

## Renewable energy: the role of the auctions of energy in Brazil and the acting of the sources of biomass

Heitor Lopes Ferreira

Doutorando em Administração programa de pós-graduação UNIVOVE. Mestre em Engenharia da Produção pela Universidade Tecnológica Federal do Paraná, Graduado em Administração de Empresas pela Universidade Estadual de Ponta Grossa, São Paulo, Brasil  
leandro.patah@uol.com.br

Leandro Alves Patah

Doutorado em Engenharia de Produção pela Universidade de São Paulo  
Professor Titular da Universidade Nove de Julho, São Paulo, Brasil  
leandro.patah@uol.com.br

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## Abstract

Energy is the watchword and its generation is a challenge. Fossil fuels still dominate as the primary energy matrix, according to the IEA (2015) until the year 2013 oil was responsible for 47% of all energy generated in the world. In Brazil, unlike the great powers, the hydroelectric power stations are responsible for 64% of all energy generated thanks to its rich basin. Even though the hydroelectric stations are the main source of energy generation in Brazil, the construction of new dams is not increasing at the same speed as its growing demand. In a recent study sponsored by the EPE (energy research company) between the years 2016 to 2020 energy demand in Brazil will grow 4% per year reaching 633 TWh in 2020. Faced with this growing demand the Brazilian government since 2004 has been promoting sales auctions and power purchase mediated by the CCEE (Commercialization Chamber of Electric energy) focused on exploration in renewable energy sources. This article aims to analyze the participation of the sources of power generation coming from biomass and highlight its growth in the Brazilian market as a sustainable energy source. To serve this purpose will be analyzed official documents issued by the Brazilian regulatory agencies that demonstrate the gains from the generation and sale of energy. As a result is expected to demonstrate the behavior of companies investing in the creation of power plants whose fuel is Biomass.

**Key words:** Renewable energy; Auctions of Energy; Biomass.

## Energia renovável: o papel dos leilões de energia no Brasil e o desempenho das fontes de biomassa

### Resumo

Energia é a palavra de ordem e sua geração é um desafio. Os combustíveis fósseis ainda dominam como matriz de energia primária. De acordo com a IEA (2015), até o ano 2013 o petróleo foi responsável por 47% de toda a energia gerada no mundo. No Brasil, ao contrário dos grandes poderes, as centrais hidrelétricas são responsáveis por 64% de toda a energia gerada, graças à sua rica bacia. Mesmo que as estações hidrelétricas sejam a principal fonte de geração de energia no Brasil, a construção de novas barragens não está aumentando na mesma velocidade que a demanda crescente. Em um estudo recente patrocinado pela EPE (empresa de pesquisa de energia) entre os anos de 2016 a 2020, a demanda de energia no Brasil crescerá 4% ao ano atingindo 633 TWh em 2020. Em face dessa crescente demanda, o governo brasileiro vem promovendo leilões de vendas desde 2004 e a compra de energia mediada pela CCEE (Câmara de Comercialização de Energia Elétrica) é focada em exploração em fontes de energia renováveis. Este artigo visa analisar a participação das fontes de geração de energia provenientes da biomassa e destacar seu crescimento no mercado brasileiro como fonte de energia sustentável. Para atender a este objetivo, foram analisados documentos oficiais emitidos pelas agências reguladoras brasileiras que demonstram os ganhos com a geração e venda de energia. Como resultado, espera-se demonstrar o comportamento das empresas que investem na criação de usinas de energia, cujo combustível é a biomassa.

**Palavras-chave:** Energia Renovável; Leilões de Energia; Biomassa.

## **Energía renovable: el papel de las subastas de energía en Brasil y la actuación de las fuentes de la biomasa**

### **Resumen**

La energía es la consigna y su generación es un desafío. Los combustibles fósiles siguen dominando como matriz energética primaria, según la AIE (2015) hasta el año 2013 el petróleo fue responsable del 47% de toda la energía generada en el mundo. En Brasil, a diferencia de las grandes potencias, las centrales hidroeléctricas son responsables del 64% de toda la energía generada gracias a su rica cuenca. Aunque las centrales hidroeléctricas son la principal fuente de generación de energía en Brasil, la construcción de nuevas represas no aumenta a la misma velocidad que su creciente demanda. En un reciente estudio patrocinado por la EPE entre los años 2016 y 2020, la demanda de energía en Brasil crecerá un 4% anual, llegando a 633 TWh en 2020. Ante esta creciente demanda, el gobierno brasileño desde 2004 ha venido promoviendo subastas de ventas Y compra de energía mediada por la CCEE (Cámara de Comercialización de Energía Eléctrica) enfocada a la exploración en fuentes de energía renovable. Este artículo pretende analizar la participación de las fuentes de generación de energía procedentes de la biomasa y destacar su crecimiento en el mercado brasileño como fuente de energía sostenible. Para ello se analizarán documentos oficiales emitidos por las agencias reguladoras brasileñas que demuestren los beneficios de la generación y venta de energía. Como resultado se espera demostrar el comportamiento de las empresas que invierten en la creación de plantas de energía cuyo combustible es la Biomasa.

**Palabras clave:** Energías Renovables; Subastas de Energía; Biomasa.

### **1 Introduction**

The development of regions and countries requires adequate and continuous supply of energy for their viability, and this is the worldwide challenge for all nations. According to IEA (2015) by the year 2013, 47% of all energy generated in the world came from fossil sources (petroleum). Brazil, different from several countries, has several sources of renewable generation in its matrix. According to the International Energy Agency - IEA (2015), renewable energy sources are considered sources whose speed of renewal is higher than the speed of consumption, and within this definition are renewable sources: Solar, Wind, Geothermal, Bioenergy and the Energy of the Sea.

The Energy Auctions existing in Brazil since 2004 are reflections of a problem that originated in the 1980s, when Brazil did not have the resources to invest heavily, after all the generation of energy consumed by the country was the exclusive prerogative of the Brazilian government. Only in 1988, after the promulgation of the new Brazilian constitution, was the possibility opened for the concession of public services, duly regulated in 1995 by the Laws no. 8,987 and 9,074. This gap between the concession and its regulation was the main catalyst for the energy crisis suffered in Brazil in 2001 (Abbud & Tabcredi, 2010).

After these events, in 2004 the Ministry of Mines and Energy (MME) created the Electric Energy Chamber of Commerce (CCEE) and in the same year the first Energy Auction was inserted into the National Integrated System (SIN), 17 thousand average MW from power plants that entered in operation before 2000 (CCEE, 2016). In view of the good results obtained, in 2005 the auctions of renewable energy sources were started, among them the Biomass-Based Power Plants (agricultural and forestry residues), the focus of this article.

The biomass-based power generation plants are the only ones that have a system called cogeneration whose characteristic is energy self-sufficiency obtained from the reuse of waste from their production processes. Based on this brief introduction, this article aims to analyze the participation of biomass energy generation sources and highlight its growth in the Brazilian market as a sustainable energy source. The analyzes of this article allow a better understanding of the Brazilian energy market, especially biomass-based energy sources. It is noticed that 83% of the auction winners reached values of winning bids very close to the stipulated base prices, providing to these enterprises better profitability.

In view of the above, the present work was organized in five sections besides this introduction. In the second section the theoretical reference is presented, contemplating the theoretical basis regarding the Energy Cogeneration and the Energy Generation Auctions in Brazil. The following section presents the methodological procedures used in the empirical phase of the research. In the fourth section the data and the results obtained are presented and analyzed. Finally, the fifth section presents the conclusions of the study, its limitations and suggestions for further research on the subject.

## 2 Theoretical Review

### 2.1 Energy cogeneration - Biomass

Energy Cogeneration is identified in plants that use Biomass (Sugarcane Bagasse, Pieces of Wood and Rice Bark) as fuel for generating energy for domestic consumption and exporting surplus energy, resulting from its production processes. Countries that adopt energy cogeneration systems in their matrices reduce demand for fossil fuel use by up to 35% (Oh, Lee, Jung, & Kwak, 2007).

In this context, sugarcane bagasse stands out in the world scenario as one of the most cost-effective sources among Biomass sources (CONAB, 2011)<sup>1</sup>, And Brazil being the world's largest producer of Sugar Cane, 748 million tons in the year 2015 (IBGE, 2015)<sup>2</sup>, Up to 201 million tons of bagasse, equivalent to 28% of utilization for each ton of sugar cane cultivated (Mandaloufas, Lamas, Brown, & Quintero, 2015). In other countries such as Cuba the use of bagasse reaches 32% (Botha & Blottnitz, 2006).

Although the numbers are favorable, Castro and Quiros (1991) mention that the good performance of power cogeneration plants requires the adoption of appropriate technologies to be profitable. According to Eggleston and Lima (2015) at present the most efficient technology for the generation of energy from bagasse is composed of high pressure boilers (82 - 100 bar) with superheated vapors at 525°C. Based on this optimal configuration Koodaruth (2014) mentions that the plants would produce 109 KWh of energy per ton of processed cane. It is worth noting that the energy capacity of sugarcane in relation to bagasse is equivalent to 49.5%, compared to ethanol 43.2% and in relation to vinasse 7.3% (ANEEL, 2005)<sup>3</sup>.

In terms of costs, ANEEL (2005, p.78) mentioned in its publication a study by the International Energy Agency (IEA) of 1998 in which it mentions that for the generation of energy from agricultural and forestry residues could vary between US\$ 40.00 - US\$ 50.00/MWh, for plants that invest in modern technologies such as those mentioned by Koodaruth (2014). Regarding the maintenance of generation efficiency, Madaloufas et al. (2015) mention that the cost of maintaining cogeneration systems is US \$ 6.89/MHh.

<sup>1</sup> National Supply Company - CONAB

<sup>2</sup> Brazilian Institute of Geography and Statistics - IBGE

<sup>3</sup> National Electric Energy Agency - ANEEL

Another important criterion to be considered by cogeneration plants is the type of sugar cane cultivated. Generally, plants that opt for the production of sugar, ethanol and power generation opt for the cultivation of the sugar cane denominated type I whose composition fibrous varies between 12 - 17%, already the factories that opt for the production only of ethanol and generation of energy Cultivate sugar cane type II whose fibrous composition varies between 20 - 30% (Khoodaruth & Elahee, 2013).

In Brazil, cogeneration power plants that wish to exploit the sale of surplus energy are regulated by ANEEL, which is intermediated by CCEE<sup>4</sup> In charge of the collection and realization of auctions destined to the supply of demand previously identified, subject that will be approached next.

## 2.2 Power Generation Auctions in Brazil

The auction is a marketing practice that existed a few centuries ago (Krishna, 2002), and of course, evolved over time (Klemperer, 1998; Justo, 2010). In a practical way, the auction is a mechanism that promotes competition in purchases of goods or services (objects, products, contracts), whose main characteristic is the transparency of the rules determined by the auctioneer, accessible to the probable participants, allowing them to know before their auction occurrence (Maurer & Barroso, 2011).

The traditional theory of the auctions has as presupposition four modalities. The English or open top-priced auction where the winner is the highest value bid; The German or open auction of a descending price where the auctioneer establishes a high value, which is presumed to be far from the reach of the interested parties, and with each new round, a new value, less than base price is established until the winner finishes the good or service; The closed first-price auction (sealed-bid) characterized by sealed bids where the best price is identified after opening all simultaneously; and finally the sealed-bid second-price auction, also known as Vickrey's auction where the winner is the one that presents the best offer, but the amount that will pay refers to the second best bid (Justo, 2010).

Maurer and Barroso (2011, p. 5) emphasize the importance of using the auctions on a number of fronts, and cite pioneering examples of success such as that

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<sup>4</sup> Chamber of Commerce of Electric Energy - CCEE

in the United Kingdom in the year 2000 in telecommunications in relation to 3G mobile services. Regarding the electric sector, the authors mention that the auction is being adopted in several countries: in generation, transmission, and auxiliary services to the sector. In Brazil, the world trend of adopting the auctions in the electric sector started in 2004 with the creation of the Chamber of Commerce Electric Energy (CCEE), whose model adopted, according to Rego and Parente (2013), is a variation Of the Anglo-German hybrid model proposed by Klemperer (1998)<sup>5</sup>.

The Brazilian model provides for two stages (totally virtual since 2006): In the first, called 'uniform', the generating undertakings submit bids equal to or less than the base price and the amount of lots associated with the bid, for a predetermined time. After the first step, the lowest values are classified for the phase denominated 'discriminatory', in which they offer a single bid referring to the amount of lots declared in the uniform phase. The winners are the generating undertakings that offer the lowest prices in relation to the amounts declared (CCEE, 2016).

It is important to point out that before the auctions are executed, Brazilian legislation provides for two very distinct moments: First, there are the manifestations of demands from the concessionaires responsible for distribution through market needs, under the responsibility of CCEE (Decree Law 5163, 2004); The second stage is the accreditation of energy supply agents (hydro, thermal, wind, solar) under the responsibility of the Energy Research Company - EPE (MME, Ordinance 102, 2016).

Energy-generating enterprises whose fuel is agricultural and forestry waste (Biomass) are classified as Thermoelectric Plants, but do not compete with other Thermoelectric sources that use fossil fuels (Coal, Diesel and Gas). The enterprises that use Biomass were the first of the renewable energy modality in Brazil to participate in the auctions, except for hydroelectric plants. The first Biomass auction took place in 2005, following the projects that use wind energy in 2009 and already in 2013 the projects that will use solar energy with forecast for operation in the second half of 2017 (CCEE, 2016).

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<sup>5</sup> Further details on the Anglo-German hybrid auction model check the work of Klemperer (1998) entitled Auctions with almost common values: the 'Wallet Game' and its applications. *European Economic Review* 42 (3-5), 757-769.

### 3 Methodology

This article has a quanti-qualitative approach, since it is prepared to delve into the phenomena that involve the power generating plants from the use of Biomass while at the same time searching for material that allows the understanding of the behavior as a whole. It is described as descriptive because its objective is to analyze the participation of biomass energy generation sources and highlight its growth in the Brazilian market as a sustainable energy source.

As instruments to serve these purposes, firstly the literature was searched for contents that allowed a better understanding of the studied phenomenon, its evolution and contribution to the research carried out; Later, official documents issued by Brazilian regulatory agencies and companies were analyzed, which showed the evolution and the gains obtained with the generation and commercialization of energy, the data collected were works through electronic spreadsheets and through them generated graphs and tables that explain adequately The phenomenon, here described as being the power plants that use renewable fuel called Biomass.

### 4 Discussion and results

The first auction that included energy-generating ventures that used biomass as fuel occurred in December 2005. This auction, called the 1st New Energy Auction (Bid 002/2005 - ANEEL), covered hydroelectric and thermoelectric projects that would still be built for the purpose To attend to the increase of the charges in the networks of the electric distributors (Brazil, Law 11.943, 2009). The new energy auction (LEN) is just one of the nine modalities used by CCEE. Table 1 shows the modalities of auctions that up to the year 2016 included biomass in their bidding projects as a source for energy generation.

**Table 1 - Main Biomass Thermoelectric Auctions**

CODE	DESCRIPTION	PURPOSE
LEE	Existing Energy Auction	The existing energy auction was created to contract energy generated by plants already built and in operation, whose investments have already been amortized and, therefore, have a lower cost.
LEN	New Energy Auction	The new energy auction has the purpose of attending to the increase of the load of the distributors. In this case are sold and contracted energy from power plants that will still be built. This auction can be of two types: A-5 (mills that go into commercial operation in up to five years) and A-3 (in up to three years).

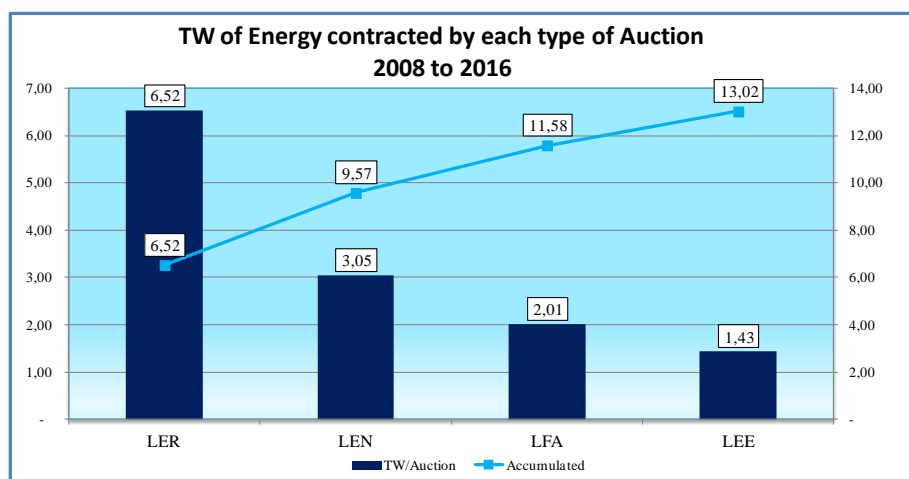


LER	Power Reserve Auction	The contracting of reserve energy was created to increase security in the supply of electricity in the National Interconnected System (SIN), with power from plants specially contracted for this purpose, either from new generation ventures or from existing ventures.
LFA	Auction of Alternative Sources	The auction of alternative sources was established with the objective of meeting market growth in the regulated environment and increasing the share of renewable energy sources (wind, biomass) and energy from Small Hydroelectric Power Plants (PCHs) in the Brazilian energy matrix.

Source: CCEE (2016)

In all, 118 biomass-based cogeneration plants supply power to the National Interconnected System (SIN), a network of all Brazilian energy distributors, and some of these plants hold contracts obtained in more than one auction. In all auctions, the systematic approach is always the same, the model adopted is the Anglo-German hybrid mentioned by Klemperer (1998), however, it has a base price and its bids are in descending order in its first phase. After qualifying the plants, the second phase is composed of a single bid (sealed-bid) to then declare one or more auction winners (CCEE, 2016).

Although biomass-based plant auctions started in 2005, actual power generation only occurred in January 2008, generating capacity for this year was approximately 0.27 TW/year. After this very timid start, between 2008 and 2016 the generation of thermoelectric energy based on biomass increased to approximately 13.02 TW/year according to CCEE (2016). Figure 1 demonstrates the growth of biomass-based thermoelectric power supply in Brazil in relation to each type of auction.



**Figure 1** - TW of Energy contracted by type of Auction

Source: CCEE (2016)

At this stage of the analysis it is important to note that the generation and distribution of energy in Brazil occurs in two forms, both of which are provided for in

legislation (Brazil, Law 5163 of 2004, Law 10.848 of 2004). The first denominated Free Contracting Environment - ACL provides for negotiations and bilateral contracts freely negotiated according to specific rules. The second denominated Regulated Contracting Environment (ACR) deals with purchase and sale operations preceded by bidding, in the form of auctions, which also have their own rules already mentioned in this article.

The Energy Trading Contracts in the Regulated Environment (CCEAR) are established between the winning auction mills and the companies that have purchased one or more lots of these auctions, and there is no link with the Brazilian state. On the other hand, the majority of the contracts are long-term, varying from 15 to 25 years, thus providing legal certainty and financial compensation for plants that opt for the exploitation of the sale of electricity as a source of energy recipe. Table 01 shows the relationship between the number of companies winning the auctions (Biomass based plants) and the number of companies that bought the energy marketed between auctions from 2005 to April 2016.

In fact, the energy trading market is booming. According to technical note no. 19/15, which deals with the Electric Energy Demand Projection for the years 2016 to 2020, the Brazilian market will grow by 4.0% a year to 633 TWh/year in 2020 (EPE, 2015) .

**Table 2 - Relationship between Number of Sellers and Purchasers of Energy**

Year Auctions	Nº Sellers (Biomass Energy)	Nº Buyers
2005	12	306
2006	11	300
2007	09	204
2008	33	71
2009	03	44
2010	13	29
2011	13	149
2013	14	481
2014	09	344
2015	33	810
2016	07	49
$\sum x, y$	<b>157</b>	<b>2787</b>
$(\bar{x}, \bar{y})$	<b>14,2</b>	<b>253,3</b>

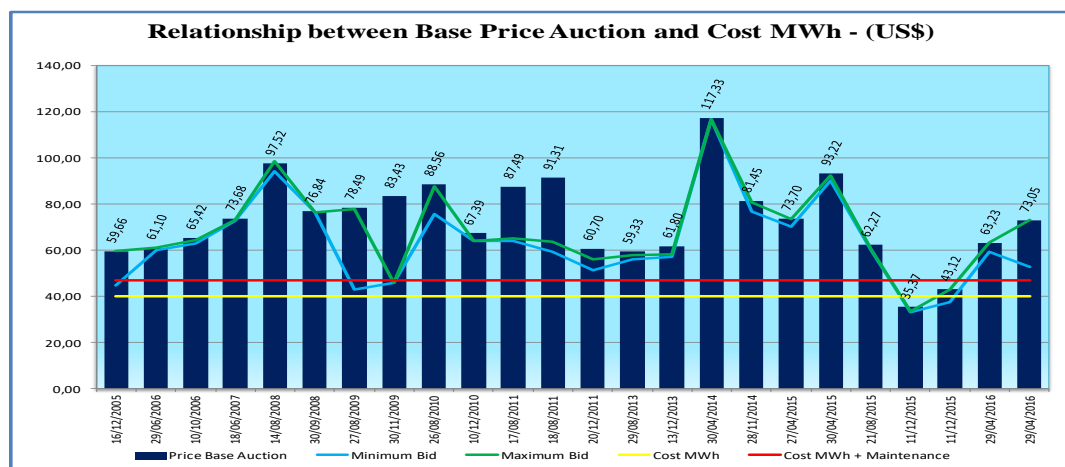
Source: CCEE (2016)

Parallel to this growth, the EPE with each new bidding also performs the calculation of the Marginal Cost of Reference (CMR), adopted as base price in the auctions. The value of the CMR is the result of the analysis of the demands of the

Regulated Contracting Environment (ACR) and the Free Contracting Environment (ACL), whose value "corresponding to the value of the highest estimate of cost of generation of the projects to be tendered, considered necessary and sufficient To meet demand" (MME, Ordinance No. 14, 2016, p.35). All amounts agreed and contracted in the auctions are corrected monthly according to the IPCA<sup>6</sup>.

Since the CMR is the base price adopted in auctions, attention is focused on the understanding of energy generation costs (\$/MWh). CCEE has a methodology for calculating generation costs according to its business profile (Hydraulic, Thermoelectric, Wind, Solar), which take into account information from the accounting records of each enterprise, and there is no standard value for cost analysis. Thus, for comparisons between the bid price offered by the Biomass plants and their energy generation costs, the parameter published by the International Energy Agency (IEA) in 1998 quoted by ANEEL in 2005 will be used. That the costs for generating energy from agricultural and forestry waste can range from US \$ 40.00 - US \$ 50.00/MWh to mills that invest in modern technologies such as those mentioned by Eggleston and Lima (2015).

Complementarily, Madaloufas et al. (2015), when investigating the generation costs at a sugar ethanol ethanol plant in Brazil, mention that the cost of maintaining power generation systems is approximately US \$ 6.89/MWh. Figure 03 based on the parameters, Cost and Base Price, allows a better understanding.



**Figure 2 - Ratio between Base price Auction and Cost/MWh.**  
Source: Adaptado de CCEE (2016)

<sup>6</sup> IPCA – The Extended Consumer Price Index is an index used as a parameter for the correction of values subject to inflation.

As shown in Figure 2, among the 24 auctions already carried out, the differences between the costs required for energy generation (IEA, 1998; Eggleston and Lima, 2015) and the base prices practiced have important differences that may influence the decision Whether or not to participate in these competitions. In at least four auctions, the minimum price range was below the energy generation cost range, which is very worrying, as was the case of the auction held on December 11, 2015, LEE, which obtained 20 winners, 18 projects for power generation for 12 months and 02 projects for power generation for 36 months. According to the CCEE (2016), the enterprises that participate in the LEE Auction are plants that have already amortized all their machines / equipment, allowing them to have lower costs when compared to companies that will still be entering or are in the process of being started.

Finally, taking into account the 157 contracts established after the 24 auctions between the years 2005 and April 2016, it was found that 57% of the winning bids, which corresponds to 90 cases, obtained a discount from the value Base of approximately 0.04%, very good adhesion of the participating plants, potentializing the gains and the perennality of these energy supplying enterprises. Table 3 shows the distribution of the number of bids in relation to the percentage of the bid in relation to the base value.

**Table 3 - Distribution No. Bids in relation to the Base Value**

Series	% Bid Relative to Base Price	N° BID	% Bidding on Total	Energy negotiated contract (MWh)	Financial amount traded (US\$ Millions)	Projected financial amount in relation to base price (US\$ Millions)
1	50,00%	0	0,00%	0	-	-
2	57,69%	2	1,27%	43.824	3,51	6,08
3	61,53%	0	0,00%	0	-	-
4	65,37%	1	0,64%	1.279.836	121,58	185,99
5	69,22%	3	1,91%	210.384	21,01	30,35
6	73,06%	5	3,18%	8.701.108	924,61	1.265,55
7	76,90%	5	3,18%	8.629.136	889,74	1.157,01
8	80,75%	1	0,64%	745.090	148,27	183,62
9	84,59%	3	1,91%	2.761.368	318,01	375,94
10	88,43%	6	3,82%	12.228.972	1.653,78	1.870,16
11	92,28%	3	1,91%	1.420.128	180,26	195,34
12	96,12%	25	15,92%	58.942.485	8.559,17	8.904,67
13	99,96%	90	57,32%	274.266.657	47.541,53	47.560,55
14	100,00%	13	8,28%	9.943.289	1.811,10	1.811,10

Source: CCEE (2016)

## 5 Conclusions

Reflecting on the data collected and presented in this article, it is confirmed the worldwide trend of growth of energy supply whose main concern is the exploration of renewable sources, as is the case of Biomass based plants, and other renewable sources Such as wind power and solar power in Brazil. Among the renewable sources, Biomass-based Thermoelectric Plants are the ones that respond more quickly to changes in demand, offering to the market the excess of existing capacity in their facilities, even if there is a probability of eventual problems in their sugarcane crops, Majority of biomass-based plants in Brazil.

With regard to the auctions already carried out, the Brazilian government has relaxed the power purchase systems previously exploited by state companies, enabling the consumer to opt for free marketing through the ACL or to opt for an environment regulated and intermediated by the Brazilian government through the RTAs, Channel used by ANEEL to execute its auctions organized and coordinated by CCEE. As for the system adopted for the execution of the auctions, it favors the buying agents that can acquire energy at more attractive prices, when compared to the prices practiced in the free market, whose main attraction is the long contracts established between the winners of the auctions and buyers, monitored by CCEE.

With this systematics, it was expected that there would be more competition between the plants that were able to participate in the auctions, a fact not proven by the fact that of the 157 winners of these auctions, 131 mills (83%) reached values of winning bids very close to the base values Stipulated in these auctions, a result that refers to two probable causes. The first refers to the base price stipulated in these auctions that takes into account the variation in the demands of the ACL and ACR markets, which in many cases inhibits the more effective participation of biomass-based ventures. The second, and perhaps most likely, cause concerns the management of energy generation costs. Although CCEE takes into consideration the accounting data reported by each interested enterprise indicating the feasibility of the bids, there is a possibility that the profit margin obtained does not compensate the long-term commitment discouraged from participating in the auctions.

In this way it is possible to affirm that Biomass Plants try to minimize possible financial losses by offering bids below the base value, which does not harm them in

their business mainly when the contracts are long term. It is worth remembering that Biomass Plants do not only produce energy, in 85% of the plants the fuel comes from sugarcane bagasse, also used in the production of sugar and alcohol ethanol. These plants offer to the market only the surplus of their generating facilities.

The main limitations were the collection of all the necessary information with the energy management agencies in Brazil, the data exist are accessible and are more unstructured, making it difficult to carry out the analyzes, but it is an excellent challenge, mainly as regards the creation of a cost parameter that allows Rapid analysis without the need for an accounting survey, important without doubt, but which hinder decision making in high pressure environments such as energy auctions.

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