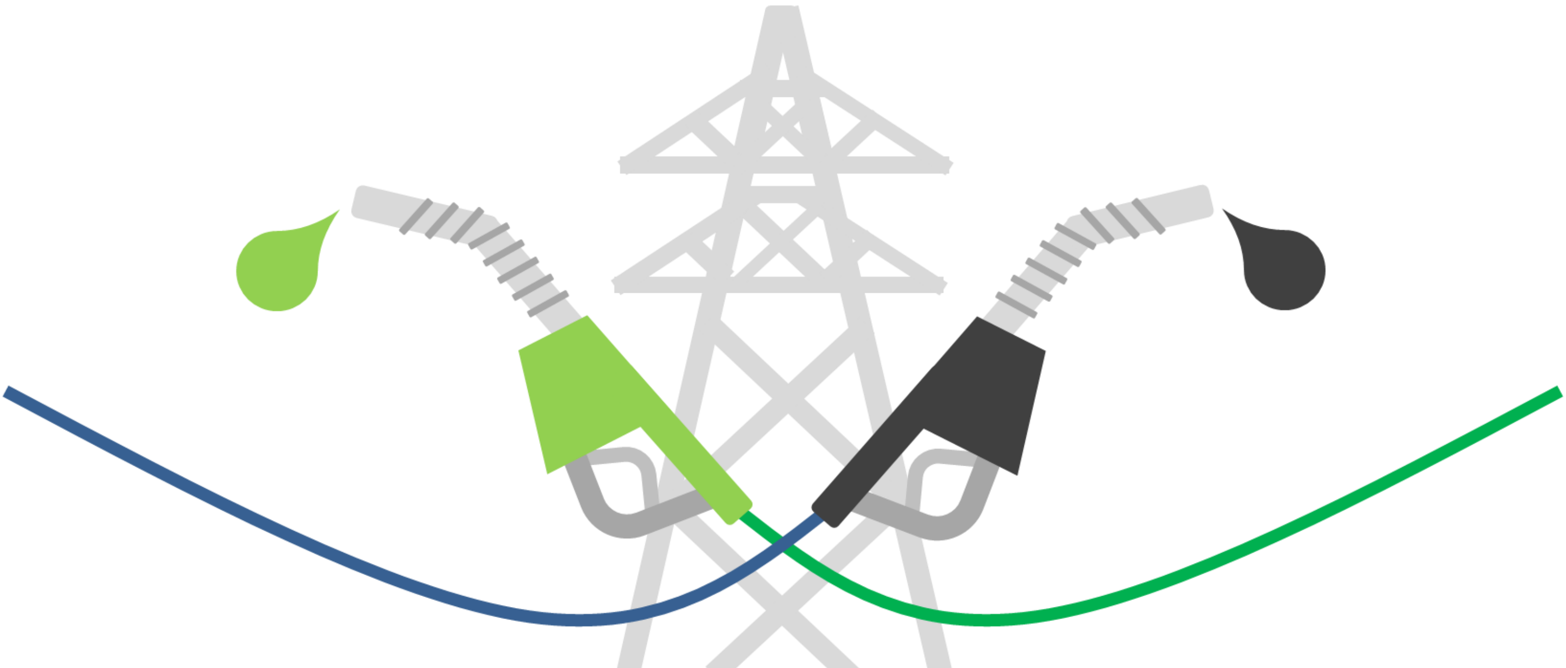
MINISTRY OF MINES AND ENERGY

ANALYSIS OF BIOFUELS' CURRENT OUTLOOK

YEAR 2019



Rio de Janeiro, July 2020

Empresa de Pesquisa Energética

MINISTÉRIO DE MINAS E ENERGIA

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Analysis Of Biofuels' Current Outlook

Year 2019

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President
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Erik Eduardo Rego

Corporate Managment Director
Angela Regina Livino de Carvalho

URL: www.epe.gov.br

Head Quarters
SAN – Quadra 1 – Bloco B – Sala 100-A
70041-903 - Brasília – DF

Central Office
Av. Rio Branco, 01 – 11º Andar
20090-003 - Rio de Janeiro – RJ

Executive Coordenation
Angela Oliveira da Costa

Technical Coordenation
Angela Oliveira da Costa
Rafael Barros Araujo

Technical Team
Angela Oliveira da Costa
Dan Abensur Gandelman
Euler João Geraldo da Silva
Juliana Rangel do Nascimento
Leônidas Bially Olegario dos Santos
Marina Damião Besteti Ribeiro
Paula Isabel da Costa Barbosa
Rachel Martins Henriques
Rafael Barros Araujo

Administrative Assistent
Sergio Augusto Melo de Castro

Intern
Igor Manzolillo Horta Fernandes Francisco

EPE-DPG-SDB-Bios-NT-01-2020-r0

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Presentation

The Energy Research Office presents its eleventh edition of the Biofuels Conjuncture Analysis, focusing on the year 2018. Every year, the publication consolidates the most relevant facts related to biofuels, which occurred in the year prior to its disclosure. It is launched in the second quarter, after the end of the sugar-energy crop season and the consolidation of statistics of the most important agencies in the area. In the current period of exceptionality, it should be noted that Covid-19 impacts were noticed in the second quarter of 2020, and will be further addressed in the next edition of this document.

The main topics covered are: ethanol supply and demand and its production and transportation infrastructure; biodiesel market; share of bioelectricity in the national matrix and in energy auctions; biofuels international market; expectations about new biofuels; greenhouse gas emissions avoided by the use of these renewable energy sources, and the monitoring of the National Biofuels Policy (RenovaBio).

This edition, besides assessing the main events that took place in 2019, presents an attached text on the productive integration between energy and food and the resilience of the agro-energy sector, through a brief assessment of Covid-19 pandemic impacts on the biofuels sector.

CONTENTS

List of Charts

List of Tables

List of Figures

1. Ethanol Supply

In 2019, Brazilian ethanol production was 36 billion liters, a new historical record, representing an 11% increase over 2018. Sugar production grew by 5%, reaching 30 million tons. The sugarcane sector processed 654 million tons of sugarcane, production 7.5% higher than in 2018, and similar to that shown in 2015 (MAPA, 2020).

The 2019/20 crop had a larger destination of the mix for ethanol production, similarly to what was observed in the previous one, due to the maintenance of the low level of sugar prices in the international market and the PE/PG ratio favorable to hydrous ethanol consumption, as will be presented in the section 3.1 (CONAB, 2020a).

It should also be noted that the domestic corn ethanol production again registered a significant growth, reaching 1.3 billion liters in 2019 (UNICA, 2020a).

A reduction in sugarcane milling is expected for the 2019/20 crop, due to the recent market fluctuations and the consequences of the new coronavirus pandemic, despite the expectation of favorable climatic conditions. In order to take advantage of the promising price prospects in the international sugar market and minimize the effects of the drop in demand and in the ethanol price, it is estimated that production will be more directed towards the commodity, with its mix evolving from 34.9% to 42.4%. Moreover, there are some difficulties in sugar production in other important global players (CONAB, 2020a) (CONAB, 2020b). It is noteworthy that these expectations of the National Supply Company (CONAB) already consider some impacts caused by Covid-19 pandemic, however its effective developments can only be measured throughout the year.

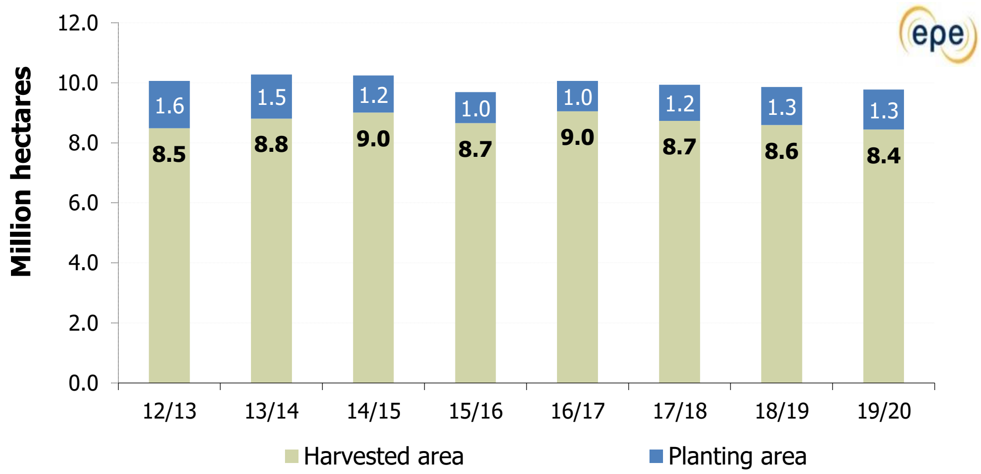
1.1. Sugarcane Area, Agricultural Productivity and Yield

Area

According to the National Supply Company (CONAB), the total area harvested by the sugar-energy sector in the 2019/20 crop season was 8.4 million hectares, a 1.7% decrease compared to the previous year. Leased areas not suitable for mechanized harvesting have been discontinued sugarcane planting and, as a result, have been allocated to other crops, such as soybeans (CONAB, 2020a) (CONAB, 2020b).

Since the 2013/14 crop season, sugarcane harvested area has been fluctuated around 8.8 million hectares (Chart 1). The main reasons include the return of leased areas (and planting of other crops), existence of a few greenfield projects, and shutdown of several existing production units. The planting area was similar to that observed in the previous crop season, 1.3 million hectares. With the exception of Northeast region, all other regions presented larger planted area. The Center-West region should be highlighted, with an 11.9% increase in relation to the previous period (CONAB, 2020a) (CONAB, 2020b).

Chart 1 – Sugarcane harvested and sugarcane planting area (Brazil)



Source: EPE from (CONAB, 2020a) (CONAB, 2020b)

For the 2020/21 crop season, CONAB estimates that the area might remain around 8.4 million hectares. The main producing state, São Paulo, will probably present a 1.2% reduction in the area (CONAB, 2020a).

Agricultural Productivity

The average productivity of the Brazilian sugar-energy sector in the 2019/20 crop season was 76.1 tc/ha, a 5.4% increase compared to the previous one (72.2 tc/ha). The Center-South region, which accounted for 92% of total production, presented a 2.7% increment. In the North-Northeast region, the increase was of 10%. Improved productivity is due to favorable climatic conditions during the crop season, as well as investments in renovation, planting improvements and introduction of new varieties (CONAB, 2020a).

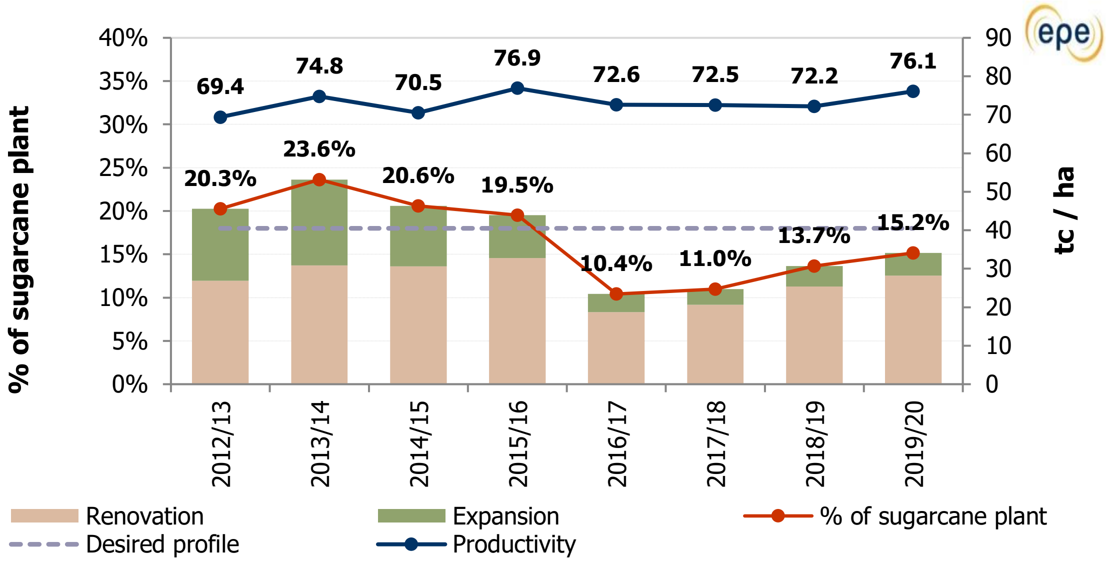
Evaluating the performance of sugarcane production also requires verifying how the sugarcane cultivation area is distributed, which is differentiated into: reformed, reforming, expansion, and ratoon sugarcane area.[1] The share of sugarcane plant[2] (sugarcane plant/total sugarcane) considered ideal is 18%, a percentage related to a renewal of sugarcane after five crops (UNICA, 2017).

Chart 2 presents the evolution of the share of sugarcane plant in the total sugarcane harvested in Brazil, excluding the sugarcane area under reformation (CONAB, 2020a) (CONAB, 2020b).

[1]Reformed area is that which was recovered in the previous crop year and is available for harvest. Area under reformation is one that will not be harvested, as it is in recovery period for sugarcane replanting or other uses. Area of expansion is the class of sugarcane crops that, for the first time, is available for harvest. Ratoon-sugarcane area is one that has been through more than one cut.

[2]Sugarcane-plant area is equivalent to the sum of the reformed and expansion areas.

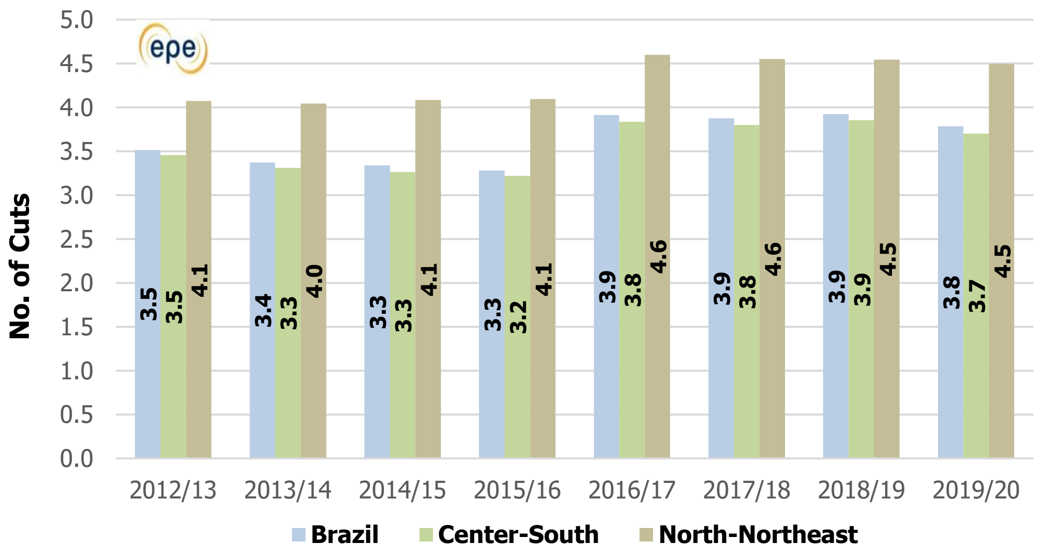
Chart 2 – Share of sugarcane plant in total harvested area and yield (Brazil)



Source: EPE from (CONAB, 2020a) (CONAB, 2020b) and (UNICA, 2017)

It is verified that, despite the increased participation of sugarcane plant in the 2019/20 crop season compared to that observed in the previous one, reaching 15%, it still remains far from the ideal value (18%). Improved agricultural productivity was accompanied by a 4% reduction in the average age of Brazilian sugarcane plantation[3], as can be seen in Chart 3. The marked difference between the North-Northeast and Center-South regions is also noteworthy.

Chart 3 – Average age of sugarcane plantation (Brazil and regions)



Source: EPE from (CONAB, 2020a) (CONAB, 2020b)

[3]The higher the average cutting stage (sugarcane-plantation age), the smaller the area with younger sugarcane and, consequently, the lower the average productivity, since this latter decreases with each cut.

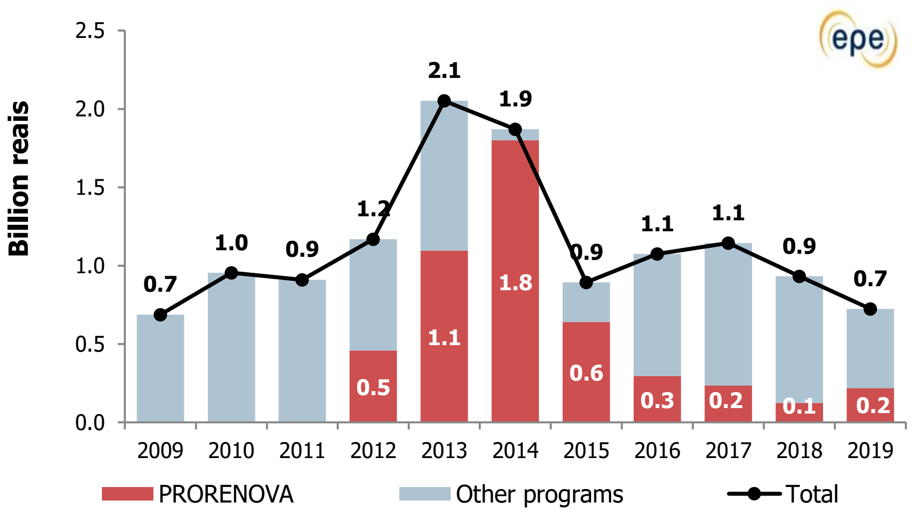
The previous chart shows that the average age of sugarcane plantation in Brazil had been showing a gradual fall from 2011/12 to 2015/16 crop season. However, it increased by 19% in the 2016/17 crop season (3.9 cuts), a level that has been maintained.

For the 2020/21 crop season, the productivity estimated by CONAB is 75 tc/ha, a 1.5% decrease in relation to the previous one (CONAB, 2020a).

Improvements in the average age of sugarcane plantation from 2012 onwards converge with the introduction of BNDES' PRORENOVA (Support Program for Renewal and Implementation of New Sugarcane Plantation).[4] The limit per financing operation is R$150 million, limited to 80% of the project value. Exclusive use for planting protected varieties or potential clones of sugarcane (sugarcane plant) continues in force (BNDES, 2020a).

Chart 4 shows the total amount raised from public financing for sugarcane cultivation, in billions reais. From 2012, this amount corresponds to PRORENOVA plus the values of other programs in which agricultural machinery and implements are purchased.

Chart 4 – Amount raised from public funding for sugarcane cultivation



Source: EPE from (BNDES, 2020b)

As shown in Chart 4, BNDES' total disbursements in the agricultural area for sugarcane cultivation in 2019 were 0.7 billion reais. The chart shows that this total amount is at the same level observed in 2009, the smallest value registered so far (BNDES, 2020b). In 2019, PRORENOVA registered a 75% increase when compared to 2018.

As for total investments in the sugar-energy segment, there was a slight reduction,

[4]In addition to PRORENOVA, there are other BNDES' programs that can be used by the sugar-energy sector: PAISS (Joint Plan for Supporting the Industrial Technological Innovation of the Sugar-Energy Sector), BNDES Finem, Fundo Clima, and ABC (Low Carbon Agriculture) Program (BNDES, 2020c).

totaling R$ 1.9 billion in 2019. It should be noted that the investment in the sector reached its historic peak in 2010, with the amount of R$ 7.4 billion.

In an important action for investments in the biofuels sector, the Ministry of Mines and Energy approved the issuance of encouraged debentures through Ordinance No. 252, of June 17th, 2019. With this instrument, companies can raise funds from the capital market to invest in the renovation of sugarcane plantations and also in their industrial facilities. In 2019, seven companies had their issuance of securities authorized by the MME (MME, 2019b).

Sugarcane Yield (ATR[5]/tc)

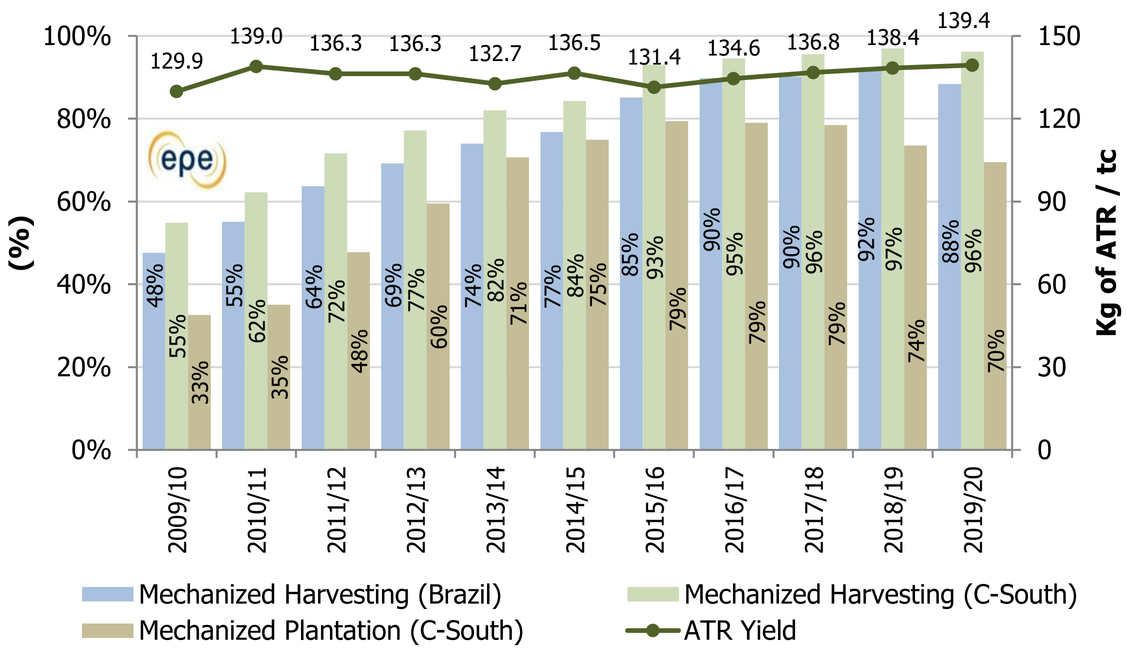
Sugarcane yield in the 2019/20 crop season was 139.3 kg ATR/tc, a 0.7% increment over the previous one (138.4 kg ATR/tc), the best record since the 2009/2010 crop season (CONAB, 2020a) (CONAB, 2020b). The Center-West and Northeast regions presented the highest growth, of 1.9%, and 1.0%, respectively, and the Southeast region presented a 0.3% decrease. Climatic conditions, crop age, mineral and vegetable impurities and the lag between deployment of the mechanized plantation and the sugarcane harvesting are the main factors that influence this indicator.

The mechanized sugarcane harvesting was implemented in the country mainly to achieve the goals imposed by environmental laws and agreements to reduce burning. However, it is observed that there was a mismatch between mechanization of harvesting and mechanization of planting, in addition to other operations related to its cultivation. Thus, there was an increment in the amount of mineral and vegetable impurities that is carried into the industrial unit, along with sugarcane, degrading its quality.

As indicated in Chart 5, in 2019, mechanization of harvesting in Brazil decreased from 92% to 88%. In the Center-South region, mechanized harvesting decreased from 97% to 96% (CONAB, 2020a) (CONAB, 2020b), while mechanization of planting fell even more, from 74% to 70%, maintaining the trend observed in the previous crop season (CTC, 2020). The combination of these two movements led to an increase in the lag in this producing region, which rose from 23% to 26% (CONAB, 2020a) (CONAB, 2020b) (CTC, 2020). Since the last crop, reduced share of mechanized planting is observed, in order to seek productivity recovery and cost reduction (due to the high consumption of seedlings and failures in planting with the use of machines), added to expansion in using MEIOSI technique (UDOP, 2019).[6]

[5] Total Recoverable Sugars.
[6] MEIOSI – Inter-rotational Method Occurring Simultaneously.

Chart 5 – Mechanized Harvesting and Planting x Sugarcane Yield



Note: Harvesting data were extracted from CONAB (CONAB, 2020a) (CONAB, 2020b), while the mechanized planting data were obtained from plants associated with CTC (CTC, 2020), which represent only a portion of the sugar-energy sector, not including suppliers. According to CTC (CTC, 2020), in 2019, the Center-South region had a 98.8% mechanized harvesting.

Source: (CONAB, 2020a) (CONAB, 2020b) , (CTC, 2020) and (UNICA, 2013a) (UNICA, 2013b) (UNICA, 2014a) (UNICA, 2017)

CONAB (CONAB, 2020a) estimates that the 2020/21 crop season will present the same yield.

It is important to highlight that the main component that interferes with the yield is the amount of total impurities (minerals and vegetables) present in the harvested sugarcane, due to the inadequate introduction of mechanization in agricultural processes, as mentioned above. In 2019/20 crop season, this content remained in 9.1%, concomitantly with that of vegetable impurities, which remained in 8.1%. As a comparison, the total impurity content in 2008 was 6.7% (CTC, 2020) (UNICA, 2013a)

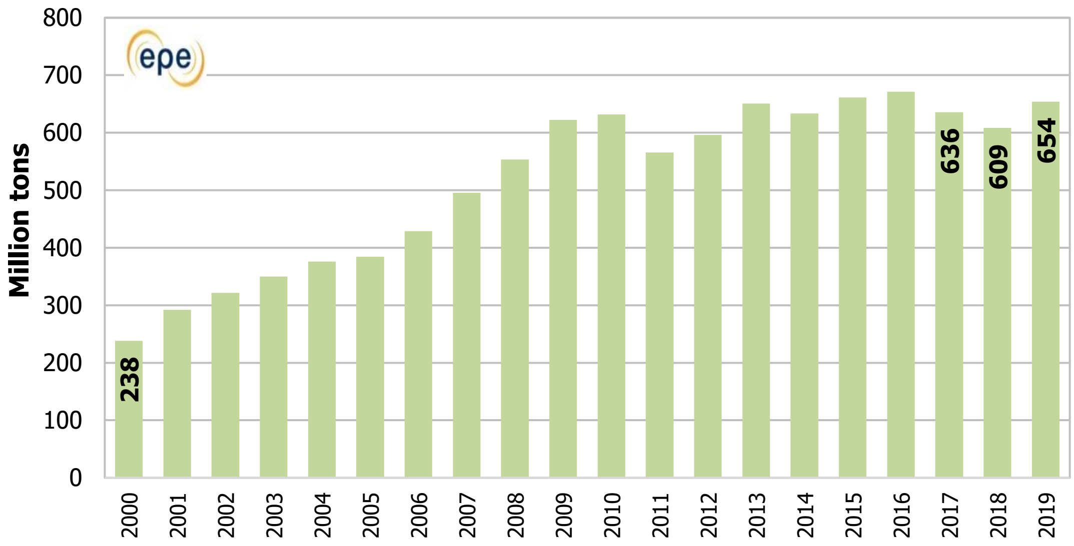
In this sense, varietal[7] and agronomic managements are essential to the best production performance in terms of productivity and yield, which should be combined with the equalization of crop mechanization. Some important actions in this regard are: adequacy of spacing between the sugarcane lines; size of the field to avoid trampling during harvester maneuvers; grouping of varieties and height of the swaths, to make the cut closest to the ground;[8] and planting varieties best suited for each type of soil and crop.

[7]For mechanized harvesting, the more upright the sugarcane remains, the lower the amount of plant and mineral impurities that will be taken into the industrial unit, given the cutting height adjustment of the tips on the harvester.
[8]Sugarcane has higher sucrose content near the ground.

1.2. Sugarcane Processing

Total processed sugarcane reached 654 million tons in 2019, 7.5% more than in 2018, as presented by Chart 6 (MAPA, 2020). It should be noted that the productivity improvement in this period offset the fall in the harvested area.

Chart 6 – Annual history of sugarcane processing



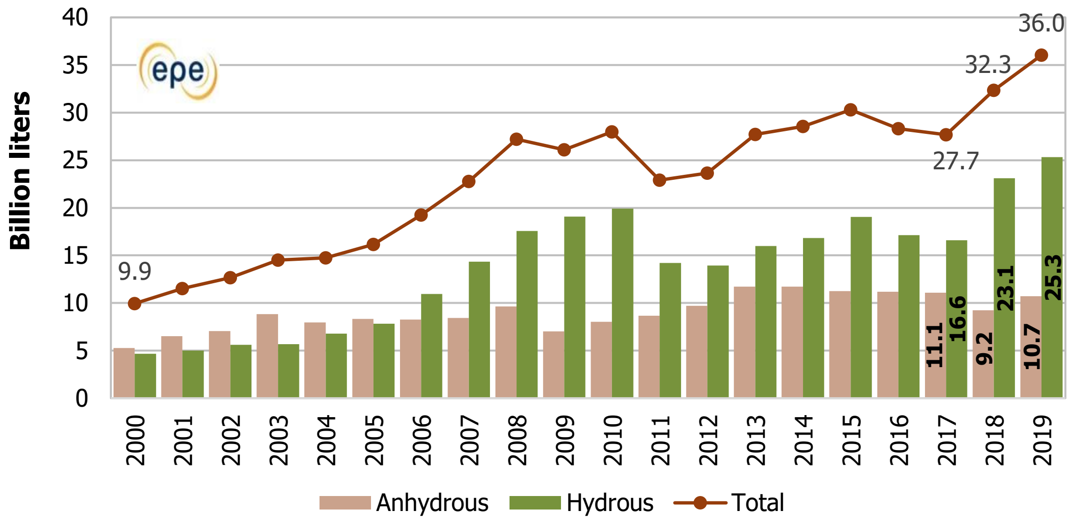
Source: EPE from (MAPA, 2020)

According to CONAB, from crop year perspective, the amount of sugarcane processed in 2019/20 (642.7 Mtc) was 4% higher compared to 2018/19 (CONAB, 2020b).

1.3. Ethanol production

In 2019, 36 billion liters of ethanol were produced, divided into 25.3 billion hydrous ethanol (10% increase) and 10.7 billion anhydrous ethanol (16% increase). Thus, the total volume of ethanol produced was 11% higher than 2018, reaching a second consecutive historical record, as illustrated by Chart 7 (MAPA, 2020).

Chart 7 – Brazilian ethanol production



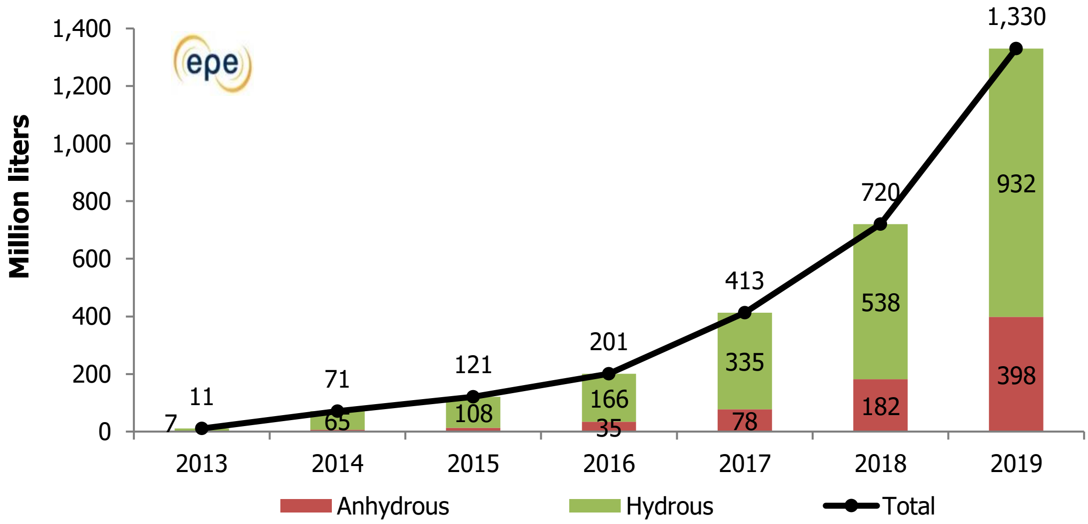
Source: EPE from (MAPA, 2020)

Ethanol production growth in 2019 was due to the following factors:

- Fall in sugar prices, as observed in the last years (more details in Item 1.4).
- Average prices of hydrous ethanol and gasoline type C more favorable to ethanol (more details in Item 3).

Particularly, ethanol from maize has shown a high growth in the last years (more than 10 times). Its production is concentrated in the states of Mato Grosso and Goiás and reached 1.2 billion liters in 2019 (see Chart 8), 85% greater than in 2018.

Chart 8 – Brazilian corn ethanol production



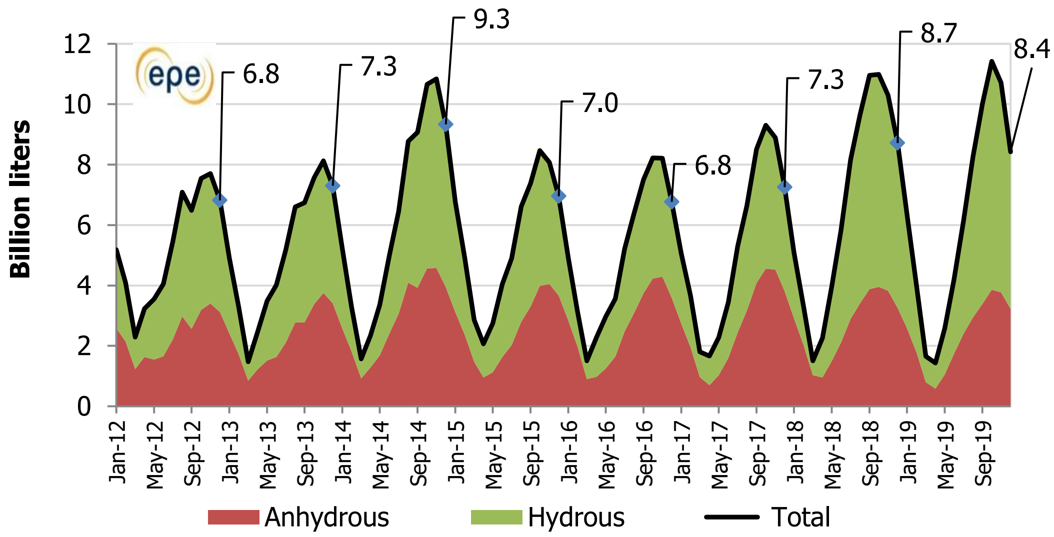
Source: EPE from (UNICA, 2020a)

From crop tear perspective, the value recorded in 2019/20 was 1.7 billion liters, and the estimates for 2020/21 crop season indicate that ethanol production from cereal will be 2.7 billion liters, a 61% growth, reaffirming its potential within the portfolio of options for the biofuels sector and for the Brazilian energy matrix (CONAB, 2020a).

Ethanol stock

Chart 9 displays the history of monthly physical stock variation[9] of ethanol reported to MAPA. It can be observed that the passage stock,[10] on December 31st, 2019, was 8.4 billion liters of ethanol. Of these, 3.2 billion were anhydrous ethanol, which corresponded to a 1% reduction compared to December 2018. In turn, hydrous ethanol had a 5% increase in stocks. In this period, the total volume of fuel ethanol consumed increased by 11%, which will be analyzed in Item 2 of this study (MAPA, 2020).

Chart 9 – Monthly evolution of physical ethanol stock



Source: EPE from (MAPA, 2020)

The current rules regarding the mandatory stock of anhydrous ethanol are established by ANP Resolution No. 719, of February 22nd, 2018 (ANP, 2018c). According to it, the minimum mandatory anhydrous stock for ethanol produced by the plants is 25% and 4% in January 31st and March 31st of each year, respectively, in relation to the total traded in the previous year. For distributors, it represents 10 days of commercialization, and the ANP is authorized to determine the extension to 15 days, if necessary for supply purposes during the off season.

The available stock of anhydrous ethanol observed on March 31st, 2020 was 1,067 million liters (MAPA, 2020), volume that meets that one stipulated by ANP.

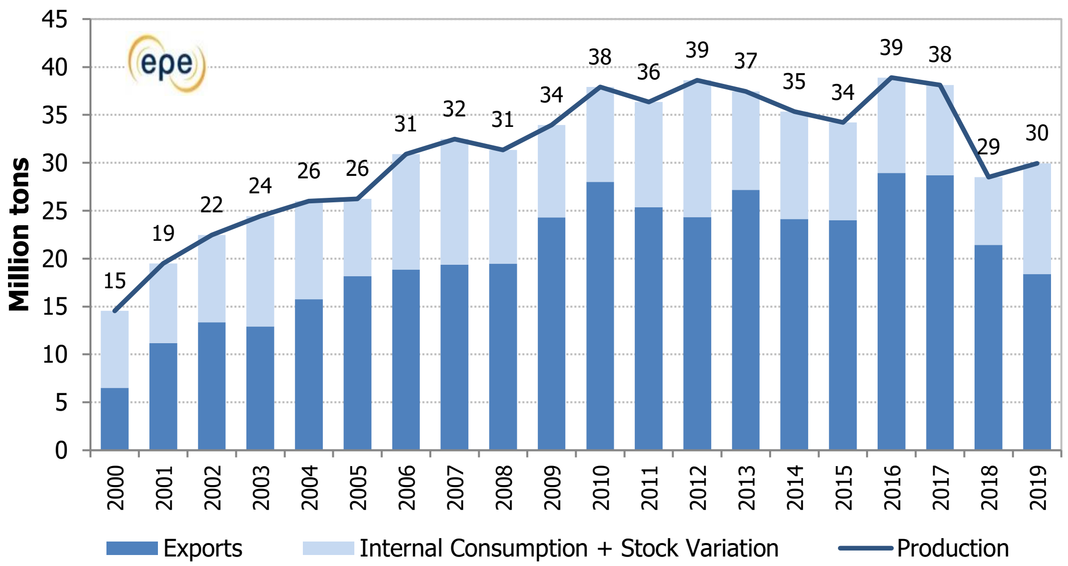
[9]Physical Stock is the actual volume stored in the production unit's tanks, including the volume already sold but not delivered.
[10]Passage stock corresponds to that stored in the production unit's tanks at the end of the calendar year.

In 2018, Draft Legislative Decree No. 61 (SENADO FEDERAL, 2018) proposed to make the hydrous fuel ethanol commercialization system more flexible so as to allow its suppliers to sell it directly to the dealers, without the need for the distributor as an intermediary agent. This matter has been the subject of much debate and is quite complex. In 2019, EPE prepared a study on the direct sale of hydrous ethanol, deepening the preliminary assessment carried out in the previous year (EPE, 2019d). The study pointed out that, in order for direct sales to be possible, changes in tax legislation and in the devices that regulate and inspect the functioning of the market become necessary.

1.4. Sugar production

In 2019, Brazilian sugar production reached 30 million tons (5% more than in 2018), as can be observed in Chart 10. Exports presented a fall of 3 million tons, while the "domestic consumption + stock variation" component increased by 4.5 million. In 2010, sugar exports were 18.4 million tons (14% reduction), the lowest since 2005 (MAPA, 2020)

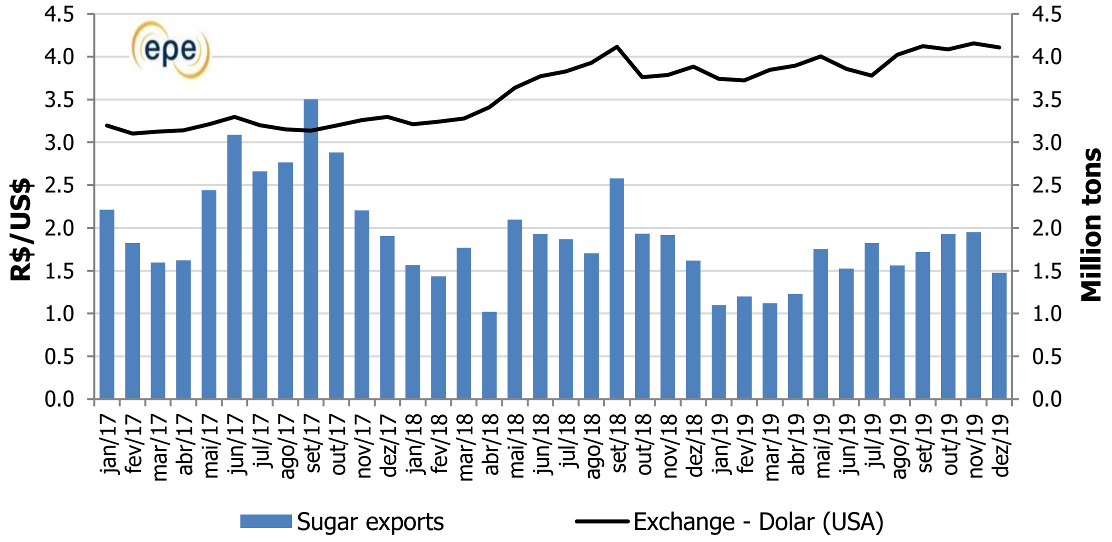
Chart 10 – Brazilian sugar production and exports



Source: EPE from (MAPA, 2020)

Chart 11 shows the behavior of Brazilian monthly sugar exports, which remained well below those observed in previous years, similarly to what was observed in 2018. It should be noted that the exchange rate of the dollar showed an upward trajectory during 2019.

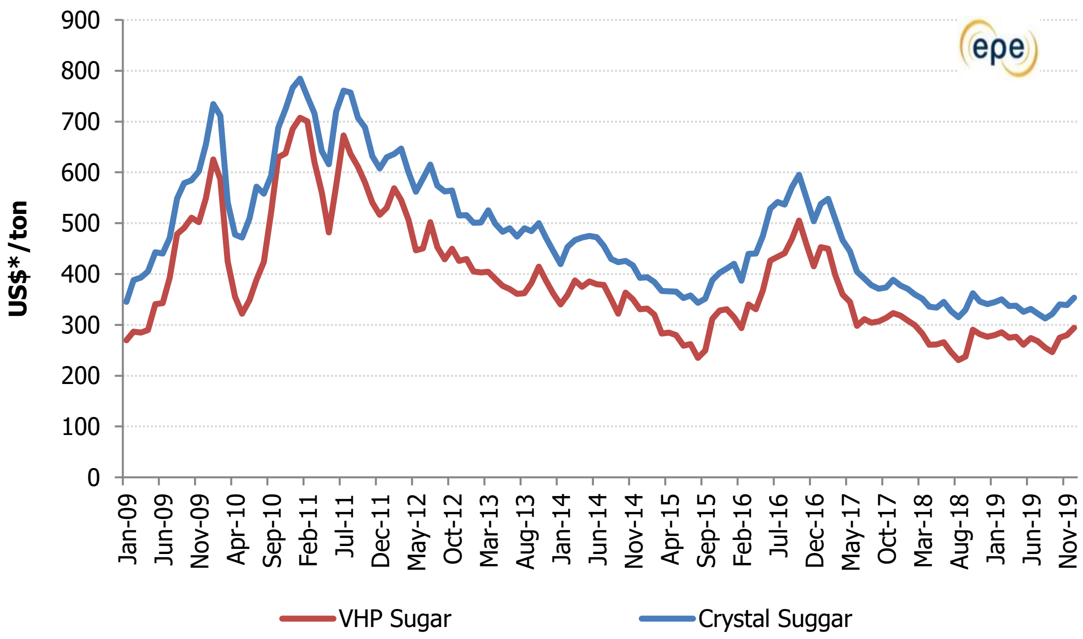
Chart 11 – Brazilian sugar exports and foreign exchange



Source: EPE from (MAPA, 2020), (MDIC, 2020) and (BC, 2020)

Regarding the average prices of VHP sugar (NYCSCE/ICE) and crystal sugar (LIFFE), there was a decrease of 1% and 3 % compared to 2018, respectively, as can be seen from the analysis of Chart 12. As of September 2019, sugar appreciated, with clear signs of a drop in world stocks.

Chart 12 – International prices for VHP and crystal sugar



Note: VHP Sugar: New York Stock Exchange (NYCSCE/ICE) – Contract 11; Refined sugar: and London Stock Exchange (LIFFE/ICE) – Contract 5.

Source: EPE from USDA (2020)

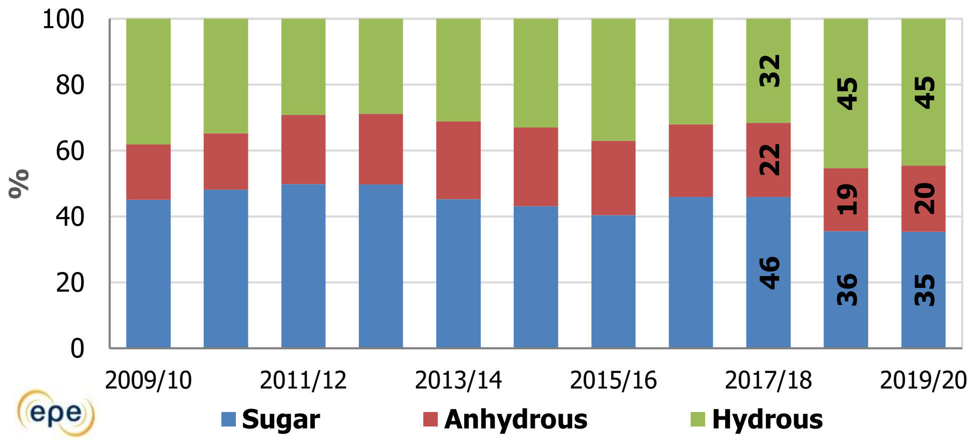
The 2018/19 world crop season had a negative balance (supply/demand), in the order of 800 thousand tons, with the stock/consumption ratio at 46.7%. For the 2018/19 crop season, the expectation is that a 10-million-ton deficit and a 40% stock/consumption ratio occur, the lowest value since 2011/12. The prospects for the next crop season (2020/21) are for greater pressure on the supply-demand balance. The market depends on how important players' production will behave, such as Brazil, India, and Thailand. For the 2019/20 crop season, a 3.0-million-ton deficit is estimated, with a 38.3% stock/consumption ratio (DATAGRO, 2020).

Several factors can influence the world sugar market, such as global stocks, the oil market, and the exchange rate. Other factors may also contribute. For example, in 2015, the World Health Organization recommended that free sugar consumption should be less than 10% of daily energy consumption to reduce overweight and obesity (WHO, 2015). Thus, some countries, such as Mexico, France, Norway, and the United Kingdom have initiatives in this direction, which may reduce the demand for this product. Since 2018, Brazilian Ministry of Health signed an agreement with food industry associations to reduce 144,000 tons of sugar in cakes, cake mixes, milk products, chocolate, sugary drinks and filled cookies (MS, 2018).

1.5. Production mix

In 2018, the percentage of ATR destined for ethanol production was of 65%, similarly to that of the previous year, as shown in Chart 13 (CONAB, 2020a). It should be noted that throughout the period analyzed, Brazilian plants have allocated most of the RTA to ethanol. Since the 2018/2019 crop season, with surplus in the world sugar balance and the fall in its price, there was an even greater destination for ethanol production. In the 2020/21 crop season, this distribution should present a variation of 7 percentage points for sugar, surpassing 42%, but still maintaining a mostly alcoholic profile.

Chart 13 – Production mix (sugar x ethanol)



Source: EPE from (CONAB, 2020a)

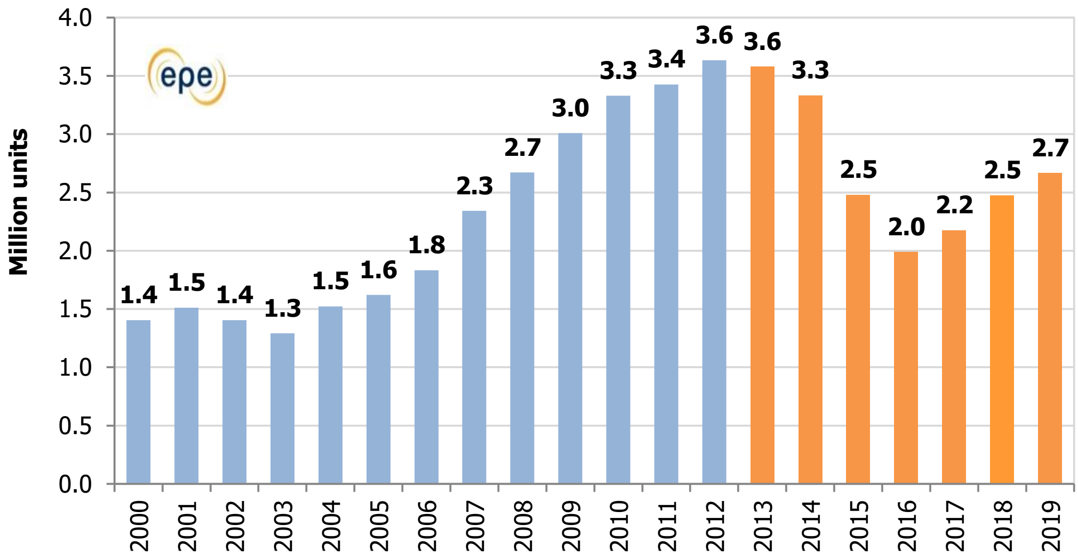
In 2018, the ATR compensation in the state of São Paulo was R$0.63/kg (CONSECANA, 2020), 11% more than in 2018.

2. Otto Cycle Demand

2.1. Licensing and fleet of light-duty vehicles

In 2019, 2.7 million new light-duty vehicles were licensed in Brazil, 7.7% more than in 2018 (ANFAVEA, 2020). This third successive increase, after a period of four consecutive declines, led annual licensing to the same level as in 2008, still below the record 3.6 million units licensed in 2012 and 2013, as shown by Chart 14.

Chart 14 – Licensing of light vehicles



Source: EPE from (ANFAVEA, 2020)

Of the total licensing of light-duty vehicles, by segmentation, 84.9% were automobiles and 15.1% light commercial vehicles. In separation per fuel, the category flex fuel presented the greatest participation in total licensing, with 87.4%, followed by diesel-powered vehicles with 9.4%, gasoline with 2.8%, and a small percentage of hybrid vehicles (11,858 units, 0.4% of the total). It should be noted that, despite the reduced participation, the total number of hybrid vehicles licensed in 2019 was almost three times that registered in 2018. In terms of motorization, for the tenth consecutive year, most cars with 1.0-liter to 2.0-liter engines were licensed, accounting for 59.4% of the total (ANFAVEA, 2020).

The commercialization of used vehicles[11] slightly increased in 2019 (2.2% over 2018) to 14.6 million units, representing 84.6% of total vehicle sales (new + used). There was a significant 6.8% decrease in sales of used cars (0 to 3 years), from 2018 to 2019, which reached 2.3 million units, the lowest value of the last five years. On the other hand,

[11]This includes used motorcycles and heavy commercial vehicles.

there was a 4.1% increase in sales of older used vehicles,[12] reaching 12.3 million units (FENAUTO, 2020).

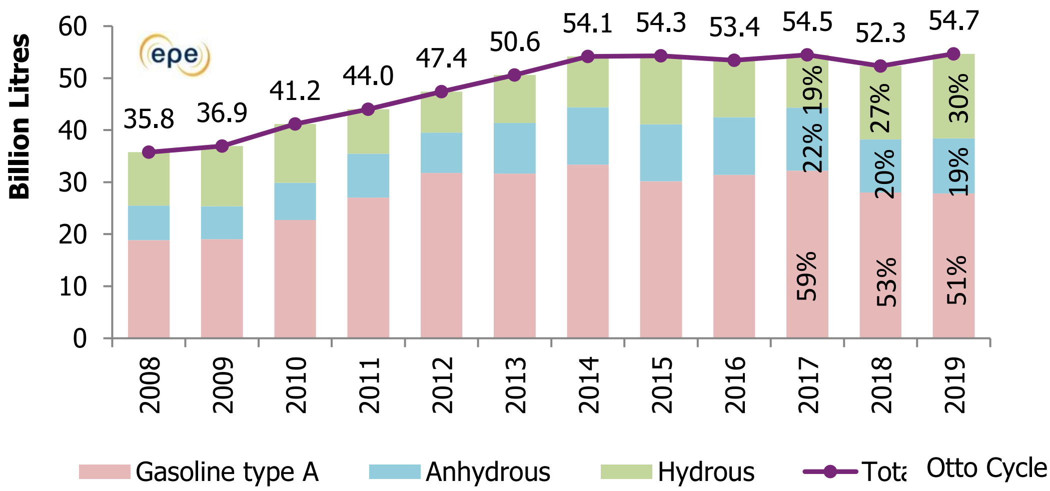
As for motorcycles, in 2019, 1.1 million new units were licensed, 13.3% more than in the previous year, according to data from ABRACICLO (ABRACICLO, 2020). This was the second growth after a period of six consecutive falls.

As a result of the licensing observed in 2019, the Brazilian Otto cycle light vehicle fleet grew 1.5% and remained at around 38 million units, with the technology flex fuel representing 78.4% of the total.

2.2. Fuel demand of Otto cycle fleet

Total energy demand for Otto cycle light-duty vehicles in 2019 was 54.7 billion liters of gasoline equivalent, a 4.6% increase over the previous year. In the distribution per fuel, gasoline type A dropped from 53.5% to 50.9%, and anhydrous ethanol increased from 26.9% to 29.8%, as shown by Chart 15. The share of anhydrous ethanol decreased from 19.5% to 19.3%, remaining at the same level of 2019. This movement caused total fuel ethanol to improve its share from 46.5% in 2018 to 49.1% in 2019, incrementing the renewability of the Otto cycle matrix (EPE, 2020a). The reasons for this behavior will be cited in the next section of this document.

Chart 15 – Otto cycle demand and share of different fuels

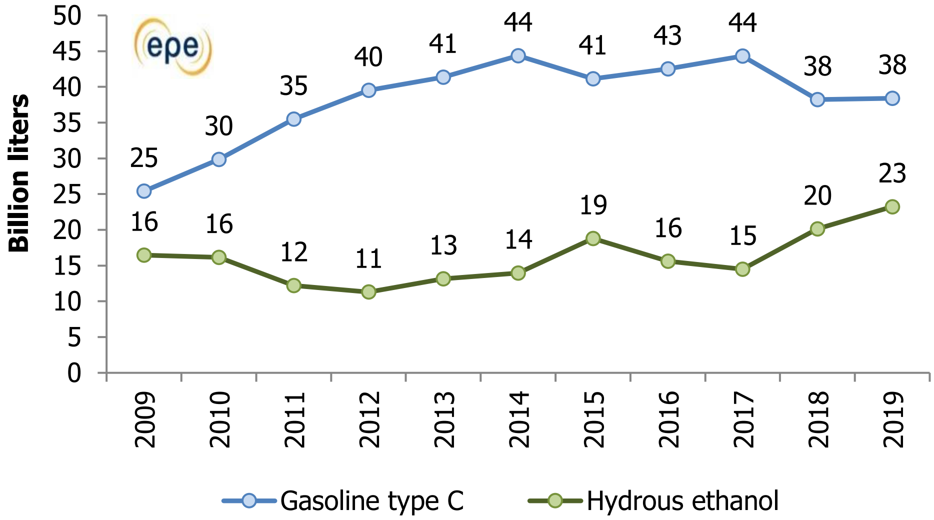


Note: Demand data excludes the CNG share.
Source: EPE from (EPE, 2020a)

Demand for hydrous ethanol in 2019 totaled 23.2 billion liters, representing a 15.5% growth over the previous year, and consumption of gasoline type C reached 38.4 billion liters, maintaining the same levels observed in 2019 (EPE, 2020a), as Chart 16 illustrates.

[12] Used vehicles with more than 3 years old.

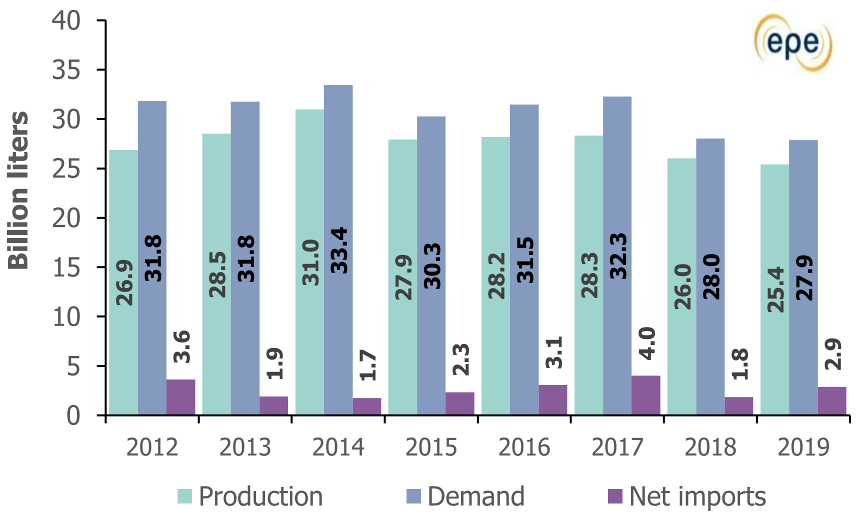
Chart 16 – Annual demand for hydrous ethanol and gasoline type C



Source: EPE from (EPE, 2020a)

Chart 17 presents the evolution of demand, production and net imports of gasoline type A, for the period 2012-2019.

Chart 17 – Production, demand and net imports of gasoline type A



Source: EPE from (EPE, 2020a)

In 2019, while domestic demand for gasoline type A remained at the same level as the previous year, reaching 28 billion liters, its production decreased 2.4%, to 25 billion liters. The trade balance of gasoline type A was 2.9 billion liters of net imports, an expressive 56% increase in relation to the previous year (EPE, 2020a). Refinery processed oil load was slightly reduced, that is, 1.0% in relation to 2019 values (ANP, 2020g). While the demand for fossil diesel was 2.4% greater, its production by the national refining park decreased 1.5% (more details in Item 6).

3. Economic Analysis

3.1. Otto cycle fuel prices

In 2019, hydrous ethanol prices decreased by 4.1% in December 2019, while those for gasoline type C presented an average 4.5% decrease, as will be detailed below. As described in Item 1, the plant production profile remained predominantly alcoholic, in line with the maintenance of low sugar prices in the international market. Regarding gasoline, the price at the refinery has undergone several adjustments, due to Petrobras' international price parity policy.

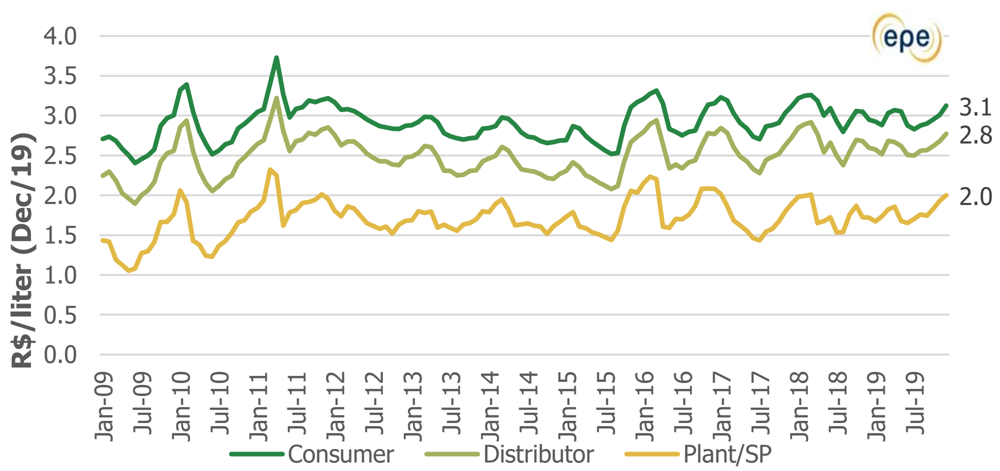
Since 2017, the PIS/COFINS on ethanol imports and commercialization is R$241.81/m^3, and for gasoline, R$ 792.5/m^3 (BRASIL, 2017a) (BRASIL, 2017b).

Every month, the National Council for Finance Policy (DO) releases the Fuel Reference Prices, establishing the End-Consumer Weighted Average Price (PMPF),[13] which serves as a parameter for ICMS taxes (CONFAZ/MF, 2020).

Thus, for a demand for Otto cycle fuels 4.6% higher than that observed in the previous year, hydrous ethanol consumption showed a 15.5% increase, while for gasoline type C it remained at the same level, with a slight 0.5% increase (EPE, 2020a).

Chart 18 presents a comparison of average prices[14] of hydrous ethanol with regard to the consumer (Brazil), the distributor (Brazil), and the plants (São Paulo).

Chart 18 – Hydrous ethanol prices



Note: Prices deflated by the IPCA, in values of December 2019
Source: EPE from (ANP, 2020b) and (CEPEA/ESALQ, 2020)

[13]The changes were in the following states: AC, AL, AP, ES, MA, MT, PI, RR, RS, SP and TO.
[14]Average prices weighted by Brazilian production of the federation units are in current values, deflated by the IPCA of December 2019.

The difference between the minimum and maximum prices of hydrous ethanol for consumers throughout 2019 was R$0.30/liter (10.5%, between December and July), lower than those observed in the last two years: in 2018, R$0.46/liter (16.6% between March and August), and in 2017, R$0.53/liter (19.5% between January and July), in values of December 2019.

As usually happens, due to the fluctuations related to the sugarcane planting and harvesting cycles and the evolution of ethanol stocks, the price of ethanol went up during the off season, in early 2019, decreased with the beginning of the crop season and, later, rose again when it was ending. The maximum difference in values reached R$ 0.37/liter (equivalent to an 11.4% reduction) in February 2019 when compared to the same months of 2018. It is worth mentioning that the average annual margins on hydrous ethanol resale in 2019, of R$ 0.36/litter, remained around 10% below that observed in 2018 (R$ 0.39/liter). In turn, the distribution margins reached R$0.82/liter, an 8.9% decrease.

Average annual prices for hydrous ethanol and gasoline type C for the consumer are shown in Table 1, as well as the relative average price (PE/PG) and its variations.

Table 1 – Average and relative annual prices of hydrous ethanol, gasoline type C (PE/PG)

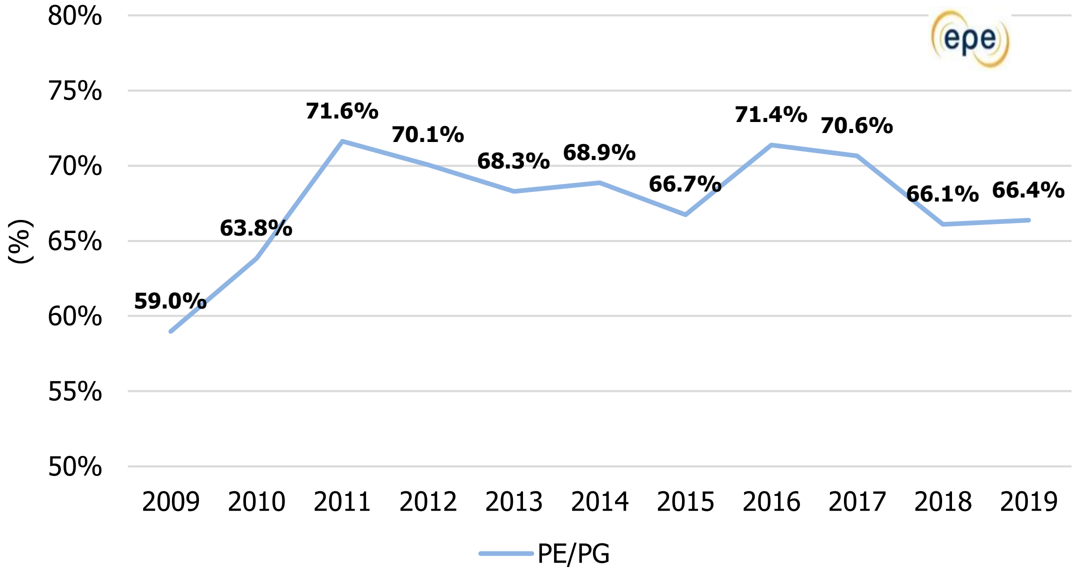
Year	Hydrous ethanol	Var. (% yearly)	Gasoline type C (R$ Dec2019/l)	Var. (% yearly)	PE/PG	Var. (% yearly)
2009	2.50	73.9	4.24	69.2	0.59	2.8
2010	2.74	84.6	4.30	70.7	0.64	8.2
2011	3.07	11.7	4.28	-0.5	0.72	12.2
2012	2.84	-7.2	4.06	-5.1	0.70	-2.2
2013	2.74	-3.8	4.01	-1.3	0.68	-2.5
2014	2.70	-1.3	3.92	-2.1	0.69	0.8
2015	2.67	-1.2	3.99	1.9	0.67	-3.1
2016	2.93	10.0	4.11	2.9	0.71	6.9
2017	2.88	-1.9	4.07	-0.9	0.71	-1.0
2018	3.03	5.3	4.58	12.5	0.66	-6.4
2019	2.90	-4.1	4.38	-4.5	0.66	0.4

Note: The prices of hydrous ethanol and gasoline type C were deflated by the IPCA, in relation to December 2019.
Source: EPE from (ANP, 2020b) (BC, 2020).

In 2019, in general, the behavior of hydrous ethanol prices over the months of the year was similar to that observed for gasoline type C.

The average value of hydrous ethanol at the pump was R$2.90/liter in 2019, a 4.1% decrease compared to the previous year, while for gasoline type C the decrease was of 4.5%, corresponding to R$4.38/liter. The price of biofuel presented decrease similar to that of gasoline type C, which resulted in stabilization of the relative price (PE/PG), compared to 2018. As a result of stabilization, in 2019, the average price ratio was 66.4%, considered favorable to ethanol consumption, and representing a slightly higher ratio (only 0.30%) than in 2018. Chart 19 illustrates the change in relative annual average price (PE/PG) since 2009.

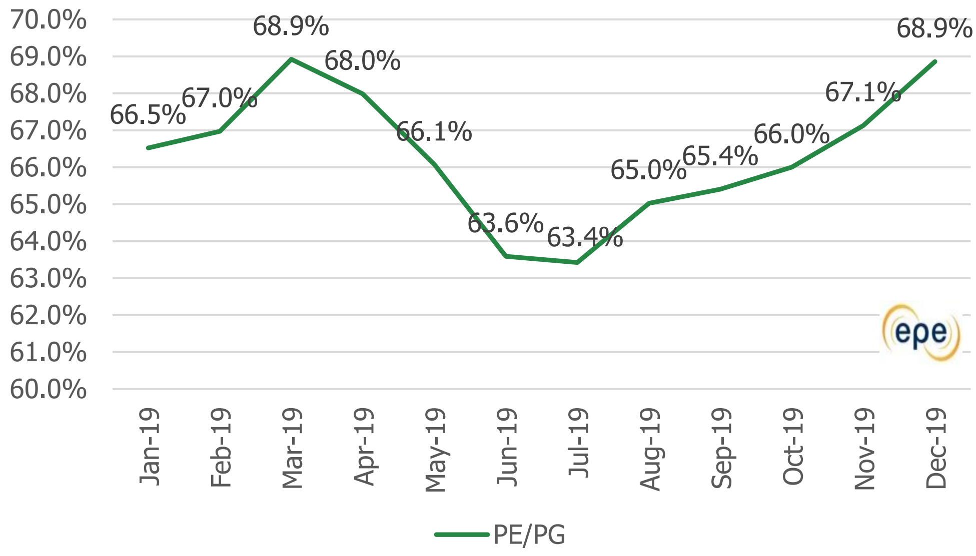
Chart 19 – Price relation between hydrous ethanol and gasoline type C (PE/PG)



Source: EPE from (ANP, 2020b)

The monthly PE/PG relative price during 2019 is illustrated in Chart 20. In January, PE/PG ratio was 66.5%, increasing slightly in February and March to 67% and 68.8%, respectively, decreasing from then on up to the level of 63.4% in July. From then on, it showed an upward trend until December, when it reached 68.9%. Thus, hydrous ethanol was competitive during the whole year. It should be noted that São Paulo, Goiás, Minas Gerais and Mato Grosso, representing, respectively, 48%, 16%, 10% and 6% of total ethanol production in the country, presented a favorable PE/PG ratio for biofuel consumption in 2019.

Chart 20 – Monthly PE/PG ratio in 2019

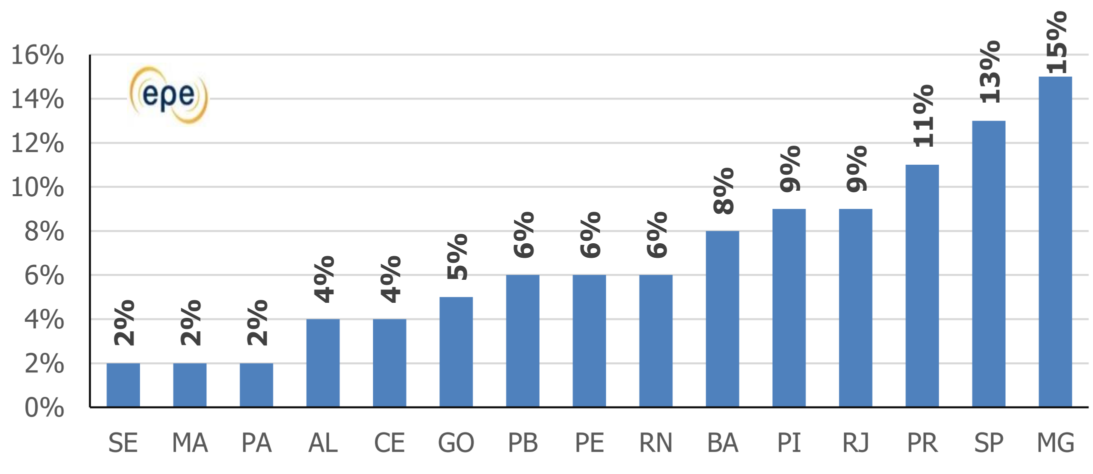


Source: EPE from (ANP, 2020b)

3.2. ICMS on Otto cycle fuels

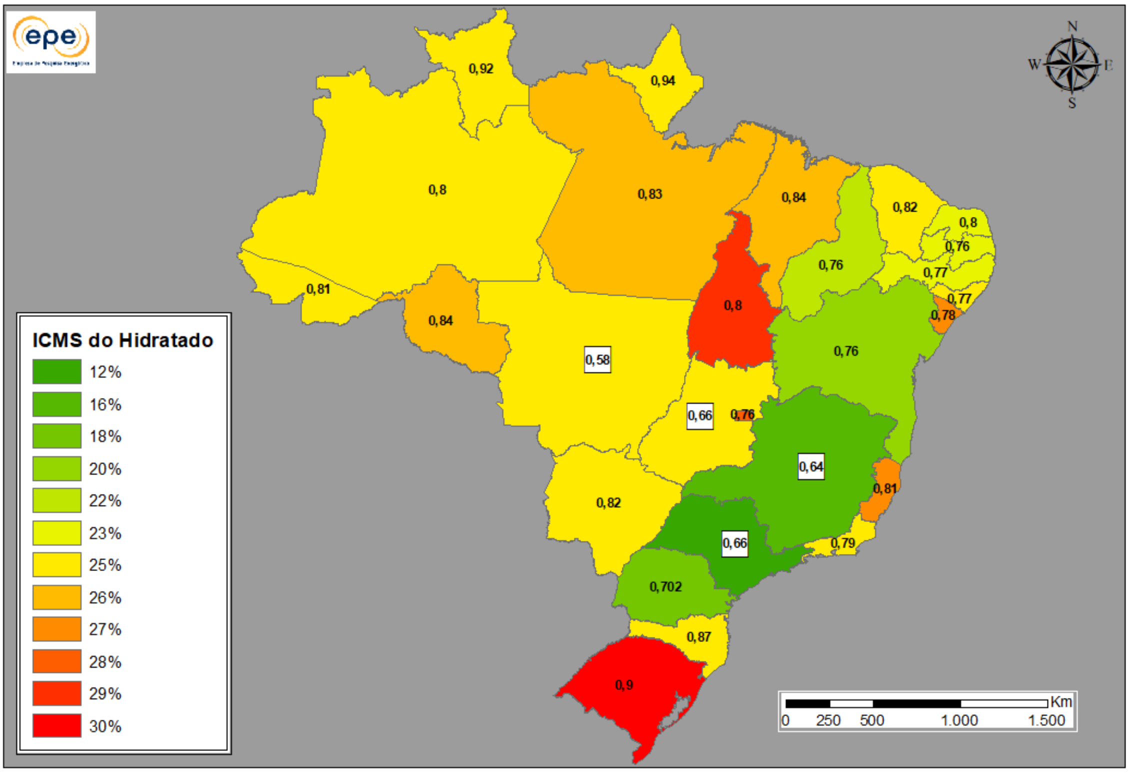
In 2019, similarly to the previous year, 15 states continued to have differentiation in the ICMS rates for ethanol and gasoline, as a way of promoting the biofuel market, as illustrated by Chart 21. Minas Gerais and São Paulo maintained the largest difference between taxes, 15% and 13%, respectively.

Chart 21 – Tax Differentiation – 2019 ICMS (gasoline x ethanol)



Source: (CONFAZ/MF, 2020) and (FECOMBUSTIVEIS, 2020)

Figure 1 illustrates the relationship between ICMS taxation and the competitiveness of hydrous ethanol in Brazilian states in 2019.



Source: EPE from (ANP, 2020b), (CONFAZ/MF, 2020) and (FECOMBUSTIVEIS, 2020)

Figure 1 – Ethanol ICMS rate and PE/PG ratio per state in 2019

In 2018, the average PE/PG ratio for Brazil was 66.4%. The state of Mato Grosso had an average annual ratio of 58%, the lowest in the country. In São Paulo, largest producer and consumer,[15] the average ratio was 65.6% (the ICMS tax rate for ethanol is the lowest in the country, 12%). In Minas Gerais, which has the second lowest rate (16%), the annual PE/PG value was 64.4%. The least competitive states were Amapá and Roraima, where the price of ethanol reached, on average, 94% and 92% of the price of gasoline type C, respectively, and it was equal to or slightly lower than the price of fossil derivatives in several months of the year.

[15]São Paulo accounted for 48.1% of national ethanol production (anhydrous and hydrous) and 47.2% of Brazilian hydrous consumption in 2019 (MAPA, 2020).

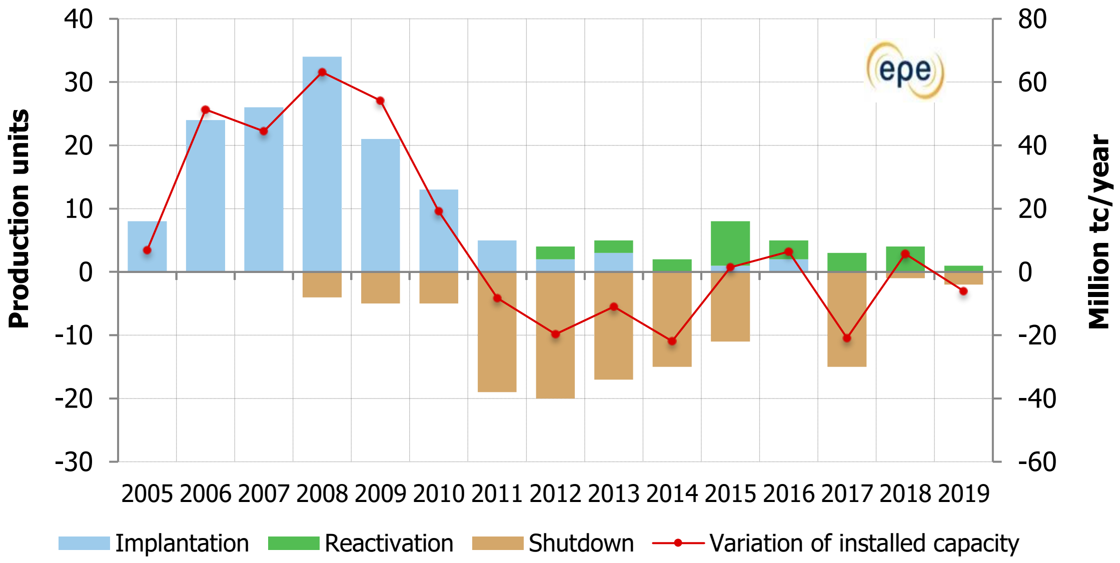
4. Ethanol Production Capacity and Infrastructure

4.1. Productive capacity

In 2019, one production unit was reactivated,[16] with milling capacity of 1.5 million tons. On the other hand, three units with aggregate capacity of 7.5 million tons were closed. This year, there was no implementation of any new sugarcane ethanol unit. Thus, the annual balance amounts to an increase of about 6 million tons.

Chart 22 shows the flow of deployment, reactivation and shutdown of units between 2005 and 2019. The number of new deployments has fallen significantly since 2011. The nominal sugarcane milling capacity is estimated to have grown by 165 million tons over the period, considering deployed, decommissioned and reactivated units.

Chart 22 – Flow of sugarcane plants in Brazil



Source: EPE from MAPA (2020b), (MAPA, 2020), (UNICA, 2014) and (UNICA, 2014b)

According to MAPA (MAPA, 2020b), the number of sugar and alcohol units in operation in December 2019 was 366, corresponding to an effective milling capacity of about 745 million tons.[17] Therefore, adopting the milling performed in 2019, which was approximately 654 million tons, the occupancy rate of the sugar and alcohol industry was 88%.

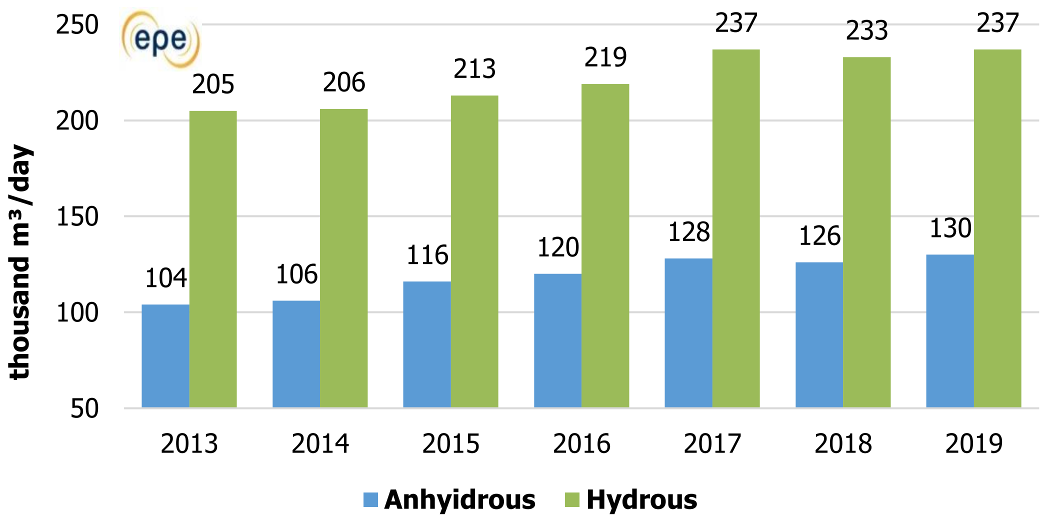
In 2019, two corn ethanol full type units and one flex type unit were implemented, totaling 12 operational plants (four full type and eight flex type). At the end of the year, the total corn processing capacity was 9.4 million tons/year, and the production of ethanol was around 2.0 billion liters/year. According to ANP and the National Corn

[16]Current accounting does not include: units identified as producing spirits (including those registered in MAPA); non-sugarcane ethanol producing units and those that came to a standstill and returned in the same calendar year.
[17]The calculation considers the units that paralyzed operations up to December 31st, as well as the milling capacity growth in the same year. It also considers an average capacity factor of 90%.

Ethanol Union, 10 units under construction were identified, mostly of the full type, which will add 2.4 billion liters to the production capacity of ethanol from this cereal (ANP, 2020a) (UNEM, 2019).

According to ANP, at the end of December 2019, 363 units were able to sell anhydrous and hydrous ethanol,[18] whose production capacities were 130 thousand m³/day and 237 thousand m³/day, respectively. In addition to these units, there were 15 requests for the construction of new plants, which will add a capacity of 3,400 m³/day of anhydrous and 5,000 m³/day of hydrous ethanol (ANP, 2020a). Chart 23 presents the evolution of installed ethanol production capacity in Brazil since 2013, where it is possible to observe an increment of 32 thousand m^3/day for hydrous ethanol and 26 thousand m^3 /day for anhydrous ethanol.

Chart 23 – Evolution of installed ethanol production capacity in Brazil



Source: EPE from (ANP, 2020a)

MAPA controls the units in the sugar and alcohol sector that are in operation, including the sugar plants. ANP controls units that are able to sell anhydrous and hydrous ethanol, even if they are not in operation on a certain date. The differences between the reports of the two entities are due to the different objectives pursued.

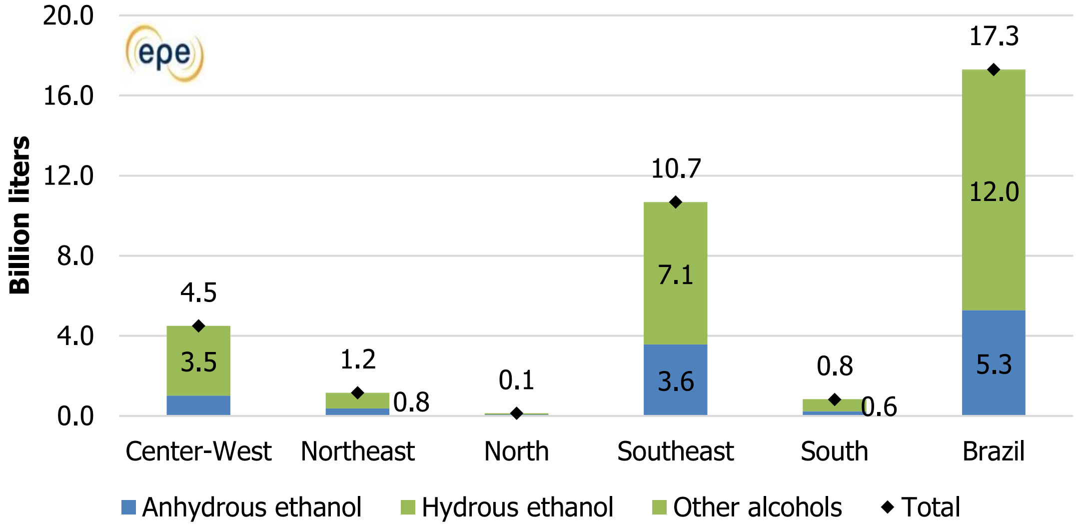
4.2. Tankage

In 2019, Brazil recorded tankage of more than 17 billion liters, 12 for hydrous ethanol, 5.3 for anhydrous ethanol, and 0.06 for other alcohols. Among the regions, the Southeast stands out, with 10.7 billion liters (62%), demonstrating compliance with the highest volumes consumed by it.

Chart 24 shows Brazil's tankage per type of ethanol and per region in 2019.

[18] The report does not characterize whether the unit is operating or is at a standstill and there are no exclusively sugar producing units. It includes one full-type corn unit.

Chart 24 – Brazilian ethanol tankage capacity per region in 2019



Source: EPE from (ANP, 2020e)

4.3. Pipelines

Figure 2 introduces Logum's integrated ethanol logistics system, which consists of its own pipeline project and the use of existing ones, whose length is 1,054 km, with maximum annual transportation capacity of up to 6 billion liters of ethanol (LOGUM, 2020).

Source: (LOGUM, 2020)

Figure 2 – Integrated logistics system for ethanol

The pipeline sections that are already in operation are:

i. Owned: Ribeirão Preto (SP) – Paulínia (operating capacity of 2.8 billion liters/year) and Uberaba (MG) – Ribeirão Preto (SP) (operating capacity of 1.8 billion liters/year);

ii. Subcontractors: Paulínia (SP) – Barueri (SP); Paulínia (SP) – Rio de Janeiro (RJ) and Guararema (SP) – Guarulhos (SP).

Tank storage capacity (usable volume) at system operating terminals is 619 million liters (LOGUM, 2020).

In 2018, the volume of ethanol handled was 2.4 million liters, 4.2% more than the previous year. On October 24th, 2019, the Ministry of Mines and Energy published Ordinances for the framing of pipeline projects for the transportation of fuels within the Special Regime of Incentive for Infrastructure Development (REIDI). REIDI benefits companies with projects for the implementation of infrastructure works in the sectors of transportation, ports, and energy. This benefit represents a 4.5% reduction in project implementation costs (MME, 2019a).

Among the next projects to expand the pipeline network, a new connection in the state of São Paulo stands out, which will connect the Guararema Land Terminal to the distribution bases in São José dos Campos. The 42.5-km ethanol pipeline will pass through the municipalities of Guararema, Santa Branca, Jacareí and São José dos Campos, and it is expected to be operational in 2021, with a yearly capacity of 40 million liters (NOVACANA, 2020c).

The construction of the pipeline depends on ANP's final opinion, and the project documents are still under analysis by the regulatory agency (NOVACANA, 2020c).

4.4. Ports

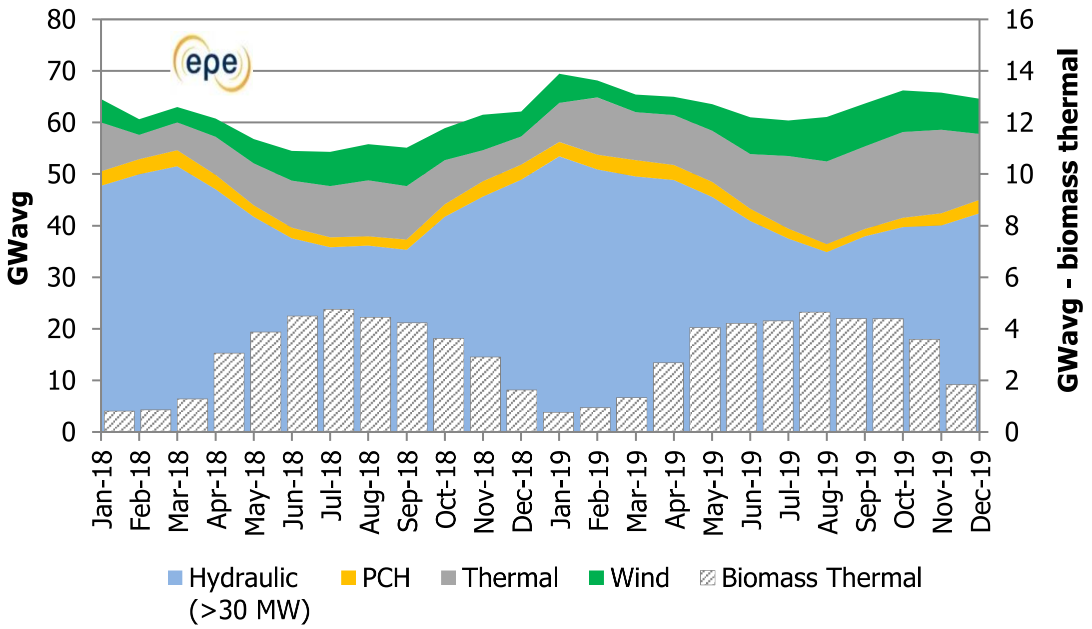
In 2019, nearly all ethanol sent abroad was exported by sea (2.0 billion liters), while imports through this route totaled 99.0% (1.4 billion of a total of 1.5 billion liters). The Port of Santos – SP represented 85.2% of exported volumes, followed by Paranaguá – PR, with 14.8% (ME, 2020).The Port of São Luís – MA (51.8%) continued to be the main port for imported ethanol to enter in the country, followed by the Port of Santos (24.9%) and Port of Suape – PE (18.4%) (ME, 2020).

5. Bioelectricity

The share of biomass thermal generation has become increasingly significant on the national scene. Between January and December 2019, there was a 3.4% increase in injection compared to the same period of 2017. Sugarcane bagasse remains the most used fuel, with 82%, while the share of other biomass in exports of energy to the National Interconnected System (SIN) has remained stable, as described in Item 5.2.

In 2019, the share of energy exported from sugarcane in the national electricity matrix was 3.8%, maintaining the same level of the previous year. The sugarcane plants injected 2.6 GWavg into SIN, 4.5% more than what was verified in 2018. Chart 25 presents the seasonal share of sugarcane biomass in electricity generation in 2018/2019. It is possible to note the complementarity with the water source, since the increase in the generation of bioelectricity occurs during crop season, a period concomitant with the drought (CCEE, 2020).

Chart 25 – Share of sugarcane biomass in electricity generation



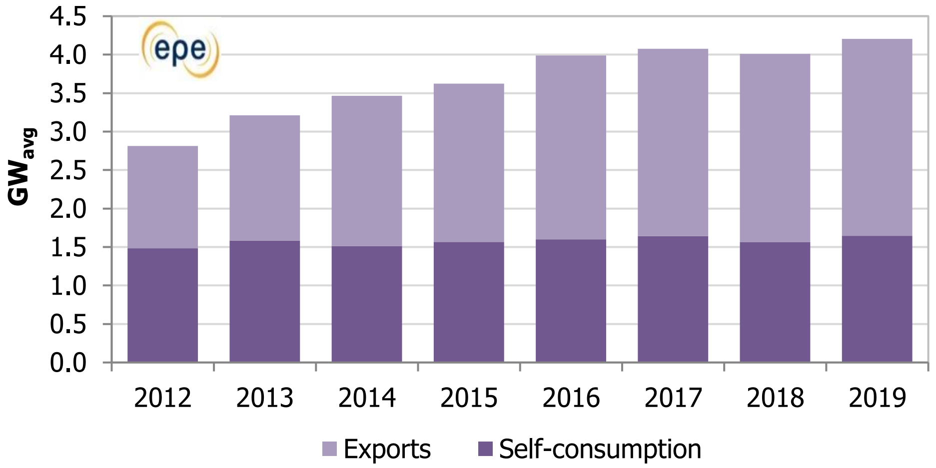
Source: EPE from (CCEE, 2020)

5.1. Energy exporting and trading

In addition to energy self-sufficiency, sugarcane biomass plants are characterized by the supply of energy to SIN.[19]

According to Chart 26, in 2012-2019, there was a growth in electricity generation from this source, driven by a boost in electricity exports, with the share of self-consumption remaining at the same level. It is possible to note that these values have remained stable over the last years.

Chart 26 – Self-consumption and energy exported by sugarcane biomass plants



Source: EPE from (CCEE, 2020) and (EPE, 2020a)

Of the 366 sugarcane biomass plants in operation in 2019, 220 traded electricity, eight more than the previous year. Of those that export energy to SIN, part operates exclusively in ACL (60%) or ACR (17%), and the remainder (23%) sells in both contracting environments.

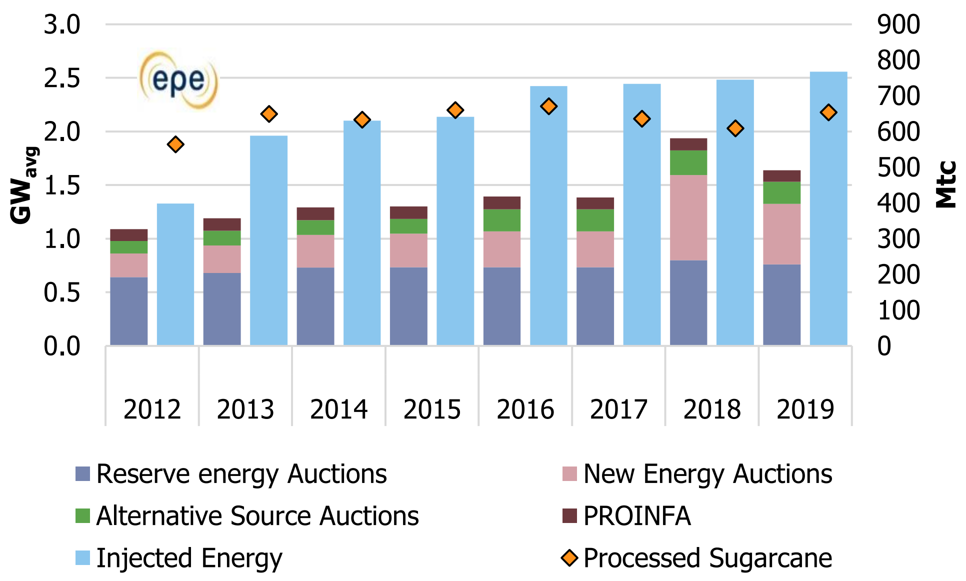
In order to improve the competitiveness of sources derived from biomass and stimulate the growth of bioelectricity in the Brazilian electricity matrix, the federal government promoted the creation of regulatory mechanisms and incentive policies, such as specific auctions. In 2008, the first reserve energy auction (LER 2008) exclusively dedicated to biomass was held. On this occasion, more than 590 MW_{avg} were contracted, the maximum amount recorded, with the commissioning scheduled for 2009 and 2012.

In 2019, the sugar-energy plants had contracts of 1.5 GW_{avg}. As a result of the events that year, the sugarcane plants added 76.9 MW_{avg} through LEN A-4 and A-6 (CCEE,

[19] The sugarcane industry plants sell electricity in the Regulated (ACR) and Free (ACL) Contracting Environments. In ACR, the energy purchase and sale operations are concentrated through bids in which new, reserve (LER) and alternative sources (LFA) auctions are held. The auction model was structured to ensure greater transparency and competition in energy trading. In ACL, the generation, trading, importation, exportation and free consumers act in freely negotiated bilateral purchase and sale agreements, and distributors are not allowed to purchase energy in this market. In addition, there is the Incentive Program for Alternative Sources of Electric Energy (PROINFA), created in 2004 (CCEE, 2020); (ELETROBRÁS, 2018).

2020). Chart 27 highlights the larger amount exported to SIN (ACR and ACL), the total contracted per modality via energy auctions, and the sugarcane processed in recent years. It is observed that, in 2019, there was a 7.5% increase in the amount of processed sugarcane and 4.5% increase in the injection into SIN.

Chart 27 – History of energy exported to SIN and processed sugarcane



Source: EPE from (CCEE, 2020) and (MAPA, 2020)

In 2019, thermal plants continued to play a significant role in demand supply (CCEE, 2020). Chart 28 illustrates the monthly injection of energy into SIN by sugarcane biomass thermal plants versus PLD (Differences Settlement Price[20]), in 2018 reais. It can be noted that, in 2018, generation occurred during the crop season, when the smallest contribution from hydroelectric plants is observed, which increased the demand for thermal energy and the maximum PLD values for this year were also recorded. In 2019, the crop peak occurred in a period different from the highest PLD value. Initially, there was an increase due to the rain delay in the first quarter of 2019. With the regulation of affluence and a lower than expected consumption of electricity, as well as the balance between supply and demand, PLD fluctuated throughout the year, with a certain predominance of lower prices than in 2018. However, despite lower PLD in 2019, biomass thermoelectric generation was similar to the generation in 2018, which may signal a commitment to energy delivery between generators and consumers (both ACR and ACL).

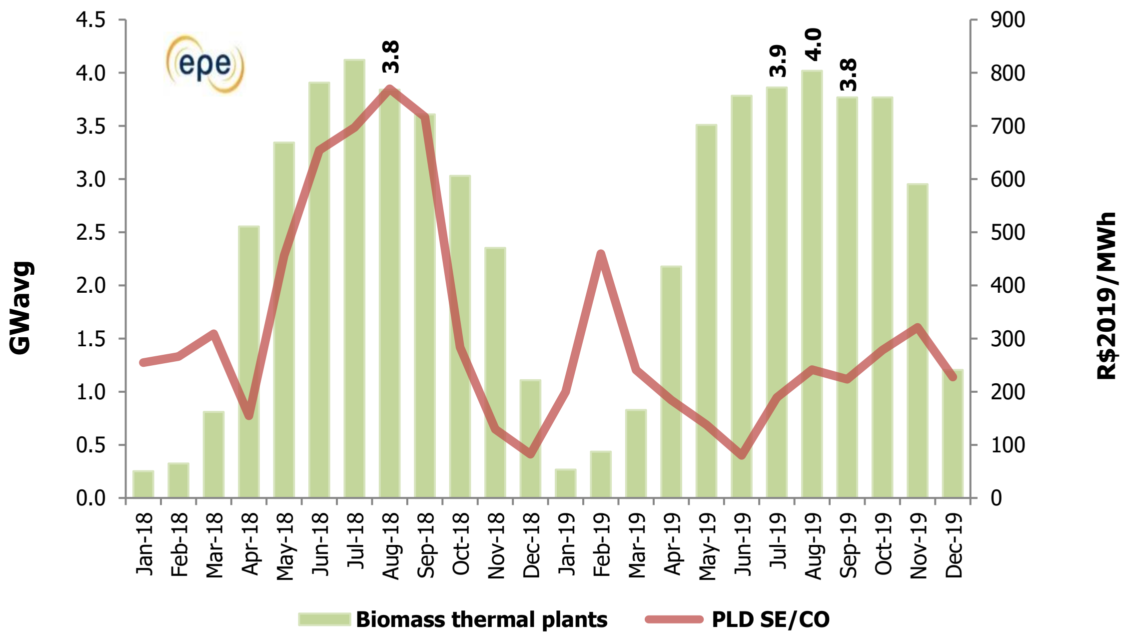
The values stipulated by ANEEL for PLD in 2019 were R$513.9/MWh as the upper limit (1.7% increase) and R$42.4/MWh for the lower limit (5.5% increase).[21] The fluctuation

[20]Updated weekly, this parameter aims to find the optimal solution of balancing the present benefit of water use with the future benefit of water storage, measured in terms of the expected fuel economy in thermal power plants.

[21]In 2017, the limits ranged from R$505.18/MWh to R$40.16/MWh. The boundary values for PLD defined for 2020 were R$559.75/MWh and R$39.68/MWh, an 8.9% increase and a 5.5% decrease, respectively, over the previous year.

in PLD recorded throughout 2019 was due to several factors, mainly the hydrological uncertainties observed in the period (ANEEL, 2020a).

Chart 28 – Thermal generation of sugarcane biomass versus PLD



Note: PLD is calculated for the N, NE, S, SE/CW submarkets. In this chart, the value used for comparing the submarket is that for SE/CW.
Source: EPE from (CCEE, 2020)

The units continued their movement towards efficiency, since there was an increase in electricity exports per ton of sugarcane processed, as mentioned. Federal incentives contributed to this trajectory, such as BNDES' financing lines. The amounts financed by this bank to encourage bioelectricity rose from R$94 million in 2019 to R$143 million in 2019, a 52% increase (BNDES, 2020b).

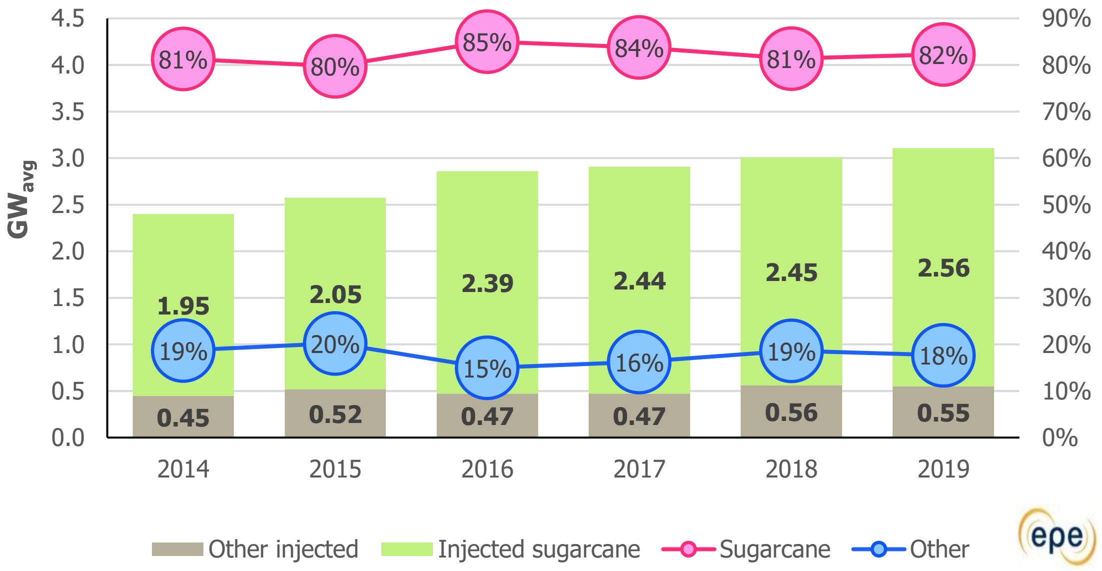
5.2. Bioelectricity of other biomass

In the last five years, there was a significant increase in the exports of electricity from biomass. In 2019, in addition to the aforementioned sugarcane by-products, 560 MWavg were generated in projects that use fuel derived from animal or vegetable organic matter, which corresponded to a slight 1.7% decrease compared to the previous year.

The generation through these other biomasses (excluding sugarcane) represented 0.8% of the electricity matrix in 2019. The black liquor (63%) stands out, largely driven by the growth of pulp production in the last five years, biogas (19%), and forest waste (11%). Elephant grass, charcoal, rice husk, auto-oven gas and firewood also contribute, however with smaller share.

The share of these sources in the total composition of energy exported by biomass in SIN remains around 18% since 2004. Although their contribution has remained at the same level, about 100MWavg were added in the last five years, as shown in Chart 29.

Chart 29 – Share of other biomass X sugarcane



Source: EPE from (CCEE, 2020)

Unlike sugarcane, which has a well-defined seasonality, and consequently a high variation of the energy exported to the grid, the generation from other biomass can be said to be more controllable and deterministic, mainly due to the possibility of fuel storage. It is worth mentioning that this is an important attribute for the electricity sector, contributing to greater energy security and systemic reliability, at a time of great challenges and structural changes occurring in the energy generator park.

6. Biodiesel

In 2018, 5.9 billion liters of biodiesel were consumed in Brazil, an 11.3% increase compared to 2018. The percentage of mandatory addition of biodiesel to the mixture with fossil diesel was increased from 10% to 11% in September. This amount reached 12% in March 2020, as provided for in CNPE Resolution No. 16/2018 (CNPE, 2018a).

Due to the National Program for the Production and Use of Biodiesel (PNPB), started in 2005, over 40.6 billion liters of this biofuel have been produced by December 2019. Comparatively, Brazil has maintained its position among the three largest producers and consumers of biodiesel in the international ranking, along with the USA and Indonesia (USDA, 2019a). According to ANP data, the Brazilian biodiesel sector registered a total of 51 producing plants in December 2019, with a greater concentration in the Center-West and South regions of the country (ANP, 2020c).

Enacted in December 2017, the National Biofuels Policy (RenovaBio) started its operationalization schedule in 2019. Thus, it is noteworthy that the first biofuel producer company certified for the issuance of decarbonization credits (CBIOs), within the scope of RenovaBio, was a plant producing biodiesel from waste oil. For more details, refer to Item 10 - RenovaBio.

In 2019, ANP started discussions on the regulation of paraffinic hydrocarbon-based biodiesel, to assess the possibility of its commercialization in the country. The draft Resolution was made available for public consultation in March 2020, but has been suspended, like all others in progress, due to Covid-19 pandemic impacts. More information about this biofuel can be consulted in Item 8 - New Biofuels, and in the technical note of EPE, Renewable fuels for use in diesel cycle engines (EPE, 2020b).

6.1. Evolution of the Biodiesel Regulatory Framework

Since the mandatory use of biodiesel in the mixture with fossil diesel was instituted, through Law No. 11,097/2005 (BRASIL, 2005), a rapid evolution towards the addition of biofuel at higher levels was observed. The initial value was set at 2% in volume, in 2008, reaching 5% already in 2010, when the expected value would occur only in 2013. In subsequent years, there was a gradual increase in the minimum mandatory percentages for diesel B, reaching 12% in March 2020.

Law No. 13,263/2016 authorized the National Energy Policy Council (CNPE) to increase the percentage of biodiesel in the mixture to the level of 15%, provided that the conditions for approval of engine tests for this content are met (BRASIL, 2016). In this context, CNPE Resolution No. 16/2018 proposed a schedule for increasing the percentage of biodiesel in the mixture with diesel by 1% per year, reaching 15% in 2023 (CNPE, 2018b).

Although CNPE Resolution of December 2018 set forth the percentage of 11% of biodiesel in the diesel B blend, in June 2019, the modification was postponed to August, in accordance with ANP Resolution No. 758/2018 (ANP, 2018a), due to results of the tests of BX blends in engines carried out by the automotive manufacturers. In a report that evaluated the use of blends with B15 biodiesel, it was observed that an increase in the biofuel content in the blend with fossil diesel reduces the efficiency of the gas treatment system of Euro 6 engines, which will be adopted in the Proconve P8 phase (MME, 2019c). This will be the exhaust pollutant reduction technology that can be used in Brazil from 2022/23, when this phase is expected to come into force for heavy vehicles.

ANP Resolution No. 758/2018 seeks to improve the useful life of diesel B (with a biodiesel blend) in all its commercialization stages, and thereby make the implantation of subsequent blends safer (ANP, 2018a).

The evolution of the levels of mandatory addition of biodiesel to fossil diesel is detailed in Figure 3.

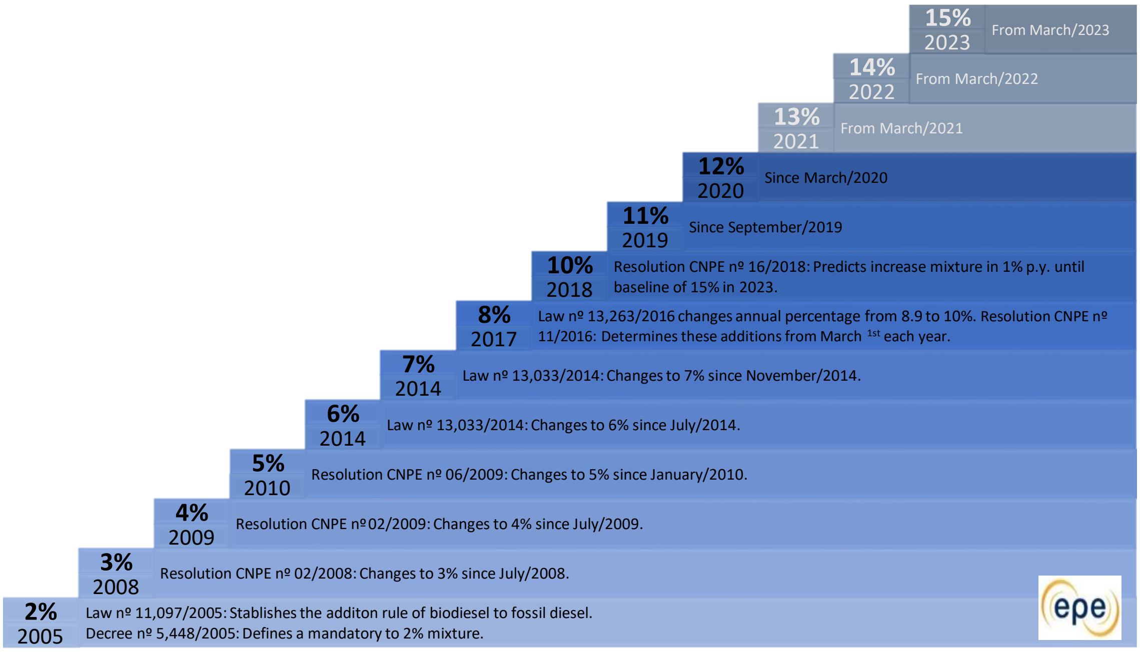


Figure 3 – Evolution of the biodiesel regulatory framework

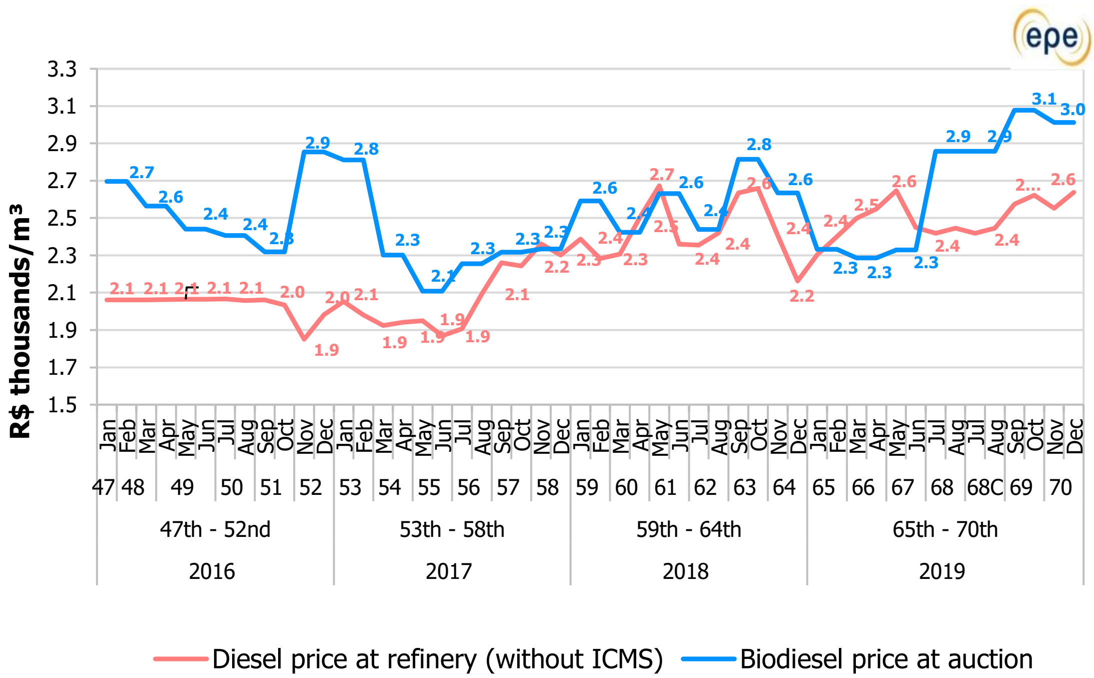
Source: (EPE, 2020b)

Law No. 11,097/2005 (BRASIL, 2005) presents a broad definition for biodiesel as any fuel derived from renewable biomass for use in diesel cycle engines. Currently, ANP Resolution No. 45/2014 (ANP, 2014) is in force, which defines biofuel as being a blend of mixture of fatty acid esters. After more than 15 years, it proved necessary that the regulation allowed incorporating the technological advances observed, enabling the use of other renewable fuels from biomass in diesel cycle engines, which can also be added to fossil diesel to compose the diesel B blend. In this sense, in 2019, ANP initiated technical discussions to validate the use of biofuels that can be manufactured by different processes that will result in a product called "green diesel." More details of this new biofuel are presented in Item 8.

6.2. Biodiesel Auctions & Prices

ANP held six auctions from January to December 2019 for biodiesel purchasing by fuel distributors, totaling 70 since the program began. The last event (no. 70) was scheduled for delivery in early 2020. As shown in Chart 30, there was an approximation of the average selling prices[22] between biodiesel and fossil diesel, which occurred in 2017 and 2018. This fact repeated in the first three events of 2019, when the price of biodiesel was lower than that of fossil diesel (ANP, 2020d).

Chart 30 – Average prices – biodiesel and diesel without ICMS

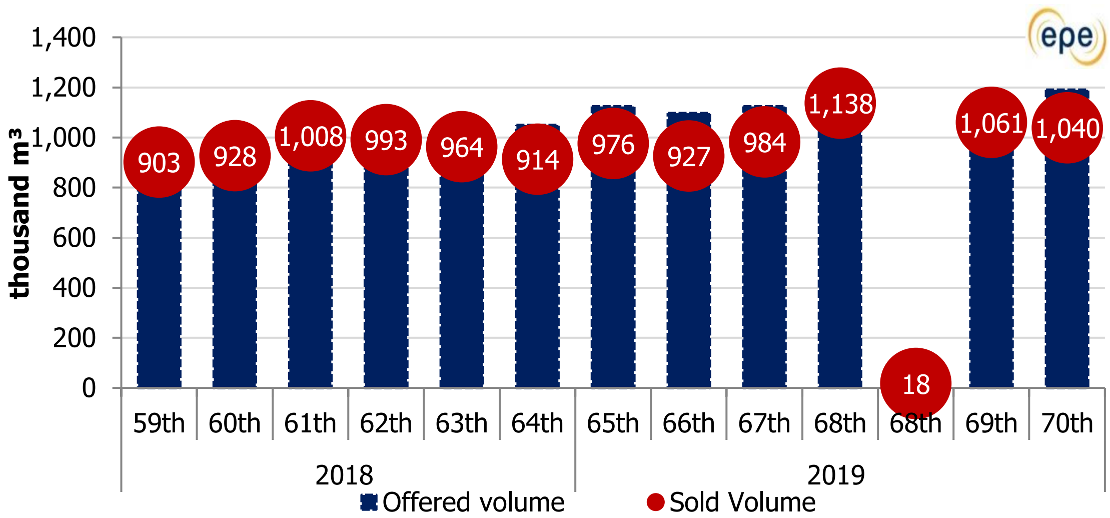


Note 1: Biodiesel prices correspond to the indicated auctions.
Note 2: The price of diesel corresponds to its value at the refinery.
Note 3: Diesel and biodiesel prices are presented in current values.
Source: EPE from (ANP, 2020d)

According to Chart 31, it is possible to note a 10% increase in the volume of biodiesel offered in the auctions relative to 2018, while the volume sold was 8% higher, due to the increase in the mandatory percentage for B11 for the same period. In the case of auction 68, exactly the one that marks the increase in the percentage, the volumes initially offered, of 1,140 thousand m³, were not sufficient to meet the market demand, and it was necessary to held a complementary auction. In this, the additional volume offered was 18.8 thousand m³, and the amount sold was 18.05 thousand m³. In the following auctions, the market for this biofuel showed an adequate adjustment between supply and demand (ANP, 2020d).

[22]Diesel in the refinery and biodiesel in the producer.

Chart 31 – Biodiesel volume in Auctions – Offered vs. Sold



Note: Auction 68 was marked by the need for a complementary event to meet the targets.
Source: EPE a from (ANP, 2020d)

CNPE Resolution No. 3, published in October 2015 (CNPE, 2015), defined guidelines for authorizing marketing and voluntary use of biodiesel, in amount superior to the percentage of its mandatory addition to diesel[23]. ANP has established the rules for authoritative biodiesel to take advantage of and stimulate the conditions that can make it competitive with diesel, especially in regions far from oil refineries and with abundant production capacity.

Authoritative biodiesel is traded through regular auctions[24] at a later stage than the mandatory volume. Some current rules were changed from the 48th auction (in 2016) to reduce bureaucracy. Specific projects that use mixtures other than those provided for in the legislation are exempt from submitting to auctions, which may require the purchase of direct biodiesel from producers, but require authorization from ANP.

Although a little over 136 million m³ of authoritative biodiesel has been offered for 2019, only 3.8% of this total was sold. Trading for voluntary use took place in auctions 59th to 64th, with movement of 5.1 million m³ of biodiesel and R$12.8 million reais (ANP, 2020d), less than 50% of that traded in 2018.

The restructuring of the market, due to the probable change in the biodiesel commercialization system, is discussed within the *Abastece Brasil* initiative, a new downstream scenario subcommittee, in the WG – Commercialization of biodiesel (MME, 2019d).

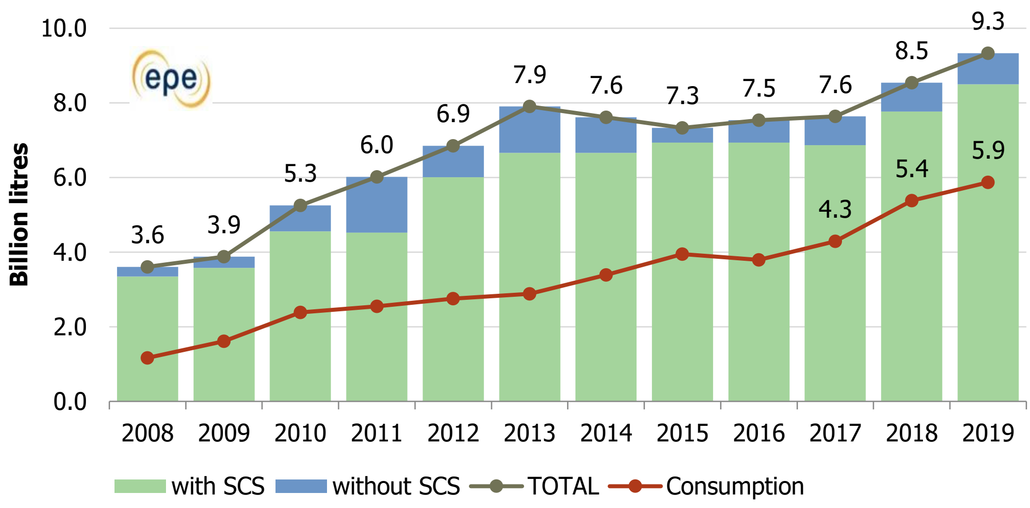
[23]The maximum volume percentages of biodiesel addition to diesel oil are: 20% in captive fleets or road consumers served by supply point; 30% in rail transportation; 30% in agricultural and industrial use; and 100% in experimental use, specific or other applications (CNPE, 2015).
[24]The auctions are held in two stages. In the first, the producing plants make their offers considering exclusively the volumes offered and not sold during the regular auction. In the next step, the distributors make purchases for customers who are interested in using biodiesel in levels above 10% already established. The ordinance states that the consolidate auction result shall discriminate the biodiesel volumes and the prices for the two markets separately, the regular mandatory mix and the voluntary use market.

6.3. Regional production and installed capacity

According to ANP data, in December 2019, the installed capacity corresponded to 9.3 billion liters, divided among the 51 authorized producing plants. Chart 32 shows the annual authorized capacity, with distinction for plants that have a Social Fuel Seal (SCS), as well as indicating annual consumption, demonstrating the effect of overcapacity since 2008 (ANP, 2020c).

It is observed that production in 2019 corresponded to 63% of the installed capacity in the country, which shows that there is potential for growth in the production of this biofuel (ANP, 2020c).

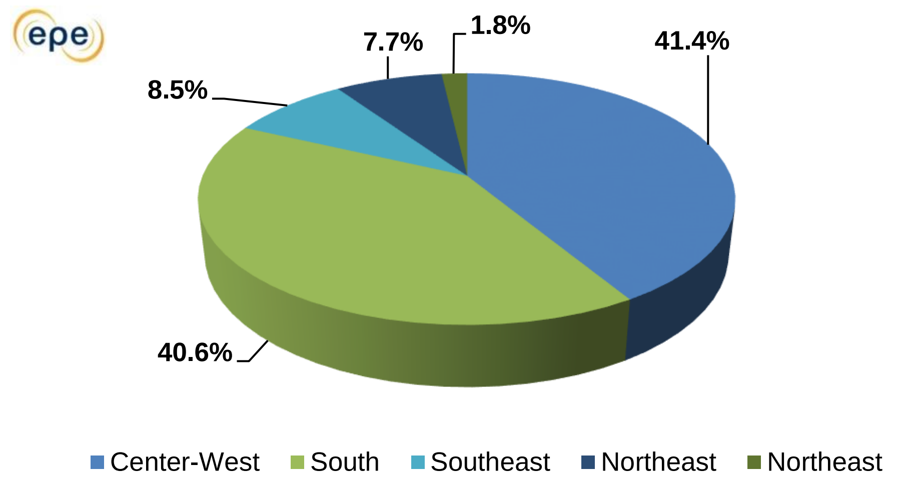
Chart 32 – Authorized Nominal Capacity and Biodiesel consumption in 2019



Source: EPE from (EPE, 2020a) and (ANP, 2020c).
Note: The Social Fuel Seal (SCS) is a distinction given to companies that produce biodiesel that use products from family farms in their production chain. The objective is to guarantee income and stimulate the social inclusion of producing families. Biodiesel producers and SCS holders benefit from access to better financing conditions from financial institutions.

At the national level, biodiesel production in the Center-West and South regions has always stood out due to the abundant availability of the main raw materials (soy and tallow), although the largest volume of sales/consumption is concentrated in the Southeast region. Chart 33 presents the biodiesel production per region in 2019, with a greater concentration of production in the Center-West (41.4%) and South (40.6%) regions.

Chart 33 – Biodiesel production per region in 2019

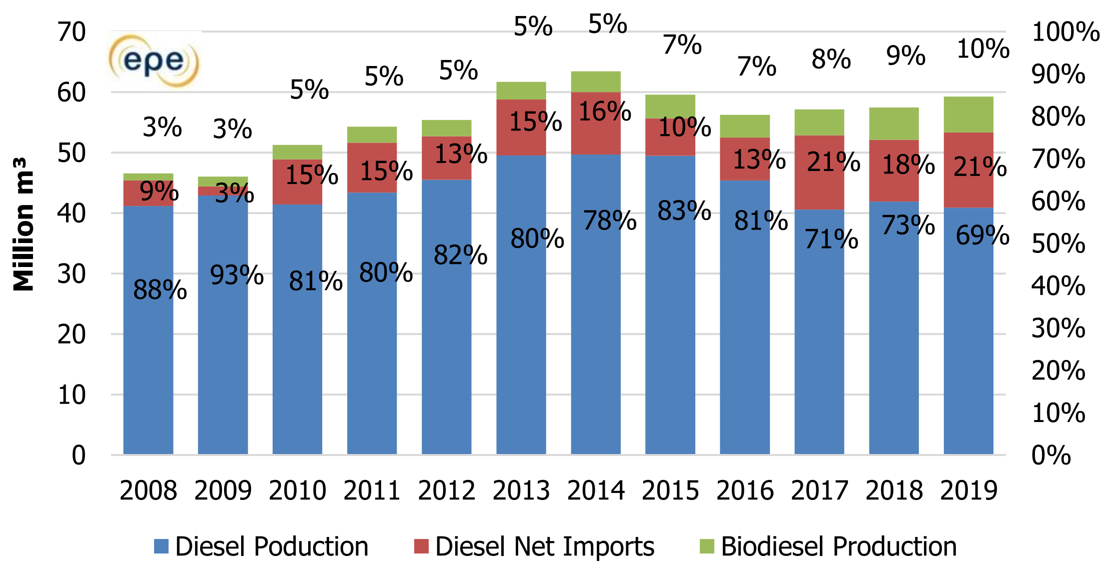


Source: EPE from (ANP, 2020c)

The larger share of biodiesel in the Diesel cycle attenuated the need to import fossil diesel, and, once again, the increase in the mandatory percentage was the main reason for this growth in the production and consumption of biofuel. In contrast, the production of diesel A by the national refining park was reduced by 2.4%.

Chart 34 shows the evolution of diesel A production and imports and biodiesel production. It is possible to verify that biodiesel production surpassed in 10.3% that of the previous year, and the consumption of diesel B grew only 1.6% in the same period.

Chart 34 – Diesel A offer and biodiesel production



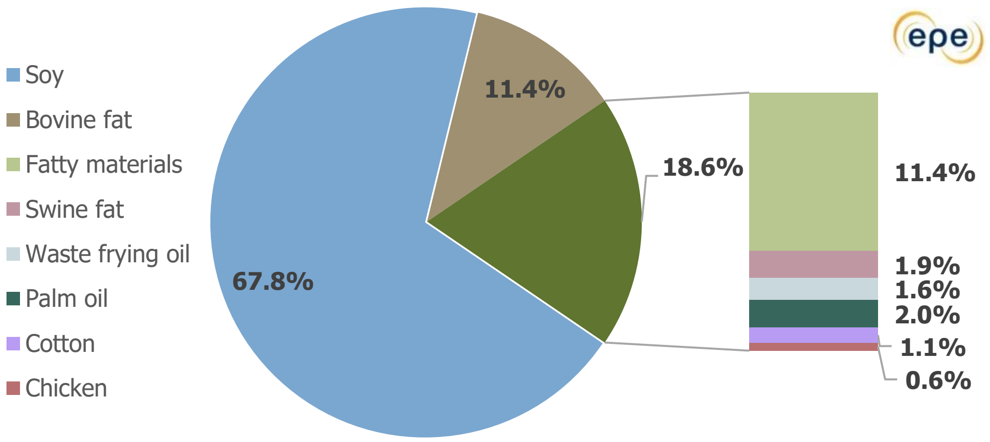
Source: EPE from (EPE, 2020a)

6.4. Raw Material for Biodiesel

Regarding all biodiesel consumed in 2019, 3.7 billion liters were produced from soybean oil, which is an 8% growth between January and December 2019 compared to 2018 (ANP, 2020c).

As illustrated by Chart 35, in 2019 soybean oil remained as the main raw material for obtaining biodiesel (69.8% in the input basket), followed by bovine fat and other raw materials, and the fatty materials stand out.

Chart 35 – Share of raw materials for biodiesel production in 2019



Source: EPE from (ANP, 2020c)

Given the trajectory presented over the past few years, soy will probably remain in a prominent position among the inputs used in the biodiesel production for a long period, although other raw materials are already emerging in this market. As occurred with bovine tallow, it is believed that palm and residual oils may also be prominent in the medium term. In view of the need to meet the expected mandatory higher percentages, there is need to diversify the input mix (ANP, 2020c) (EPE, 2019b).

Soybean production in Brazil was 120.8 million tons (123.1 million in 2018), a 2% decrease compared to the previous year. In turn, soybean oil production was 8.8 million tons, representing a 0.5% decrease. Domestic processing remained at the same level as 2018.

Soybean processing capacity is 63.6 million tons per year, according to the Brazilian Vegetable Oil Industries Association (ABIOVE, 2020). Due to the fact that the legislation in force favors the grain exports, this industry operates idly. Table 2 summarizes the situation of the soy complex in 2018 and 2019.

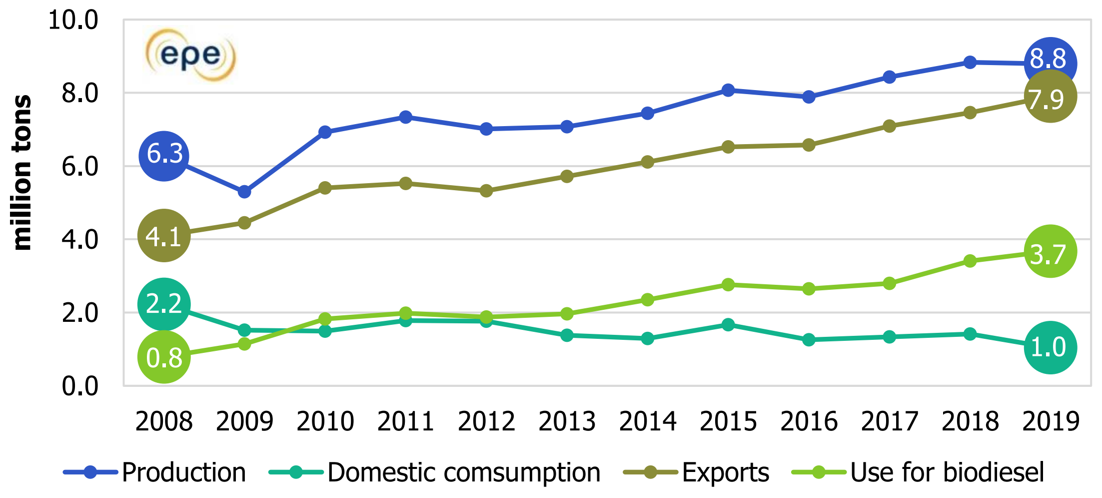
Table 2 – Soy complex[25]

Million tons	2018	2019	Δ % (2018-2019)
Soybean production	123.1	120.8	-2%
Installed soybean processing capacity	63.6	63.3	-0.5%
Soybean exports	83.3	74.1	-11%
Processed soy	43.6	43.5	-0.2%
Soybean meal produced	33.2	33.5	0.9%
Soybean oil produced	8.8	8.8	0.0%
Soybean oil exports	1.4	1.0	-26%
Consumption of food oil and others	7.6	7.9	4.0%
Consumption of soybean oil for biodiesel	3.4	3.7	8.8%

Note: The density considered for soybean oil was 0.92kg/l
Source: (ABIOVE, 2020) (ANP, 2020c)

Chart 36 illustrates the behavior of the Brazilian soybean oil market since 2008.

Chart 36 – Soybean Oil Market



Note 1: Domestic consumption includes biodiesel oil, food and other uses.
Source: EPE from (ABIOVE, 2020)

According to ABIOVE data, soybean oil production between 2008 and 2019 grew by 40%. This growth rate is much lower than the volume destined for biodiesel production, which went from 0.8 million to 3.7 million tons, a 365% increase over the same period. It is observed that this upward trend is accompanied by greater use of this oil for biodiesel, with higher mandatory percentages. Soybean oil exports fell by 53% in this period (ABIOVE, 2020).

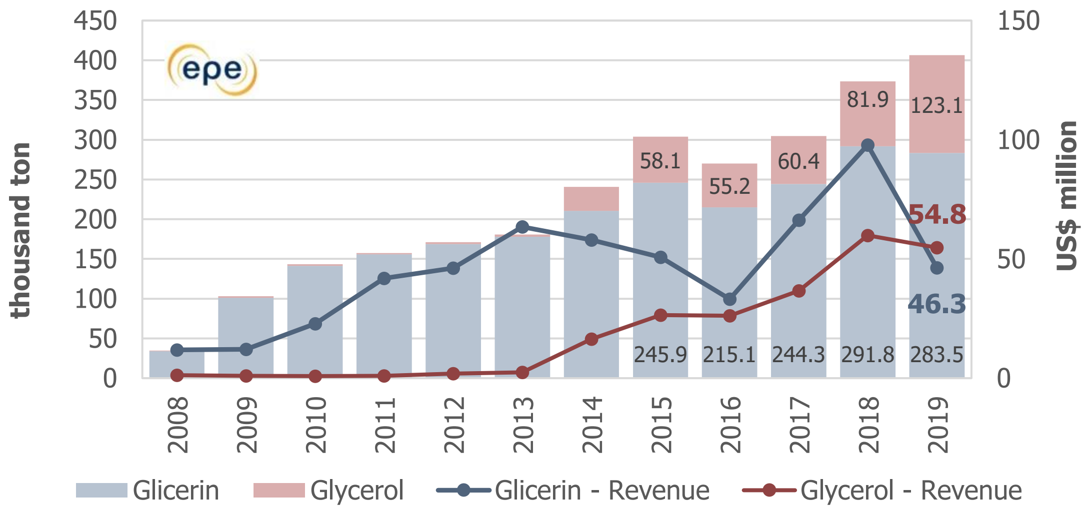
[25]The values referring to domestic consumption of soybean seed and other purposes were not considered.

6.5. Biodiesel Co-Products

Crude glycerin is a co-product of the biodiesel chain, which corresponds to approximately 10% in mass of the biofuel produced. In 2019, it is estimated that 0.6 million tons were produced (BIODIESELBR, 2019). Its total exports were 283 thousand tons, 2.8% less than the previous year, as shown by Chart 37 Revenue from crude glycerin exports was US$46.3 million, 42.7% less than in 2018, due to a greater offer in the market causing the product international price to drop. China remains the largest exports destination, with 90.3% of the total (ME, 2020).

Glycerol is a classification for refined glycerin, which has better prices in the international market than crude glycerin, and several plants are installing equipment for its purification, aiming at better revenues. Glycerol exports have been growing rapidly since 2013. In 2010, it totaled 123 thousand tons, a 50% increase over the previous year; however, there was a decrease in the revenue, from US$59.9 million in 2018 to US$54.8 million in 2019, representing an 8.5% retraction. The reason for this retraction was the decrease in product international prices (ME, 2020).

Chart 37 – Crude glycerin and glycerol exports



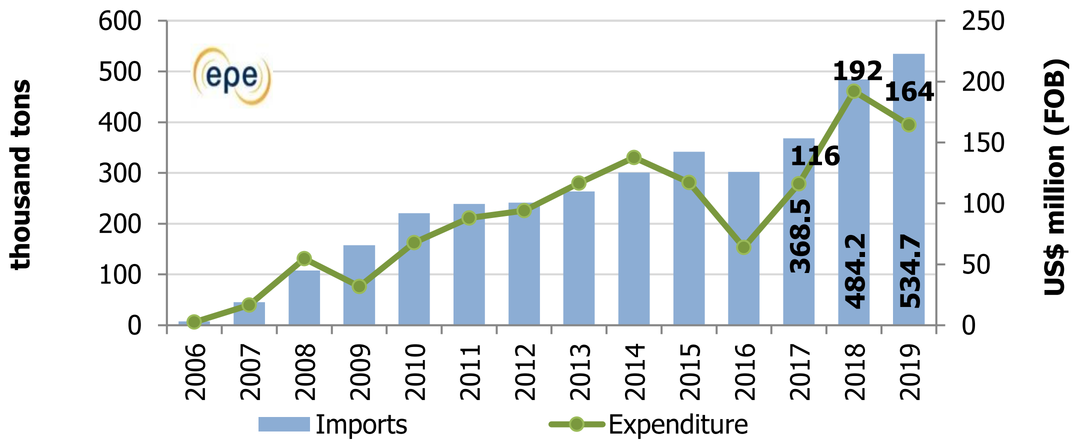
Source: (ME, 2020)

6.6. Methanol

Methanol is a fundamental input for obtaining Brazilian biodiesel. The USA concentrates world production due to the low prices of natural gas, which is the basic raw material for its production. Brazil imported 535 thousand tons of this input in 2019 for biodiesel production, most of which came from Chile, Trinidad and Tobago, Venezuela, and Saudi Arabia. Chart 38 shows the amount of methanol imported exclusively for biodiesel production and the resulting expenditure. The total in 2019 was 21.3% less than in 2018 and the expenditure totaled US$164 million (14.4% less than in 2017) (ANP, 2020c) (BIODIESELBR, 2020) (ME, 2020). The boost in imports of this input is directly related to the intensification of biodiesel production, caused by a higher mandatory percentage in 2010.

Methanol is a commodity and, therefore, its selling price is determined by the interaction between supply and demand in the world market. In the case of Brazil, the recent reduction in the cost of importing the product results from greater availability of this product at low prices in the market, and represents an additional factor for the development of a future national production (EPE, 2019b).

Chart 38 – Methanol imports for biodiesel



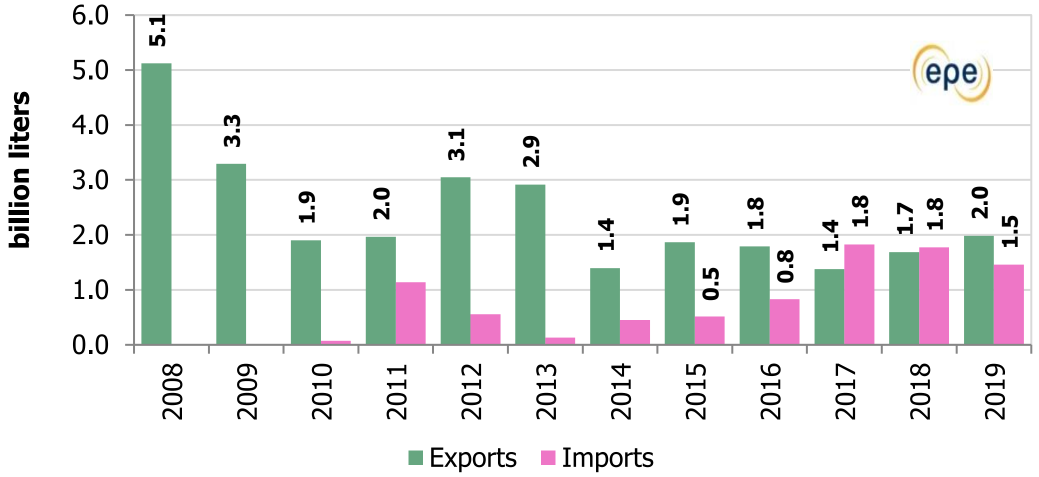
Source: EPE from (ANP, 2020c) and (ME, 2020)

7. Biofuels International Market

In 2019, there was maintenance of the characteristics of the biofuels international market of support for policies to encourage energy efficiency and/or promote more advanced energy sources and the modest volumes traded. The two main countries, Brazil and the United States, maintained their high share in this market, with 85% of production and marketing (RFA, 2020).

In 2019, Brazil was a net exporter of ethanol, exporting 2 billion liters, and the volume imported was of 1.5 billion liters (Chart 39) (ME, 2020).

Chart 39 – Brazilian exports and imports of ethanol – 2008 to 2019



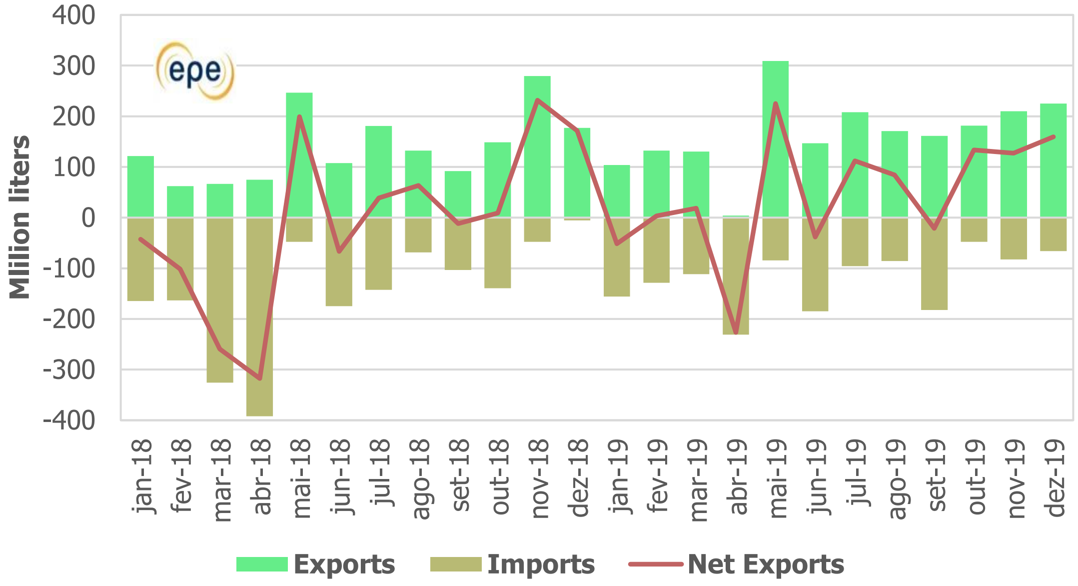
Source: EPE from (ME, 2020)

Since January 2017 to date, Brazilian ethanol imports have already shown significant volumes, with net exports in the intense crop months (Chart 40). CAMEX Resolution No.72 had been published to limit increasing imports, whose effects expired at the end of August 2019. This measure released from the imports tax a total volume of 1.2 billion liters of ethanol imported in the period in effect, with a quarterly quota of 150 million liters (ME, 2017).

On August 31st, 2019, CAMEX 72/17 expiration date, Ordinance No. 547 was published, which extends the import quota for an additional 12-month period from the date of publication, changing the volumes to the total of 750 million liters, distributed in 187.5 million liters quarterly (ME, 2019).

With the measures taken, ethanol imports remained high in 2019, even though the volumes traded constituted positive net exports.

Chart 40 – Monthly exports and imports of ethanol – 2018 to 2019



Source: EPE from (ME, 2020)

In relation to biodiesel, world trade remained concentrated between Europe, Argentina and the United States, with no relevant share of Brazil in volumes commercialized.[26]

United States

In 2019, the United States produced 60 billion liters of fuel ethanol, of which 55 billion were intended for the domestic market (EIA, 2020a). Its demand, linked to gasoline by the E10 blend, has been stable at around 50 billion liters (EIA, 2020b). The outflow for excess ethanol volumes has been the foreign market, in which the country has become the world's largest exporter of biofuel since 2014.

In 2019, net exports reached 4.9 billion liters. The United States exported mainly to Brazil (1.3 billion), followed by Canada (1.2 billion). The imported volumes came exclusively from Brazil, representing about one billion liters (EIA, 2020b).

The United States uses biodiesel in any percentage of addition, and B20 blend is more common (USDOE, 2020). In 2019, 6.5 billion liters of biofuel were produced, and 6.9 billion were consumed, with the difference supplied by importing 0.2 billion liters and using the stock (EIA, 2020a). Until 2017, American imports of biodiesel were high, reaching 2.3 billion liters in 2016, mostly from Argentina and Indonesia (80% or 1.8 billion liters). Nevertheless, after anti-dumping measures applied to both countries starting that year (USITC, 2018), volumes fell again in 2018, reaching 0.6 billion liters in 2019 (EIA, 2020a).

[26]In 2019, Brazil exported 327 tons of biodiesel (ME, 2020).

In relation to advanced biofuels, due to the difficulty in establishing production of cellulosic ethanol at the commercial level, EPA (Environment Protection Agency) again decreased RFS targets for this portion of biofuel in relation to the original values, as shown in Table 3. On December 19th, 2019, the agency reduced the target set for that year from 39.8 billion to 2.2 billion liters, in order for it to be in line with the actual volume produced. On the other hand, the target related to biomass diesel has grown from 3.8 billion original liters to 9.2 billion, an increase even compared to volumes previously modified for this category in 2019 (8.0 billion liters) (EPA, 2019).

Table 3 – RFS final volumes (billion liters)

	2019*	2019	2020*	2020	2021
Cellulosic biofuels	32.2	1.6	39.8	2.2	No alter.
Biomass diesel	3.8	8.0	3.8	9.2	9.2
Advanced biofuels	49.2	18.6	56.8	19.3	No alter.
Renewable fuels	106.0	75.4	113.6	76.1	No alter.

*Original volumes as released in the 2007 Energy Independence and Security Act
Source: (EPA, 2019), (EUA, 2007)

European Union

The bloc currently maintains an action plan for mitigating GHG and energy security, with goals for the years 2020, 2030 and 2050. For 2020, the current Triple 20 goals remain: 20% reduction in GHG emissions compared to 1990; 20% share of renewable sources in energy consumption, with 10% in automotive consumption, and 20% increase in energy efficiency compared to 1990. By 2030, the goals will be increased to 40%, 32% and 32.5%, respectively (EC, 2018).

In favor of second generation biofuels, the block will limit the share of traditional biofuels (sugarcane and corn ethanol and oilseed biodiesel) to a maximum of 7% in energy demand by 2020, eliminating its share in final demand by 2030 (BIOMASS MAGAZINE, 2018).

The European Union is a few months away from completing the deadline for meeting the Triple 20 goals. The goals for the participation of renewable sources in final consumption and for the level of mitigation of GHG emissions are close to being achieved, and in 2018, the share of renewable sources in final consumption was 18% and, in 2017, GHG emissions were 78% compared to the 1990 emissions level (EUROSTAT, 2020). However, the bloc may not reach the target of 20% increase in energy efficiency for 2020, having reached a primary energy consumption 4.9% below the value established for the goal (EURACTIV, 2020). On December 26th, 2018, the European Commission assembled a task force to mobilize efforts to achieve the goal by the end of the year (EC, 2019).

Asia

China is the world's third largest ethanol producer, with a production of 3.4 billion liters of sugarcane ethanol in 2019 (RFA, 2020), with exclusively domestic destination. Currently, the country has an E10 blending program in 10 provinces and intended to extend it to the rest of the country later this year, but considerations about the possible resulting increase in the price of sugarcane, coupled with local problems of crop production decrease, forced the government to delay national blending plans until after 2020 (REUTERS, 2020).

In 2019, Indonesia overtook the United States and Brazil, becoming the world's largest biodiesel producer, with 7.9 billion liters of biodiesel produced from palm oil (REN21, 2020). Biodiesel consumption in the country is driven by the B20 blending mandate and supported by funds from the tax on crude palm oil exports – CPO. Consumption is mainly used for the road transportation sector, with a small fraction used for electricity generation (USDA, 2019a).

South Korea is one of the main destinations for ethanol exported from Brazil (510 million liters), representing 26% of the total (ME, 2020). The country uses ethanol exclusively in industry and in the food sector, but the government studies the use of fuel ethanol, due to the environmental benefits (as a way of mitigating the problems of air pollution in large South Korean cities) and energy security (USDA, 2019b).

8. New Biofuels

The conjuncture of oil prices and the economic situation of developed countries, still recovering, have reduced investments in plants and advanced biofuels projects in the world. The worldwide implementation of commercial lignocellulose (E2G) ethanol production continues at a slow pace, while other advanced biofuels (e.g., HVO and BioQAV), and advanced automotive technologies (e.g., hybrid and electric vehicles) have received increasing attention

In Brazil, there are the Bioflex-I commercial plants of GranBio, in São Miguel dos Campos (AL), with a nominal capacity of 60 million liters/year, and the plants of Raízen, in Piracicaba (SP), with a capacity of 42 million liters/year. There is also the experimental project at the Sugarcane Technology Center (CTC), with a capacity of 3 million liters (GRANBIO, 2020) (RAÍZEN, 2018). The commercial units have faced technical challenges and made adjustments to their processes, still operating below nominal capacity. In 2017, GranBio produced 28 million liters of lignocellulosic ethanol, of which 5 million were exported to the United States, and in the 2018/19 crop, Raízen placed on the market 16.5 million liters of E2G, a very small volume if compared to the 2.5 billion liters produced by the company (FAPESP, 2019). The company currently directs its sugarcane production to thermoelectric generation, with the forecast of returning to operations in August this year (NOVACANA, 2020b).

Abroad, E2G projects have not been able to reach commercial production and many plants have stopped their operations, with no plans to resume. Table 4 presents the situation of lignocellulosic ethanol plants in the world.

Table 4 - Situation of commercial lignocellulose ethanol plants in the world

Company	Project	Country	Capacity (million liters yearly)	Situation
Abengoa Bioenergy Biomass of Kansas, LLC	Commercial (acquired by Synata Bio Inc.)	USA	95	No operation
Aemetis	Aemetis Commercial	USA	44	Project
Beta Renewables (acquired by Versalis)	Alpha	USA	76	No operation
Beta Renewables (acquired by Versalis)	Energochemica	Slovakia	70	No operation
Beta Renewables (acquired by Versalis)	Fujiang Bioproject	China	114	No operation
Beta Renewables (acquired by Versalis)	IBP-Italian Bio Fuel	Italy	51	No operation
Borregaard Industries AS	ChemCell Ethanol	Norway	20	In operation
Clariant	Clariant Romania	Romania	63	Under construction
COFCO Zhaodong Co.	COFCO Commercial	China	63	Project
DuPont	Commercial facility Iowa (acquired pela VERBIO)	USA	105	No operation
Enviral	Clariant Slovakia	Slovakia	63	Project
Fiberight LLC	Commercial plant	USA	23	Under construction
GranBio	Bioflex-I	Brazil	60	In operation
Henan Tianguan Group	Henan II	China	38	No operation
Ineos Bio	Indian River County Facility (acquired Alliance Bio-Products in 2016)	USA	30	No operation
Longlive Bio-technology Co. Ltd.	Longlive	China	76	No operation
Maabjerg Energy Concept Consortium	Flagship integrated biorefinery	Denmark	63	No operation
POET-DSM Advanced Biofuels	Project Liberty	USA	95	In operation
Raízen Energia	Brazil	Brazil	42	In operation
St1 Biofuels Oy em coop. c/ North European Bio Tech Oy	Cellunolix®	Finland	51	Project

Source: (MDPI, 2019)

Among the new biofuels, HVO (Hydrotreated Vegetable Oil) and aviation biokerosene (BioQAV) are worth mentioning. HVO is the fuel originated from the hydrogenation of oils (e,g., soy, palm, and animal fat), which results in a mixture of hydrocarbons with a paraffin base, free of sulfur and aromatic compounds, and with a high cetane number. This fuel has greater storage stability, better cold flow properties and can be used in diesel engines without the limits or mixing modifications required by the fatty acid ester. In addition to renewable diesel (green diesel or hydrobiodiesel), aviation fuel, bionafta and biopropane can also be produced from HVO ((EC, 2018) qt. in (EPE, 2020b)).

Currently, HVO represents the third largest biofuel in volume produced in the world, although with still modest volumes. From 2018 to 2019, HVO production grew 8.3%, from 6.0 billion to 6.5 billion liters, while production of traditional biodiesel (FAME or fatty acids and methyl esters) grew by 13% in the same period, to 47.4 billion liters (REN21, 2020).

It should be noted that this biofuel has high energy consumption in some technological routes, which can impact production costs, affect price formation, and influence the penetration in Brazilian fuel market. EPE has prepared a Technical Note, which presents characteristics, opportunities and barriers for the insertion of green diesel in the Brazilian energy matrix (EPE, 2020b).

For BioQAV, the United Nations International Civil Aviation Organization (ICAO/UN) has established an emission reduction agreement with airlines, called CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation), in which defines carbon neutral growth in the aviation industry, starting in 2021 (ICAO, 2018).

In addition to instruments for offsetting emissions and promoting energy efficiency, CORSIA provides for the use of alternative aviation fuels that are drop-in,[27] in particular those with processes certified by ASTM International (American Society for Testing and Materials International), according to Table 5. The raw materials used are defined according as the technologies go through the approval process of the subcommittee "Aviation Fuels" of ASTM International (ASTM, 2018).

Table 5 – Technological routes approved for the production of Alternative Aviation Kerosene

Route Name	Raw material	Main Product	Maximum Blend	Producers
HEFA-SPK	fats, oils and greases	Iso- and N-paraffins	50%	UOP, Neste and Syntroleum
FT-SPK	agricultural and forest waste, wood, and solid waste	Iso- and N-paraffins	50%	SASOL, Shell and Syntroleum,
FT-SPK/A	agricultural and forest waste, wood, and solid waste	Iso- and N-paraffins and aromatic products	50%	SASOL, Shell and Syntroleum,
ATJ-SPK	renewable raw materials (sugar cane, corn or forest residues)	Iso- and N-paraffins	50%	GEVO, Cobalt and Lanzatech
SIP	sugars	paraffins	10%	Amyris

Source: (ASTM, 2015) (ASTM, 2018)

[27]Drop-in biofuels are hydrocarbons, functionally equivalent to those of petrochemical origin and fully compatible with the existing oil infrastructure (DOE, 2019); (IEA, 2019); KARATZOS *et al.*, 2017; OH *et al.*, 2018; ZHANG; ZHAO, 2015 qtd. in (SCALDAFERRI, C. A, 2019); (NREL, 2013).

Observing the ASTM International certified technological processes, the following raw materials available in Brazil can be used more promisingly (in alphabetical order): babassu, forest resources (eucalyptus), *macauba*, palm, soy and sugarcane.

It is important to emphasize that there are still industrial and economic challenges for BioQAV to be competitive with aviation kerosene of fossil origin, in Brazil and worldwide.

Although no projects are planned for a significant production of BioQAV, there is a study for the installation of a pilot plant in Ceará, for deployment of a renewable electric energy network (wind or solar), to produce hydrogen and aviation biokerosene, with the higher specifications than those required by global regulation. Among its differentials, it is emphasized that it will be a mobile plant with possibility of being transported to airports with difficulty in supply, such as regional ones. An important link was established between governments (German and Brazilian), academia and the private sector, for the development of a disruptive technology with a neutral impact on the environment and society (GOVERNO DO CEARÁ, 2020).

With regard to biogas, it is worth mentioning that its production has been increasingly significant in the national energy scenario. Installed capacity in distributed generation doubled from 2018 to 2019, when it reached 37 MW, with the main inputs being agro-industrial, animal, and urban waste (ANEEL, 2020b). Its participation in the internal energy supply is still timid (0.1%), but it has been showing accelerated annual growth of 23% in the last five years. It should be added that a large part of the potential of this biofuel is found in the sugar-energy sector, and the sugar-energy plant that won the A-5/2016 auction is expected to start operations in 2021, with an installed capacity of 21 MW (EPE, 2020a).

9. Greenhouse Gas Emissions

Brazil plays a prominent international role in discussions and negotiations on climate change. A whole legal framework has been built in the country whose objective is to promote the use of renewable sources, especially biofuels. Another important step towards this end was taken in December 2017, with the establishment of the National Biofuels Policy – RenovaBio, which will be addressed in Item 10 of this document (BRASIL, 2017c).

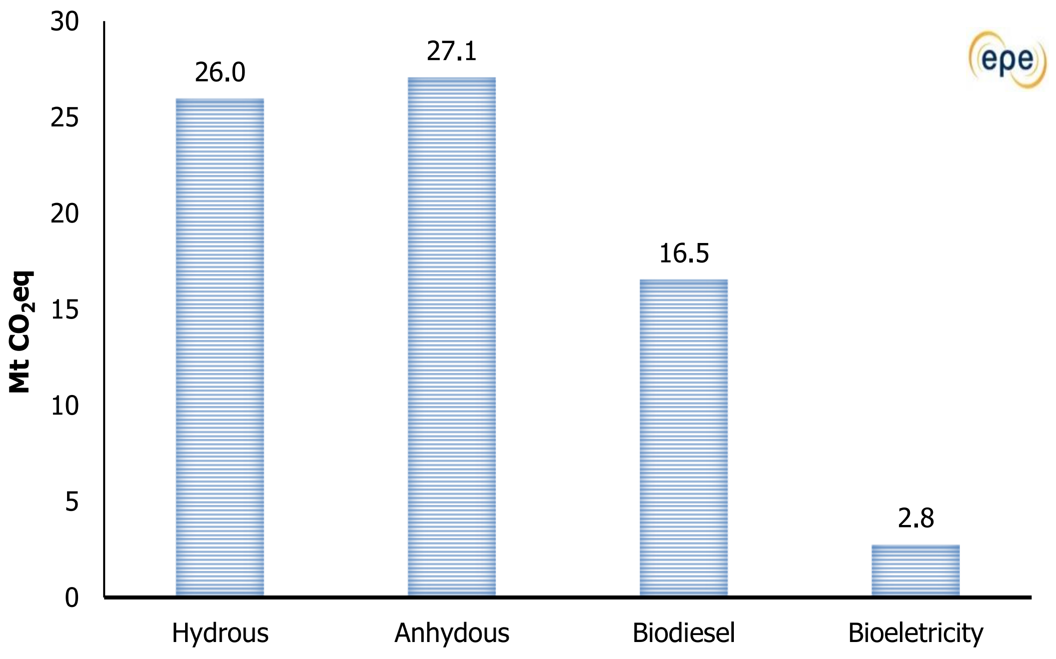
The high share of renewable sources in the national energy matrix provides a significant reduction in GHG emissions. As for liquid biofuels, emissions avoided by the use of ethanol (anhydrous and hydrated) and biodiesel, compared to fossil equivalents (gasoline and diesel), totaled 69.6 $MtCO_2$ in 2019.

In addition to liquid biofuels, sugarcane bioelectricity also contributes to reducing CO_2. To estimate the avoided emissions, the tCO_2 emission factor per MWh generated was used, calculated by the Ministry of Science, Technology and Innovation (MCTI, 2020). This indicator has fluctuated in recent years, due both to a higher thermal share of various fossil fuel sources in electricity generation in times of water scarcity, and to a greater contribution of other renewable sources, such as wind which presents increasing injection. In 2019, there was an increment in fossil thermal generation (15%), with a significant drop in the share of oil-fired thermal plants (69.7%) and growth of natural gas-fired (15.5%) and mineral coal (8.8%) thermal plants. In addition, there was a greater participation of biomass (3.4%) and wind (17%) plants, and water plants maintenance. These changes combined had little impact on this factor, going from 0.074 tCO_2/MWh to 0.075 tCO_2/MWh in 2019.

Considering the exported energy and self-consumption by the sugar-energy units, the CO_2 values avoided are significant. The stability of the emission factor of the matrix was reflected in this indicator and, considering that the amount of energy generated by the sugarcane biomass plants remained unchanged in 2019, the total avoided GHG remained at the same level. Thus, the amount of emissions avoided in 2019 was 5.3% higher than that of 2018 (2.6 $MtCO_2$), adding up to 2.8 $MtCO_2$, of which 1.1 came from self-consumption and 1.7 $MtCO_2$ from exported energy.

Chart 41illustrates the avoided emissions resulting from the use of biofuels (anhydrous and hydrous ethanol and biodiesel) and of bioelectricity of sugarcane.

Chart 41 – Emissions Avoided with Biofuels in 2019 – Brazil



Source: EPE from (EPE, 2020a), (IPCC, 2006), (ROSA, OLIVEIRA, COSTA, PIMENTEIRA, & MATTOS, 2003) and (MCTI, 2020)

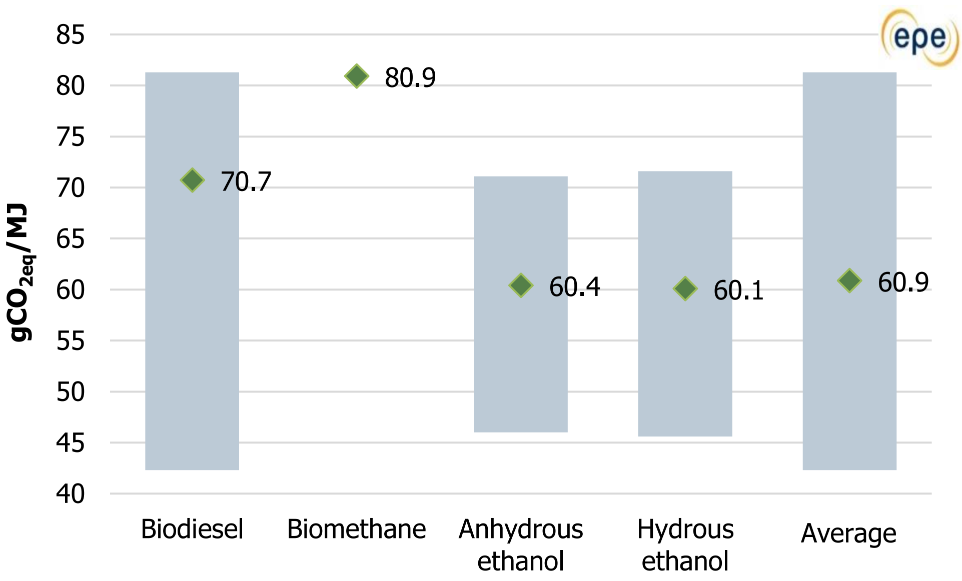
10. RenovaBio

The year of 2019 was an important year for the implementation of the National Biofuels Policy. Based on its three main operating instruments (annual carbon intensity reduction targets (gCO_2/MJ) for a minimum period of 10 years, Biofuels Certification and Decarbonization Credit - CBIO), several actions were taken by the agents involved. In this section, the main events and the current panorama of RenovaBio will be presented.

In January 2019, ANP approved the accreditation of the first inspecting company for the Certification of Efficient Biofuel Production, as provided for in the Law that created RenovaBio. In January 2020, there were already 10 inspection companies accredited (ANP, 2020f).

The first Certificate of Efficient Production of Biofuels was issued in October 17th for a biodiesel production unit using residual oil. The number of certified companies has evolved rapidly and reached a total of 220 approvals on June 29th, 2020, with the following profile: 20 biodiesel units; 195 1st generation sugarcane ethanol producers; two flex type corn ethanol units and one full type, one 2nd generation in an integrated plant, and a biomethane unit. Additionally, there are 24 processes in progress, that is, 11% of the total (ANP, 2020f). Chart 42 presents the average of the Energy-Environmental Efficiency Rating of the certified units for each biofuel, as well as the range between the minimum and maximum values. Biodiesel and biomethane have the highest scores.

Chart 42 – Energy-Environmental Efficiency Rating of the certified units

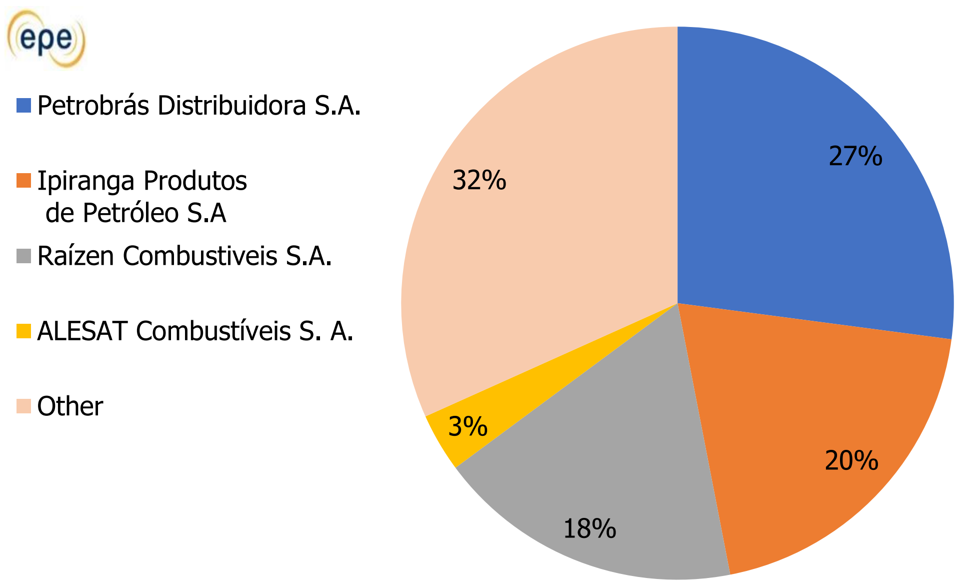


Source: EPE from (ANP, 2020f)

From these scores and, using the respective ethanol and biodiesel production in 2019 from the units already certified, as well as their eligible volumes, it is estimated that the potential number of CBIO is around 32 million.[28] However, as the certifications occurred throughout the year, this amount drops significantly for 2020, since they are linked to the commercialization of biofuels with distributors. It should be noted that 11% of the total certifications still need to be approved and are not included in this calculation.

Following the schedule provided by the program, ANP Resolution No. 791, of June 12th, 2019, was published, which addresses[29] the individualization of the mandatory annual goals for reducing GHG emissions for commercialization of fuels by distributors (ANP, 2019a). CNPE Resolution No. 15, of June 24th, 2019, redefined the mandatory annual targets for reducing GHG emissions for commercialization of fuels. It should be noted that, due to Covid-19 pandemic impacts, a proposal to revise the goals for 2020, as well as its extension until 2030, is in the process of public consultation (MME, 2020). According to the proposal, the total of CBIO to be marketed in 2020 is 14.53 million and, for 2030 it is 90.67 million. According to Chart 43, three companies will be responsible for the acquisition of approximately 65% of CBIO in 2020 (ANP, 2020f). It should be noted that these goals are subject to review by the Council every year.

Chart 43 – 2020 CBIO Individual Goal



Source: (ANP, 2020f)

At the end of the year, ANP published Resolution No. 802, of December 5th, 2019 (ANP, 2019b), which establishes the procedures for generating the ballast necessary for the primary issuance of Decarbonization Credits, through the CBIO Platform, in operation since the beginning of January 2020. The ballast have to be requested by certified biofuels producers and holders of contracts signed with the Federal Data Processing Service (Serpro). The platform considers invoices issued as of December 24th, 2019. Valid

[28]The impacts of the Covid-19 pandemic, as well as changes in the production mix, could alter this potential.
[29]According to Decree No. 9.308, of March 15, 2018 (BRASIL, 2018), which was replaced by Decree No. 9.888, of June 27, 2019, ANP is responsible for detailing the goals of each distributor, according to its market share of fossil fuels in the previous year (BRASIL, 2019).

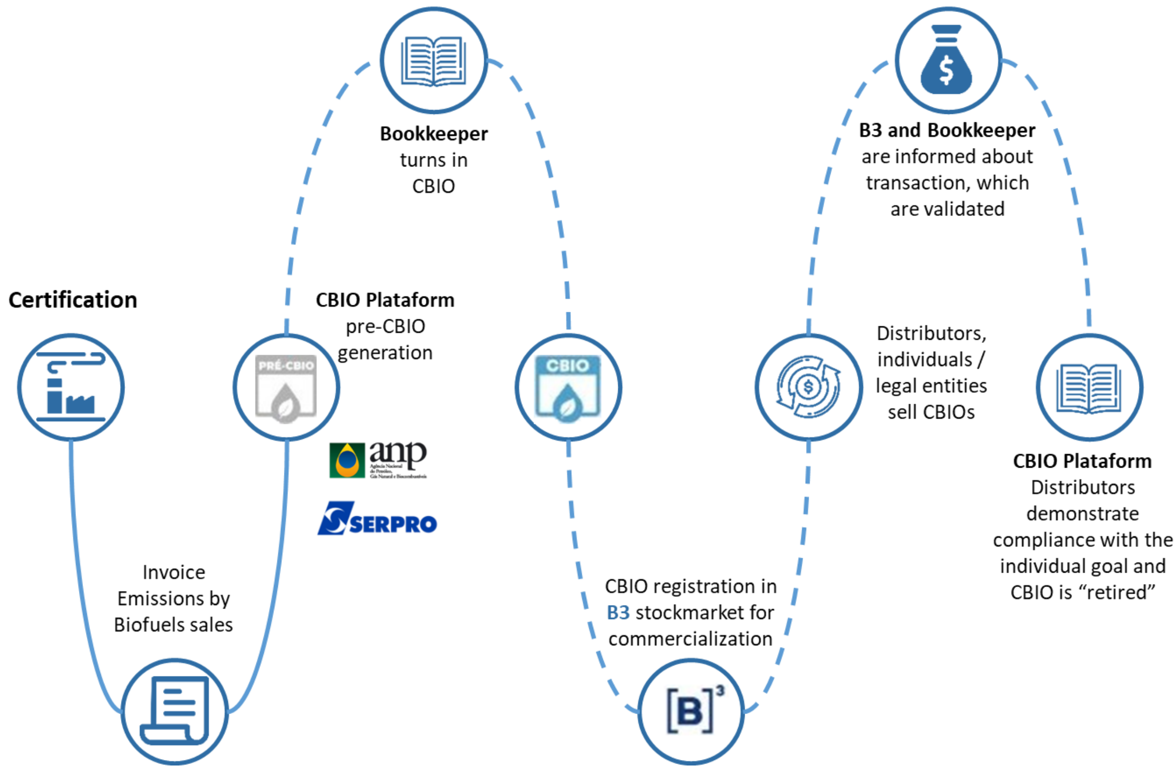
invoices generate what has been called "pre-CBIO," which can be converted into securities (CBIO) by bookkeeping agents[30] and placed for trading in organized markets. In February 2020, there were 10 requests from producers. (SERPRO, 2020)

Article 7, § 2 of Law 13,576 / 2017 (BRASIL, 2017c) indicates that:

"The proof of compliance with the individual goal by each fuel distributor shall be carried out based on the amount of Decarbonization Credits in its property, on the date defined in the regulation."

This proof have to occur through ANP Platform, when they will be removed from the market, as detailed in Figure 4.

Figure 4 – CBIO Flow



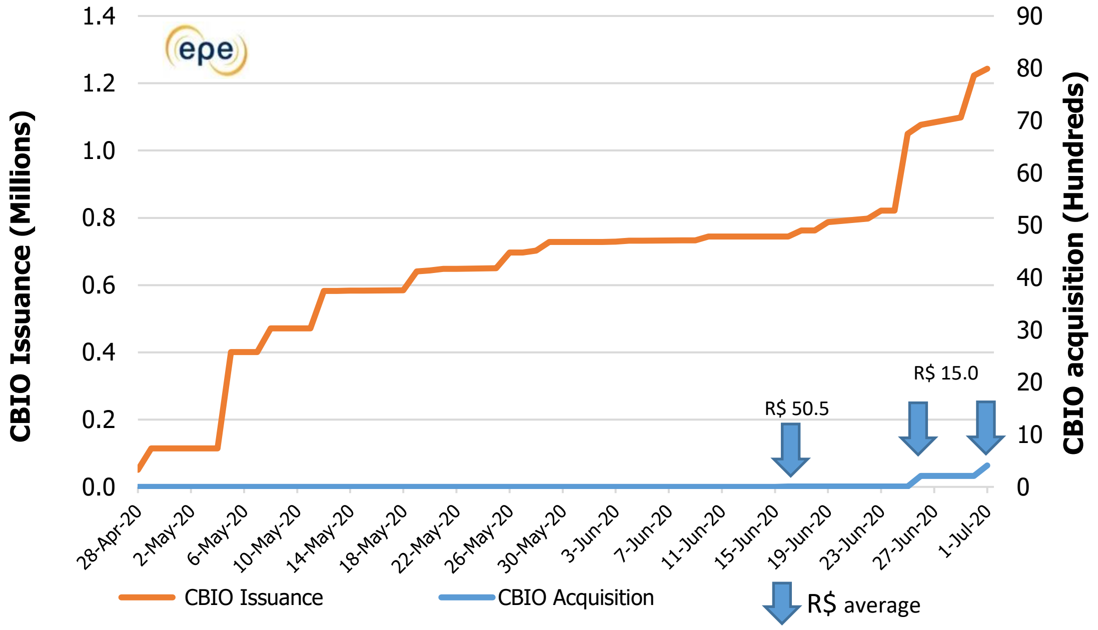
Source: EPE from (ANP, 2020f) and adapted from NovaCana (NOVACANA, 2020a)

Decarbonization credits began to be issued and made available at B3 in late April 2020 and until June 29th, represented 1.2 million CBIO.

In June, there were three credit negotiations by non-obliged parties, with negotiations totaling 6,200 units, at weighted average prices of R$ 16.00. Chart 44 shows the evolution of the accumulated quantities of CBIOs issued and traded, as well as the prices of these negotiations.

[30]Bank or financial institution hired by the producer or importer of biofuel, responsible for issuing book-free Decarbonization Credits on behalf of the primary issuer (BRASIL, 2017c).

Chart 44 – Issuance X Marketing (accumulated) and CBIO prices at B3



Source: EPE based on B3 (B3, 2020)

One aspect that is still under debate is the taxation of CBIO. The subject has been dealt with by Provisional Measure No. 897, of 2019 (BRASIL, 2019), and the proposal is a 15% taxation on profits earned in sale operations, in a manner similar to that observed in financial market securities (financial assets and securities). However, the Federal Revenue Office requested the veto of the MP article because it understands that this rate would represent a tax waiver, as the current rate is 34%, which includes income tax (IRPJ) and Social Contribution on Net Income (CSLL).

Thus, with the entire structured regulatory framework, the certifications of biofuel producers or importers and the development of the CBIO Platform, RenovaBio has the potential to bring economic, social and environmental benefits to Brazil.

11. The agro-energy sector and its resilience: Covid-19 impacts

11.1. Introduction

Globally, Brazil stands out for the wide participation of renewable sources in its energy matrix, for its favorable edaphoclimatic conditions, extensive availability of land, and government incentives, as already highlighted in EPE studies (EPE, 2016b).

Specifically for biofuels, over the years, several public policies were implemented, such as the National Alcohol Program (PROALCOOL), in the 1970s, the National Program for the Production and Use of Biodiesel (PNPB) in 2005, and more recently, in 2017, the National Biofuels Policy (Renovabio) (EPE, 2016b) and (EPE, 2018a). In addition, the country has mandates for adding biofuels to oil derivatives (anhydrous ethanol in gasoline type A and biodiesel in diesel A oil) and specific financing lines for the sector (BNDES, 2020c); (BRASIL, 2016); (MAPA, 2020). Another important point was the adoption of flex fuel technology in 2003 by automotive manufacturers, enabling the use of up to 100% hydrous ethanol in vehicles. In 2019, EPE evaluated, in the article of the commemorative edition of the Biofuels Conjuncture Analysis, the evolution of biofuels in the national matrix over the last decade, in which the impacts of these initiatives are highlighted (EPE, 2019c).

Thus, Brazil has a successful history in the production and use of biofuels in the transportation sector, whose share reached 25% in 2019, when a record of hydrous ethanol production and an increase in the biodiesel content in diesel B was also recorded. Thus, the ester contributed with 4.5% and total ethanol with 20.6% of the final energy consumption of the vehicle matrix. It is noteworthy that the total of renewable sources in demand in the Otto cycle was 49.1% (EPE, 2020a).

The origin of this chain is in the agricultural segment, whose diversity offers a variety of co-products that can be directed at producing biofuels and food. Unlike some regions of the world, this productive interrelation minimizes the possible competition for land use in the national territory. This interface is beneficial, as it favors the production of biofuels, promoting the diversity of the energy matrix; contributes to food security by developing agriculture and generating income in a sustainable manner in the countryside; fosters regional and national economic development; relieves the effects of global climate change, as well as reducing the emission of local pollutants. Thus, this article aims to analyze the productive integration between energy and food and the resilience of the agro-energy sector, through a brief assessment of Covid-19 pandemic impacts on this sector.

11.2. Productive integration between biofuels and food

In view of all the potential presented and enjoyed in the production and use of biofuels, it is worth noting that Brazil has possibilities of reaching more efficient levels, observing the edaphoclimatic characteristics inherent to each region, related to its agricultural products and its transportation matrix.

According to LA ROVERE and TOLMASQUIM (LA ROVERE, E. L. e TOLMASQUIM, M. T., 1986), integrated food and energy production systems (SIPAE) presuppose land use planning, as well as balanced interrelationships between soil, water and forest resources in relation to agricultural waste. For this purpose, agricultural and industrial technologies are used that maximize the use of by-products and waste, in addition to the diversification of raw materials.

Its main advantages include less environmental impact and enhanced efficiency, which generally have positive economic and social effects. The advantages already obtained by Brazil in the production and use of biofuels could be maximized, if these integrated systems are widely adopted.

In addition to the main large biofuel producers, which already apply advanced agro-industrial techniques, reaching world productivity records, there are 6,887 cooperatives in operation in Brazil, of which 1,613 are agricultural cooperatives, and some are already integrated into the production system. It is registered that in 2018 there were 1 million cooperative members and 209 thousand employees, according to the 2019 Statistical Yearbook of Cooperative Sector of the Organization of Brazilian Cooperatives (2019). Among the main co-products of these cooperatives, which can be used for the production of biofuels, soy, sugar cane, corn, rice and fatty inputs of animal origin (poultry, pigs, and fish) stand out. Some of those cooperatives, already integrated into the production system (currently 50 thousand families), provide raw material for companies producing biodiesel, which have the differential of having the Social Fuel Seal (SCS).[31]

Regarding the legal framework, Brazilian legislation is quite advanced in terms of protecting the environment (MMA, 2020) (BRASIL, 1981), natural resources and local communities (BRASIL, 2007). This legislative apparatus converges with the Sustainable Development Goals (SDG 2) of the Food and Agriculture and Organization – FAO (FAO, 2018), which aims to produce nutritious and sufficient food, in the entire agricultural area, seeking to achieve Zero Hunger by 2030. The production of national biofuels has to meet the legal requirements, since the non-observance of these premises may result in the imposition of sanctions and non-tariff barriers, which may restrict their participation in international trade.

In this sense, the ethanol (cane and corn) and biodiesel production chains will be described below, in order to detail the existing integration between energy and food.

[31]Social Fuel Seal differentiates biodiesel production companies that support family farming. Producers who own SCS obtain sales advantages and better financing conditions (CASA CIVIL, 2017).

11.2.1. Sugar-Energy Sector

The sugar-energy sector has great relevance for the Brazilian economy, with 366 units, the majority with production capacity for both ethanol and sugar.

It has a high potential for job creation, as it is labor intensive, especially in the agricultural area, intensified during the harvest period. In addition, there are a number of indirect jobs linked to its production chain. It is estimated that the total number of people employed directly in this sector, in the agricultural (75%), industrial (20%) and administrative (5%) stages, was around 250 thousand in the 2019/2020 crop in Brazil, based on the recent study by consultancy Wiabiliza (NOVACANA, 2020d).[32] In order to estimate the number of indirect jobs in this segment, the corresponding multiplier for the biofuels sector (and not just in the sugarcane sector) of the IBGE Input-Output Matrix was used, whose value is 11.49 (IBGE, 2015). Thus, to the 250 thousand direct jobs generated, another 2.9 million indirect jobs are added in this same region. It is registered that the number of direct jobs in the sector in 2013 varied between 613 thousand and 1.0 million (NEVES, M. F.; TROMBIN, V. G. (Coord.), 2014). However, the study already signaled a downward trend, due to the increasing adoption of the mechanization of agricultural practices and industrial automation.

The production units have increasingly sought energy integration in order to improve their productivity and the use of by-products. Bioelectricity, generated from sugarcane bagasse and straw, is used for self-consumption by the plants and the surplus can be exported to the National Interconnected System (SIN). Revenue from the sale of bioelectricity is increasingly relevant, becoming the third asset in the sector. It is characteristic of the sugar-energy units that production between sugar and ethanol is more flexible, allowing it to adjust to market fluctuations, varying the production mix, with the aim of maximizing its revenues and minimizing losses. For example, in the last two years, with a higher production of biofuel, the mix for ethanol was at an average value of 65%, according to Item 1 of this study.

Another important point is the use of vinasse for crop fertirrigation and, more recently, its use has been developed, together with filter cake, for the production of biogas. This biofuel can be used in agricultural machinery and in trucks, as well as in electrical generation and injected into the pipeline network.

Ethanol production has shown expressive growth and reached a record value of 36 billion liters in 2019. About 95% of the total is intended for energy use, with the remainder being mainly used for the composition of alcoholic beverages, cleaning products and paints.

With regard to sugar, its national production reached 39 million tons in 2016 and, in the last two years, it showed a reduction, due to the drop in the price of the commodity,

[32]According to Wiabiliza, 387.97 people are needed for every one million tons of crushed sugarcane, in all stages of production (agricultural, plant and administrative). This factor is multiplied by the sugarcane milling in the 2019/2020 crop in Brazil (642 Mtc), to estimate the number of direct jobs in the sector.

which led to the redirection of the mix to greater production of ethanol.

The average national consumption of sugar is 11 million tons, and most of the national production is exported. The country is an important global player, accounting for around 42% of international trade. Sugar exports had a significant 35.1% growth from January to April 2020, compared to the same period in 2019 (IPEA, 2020).

Sugarcane derivatives are responsible for an important participation in the final consumption of energy in Brazil, in several sectors of the economic activity: in the transportation sector, they represent 21%; in the industrial sector, 17% (and 68% of these are in the food and beverage segment); and in the energy sector, 52% (EPE, 2020a).

11.2.2. Corn Ethanol Production Sector

The production of ethanol from corn has shown significant growth in recent years. The use of this commodity makes it possible to take advantage of opportunities for lowering the price of grain in the foreign market, since the logistical costs of the flow from the Center-West region impact the competitiveness of the product internationally. An important point is that the cereal can be stored, unlike sugarcane. Thus, ethanol production can be carried out in a period of greater economic attractiveness.

The productive units can be of the full type, which process only corn, or of the flex type, which use cereal and sugarcane. In the latter, it is possible to operate in the sugarcane off season, reducing operational idleness and the instability of ethanol prices throughout the year (season and off season); decreasing storage infrastructure costs for transit stock; enhancing the competitiveness of hydrous ethanol compared to gasoline (mainly in the off season) and increasing the total ethanol supply.

From corn ethanol production, corn oil, destined for human consumption, and DDGS (distiller's dried grains with solubles), for animal nutrition, containing between 30% and 35% of protein, are generated as co-products (MILANEZ et all, 2014) (IMEA, 2017). Mato Grosso is the main producer of corn and, consequently, of corn ethanol. The cereal production in the 2019/20 crop was around 98 million tons, and 40% of the production was exported. The volume of corn ethanol in this period was 1.7 billion liters (CONAB, 2020b). Other states in the Center-West and North regions are also expanding the production of this biofuel. It should be added that this is one of the main cereals produced in cooperatives in Brazil, in which there is a significant participation of family farming, providing employment and income generation in the field.

11.2.3. Biodiesel Sector

The National Program for the Production and Use of Biodiesel (PNPB), established through Law No. 11,097/2005 (BRASIL, 2005), inserted this biofuel into the national energy matrix. The objective of this policy was to implement in a sustainable manner, both technically and economically, its production and use, with a focus on social inclusion and regional development, via job and income generation. This Program established the regulatory framework that defines a normative basis for the production and commercialization of biodiesel in the country, involving the definition of the tax model and mechanisms for the inclusion of family farming, embodied in the Social Fuel Seal (SCS).[33]

Since the mandatory use of biodiesel in the mixture with fossil diesel was instituted, there has been a rapid evolution towards higher levels of addition. The initial value was set at 2% in volume, in 2008, reaching 5% already in 2010, when the expected value would occur only in 2013. In subsequent years, there was a gradual increase in the minimum mandatory percentages for diesel B, reaching 12% in March 2020.

In 2019, the main raw materials used for their production were soy and animal fat (beef, pork and chicken), with 68% and 14%, respectively. Production was strongly regionalized, with the Center-West and South regions responsible for 82.9% of total production in the same year

The main product from soy is bran for animal feed, as the oil can have other applications, such as in the food industry, in addition to use in the biodiesel production process. According to ABIOVE, in 2019, the production of bran was 33.5 million tons, and the use in the domestic market was 52%. For oil, production reached 8.8 million tons, 92% of which remained in the country.

Brazil is a major producer of soybeans, 120 million tonnes in 2019, and 60% of the production is exported (ABIOVE, 2020).

One of the important results of the inclusion of biodiesel in the Brazilian energy matrix was the strengthening of cooperative activity. The insertion of SCS incorporated family farming into the production of the new biofuel (EPE, 2016b). According to the 2017 Agriculture Census (IBGE, 2017), that year, of the total of more than 5 million rural properties across Brazil, 579 thousand were linked to cooperatives, with approximately 410 thousand family farms (MAPA, 2019). With regard to these families, around 100 thousand participated in the supply of raw materials for the production of biodiesel, providing an income of around R$ 3.8 billion for this segment in 2016 (CASA CIVIL, 2017), which from 2010 to 2017 represented, on average, 3.5% of national GDP, with the value of R$ 243.2 billion (in 2017 reais) (IBGE, 2018).

Finally, it should be noted that the sector of small cooperatives and family farming accounts for a large part of the wide variety of foods in the typical basket of the Brazilian family, which includes rice, beans, corn, vegetables and vegetables (MUR, D. C. C., 2019). Cooperatives represent around 50% of total agricultural GDP (IBGE, 2020).

[33]Social Fuel Seal differentiates biodiesel production companies that support family farming. Producers who own SCS obtain sales advantages and better financing conditions (CASA CIVIL, 2017).

11.3. The agro-energy sector and its resilience: Covid-19 impacts

The unprecedented situation caused by the Covid-19 pandemic for society and for the global economy showed a large part of the economic and social "modus operandi" in force to date. In Brazil, measures to restrict personal mobility have led to a drastic reduction in consumption, both for oil products and biofuels. Given this context, a recent study by EPE analyzed the impacts and consequences of the pandemic on the Brazilian fuel market, based on the construction of three distinct trajectories for the short term (EPE, 2020c).

Until May 2020, there was a drop in sales of gasoline type C of 11.6%, hydrous ethanol of 21.6% and diesel B of 3.4%, compared to the same period of 2019 (ANP, 2020g) (MAPA, 2020).

For the sugar-energy sector, the drop in demand for ethanol (anhydrous and hydrous), caused the mix to be shifted to sugar production. The revenue obtained from the sale of bioelectricity contributed to the units' cash flow in this period. As previously mentioned, corn ethanol producers can store this cereal, awaiting better opportunities for its commercialization and/or for ethanol production.

Regarding biodiesel, there was less impact of the pandemic on its demand, since the mixture of fossil diesel and biodiesel is intended, in greater volume, for the movement of goods. The increase in the percentage of mandatory mixing, from 11% to 12%, starting in March 2020, resulted in a higher consumption, which could be even greater, if there was no drop in demand for the Diesel cycle.

On the other hand, April data point to production growth in the 2019/2020 crop for corn (2.2%), sugarcane (0.9%) and soy (5.2%) (IBGE, 2020). These crops have a relevant share in the agricultural GDP: the production of corn (6.1%), sugarcane (9.6%) and soybeans in grains (26%), together, represent about 42% of this indicator (IPEA, 2020). Thus, it is possible to observe that, despite the adverse scenario, the national agricultural sector has shown economic growth when compared to other sectors of the economy.

The importance of the agricultural sector in the national economy is highlighted. In the 1st quarter of 2020, the national GDP retracted by 1.5% in relation to the previous quarter and, by 0.3%, considering the same period in 2019. In turn, between January and March 2020, agricultural GDP increased by 1.9%, representing a slight increment in agricultural production, reflecting the plantations carried out in 2019 and maintaining consumption levels, in line with employment of modern techniques in this production sector (IBGE, 2020).

Companies in Brazil and around the world are reevaluating strategies - and investors are re-analyzing risks - in response to the deep financial uncertainties and difficulties of the moment. At the national level, investments in the production chain were postponed, such as the implementation of corn ethanol plants.

Investment prospects for energy have been addressed in studies released by the IEA recently (IEA, 2020b). As a reflection of the drop in demand, the deceleration of resources invested in new energy projects was observed. In the pre-crisis period, investments of 2% were expected to be higher; after the crisis, the prospect is for a 20% reduction. However, the renewable sector will be the least impacted. For the transportation sector, part of this explanation is due to the existence of mandatory mixtures in the main world players (IEA, 2020a). Additionally, the incentive to biofuels through policies such as RFS (USA), RED[34] (EU) and RenovaBio (Brazil) remains the main determinant of investment in this sector, which is based on energy security and sustainability. In addition, the crisis caused by the pandemic can be seen as an opportunity for more relevant investments in renewable sources and green infrastructure to avoid lock-in with obsolete and inefficient systems.

As noted, the synergy between food and energy production is significant.

In a context in which there is a retraction in the demand for biofuels, the existence of a robust agro-energy industry maintains this chain in full operation.

[34]RED - Renewable Energy Directive - European Union directives.

11.4. Final Considerations

It was possible to observe that the integration between the production of food and energy is an important element for sustaining the national agro-energy sector, and this synergy is highlighted in the Covid-19 pandemic. Due to its extension and location, the Brazilian territory has climatic characteristics that enable the production of several energy resources, a competitive advantage presented by a few nations.

It was noted that, as of March 2020, fuel consumption and production were affected by the impacts caused by Covid-19. In Brazil, the energy sector has a significant share of renewable fuels and restrictions on mobility, produced by the crisis, resulted in impacts on this sector, with a drop in fuel demand, both for the Otto cycle and for the Diesel cycle. This fact was not verified in the food segment, which registered an improved production of the main energy crops.

Among the points of interest, it should be noted that energy production in synergy with food production presents beneficial resilience to both sectors and, in the national case, they are not linked to the dispute for land use. The action of cooperative units for the production of inputs, which can be directed towards obtaining food and biofuels, strengthens the generation of jobs and income in the countryside, and it is worth noting the importance of cooperatives and family farming, which are responsible for around 50% of national agricultural GDP and for the production of most of the products that compose the typical Brazilian food basket.

Energy policies encouraging the use of biofuels in Brazil have sought energy security and to promote social economic development, meeting sustainability requirements. It is important to note that this legal apparatus is in line with the FAO's Sustainable Development Goals (SDG 2), which aim to achieve Zero Hunger through production of nutritious and sufficient food by 2030.

The country has historically had a great agricultural vocation, with a strong agro and mining-export tradition, focused on primary commodities. Taking advantage of competitiveness for agro-energy production can provide the support for the country to promote the production of goods with greater added value, contributing even more to the production of national wealth.

The repercussions of this pandemic and its scope and depth should be better evaluated in future studies, once its most immediate effects on public health and mobility have been overcome.

It was possible to observe throughout this article that the existence of a high interrelation between agricultural production and biofuels brings countless positive developments, in addition to increasing sector resilience, making the impacts of exceptional situations such as the one we experience be better dealt with than other sectors of the economy.

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