Chapter 6

Bioelectricity's Potential Availability from Last Brazilian Sugarcane Harvest

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Additional information is available at the end of the chapter

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Abstract

This chapter presents and discusses the potential of power generation from last sugarcane harvest (2016/2017), mainly by the combustion of two by-products; bagasse and straw. Bioelectricity production from the bagasse and the straw is possible through the grinding sugarcane, and both are available in the driest period of the year (May to September) and match with the water shortage in the reservoirs of hydroelectric power plants to the same period. Brazil is the largest producer of sugarcane of the world, in 2016/2017 reaped 657,189.900 tons, this crop is concentrated in four states that are responsible for over 90% of the bioelectricity production. Considering 2016/2017 harvest, we have foreseen that the availability of bioelectricity could reach 74,994 GWh, but if we aggregate straw to the combustion at the boiler, the electricity produced would reach 111,558 GWh. This power energy produced is almost 20% of total power energy supply in 2016, when power generation was 570,562 GWh. This way, Brazil could increase the share of the renewable resources at its power energy matrix and avoid greenhouse gas emission. Moreover, we present a deep discussion about the current federal regulatory scope of Brazilian electricity market and how bioelectricity fits into this competitive market.

Keywords: bioelectricity, bagasse, straw, sugarcane, gases, Brazil

1. Introduction

Electric energy is crucial to the economic development and welfare of mankind. Most developing countries have had a strong economic growth, which has demanded higher electricity consumption [1]. However [2], to increase power generation requires the use of technologies from renewable resources that pollute less in addition to mitigate the emission of CO_2. According to Furuoka [3], several countries around the world struggle to draw up effective policies aimed at reducing emissions of carbon dioxide (CO_2) that is the cause of more than 60% of the global greenhouse effect. Several studies have shown that when renewable energy is consumed less carbon is emitted [4]. For the Organization of Economic Cooperation and Development (OECD), the utilization of renewable energy is considered environmentally friendly and according to Jebli and Belloumi [5], renewable energy is an important resource for the development of economic and social activities.

Brazil is renowned for thriving agribusiness, and sugarcane is the crop that stands out in the Brazilian economy [6]. Brazil produces a significant amount of biomass, which is converted into ethanol and/or in the production of electrical energy. Brazil is the world's largest producer of sugarcane, the largest producer and exporter of sugar and the second largest producer of ethanol [7].

Before the Intended Nationally Determined Contribution- INDC, Brazil has undertaken to reduce greenhouse gas emissions to 43% below 2005 levels. For this, the country has undertaken measures to increase the participation of sustainable bioenergy in its energy matrix to approximately 18% until 2030, restore and reforest 12 million hectares of forests as well as reach an estimated 45% participation of renewable energies in the energy matrix in 2030 [6].

2. Bioelectricity generation in Brazil

Power energy installed capacity in 2016 was shared as follows: hydro 101,598 MW (71,5%), thermal (natural gas + liquefied natural gas) 12,414 MW (8,7%), wind 9,611 MW (6,8%), thermal (biomass) 7,640 MW (5,4%), thermal (fuel oil + diesel) 4,732 MW (3,3%), thermal (coal) 3,174 (2,2%), nuclear 1,990 MW (1,4%), others (waste + importation) 867 MW (0,6%) and solar 16 MW (0%) [7] (see **Figure 1**).

We can affirm that Brazilian power matrix still is clean, because renewable sources hold 84% of the installed capacity. The solar source has just 16 MW installed, but probably next decades it will be the source that will grow more. Nowadays, there is a strong stimulus to install photovoltaic (PV) panels at residential and commercial sectors as well as the combined heat and power (CHP) systems in the industrial sector. The goal is to become self-sufficient in electricity consumption. Factors such as a fall of PV's facilities installation cost, the sale of surplus electricity to the power grid and the increasing environmental pressure are leading to the expansion of the use of renewable sources.

2.1. Greenhouse gases

However, fossil fuels remain as the main source of the world's energy mix [8]. In global debates on climate issues there is the need for unanimous reductions in emissions of carbon dioxide (CO_2), arising from the massive use of petroleum, coal, and natural gas as fuels [9]. Thus, renewable resources such a solar, wind, biomass have emerged as an alternative in the production of electricity on a large scale, most of them in the mode of distributed generation, besides being less aggressive to the environment [10]. The vast majority of countries are aware

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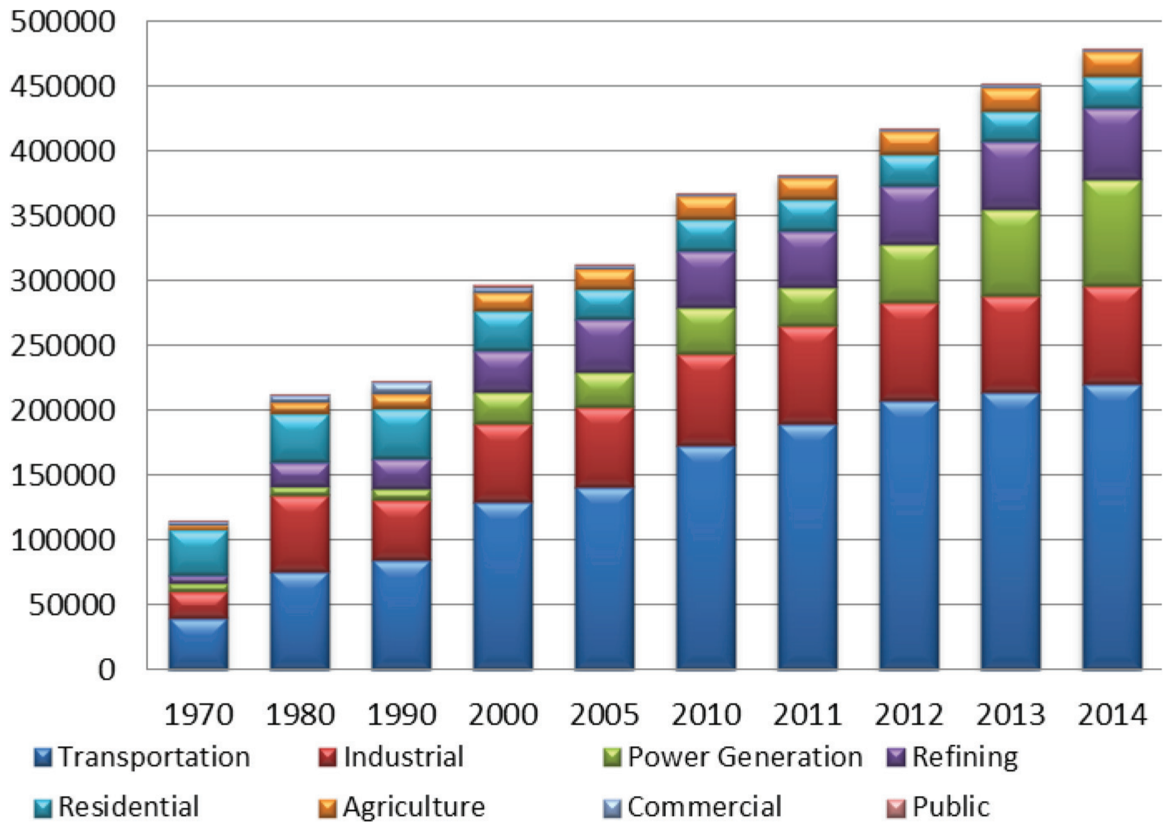

Figure 1. Brazilian-installed capacity of power energy. *Source – ONS 2017.*

of the strong dependence on fossil fuels in the energy production currently, its participation on the world energy matrix is 86% because of this, carbon dioxide emissions have reached the volume of 33.508 Gtons, or 0.1% more than 2015 [11].

To make matters worse, the transaction named "carbon credits" has emerged as an alternative to the developed countries and/or large enterprises, with appointments or goals of reduction of GHG emissions to be reached, acquires the "certified emission reductions" (carbon credits) and therefore promotes the implementation of energy projects that use renewable energy sources in developing countries. However, this market of carbon credits has not been consolidated as intended, since the value of the carbon credit did not reach attractive values expected. Thus, the initial enthusiasm about the commercialization of carbon credits goes through a phase of low motivation; therefore, the expectation of being a source financial for energy renewable projects has decreased substantially.

To be competitive developing countries are pressured to produce energy with sustainability and preserve natural resources, and that is just possible with the implementation of innovative technologies that reduce carbon emissions and environmental impacts [12, 13]. Sustainable production system is a global necessity which represents a competitive advantage and new market opportunities [14]. With the use of sugarcane waste to produce bioelectricity it is possible to soften the impacts of GHG and increase the share of renewable energy sources. According to the authors [15], this is a reality that makes it possible for energy crops to contribute significantly to the sustainability of the planet. The cultivation of sugarcane has a

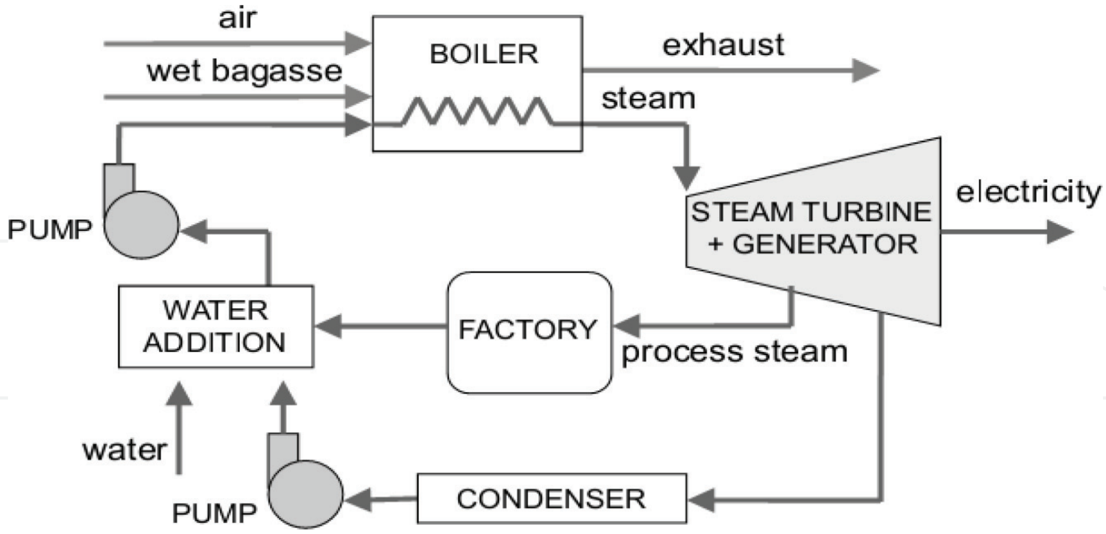

Figure 2. Brazil; $CO_{2\ eq}$ emissions by sector (kton).

great conversion efficiency of photosynthesis. As researched by Paula et al. [16], the production of a ton of biomass fixed minimum 0.42 tons of carbon, equivalent to mitigate 1.54 tons of carbon dioxide (CO_2) from the atmosphere. There are technologies already available to provide electricity from biomass-like energy sources. On the other hand, it is known that the bagasse burning in boilers emits pollutants in the atmosphere, the contents of which are particulates, carbon monoxide (CO), unburned hydrocarbons (C_XH_Y) and nitrogen oxides (NO_X). The researchers Teixeira et al. [58] affirm that the principal mechanism of NO_X formation is related to the "fuel mechanism" which overcomes the others.

The transportation sector is the greatest pollutant of GHG emission on Brazil with 46%. We can observe that from the year 2000 the power generation has increased its share of contribution of the CO_2 emission (17%). It is because the thermal power plants, by burning several fuels, have been activated to operate at the base and the intermediate part of the load curve and not only to meet peak demand. The electrification of rural areas has affected the fall in gas emissions from this sector, because the cooking is no longer made with firewood. Last 44 years, the emissions went from 114.26 to 479.1 Gton of CO_2 equivalent (**Figure 2**).

2.2. The sugarcane biomass

Lignocellulosic biomass is the renewable resource used in the production of bioenergy, where the goal is trying to reduce the massive presence of fossil fuels. Lignocellulosic biomass refers to plant dry matter, mainly composed of cellulose, hemicellulose and lignin [18]. The agricultural and industrial wastes are the most promising biomass for its use in the power generation because they are abundant and relatively low cost [19]. In Brazil, straw and bagasse are the renewable resources used by the combined heat and power (CHP) systems, both are derived from sugarcane. Other biomass resources known are black liquor, scraps of wood, rice husk, the elephant grass, and corn cob [20].

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The ethanol production occurs in sugar mills. In the country, currently there are 520 factories operating in 23 states. Nowadays, there is a high concentration in the Southeast region, where more than two thirds of the plants are located, mainly in the State of São Paulo where are working 280 plants. The state of Minas Gerais with 45 power plants has the third position. In the last decade, the expansion of the sugarcane crops has occurred in the Midwest region of the country [21].

The energy contained in sugarcane is composed 1/3 in the form of sugars contained in the broth that is used in the production of sugar and ethanol, or 1/3 in the form of fibers contained in the thatched roofs and 1/3 in the form of leaf and stalk point. According to the national supply company [22] the production of Brazilian sugarcane 2016/2017 harvest was around 657,180,000 ton; harvested area has been estimated at 9,050,000 hectares. The sugarcane industry was destined primarily to produce sugar and ethanol, but sustainable production practices in the industrial process have led to the obtaining of two new by-products bagasse and straw, both used in the power production, ethanol from second generation bioplastics, xylitol and others [23].

Bagasse is the most important solid by-product of the processing of sugarcane. Maliger et al. [24] claim that the dry residue is composed of 32–48% of cellulose, 23–32% of hemicellulose, 19–24% of lignin, and 1–5.5% ash. According to the authors [25], these values can vary according to the variety and age of sugarcane, soil type and fertility and the harvest system. Saidur et al. [26] report that the lignin content of cellulosic fuel is strongly correlated with the caloric content. The straw is another by-product of sugarcane and its use is in the experimental stage, unlike the straw residue that must be collected from the field. The amount of bagasse generated in the process is in the range of 250–280 kg per ton of sugarcane crushed and has 50% humidity [27, 28, 29]. According to Pellegrini et al. [30], the need for cost reduction coupled with the recovery of by-products of sugarcane, and the environmental pressures have made a useful by-product residue to fuel CHP system. In fact, the generation of thermal and electric energy has been a practice routine at ethanol mills for decades and this use is not unique to Brazil. A ton of sugarcane produces on average 120 kWh using bagasse as fuel; this value can vary depending on the quality of the bagasse, crop season, the variety of sugarcane, kind of soil, CHP facilities, types of boilers and turbines, content humidity, and so on. [31].

The straw mixed with the bagasse is transported to the plant, where the separation of the vegetable and mineral impurities is carried out through the Dry Cane Cleaning System (SLCS). After separation, the straw together with the bagasse is transported in the same mat to the boiler or destined to the storage. According [32] if all the straw were left in the field can compromise the sprouting of the pests in large quantity, thus the removal of part of this vegetable waste is appropriate. The ideal is to collect 50% of the straw, which facilitates the management of fertilizer knuckle-dusters, favors the sprouting of sugarcane, inhibits the hosting of pests and reduces the risks with fires [33] to avoid the partial collapse of the straw, keeping an adequate amount to cover the ground. Therefore, this action protects the soil against erosion and direct radiation, increases the rate of water infiltration, reduces evaporation and perspiration and improves the control of plants weeds.

The straw added to the bagasse significantly increases the production of bioelectricity. Thus, in the case of the addition of 10% straw, with a moisture content of 15%, the production of electric energy would increase up to 23% and, when all the available straw is added, the power generation would increase by 102%. Inside the mills the consumption of electromechanical energy required to process 1 ton of sugarcane must be at least 28 kWh, but depending on the technology used up to 35 kWh may be required [34].

The mechanization of the harvest was made official with Act 11,241, dated September 19, 2002, gradually eliminating the use of fire as a facilitator of sugarcane cutting in areas susceptible to mechanization with declivity of less than 12% [35]. With the changes occurring, the mechanized harvest eliminated the emission of particulates and generated straw, which is now used as fuel in the generation of electric energy, if there is a surplus it is commercialized in the market.

2.3. CHP generation at sugar and ethanol mills

A study made by International Renewable Energy Agency [17] identifies three crucial factors to determine the use of biomass to power generation, they are: (1) the biomass storage, which can be in a variety of ways and has different properties impacting its use in generation of electrical energy, (2) biomass conversion; it comes from processes in which biomass is stocked in the form of chemical energy that will be used to generate heat and/or electric power and (3) power generation technologies.

The production incremental innovation of the sugarcane mills has come from genetic improvement technologies, modern machines and equipment, and energy efficiency measures allowed the development of the third product of sugarcane, the electric energy. The viability of biomass CHP plants is usually governed by the price of electricity and the availability and cost of the biomass feedstock. Although many sources of biomass are available for co-generation, the greatest potential lies in the sugarcane and wood processing industries, as the feedstock is readily available at low cost and the process heat needs are onsite [36]. Around the world, the rapid growth of the small-scale renewable market means that renewable power generation is rarely well-balanced.

Bioelectricity in Brazil has great challenges to face, but there are also great chances of establishing itself as a safe and reliable alternative in the supply of electric energy, especially to complement the drought season of the Southeast/Midwest region. The opportunity cost in the electricity market has been favorable, especially in the spot market. The rainfall regime in the mentioned region has been very irregular in the last 5 years, due to the climatic phenomenon called El Niño. Therefore, the useful volume or energy load in the form of water at hydroelectric plant reservoirs has decreased significantly and, with this, the threat of a blackout became more constant.

In Brazil, CHP facilities have bagasse as the main fuel used in sugar and ethanol mills. CHP systems are known as the simultaneous production of thermal, mechanical and electrical energy, in which a primary energy source feeds a thermal equipment that turns the chemical energy of the fuel into a mechanical shaft driven by the combustion reaction, which is then

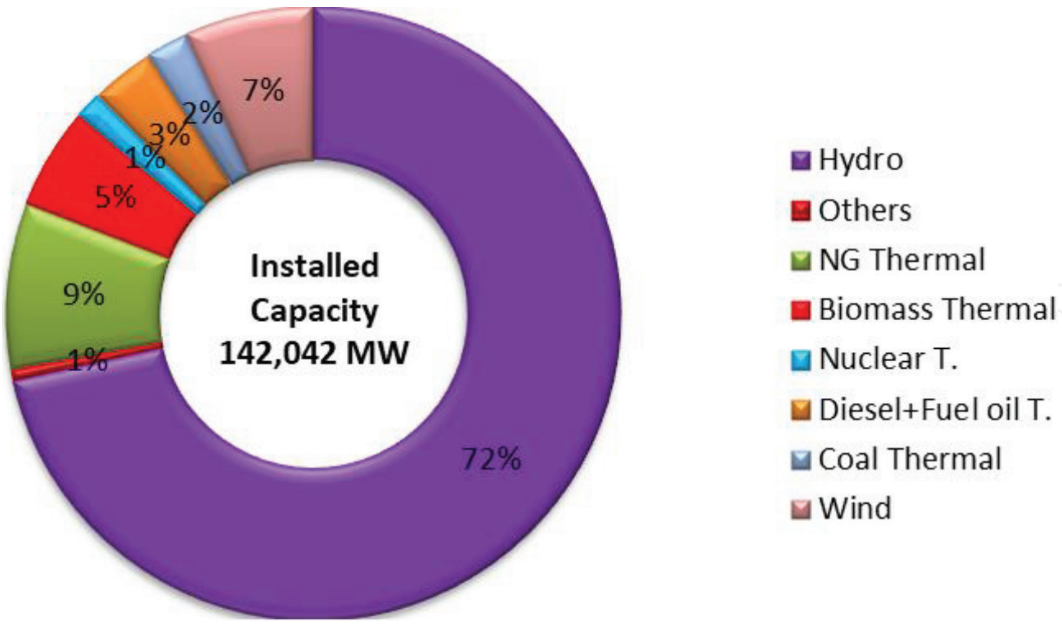

Figure 3. Rankine cycle in the CHP process at the Brazilian sugar and ethanol mills.

converted into energy through generators [37]. The technology adopted in the co-generation of the sugar-energy plants, the new denomination of the sugar and ethanol mills is the Rankine cycle [38, 30] due to the need for thermal, mechanical and electrical energy (**Figure 3**).

Carvalho and Pontes [39] complement that this technology uses water as the working fluid. The water is pumped to the boiler to release thermal energy in the form of steam; with temperature (1000–1300°C) and high pressure, the thermal energy goes through an expansion process in the turbines for the conversion of thermal energy to mechanical energy and after that to power energy. For authors such as Pellegrini et al. and [30], Ensinas et al. [40], the CHP system aiming only at self-sufficiency is of low efficiency because it uses boilers of 21 kgfcm^{-2} and 300°C, with backpressure turbines that are responsible for the industrial electromechanical demands of the plant. On the other hand, to produce surplus electric power, the units use boilers above 42 kgfcm^{-2} and extraction-condensation turbines.

The determinant factor for greater generation of electricity surplus is the configuration adopted by the CHP system, which Alves et al. [34] describe as the backpressure steam turbine (BPST) system. This system is designed to meet the energy demands of the process and operates only during the sugarcane harvest. Sugar and ethanol mills to produce surplus electric energy adopt the backpressure steam turbine system and condensing extraction steam turbine (BPS-C), which is indicated to generate steam of high pressure; thus, thermal and electrical energy are produced for meeting the demand of the plant and still have surplus electricity to trade at the market. This system operates with boilers above 67 bars with a steam outlet temperature of around 540°C. They are automatic control extraction-condensation turbines and the combination of backpressure steam turbines with axial flow condensation turbines. In modern boilers, the burning is made in suspension, with rotating grates, pin hole, tipper or fluidized bed, which allows biomass conversion efficiency. According to Bocci et al. [41], fluidized bed boilers allow greater efficiency in the conversion, generate more electricity due to the more complete burning of the fuel. According to Castro et al. [42], the use of high-pressure boilers and efficient steam turbines allows to increase power generation by providing surplus electricity .

2.4. Power energy generation from bagasse and straw

In Brazil, the production of electricity from alternative sources has been supported by Act 10,848 of March 15, 2004 [43]. This law provides for the sale of electric energy to increase the participation of wind, biomass and small hydroelectric power plants (SHPs) in the National Interconnected Electric System (NIS). The generation obtained from sugarcane biomass is managed by the Incentive Program for Alternative Energy Sources (PROINFA), described in Decree No. 5025 of March 30, 2004 [44].

Regarding the electric energy delivered by the national electric system operator (ONS), in 2016, it reached the value of 570,562 GWh. Hydroelectricity still prevails with the largest generation share, with 71.7% of the supply. Thermal plants have an 18.9% stake, of which 48% of them operate with natural gas, 38% with oil derivatives, 13% with coal and 1% with other sources. Biomass-fired CHP system accounts 8.9% of the electricity supply, 78% of which comes from the combustion of sugarcane bagasse, 20% from forest residues and 2% from others biomass. Power production from wind turbines is 3.6% and, finally electric energy supply from solar facilities is 0.2% (**Figure 4**).

The cost of power generation of a CHP plant is always much higher than a configuration of only one power plant. There are intrinsic factors to the CHP systems, installed at the sugar-energy mills, which increase the final cost of the kWh generated. Among them, the following can be included in the biomass storage system; in the case of bagasse, the cost usually varies between US$ 10.00/ton up and US$ 160 per ton [17]. The burning costs range in US$ 0.06–0.29/kWh. Other costs that can be considered are equipment costs, financing costs, operation, and maintenance costs (usually in the range of 20% of installed costs).

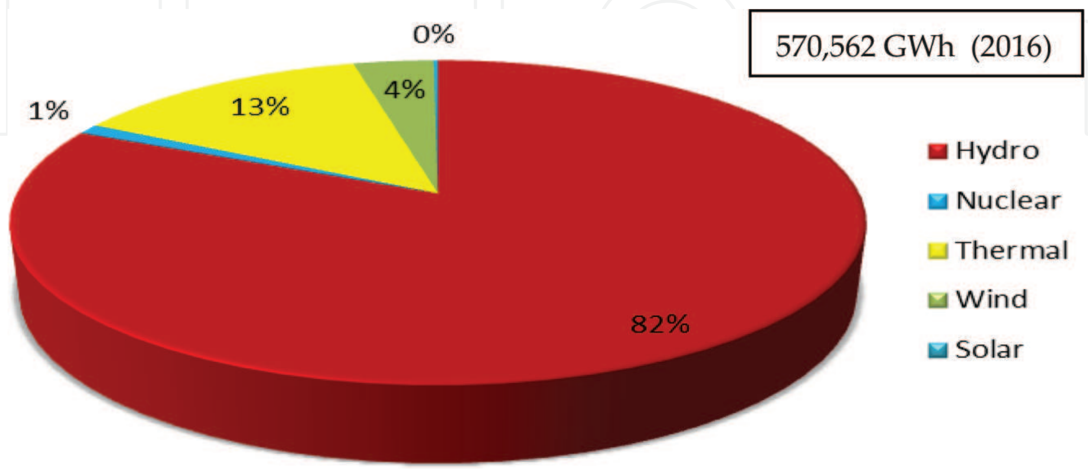

Figure 4. Power production by source.

Item	Unity	Quantity
Sugarcane harvested	Ton	657,184,000
Bagasse available with 50% humidity (280 kg per sugarcane ton)	Ton	184,011,520
Bagasse for starting in the boiler after maintenance or next harvest (5%)	Ton	9,200,576
Bagasse available for CHP generation	Ton	174,810,944
Straw available potential for CHP generation (310 kg per sugarcane ton)	Ton	101,863,520
Power generation potential using bagasse (0.000429 GWh/tonne of bagasse × 174,810,944 tonne bagasse)	GWh	74,994
Electric energy needed to meet internal demand of the mills (0.00003 GWh/ton of sugarcane) × 657,184,000 ton of sugarcane	GWh	19,715
Potential of electrical energy available from bagasse-fired	GWh	55,279
Potential of electrical energy available from straw-fired with 15% moisture	GWh	56,384
Total electric energy available (bagasse + straw)	**GWh**	**111,663**

Table 1. Potential of power generation based on the quantity of bagasse and straw of the last harvest 2016/2017.

Sugarcane production in the 2016/2017 harvest was 657,184,000 tons [22]. Based on the authors [27, 28, 34, 45], we estimated that 184,011,520 tons of bagasse and 203,727,040 tons of straw could be extracted. Of this total, 5% of the bagasse must be reserved for the sugar and ethanol plants to have bagasse stock required to start the boilers or the mandatory maintenance shutdowns. Therefore, 174,810,944 tons would be hypothetically available to produce power energy, aiming at the energy self-sufficiency of the plant and its commercialization at electric energy market. Then, of this amount of bagasse, it is possible to produce 74,994 GWh, of which 19,715 GWh are destined to meet the power demand of the mills, the remaining 55,279 GWh is destined for negotiation at electricity market.

About the straw, it is indicated by scientific literature to leave 50% of the biomass on the field; therefore, the amount of straw that can be harvested would be 101,863,520 tons. Modern boilers allow greater efficiency in conversion and would support the addition of 50% straw with a moisture content of 15%. The arrangement of the boilers into the CHP system would allow an increase of 36,669 GWh, this way the potential electric power generated by the biomass mix bagasse-straw would increase to 111,663 GWh. The current norms of electricity regulation in the world assume special relevance in the processes of environmental control needed to soften global warming and provide sustainable economic growth [13] (**Table 1**).

3. Structure of the Brazilian electricity sector

In Brazil, the structure of the electricity sector is hierarchical, and the Ministry of Mines and Energy (MME) is responsible for formulating policy adjustments for the energy sector. It is regulated by the National Electric Energy Agency (ANEEL), which supervises the electric sector, ensuring the quality of services rendered, the universalization of service and the establishment of tariffs for final consumers. Below ANEEL is the National System Operator (ONS) that coordinates and controls the generation and transmission of electricity from the interconnected system. The Electric Energy Trading Chamber (EETC), under the supervision of ANEEL, is responsible for contract management, short-term market (STM) liquidation and energy auctions.

3.1. The Brazilian electricity market

Institutional arrangements therefore define the way in which an economic system coordinates a specific set of economic activities. In the last decades, energy market players have made many agreements to address energy issues, ranging from increasing international energy exchange to reducing emissions and increasing flexibility in the distribution of electricity amid growing resources of intermittent renewable energy [46]. The institutional arrangements that regulate the commercialization of electric energy are important for development policies, especially for those that require cooperation of public and private agents. The Brazilian energy matrix diversified, with a variety of generation sources, to small-scale projects alongside those of large size, distributed in the geographic regions of the country [47] with increased participation of the private sector [48]. The Brazilian electric sector consolidated the rules trough Act No. 10,848 [43] and Decree No. 5163 [49]; both regulate the sale of electric energy between concessionaires, permit holders and authorized power services and facilities as well as of these agents with their consumers at SIN. The dynamic of the market occurs through regulated contracting or free agreement about electricity trading. In this specific context, contractual mechanisms have been developed to diversify the inflow of private capital investments.

3.2. Arrangement in the commercialization of electric energy

The commercialization of electricity in Brazil is carried out in two market spheres: The Regulated Contracting Environment (RCE) and the Free Contracting Environment (FCE); all contracting environments need to be registered in the EETC and serve as a basis for accounting and settlement of differences in the short-term market (**Table 2**).

	Free environment	Regulated environment
Participants	Power producers, marketers,	Power producers, distributors and marketers. Marketers can trade power energy only in existing energy auctions
Hiring	Free and special consumers	Held by means of energy auctions promoted by CCEE under ANEEL delegation.
Type of contract	Free negotiation between buyers and sellers	Regulated by ANEEL, called the Regulated Contracting Environment (RCE)
Price	Agreement freely established between the parties	Fixed in the auction

Table 2. Differentiating between the two marketing schemes.

3.3. Regulated contracting environment (RCE)

The bilateral agreements through Electric Energy Trading Contracts in the Regulated Environment are opened according to the national energy planning and in two modalities, current electric energy and new power generation [50]. At the end of the auctions, the commercialization of electric energy inside the RCE is done through standardized bilateral contracts, entered between each seller and all concessionaires, permit holders and authorized public service providers [51]. According the Federal Law 10,848 [43] current electric energy agreements have a duration of 1–15 years, while new power generation contracts can be from 15 to 35 years. Decree No. 6048, dated February 27, 2007 [52], regulated the auctions of renewable sources like wind, biomass, and electric energy from small hydroelectric plants—with a term of 1–5 years in the start and duration of 10–30 years.

3.4. Free contracting environment

The commercialization of electricity in the Free Contracting Environment is carried out through the purchase and sale of electric energy between concessionary agents, permission holders and generation-authorized buyers and sellers, traders, importers of electric energy, on the one hand, and free or special consumers, on the other hand [51]. All contracts negotiated in the ACL have their conditions of service, the price and other contractual clauses freely negotiated between the parties. Free consumers are considered those whose contracted demand is equal to or greater than 3000 kW, serviced at a supply voltage above 69 kV. These customers can acquire electric energy from any incentive and/or conventional source [53]. According to Araujo et al. [54], the special consumers are those whose contracted demand is greater than or equal to 500 kW, individually or by actual communion (same address) or law. In Brazil, the environment that allows producers and traders to freely sell electric energy is the short-term market [51].

3.5. Short-term market

The EETC measures the amount produced or consumed by each agent. The differences determined are settled in the short-term market (STM), or spot market, at the settlement price of differences (SPD) that is determined weekly for each load level, limited by the maximum and minimum price of each assessment period of the market [51].

To trade electricity in the short-term (spot) market, agents must inject into the SIN the electricity produced, which is accounted by EETC. The Electric Energy Trading Chamber performs three tasks: (1) manages all contracts for the purchase and sale of energy, (2) records the daily measurement of what is generated in the plants and consumed by all agents participating in the system, (3) accounts for amounts payable and receivable based on purchase and sale agreements and effective generation and consumption. With the amounts calculated, the EETC carries out the liquidation, which is the settlement of accounts between the creditors and debtors' agents. These differences are determined by the amount of the settlement price of differences (SPD) [51]. This price is used to value the energy not contracted among the agents of EETC (leftovers or differences) in the short-term market. The credits and debits resulting from this contracting are settled between the agents in a centralized way in the EETC. The sale or purchase price of the energy that exceeds or is lacking in the contracts is added to the system service charges (SSC) [54]. The settlement price of differences reflects the marginal cost of new electricity in the system. In the rainy season, when supply and demand for electricity in the country are balanced, the price of electric power is lowered and, consecutively, the SPD as well. When the water reservoirs are low, there is a lack of energy and the thermal plants are linked to a high marginal cost, pushing up the energy price and the SPD [55].

The crisis in the Brazilian electricity supply, which occurred due to climate issues, lack of planning and investments by the federal government, has been causing losses to the public coffers and society. During the period from December 2013 to April 2014, the market value of the SPD in the Southeast/Midwest region increased from US$ 0.09232 to US$ 0.26121 per kWh. This increase was due to the entry into operation of many thermal power plants caused by the low level of water in hydroelectric reservoirs [56]. Between 2015 and November 2017 there was no contracting of new energy from biomass, wind and solar. During the period from 2015 to August 2017, the behavior of SPD prices was lower than US$ 0.07936/kWh, but in November 2017, prices reacted and reached US$ 0.16946/kWh [51].

4. Conclusions

Hypothetically, the amount of carbon dioxide absorbed could reach 276.03 million of CO_2 equivalent tons, resulting from 657,184,000 tons of sugarcane harvested in 2016/2017. Regardless of installed capacity, all sugar and ethanol plants produce energy to be self-sufficient, in terms of thermal, mechanical and/or electrical energy. Discounting this domestic demand, the electric energy produced is injected and sold in the National Interconnected System (SIN). The most commonly used fuel in the boilers of sugarcane plants is bagasse, the straw is a potential fuel in the experimental stage. The energy potential of the straw should be considered with caution, since the sugar-alcohol boilers are limited to the addition of this fuel to the bagasse; in some cases the mixture is made up to 30% straw. Therefore, the possibility of using the full potential of the electric energy through the burning of bagasse and straw requires the adaptation of the boilers and the selection of the best straw collection system in the field, considering the economic viability.

The potential power generation from the combustion of bagasse and straw will be 111,558 GWh; this energy would be equivalent to 20.4% of the electric energy delivered by the national electric grid operator (ONS) in 2016. Nowadays, discussing energy security has another nuance that of preventing the market from collapsing, especially by the eventual lack of electricity supply, whether due to climatic issues or armed conflicts [57, 59]. Brazil suffers more with the first question, the dependence of the availability of water in the hydro basins makes it very vulnerable. Fortunately Brazil has several renewable sources that could hold the matrix of the power energy supply clean. As for the electric energy market and the way to market bioelectricity, we may claim that there are endogenous risks such as the technology chosen, the quality of biomass, tax exemptions, but, there are exogenous risks too, such as the performance of the country's economy, the volatility of electric energy prices, the political context, and so on. However, in Brazil, bioelectricity comes definitively to stay; therefore, its competitiveness should be put to the test, but the prospects of success seem to be attractive.

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