



TECHNICAL NOTE

Investments and Operating and Maintenance Costs in the Biofuel Sector: 2023 - 2032

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Investments and Operating and Maintenance Costs in the Biofuel Sector: 2023 - 2032

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■ Summary

Introduction.....	1
1. Ethanol	1
2. Biodiesel	4
3. Biogas and Biomethane.....	5
4. Other Biofuels	6
5. Summary	6
Acknowledgments	7
References	8

■ List of Tables

Table 1. CAPEX estimate of first generation sugarcane mills	2
Table 2. CAPEX and OPEX estimates for ethanol between 2023 and 2032.....	3
Table 3. CAPEX and OPEX estimates for biofuels between 2023 and 2032	6

■ List of Charts

Graphic 1: CAPEX for ethanol between 2023 and 2032 (billions of R\$ and %)	4
Graphic 2: CAPEX for biofuels between 2023 and 2032 (billion R\$ and %)	7

Introduction

This technical note aims to disclose assumptions and investment estimates (CAPEX, capital expenditure) and operational and maintenance costs (OPEX, operational expenditure) related to biofuels for the period 2023-2032, including ethanol (cane and corn), biodiesel, biogas (from the sugar-energy sector) and BioQAV/Green Diesel. The supply and demand values for biofuels refer to the average scenario of the document Ethanol Supply and Demand Scenarios for the Otto Cycle 2023-2032 and to internal studies on the horizon up to 2032 (EPE, 2002a, 2022b).

1. Ethanol

It is estimated that the Brazilian ethanol production will reach 45.8 billion liters in 2032, according to the average growth scenario presented in the document Ethanol Supply and Demand Scenarios for the Otto Cycle (EPE, 2022a). In addition to the participation of conventional sugarcane, the volumes of corn ethanol and lignocellulosic ethanol will reach, respectively, 9.1 billion and 600 million liters in 2032. The amount of sugarcane destined for the production of biofuel is estimated at 423 million tons, about 56% of the total (EPE, 2022a).

First generation sugarcane ethanol

In the study period (2023-2032), it is estimated that 7 new units (greenfields) of sugarcane will enter, which will increase the nominal crushing capacity by 18 million tons. It is also considered the expansion of the capacity of existing plants, by 24 million tons, as authorized by the ANP (2022a).

For the evaluation of the necessary investments in the medium term (last five years), it was considered that the units would be mixed, with an optimized technological profile and an average size of 4 million tons of nominal sugarcane crushing capacity, with an average investment of R\$ 561.1/ tc¹. For the expansion of existing units, an average investment of R\$ 248.5/ton was adopted. Such values consider the leasing of land, agricultural machinery and the industrial part with optimized cogeneration, as detailed in Table 1.

¹ Note: CAPEX was given per ton of sugarcane, as it is possible to allocate part of the ATR to produce sugar, which does not occur in the E2G and corn ethanol units.

Table 1. CAPEX estimate of first generation sugarcane mills

CAPEX	R\$_(dec. 2021) / tc
New units (<i>Greenfield</i>)	561,1
Industrial (includes optimized cogeneration)	441,3
Agricultural machinery (includes trucks)	94,7
Lease (Midwest region)	25,1
Expansion of existing plants (<i>Brownfield</i>)	248,5

Source: EPE based on LNBR (2022) e NOVACANA (2022a)

Thus, based on the flow of units, investments in industrial capacity, only for first generation sugarcane ethanol, will be around 11.8 billion, of which 5.8 billion are greenfield units and the remainder in expansions.

The cost of forming the sugarcane field considered the participation of each producing region (Center-South and Northeast) and their relative costs, recorded in the 2021/22 (Center-West) and 2020/21 (North-Northeast) harvests (PECEGE, 2022). The proportion of 17% between the areas of plant cane (new + renovated) and total cane was also assumed. In this way, an average cost of approximately R\$ 30.6 /tc was obtained. Investment in the formation of sugarcane for ethanol was estimated at R\$ 20.2 billion.

Regarding operating costs (OPEX), an indicator of 2.16 R\$/liter was used, with 87% for biomass, based on LNBR (2022), which results in the value of R\$ 690 billion in the whole period. The OPEX calculation considered the cane destined for the production of ethanol from all units in operation each year.

Lignocellulosic ethanol

For lignocellulosic ethanol (2G, second generation), the entry of seven units attached to the first generation was considered, with an average specific ethanol production capacity of 82,000 m³/year during the study period. The investment estimate is based on the values of the commercial units in operation in Brazil and the announcements made in 2022 for projects of this type, establishing a factor of R\$ 12.20/liter (NOVACANA, 2022b; RAÍZEN, 2022). Thus, investments total R\$ 8.0 billion in 2032. The volume projected for the production of E2G, of 600 million liters in 2032, is also considered (EPE, 2022a). The estimated operating cost is R\$ 1.7/liter (LNBR, 2022), which leads to an OPEX of R\$ 4.2 billion.

Corn ethanol

With regard to corn ethanol, the reference scenario projects the entry of 33 units by 2032, eight of which are flex-type (process sugarcane and corn) and twenty-five are full-type (process only corn). Thus, the added production capacity will be 5.5 billion liters of ethanol, totaling 10.1 billion liters in 2032, with production reaching 9.1 billion liters.

The CAPEX for the implementation of a flex plant is R\$ 1.18/liter and, for a full plant, it is R\$ 2.13/liter (LNBR, 2022). OPEX was only considered for the latter type of unit and is equivalent to R\$ 1.76/liter (NOVACANA, 2022c). For the flex unit, it was assumed that this expense will be allocated to the sugarcane ethanol producing unit. In this way, the estimated investment in the construction of corn ethanol plants is around R\$ 11.6 billion and operating costs of R\$ 67.0 billion.

Ethanol outflow infrastructure

With the projected expansion of the ethanol market, in addition to increasing storage capacity, it is necessary to invest in diversifying the modes used in distribution, to make the transport system more efficient. EPE published the Indicative Oil Pipeline Plan (PIO) – 2021-2022 cycle. The studies developed within the scope of the PIO seek to improve the analysis of the logistical supply flows, through the technical, economic and environmental feasibility study of transport pipeline projects and associated systems with a view to meeting existing national demands. (EPE, 2022c).

Logum Logística S.A. invests in a project to build its own pipelines and use existing ones, with an annual handling capacity of 9.0 billion liters. The total estimated value for the project is R\$ 5.2 billion, of which R\$ 1.2 billion has already been invested in the sections built and currently in operation (Ribeirão Preto (SP) – Paulínia (SP), Uberaba (MG) - Ribeirão Preto (SP)) (LOGUM, 2022).

Table 2 summarizes investments in ethanol in the period from 2023 to 2032, for brownfield and greenfield units.

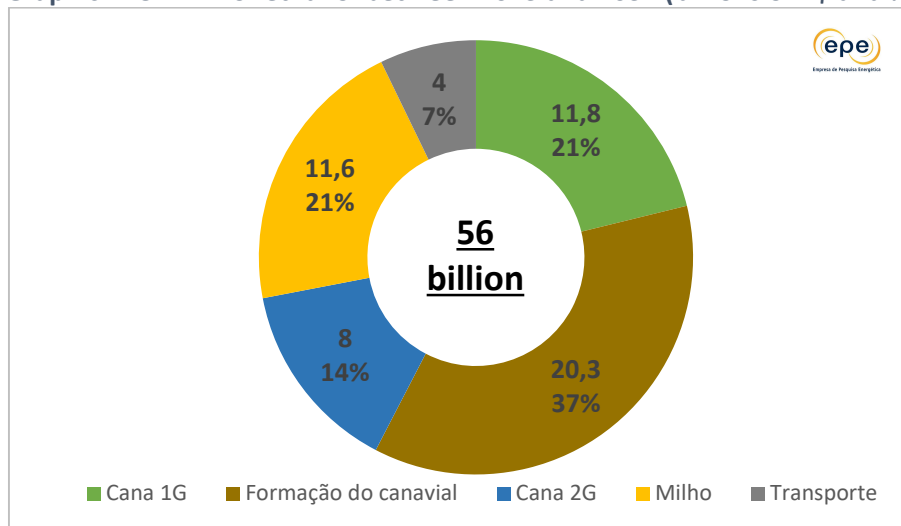
Table 2. CAPEX and OPEX estimates for ethanol between 2023 and 2032

ETANOL	CAPEX (R\$ Billion)	OPEX (R\$ Billion)
Sugarcane Ethanol 1G	11,8	86,8
Formation of the cane field	20,3	603,2
Sugarcane Ethanol 2G	8,0	4,2
Corn Ethanol	11,6	67
TOTAL	51,6	761,2
Transport	4	n/e

Fonte: EPE com base em LNBR (2022), NOVACANA (2022a, 2022b, 2022c) e LOGUM (2022)

Graphic 1 presents the participation and values of industrial CAPEX and formation of sugarcane for ethanol between 2023 and 2032.

Graphic 1: CAPEX for ethanol between 2023 and 2032 (billions of R\$ and %)



Source: EPE based on LNBR (2022), NOVACANA (2022a, 2022b, 2022c) and LOGUM (2022)

Incorporating the investments and costs related to sugar production, the values for 1G cane would reach R\$ 55.2 billion (includes formation of the sugarcane field) and R\$ 1.3 trillion, respectively.

2. Biodiesel

Biodiesel consumption is determined by its percentage to be added to the projected demand for diesel B, which reaches 83.2 billion liters in 2032 (EPE, 2022b).

Despite the evolution schedule of the biodiesel content in fossil diesel oil provided for in CNPE Resolution No. 16/2018 (CNPE, 2018), the institutional duty entrusted to the CNPE, in the protection of consumer interests in terms of price, quality and fuel supply, implied a reduction in the percentage of mandatory blending of biodiesel in diesel oil in relation to the original schedule, throughout 2021 and in 2022. In 2022, the addition of biofuel was 10%, according to CNPE Resolution No. 25/2021 (CNPE, 2021). For the projection (2023-2032), the BX mixture follows the provisions of CNPE Resolution No. 16/2018. Thus, the demand for biodiesel will reach 12 billion liters in 2032 (EPE, 2022b).

In this study, investments calculation in this segment was based on data on the expansion and construction of new biodiesel units by ANP (ANP, 2022). According to information made available up to September 2022, the 7 expansion requests reach 500 million liters and the construction of 11 new units adds up to 3.1 billion liters. On this total of 3.6 billion liters added, an average CAPEX of R\$ 0.63/liter/year was applied for new units and R\$ 0.45/liter/year for expansions (BIODIESELBR, 2022), which represents investments of R\$ 2.2 billion (until 2032). Adopting a utilization factor of 92%, due to scheduled stoppages and adverse events, the effective biodiesel production capacity would be 15.7 billion liters at the end of the period, which would represent an idle capacity of about 30% (EPE, 2022b).

Considering that soy will remain the main input used in the production of biodiesel, an average of 72% during the study period, the projection of investments in its processing capacity is based on the implementation of units of 4,000 t/day (ABIOVE, 2016) , with an estimated cost of R\$ 519 million. These units produce bran, food soy oil and for other purposes, including the production of biodiesel. For the analysis of the need for additional crushing of grains, only the additional demand for soybean oil for biodiesel production was considered. It should be noted that necessary investments for the processing of other types of oilseeds were not considered, although there are ongoing public policies for greater diversification of inputs. It was estimated that it will be necessary to implement four soybean processing units, totaling 5.8 Mt/year, which would represent an investment of R\$ 2.1 billion by 2032.

The OPEX for biodiesel production was estimated based on average sales prices at biofuel auctions between 2015 and 2019 (ANP, 2020) and on information from industry experts (UBRABIO, 2019), being updated based on soybean prices until December 2021 (INDEX MUNDI, 2022), resulting in a factor of R\$ 3.92/liter. Operating costs between 2023 and 2032 are estimated at R\$ 432 billion. It is noteworthy that the main component of this cost is the fatty input used as raw material. It is observed that the biodiesel production units have an intermittent profile throughout the year and the sector had peculiarities with regard to the product commercialization system, auctions until December 2021, and free negotiation between producers and distributors from January of 2022 (CNPE, 2020). Thus, it is estimated that this cost indicator has a wide range.

3. Biogas and Biomethane

The methodology for estimating the investments required for the construction of a Thermoelectric Unit (UTE), using biogas/biomethane as an input, took as reference three existing projects with a short-term operating perspective, two in São Paulo and one in Mato Grosso. These total a production capacity of 65 million Nm³ /year and CAPEX R\$ 670 million (NOVACANA, 2022a) (UDOP, 2022), which results in an investment factor of R\$ 10.32 / Nm³ / year.

Biogas production was based on the document Scenarios of Ethanol Supply and Demand of the Otto Cycle (EPE, 2022a), which estimated that the potential for biogas production through fermentation of vinasse, filter cake and straws and tips² will reach in 2032 , in the medium scenario, 12 billion Nm³ or 6.6 billion Nm³ of biomethane. Thus, the estimated CAPEX for the production of this biomethane potential would be around R\$ 68 billion at the end of the period.

It was accepted that the production of biogas will take place in an area continuous with the plants in the sugar-energy sector, using part of the existing facilities.

² It was considered 20% of straw removed from the field (SUCRE, 2019).

Operation and maintenance costs were calculated based on data provided by BNDES (2020a; 2020b), referring to the profile of a plant producing biogas of 33 million Nm³/year and 18.2 million Nm³/year of biomethane. Considering the sector's production potential, there's an accumulated expenditure between 2023 and 2032 of the order of R\$ 7 billion for biomethane, having as reference a factor of R\$ 0.115/Nm³. For existing projects, the OPEX value in the period would be R\$ 7.5 million.

4. Other Biofuels

The projections incorporate the participation of new biofuels, whose perspective of entering the national energy matrix should occur within the horizon of this study (EPE, 2022b). Sustainable aviation fuels (SAF) and Green Diesel for use in Diesel cycle engines emerge as drop-in alternatives to their fossil analogues. There are technical and economic challenges to be overcome for the feasibility of this scenario, among which the definition of technology for its production, as well as the choice of different raw materials that can be used in the process.

In order to estimate the necessary investments, the assumption was made to introduce a unit with joint production of SAF, HVO (hydrotreated vegetable oil), bionaphtha and LPG, using palm oil as raw material, with an average profile of around 500 million liters per year and a production ratio of 40% for SAF and 42% for HVO.

The projected investment necessary for the installation of the type of plant adopted will be in the order of 400 million dollars or 2.0 billion reais, according to the partnership announced between Vibra Energia and Brasil BioFuels (BBF) (BRASIL BIOFUELS, 2022). Operating costs related to the production of these biofuels at this plant are not listed here.

5. Summary

Based on the study cycle for the 2032 horizon (EPE, 2022a; 2022b), it is estimated that investments (CAPEX) and operating costs (OPEX) for ethanol, biodiesel, biogas/biomethane and BioQAV/Green Diesel will be around 63 billion and 844 billion reais, respectively.

Table 3. CAPEX and OPEX estimates for biofuels between 2023 and 2032

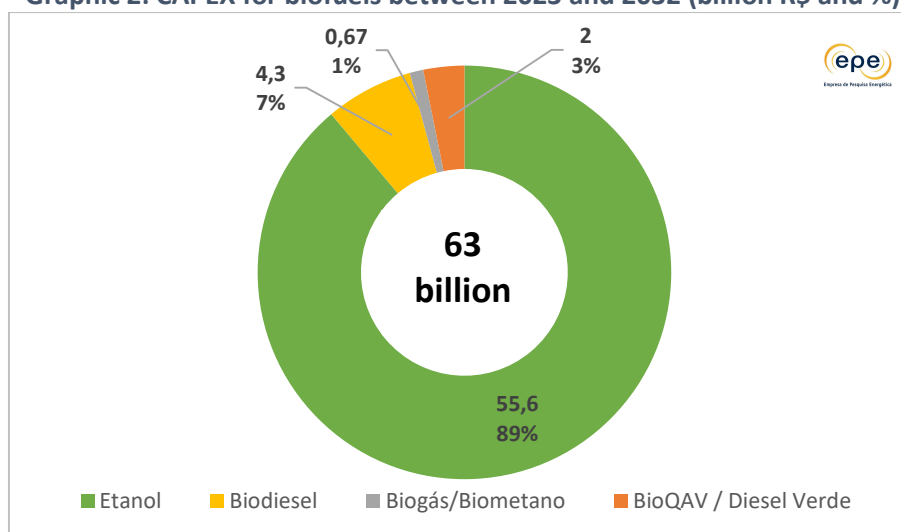
	CAPEX (R\$ Billions)	OPEX (R\$ Billions)
Ethanol	55,6	761
Biodiesel	4,3	432
Biomethane¹	0,7	0,01
BioQAV / Green Diesel	2,0	n/e
TOTAL	62,6	1.193

Note 1: For biomethane, only projects under construction are considered.

Source: EPE.

Graphic 2 shows the participation and values of industrial CAPEX for biofuels and sugarcane plantation formation for ethanol between 2023 and 2032.

Graphic 2: CAPEX for biofuels between 2023 and 2032 (billion R\$ and %)



Source: EPE based on LNBR (2022), NOVACANA (2022a, 2022b, 2022c) and LOGUM (2022)

Considering investments related to sugar production (1G cane), CAPEX totals R\$ 86 billion and OPEX R\$ 1,667 billion.

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