodal methodology and guarantees the total amount to cover the transmission cost. The nodal tariff allocates the cost of the system to the ones that most uses. [18]

3. RENEWABLE ELETRIC POWER PLANTS

The world's urge for clean energy, the fear of global warming and Brazil`s need to diversify the energetic matrix, led the governmental policy to promote the development of renewable sources of energy.

3.1. BRAZILIAN'S POLICY OF RENEWABLE POWER GENERATION

In 2002, the Law n. 10, 438 [12] was approved, and created incentives for alternative sources of energy.

3.1.1. LAW 10,438/02[11]

PROINFA (Program of Incentive to Alternative Source of Energy) was the first governmental program designed to promote alternative sources of energy; the main goal was to increase the share of power plants from wind, biomass and small hydroelectric sources in the electric energy matrix.

The Ministry of Mines and Energy was responsible for defining guidelines, to elaborate planning and define the economic value of each power plant source. Eletrobras became in charge of celebrating the selling and buying energy contracts.

It was also established that the amount spent by Eletrobras to buy the electric energy (including administrative, financials and tributary costs) would be shared by the final consumers supplied in SIN, except for the consumers classified as Residential Lower income (the ones that consume less than 80 kWh/month)

In the Program, it is predicted to implant 144 power plants, which will add a total of 3,299.40 MW to the installed capacity. This number corresponds to 1,191.24 MW from 63 small hydroelectric plants, 1,422.92 from 54 wind farms and 27 biomass power plants [13].

However, most of the power plants should have been installed until 2004. The date was postponed to 2011. The lack of a regulatory framework did not allow the development of the green enterprises, even with the governmental help.

Account for Energetic Development (CDE), was also created by the Law no. 10,438. It is main goal is to promote the energetic development, the access to electric energy for all consumers in Brazil, the development of the gas grid, as well to guarantee a competitive price to the alternative source of energy.

Another measure was to give a discount in the distribution and transmission tariff to the power plants under 30 MW. This discount has being debated, because, it has lead the companies to design enterprises smaller than 30 MW, instead of taking advantage of the full resource capacity. [24]

3.1.2. RESERVE ENERGY AND ALTERNATIVE ENERGY AUCTIONS [22]

The Reserve Energy Auction was established by Law n$^{o.}$ 10,848/2004[6]. It aims to increase security of the energy supply by contracting an extra energy capacity. According to the Law, the government will define the amount of energy that needs to be added to the system.

The Decree n$^{o.}$ 6,353[23], of 2008, decided that the reserve energy will be purchased through energy auctions. These auctions will be organized by ANEEL, using MME guidelines.

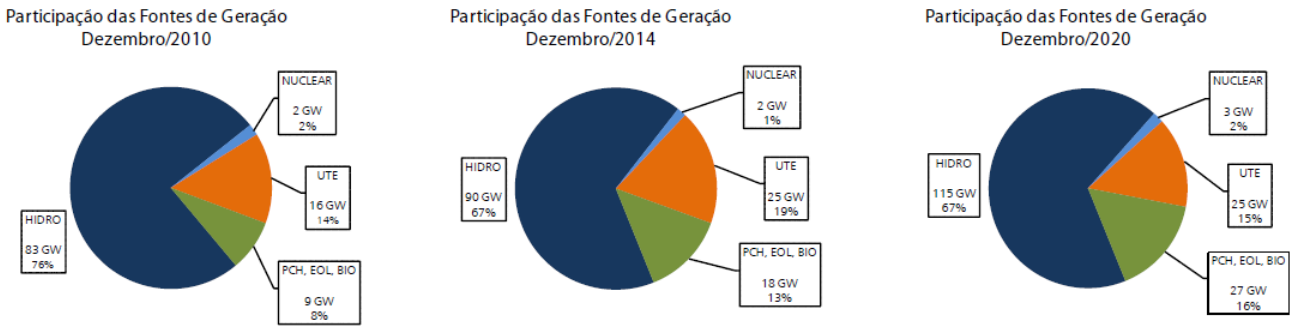
The amount of energy to be sold in the auction will be established by MME, based on EPE studies.

The government decided that the auctions should be destined to incorporate alternative source of energy to the energetic matrix. In 2008, the first auction was organized; the main goal was to purchase energy from Biomass source.

Also, in order to the increase alternative sources of energy in Brazil matrix, MME together with ANEEL have been promoting auctions exclusive designed to alternative sources of energy the first one happened in 2007.

3.2. THE PARTICIPATION OF ALTERNATIVES ELECTRIC ENERGY GENERATOR IN THE BRAZILIAN MATRIX [11]

The power capacity of alternatives electric energy sources grows 12% a year in the Brazilian market. In December of 2020, there will be 27 GW produced by alternative sources of energy, including small hydroelectric, wind energy and Biomass power plant. This power capacity will represent 16% of the electric energy matrix, in 2010 represented only 8%. Figure 3.1 shows the participation of each kind of power source in the Brazilian Electric Matrix.



Fonte: EPE

Figure 3.1 – the evolution of the installed power capacity per kind of generation source (GW and %) [11]
Legend:
PCH – Small Hydroeletric plant
EOL- Wind Power Plant
BIO – Biomass power plant
Hidro – Hydroeltric power plant
UTE – Thermoelectric power plant
Nuclear – Nuclear power plant

The tables 3.1 and 3.2 show the growth of electric power capacity from the different kinds of sources that compose the Brazilian electric matrix, during the period from 2.010 to 2020. The alternative sources of energy that show significant growth are mainly based on Eolic and Biomass power. The Eolic participation goes from 0,8% in 2010 to 6,7% in 2020. Also, Biomass power plants goes from 4,1% to 5,4% [11].

TABLE(3.1) - Installed Capacity Evolution per Power Source (MW) [11]											
SOURCE	**2.010**	**2.011**	**2.012**	**2.013**	**2.014**	**2.015**	**2.016**	**2.017**	**2.018**	**2.019**	**2.020**
Hydro[(a)]	82.939	84.736	86.741	88.966	89.856	94.053	98.946	104.415	109.412	111.624	115.123
Uranium	2.007	2.007	2.007	2.007	2.007	2.007	3.412	3.412	3.412	3.412	3.412
Natural Gas	9.180	9.384	10.184	11.309	11.659	11.659	11.659	11.659	11.659	11.659	11.659
Coal	1.765	2.485	3.205	3.205	3.205	3.205	3.205	3.205	3.205	3.205	3.205
Fuel Oil	2.371	3.744	5.172	8.790	8.790	8.790	8.790	8.790	8.790	8.790	8.790
Diesel Oil	1.497	1.497	1.471	1.471	1.121	1.121	1.121	1.121	1.121	1.121	1.121
Process Gas Technology	686	686	686	686	686	686	686	686	686	686	686
Small Hydro Plants	3.806	4.201	4.230	4.376	4.633	4.957	5.187	5.457	5.737	6.047	6.447
Biomass	4.496	5.444	6.272	6.681	7.053	7.353	7.653	8.003	8.333	8.703	9.163
Eolic	831	1.283	3.224	5.272	6.172	7.022	7.782	8.682	9.532	10.532	11.532
Total[(b)]	**109.578**	**115.467**	**123.192**	**132.763**	**135.182**	**140.853**	**148.441**	**155.430**	**161.887**	**165.779**	**171.138**

Note: The values indicate the installed power in December of each year.

(b) It includes the estimation of imported power produced by Itaipu Hydroelectric Station that Paraguayan electric system does not consume.

(c) It does not considerer self-production, for studies propose, it is accounted as a decrease from the load

TABLE(3.2) - Installed Power Capacity Evolution per kind of Source (%) [11]											
SOURCE	**2.010**	**2.011**	**2.012**	**2.013**	**2.014**	**2.015**	**2.016**	**2.017**	**2.018**	**2.019**	**2.020**
Hydro	75,7%	73,4%	70,4%	67,0%	66,5%	66,8%	66,7%	67,2%	67,6%	67,3%	67,3%
Uranium	1,8%	1,7%	1,6%	1,5%	1,5%	1,4%	2,3%	2,2%	2,1%	2,1%	2,0%
Natural Gas	8,4%	8,1%	8,3%	8,5%	8,6%	8,3%	7,9%	7,5%	7,2%	7,0%	6,8%
Coal	1,6%	2,2%	2,6%	2,4%	2,4%	2,3%	2,2%	2,1%	2,0%	1,9%	1,9%
Fuel Oil	2,2%	3,2%	4,2%	6,6%	6,5%	6,2%	5,9%	5,7%	5,4%	5,3%	5,1%
Diesel oil	1,4%	1,3%	1,2%	1,1%	0,8%	0,8%	0,8%	0,7%	0,7%	0,7%	0,7%
Process Gas Technolegy	0,6%	0,6%	0,6%	0,5%	0,5%	0,5%	0,5%	0,4%	0,4%	0,4%	0,4%
Small Hydro Plants	3,5%	3,6%	3,4%	3,3%	3,4%	3,5%	3,5%	3,5%	3,5%	3,6%	3,8%
Biomass	4,1%	4,7%	5,1%	5,0%	5,2%	5,2%	5,2%	5,1%	5,1%	5,2%	5,4%
Eolic	0,8%	1,1%	2,6%	4,0%	4,6%	5,0%	5,2%	5,6%	5,9%	6,4%	6,7%
Total	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**

Another important data is the amount of energy already purchased. The Figure x presents that there is a significant amount of energy contracted until 2013. This corroborate with the expansions of the alternative source of energy are going to expend.

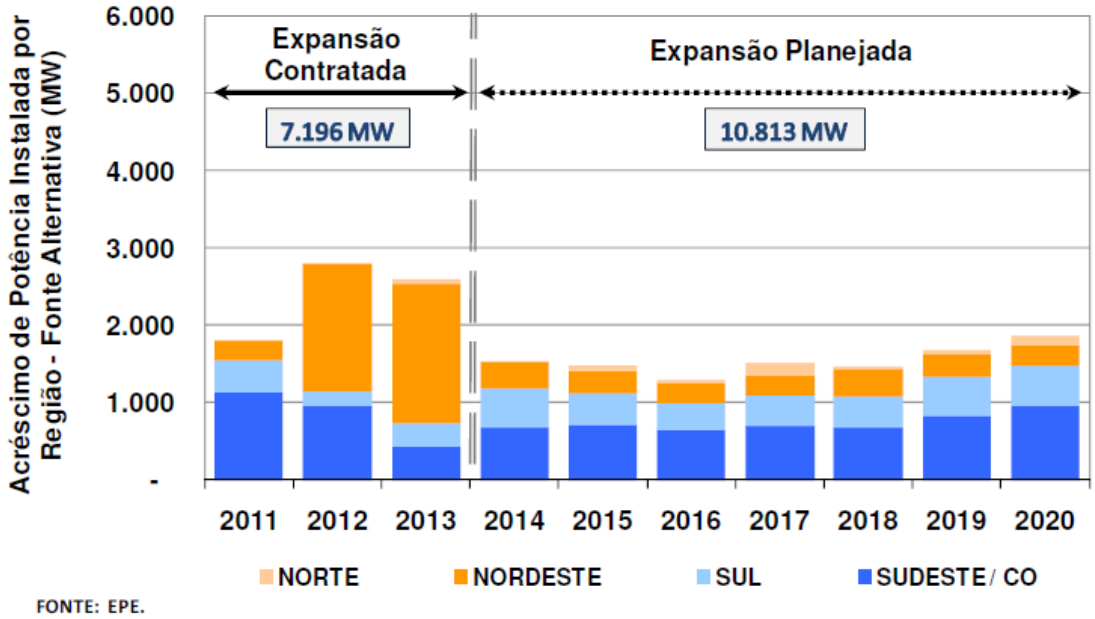


Figure 3.2 – Energy negotiated.[11]

As one can see alternative sources of energy participation in the Brazilian Matrix is going to grow fast and play a big paper in the electric energy industry. It is the State job to provide infrastructure to these new source of energy.

3.3. BIOMASS FROM SUGARCANE BAGASSE

Biomass is any kind of renewable resource that is originated from organic matter (vegetal or animal), which can be used to produce energy. [16]

The major source of biomass used in Brazil is sugarcane bagasse, which is one of the remains from the production of sugar or of ethanol. Since it has a big energetic value, it is

already used to produce thermal and electric energy during the process to fabricate sugar or ethanol. The excess of electric energy produced can be sold the Brazilian Electric market.[11]

In the case of sugar-ethanol industry most of the power plants uses low pressure generators. The Brazilian government is incentivizing the generators to modernize their utilities, more energy can go to the SIN.[11]

It is estimated a power capacity over 16,000 MW produced from sugarcane bagasse plants. The map in the figure 3.3 shows where the majority of these power plants are located around Brazil.

In the reserve energy auction of August, 18th of 2011, 7 Biomass new projects were sold energy. The total capacity purchased was 357 MW and average price was US$ 62.75[3][25]. In comaparision, in the auction that happened in august, 17th of 2011,the hydroelectric power plant was sold at US$ 63.75 [26]. As one can see, Biomass source is becoming as competitive as Hydro[4].

[3] The exchange rate used was 1.60 from the auction day, August 18th of 2011.

[4] Historically, the hydroelectric power plants are considered the cheapes eletric energy source tha Brazil has. But this is changing, as new technologies for alternative source of energy are improving.

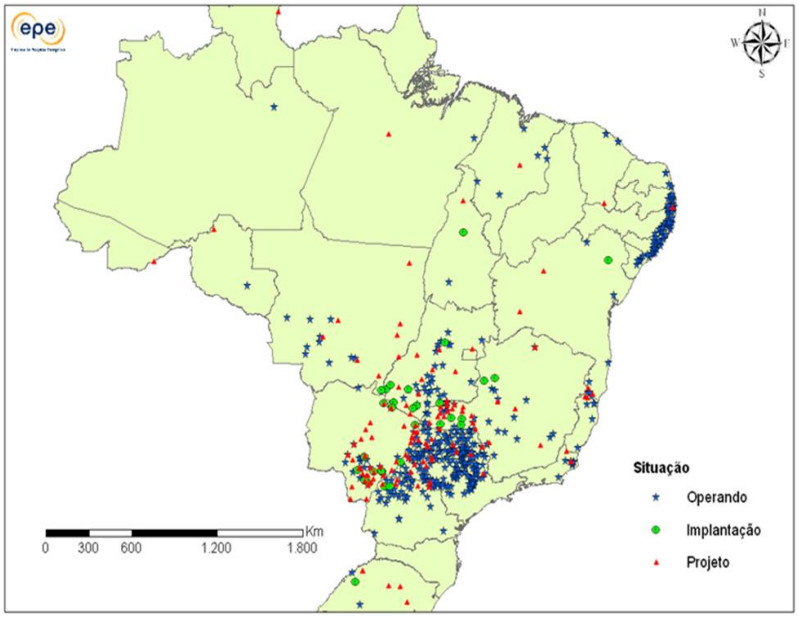


Figure 3.3 – The distribution of Biomass power plant over Brazil [14]

The power plants might be located in areas where the distribution system is well developed; in the State of Sao Paulo, delivering electric energy to final consumers is not a main problem. The real challenge exists in areas where the system is not well developed, usually areas that are not too populated.

In the State of Mato Grosso do Sul, the total area is 357,124.962 km^2, as figure 3.4 shows that the electric energy potential are dispersed all over the State and the major final market are located in the southeast. Also, there are few basic grid power line and substations to provides energy for the whole state.

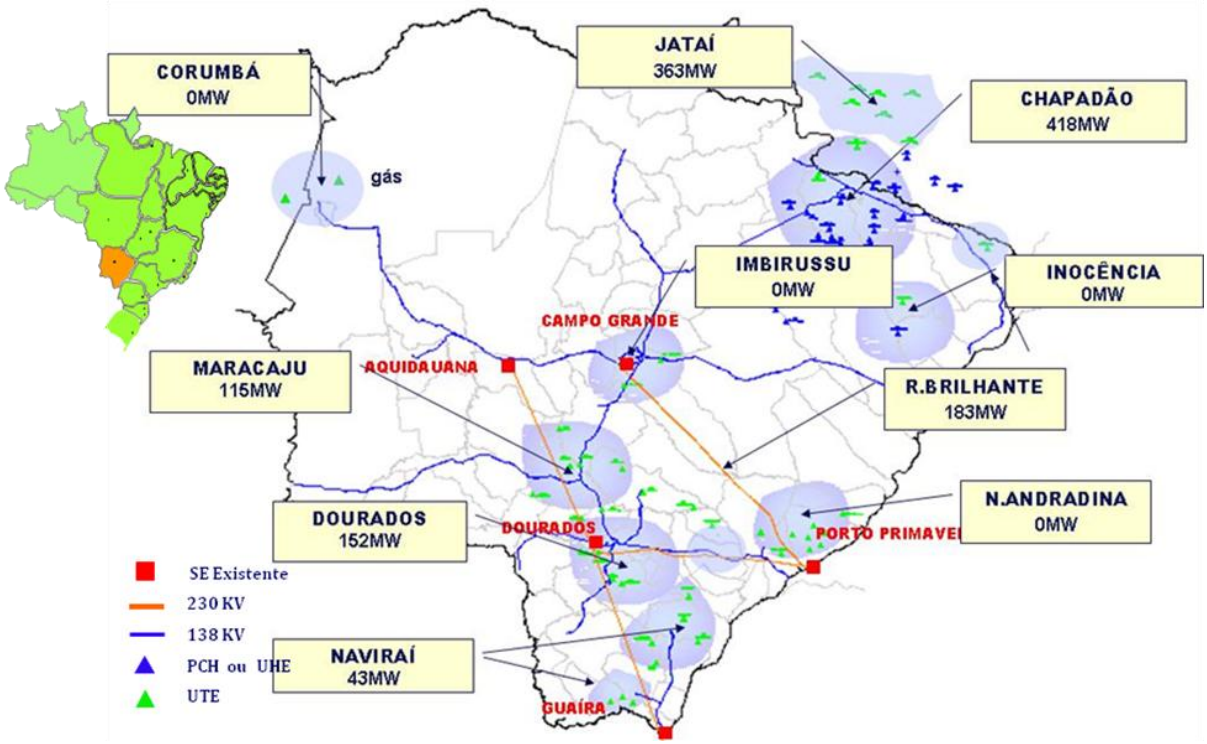


Figure [3.4] – Location Bagasse Power in Mato Grosso do Sul and the existent basic transmission lines [14]

Therefore, in order to connect these power stations to the SIN, it is necessary major investment not only in the basic grid but also to interconnect the power plants to the SIN. If the power plant is responsible for it one access to the basic grid, the costs could make impossible for its existence.

3.4. EOLIC POWER PLANTS

According to the Brazilian Wind Potential Atlas, the wind power potential in Brazil is about 143.5 GW that is bigger than the actual installed capacity[5]. However this data is based on wind generators that are 50 meters, now a days, the new power plants are using 60 m generators [15]. In this case, considering the new technology, the Brazilian wind power potential goes up to 300 GW [14].

[5] The Total installed capacity in Brazil is

In the reserve energy auction of August, 18th of 2011, 34 wind power plants were Bi new projects were sold energy. The total capacity purchased was 861,1 MW and average price was US$ 62.21[6][25]. In comparison, in the auction that happened in august, 17th of 2011,the hydroelectric power plant was sold at US$ 63.75 [26]. Like in the case of Biomass source, wind farms are becoming as competitive as Hydro[7].

Most of these potentials are located in t shore o Brazil, especially in the northeast and in the south. The map in figure 3.5 shows the locations of the wind power potential in Brazil.

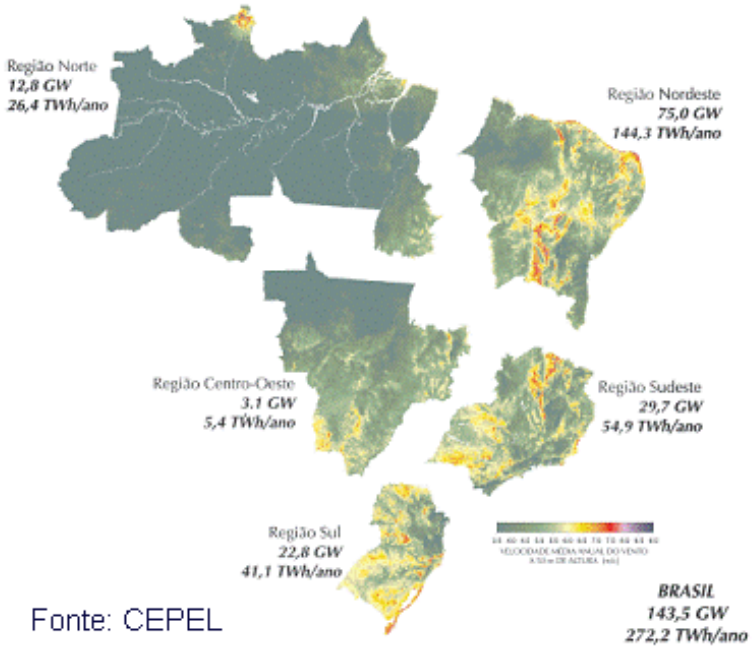


Figure 3.5 - Power wind potential considering annual wind average of 7 m/s [15]

[6] The exchange rate used was 1.60 from the auction day, August 18th of 2011.

[7] Historically, the hydroelectric power plants are considered the cheapes eletric energy source tha Brazil has. But this is changing, as new technologies for alternative source of energy are improving.

However, like in the case of Biomass, the wind potentials are located in remote area, which makes necessary to develop the transmission system to ensure the development of these power potentials.

4. ALTERNATIVE SOUCE OF ENERGY ACCESS TO THE TRANSMISSION SYSTEM

4.1. BRAZILIAN REGULATION TO CONNECT ALTERNATIVE SOURCES TO THE TRANSMISSION POWER SYSTEM [27]

Chapter 3 showed the challenge to connect the alternative power stations in Mato Grosso do Sul to the SIN. In order to reduce the high transmission cost, the EPE studies showed that the way with minimum cost to connect the power stations to the SIN was through shared facilities.

In order to provide the regulatory framework, in 2008, by the Decree nº 6,460 established the concept of the transmission facilities of exclusive interest to Central Generation (ICG). ANEEL published the Resolution n$^{os.}$ 320/2008 and 312/2008, both from 2008.

The ICGs are shared facilities by electric energy generators, all the equipments are less than 230 kV. These facilities can be part of a transmission concession, being authorized or a new concession that will be auctioned. The figure 4.1 represents the power system configuration

In this new regulatory framework, the basic grid substations are called gatherers, because they are integrating the power potential in the area to the load in the southeast.

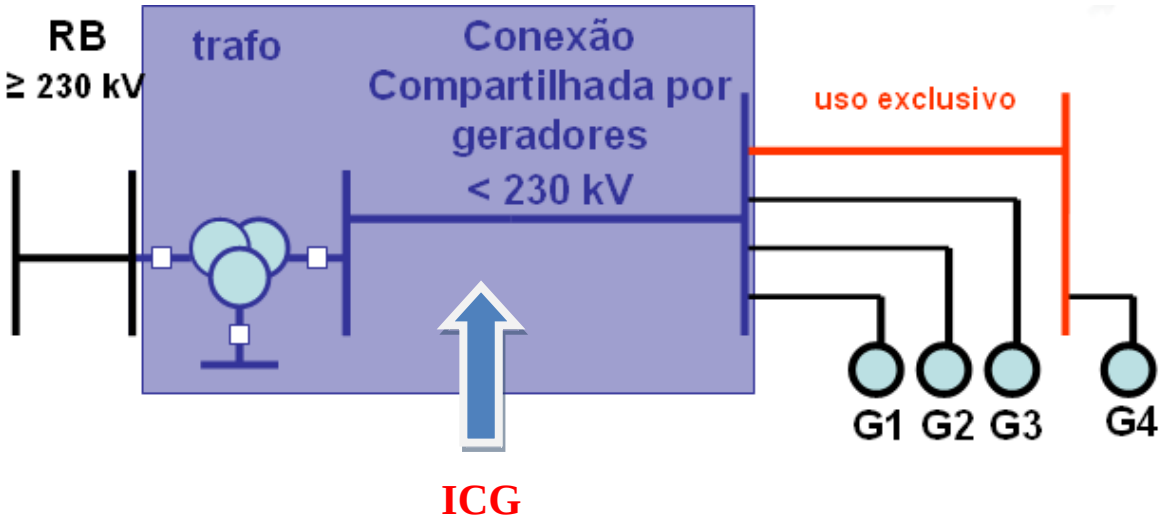


Figure 4.1 – Power system configuration

Since the ICG are exclusive used by generators and are less than 230 kV, the transmission utilities cost cannot be allocated to the basic grid tariff. Therefore, the generators agents pay the total revenue amount that relative to ICG utilities. The power stations share the costs based on the installed capacity of each agent.

Since generators start to operate in different period of time, this creates a problem to the transmission agents. The solution to that was fixed amount of payment that every generator must pay for 5 years. During this time the difference between the amount that the transmission facility should receive and the amount collected is allocated in the tariffs in the basic grid. In the figure 4.2, one can see the cost allocation in time.

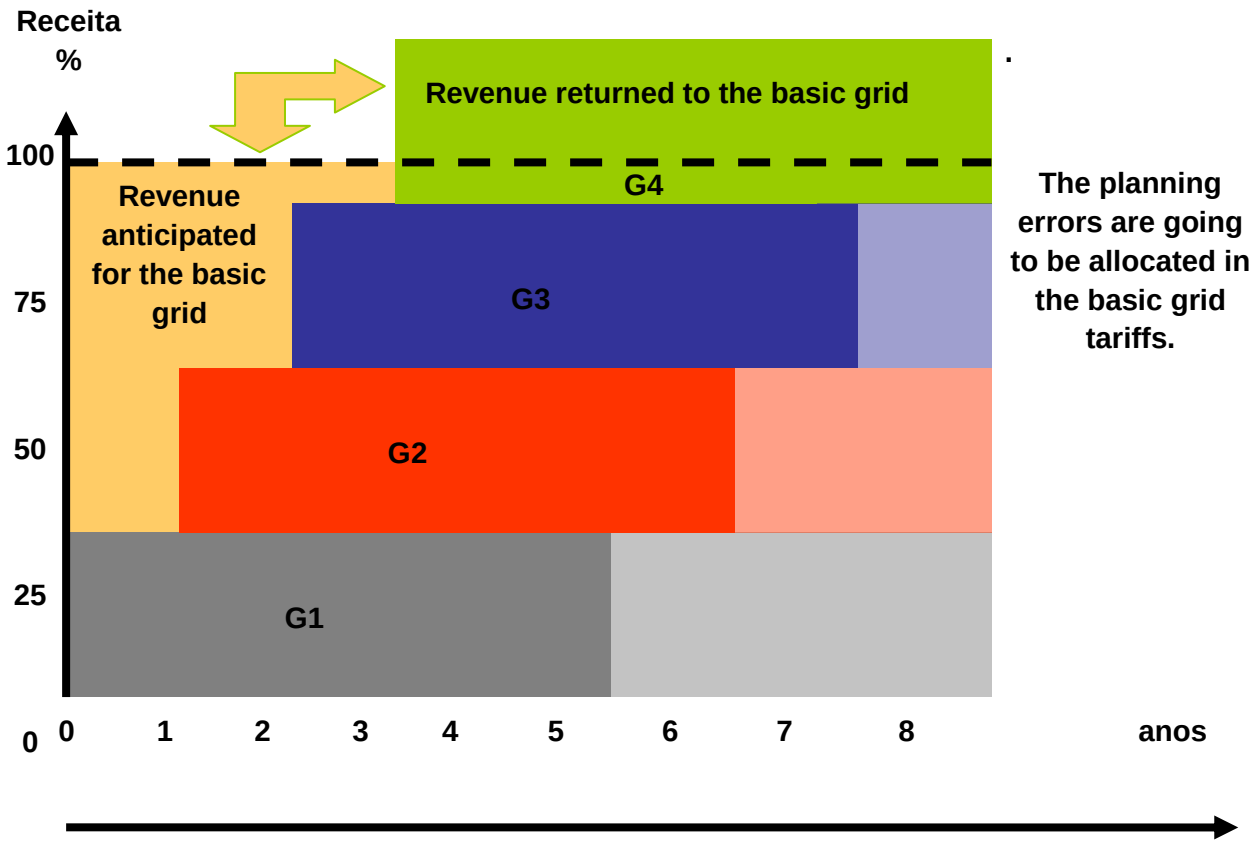


Figure 4.2 - ICG allocation cost in time

4.2. AUCTION PROCEDURE [11]

The planning of the transmissions facilities to connect renewable sources begins with the knowledge of how many power plants need to access the basic grid. First, generator entrepreneurs subscribe power plant project in EPE database. Using this data, EPE designs the expansion in the basic grid and the ICGs, based on the necessity to integrate these new sources to the system, as well on the need to indentify the amount of investment needed to calculate tariffs and fee[8].

[8] The generators plants fee are based on a stable 10 years fee, which are calculated before the electric energy auctions based on the estimated amount of investment in 10 years.

After an energy auction, ANEEL organize a public call dedicated to the generator owners that want to access the ICGs. The power plants owners must grant a financial warranty that they are going to access the transmission system.[9] After the result of the public call, EPE design the transmissions utilities based on the generators that had participated in the public call. Finally, the transmission utilities auction is organized by ANEEL.

The warranties are released after the generators have signed a connection contract with the transmission owner that has won the auction. Only then, the ICG are constructed, final schedule is according to the date agreed in the connections contract. The transmission utilities are only in title of the ICG revenue after the date agreed, if the utility is operating.

On another hand, the transmission utilities that are classified as basic grid, they must follow the concession contract schedule. They have the right to the revenue after the scheduled date, if the utility is operating.

A wind energy auction was organized in 2009. By that time, EPE had in its database a total of 13,000 MW in installed capacity distributed in 441 wind power stations. The first EPE studies, it was projected 32 gathering stations and 28 ICG substations. In December of 2009, energy auction had happened, in which it was traded a total 1,180 MW, distributed in 71 generator enterprise. The majority of enterprises were located in the northeast of Brazil.

In order to organize the documents to the public call, EPE studies indicated 6 gathering stations: 3 in the State of Ceara, 2 in Rio Grande do Norte and one in Bahia. In the public call, 33 wind power enterprises granted a warranty. After that, EPE indicate 3 gathering

[9] The warranties are important because they avoid the waste of investment in the power lines

substation to participate in the transmission auction. Finally, ANEEL organized the transmission utilities auction n$^{o.}$ 006/2010 [29].

4.3. ICG AUCTION RESULTS

Since the ICG were regulated, ANEEL organized 3 auctions considering this model.

The first one, Auction 008/2008 [29], of 2008, had as main proposal to connect 27 biomass and small hydroelectric plants in the State of Mato Grosso do Sul. It considered 8 gathering substations and was divided in three lots. The average percentage of reduction of the maximum annual revenue permitted was 16%. The Table 4.1 shows auction results.

Table 4.1 – Auction 008/2008 Result [31]

	LOT A	**LOT B**	**LOT C**
WINNER	COBRA INSTALACIONES Y SERVICIOS S.A.	ELECNOR TRANSMISSÃO DE ENERGIA S.A.	CONSÓRCIO TRANSENERGIA RENOVÁVEL - FURNAS 49% (LÍDER); DELTA 25,50%; FUAD RASSI 25,50%
BASIC GRID POWER LINE (km)	756	444	366
ICG POWER LINE (km)	75	22	125
SUBSTATION	4	4	5
EXCLUSIVE LINES (km)[10]	224	150	272
MAXIMUM ANNUAL REVENUE ($)[a]	36,326,446.63	23,699,924.54	26,178,189.57
ANNUAL REVENUE BIDED($)[a]	29,785,276.07	21,329,926.38	21,165,644.17
DIFFERENCE BETWEEN THE MAXIMUM REVENUE AND THE BIDED ONE($)[a]	6,541,170.552	2,369,998.16	5,012,545.40
REDUCTION PERCENTAGE	18.01%	10,0%	19,15%

Note: Exchange Rate 1.63 from November, 24th of 2008

[10] Exclusive power lines are the one that connects only one power station.

The Auction itself was success, the issues begins with the implementation of the project. The economic crises of 2008 hit most of the generators, 8 of them refused to sign the connection contract. Others required cancelling the contract or postponed the date to start operation. In total 48%[11] of the generator still haven't scheduled a date to connect the transmission system. The ones that sold energy in the regulated environment auctions are the ones that are keeping the dates.

This first auction considered the possibility that the generator could sell its energy in the free environment, therefore in order to take part of the public call it was not required a energy contract. The public call happened before the energy auction.

Another issue was the construction of the Substation Chapadão, the local population did not accepted place of the utility. They argued that the position of the transmission line would affect the agriculture business, because the pesticide airplanes are forbidden to fly over the transmissions line. Therefore, the final position of the substation had to be moved in order to change transmission lines path. Since this substation affected all three lots, all the projects were at least one year delayed [16].

The second was Auction 006/2010[28], of 2010, and had as main proposal to connect 33 wind power plants located in the northeast of Brazil. It was also divided in three lots. The table 4.2 shows the results of the auction.

Another change was that the Public Call happened after the energy auction, which reduces the risk of generators waiver.

[11] Dada supplied by SFG- Superitendencia de Fiscalização da Geraçao – ANEEL.

Table 4.2 – Auction 006/2010 Result[32]

	LOT A	**LOT B**	**LOT C**
WINNER	CHESF – COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A	CHESF – COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A	CHESF – COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A
BASIC GRID POWER LINE (km)	274	115	97
ICG POWER LINE (km)	0		
SUBSTATION	2	1	1
EXCLUSIVE LINES (km)	0		
MAXIMUM ANNUAL REVENUE ($)[a]	12,644,838.15	5,937,982.00	4,114,168.00
ANNUAL REVENUE BIDED($)[a]	5,968,994.00	2,421,965.00	2,727,595.00
DIFFERENCE BETWEEN THE MAXIMUM REVENUE AND THE BIDED ONE($)[a]	6,675,844.00	3,516,017.00	1,386,572.00
REDUCTION PERCENTAGE	52,8%	59,2%	34%

Note: Exchange rate: 1.73 from September, 3rd of 2010

One more time, the auction was success. However the project is already. The contractual conclusion date is May, 23rd of 2012; Lots B and C are predicted finish only in July 19th and August, 26th of 2013. The company is claims difficult to obtain the environmental license [16].

The Table 4.3 shows the amount of power that will be operating before the transmission system is working. As we can see all the power station are going to be ready before the transmission utilities.

Table 4.3- The Impact of Transmission System Delay

Gathering Station	SE Acaraú II	João Camara	Igaporã
Contract fanal deadline	**jul/13**	**fev/13**	**ago/13**
Eolic that will be ready before the conclusion of transmission utilities	186,00MW	329,60MW	350,40MW
Eolic that will be after the conclusion of transmission utilities	0,00MW	0,00MW	0,00MW

Source: SFG/ ANEEL

The difference between this project and first one is that there are no exclusive lines to be constructed by the transmission owner. This reduce the transmission loses, if the generator decides to not give up the project.

The last auction was held in 2011, it was the auction n$^{o.}$ 01/2011[30], the goal is to connect 44 wind farms in the northeast of Brazil. The table 4.4 shows the auction result

Table 4.4 – Auction 001/2011 Result [33]

	LOT A	**LOT B**	**LOT C**
WINNER	CONSORCIO EXTREMOZ - COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A(49%) CTEEP (51%)	CHESF – COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A	CHESF – COMPANHIA HYDRO ELÉTRICA DO SÃO FRANCISCO S.A
BASIC GRID POWER LINE (km)	299,5	65	65
ICG POWER LINE (km)			
SUBSTATION	3	1	2
EXCLUSIVE LINES (km)	0		
MAXIMUM ANNUAL REVENUE ($)[a]	4,771,.371.07	3,440,113.21	7,656,955.97
ANNUAL REVENUE BIDED($)[a]	20,063,976,10	2,545,683.65	4,900,451.57
DIFFERENCE BETWEEN THE MAXIMUM REVENUE AND THE BIDED ONE($)[a]	27,707,394.97	894,429.56	2,756,504.40
REDUCTION PERCENTAGE	58,0%	26,0%	36,0%

Note: Exchange Rate :1.59 from June, 10th of 2011

The auction was a success, the project implementation cannot be analyzed because it still in the beginning.

5. EVALUATION OF THE BRAZILIAN REGULATION FOR THE CONNECTION OF RENEWABLE GENERATORS TO THE TRANSMISSION SYSTEM

Chapter 4 showed that the transmission auctions were a success; the transmission owners are participating and biding the projects. However, there are still some problems the waiver of generators and the delays in the projects bring risk of loss to generators owners, to transmissions owners, and also to the Brazilian society

5.1. GENERATORS WAIVER

The main reason that caused the generators waiver in the first project was that they had not sold their energy by the time of the Public Call happened. Therefore, it is important to require an energy contract before the Public Call. One can argue that the generator owner wants to sell energy free market. Even in the free market there is an energy contract.

The changing in order to do the energy auction before the Public call for the ICGs has seemed to show affect in the problem. However, transmission system are to expensive to run the risk, therefore, it is important to be sure that they are going to connect to the system.

5.2. DELAYS OF THE TRANSMISSION FACILITIES

The delays in the built of the transmission utilities that the propose is to connect generators brings a big risk to power plants owner and a cost for the society. Specially if the

energy has been sold in the energy auctions. In this case, the cost of the energy goes to the consumer tariff[12].

Delays in construction of the transmission utilities from chapter 4 were caused by environmental issues; in this case the Brazilian Society must keep the financial lost.

However, the delays in transmission project are becoming constant in the sector, sometimes the transmission owners claim difficulty to obtain the environmental license in cases that are not true. Although, fines are applied to this type of case, it seems to not be the solution of the problem.

One improvement that can be made is to adopt Design – Build-Finance – Operate (DBFO) methodology to the transmission auction. In this case, it is required the presence of private bank to finance the project. In most cases, this has improved the management skill, once that the financial risk is in the hand of the private bank. The figure 5.1 shows the structure of a DBFO.[21]

[12] The Distribution Tariff of uses considers the energy cost as one of the non possible to the distributions company to manage, therefore it goes straight to the tarrif.

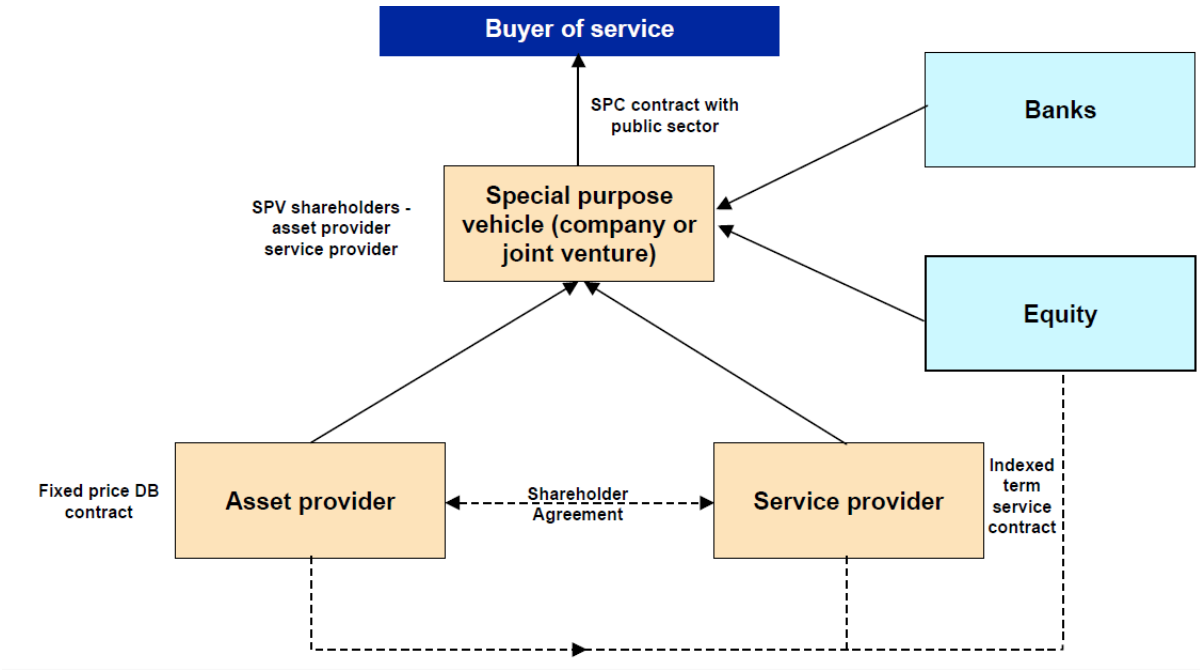


Figure 5.1 – DBFO Structure[21]

However, this structure has proven to be more expensive, because the banks put most of the risk in the capital cost. [21] Therefore, it is necessary to study more this model in order to see if it applies to the Brazilian case.

Another way to improve the management would be to allocate the financial cost of the delays to the transmission owners.

In either way the transmission cost are going to increase, once that companies are going to transfer the risk to the costs.

6. CONCLUSION

The fear of global warming and the necessity to reduce the dependence on petroleum led to the development of new sources of energy, such as biomass power plant and wind farms.

In Brazil, we have other challenge: to diversify electric energy matrix by reducing the dependence hydroelectric plants. Therefore, one of the Brazilian Government guidelines is to double the amount of alternative of source energy in the Brazilian energy matrix until 2020 years. In order to do that is necessary to create the ideal regulatory framework to incentive the growth of this kind of energy.

As chapter 3 showed, Brazil has to major sources of alternative energy: Biomass and wind power. Both are developing very fast and the auctions have hit competitive prices of energy. Reserve energy auctions and the ICG model have worked as a regulatory framework in order to help the development of alternative sources of energy.

ICG auctions have been important to connect remote located alternative sources of energy to Brazilian transmission. Chapter 4 showed that the auctions itself have been a successful. However, the waiver of generator and the delay in the construction of the transmission utilities has been some issues to the projects.

In order to avoid the waiver of the generators from the ICG projects, the energy contracts should be demand before the ICG Public Calls.

The DBFO mode has proved to improve the management of the public - private partnership project. This can be adopted in order to improve the performance of the transmission companies, in this way avoid the delays in construction of these utilities.

In conclusion, one can say that the regulatory framework that has been developed is allowing increase of alternate source of energy in the Brazilian Electric Energy matrix. The ICG model is providing the connection of the generators to the transmission system. However, there are issues as the waiver of the power generators and the delays in the construction of transmission system that show that the regulation needs to be improved. This paper brings some proposal of changes to the actual regulation.

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