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New Roles for Government and Markets

An Evaluation of the Regulation of Incentives for Alternative Electricity Sources in Brazil

Chamber of Electric Energy Commercialization

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Abstract

One of the fundamental challenger's humankind faces, in the 21st century, is to reduce the greenhouse gases emission without impact the economic development and the population life style. The modern civilization is based in fossil fuel use, for example, to produce electric energy. The purposes of this paper are to present and to evaluate the development and the implementation of economic politics to stimulate the alternative sources use in Brazilian electric sector.

1 – Introduction

The industry expansion, which has started with the Industrial Revolution in 18th century, is supported by use of fossil fuel, initially the mineral coal, later the oil and, more recently, the natural gas. The electric sector reflects this scenario worldwide, with the strong presence of thermal generation that uses fossil fuels, as illustrated in Figure 1.

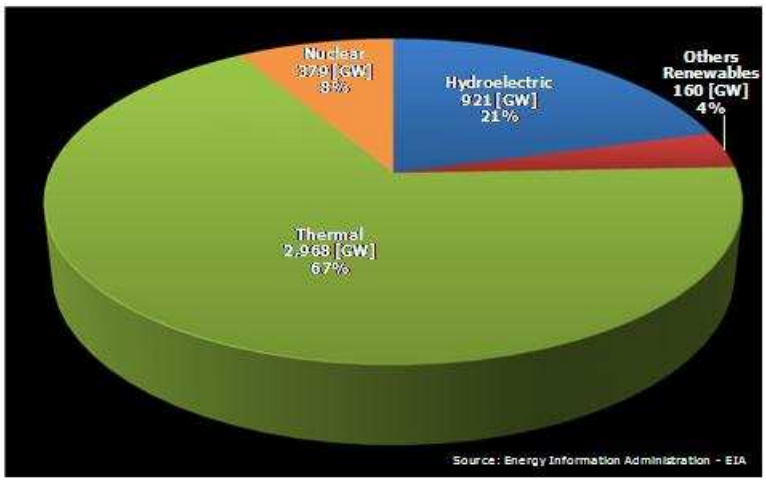


Figure 1: World Electricity Installed Capacity by Type

This industrial scenario and electric energy production, with large use of fossil fuels, always impacts the environment: solid particles emissions in the atmosphere and water contamination are problems known for centuries. In final of 20th century an important discussion has placed: the greenhouse gases emission.

The greenhouse effect is a natural and important process to keep the life conditions in the Earth. In main lines, gases present in the atmosphere, like the carbon dioxide (CO_2), methane (CH_4), sulphur oxides (SOx), amongst others, form a natural barrier that holds back part of the Sun heat received in the atmosphere, keeping the global temperatures in levels adjusted for the life development. Therefore, the greenhouse effect benefits the planet and life development.

However, the great use of fossil fuel in the process of human development has raised the greenhouse gases emission, increasing its concentration in the atmosphere and promoting important climatic changes that can affect the future of the planet.

Intergovernmental Panel on Climate Change (IPCC) studies point out that the temperatures worldwide have been increasing since middle of 21st century, causing, as consequence, increase of seas levels and snow reduction in some areas of the planet.

The data presented by the IPCC had been contested for several researchers worldwide. However, the precaution principle indicates that effective acts must be taken to reduce the greenhouse gases emission.

Electric energy supply, with high fossil fuel use, is the mainly source of greenhouse gases emission, as illustrated in Figure 2.

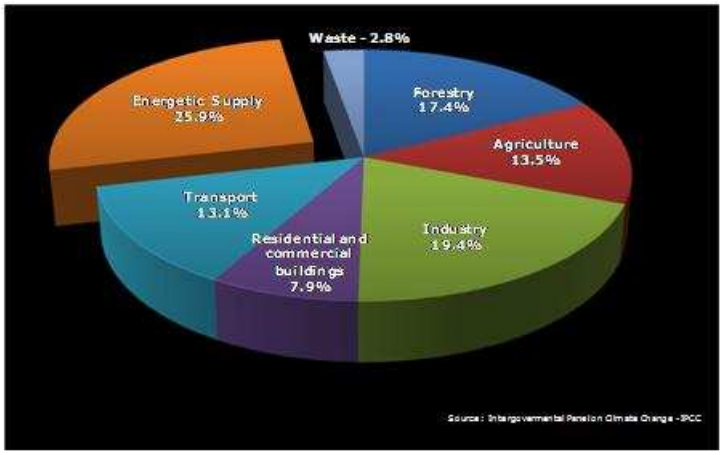


Figure 2: Distribution of Greenhouse gases emission

Therefore, there is the challenge of development alternative energy sources that not use fossil fuels to reduce greenhouse gases emission.

This paper presents the Brazilian experience in the development of regulatory and commercial policies to incentive the renewable energy sources in the electrical sector.

2 – Brazilian electric sector overview

The Brazilian electric sector had faced a recent reform that has established a new institutional basis with creation of institutions meanwhile the existing ones had its attributions reviewed. The purposes of the new model are to build a stable regulatory set-up, guarantee security of supply, achieve fair tariffs, respect contracts and reintroduce planning in order to cope with demand growth.

2.1 – Brazilian energy commercialization overview

Throughout 2004, the Federal Government set the basis for a new model for the Brazilian Electric Sector, supported by Laws 10,847 and 10,848, dated on March 15, 2004, and by Decree 5,163, dated on July 30, 2004. One of the main components of the new electricity model is the creation of two energy trading markets, as presented in Figure 3: a Regulated Contracting Environment (RCE), with a distributors' pool buys electricity from generators in public auctions under set prices, and a Free Contracting Environment (FCE), with free consumers and generators freely negotiating their own bilateral contracts.

Figure 3: Brazilian commercialization model overview

The RCE is a trading environment where a distributors' pool buys electricity to supply its captive consumers[1] mainly using auctions. The RCE auction system is related to the service of captive consumers by distribution utilities, and its aim is to ensure the provision of energy to these consumers in a reliable, equitable and economically efficient way (fair tariffs) through auctions and regulated pooled contracts.

Auctions may then be understood as an environment for regulated competition, with rules and institutions that make competition more transparent and minimize the market power risk. The existence of an official market for electric energy, operating through public auctions, may thus operate as an important instrument to consolidate the liberalization process of the electricity supply industry in Brazil.

To attract investment in generation, energy auctions for long term energy contracts (15 and 30 years) were created to direct energy contracting by distribution utilities. This scheme aims at reducing risks for investors, while the auction by least price stimulates economic efficiency and in principle gives correct signals for the system expansion cost through competition. These auctions

[1]Captive consumer is the consumer that must buy all its demand exclusively from the distributor that it is connected, it means that captive consumer has no choice to acquire energy and pays a regulated price - it is the opposite side from the free consumer.

contemplate blocks of hydro and thermal plants, auctioned separately in order to obviate the issue of thermal investment in a hydro-based system.

Finally, these auctions are fed by governmental planning studies to propose feasible (and with a preliminary environmental license) expansion projects for a forecast demand growth, together with demand forecasts by distribution companies, although investors may propose alternative projects in the auction blocks.

In the other hand, the FCE is comprised of free consumers who have the right to choose their electricity supplier paying a rate for using the distribution or transmission system. In FCE Agents are free to make bilateral contracts, defining prices, quantities, durations and hedge clauses.

The free market was created in Brazil more than one decade ago. The right to be a free consumer was established by Law 9,074/1995, afterwards altered by Law 9,648/1998 and complemented by ANEEL's Resolution 264/1998. This Law determined that the market should be gradually liberalized to allow large consumers to become free. The Table 1 shows the criteria to be a free consumer nowadays.

Table 1– Current criteria to be free consumer

Minimum Demand	Minimum Voltage	Connecting Date
3 MW	69 kV	Before 08 July 1995
	-	After 08 July 1995

The contracts in Brazil are financial instruments. The responsibility of energy delivery is of the electrical system, that has its operation coordinated for the National Power System Operator[2] (Operador Nacional do Sistema Elétrico - ONS).

The differences between the amount produced or consumed and the amount contracted are settled on the spot market and are valued according to the spot price, also called Price for the Settlement of Differences (PLD – Preço de Liquidação das Diferenças). The spot market operation and its financial settlement process are CCEE[3] responsibilities, as illustrated in Figure 4.

[2] The National Power System Operator - ONS (Operador Nacional do Sistema Elétrico) has the attributions to operate, to supervise and to control power generation and to manage Brazilian power transmission grid. Its paramount purpose is to coordinate efforts to meet power requirements while optimizing costs and ensuring system reliability. ONS also defines high-voltage transmission grid access conditions.

[3] Chamber of Electric Energy Commercialization (CCEE) is regulated and supervised by Brazilian Electricity Regulatory Agency (ANEEL). CCEE is responsible to promote electricity commercialization in Brazil, making regular accounting and settlement feasible in short-term market.

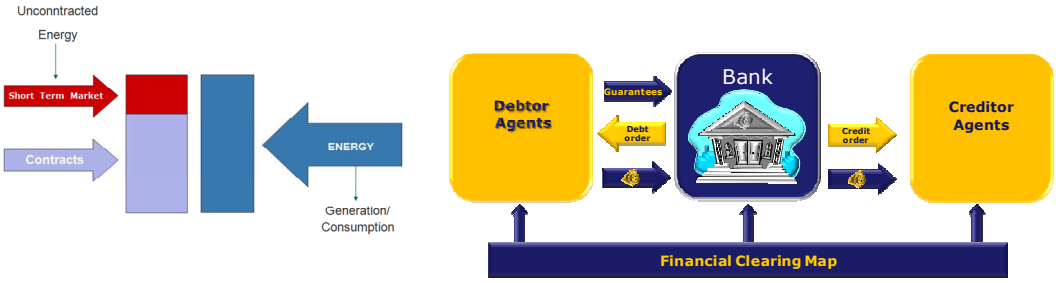


Figure 4 - Spot market and financial settlement overview

2.2 – Brazilian electricity installed capacity

Brazil presents a specific scenario in terms of electricity installed capacity, with its electric matrix based in renewable sources, mainly hydraulic, as presented in Figure 5.

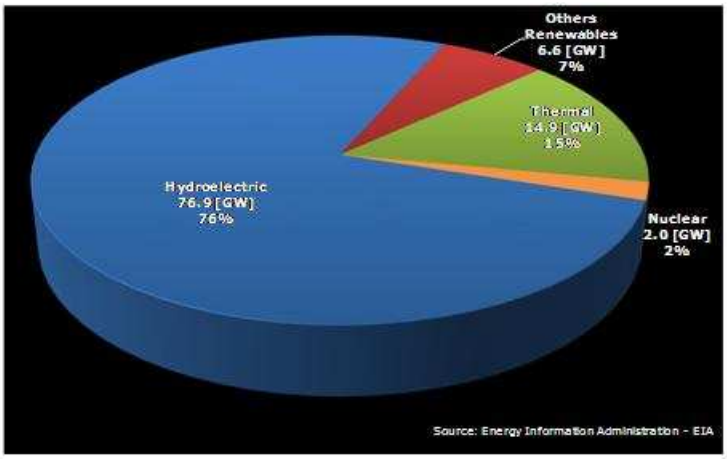


Figure 5: Brazilian electricity installed capacity in 2007

However, it is difficult to built new hydraulic plants nowadays because of the social and environment issues are very stronger. In fact, the hydraulic plants constructed in the past were concentrated in the South and Southeastern of the country, next to system load center. Energy Research Company[4] (Empresa de Pesquisa Energética – EPE) studies points out the hydraulic remaining potential in Brazil is about 174 GW and it is concentrated in distant regions with important social and environment problems that need to be equated before the building of new plants. The Figure 6 shows EPE's information about the Brazilian hydraulic potential.

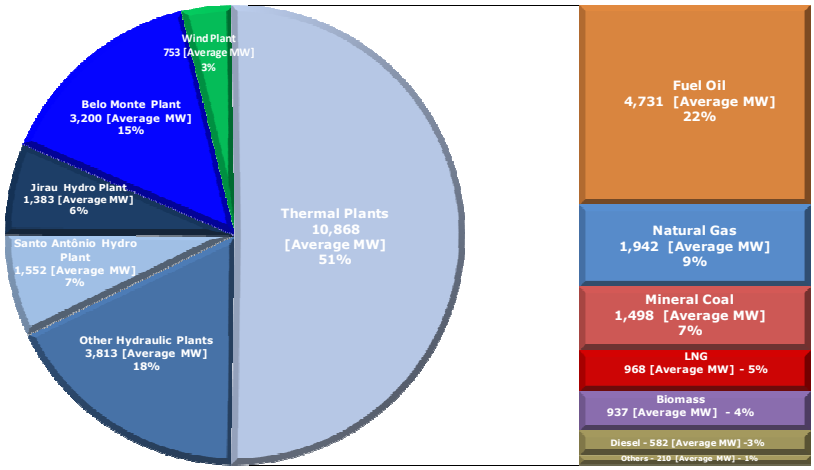
[4] The Energy Research Company - EPE (Empresa de Pesquisa Energética) is subordinated to the MME with the purpose to carry out studies in order to provide fundamental and strategic information to Brazilian policy makers decisions on planning and expansion of energy sector.

Basin	Total Potential	Tapped Potential	
	[GW]	[GW]	[%]
Amazonas	106.1	0.8	1%
Tocantins/Araguaia	28.0	12.2	44%
Atlântico Ne Ocidental	0.4	0.0	0%
Parnaíba	1.0	0.2	22%
Atlântico Ne Oriental	0.2	0.0	5%
São Francisco	17.8	10.3	58%
Atlântico Leste	4.1	1.1	27%
Atlântico Sudeste	14.7	4.1	28%
Paraná	57.8	41.7	72%
Paraguai	3.1	0.5	16%
Uruguai	12.8	5.2	40%
Atlântico Sul	5.4	1.6	30%
Total	251.6	77.8	31%

Source: EPE – 2030 Energy National Plan

Figure 6: Brazilian hydraulic potential

The data on Figure 6 indicate that there is an amount hydraulic potential to be explored. However, due to problems presented above, the new plants auctions[5] results show a thermal capacity growth, as illustrated in Figure 7.



Source: CCEE

Figure 7: Total energy negotiated in auction

There are other alternatives. One way, it is the development of nuclear plants, that it possibilities use of great Brazilian uranium reserves, that there are estimate about 309,379 tones[6]. Other way is the development of alternative electric energy source, like the wind, solar photovoltaic, biomass and small hydroelectric plants. This way requires regulation and commercial instruments development to promote its kind of electric energy.

[5] There were 10 auctions occurred related to energy from new power plants. These auctions started in 2005 and, since then, have occurred annually. The last auction occurred in July 30Th 2010, when were negotiated 327 Average MW of Hydraulic Energy with an Average Price of 37.98 €/MWh

[6] Data estimated by EPE, presented in 2030 National Energy Plan – Plano Nacional de Energia 2030, for a cost about 80 US$/kg.

3 – The Brazilian experience in the development of alternative energy electric sources

It was presented that the Brazilian electric matrix is based in renewable sources, mainly in great hydraulic plants. However, the country differ traditional renewable sources (great hydraulics) and others renewable sources, that there are a subgroup and named alternative sources. There are classified like alternative sources in Brazil the wind plants, the biomass plants, the solar photovoltaic plants and the small hydroelectric plants[7] (PCHs). The Brazilian legislation has been introduced the incentive energetic sources, a special group of alternative sources that have discount in transport tariffs. The Figure 8 represents the treatment of alternative sources in Brazil.

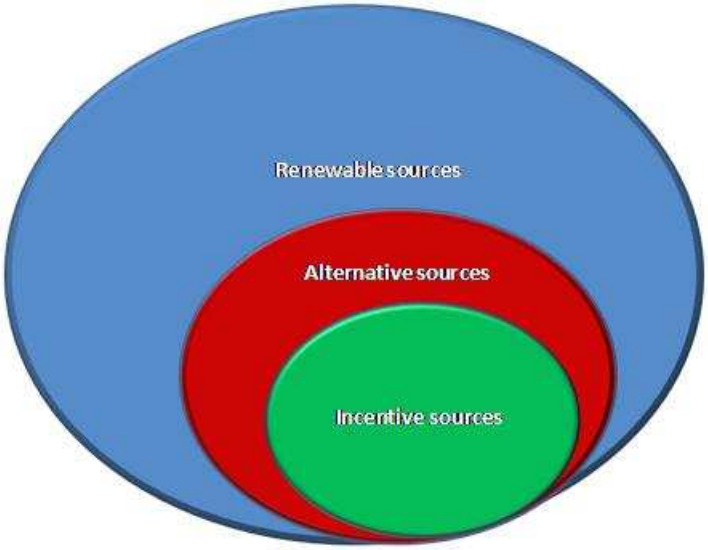


Figure 8: Renewable sources in Brazil

Brazil has a great experience in great hydraulic plants development, with international expertise. Then, the focus of this paper is evaluate the regulation and commercialization process built to development the alternative and incentive sources.

3.1 - Alternative Sources Potential for Electricity Generation in Brazil

Brazil presents an important potential to produce electric energy from alternative sources, mainly the biomass, small hydroelectric plants (Pequenas Centrais Hidrelétricas – PCHs), wind and solar photovoltaic plants.

3.1.1 - Biomass

The biomass is a traditional energy source in Brazil, as noticed in automotive segment since 1980 decade with alcohol used as fuel. The electric energy sector

[7] Law 9,427, dated on 1996, defines incentive energetic sources, such as small hydro plants (PCHs, in Portuguese acronym), biomass, wind and photovoltaic plants, with potential into transmission and distribution grid limited to 30 MW.

uses biomass to produce electricity, mainly sugar cane waste. The Figure 9 shows the Brazilian electricity installed capacity from biomass sources in 2010.

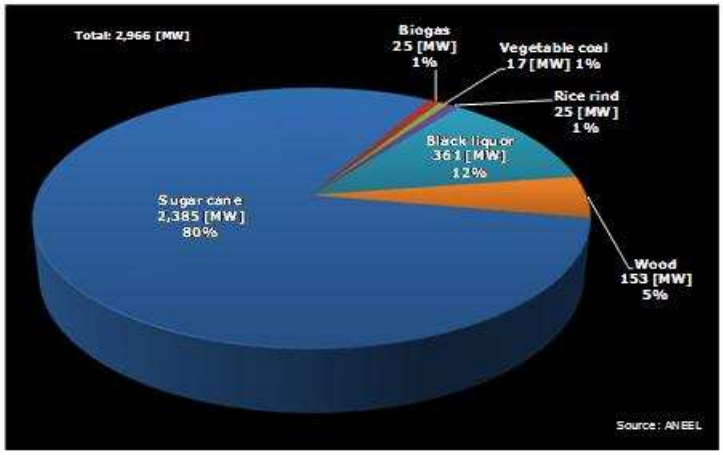


Figure 9: Brazilian biomass capacity installed in 2010

Sugar cane biomass is the main source considering the others biomass energetic resources in Brazil, as indicated on Figure 8. According to Castro and Dantas (2008), this massive presence is due to the scale of production in Brazilian sugar and alcohol segment and its goal of equalizing self consumption and self generation - 98% of sugar and alcohol plants electricity consumption are supplied by electricity from sugarcane bagasse.

The sugarcane segment in Brazil presented, in technological terms, low-efficiency phases in cogeneration process in the past, considering steam production to industrial process was its main objective, meanwhile electricity was a sub product. However, the changes in Brazilian electricity sector – implement of Proinfa and the opening process in free market – stimulated cultural changes, inducing the adoption of technologies more efficient that could make possible the increase in these sources potential. The mainly technological changes in this segment were:

- Counter-pressure steam turbine generator, used in cogeneration process;
- Extraction-condensing type steam turbine generator, used in cogeneration process or in independent model;
- Integrated biomass gasification combined cycle system.

EPE, the Brazilian Energy Research Company, estimates that sugar cane biomass plants can reach an installed capacity of 6,830 MW until 2030, as presented on Table 2.

Table 2: Installed Capacity estimate of generation from sugar cane bagasse

Installed Capacity [MW]	2010	2020	2030
Low-efficiency cycles	140	90	30
Counter-pressure turbines cycles	2,005	2,820	4,170
Extraction-condensing turbines cycles	240	980	1,750
Combined cycle system	0	220	880
TOTAL	2,385	4,110	6,830

Source: EPE – 2030 National Energy Plan

Table 2 indicates a trend in sugar and alcohol segment: more-efficient technology will be reinforced, receiving more investments rather than traditional technology.

3.1.2 – Small hydroelectric plants

Brazilian law classifies over-1MW-below-30MW hydroelectric plant as Small Hydroelectric Plant (PCH, in Portuguese acronym), its reservoir must have 3 squared kilometer, in the maximum. These plants are designated as alternative energy sources, with specific legislation and a set of trading rules, as you will see later in this paper. Nowadays, small plants' installed capacity represents 3,299 MW in Brazil (ANEEL, 2010).

Throughout the years, the generation expansion plan had prioritized big hydroelectric plants instead of small hydro plants segment. This scenario presented some change in 80's, with a small hydro plants national programme, which objective was spread the use of the electric energy from hydroelectric plants in simple form and low cost, using Brazilian technology, with lesser time for implantation and lesser impacts to the environment (Cardoso, Almeida e Nogueira, 2007).

In 1998, the ANEEL established the PCHs definition criteria, a key issue for the recent development of these plants. According to Cardoso, Almeida and Nogueira (2007), the changes in the legislation had helped to extend the potential band of these plants, providing scale profits and making possible financial advantages and benefits related to ambient licensing, becoming them more attractive for private investors. The National Center of Reference in PCHs (CERPCH, in Portuguese acronym) previews a potential of 12.310 MW in this segment, as illustrated in Table 3.

Table 3: PCHs Potential in Brazil

Region	Potential [MW]	Potencial [%]
Southeast	4.101	33%
South	3,398	28%
Centre-Western	3,146	26%
North	931	7%
Northeast	734	6%
Brasil	**12,310**	**100**

Source: CERPCH – http://www.cerpch.unifei.edu.br/potencialidades.php

Table 3 shows that the PCHs potential is concentrated in South, Southeastern and Center-West regions, that is, next to the mainly load points of the Brazilian electrical system. It implies in lower investment in transmission structure, what facilitates the connection of these plants.

3.1.3 – Wind power

Wind power. That is the source of energy generation with the highest growth in the world, having presented the impressive growth of 2.5% from the year of 1996, as showed in Figure 10.

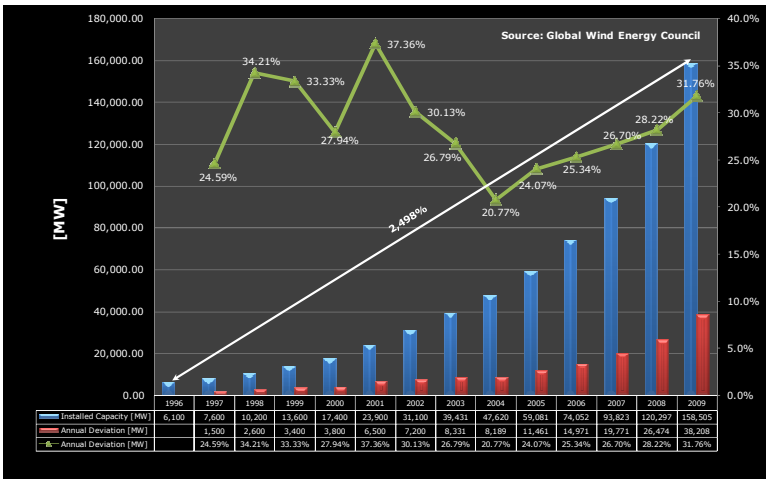


Figure 10: Evolution of World Wind Energy Installed Capacity

Analyzing Figure 9 data, a trend of sustainable growth in wind power source investments from middle of the current decade is noticed.

Five countries concentrate more than 70% of wind power installed capacity world-wide and had maintain great investments in 2009, as shown in Table 4, with prominence for China, such more than duplicated its wind park throughout 2009.

Table 4: Wind Energy Capacity Installed - 2009

Country	Installed Capacity		Annual Growth	
	[MW]	[%]	[MW]	[%]
USA	35,159	22.3	9,922	39.3
Germany	25,777	16.3	1,917	8.0
China	25,104	15.9	13,000	107
Spain	19,149	12.1	2,459	14.7
India	10,926	6.9	1,271	13.2
Brazil	606	0.38	264,6	77.8
World	158,505	100	38,208	31.8

Source: GWEC

The wind power segment growth in some countries, as China, Germany and USA, is characterized by the development of specific politics for the promotion of this technology. According to Castro *et alli*. (2010), these countries had promoted the markets creation for the wind energy through specific mechanisms of

negotiation, considering each scenario. For example, the green energy certificates had been promoted in some American states.

In Brazil, the installed capacity still is timid: 798 MW in June 2010 (ANEEL data). However, agreement already established reaches 1,800 MW to be installed in the next years and a great potential to be developed, mainly in the littoral areas of the country.

According to the governmental estimate, Brazilian wind power potential is 143.5 GW, with prominence for the Northeast region, as illustrated in Table 5.

Table 5: Brazilian Wind Power Potential

Region	Potential		Capacity	
	GW	[%]	TWh/ano	[%]
Northeast	75.0	52.3%	144.3	53.0%
Southeast	29.7	20.7%	54.9	20.2%
South	22.8	15.9%	41.1	15.1%
North	12.8	8.9%	26.4	9.7%
Centre-Western	3.1	2.2%	5.4	2.0%
Brazil	**143.5**	**100.0%**	**272.2**	**100.0%**

Source: Brazilian Wind Energy Atlas

It is worth to mention that the official estimate is considered conservative and needs some revision. In 2009, the "Letter of the Winds" ("Carta dos Ventos", in Portuguese) was elaborated, joint document by the Brazilian states governments and the Ministry of Energy, establishing seven key questions that must be solved in order to develop wind energy generation in Brazil:

1. improvement of the Brazilian regulatory structure;

2. development of transmission and distribution infrastructure to connect new wind power plants to the National Interconnected System;

3. development of methodologies of collection, systematization and storages of essential data for new wind energy projects (example: speed of the winds);

4. set of initiatives to facilitate the environmental licensing;

5. qualification and formation of human resources;

6. promotion of research programs on wind power generation;

7. Brazilian wind power potential review.

Considered as the main impediment for the wind power development in Brazil, the cost of generation has suffered in recent years significant reductions making this energy more competitive in relation to other sources. The results of the

auction occurred in the 2009 end, that it will be detailed later in this article, confirm this trend.

Another important obstacle is the lack of wind turbines and specific equipment manufacturers in Brazil. The solution for this problem passes, necessarily, for the sprouting of a steady market to trade energy from wind source. It means that we will have investment in wind energy generation equipment in case there is a politic of promotion for this energy, inducing allocation of resources in this segment.

It is worth to mention that, in Brazil, biomass and wind power can be used as a complement of the hydroelectric source. In fact, the periods of bigger availability of these sources coincide with the lesser hydroelectric plant generation, and vice versa. Figure 11 presents example of complementation between wind power, biomass and hydraulical sources throughout the time.

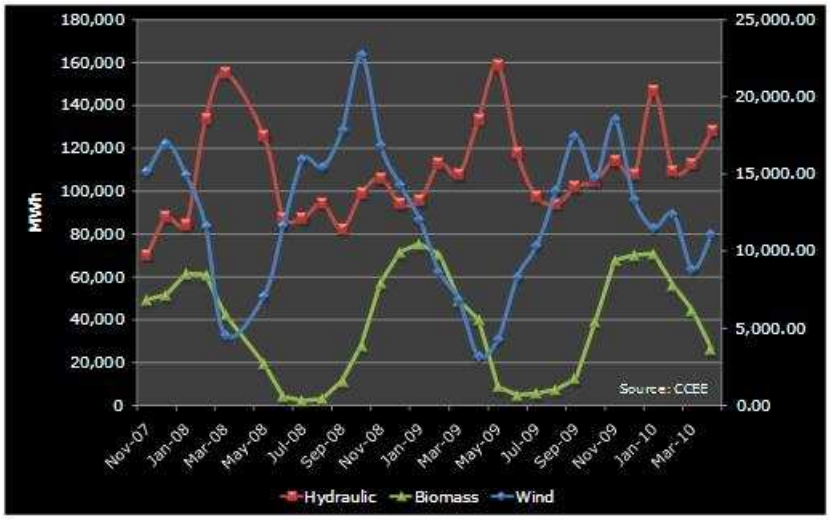


Figure 11: Complementarily between wind and hydraulic plants

3.2 - Regulation and Commercialization of Alternative Sources of Energy in Brazil

The potential of alternative sources in Brazil is relevant. However, to this potential change into generation enterprises it depends on incentive and specific regulation programs that regulate the energy installation and the commercialization of these sources.

An important decision, and pioneer for the alternative sources introduction in Brazil was the Programme of Incentive to the Alternative Electric Energy Sources (PROINFA, in Portuguese acronym) implantation in 2003. Other more recent initiatives establish specific set of rules for energy commercialization with free and special consumers and the accomplishment of auctions for alternative electric energy sources.

3.2.1 – Programme of Incentive to the Alternative Electric Energy Sources - Proinfa

A relevant fact to develop the alternative sources in Brazil, the PROINFA was established by the Brazilian Government, being managed by Eletrobras[8].

To trade the PROINFA energy, a tariff of purchase was stipulated for each source in 20-years contracts. The goal was the trading of 3,300 MW shared equally between sources: wind (1,100 MW), biomass (1,100 MW) and small hydro (1,100 MW). There was the possibility of change in this allotment, in function of offers. In fact, at the moment of the contract it had greater offers of wind power plants than biomass, what it lead bigger trading related to wind parks, as shown on Table 6.

Table 6: PROINFA Contracting

Technology	Purpose Contracting [MW]	Effective Contracting [N°]	Effective Contracting [MW]	Effective Contracting [%]	Average Price [€/MWh]
Biomass	1,100	27	685	20.76%	49.43
PCHs	1,100	63	1,191	36.11%	61.30
Wind	1,100	54	1,423	43.13%	100.04
Total	3,300	144	3,299	100.00%	69.73

Sources: MME and Eletrobras

According to Castro and Dantas (2008), the low offer of energy from biomass source was a consequence of the price offered by the government (€ 35.65 /MWh – 2004 data), considered insufficient by sugar and alcohol segment investors besides connections problems in some regions.

In operational terms, the Eletrobras acts as the PROINFA trader, acquiring the energy of the plants proprietors and transferring it to the consumers with the tariff wire collection related to electric energy distribution service. In this case, the discos (distributors) are responsible for the payment of this energy, as illustrated in Figure 12. Eventual differences between the contracted sums and the produced energy are eliminated in the short-term market.

[8] Eletrobras was created in 1962 as a holding controlled by the Federal Government. Historically Eletrobras has been responsible for implementing electric policy, conservation and environmental management programs. It controls CGTEE, Chesf, Furnas, Eletronorte, Eletronuclear and Eletrosul, companies that generate and transmit electricity in the Brazil.

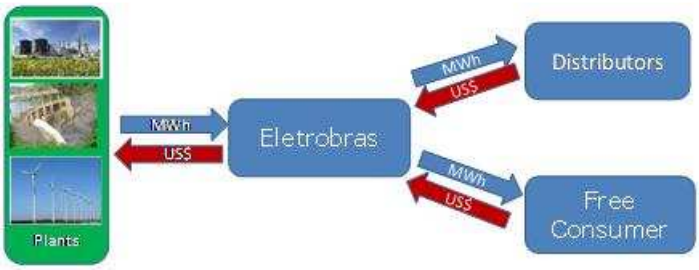


Figure 12: PROINFA commercial operation overview

Although it is an important mark for the alternative sources of energy development in Brazil, the PROINFA faced problems that had implied behind schedule in the projects. According to Dutra and Szklo (2008), the main challenges had been:

- Difficulty of financial capacity evidence in several entrepreneurs, what it provoked shareholder rearrangements in investor's capital and consequent delay in the attainment of financings operations;
- • necessity of projects revision;
- • lack of a robust industrial park in Brazil to comply with the programme requests regarding that a share of wind power plant equipments must be produced in Brazil.

Although the difficulties, the PROINFA has currently 102 operating plants, as discriminated in Table 7. A second phase of the program was planned for 2008 beginning; however, the improvement of the technology, with consequent reduction in its costs, induced the Federal Government to search other ways to stimulate the development of these sources. Currently, the expansion of the energy alternative sources in Brazil has the free market of energy as base, mainly, by auctions of energy, as it will be discussed following.

Table 7: PROINFA' Plants Data – May 2010

Source	Plants in operation				Delayed Projects			
	Nº	[%]	Capacity [MW]	[%]	Nº	[%]	Capacity [MW]	[%]
Biomass	19	18.6%	552	24.1%	8	19.1%	133	13.2%
PCHs	48	47.1%	973	42.5%	15	35.7%	218	21.6%
Wind	35	34.3%	765	33.4%	19	45.2%	658	65.2%
Total	102	100.0%	2,290	100.0%	42	100.0%	1,009	100.0%

Sources: CCEE and Eletrobras

3.2.2 - Commercialization of stimulated energy

Law 9,427, of 1996, instituted discounting in transport tariffs of "not conventional sources" of energy – in Brazil called "stimulated sources" -, with intention to become them competitive in relation to the traditional sources of electric energy.

The small hydro, photovoltaic solar generation, biomass and wind energy are classified as "stimulated sources" of energy and whose potential to the electrical system cannot exceed 30 MW. On the other hand, the final users of this energy are free consumers, who must have contracted demand minimum of 3 MW, and the special consumers, whose must have contracted demand minimum of 500 kW. What it distinguishes the free consumers from the special ones is that the first ones can acquire energy from source, while the seconds' buy is restrict to stimulated sources.

The incentive to the plant is characterized with a 50% or 100% discount in the transport tariff of energy, percentage that varies in accordance with the ANEEL's determinations. If any plant violates the commercialization rules, it will lose the discount.

The final consumers discounting depends on its contract model, that can directly be carried through of energy generators or traders, and eventual discounting loss of the plants of which it acquires energy. The determination of the final discounting of the consumers is determined monthly by the CCEE and informed to the distribution lines and transmission properties, so that they can effectively be practiced.

Consulting the available data of this market, estimated by CCEE, it is noticed a strong presence of the small hydro plants, responsible for 70% of the total commercialized, followed of biomass, with 29% and low presence of wind energy, with 1% of the market. It still has timid presence of the wind energy in the Brazilian free market, probably in function of its prices not yet to present competitiveness in relation to the too much sources. However, it has a trend of reduction in the price of the wind energy, it becomes what it more competitive with passing of the years.

In demand side, the stimulated sources market seems sufficiently promising, with expressive potential of growth. This statement has endorsement in the number of consumers who act in the Brazilian free market: while the number of traditional free consumers presents stability, the number of special consumers presented growth of 42% from April 2009 to March 2010, as illustrated in Figure 13.

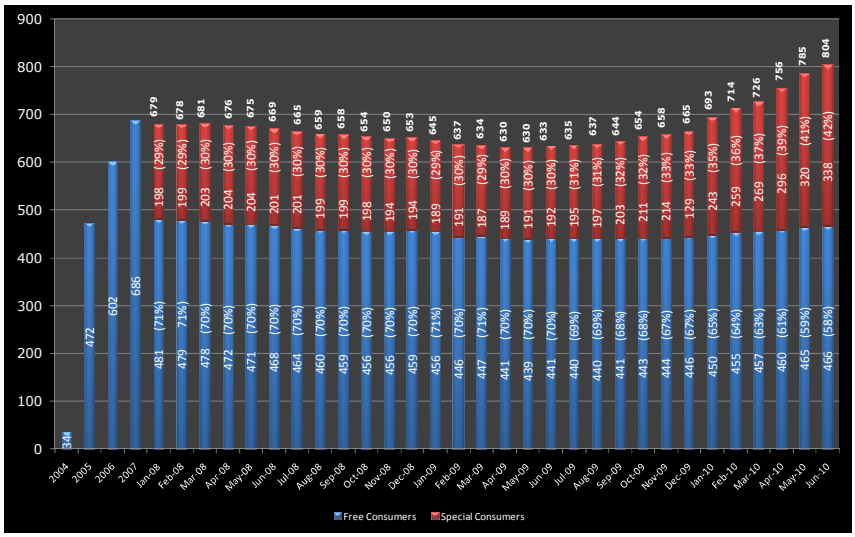


Figure 13: Evolution of Brazilian Free Market

3.2.3 - Auctions of Energy

As presented, the energy auctions are the main principle of generation expansion in Brazilian electric sector. In this sense, the Federal Government promotes open auctions for all kinds of power plants and other specific ones for alternative sources, especially small hydro, biomass and wind power.

The auctions had presented efficient results to commercialize energy, reducing costs in the negotiation of great sums of electric energy. Besides, they are efficient alternative to promote competition and to contribute for the reduction of electric energy final tariffs in Brazil.

In methodological terms, Brazil adopted the auctions with the criterion of lesser price, that is, the winning entrepreneurs are those that offer energy to the lesser value. Such systematic presented itself successful throughout the years, marked by competition.

There are two kinds of auctions to guarantee the Brazilian electrical system expansion:

- New plants auction: distributors buy energy according to the amounts of energy (demand) declared. Contracts between the winning companies and the distributor companies are signed, the last one is responsible for the payment of this energy.

- Reserve auction: they have the purpose to contract an additional sum of energy, in order to provide more security to the Brazilian electrical system. Distributors and free and special consumers are responsible for

the payment of this energy, through a charge calculated monthly by CCEE.

The amount of alternative energy negotiated in auctions - new energy and reserve - reaches totalizes 1,862 [Average MW], shared by the sources as illustrated in Figure 14. This sum represents 8.77% of the total negotiated in auctions of new plants since December 2005.

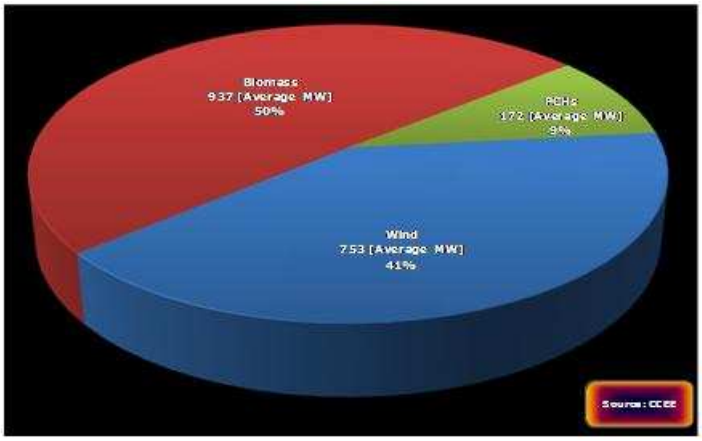


Figure 14: Alternative Sources in Brazilian Auctions

The reserve auction occurred in December 2009, exclusive for wind power, confirms the auctions mechanism efficiency considering the competition point. The initial price was established at 71.86 €/MWh and the final result of the auction presented an average price of 50.42 €/MWh, a decrease of € 15.44 after more than seven hours of competition between the seller participants.

Two auctions for alternative sources energy are estimated for 2010 (August 25 and 26): one auction of new enterprises and another one of reserve energy. For these auctions, 15,774 MW had been registered (Table 8). The Federal Government set of rules establish that the investors can choose in which auction they will take part in.

Table 8: Registered plants in 2010 auctions

Source	N° of Plants	[%]	Capacity [MW]	[%]
Wind	425	82.21%	11,214	71.10%
Biomass	68	13.15%	4,170	26.43%
PCHs	24	4.64%	390	2.47%
Total	517	100.00%	15,774	100.00

Source: EPE

4 - The Alternative Sources Role to mitigate the Greenhouse Effect

The participation of the electric sector in greenhouse effect is directly associated to the thermoelectric plants technology and with the frequency of its

generation. In Brazil, the control of the plants generation is centered and delegated to National Power System Operator (ONS). In this sense, thermoelectric plants produce electricity when the hydro electrical generation cost, calculated from computational models, surpasses the thermoelectrical generation cost. Study carried through PSR Consulting (2008) sample that the average emission of gases (greenhouse effect) of a thermoelectric can be express for the following equation:

$$Plant's\ Emission = Factor\ of\ Power\ Plants\ Emission\ x\ Frequency\ of\ Production\ x\ Power\ x\ 8{,}760$$

Typical factors of plant emission and the generation frequency are shown in Tables 9 and 10. It is observed out that the presented generation frequency results from simulations carried through PSR studies.

Table 9: Typical Emission Factors of Thermal Power Plants

Technology	Emission [tCO2/MWh]
Natural Gas – combined cycle	0.46
Natural Gas – simple cycle	0.51
Oil	0.71
Imported coal	0.89
National coal	1.14

Source: PSR

Table 10: Thermal Production Frequency

Unitary Generation Cost [€/MWh]	Production Frequency
38,02	45%
57,03	31%
76,05	21%
95,06	15%
114,07	11%
133,08	9%

Source: PSR

It is perceived, for the PSR study, that the Brazilian electric sector participation in the greenhouse effect is directly associated to the thermoelectric matrix that Brazil can adopt and the hydrological conditions that restrict the hydro generation, raising the cost of this generation and propitiating higher thermoelectric generation.

As presented, the Brazilian electrical system expansion based on traditional thermoelectric plants can be diversified and, in certain way, substituted by renewable energy sources. Different from the thermoelectric plants, the generation process of these plants is not determined by the ONS, therefore:

- Wind power plants will generate according to the wind, its fuel;
- Biomass plants concentrate its generation in the period of harvest of the sugar cane, moment when it has available fuel;

- Small hydro plants do not count on great reservoirs of regularization, producing energy according to available affluence.

In other words, the generation of the alternative sources plants is considered in the "base" of the operation, dislocating thermoelectric generation. Then, how bigger the installed park of alternative sources, minor will be the generation frequency of these plants, what, according to expression defined for the PSR, reduces the gases emission (greenhouse effect) by electric sector. This is illustrated in Table 11, that it shows to gases emission forecasts (greenhouse effect) of the Brazilian electric sector for period 2010-2019 in two hypotheses:

- Considering the energy contracted in the two reserve energy auctions (530 Average MW of biomass and 753 Average MW of wind)
- Without considering this reserve energy amount commercialized.

Table 11: Greenhouse Gases Emissions in Brazilian Electric Sector - 2010-2019 Estimate

Year	Greenhouse Gases Emissions in Brazilian Electric Sector [MT CO_2]			
	With Reserve Energy	Without Reserve Energy	Δ	Δ [%]
2010	28	26	2	-7.14%
2011	34	32	2	-5.88%
2012	40	38	2	-5.00%
2013	49	46	3	-6.12%
2014	53	50	3	-5.66%
2015	51	47	4	-7.84%
2016	50	46	4	-8.00%
2017	52	47	5	-9.62%
2018	53	49	4	-7.55%
2019	53	51	4	-3.77%

Source: Estimate data based on EPE information (PDE 2010-2019)

Alternative energy commercialization (wind and biomass) contributes to reduce the greenhouse gases emission throughout the period.

5 – Conclusions

The Brazilian electric matrix, based on renewable sources, is an important contribution of the country to reduce the greenhouse gases emission. As complement, the country focus on alternative sources development from the implementation of a set of rules that promote the research and growth of the technological park of the biomass, wind and small hydroelectric plants, as it was presented in this document.

There are still challenges to be equated, such as the continuity of wind power energy investment to guarantee the development of Brazilian industrial park able to produce wind turbine and other equipment necessary for the sustainable development of the Brazilian wind park, with appropriated cost. Such reflection can be extended for the field of the photovoltaic solar generation, still incipient in Brazil, with restrictions to reach moved away communities.

Another point in guideline is the investment in projects of microgeneration of energy - projects of renewable sources with installed capacity lower than 1 MW, debated at this moment with MME, ANEEL, EPE, ONS and CCEE professionals. The main focus of these projects would be the self-supply. To make possible such initiative, it has a bill in quarrel in the Brazilian Parliament that would become obligator the purchase of the excess of the produced energy of these enterprises for the deliverers.

In demand side, the country has developed important projects of energy efficiency, sponsored for resources from research and developments (R&D) projects of the distribution companies and for initiative of the industrial consumers. An embryonic idea in quarrel for the Brazilian Association of Companies of Energy Conservation Services (ABESCO), with participation of MME and EPE, is the implantation of Energy Efficiency Auctions. Such auctions directly aim at the commercialization of projects of energy efficiency for attendance of share of distributor demand, competing with projects of new plants directly. That is, the distributors could opt between taking care of its market through the expansion of the system or promoting the reduction of the demand in its concession area. This experience already is successful in some North American markets - New Jersey and PJM.

A complement to the governmental incentives is the possibility of the plants that use renewable sources to commercialize Clean Development Mechanisms (CDM) credits. Although the commercialization of CDMs is not enough to guarantee the new plants implementation, the revenues gotten from the commercialization of these certificates can make some projects possible.

Considering the information presented in this paper, important initiatives to stimulate the electric energy production by renewable sources have been established in Brazil. Despite the Brazilian electric matrix detains an innate renewable characteristic, Brazil is making efforts to implement incentive mechanisms for the alternative sources and stimulated sources of energy.

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