Implementation of bioenergy in Brazil - 2024 update

Country Reports

IEA Bioenergy: 12 2024

This report was prepared based on data from the 2024 IEA World Energy Balances and Renewables Information[1], combined with data and information provided by the IEA Bioenergy Executive Committee and Task members. Reference is also made to FAOstat as well as data from national statistics. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report for all country reports.

Edited by: Luc Pelkmans, Technical Coordinator IEA Bioenergy

Contributions: José Nilton de Souza Vieira, Marlon Arraes Jardim Leal (Ministry of Mines and Energy, Brazil)

HIGHLIGHTS

- Renewables made up 50% of Brazil's total energy supply in 2022. Around 60% of renewable energy supply is from biomass.
- Brazil is a net exporter of oil, but for natural gas and coal it relies for 30% and 80% respectively on imports for its domestic consumption. There is no import dependency for bioenergy carriers. Considering its role in total energy supply (31% of TES), bioenergy therefore makes a major contribution to energy security.
- The main application of bioenergy is in the use of solid biomass for renewable heat, particularly in industries (40%). Bioenergy represents more than 50% of heat provision.
- Biofuels represent 22% of transport energy in Brazil, which is very high compared to other countries in the world. Bioethanol is the most important biofuel, on average representing almost 40% by energy of combined gasoline and ethanol use. The role of biodiesel is growing (to replace diesel in heavy duty vehicles) and in 2022 represented 9.3% by energy of diesel use.
- Electricity production in Brazil is dominated by hydropower, with a modest role for bioenergy (mostly through industry CHP plants). The role of wind and solar power is growing.
- Since the early 2000s, the Brazilian government has resorted to public policies to stimulate the biofuels market, such as tax differentiation between fossil fuels and renewables, mandatory mixing of anhydrous ethanol in gasoline and biodiesel in fossil diesel and the inclusion of flex fuel vehicles, enabling the use of E100. The latest actions are an additional boost to the matrix's renewability are the National Biofuels Policy – RenovaBio and Future Fuels' Program. In 2022, the Brazilian National Congress has approved an Amendment to the Brazilian Constitution to promote

[1] www.iea.org/statistics

the competitiveness for biofuels (lower taxation compared to fossil fuels).

CONTENTS

COUNTRY PROFILE

Population and land use

Brazil is the largest country in South America. It has a total land area of 8.36 million km² with a population of 215 million. This means that the average population density is relatively low at 25 persons per km².

Around 60% of the land area is forest land – most of it in the Amazon region. 27% of the land area is agricultural land, which consists for three quarters of mostly extensively used permanent meadows/pastures and one quarter of arable land.

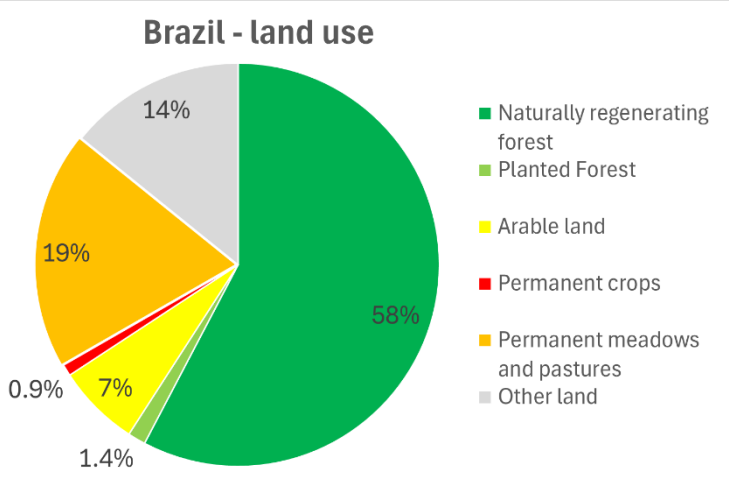

***Figure 1**: Land use in Brazil (2022 figures - Source: FAOstat)*

More detailed information about land use in Brazil can be found in the link in footnote[2]

Final energy consumption

Overall final energy consumption in Brazil (*also including non-energy use of oil, natural gas, and coal in industry*) comes down to around 1.1 tonnes of oil equivalent (toe) per capita, which is around 2 times lower than the average of IEA Bioenergy member countries. Particularly energy use in residential sectors, as well as commercial and public services is very low.

***Table 1**: Distribution of the final consumption of energy carriers by sector in Brazil (2022 figures - data source: IEA (2024) World Energy Balances and Renewables Information)*

Final consumption energy carriers	Toe/capita (2022)	% of total	*Median* (toe/capita)*
Industry (energy use)	0.38	34%	*0.71*
Industry (non-energy use)	0.07	6%	*0.18*
Transport	0.42	37%	*0.66*
Residential	0.13	12%	*0.50*
Commercial & public services	0.06	6%	*0.32*
other	0.06	6%	*0.08*
Total	1.13		*2.50*

** Median of the 23 member countries of IEA Bioenergy[3]*

[2] https://brasil.mapbiomas.org/wp-content/uploads/sites/4/2023/09/FACT_port-versao-final.pdf

[3] Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

THE CONTRIBUTION OF BIOENERGY IN NATIONAL ENERGY SUPPLY

TOTAL ENERGY SUPPLY

The total energy supply (TES) of Brazil in 2022 amounted to 12.4 exajoules (EJ), of which around half are fossil fuels. Oil products account for 37% of the energy supply (4.7 EJ); the role of natural gas and coal is much lower with respectively 9.3% (1.2 EJ) and 4.7% (0.59 EJ). Renewable energy sources have a share of merely 47% or 5.9 EJ. Around two thirds of renewable energy supply in 2022 comes from biomass (3.9 EJ), followed by hydropower (1.5 EJ), wind energy (0.3 EJ) and a small share of solar energy (0.15 EJ).

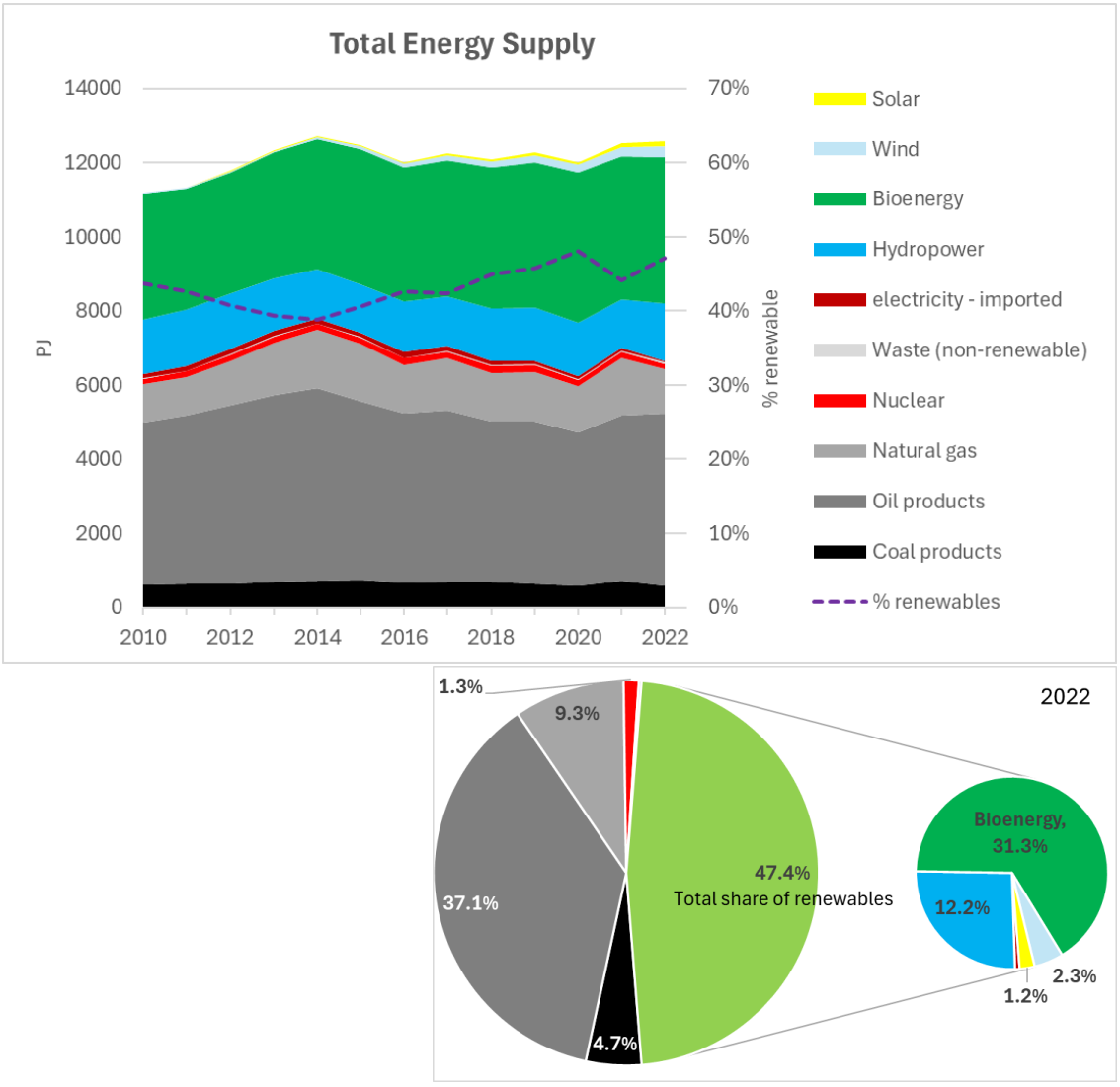

***Figure 2**: Total energy supply[4] and the contribution of different energy sources in Brazil, with distribution in 2022 (data source: IEA (2024) World Energy Balances and Renewables Information).*

[4] Total energy supply represents all the energy required to supply end users in the country. Some of these energy sources are used directly while most are transformed into fuels or electricity for final consumption. In terms of the role in the energy system this distribution overestimates the role of resources producing electricity with a high share of unused waste heat (like coal or nuclear plants).

After a continuous growth in the 2000s (see also 2021 Country Report[5]) total energy supply in Brazil has more or less stabilized around 12 EJ since 2014. Since then, the share of oil in TES came down from 41% to 36-37% of TES. The share of gas fluctuated around 11-12%; there was a drop in 2022 to 9.3% of TES, which might be due to increased gas prices. The share of coal decreased slightly from 5.9% in 2010 to 4.7% in 2022. Nuclear energy represented around 1.4% of TES in the past decade.

Up to 2009 the amount of renewable energy increased faster than overall energy growth (see 2021 Country Report). This stalled somewhat between 2009 and 2014. Growth picked up again since 2014, increasing the share of renewable energy from 39% to 47% of TES in 2022. The overall share of bioenergy in total energy supply increased from 28% in 2014 to 31% in 2018; there seems to be a stabilization in recent years around that level. In the same period hydropower fluctuated around 11%, wind power increased from 0.3 to 2.3% and solar energy (PV and solar thermal) from 0.2 to 1.2%.

EVOLUTION OF BIOENERGY IN TOTAL ENERGY SUPPLY

The amount of bioenergy increased from 3.3 EJ to 3.9 EJ since 2010 and seems to stabilize around that level in recent years. Most bioenergy (78%) in Brazil is from solid biomass (3070 PJ). This is predominantly bagasse, consumed for internal energy provision in the sugar and ethanol industry. Only about 350 PJ of solid biomass is consumed by the residential sector; some (890 PJ) is also used for charcoal production. The other 22% of bioenergy are predominantly liquid biofuels (845 PJ); biogas has a limited role (26 PJ). The evolution of liquid biofuels will be further discussed in the chapter on transport.

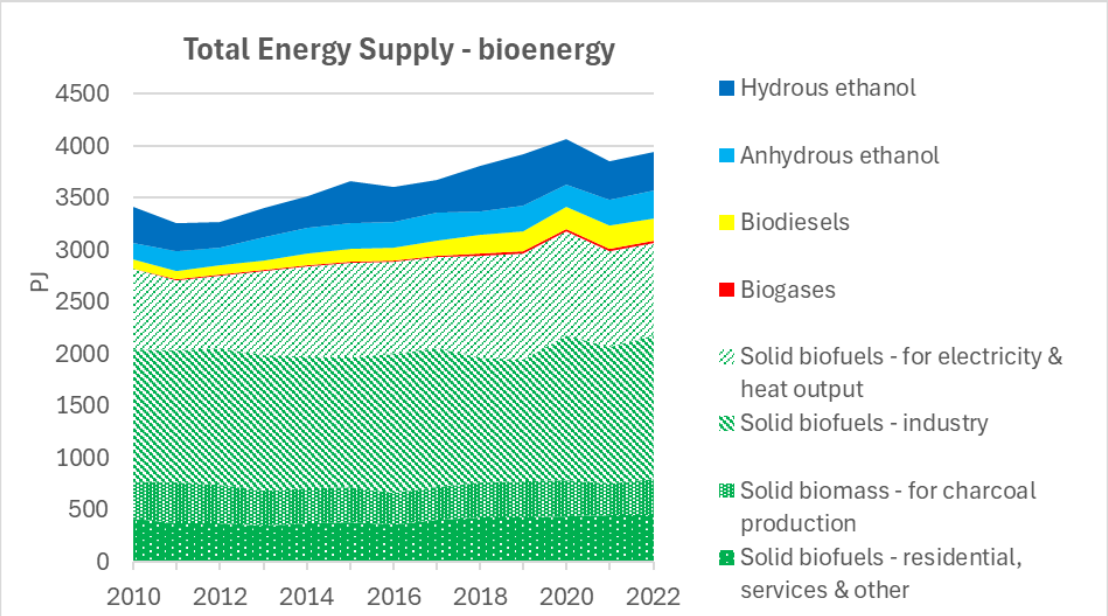

***Figure 3**: Development of total energy supply from bioenergy in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)*

[5] 2021 Country Report for Brazil available at: https://www.ieabioenergy.com/wp-content/uploads/2021/11/CountryReport2021_Brazil_final.pdf

ENERGY DEPENDENCY

The following graphs show the difference between domestic production and total energy supply of different energy carriers. Based on the difference between these figures, we can deduce the energy import dependency.

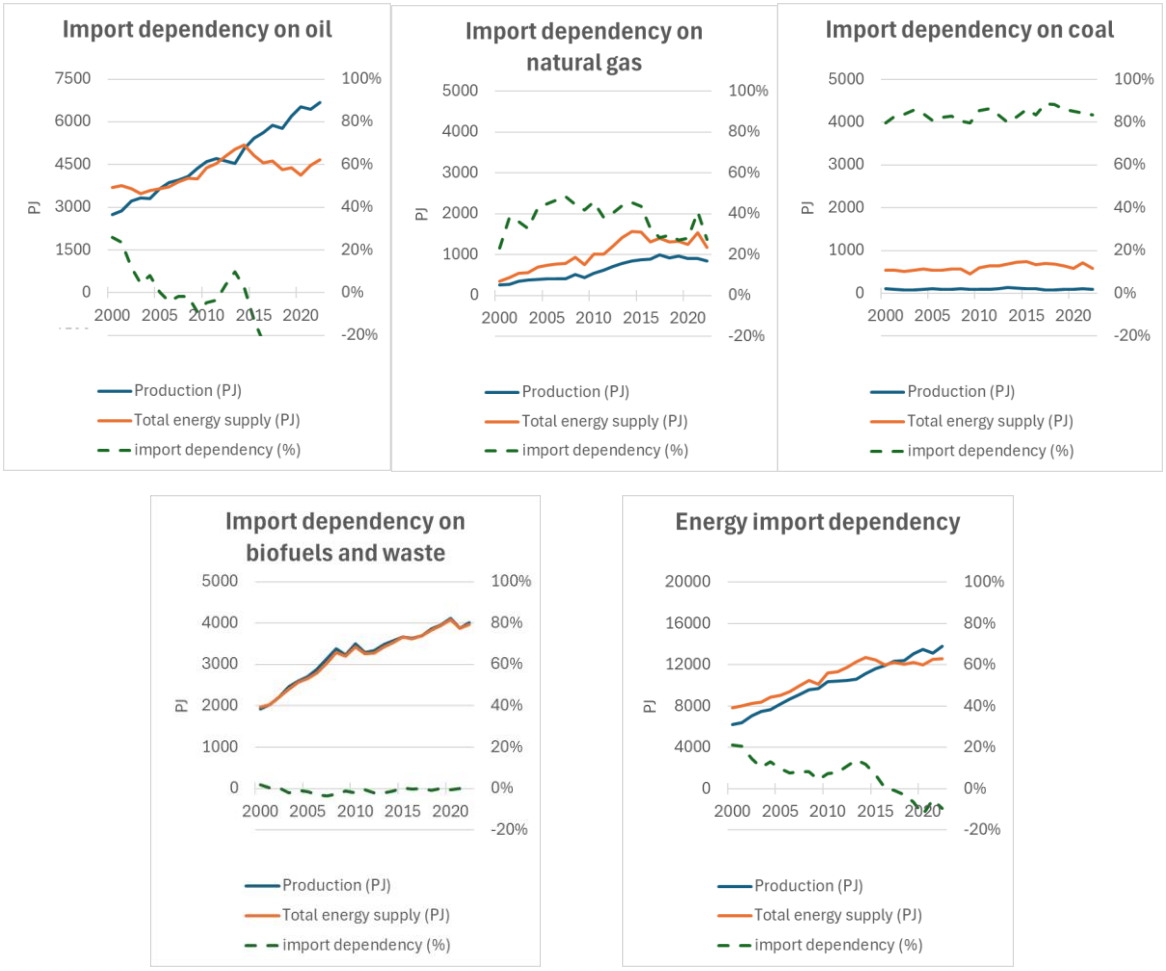

Figure 4: Evolution of energy import dependency for different energy carriers in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

Over the years, Brazil increased its production of oil - since 2015 Brazil turned into a net exporter, now producing about 50% more than its domestic consumption. For its natural gas and coal consumption, Brazil relies for 30% and 80% respectively on imports for its domestic consumption.

There is no import dependency for bioenergy carriers. Considering its role in total energy supply (31% of TES), bioenergy therefore makes a major contribution to energy security.

When looking at the different bioenergy carriers, only trade flows of ethanol need to be considered. In 2022, Brazil has a net export of 50 PJ bioethanol, which is 8% of its domestic production.

NATIONAL POLICY FRAMEWORK IN BRAZIL

One of the drivers for the national renewable energy policy framework today is the Federative Republic of Brazil's Nationally Determined Contribution (NDC) towards achieving the objective of the United Nations Framework Convention on Climate Change (UNFCCC). The first document was announced in December 2015 in the Paris Conference (COP 21)[6]. The last update was made in 2023, set the economy-wide emissions reduction targets (48%, by 2025, **53**% by 2030)[7]. The document affirms that these goals are compatible with the indicative objective of achieving carbon neutrality in 2050.

The adopted commitments consist of economy-wide, absolute targets, stated to be consistent with the sectors present in the National Inventory of Greenhouse Gas Emissions (energy; industrial processes; land use, land-use change and forestry; and waste treatment).

The NDC does not include specific sector goals, but the NDC asserts that the targets will be translated into policies and measures to be implemented by the Brazilian Federal government. This provides the broad perspective for Brazilian energy trends for the next years and guidance for the main energy planning document, the PDE (Ten Year's Energy Expansion Plan, also known as Plan for Energy Expansion), elaborated by EPE (Energy Research Agency) and published every year by the Ministry of Mines and Energy.

Also, all policies, measures, and actions to implement Brazil's NDC are carried out under the National Policy on Climate Change (Law 12,187/2009), the Law on the Protection of Native Forests (Law 12,651/2012, hereinafter referred as Forest Code), the Law on the National System of Conservation Units (Law 9,985/2000), related legislation, instruments and planning processes, and the Law No. 13,576/2017, which establishes the National Biofuels Policy (RenovaBio). RenovaBio is based in the understanding that biofuels are a relevant instrument for decarbonizing the transportation matrix, contributing to the achievement of the goals assumed in the Paris Agreement.

The Government of Brazil is committed to implementing its NDC with full respect to human rights, in particular rights of vulnerable communities, indigenous populations, traditional communities, and workers in sectors affected by relevant policies and plans, while promoting gender-responsive measures.

Brazil is a developing country with several challenges regarding poverty eradication, education, public health, employment, housing, infrastructure, and energy access. Despite these challenges, Brazil's current actions in the global effort against climate change represent one of the largest undertakings by any single country to date, having reduced its emissions by 31.6% (GWP-100; IPCC SAR) in 2020 in relation to 2005 levels[8].

One of the main important routes to reduce emissions is the use of renewable sources, including biofuels. There are several benefits from the use of biofuels in the Brazilian energy matrix, which can be observed in the economic, social, and environmental spheres. Considering liquid biofuels, since Brazilian production of gasoline and diesel is not sufficient to meet domestic demand, the

[6] Available at: http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/decreto/D9073.htm
[7] Available at: https://unfccc.int/sites/default/files/NDC/2023-11/Brazil%20First%20NDC%202023%20adjustment.pdf
[8] Source: MCTIC. Estimativas anuais de emissões de gases de efeito estufa no Brasil. Sixth edition (2022). Available at https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/estimativas-anuais-de-emissoes-gee

consumption of ethanol and biodiesel acts favourably to reduce the risks related to the instability of the world market and to increase security of energy supply. The absence of these biofuels could result in an increase in imports of fossil analogues, affecting Brazil's trade balance.

The most evident social impacts of using biofuels are related to the creation of jobs and income, whether in the agricultural phase of their production, or in the industrial stage, including in the countryside. In the case of biodiesel, a stand-out initiative is the Social Biofuel Seal (Selo Biocombustível Social), which benefits small farmers with family farming insertion to the biofuel production process. It is estimated that ethanol production supports over 1.5 million direct and indirect jobs[9] in Brazil in 2019. Indirectly, jobs are also generated in the industry of cultivation implements, agricultural machinery business and services with much trading occurring in rural areas of the country. Besides, it is possible to identify positive impacts on infrastructure, improvements in motorways and railways, in food production and in the life quality of people living in the neighbouring areas.

Table 2: *renewable energy and climate targets in Brazil.*

Sector	Share of renewables in gross final consumption per sector	GHG reduction target (Mt CO_2)
Overall target	328 MToe, ~46% renewables by 2030	412 – 484 Mt CO_2 (2019 - 2030) Carbon neutrality by 2060
Heating and cooling		135 – 188 Mt CO_2 (2019 - 2030)
Electricity	761.6 TWh, 85% renewables by 2030	56 – 41 Mt CO_2 (2019 - 2030)
Transport	Total 100 MToe, 32% renewables by 2030	191 – 224 Mt CO_2 (2019 - 2030)

Source: Ten-Year Energy Expansion Plan 2030 (EPE, 2021). The figures above are not mandatory targets (as the NDC sets economy-wide emissions reductions targets, not specific energy targets), but are part of national energy planning.

A description of renewable energy and climate policies and measures in Brazil is available at the IEA's Policies and Measures Database © OECD/IEA: https://www.iea.org/policies?country=Brazil

Specific policies related to renewable electricity, renewable heat and transport biofuels will be highlighted in the chapters about the role of bioenergy in different sectors.

[9] According to EPE (2021). Analysis of biofuels current outlook.

ROLE OF BIOENERGY IN DIFFERENT SECTORS

OVERVIEW

The overall share of renewables in **final energy consumption**[10] among electricity, transportation and heat sectors in 2022 was 50%, with bioenergy making up 30% of the energy share (Table 5). Mind that these figures are slightly different from the shares in total energy supply (where unused waste heat, e.g. in power production, is also included).

Table 3: Role of bioenergy and renewable energy in electricity, transport energy and fuel/heat consumption in 2022

Sector	Share of bioenergy	Share of renewable energy	Overall consumption
Electricity[11]	8.0%	86% *(62% hydro)*	690 TWh (2483 PJ)
Transport energy (final consumption)	21.5%	21.7%	3751 PJ
Overall fuel and heat consumption[12]	Direct biomass: 53.5%	54.6%	3817 PJ
TOTAL FINAL ENERGY CONSUMPTION	**30.3%**	**50.1%**	**10042 PJ**

Based on own calculations. Source of the data: IEA (2024) World Energy Balances and Renewables Information

IN 2022, electricity represented around 25% of final energy consumption, transport fuels (excl. electricity) represent 37% and other fuels/heat (excl. electricity) 38%.

The following paragraphs will consider the evolutions in the different sectors.

ELECTRICITY

The Brazilian power production is already largely renewable, with a dominating role of hydropower. Electricity imports from neighbour countries represent roughly 2-3% of electricity demand. Nuclear energy is quite stable at 2%. Hydropower production fluctuated between 360 and 430 TWh in the past decade, while overall electricity demand continued to grow. The relative share of hydropower in domestic electricity production went down from 75% and more before 2010 to around 60% in recent years. Years with lower hydropower were compensated with higher use of gas or oil. This can be illustrated in recent years: in 2021, only 363 TWh of hydropower was produced (i.e. 53% of

[10] Final energy consumption excludes non-energy use of coal, oil products and natural gas.

[11] Renewable electricity production compared to final consumption. Potential renewable shares of imported electricity are not included.

[12] This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded.
Electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

electricity consumption) while fossil fuels produced 131 TWh (19%); in 2022, hydropower production was much higher at 427 TWh (62%) and fossil fuels produced only 66 TWh (10%).

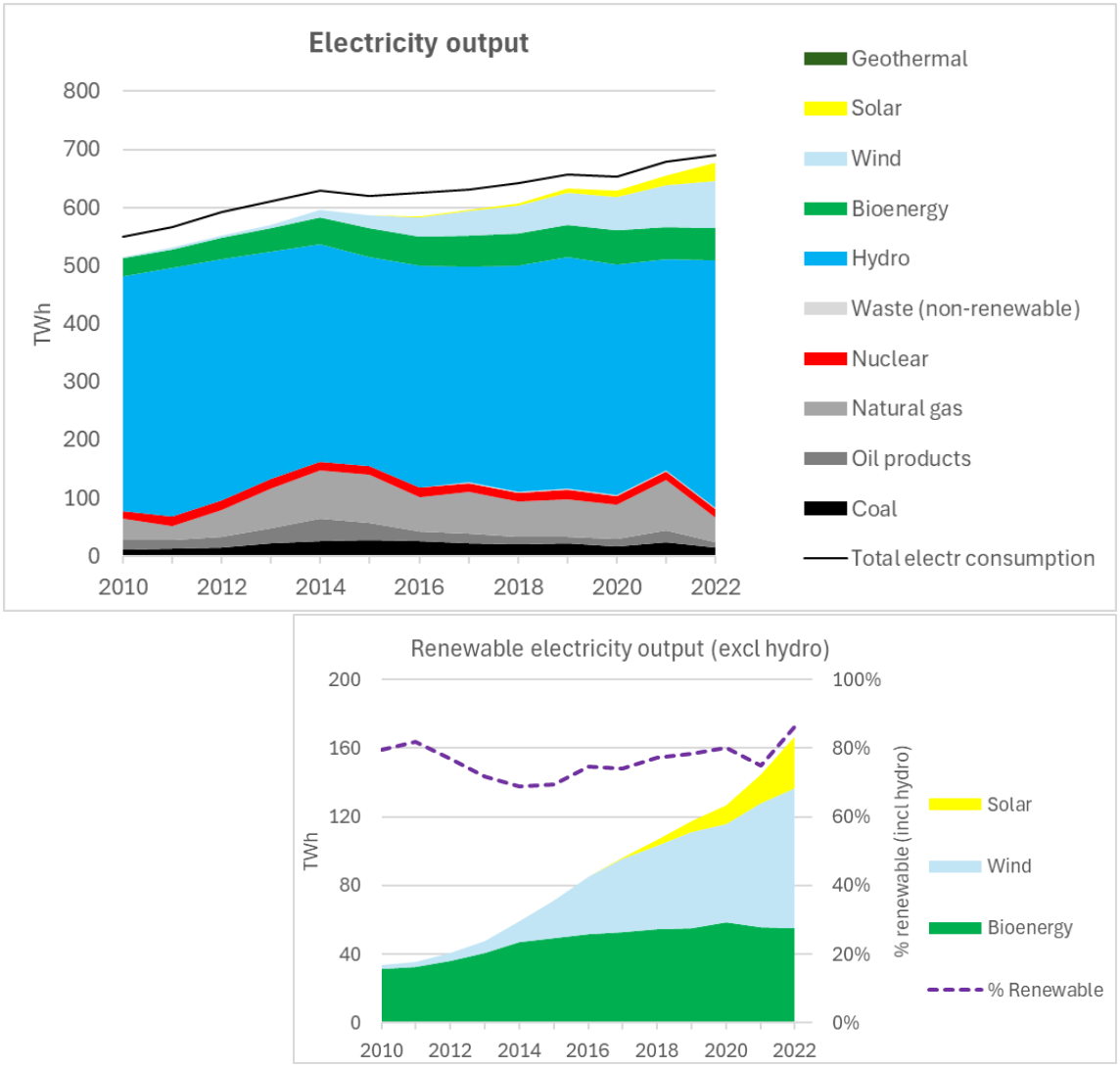

Figure 4: Evolution of the electricity mix in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

Apart from the balance between hydropower and fossil fuels, the continuous growth in electricity consumption was in fact covered by growing shares of non-hydro renewables, particularly wind energy and in recent years also solar energy. In 2022, wind energy (82 TWh), bioelectricity (55 TWh), and solar power (30 TWh) together accounted for 24% of Brazilian electricity consumption.

The following figure shows the distinction between electricity produced in electricity-only plants and combined heat and power (CHP) plants for different types of energy carriers (excl. hydro, wind or solar). 100% of nuclear power, 61% of coal power, 56% of natural gas power and 48% of coal power is produced in electricity-only plants, meaning that heat is condensed away.

On the other hand, 95% of biomass-based electricity is produced in CHP plants (particularly solid biomass), which also produce useful heat.

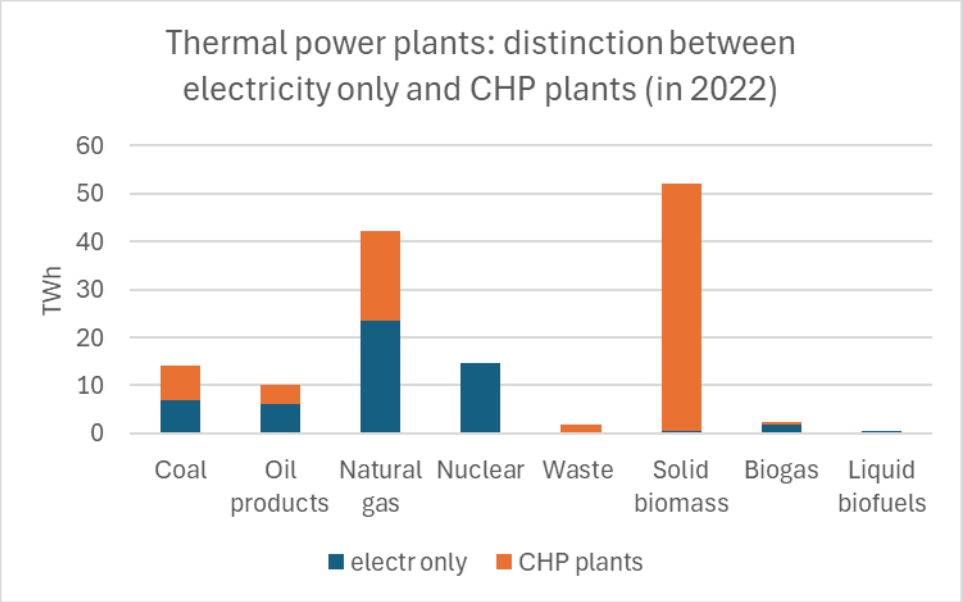

***Figure 5**: Electricity produced from electricity only vs CHP plants in Brazil in 2022 (data source: IEA (2024) World Energy Balances and Renewables Information)*

Policy framework

The federal government promoted the creation of regulatory mechanisms and incentive policies, such as specific auctions, in order to improve the competitiveness of sources derived from biomass and stimulate the growth of bioelectricity in the Brazilian electricity matrix. In 2008, the first reserve energy auction (LER 2008) exclusively dedicated to biomass was held and, at this occasion, more than 590 MW_{avg} were contracted, the maximum amount recorded (EPE, 2021).

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. 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 through Law No. 10,438, of April 26, 2002 (EPE, 2021).

More recently, RenovaBio (Law No. 13,576/2017) aims to cooperate in meeting Brazil's commitments under the Paris Agreement by pushing efficiency increase at ethanol plants, including biomass cogeneration and biogas production.

HEAT/FUEL CONSUMPTION

Figure 6 shows the role of different fuels/energy carriers for providing heat in different sectors (industry, residential sector, commercial and public services and other). Fuel use by energy producing industries for transformation and for own use is excluded. Mind that electric heating is not included in these figures as this is not separately reported in the IEA database.

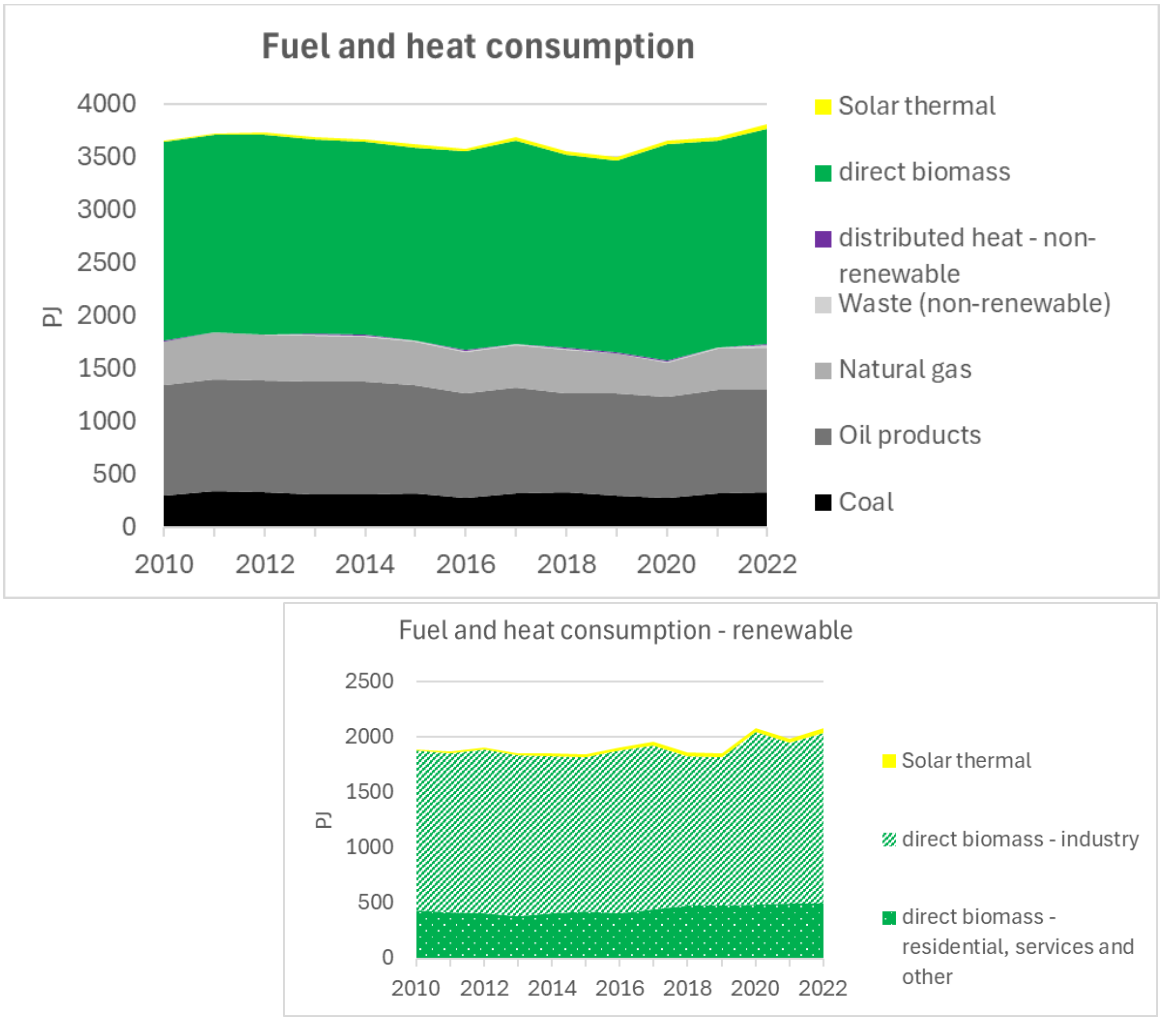

Figure 6: Evolution of fuel and heat consumption in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

45% of fuel/heat demand comes from fossil fuels, particularly oil, natural gas and coal. On the other hand, biomass (at 54%) is more important than fossil energy carriers to provide heat in Brazil. The dominant sector is industry, where fuel/heat demand is about 4 times larger than in residential sectors.

TRANSPORT

Figure 7 shows an overview of the energy used in transport in Brazil, split up by different fuels/energy carriers. Diesel and gasoline type fuels (fossil and bio) dominate the transport market. There is also some natural gas (3.2%) and aviation fuel for domestic flights (3.5%). After a long period of growth (see 2021 Country Report), transport fuel consumption stabilized between 2014 and 2019. After the COVID dip in 2020, 2022 now shows an increase again. The growth is particularly in diesel consumption, which is more related to heavy duty transport.

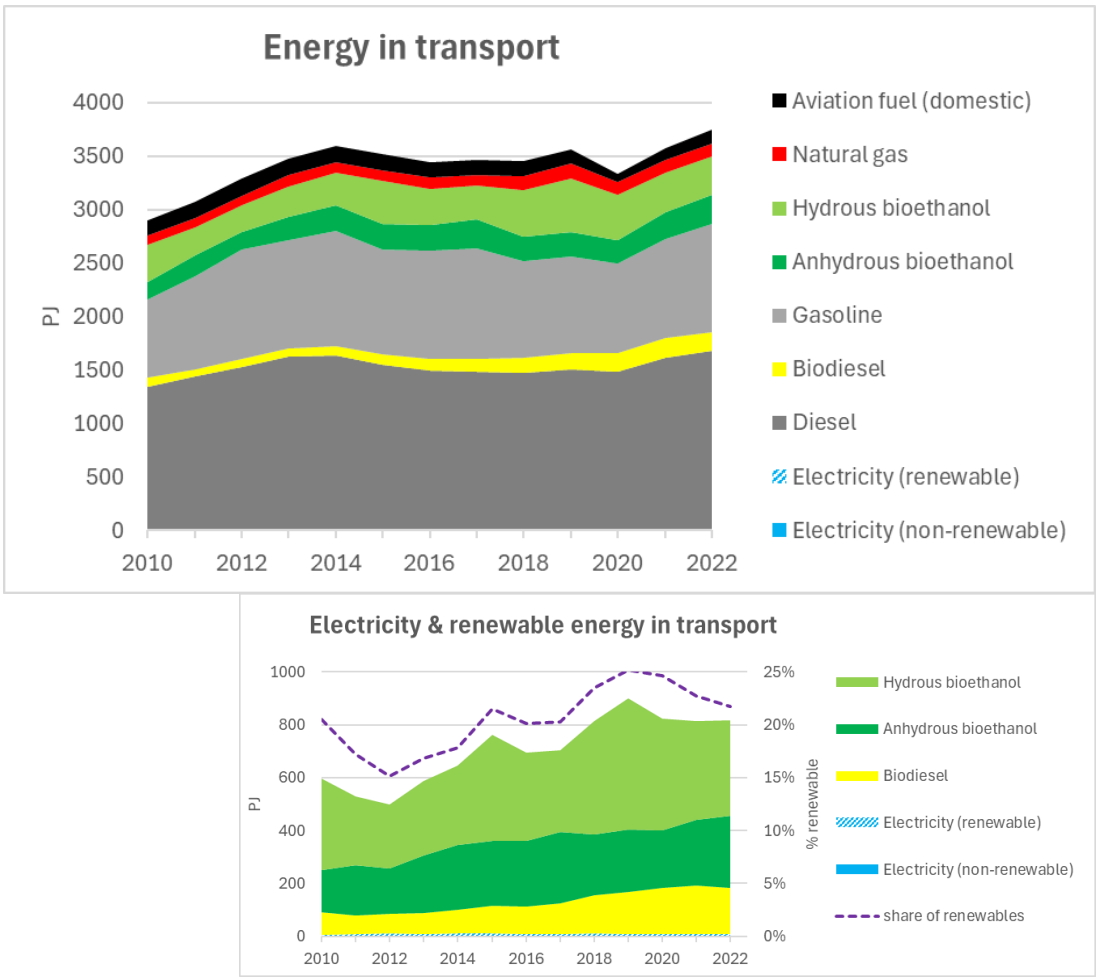

Figure 7: Evolution of transport fuels in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

The use of biofuels has grown steadily in the past 20 years (see 2021 Country Report). Overall, the share of biofuels in transport fuels was 22% in 2022 – this is a small reduction compared to 2019 when this level was at 25%.

Over the years, particularly the use of pure hydrous ethanol in FFVs has increased a lot. The consumption of anhydrous ethanol has grown with gasoline consumption. On average bioethanol represented 39% by energy of combined gasoline and ethanol use in 2022. Biodiesel was introduced in 2005 and has steadily grown as blending component in diesel, mainly for heavy duty transport. On average biodiesel represented 9.3% by energy of diesel consumption in 2022.

Electricity represents a share of 0.2% of total transport energy use in 2022. This is mostly in rail – there is no reporting of electricity used in road vehicles.

Policy framework

Brazil has had mandatory ethanol blend in gasoline since the 1970s, reaching 27% in 2015 and remaining until 2021. Additionally, the **National Alcohol Program (Proálcool)** was launched in 1975 as a result of the impacts of the 1973 oil crisis. Its objective was to make Brazil less dependent on imports of oil, reducing the vulnerability of the Brazilian economy to external events. Proálcool can be considered a pioneering biofuel program for producing an alternative fuel (hydrous ethanol), which could be used in dedicated vehicles. *Flex fuel* technology, established in 2003, enabled consumers to choose between E27 and E100.

The **Brazilian Biodiesel Production and Use Program (PNPB)**, launched in 2005, is a Federal Government program aimed at the sustainable implementation of biodiesel production and use, focusing on social inclusion and regional development, via job and income generation. Diesel oil sold at retail contains a percentage of biodiesel that makes up a blend (Bxx), imposed by Law No. 11.097/2005 (BRASIL, 2005), which presents a broad definition for biodiesel, as any fuel derived from renewable biomass for use in Diesel cycle engines.

The National Agency of Petroleum, Natural Gas and Biofuels (ANP) specified green diesel and obligations regarding the quality control according to Resolution No. 842 / 2021. With this, the regulation of biofuels in the Diesel cycle starts to incorporate current technological advances and allows the use of other biofuels in addition to FAME biodiesel (EPE, 2020).

In 2017, Brazil established the Brazilian Policy for Biofuels - **RENOVABIO**, by the Law No. 13,576/2017, which creates a regulatory framework to revitalize the biofuels sector, encouraging energy efficiency gains in biofuels production and use. The policy aimed to reduce the carbon intensity of the transport fuel matrix by 10% and avoid 620 million tons of CO2eq emissions from 2018 until 2030. Every year, the CNPE sets goals for the following year and for the next ten years.

The greenhouse gas emissions reduction target set for 2023 was 337.47 million CBIOs, with 88% (33.1 million CBIOs) of the established target met by fuel distributors. A total of 35.62 million CBIOs were issued. Since the Decarbonization Credit (CBIO) corresponds to 1 ton of CO2eq avoided in the atmosphere, this represents 35.62 million tons of CO2eq that were no longer released into the atmosphere. The average price of the CBIO was R$113.61 (US$22) and producers' revenue from this asset reached R$4.4 billion (US$85 million). From 2020 to 2023, 116.2 million CBIOs were issued, representing revenue of R$9.7 billion (US$1.86 billion).

Another important advance in the policy framework for biofuels is The **Constitutional Amendment No. 123**, enacted on **July 14, 2022**, that introduces changes to Article 225 of the Brazilian Constitution to promote competitiveness for biofuels.

Objective: The amendment aims to establish a competitive advantage for biofuels over fossil fuels, particularly in terms of taxation, as a measure to foster the biofuel industry and to address the social impacts of the extraordinary rise in oil and fuel prices.

Key Provision: The amendment adds a clause to Article 225 that mandates the maintenance of a favourable tax regime for biofuels used in final consumption. This ensures that biofuels will have a lower tax burden compared to fossil fuels, promoting their competitiveness.

Temporary Competitive Advantage: Until specific legislation is enacted, the competitive differential for biofuels will be maintained by ensuring that the percentage difference between the tax rates for fossil fuels and their biofuel substitutes, as of May 15, 2022, remains unchanged.

Guarantee of Competitive Differential: For 20 years following the amendment's promulgation, federal law cannot establish a competitive differential for biofuels below the level stipulated in May 2022.

Automatic Tax Adjustments: Any changes in tax rates for fossil fuels, whether through new laws or judicial rulings, will result in automatic adjustments to the tax rates for biofuels to maintain the same competitive differential.

Special Provision: Until December 31, 2022, the tax rate for gasoline may be set to zero, provided that the same is done for hydrated ethanol.

This amendment intention was to strengthens Brazil's commitment to supporting biofuels as a critical component of its energy mix, ensuring biofuels remain competitive in the market relative to fossil fuels.

The major update, however, in the Brazilian Policy Framework for biofuels came from the Fuel of the Future Law approval on 8 October 2024.

The **Future Fuel Law** (Lei do Combustível do Futuro) of Brazil, enacted in October 2024, aims to promote sustainable low-carbon mobility and carbon capture and storage. It establishes key national programs and modifies existing regulations to encourage the production and use of renewable energy sources, specifically in aviation, diesel, and natural gas sectors.

One of the central components of the law is the **National Program for Sustainable Aviation Fuel (ProBioQAV)**, which incentivizes the use of **Sustainable Aviation Fuel (SAF)**. Airlines will be required to reduce their greenhouse gas (GHG) emissions in domestic flights by using SAF, starting at 1% in 2027 and gradually increasing to 10% by 2037.

Additionally, the law creates the **National Green Diesel Program (PNDV)**, designed to promote the production and use of green diesel. The volumetric share of green diesel in Brazil's overall diesel consumption is set with an initial limit of 3%, though producers may voluntarily increase this percentage.

The **National Decarbonization Program for Natural Gas Producers and Importers** encourages the integration of **biomethane** and **biogas** into the natural gas supply, with targets to reduce GHG emissions starting at 1% in 2026, potentially reaching 10% by 2036. This program supports infrastructure development to facilitate the connection between biogas production facilities and gas distribution networks.

The law also provides a regulatory framework for **carbon capture and geological storage (CCS)**. The National Petroleum, Gas, and Biofuels Agency (ANP) is responsible for overseeing CCS activities, ensuring they are safe, effective, and eligible for carbon credit certification. Companies must obtain authorization for CCS projects and comply with strict monitoring requirements.

Furthermore, the law modifies the **biofuel blending mandates**, maintaining the ethanol blend in gasoline at 27%, with the possibility of increasing it to 35% if feasible. Biodiesel blending targets in diesel fuel are also adjusted, with gradual increases from 15% in 2025 to 20% by 2030.

Overall, the **Future Fuel Law** integrates and strengthens Brazil's existing environmental policies, such as the **RenovaBio** and **Mover** programs, aiming to reduce carbon intensity across various sectors while ensuring Brazil's competitiveness in global energy markets. The law supports the country's commitment to international climate goals and enhances Brazil's role in the global transition to sustainable energy sources.

Summary of Brazil's Future Fuel Law (Lei do Combustível do Futuro)

The Future Fuel Law, enacted in October 2024, is a comprehensive legislative framework designed to promote low-carbon mobility and support Brazil's energy transition. The law integrates several new and existing programs, regulates biofuel usage, and outlines mechanisms for carbon capture and storage. Below is a summary of the law, organized by the Law text Titles.

Title I: General Provisions

This title introduces the main objectives of the law, which include:

- The establishment of the **National Program for Sustainable Aviation Fuel (ProBioQAV)**, the **National Green Diesel Program (PNDV)**, and the **National Decarbonization Program for Natural Gas Producers and Importers**.
- Regulation of biofuel blending limits for ethanol in gasoline and biodiesel in diesel.
- Governance and oversight of synthetic fuel production and carbon capture and storage.

The law integrates various national initiatives such as the **RenovaBio Program**, the **Mover Program** (green mobility), the **Brazilian Vehicle Labelling Program (PBEV)**, and the **Vehicle Emission Control Program (Proconve)**.

Title II: Low-Carbon Mobility

This section highlights the integration of policies to promote low-carbon transport. The law requires a lifecycle assessment to mitigate greenhouse gas emissions, emphasizing the use of biofuels and electric vehicles. By 2032, regulations will shift from evaluating emissions based on the "well-to-wheel" cycle to a more comprehensive "cradle-to-grave" approach.

Title III: National Program for Sustainable Aviation Fuel (ProBioQAV)

ProBioQAV aims to:

- Encourage the research, production, and commercialization of **Sustainable Aviation Fuel (SAF)**.
- Mandate that airlines reduce greenhouse gas emissions in domestic operations by using increasing percentages of SAF, starting at 1% in 2027 and reaching 10% by 2037.

The National Civil Aviation Agency (ANAC) is tasked with monitoring compliance, and international standards (ICAO) are followed to align with global aviation decarbonization efforts.

Title IV: National Green Diesel Program (PNDV)

PNDV focuses on promoting the use of **Green Diesel**, produced from renewable biomass. A minimum volumetric share of green diesel in national diesel consumption is set, with a cap of 3%.

The program ensures flexibility, allowing for voluntary increases and maintaining market-based mechanisms for adoption.

Title V: National Decarbonization Program for Natural Gas and Biogas

This title incentivizes the production and use of **biomethane** and **biogas** to reduce the carbon intensity of natural gas. The program sets annual targets for biogas integration starting at 1% in 2026 and potentially reaching 10% by 2036. The certification process for biogas includes lifecycle emissions assessments to ensure transparency and efficiency.

Title VI: Carbon Capture and Geological Storage

This section establishes the regulatory framework for **carbon capture and storage (CCS)**. It covers the requirements for storage authorization, safety protocols, and monitoring. CCS activities are overseen by the **National Petroleum, Gas, and Biofuels Agency (ANP)**, ensuring that storage is conducted in a safe and effective manner, with opportunities for carbon credit certification.

Title VII: Final and Transitional Provisions

This final title includes several amendments to existing laws, including the biofuel blending mandates. For ethanol, the blend with gasoline remains at 27%, but may increase to 35% if deemed technically feasible. For biodiesel, the blend with diesel remains at 14%, but may increase to 25% if deemed technically feasible.

Key Takeaways

The Future Fuel Law positions Brazil as a leader in biofuels and low-carbon energy. By integrating biofuel programs and establishing clear decarbonization targets, the law supports Brazil's climate goals under international agreements like the Paris Accord. The inclusion of programs like ProBioQAV and PNDV underscores the government's commitment to reducing emissions across multiple sectors, from aviation to natural gas. Additionally, the development of CCS and the alignment with global sustainability standards marks an important step in Brazil's energy transition.

GAS CONSUMPTION AND THE ROLE OF BIOGAS

Natural gas plays a relatively modest role in Brazil, representing around 10% of total energy supply. The figure below shows the different users of natural gas. The most important gas users in 2022 are industry (38%), energy plants (36%) and transport (10%). Next to end user sectors, there is also some own use of gas in energy industries (producing gas) – this represents 13% of natural gas supply in Brazil.

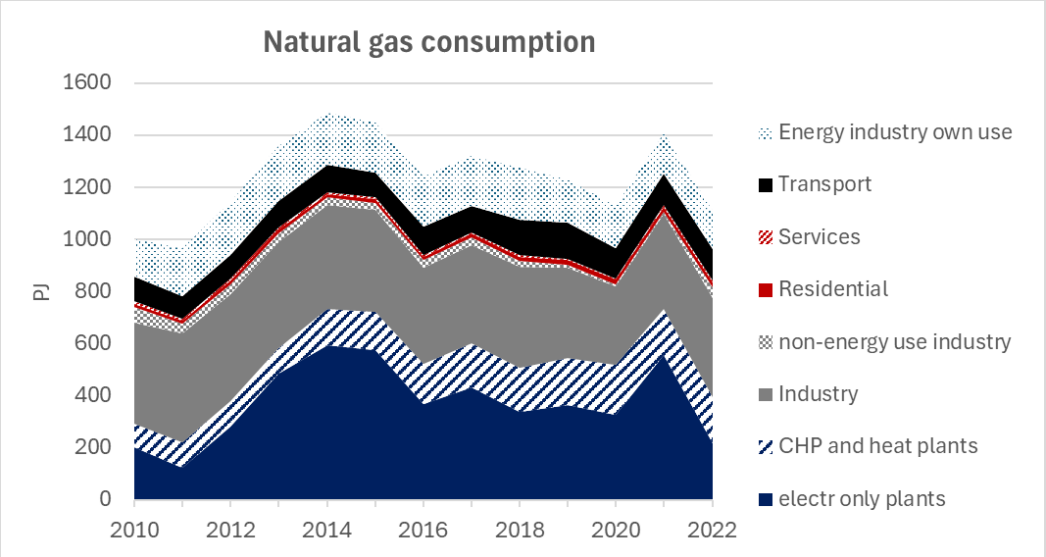

***Figure 8**: Evolution of gas consumption in different sectors in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)*

In comparison to natural gas, biogas plays a limited role. Domestic biogas production represents 2.5% of overall gas consumption.

Most biogas is used in plants that only produce electricity, particularly this application seems to be growing a lot; some is also used in combined heat and power plants. There is no reporting of biogas being upgraded for grid injection of for use in natural gas vehicles.

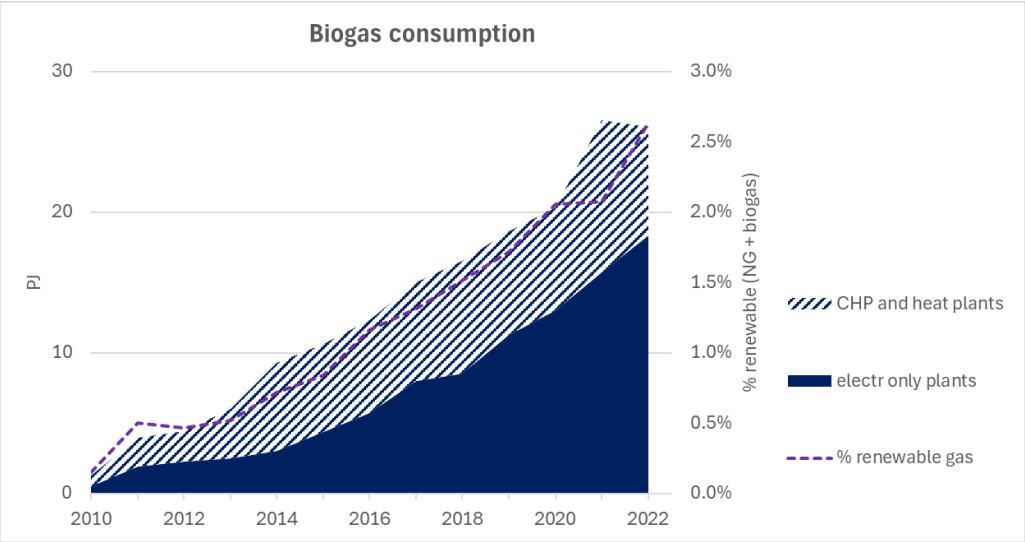

***Figure 9**: Evolution of biogas consumption in Brazil 2010 - 2022, compared to overall gas consumption (data source: IEA (2024) World Energy Balances and Renewables Information)*

FINAL ENERGY CONSUMPTION IN DIFFERENT SECTORS (EXCL TRANSPORT)

Final Energy consumption in industries

Figure 10 show the energy consumption (fuels, heat and electricity) in industries. Electricity use is for broad purposes, including processes, machineries, electric appliances, lighting, and in some cases also for heating and/or cooling. For the renewable share of electricity consumption, we consider the Brazilian electricity mix.

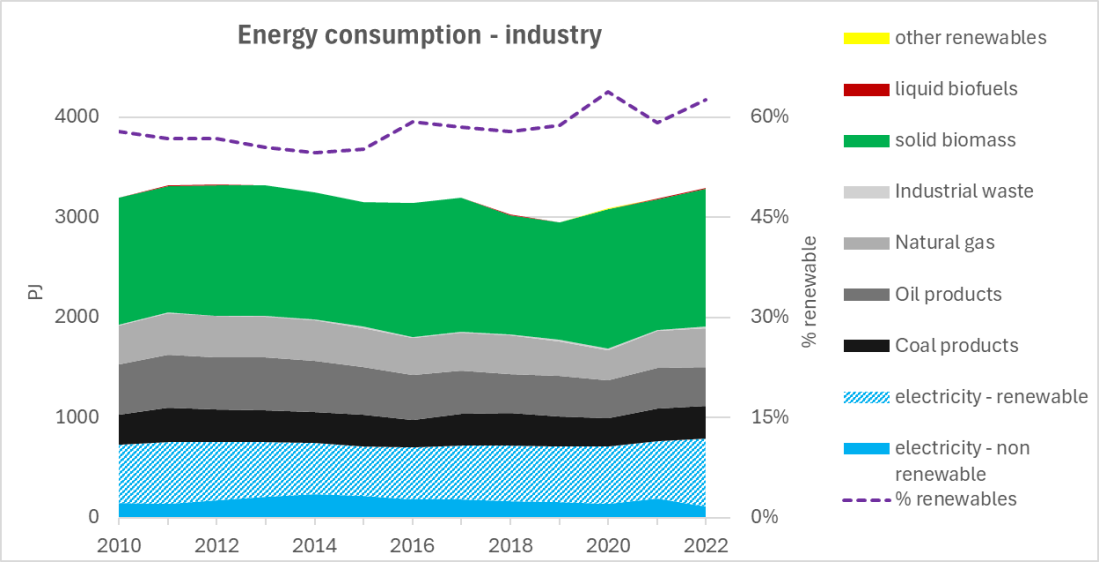

Figure 10: Evolution of final energy consumption in industries in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

In industries, electricity represents 24% of final energy consumption, so the role of fuels is substantial. Considering fuels, biomass is the dominant fuel, more than natural gas, oil and coal combined.

Overall, about 63% of final energy consumption in industries is from renewable sources, about two thirds of that from bioenergy carriers and one third from renewable electricity.

For comparison, **Figure 11** shows the **non-energy use** of coal, oil and gas in industries, e.g., for the production of chemicals. 60% of oil product consumption and 10% of natural gas consumption in Brazilian industries is for non-energy purposes.

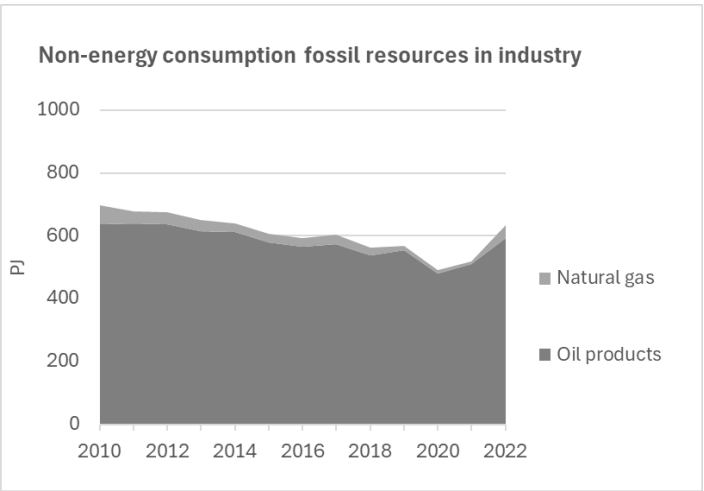

Figure 11: Evolution of non-energy use of coal, oil and gas in industries in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

Final Energy consumption in the residential sector

Figure 12 show the energy consumption (fuels, heat and electricity) in the residential sector. Electricity use is for broad purposes, including electric appliances, lighting, and partly also for heating and cooling (e.g. in heat pumps). For the renewable share of electricity consumption, we consider the Brazilian electricity mix.

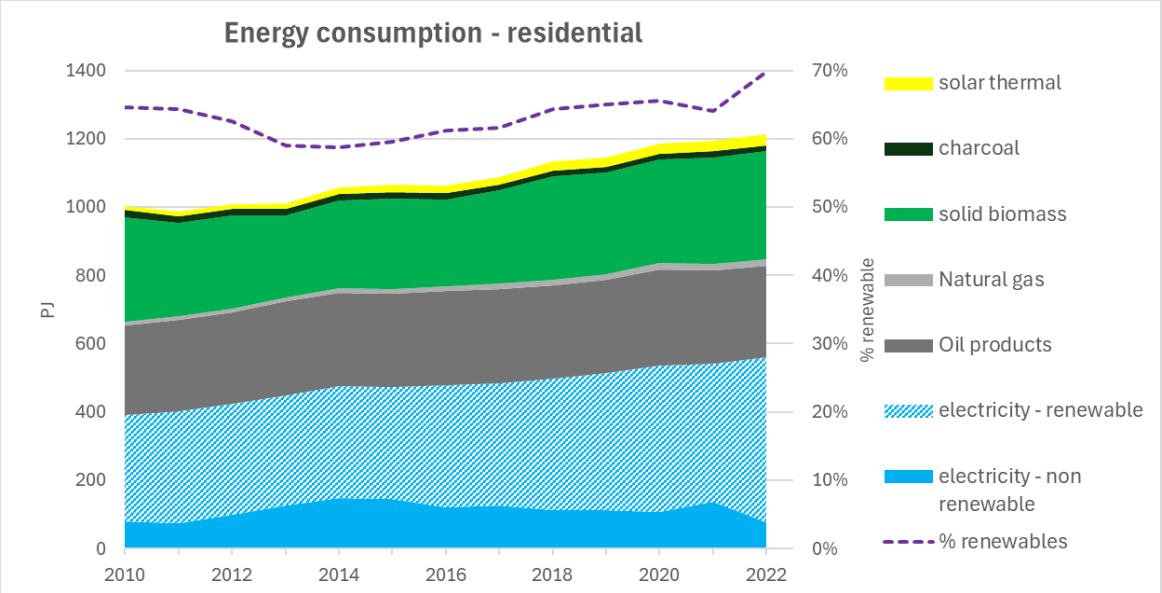

Figure 12: Evolution of final energy consumption in the residential sector in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)

Mind that energy consumption in the residential sector is about three times lower than in industries. The share of electricity in final energy consumption in the residential sector is consistently rising. Electricity now represents almost half of final energy consumption in the residential sector. The rest (use of fuels) is evenly split between oil products and biomass.

Overall, about 70% of final energy consumption in the residential sector is from renewable sources, split between renewable electricity (40%), solid biomass (26%) and smaller shares of solar thermal heat (2.8%) and charcoal (1.4%).

Final Energy consumption in commercial and public services

Figure 13 shows energy consumption (fuels, heat and electricity) in commercial/public services. Electricity use is for broad purposes, including electric appliances, lighting, servers, and partly also for heating and cooling (e.g. in heat pumps and air conditioning). For the renewable share of electricity consumption, we consider the Brazilian electricity mix.

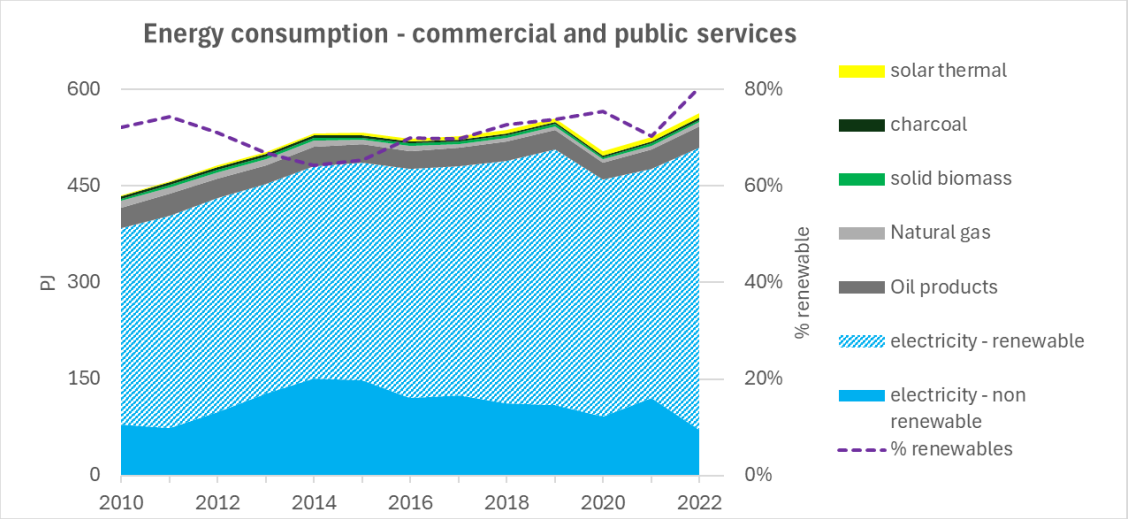

***Figure 13**: Evolution of final energy consumption in commercial and public services in Brazil (data source: IEA (2024) World Energy Balances and Renewables Information)*

Energy consumption by commercial and public services is very modest in Brazil, certainly compared to industrial energy use.

In commercial and public services, electricity plays a dominant role at 90% of final energy consumption; only small amounts of oil and gas are used. The amount of biofuels used in these sectors is marginal. The share of renewable power in the Brazilian electricity mix is decisive for the share of renewable energy in these sectors.

RESEARCH FOCUS RELATED TO BIOENERGY

Brazilian government has a number of government-backed mechanisms providing support for biofuels R&D and demonstration plants. Public and publicly oriented support totalled over 200 MR$ (USD 38 million) in 2018. This included support in the form of loans, equity participation and grants and is also available via the PAISS programme for ethanol and other biofuel production including cellulosic ethanol, and drop-in biofuels including aviation fuels.

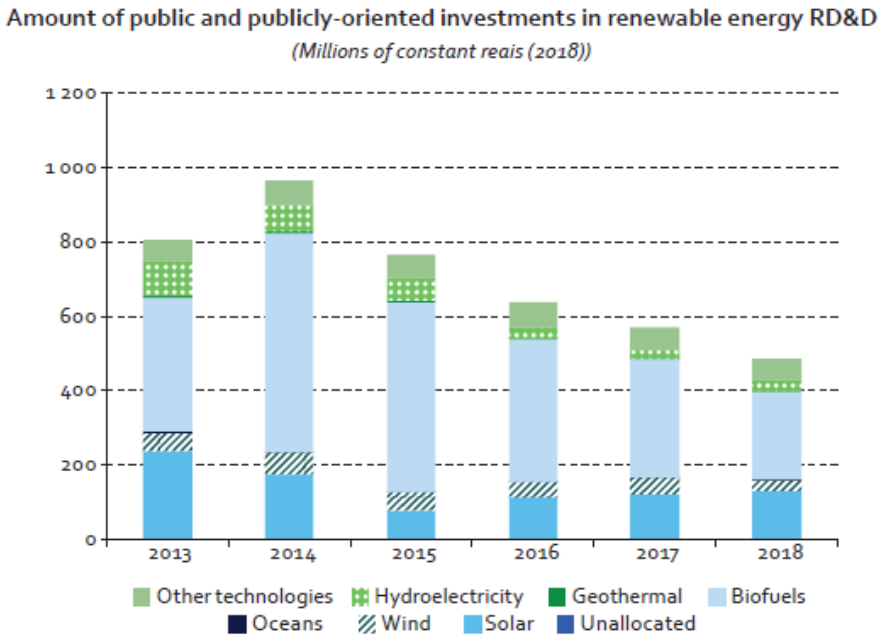

Figure 14: Public investments in renewable energy RD&D. Source: CGEE A big push for sustainability in Brazil's energy sector Figure II.11

RECENT MAJOR BIOENERGY DEVELOPMENTS

Concerning 2nd generation ethanol (E2G), currently, in Brazil, there are two commercial plants in operation. Raízen, the world's largest producer of E2G, has two units: the Costa Pinto Bioenergy Park in Piracicaba (SP) and the Bonfim unit plant in Guariba (SP). Together, these plants reach a total capacity of 112 million litres per year.

In addition to the units in operation, Raízen is constructing four more E2G plants and has three others in the planning phase. Eleven additional units are mapped in the company's expansion strategy, totalling 20 plants by 2030/2031. When all are operational, the production capacity will reach 1.6 billion litres per year.

The Future Fuels' Program, which was established through CNPE Resolution No. 7 in 2021, aims to increase the participation of sustainable and low-carbon fuels, integrating several public policies, such as RenovaBio, the Brazilian Program Production and Use of Biodiesel, the National Vehicle Labelling Program and Green Mobility and Innovation Program (MOVER), successor to Route 2030. Aviation biojet fuel and sustainable alternatives in the maritime sector will also be included. Measures for carbon capture in biofuel production and hydrogen will also be proposed by this program (EPE, 2021).

At the end of April 2021, the federal government established the guidelines for the preparation of the National Hydrogen Program, through CNPE Resolution No. 6, of April 20, 2021, for the development of its entire production and distribution and insertion chain in several important sectors, such as transport, steel, and fertilizers (EPE, 2021).

In 2024, laws no. 14,948 and no. 14,993 were enacted. The first established the legal framework for low-carbon hydrogen. The second, in turn, known as the Fuel of the Future Law, provides for the

promotion of sustainable low-carbon mobility and the capture and geological storage of carbon dioxide; it establishes the National Sustainable Aviation Fuel Program (ProBioQAV), the National Green Diesel Program (PNDV) and the National Program for Decarbonization of Natural Gas Producers and Importers and for the Incentive of Biomethane).

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