BEN

Summary Report 2024

Reference year 2023

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Content

Public Value | EPE 20 years old

In compliance with its creation law, the Energy Research Office (EPE) prepares and publishes the Brazilian Energy Balance (BEB – BEN, in Portuguese) annually, maintaining a tradition initiated by the Ministry of Mines and Energy (MME). The purpose of the BEB is to present the accounting for the supply and consumption of energy in Brazil, covering the activities of extraction of primary energy resources, their conversion into secondary forms, import and export, distribution and energy end-use.

BEB is the result of extensive research, constituting itself as a broad and systematic database, updated in annual cycles. Of paramount importance for studies related to national energy planning, BEB has also proved to be an important research tool for sectoral studies, as it presents reliable statistics, often revealing trends in energy supply and consumption. The document is taken as a reference for the country's energy data. The Summary Report of the Brazilian Energy Balance 2024 - Reference Year 2023, presents consolidated information on how much and how energy was used in Brazil in 2023.

BEB's product portfolio

Tools for monitoring energy statistics

The product portfolio of the Brazilian Energy Balance has its origin in energy statistics and seeks to diversify the ways of consolidating, making available and visualizing this data according to the different audiences interested in statistics. This portfolio has recently gained new products, such as the Interactive Brazilian Energy Balance and BEN 50 Years. Now, we present the new version of the Summary Report of the Brazilian Energy Balance. A traditional EPE publication that has a new format, more modern, didactic and explanatory to the Brazilian and international society.

Total Energy Supply

In 2023, the domestic energy supply (total energy made available in the country) reached 313,9 Mtep, registering an increase of 3.5% when compared to the previous year. The participation of renewables in the energy matrix was marked by the maintenance of the supply of hydroelectric power, growth in wind and solar photovoltaic generation and a reduction in the use of thermoelectric plants based on fossil fuels such as natural gas and petroleum derivatives.

In addition, the maintenance of hydraulic supply, associated with the significant increase in wind and solar sources in the power generation (zero loss), as well as biomass, contributed to the Brazilian energy matrix remaining at a renewable level of 49.1%, much higher than that observed in the rest of the world and in OECD[1] countries.

Electricity Supply

In the case of electricity, there was an increase in domestic supply of 33.2 TWh (+4.8%) compared to 2022.

The main highlights were:

- The share of renewables in the electricity mix achieved 89.2% in 2023.
- Solar photovoltaic generation reached 50.6 TWh (centralized generation and MMDG), growing by 68.1% and its installed capacity reached 37,843 MW, an expansion of 54.8% compared to the previous year.
- Hydroelectric generation remained practically stable, with a slight reduction of just 1.1 TWh, which represented a drop of 0.3% compared to 2022.
- Wind generation reached 95.8 TWh (17.4% increase) and its installed capacity reached 28,682 MW, an expansion of 20.7%.
- 1.9% drop in thermoelectric generation.

[1] Organisation for Economic Co-operation and Development

Final Consumption

Final consumption (both energy and non-energy) grew 4.0% in relation to the previous year.

Industry

The industrial sector increased by 2.5 million toe in absolute values. Among the sources that contributed to the increase, electricity (+2.6%) and sugarcane bagasse stand out, with a 26.1% increase due to sugar production associated with the food and beverage sector. The main movements that contributed negatively were the 5.0% reduction in the use of mineral coal in relation to 2022 due to the 4.9% reduction in steel production due to reduction to mineral coke. There was a 2.8% reduction in the use of black liquor due to the 2.9% drop in cellulose production. Additionally, the consumption of natural gas, used in various industrial segments, was reduced by 6.5%.

Except for the Cement, Non-ferrous and other metallurgy, Mining and Pelletizing and Food and beverage segments, with increases of 0.2%; 5.5%; 7.2% and 19.7% respectively, all other segments recorded a decline in consumption in 2023.

Transport

Energy consumption in transport in 2023 increased by 4.4% compared to 2022. The main highlights were the 19.2% increase in biodiesel, 6.9% in gasoline and 6.3% in ethanol (anhydrous + hydrated). In the light vehicle market, ethanol lost share in relation to automotive gasoline, now representing 38% of consumption, compared to 39% in 2022.

In the case of road freight transport, biodiesel consumption increased by 19.2%, which can be explained by the increase in the percentage of mixture with mineral diesel to 12% (B12) from April 2023. As a consequence of these movements, Brazil's transport sector presented an energy matrix made up of 22.5% renewable sources in 2023, compared to 22% in the previous year.

Final Consumption by source

Electricity

Final electricity consumption in the country in 2023 grew by 5.2%. The sectors that contributed most to this advance in absolute values were Residential, which grew by 14.1 TWh (+9.1%), followed by Commercial, which increased its consumption by 6.9 TWh (+7.1%), by Industrial, which grew by 5.7 TWh (+2.6%) and by the Agricultural Sector, with an increase of 1.5 TWh (+4.6%).

Ethanol

The final consumption of ethanol in the country (m^3) increased by 5.4% compared to 2022 and reached around 32.1 million cubic meters in 2023.

Biodiesel

Final biodiesel consumption in the country (m^3) in 2023 increased by 19.9%. The mandatory blend percentage in petroleum diesel was changed to 12% (in volume) from April 2023.

Emissions

In 2023, the total anthropic emissions associated with the Brazilian energy mix reached 428 million tons of carbon dioxide equivalent (Mt $CO_{2\text{-eq}}$), the majority (217 Mt $CO_{2\text{-eq}}$) being generated in the transport sector.

In terms of emissions per inhabitant, each Brazilian, producing and consuming energy in 2023, emitted on average 2,0t $CO_{2\text{-eq}}$.

According to the latest data released by the International Energy Agency (IEA) for the year 2021, each Brazilian emitted the equivalent of 14.5% of what an American emitted, 36% of what an OECD European citizen and 26 .2% of what a Chinese citizen issued.

The carbon intensity in the economy in 2023 was 0.13 kg CO_2/US$ppp [2015][1].

Also based on IEA data from 2021, the carbon intensity in the Brazilian economy is equivalent to 34% of the Chinese economy, 66% of the U.S. economy and practically the same level as the economy of European OECD countries.

For each ton of oil equivalent (toe) made available, Brazil emitted in 2021 the equivalent of 78% of the emission of European OECD countries, 69% of the emission of the United States (USA) and 52% of the emission of China.

The Brazilian electric sector emitted, on average, only 55.1 kg $CO_{2\text{-eq}}$ to produce 1 MWh, a very low rate when comparing with European OECD countries, USA and China.

The digital version of this document can be accessed at http://www.epe.gov.br

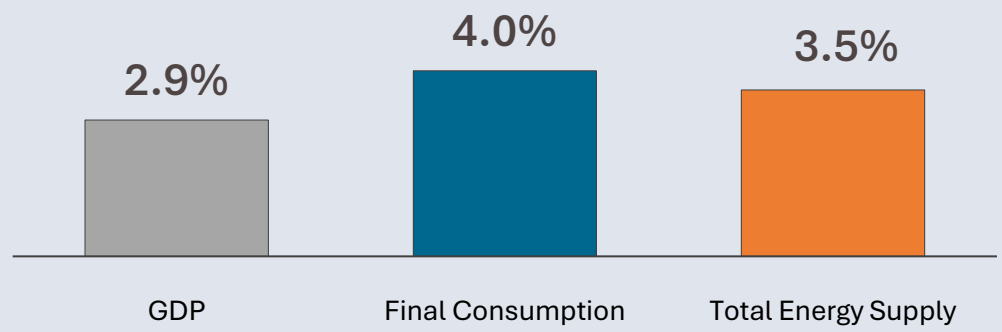
[1] In the concept of purchasing power parity.

How much Energy is used in Brasil?

The **Total Energy Supply (TES)** in Brazil recorded, in 2023, a growth of 3.5% compared to the previous year, close to the growth in Final Consumption.

Values in 10^6 toe		2022	2023
Total Energy Supply (TES)	↑	303.2	313.9
Final Consuption	↑	271.7	282.5
Losses[1]	↑	31.4	31.5

Losses:
refer to energy conversion losses in transformation centers + losses in energy distribution and storage.

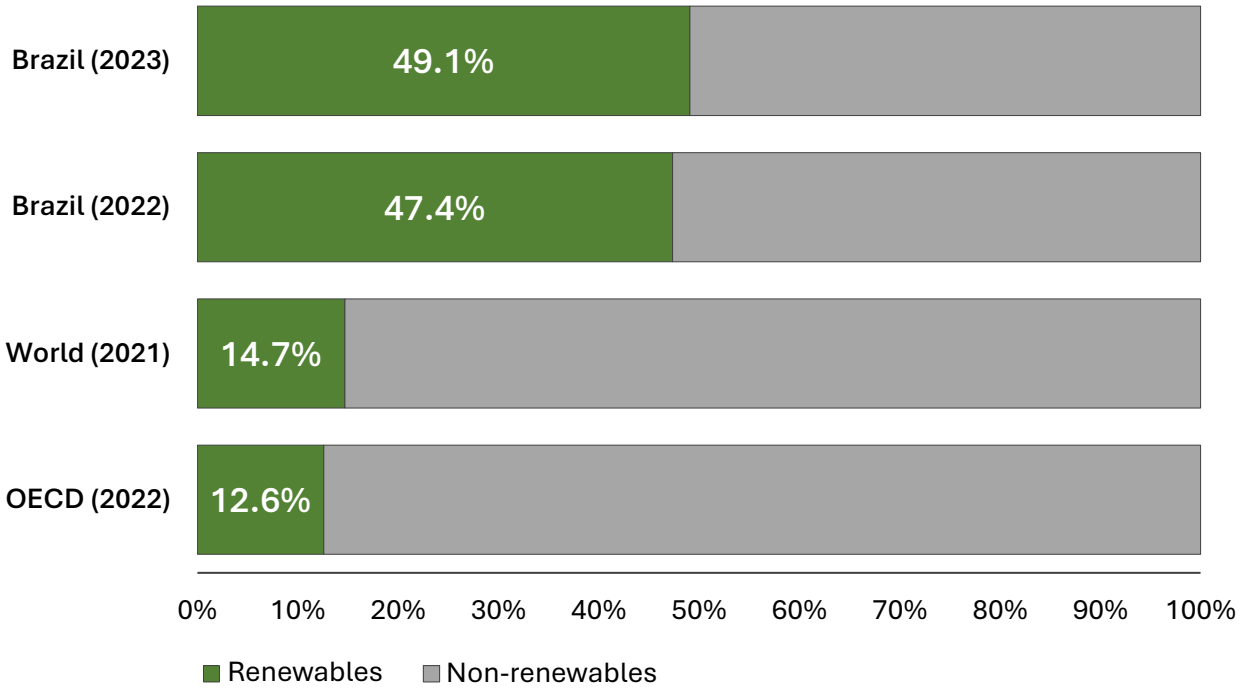


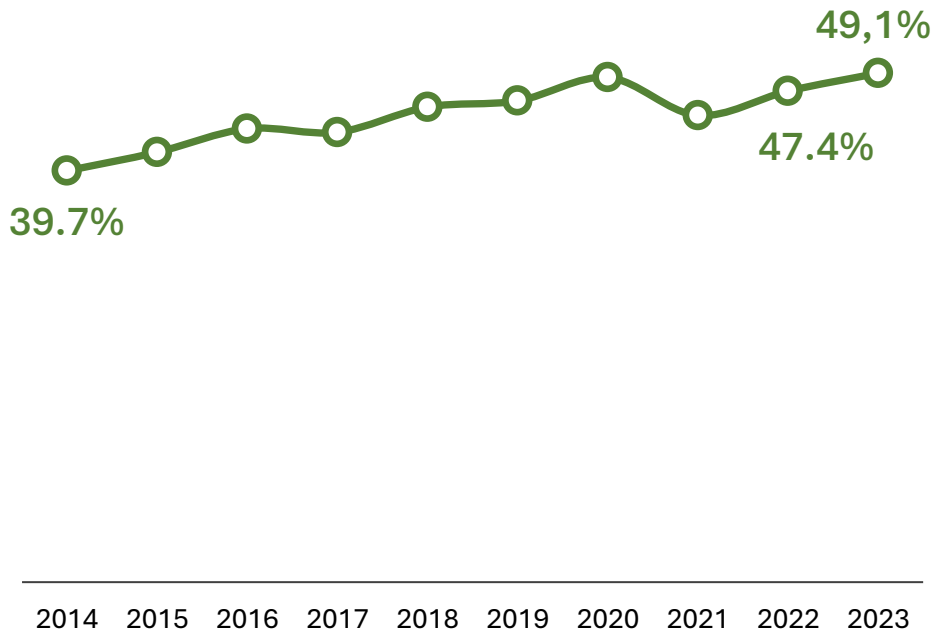
[1] Refer to energy conversion losses in transformation centers + losses in energy distribution and storage.

The **share of renewables in the energy mix**[1] was marked by an increase in the supply of biomass, wind and solar. Hydraulic energy remained stable with a favorable water regime.

Share of renewables in the TES

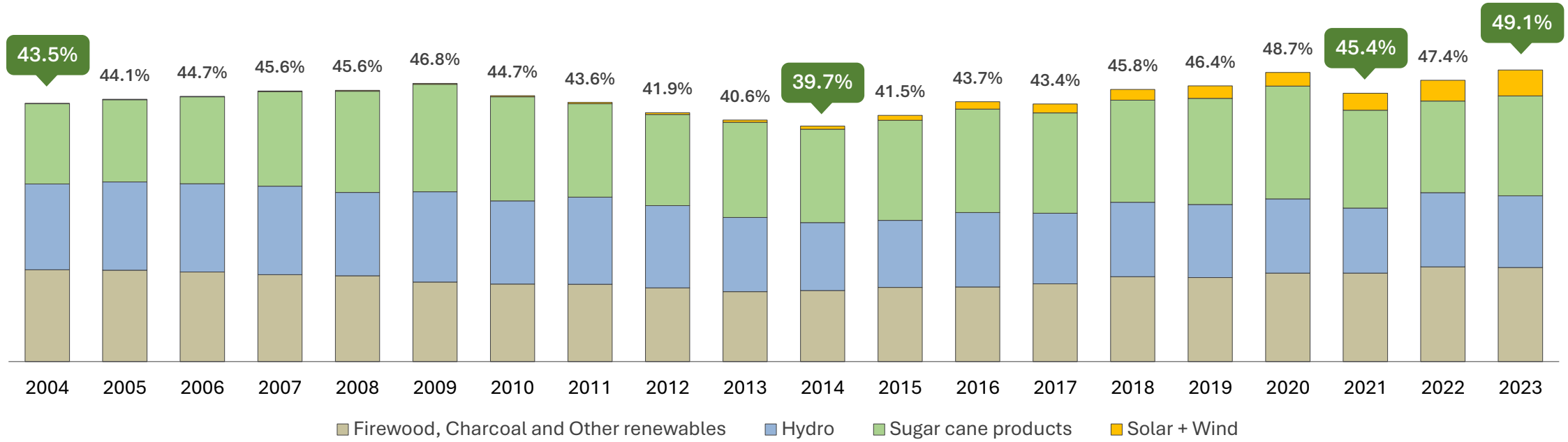
Source: International Energy Agency and EPE for Brazil. Prepared by: EPE





[1] Renewability is calculated based on the Total Energy Supply - TES

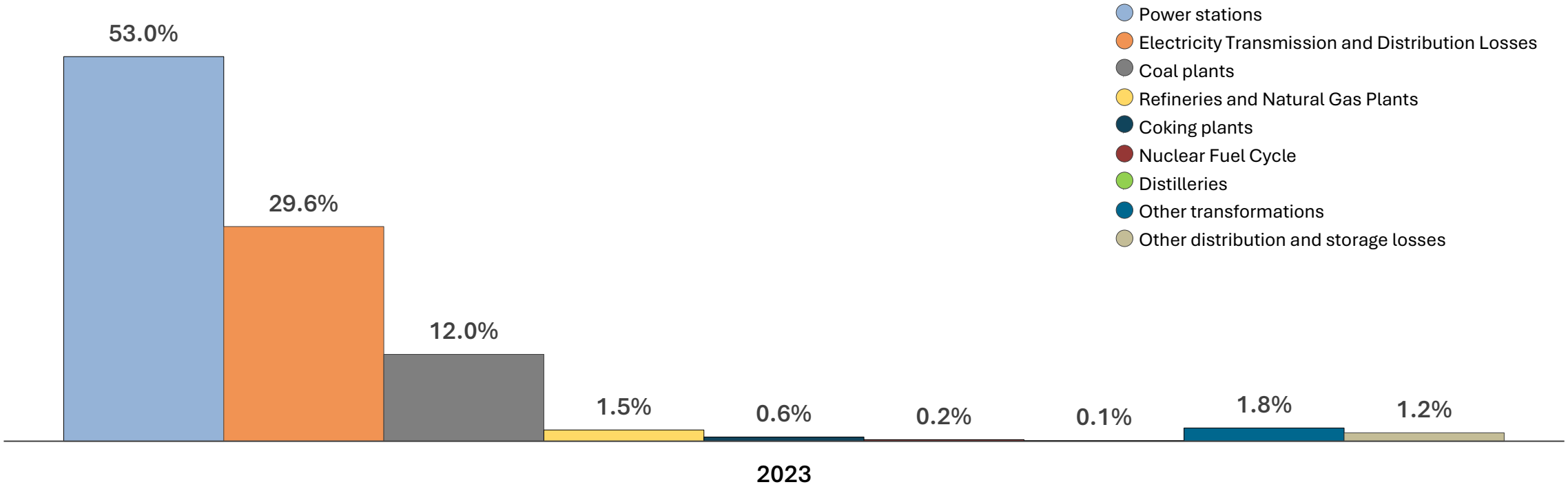
Over 20 years, the share of renewables in the **Total Energy Supply (TES) has remained at a high level, reaching 49.1% in 2023.** This shows that Brazil has already been implementing actions aimed at **energy transition** through insertion of new renewable sources into its energy matrix.



In 20 years, the diversification of renewables in the energy mix based on the development of wind and solar sources, made it possible to ensure high levels of renewability in the Total Energy Supply, even with fluctuations in the hydraulic supply and other renewable sources in the energy mix.

[1] Other renewables include Firewood and Charcoal, Sugar cane products, Black liquor, Biodiesel, Other biomass, Biogas and Charcoal industrial gas

Distribution of losses among segments[1]



The three largest segments were responsible for more than 90% of the losses that occur in the Country: power stations, electricity transmission and distribution and coal plants. The share of losses in Power Stations was lower in 2023, due to the maintenance of hydroelectric generation and the growth of wind and solar generation.

[1] Total losses correspond to losses in transformation centers, electricity transmission and distribution losses and other distribution and storage losses.

Losses in Transformation Centers

Distribution of losses (10^3 toe)

Source: EPE

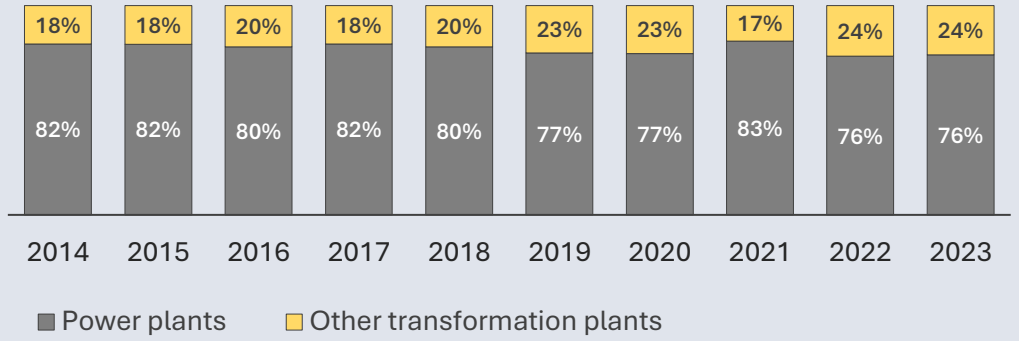
Other transformation plants

Include oil refineries, natural gas plants, coke plants, nuclear fuel cycle, coal stores, distilleries, other transformations.

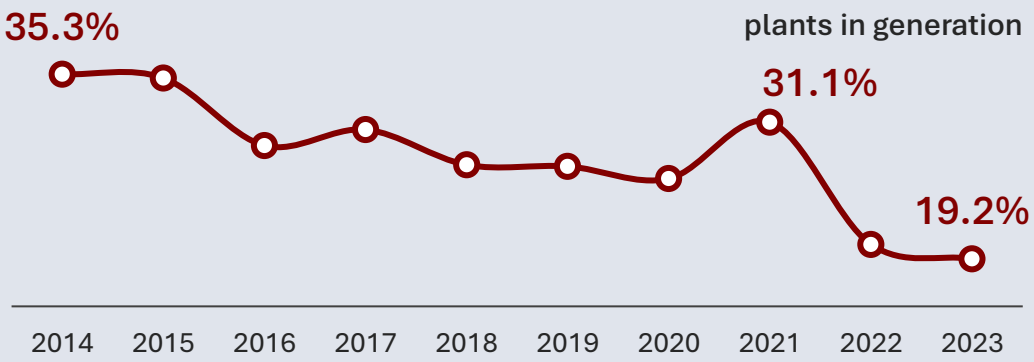
Thermoelectric power plants (including nuclear power plants)

Concentrate all losses in power plants. Therefore, the greater the participation of this type of plant in the generation mix, the greater the losses associated with power plants.

Distribution of losses



Share of thermal plants in generation



[1] Other transformation plants involve: Losses of Electricity Transmission and Distribution, Coal Plants, Refineries and Natural Gas Plants, Coke Plants, Nuclear Fuel Cycle, Distilleries, Other Transformations and Other Distribution and Storage Losses

Which Energy Resources are used in Brazil?

Breakdowns of Total Energy Supply (TES) 2023

RENEWABLES ▶ 49.1%

Sugarcane biomass

16.9%

Hydro power[1]

12.1%

Wind power

2.6%

Firewood and Charcoal

8.6%

Black liquor and Other Renewables[2]

7.2%

Solar[3]

1.7%

NON-RENEWABLES ▶ 50.9%

Oil and oil products

35.1%

Natural gas

9.6%

Coal

4.4%

Uranium

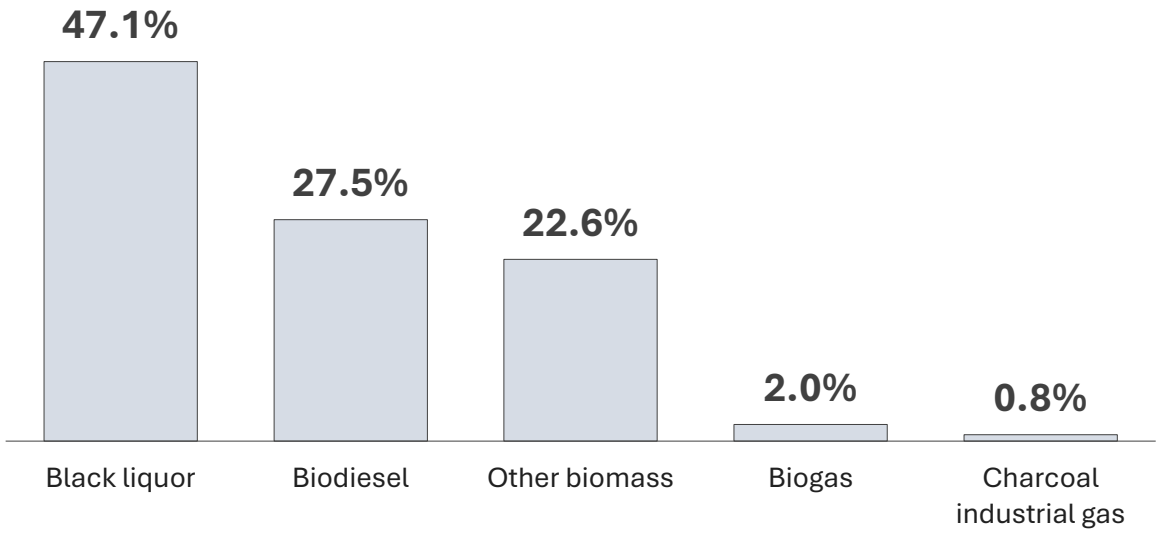
1.2%

Other non-renewable

0.6%

[1] Includes electricity imports
[2] Includes Black liquor, Biodiesel, Other biomass, biogas e Charcoal industrial gas
[3] Includes Solar photovoltaic and Solar thermal sources

The supply of "Black Liquor and Other Renewables" is divided between 5 categories of energy sources, with greater shares of black liquor, biodiesel and other biomass, which together amount to more than 97%.

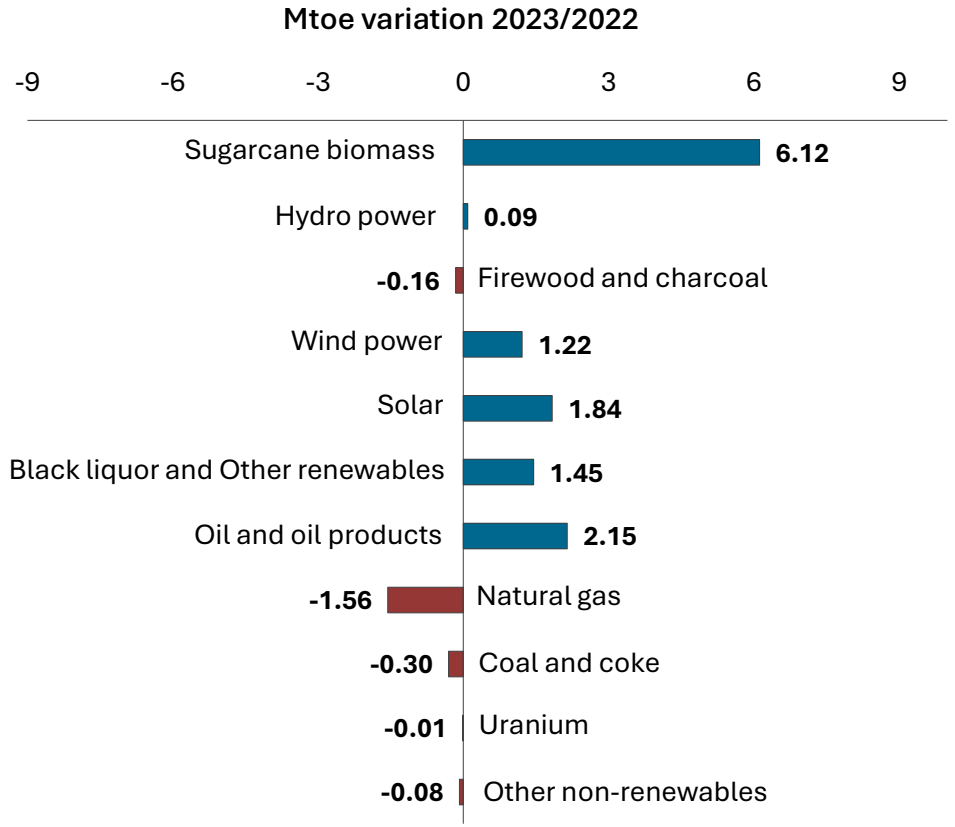


Black Liquor and Other renewables (10^6 toe)	2022	2023	Δ% 23/22
Black liquor	11,3	10,6	-5,6%
Biodiesel	5,3	6,2	18,1%
Other biomass[1]	4,1	5,1	25,0%
Biogas	0,4	0,5	5,0%
Charcoal industrial gas[2]	0,1	0,2	105,9%
Total	**21,1**	**22,6**	**6,9%**

[1] Includes rice husks, elephant grass and vegetable oils
[2] Gas from the steelmaking process with charcoal

Total Energy Supply 2022-2023

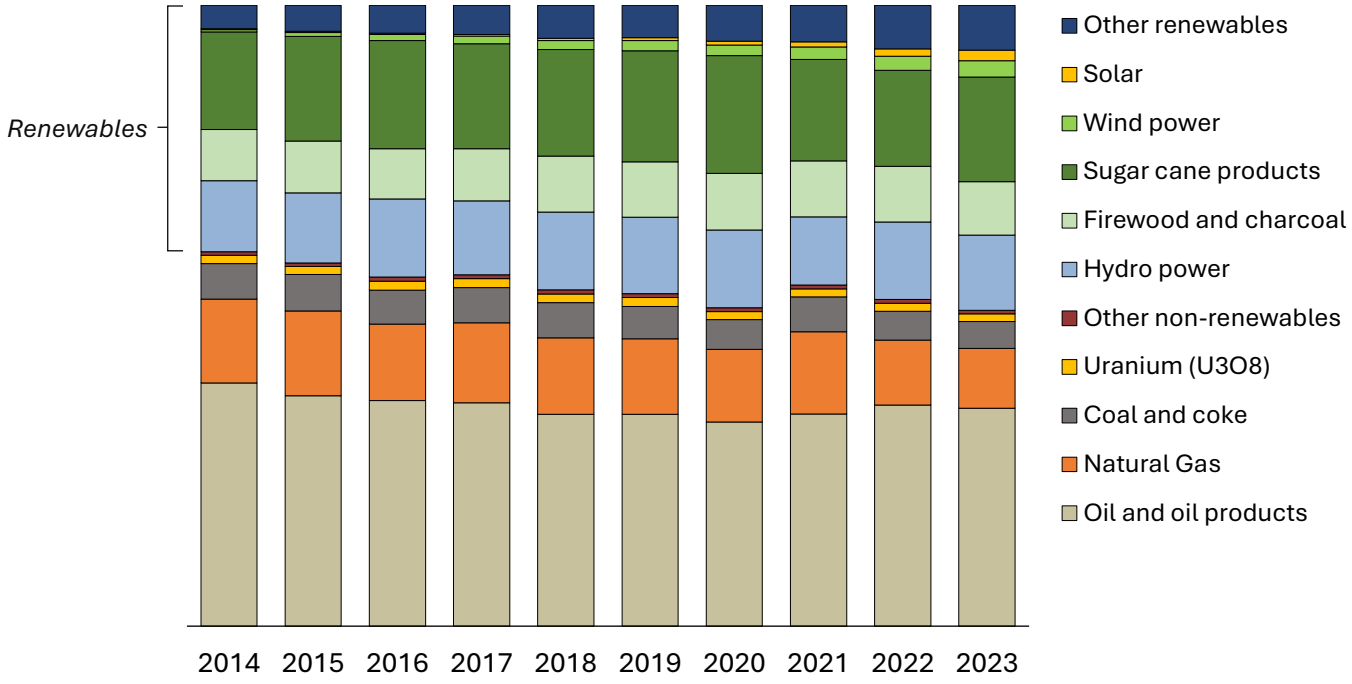
Source (Mtoe)	2022	2023	Δ% 23/22
RENEWABLES	**143.6**	**154.1**	**7.4%**
Sugarcane biomass	46.7	52.9	13.1%
Hydro power[1]	37.8	37.9	0.2%
Firewood and charcoal	27.3	27.1	-0.6%
Wind power	7.0	8.2	17.4%
Solar[2]	3.6	5.4	51.1%
Black liquor and Other renewables	21.1	22.6	6.9%
NON-RENEWABLES	**159.6**	**159.8**	**0.2%**
Oil and oil products	108.1	110.3	2.0%
Natural gas	31.7	30.2	-4.9%
Coal and coke	14.0	13.7	-2.1%
Uranium (U_3O_8)	3.9	3.8	-0.3%
Other non-renewables	1.9	1.8	-4.0%



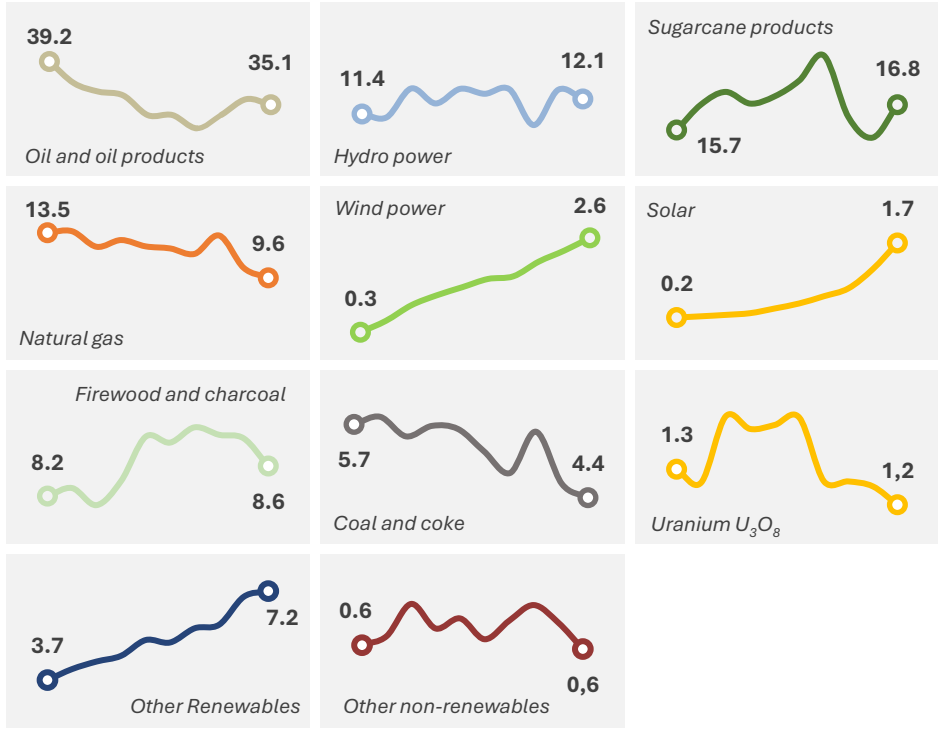
Main movements: increase in biomass due to the increase in sugar-alcohol production in the sugar-alcohol sector; reduction in natural gas due to the decrease in energy consumption and dispatch from thermoelectric plants and the drop in steel production, impacting the reduction in mineral coal.

[1] Includes import of eletricity
[2] Includes Solar photovoltaic and Solar thermal

Total Energy Supply 2014-2023

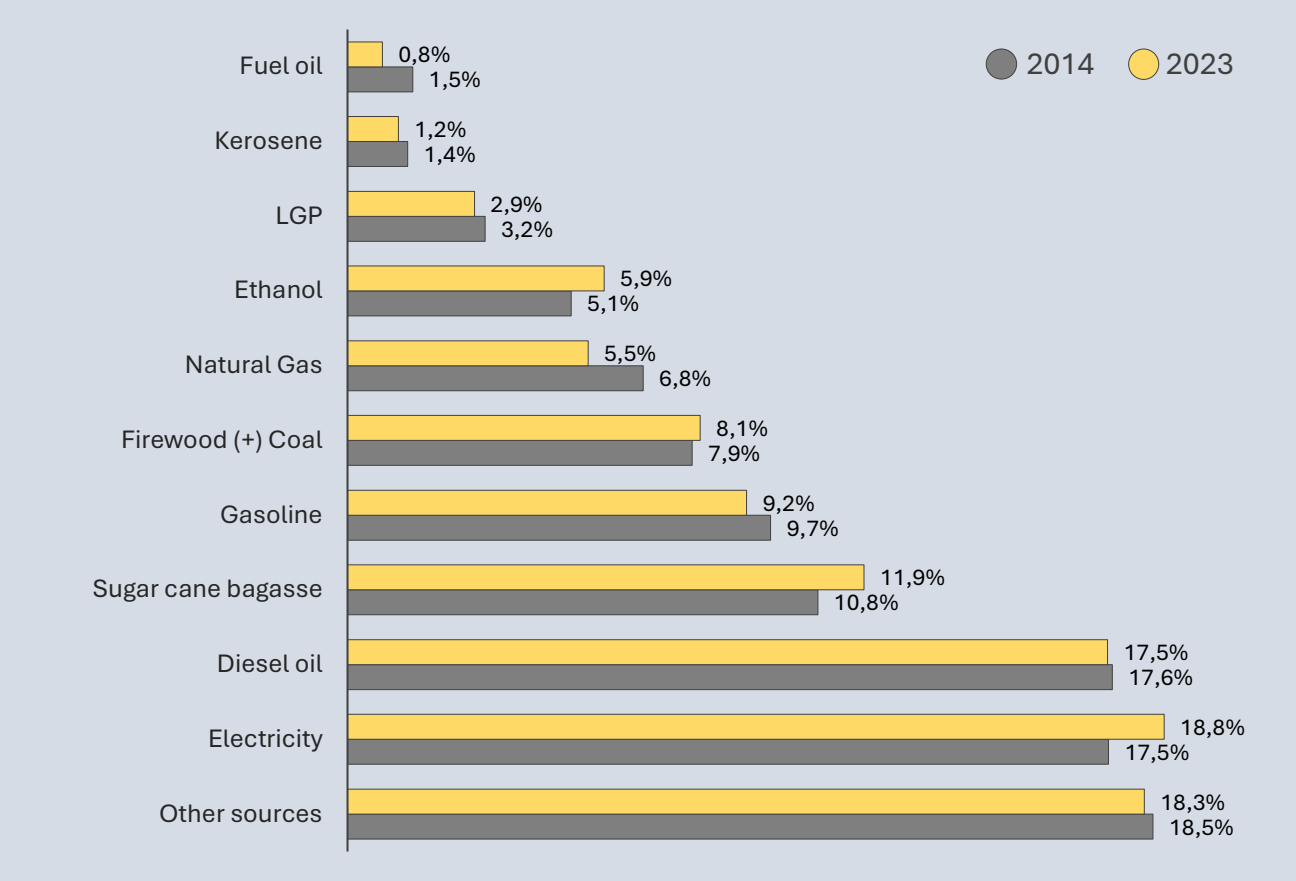


Share of sources in TES (%) between 2014 and 2023



The lower share of renewables in the energy mix in 2014 was due to the drop in hydroelectric supply that year. From 2015 onwards, renewable sources resumed a growth trajectory, reaching a 45% share in 2021 and 49.1% in 2023, mainly due to the increase in electricity generation from biomass and wind and solar sources.

Energy Consumption[1] by source (share %)



Lower share in 2023 compared to 2014

Natural gas | Fuel Oil Diesel Oil | LPG | Gasoline | Kerosene | Other Sources

Higher share in 2023 compared to 2014

Ethanol | Sugarcane bagasse | Electricity | Firewood

7 energy sources

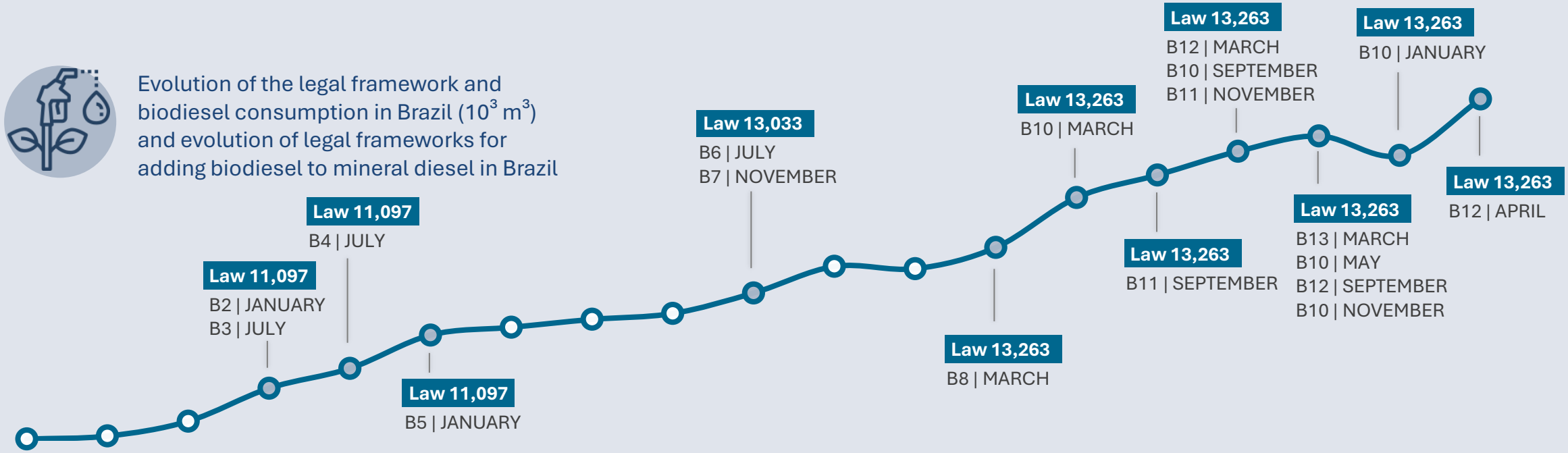
4 energy sources

[1] Does not include raw material used in transformation centers.

Highlight: Biodiesel final consumption

The growing consumption of biodiesel in Brazil is favored by the policy of adding this fuel to fossil diesel, as shown in the graph. In terms of production, Brazil is among the world's largest producers of this biofuel. The most widely used raw material for its manufacture in Brazil is soybean oil.

Evolution of the legal framework and biodiesel consumption in Brazil (10^3 m^3) and evolution of legal frameworks for adding biodiesel to mineral diesel in Brazil



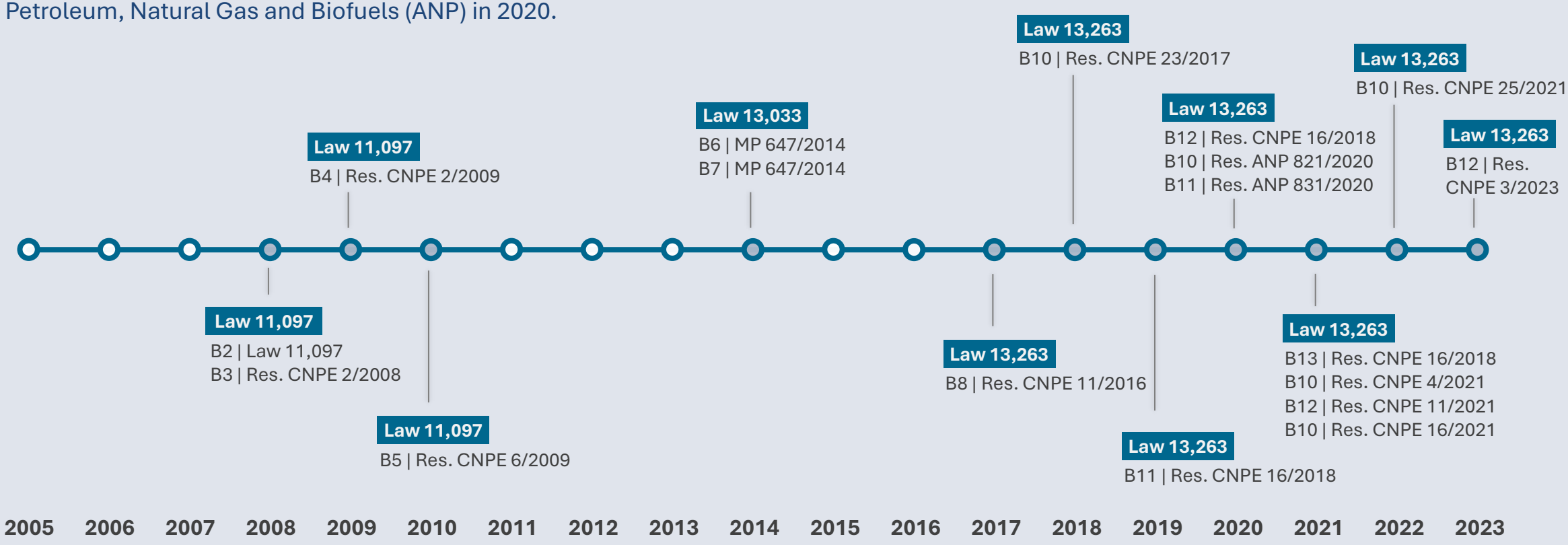
Biodiesel annual consumption (10^3 m^3)

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	66	391	1,111	1,543	2,272	2,439	2,612	2,742	3,189	3,769	3,719	4,183	5,270	5,762	6,280	6,615	6,191	7,421

Note: more details in the publication “Análise de Conjuntura dos Biocombustíveis 2022”, clicking HERE.

Highlight: Resolutions timeline

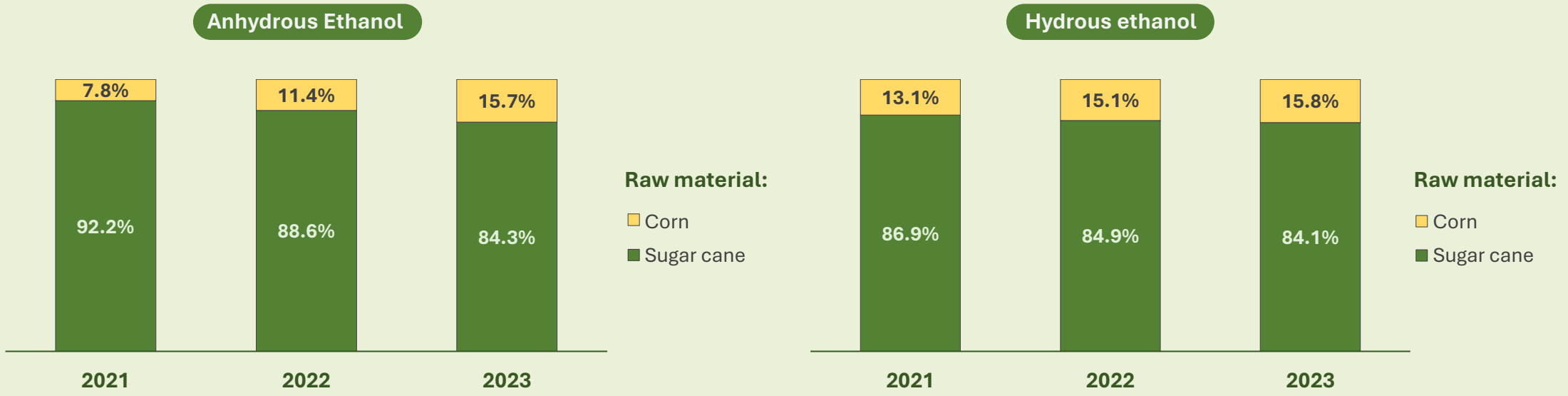
The National Energy Policy Council (CNPE), chaired by the Minister of State for Mines and Energy, is an advisory body to the President of Brazil for the formulation of energy policies and guidelines. The figure below shows the CNPE Resolutions related to the evolution of the biodiesel content in mineral diesel, in addition to the Provisional Measures (MP) of 2014 and resolutions of the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP) in 2020.



Note 1: more details in the publication “Análise de Conjuntura dos Biocombustíveis 2022”, clicking HERE.
Note 2: "Res." stands for Resolution and "MP" stands for Provisional Measure: a normative instrument, with immediate effect, with the force of law and is issued by the head of the Executive. It is the tool that allows legislation on certain cases of urgency and relevance

Highlight: Diversification of raw materials for ethanol production

The growth of corn ethanol has been favored by the increase in grain production, with the planting of second crops becoming predominant to produce biofuel. This practice uses the same area in rotation with other crops, notably soybeans. Ethanol production reached 5.8 billion liters in 2023. **This industry, concentrated in the Central-West region, generates important co-products such as distiller's dried grains with solubles[1] and corn oil and can operate throughout the year, as corn can be stored.**



Corn, used as a raw material to produce ethanol, was responsible for around 16% of the production of this biofuel in 2023.

[1] Used for animal feed.

Who uses Energy in Brazil?

64.8% of the country's energy consumption in 2023 was destined for **cargo and passenger transport** and for the **industrial sector...**

Transport
33%

Industries
31.8%

Households
10.7%

Energy Sector
8.8%

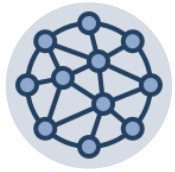
Agriculture and Livestock
5.0%

Services
5.1%

2023
282.5 Mtoe

2022
271.7 Mtoe

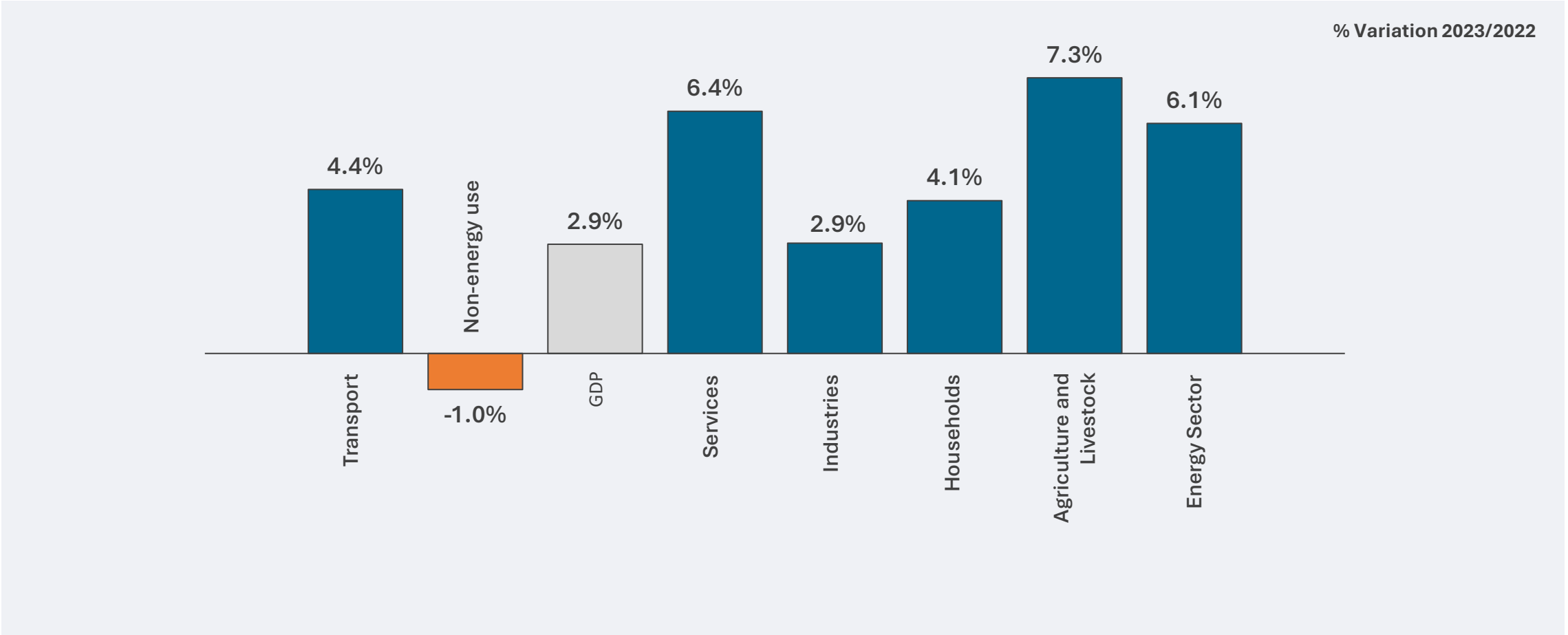
4.0% increase



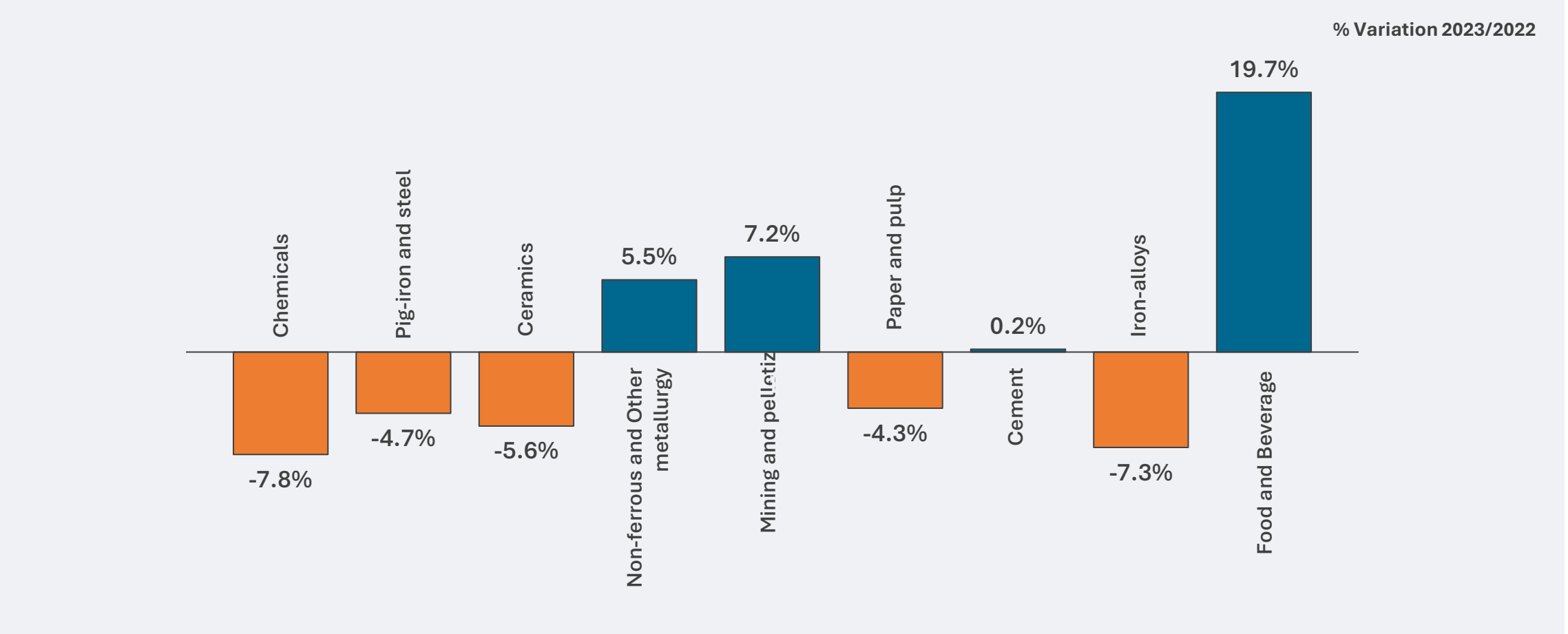
Non-energy use
5.7%

There was a 4.0% increase in energy use in 2023 compared to 2022. In this scenario, the transport sector had the largest share among the sectors and became, once again, the leader in the country in terms of energy consumption.

...but **how did energy consumption vary in Brazil (2022-2023)** when we compare all sectors of the Brazilian economy?

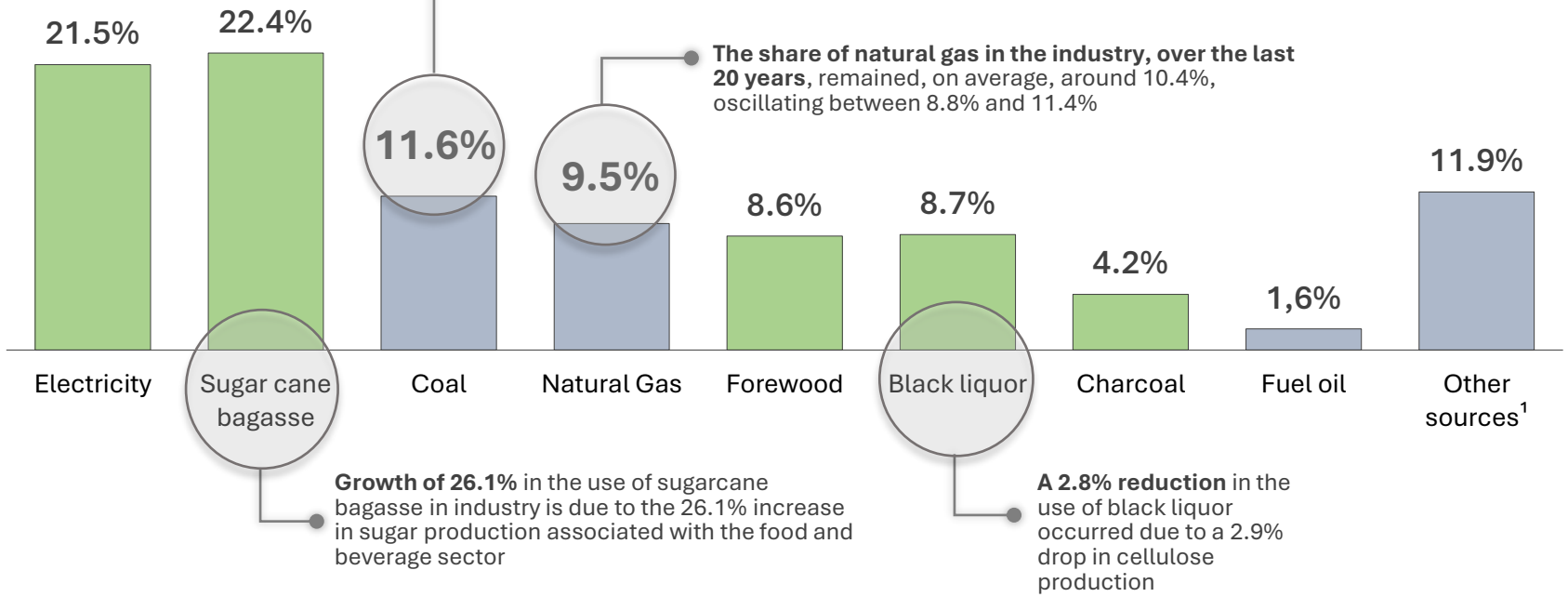


As a noteworthy sector, energy consumption in the energy-intensive segments of industry showed the following changes.



Energy consuption in industry, besides presenting 2.9% growth compared to 2022, had 64.7% renewability in its mix.

Share of energy sources sources in industry:

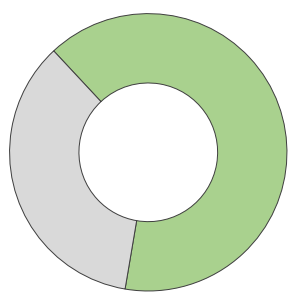


5.0% reduction in the use of mineral coal and derivatives compared to 2022 due to the 4.9% reduction in steelmaking with coal coke

The share of natural gas in the industry, over the last 20 years, remained, on average, around 10.4%, oscillating between 8.8% and 11.4%

Growth of 26.1% in the use of sugarcane bagasse in industry is due to the 26.1% increase in sugar production associated with the food and beverage sector

A 2.8% reduction in the use of black liquor occurred due to a 2.9% drop in cellulose production



64.7%
renewable

2023
89.7 Mtoe

2022
87.2 Mtoe

2.9% increase

Note: In the case of Electricity, only its share generated from renewable sources is considered, which corresponded to 89.2% of total electricity generation in 2023.

[1] "Other sources" include diesel, LPG, naphtha, kerosene, coke oven gas, tar, refinery gas, petroleum coke, among other renewable and non-renewable.

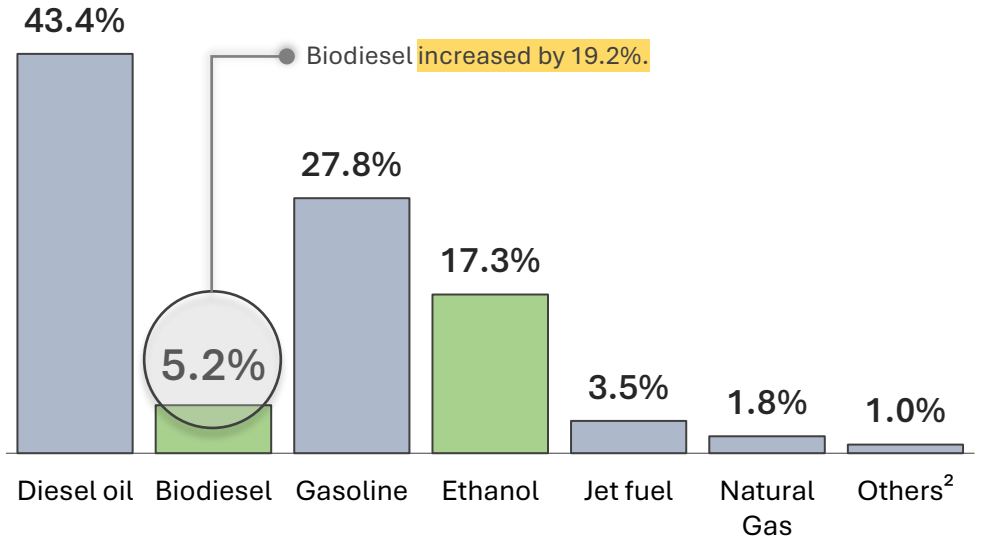
Energy consumption in 2023 in transportation[1] showed na increase of 4.4% compared to 2022. The main highlights were the increase in consumption of biodiesel (+19.2%), gasoline (+6.9%) and ethanol (+6.3%).

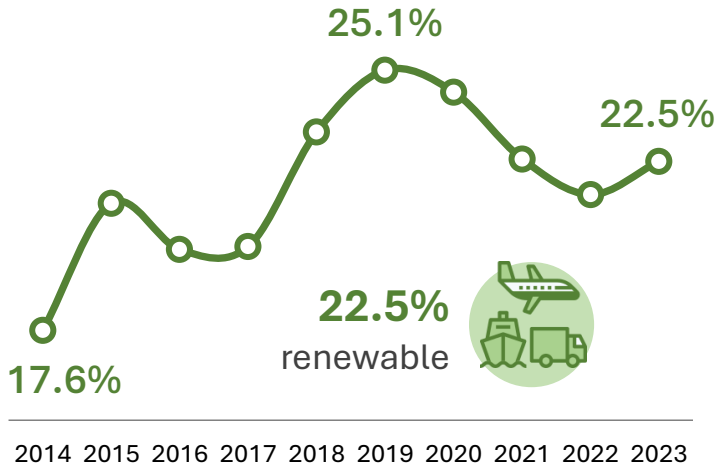
Share of energy sources sources in Transports:

2023
93.3 Mtoe

2022
89.4 Mtoe

4.4% increase





Ethanol consumption increased by 6.3% and Biodiesel, by 19.2%, both in relation to 2022. During 2023, the mandate to add biodiesel to fossil diesel was 12% in volume (B12) from April. For more information, see page 22.

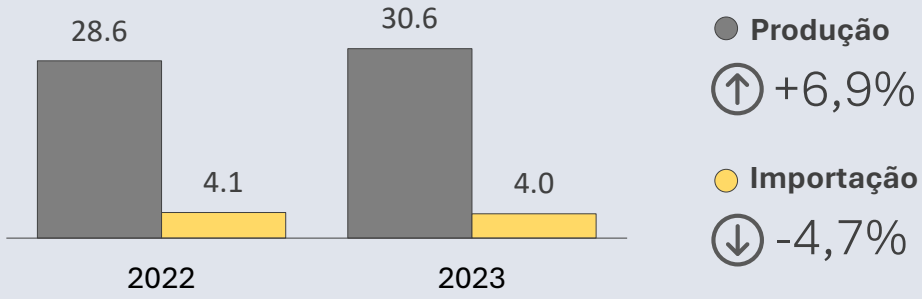
[1] The percentage variation in consumption is expressed on an energy basis, not a volumetric one.
[2] Others correspond to Fuel oil and Electricity.

Highlights: Energy consumption in transport

In 2023, the main movements are related to the production and import of gasoline A[1] **(Box 1)**, the variation in diesel oil[2] consumption and the added value of transport services **(Box 2)** and the share of ethanol consumption in the light vehicles market **(Box 3)**.

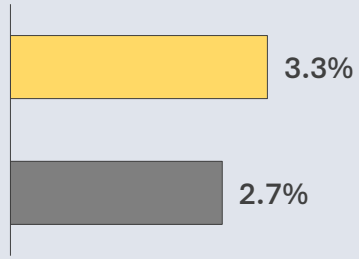
Box 1

Production and import of gasoline A (10^6 m^3)

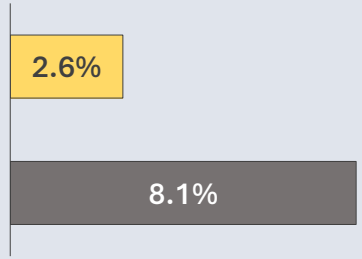


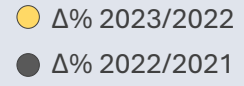
Box 2

Variation in consumption of diesel oil



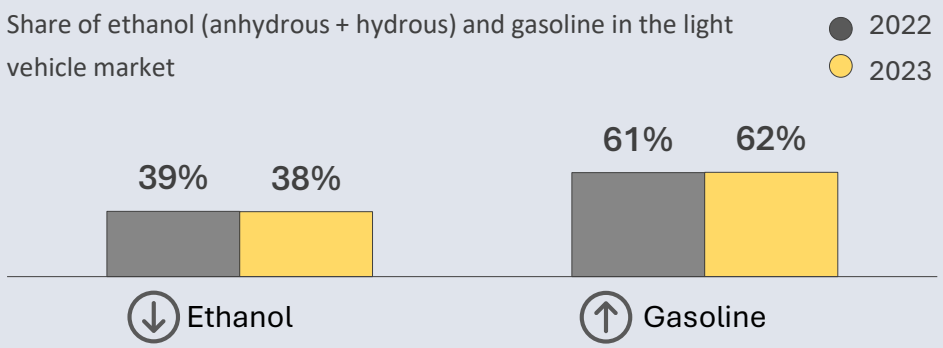
Value added by transport services





Box 3

Share of ethanol (anhydrous + hydrous) and gasoline in the light vehicle market



Both hydrous ethanol and Gasoline A, both fuels used in flexfuel engines, increased their share to a level of 6.9%

Δ% 2023/2022
Hydrous Ethanol
+6.9%

Δ% 2023/2022
Gasoline A
+6.9%

[1] Gasoline A is the one produced by oil refineries and does not have anhydrous ethanol in its composition.
[2] Includes biodiesel

Final consumption in the energy sector increased compared to 2022, that is, more energy was used for transformation in Brazil in 2023.

Source (10^3 toe)	2022	2023	Δ% 23/22
Sugarcane bagasse	12,084	13,452	11.3%
Natural gas	4,345	4,095	-5.8%
Oil products	3,770	4,005	6.2%
Electricity	3,079	3,171	3.0%
Coke oven gas	172	164	-4.8%
Total	**23,450**	**24,886**	**6.1%**

But what is energy transformation?

Transforming energy is carrying out processes to change the way energy presents itself.

For example: to transform oil into gasoline, diesel oil, kerosene and other oil products in the refinery, it is necessary to expend energy.

The consumption of **sugarcane bagasse** in the energy sector increased by 11.3% compared to 2022. This was mainly due to the growth in ethanol production in the **sugar-alcohol sector** seen in 2023. **Natural gas** suffered a reduction due to the decrease of activities on gas pipelines.

Residential energy consumption grew by 4.1% compared to 2022, with the following distribution in the use of energy sources...

Share of energy sources sources in households:

2023
30.1 Mtoe

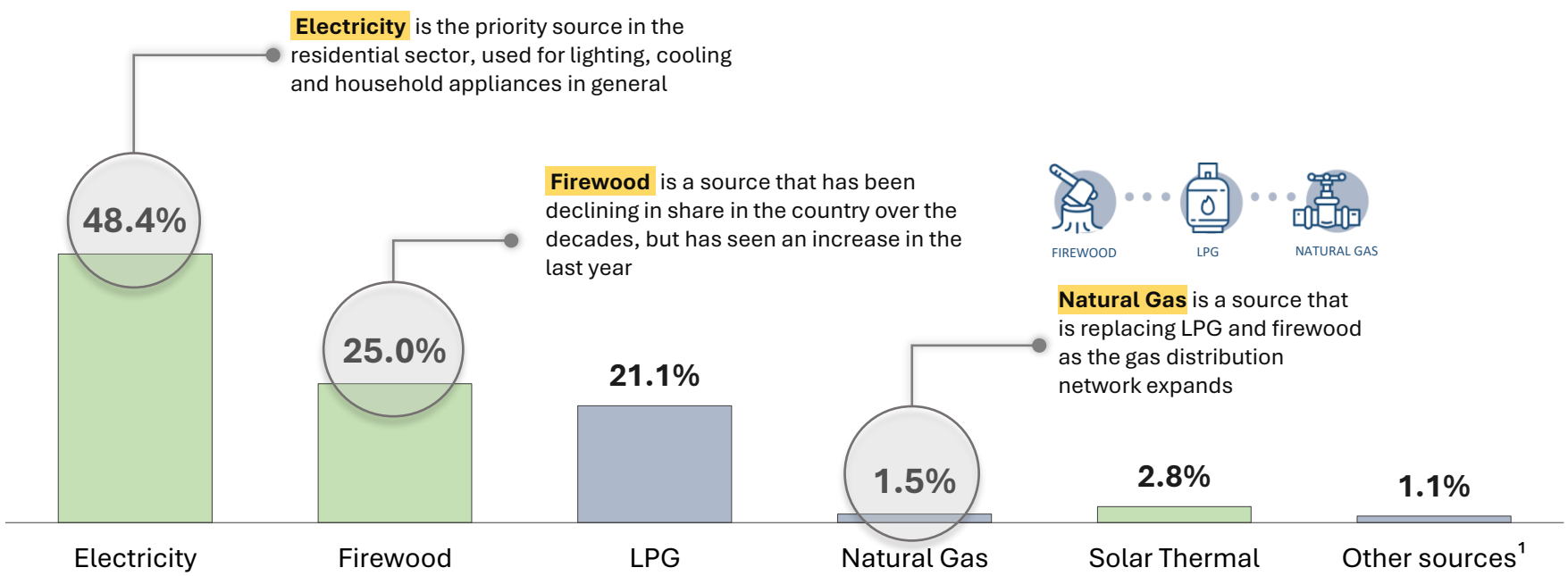
2022
29.0 Mtoe

4.1% increase

Electricity is the priority source in the residential sector, used for lighting, cooling and household appliances in general

Firewood is a source that has been declining in share in the country over the decades, but has seen an increase in the last year

Natural Gas is a source that is replacing LPG and firewood as the gas distribution network expands

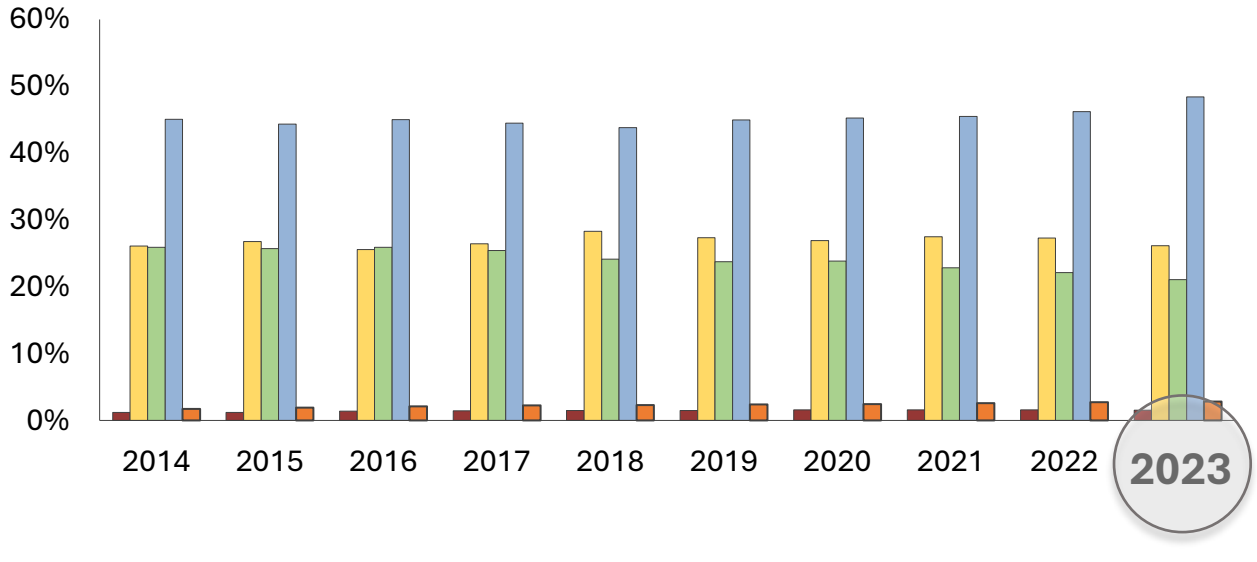


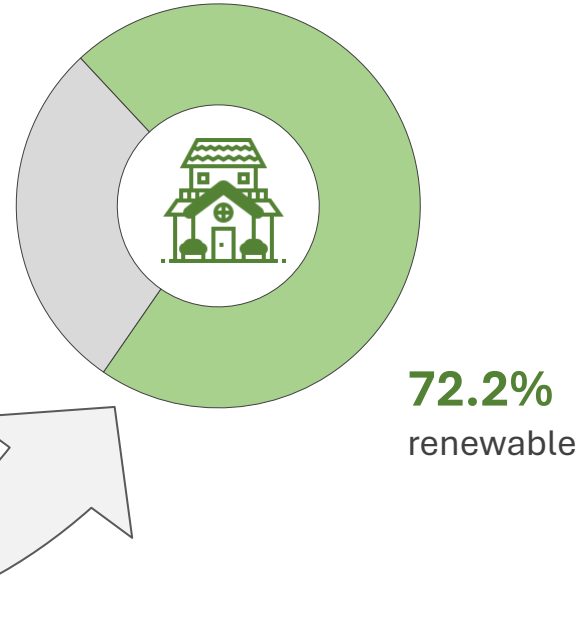
Residential consumption of **electricity, firewood, and solar thermal energy** showed **growth** compared to 2022 at respective rates **of 9.1%; 0.3%; and 7.0%**. LPG, on the other hand, showed a decline of 0.9% in residential consumption in 2023. The National Energy Balance, from 2022 onwards, incorporates the solar thermal source into its mix. It is observed that this source has a greater share than natural gas in the residential energy mix.

[1] Kerosene and charcoal.

Note: More details about energy consumption in the residential sector can be found in the Fact Sheet "Consumo Residencial por Classes de Renda", published by EPE and available HERE.

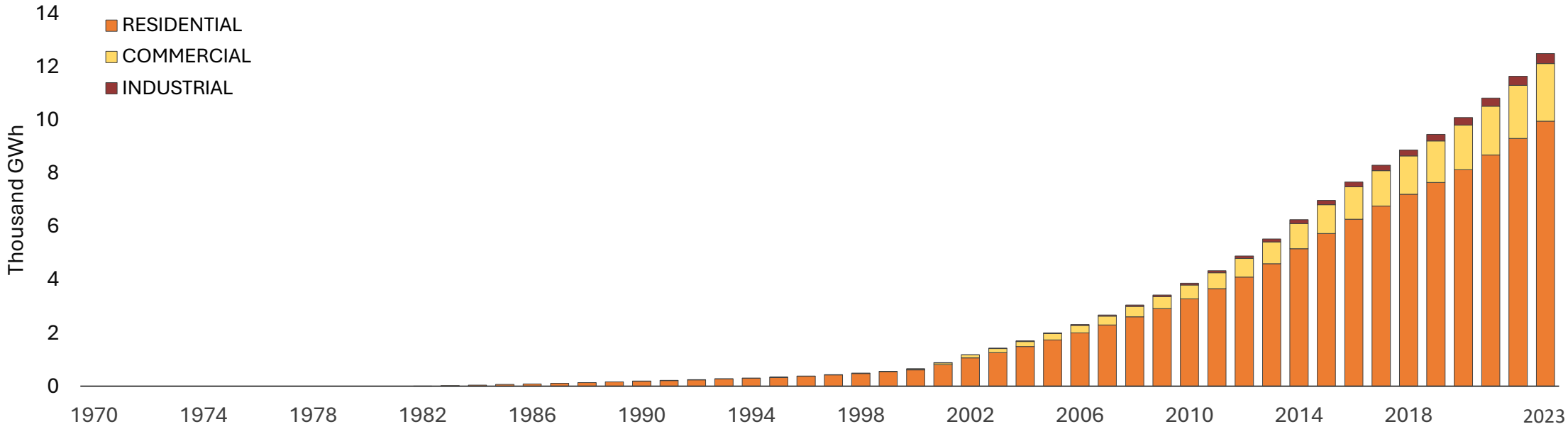
The distribution of **sources in the residential sector's energy mix** has been marked over the last ten years by the use of electricity, firewood and LPG, with a small but growing share of natural gas.





Most of Brazil's electricity comes from renewable sources. Therefore, the share of sources such as firewood and charcoal, which reached 26.1% in 2023, associated with the growing use of electricity (above 48%), allows the residential sector to present **a renewability rate of 72.2%. Attention: wood-burning stoves have an efficiency around one tenth of the efficiency of gas stoves.**

The **Solar Thermal** source, used for heating water in open, closed and vacuum tube collectors, reached 12,484 GWh equivalent[1] in 2023, the result of growth over the years with a greater contribution from consumption by the residential sector.



In 2023, the residential sector represented around 79.7% of solar thermal source consumption in Brazil. Secondly, the commercial sector was responsible for around 17.3% of consumption. Lastly, industry with less than 3%.

[1] The equivalent GWh value represents a theoretical equivalence of how much GWh would be needed to perform the same water heating service that solar thermal performs.

The use of **eletricity**

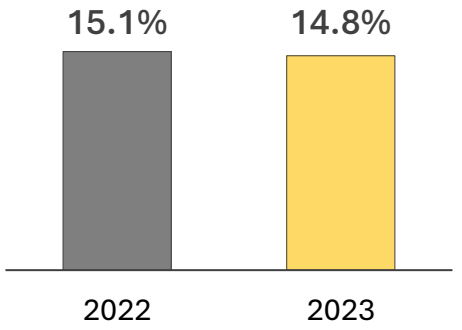
Electricity in Brazil has seen an increase in consumption and, consequently, an increase in the domestic supply made available to the population.

Values in TWh		2022	2023	Δ% 23/22
Total Electric Power Supply[1]	↑	690.1	723.2	4.8%
Power plants PS[2]	↑	551.6	565.8	2.6%
Power plants APE[3]	↑	125.6	142.3	13.3%
Electricity imports[4]	↑	12.9	15.1	17.0%
Final consumption[5]	↑	586.1	616.3	5.2%

↑ **4.8% increase** in the electricity made available to the society

↑ **5.2% increase** in final electricity consumption

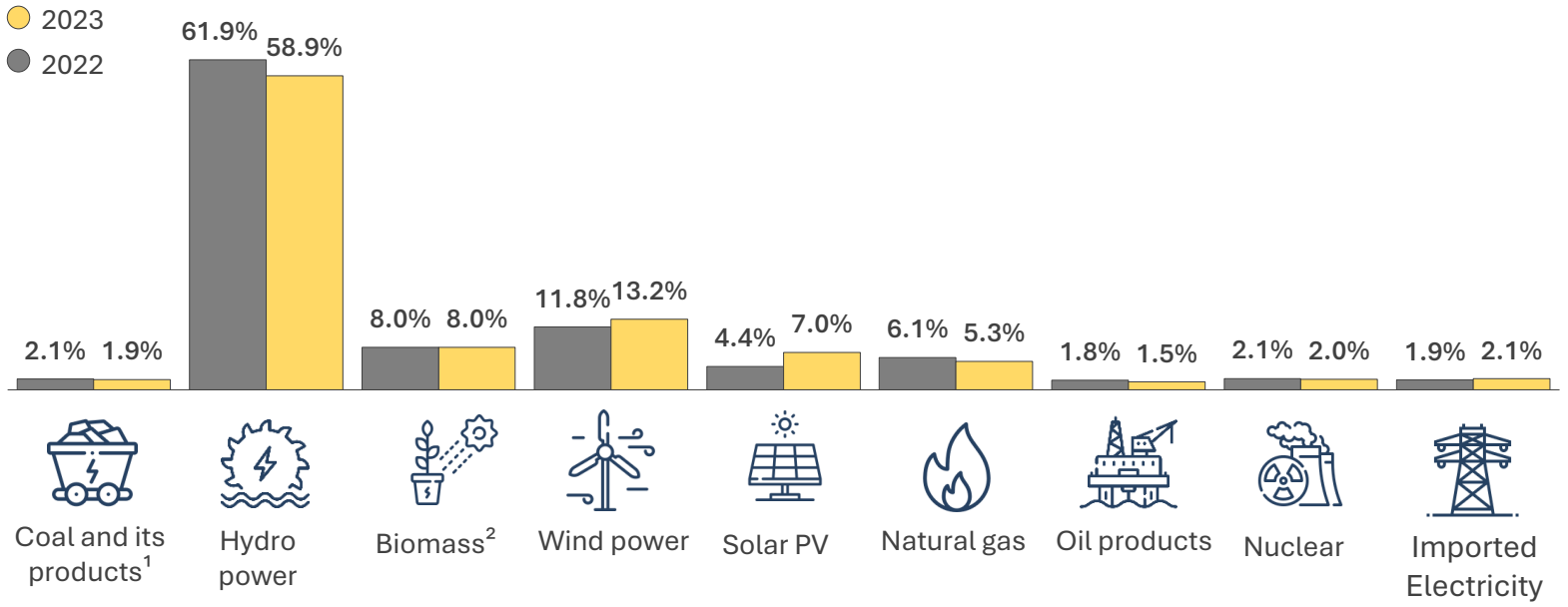
Losses in 2022 and in 2023



Losses (commercial + technical) fell by 0.3 percentage points compared to 2022.

[1] TEPS (import and Export balance) + Total national generation;
[2] Public Service; [3] Electricity self-generators; [4] Imports (-) Exports;
[5] Final electricity consumption: National Interconnected System + Isolated System + Self-production

The Brazilian electrical mix in 2023 showed changes due to the stability of the water regime associated with the increase in wind and solar supply.



2023 (TWh)

Total supply: 723.2

Hidro power supply: 441.1

2022 (TWh)

Total supply: 690.1

Hidro power supply : 440.0

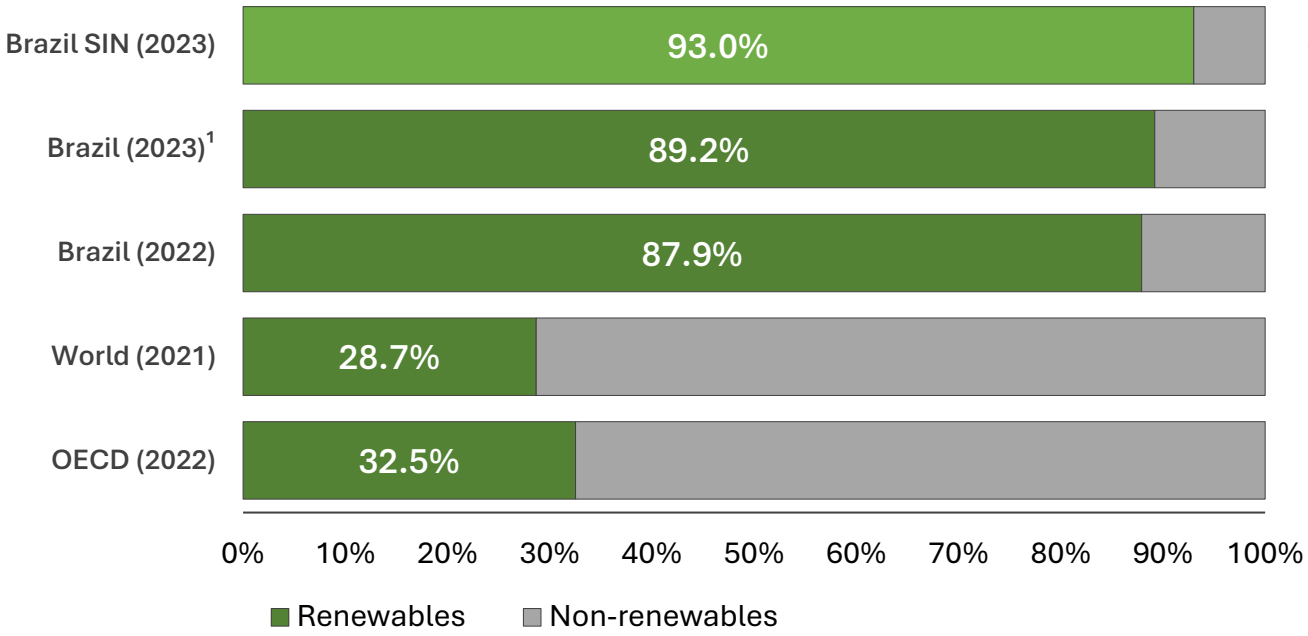
4.8% increase in the Total supply

0.2% increase in the Hydro power supply

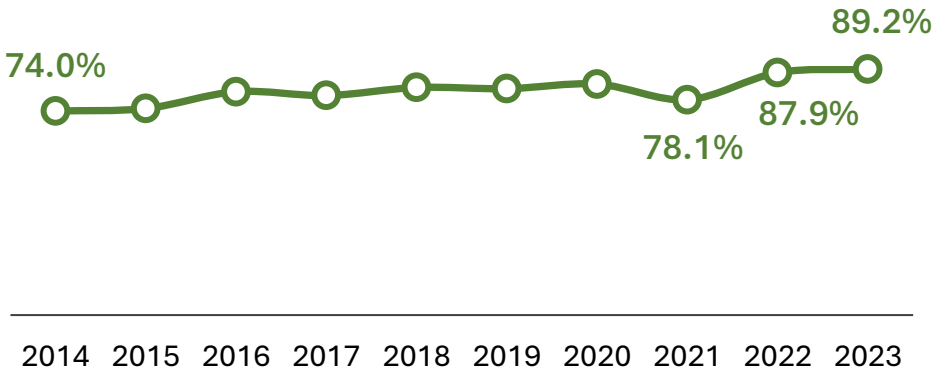
The main movements were the drop in supply from natural gas (-7.9%) and diesel oil (-24.6%), the maintenance in the supply of hydroelectricity and the increase in solar photovoltaic (+68.1%) and wind (+17.4%).

[1] Includes coke oven gas, blast furnace gas, steelmaking gas and tar
[2] Includes firewood, sugarcane bagasse, black liquor, biodiesel and other primary sources

The share of renewables in the Brazilian electricity mix (including the entire "National Interconnected System (SIN)", the "Isolated Systems" and "Self-production not injected into the grid") reached 89.2% renewability in 2023...



The renewability of the National Interconnected System (SIN) calculation excludes Isolated Systems, Electricity Imports, Self-production not injected into the grid and MMDG.

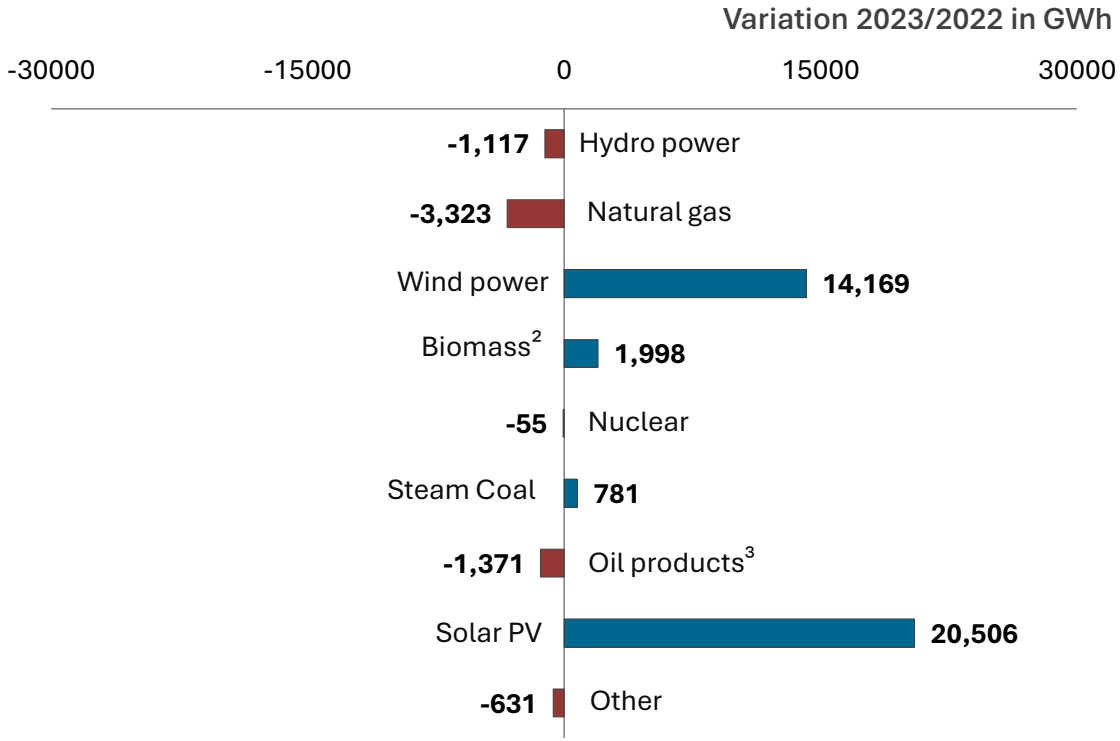


It is important to highlight that, considering only the National Interconnected System (SIN), which excludes Isolated Systems, Electricity Imports, Self-production not injected into the grid and MMDG, renewability was 93%. The positive variation in renewability, in 2023, occurred due to the maintenance of hydroelectric supply in the country, combined with the increase in wind and solar generation, and the drop in non-renewable thermoelectric generation.

[1] Renewability is calculated based on the Internal Electricity Supply, i.e. all domestic generation plus net imports, which includes the portion imported from Itaipu.

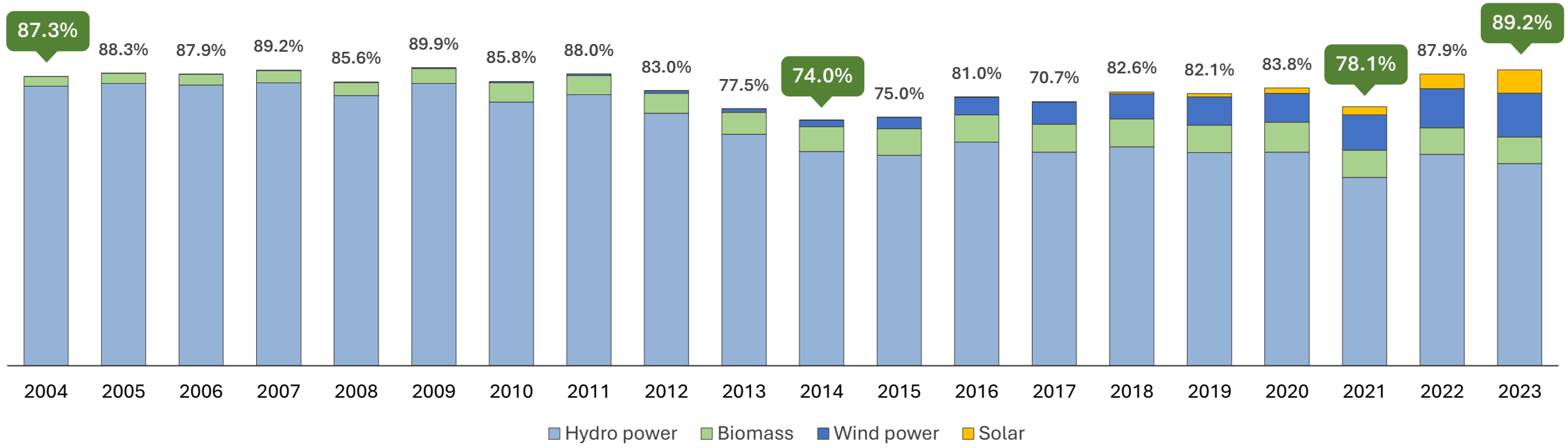
… and in fact, when analyzing **electricity generation[1] (GWh)** in 2023, it is possible to identify this combination of factors that have increased the renewability of the electricity mix.

Source	2022	2023	Δ% 23/22
Hidro power	427,114	425,996	-0.3%
Natural gas	41,911	38,589	-7.9%
Wind power	81,632	95,801	17.4%
Biomass[2]	52,212	54,210	3.8%
Nuclear	14,559	14,504	-0.4%
Steam Coal	7,988	8,770	9.8%
Oil products[3]	7,056	5,686	-19.4%
Solar PV	30,126	50,633	68.1%
Other[4]	14,563	13,932	-4.3%
Total generation	**677,162**	**708,119**	**4.6%**



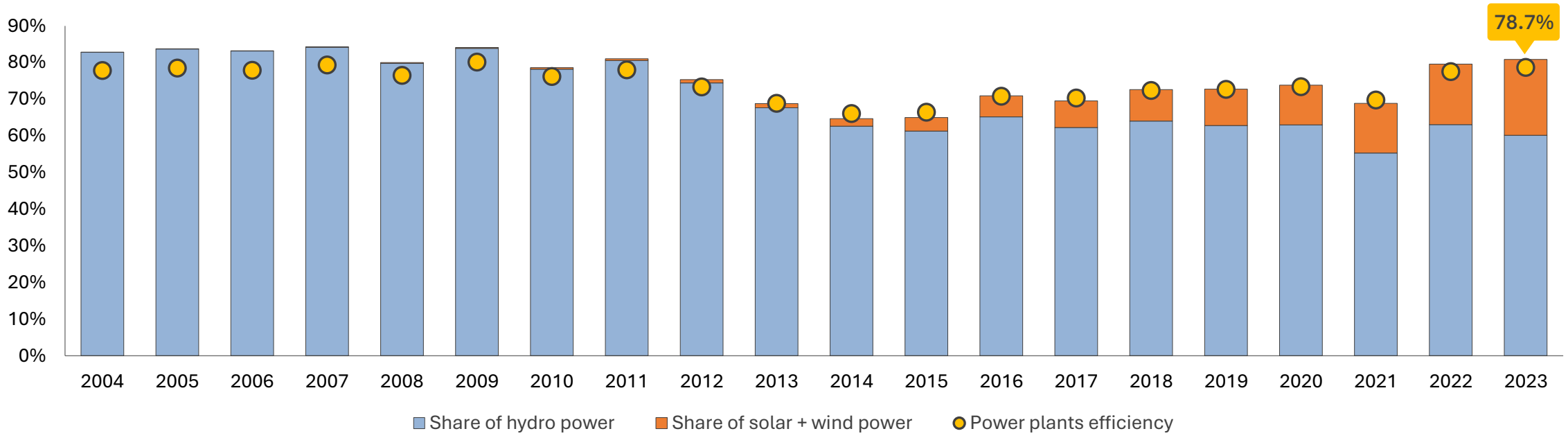
[1] Includes distributed generation
[2] Includes firewood, sugarcane bagasse, biodiesel and back liquor
[3] Includes diesel oil and fuel oil
[4] Includes other primary sources, coke plant and other secondary sources

Over the last 20 years, the share of renewable sources in the electrical mix has remained above 70%, a high level in relation to world values...



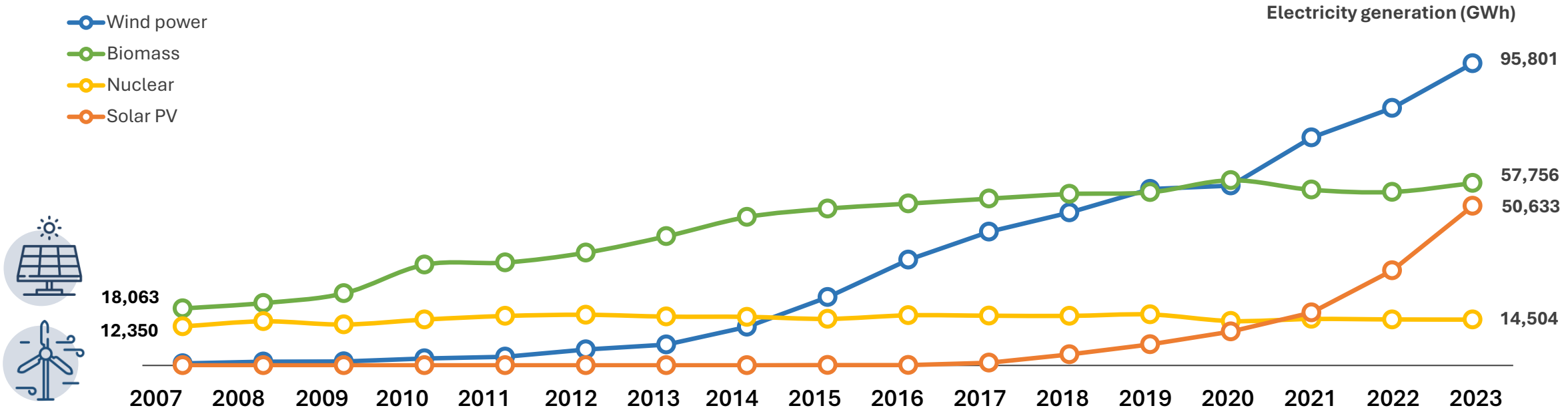
During this period, the increase in wind and solar photovoltaic generation helped maintain the renewability of the Internal Electricity Supply, even in periods of greater water stress in the country. Policies to encourage electricity generation from renewable sources contributed to the diversification of the electrical matrix, demonstrating the country's effort in the **energy transition** process aimed at reducing emissions and energy security.

In addition to the high rate of renewability, **the Brazilian electrical mix has also proven to be highly efficient over the last 20 years**, maintaining the efficiency of power plants above 65% in the period due to the large share of sources such as hydraulic, wind and solar, reaching **78.7% in 2023.**



Primary sources such as hydraulic, wind and solar, by convention, are fully converted into electricity in power plants and, therefore, do not present generation losses. The lowest efficiency rates occurred in 2014 and 2015, when hydraulic participation reached its lowest values. **In the following years, this movement began to be compensated by wind and solar, enabling higher levels of efficiency, even in periods of water stress..**

In 2023, wind generation increased by around 14 TWh, while solar photovoltaic generation increased by more than 20 TWh.



Wind generation grew by 17.4% compared to 2022, consolidating leadership among the four sources. However, the biggest evolution occurred in the Solar Photovoltaic source, with 68.1% growth compared to 2022, approaching biomass generation.

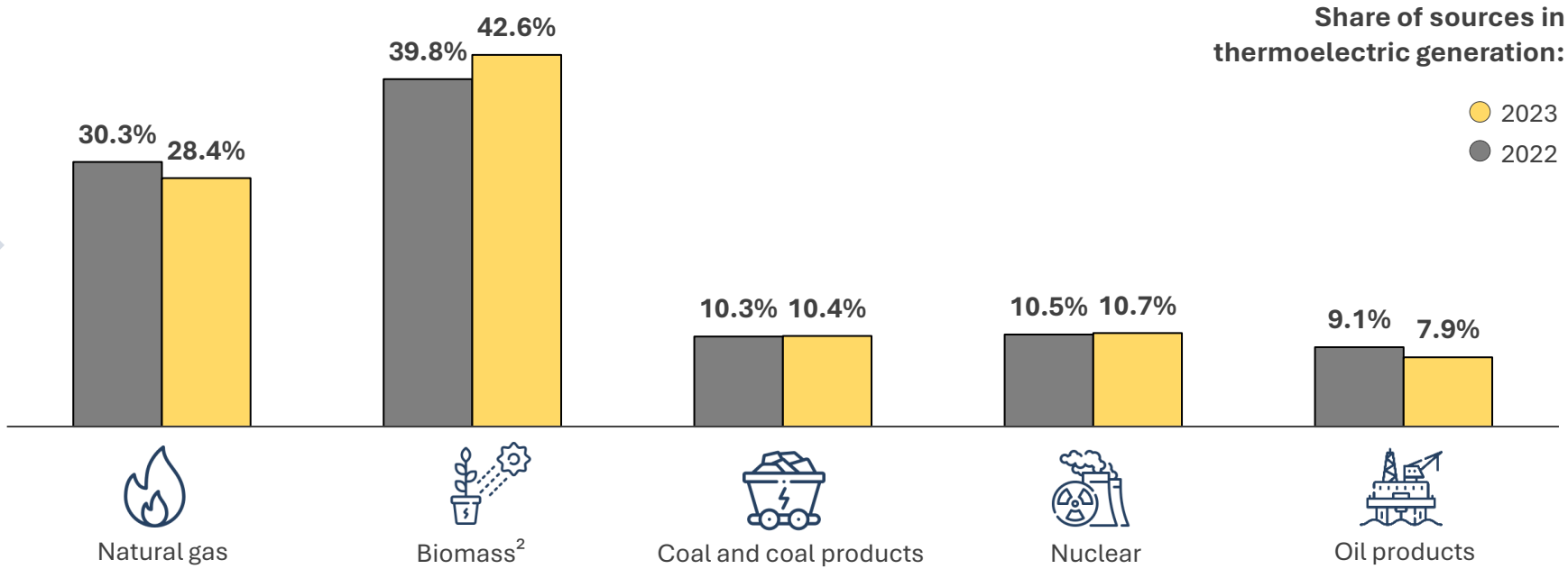
In 2023, there was a 1.9% reduction in **thermoelectric generation**. As a result, its **share** of total electricity generation[1] reduced from 20.4% in 2022 to 19.2% in 2023.

Share of thermal plants in total generation:

2023
19.2%

2022
20.4%

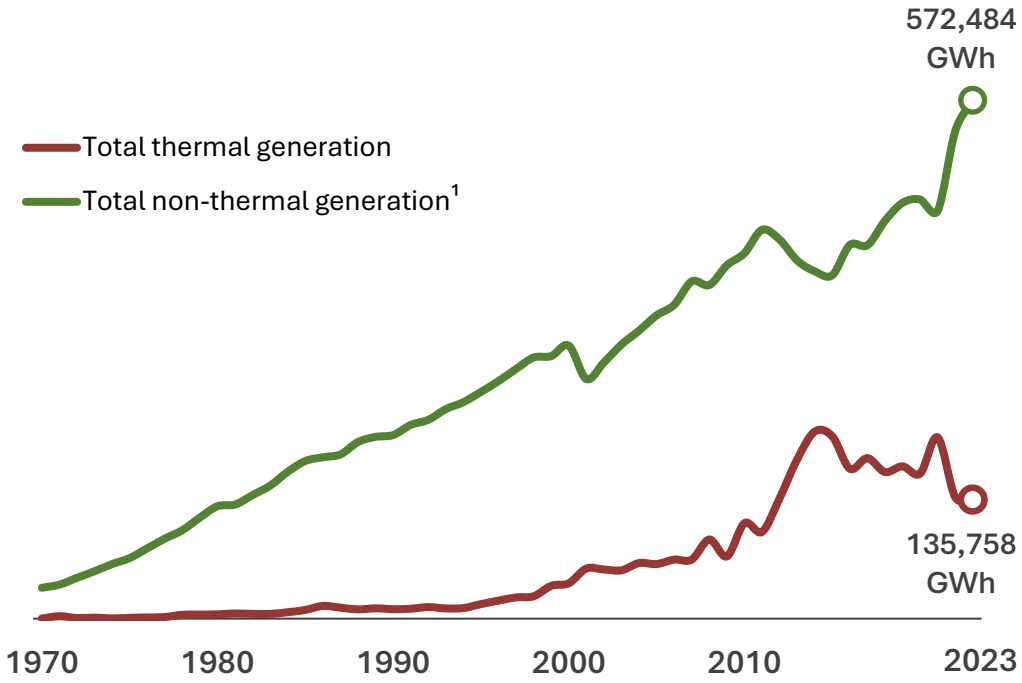
1.9% decrease
in thermal generation

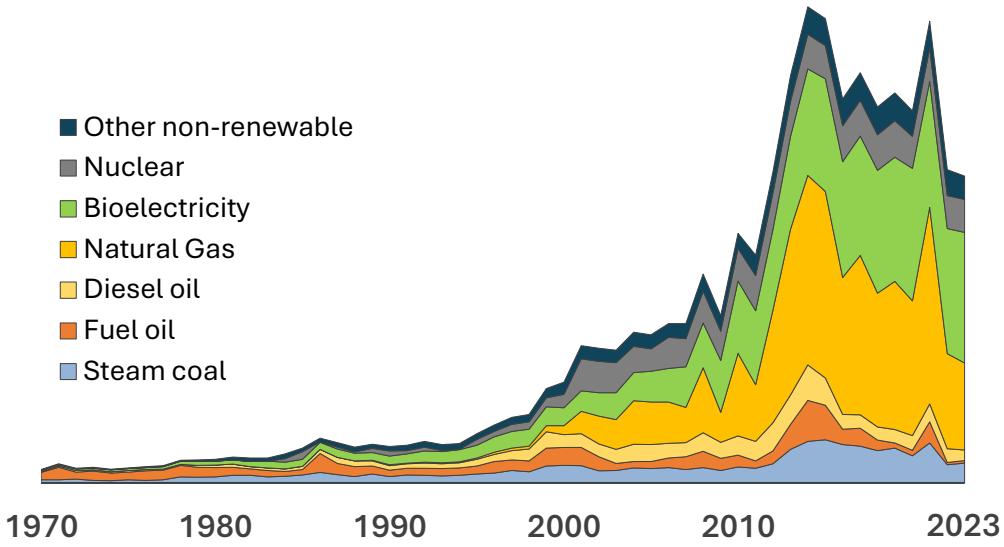


The year 2023 was marked by the reduction in thermoelectric generation, with emphasis on the reduction in the use of natural gas (-7.9%) and petroleum derivatives (-14.4%), accompanied by a small reduction in nuclear generation (-0.4%).

[1] Does not include imports (hydro) in total electric power generation
[2] Includes firewood, sugarcane bagasse, black liquor, firewood and other primary sources

Thermal generation was responsible for 135.7 TWh generated in 2023, a share of around 19% of total electricity generation.

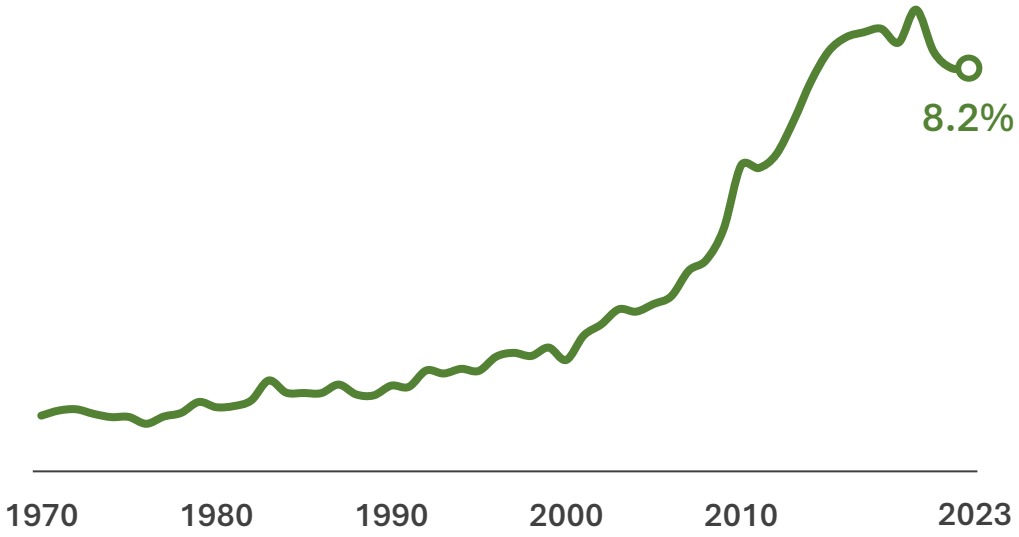


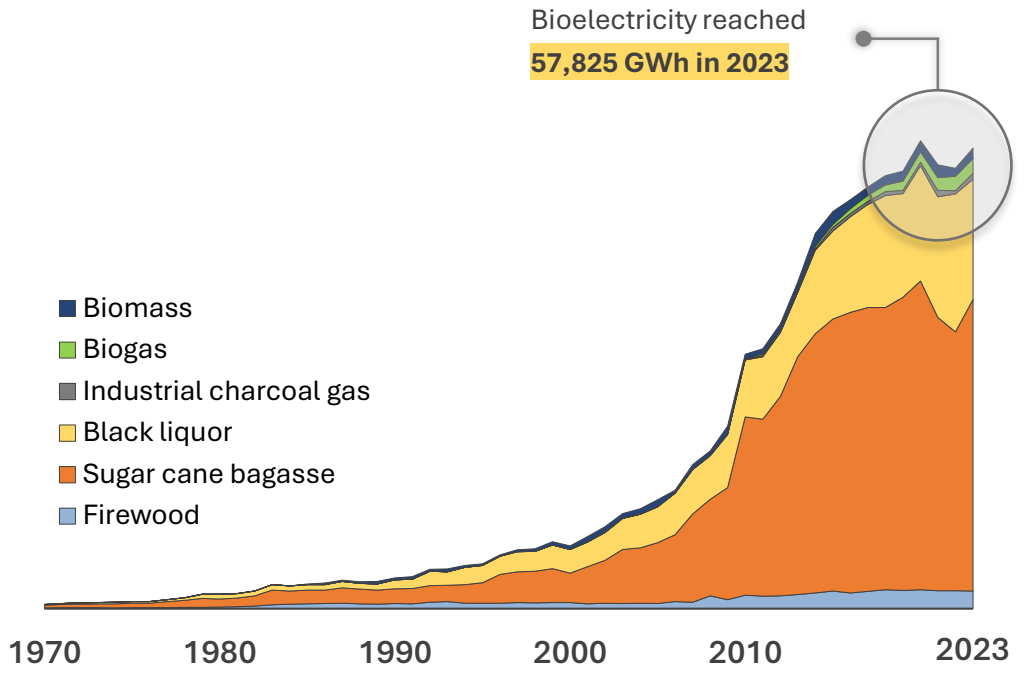


Among the thermal sources that stand out, **are the use of natural gas (28.4%) and bioelectricity (42.6%) in 2023.**

[1] Hydro, Wind and Solar PV

Bioelectricity, mainly composed of Sugarcane bagasse (63.3%) and Black liquor (26.1%) in 2023, maintained an 8.2% share in electricity generation.





Bioelectricity generation peaked in 2020, when it reached 58,742 GWh, but remained at high levels of 57,825 GWh in 2023.

[1] Does not include imports (hydro) in total electricity generation
[2] Includes sugarcane bagasse, bleach, firewood, and other primary sources

Highlight: electrical generation in Isolated Systems

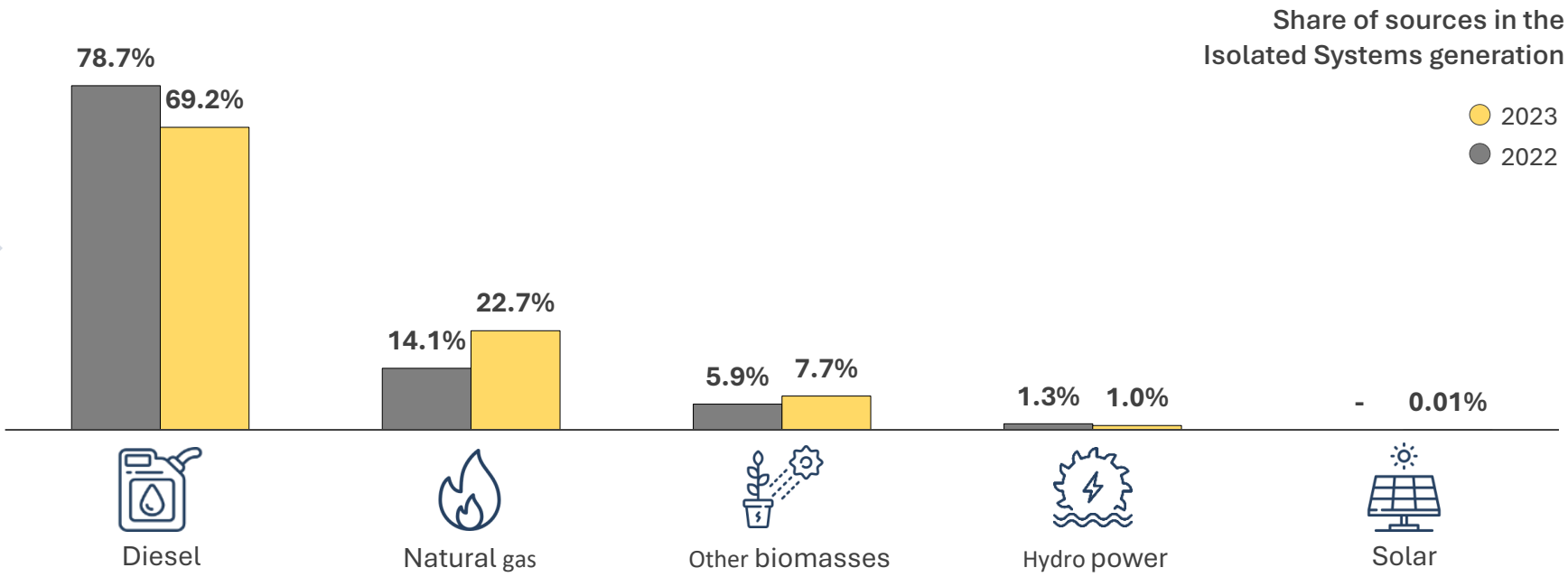
Electricity generation in Isolated Systems was 4,030 GWh in 2023 compared to 4,011 GWh in 2022, an increase of around 0.5%. The majority of electrical generation comes from diesel oil and natural gas. However, isolated systems represent only 0.6% of Brazil's total electricity generation.

Generation in Isolated Systems (GWh):

2023
4,030 GWh

2022
4,011 GWh

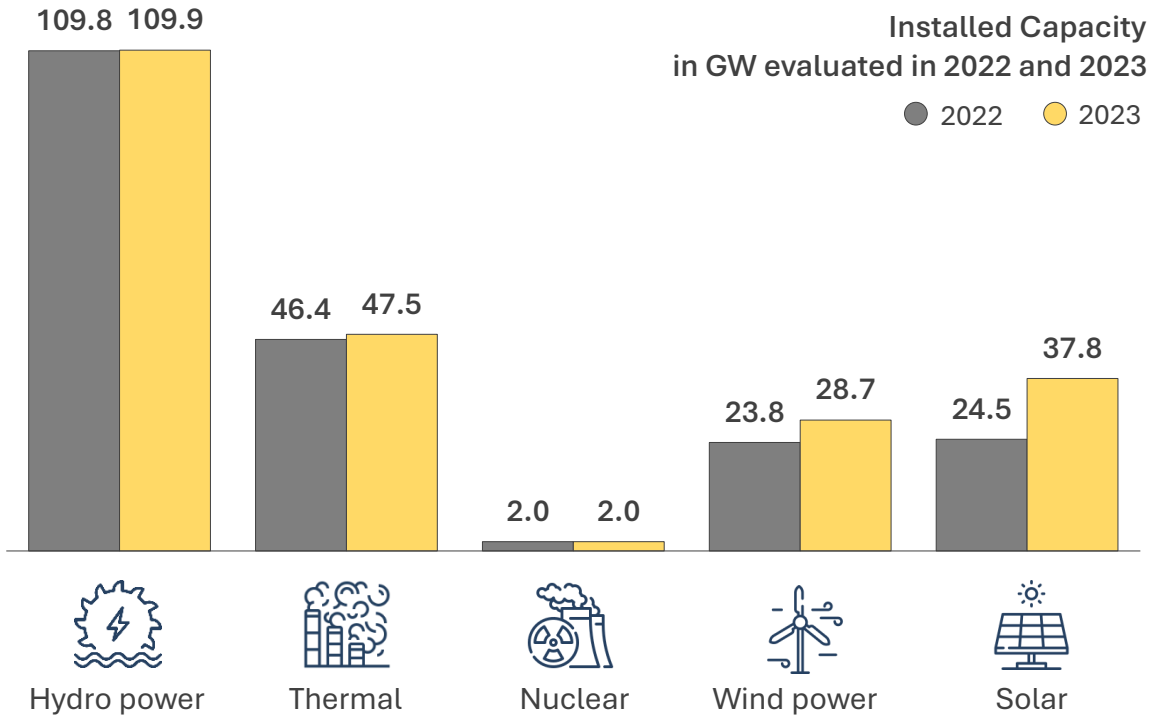
0.48% increase



Most of these systems are found in the North region, with 2 of them in Mato Grosso, in addition to Fernando de Noronha Island. Isolated Systems range from small communities to larger cities, such as Boa Vista, in Roraima, which is the only Brazilian capital not yet interconnected.

More information about Isolated Systems can be found in the Fact Sheet: "Sistemas Isolados de Energia no Brasil", clicking HERE

Installed Capacity (GW)[1] in 2023 increased by 9.4% compared to 2022, with highlights for wind and solar.



Variation in installed capacity per source (MW)

Source	2022	2023	Δ%23/22
Hydro power	109,807	109,922	0.1%
Thermal[2]	46,440	47,515	2.3%
Nuclear	1,990	1,990	0.0%
Wind power	23,761	28,682	20.7%
Solar	24,453	37,843	54.8%
Available capacity	206,451	225,952	9.4%

[1] Includes micro and mini distributed generation
[2] Includes biomass, gas, oil and coal

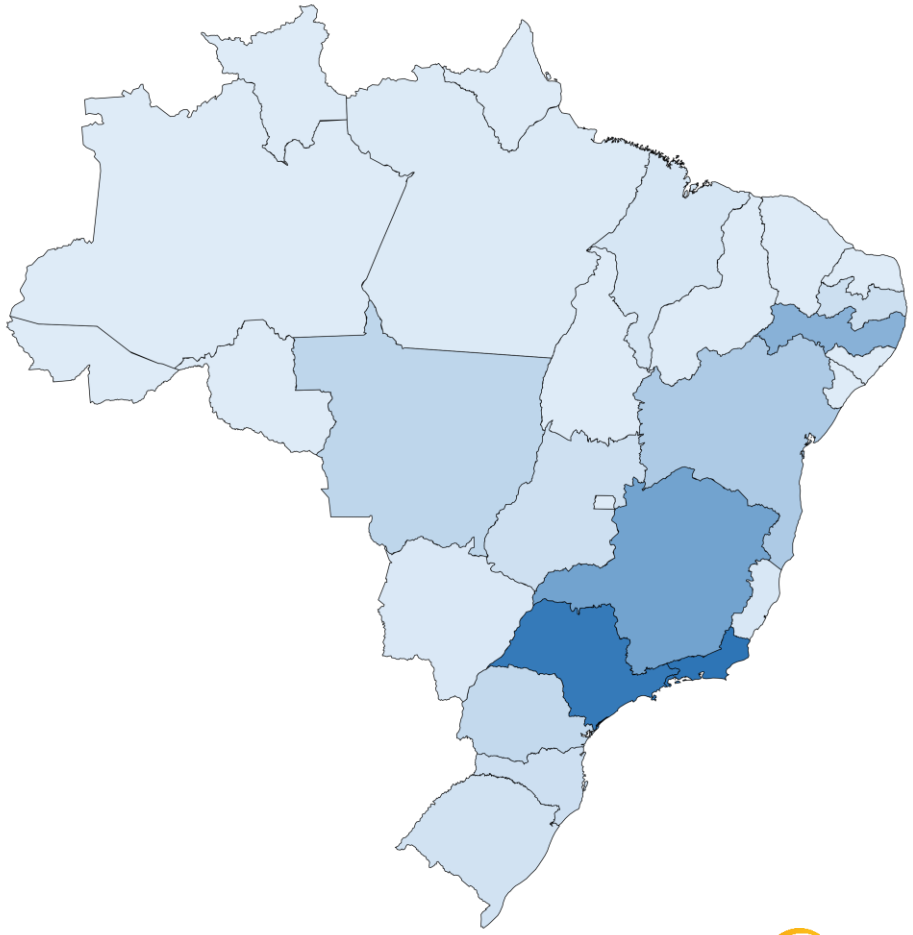
The Installed Capacity of Biogas generation by state (MW) is more concentrated in the regions with greater potential for organic matter production, agricultural, urban, industrial, and forestry waste.

Did you know?

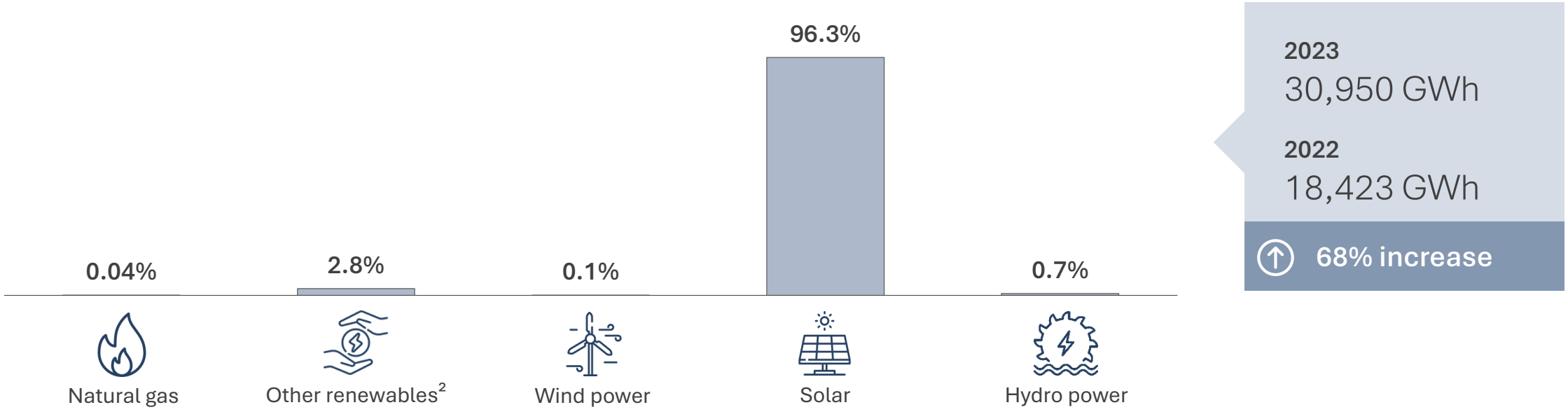
Biogas is an energy source produced by bacteria active in the decomposition of organic matter, agricultural, urban, industrial and forest residues, among others.

Present in the Brazilian energy mix, it is a renewable biofuel and has a good calorific value and can be used for electricity generation.

The map on the side shows the installed capacity for generating electricity from biogas in the states of Brazil.



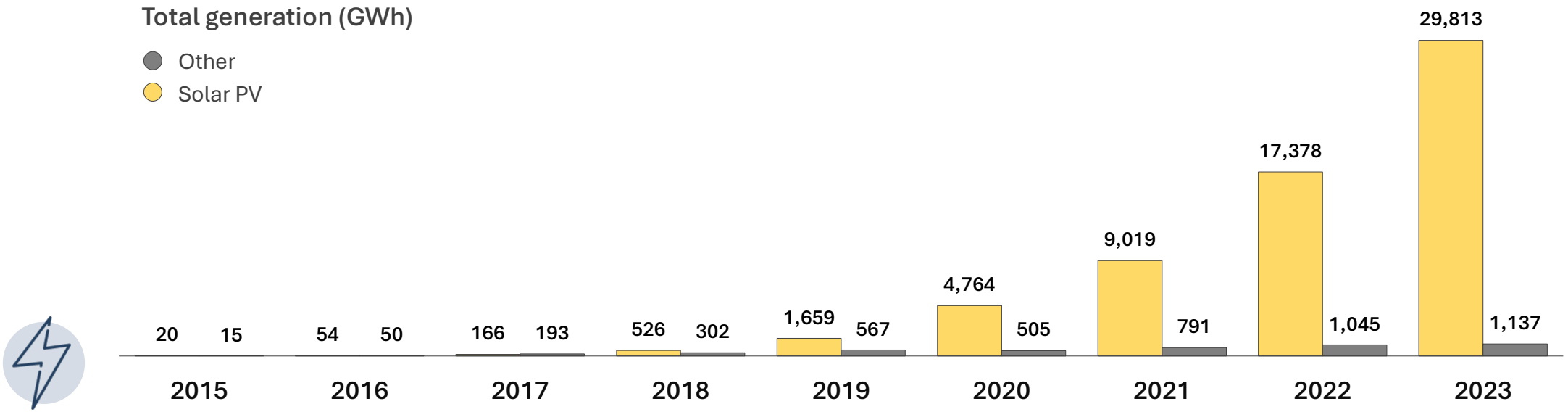
Micro and Mini Distributed Generation (MMDG)[1] in 2023 showed na increase of almost 68% compared to 2022, mantaining the following configuration of the participation of sources in energy generation:



Solar photovoltaic energy represented 96.3% of MMDG in 2023, once again being the main **source responsible for the increase recorded in micro and mini distributed generation in the country.**

[1] ANEEL Normative Resolution Nº. 482/2012;
[2] Includes biogas from agricultural and urban waste, rice hulls, blast furnace gas (biomass) and forest waste.

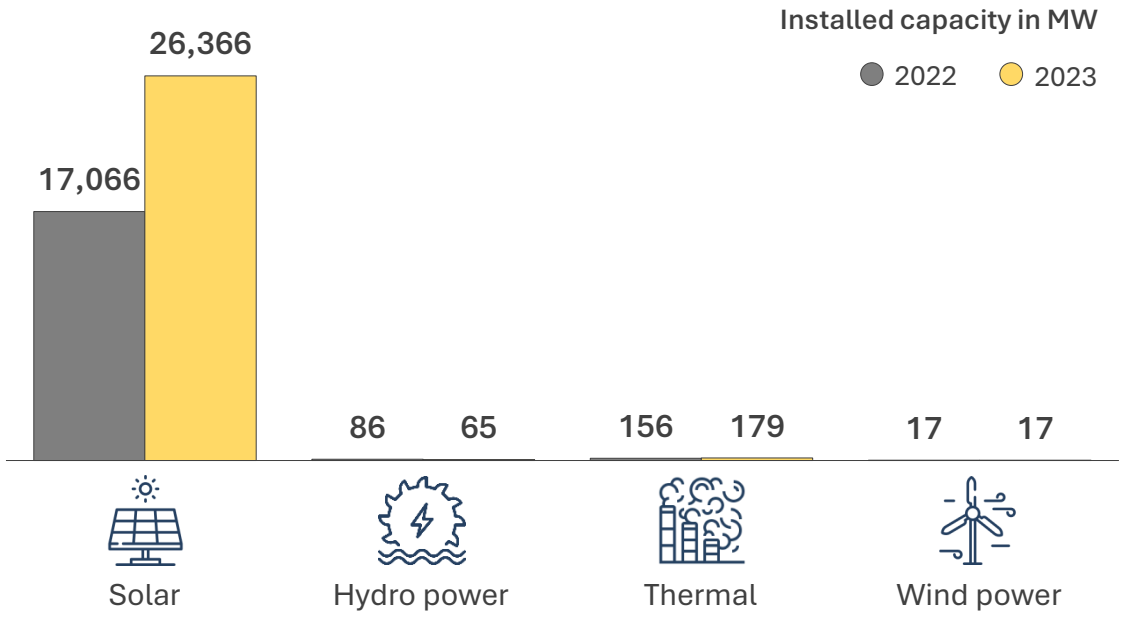
This fact has been built up over time, note that the evolution of **MMDG**[1] indicates the continuous growth trajectory of **solar PV generation** at a higher rate than other sources...

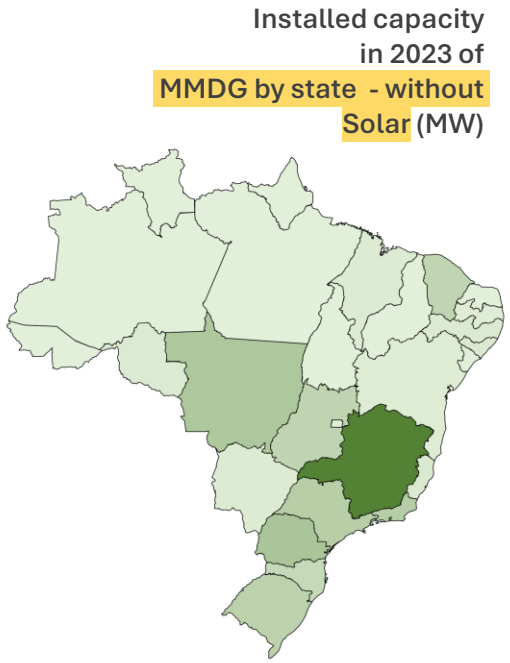


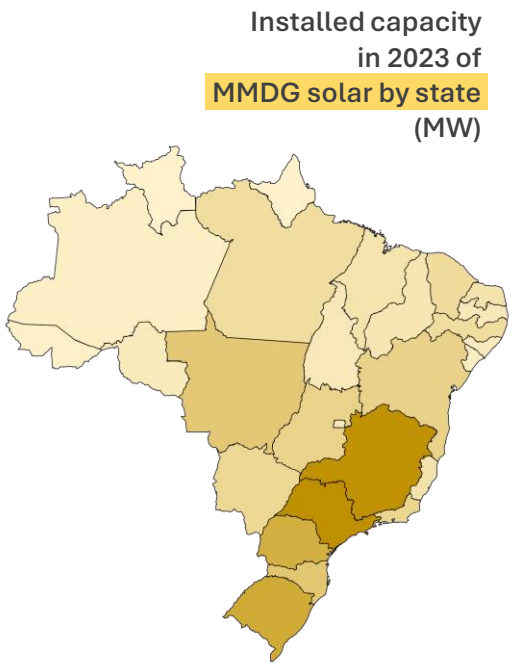
Micro and mini distributed generation in Brazil based on solar photovoltaic generation reached **26,366 MW** of installed capacity and **29,813 GWh** of generation in 2023.

[1] ANEEL Normative Resolution Nº. 482/2012

The additional installed capacity for MMDG[1] was concentrated in the center and south of Brazil, influenced by the expansion of the solar source in federal units such as Minas Gerais, São Paulo, Santa Catarina, Rio Grande do Sul, and Mato Grosso.







The majority share of installed capacity through solar panels is what defines the pace of expansion of the MMDG segment in Brazil

[1] ANEEL Normative Resolution N°. 482/2012

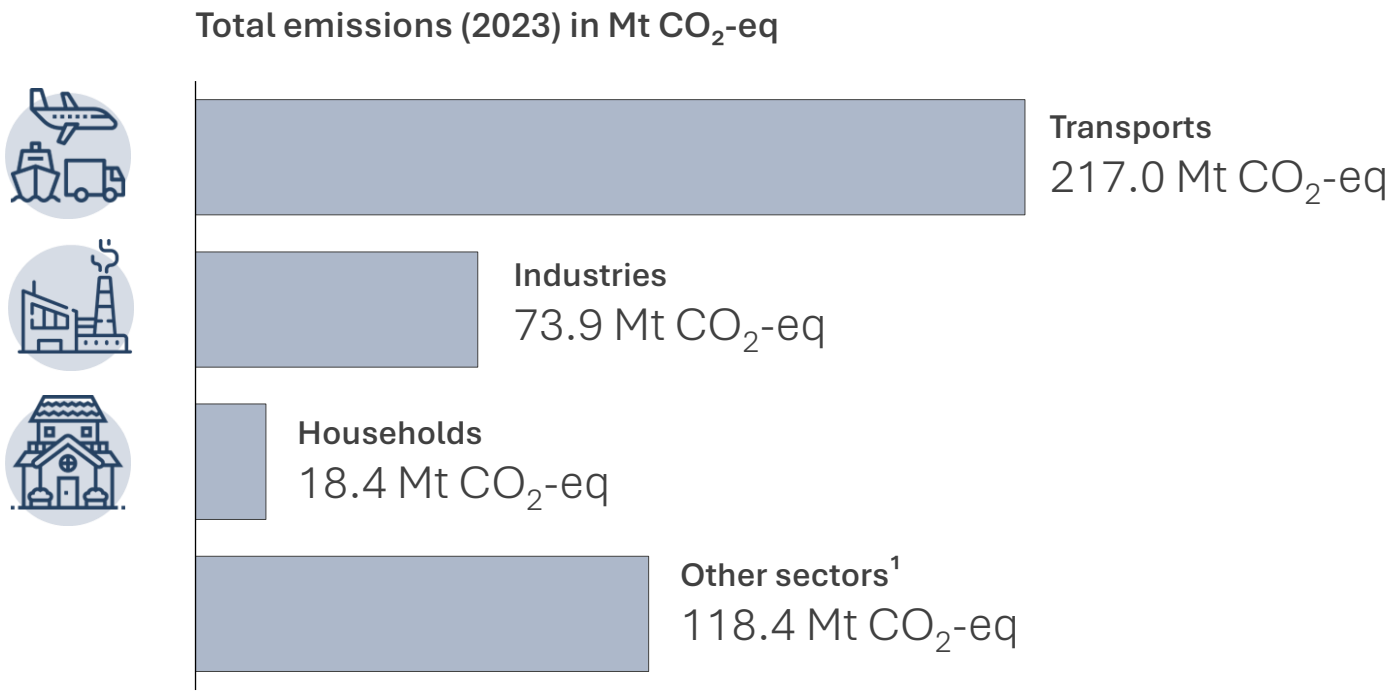
Emissions in Energy Production and Use

In 2023, the total anthropogenic **CO_2 emissions** associated with the Brazilian **energy mix** reached 427.8 million tons of CO_2 equivalent, an increase of 0.8% compared to 2022.

2023
427.8 Mt CO_2-eq

2022
424.3 Mt CO_2-eq

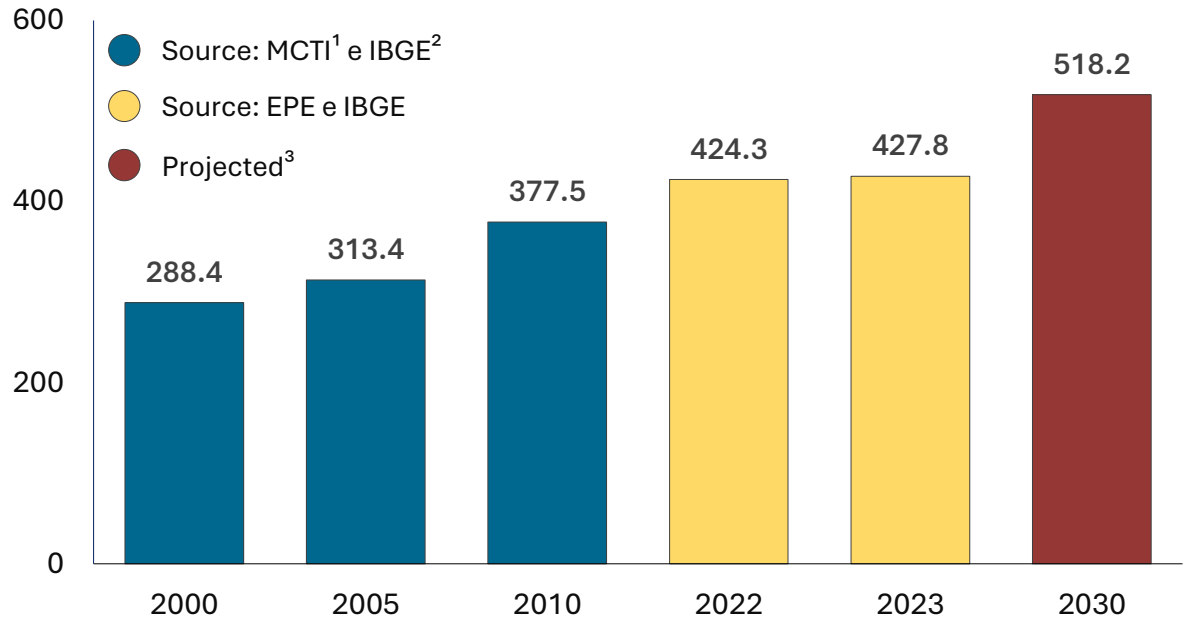
0.8% increase



[1] Includes the agricultural, services, energy, electric and fugitive emissions sectors

Evolution of total CO_2 emissions associated with the energy mix

Total emissions growth ($MtCO_2$-eq)		
Indicator	Performed	Projected
	2000 a 2023	2023 a 2030
Average annual growth rate	1.73%	2.77%

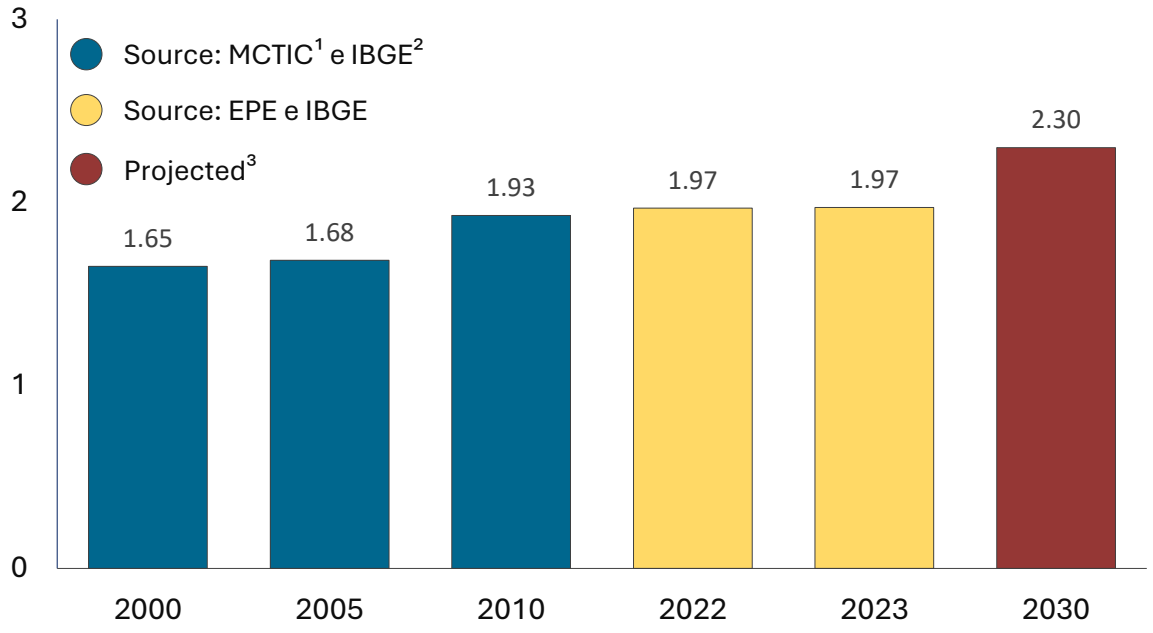


It is noted that the **increase in emissions in 2023 (+0.8%) was lower than the increase in Internal Energy Supply (+3.6%)**. This was justified by the favorable water regime and the greater share of biomass, wind and solar photovoltaics in the IES.

[1] Ministry of Science, Technology and Innovation
[2] Brazilian Institute of Geography and Statistics
[3] Ten-year Plan 2031 (PDE 2031).

Evolution of per capita CO_2 emissions associated with the energy mix

Emissions per capita growth – t CO_2-eq/inhabitant		
Indicator	Performed	Projected
	2000 a 2023	2023 a 2030
Average annual growth rate	0.77%	2.22%



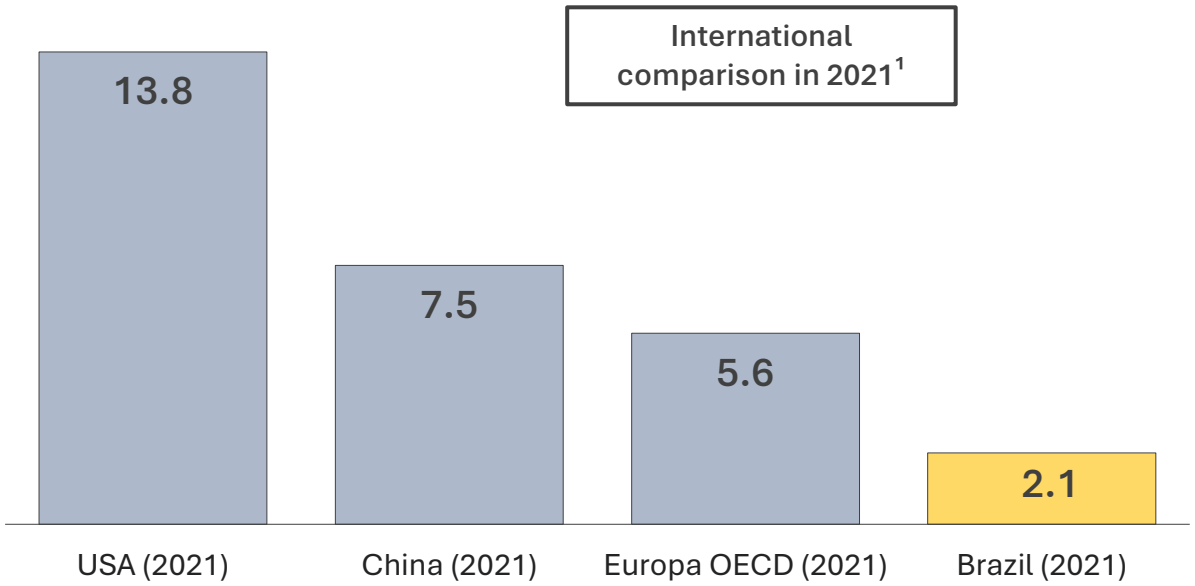
Maintenance **of per capita CO_2 emissions associated with the Brazilian energy mix**, reflecting the good performance of renewable sources in 2023.

[1] Ministry of Science, Technology and Innovation
[2] Brazilian Institute of Geography and Statistics
[3] Ten-year Plan 2031 (PDE 2031).

CO_2 emissions per capita

CO_2 emissions per capita (2021) em t CO_2/inhab

Source: International Energy Agency. Prepared by EPE



Brazil in 2023

Brazilian emissions per capita

2.0 t CO_2-eq/inhab.

Source: EPE

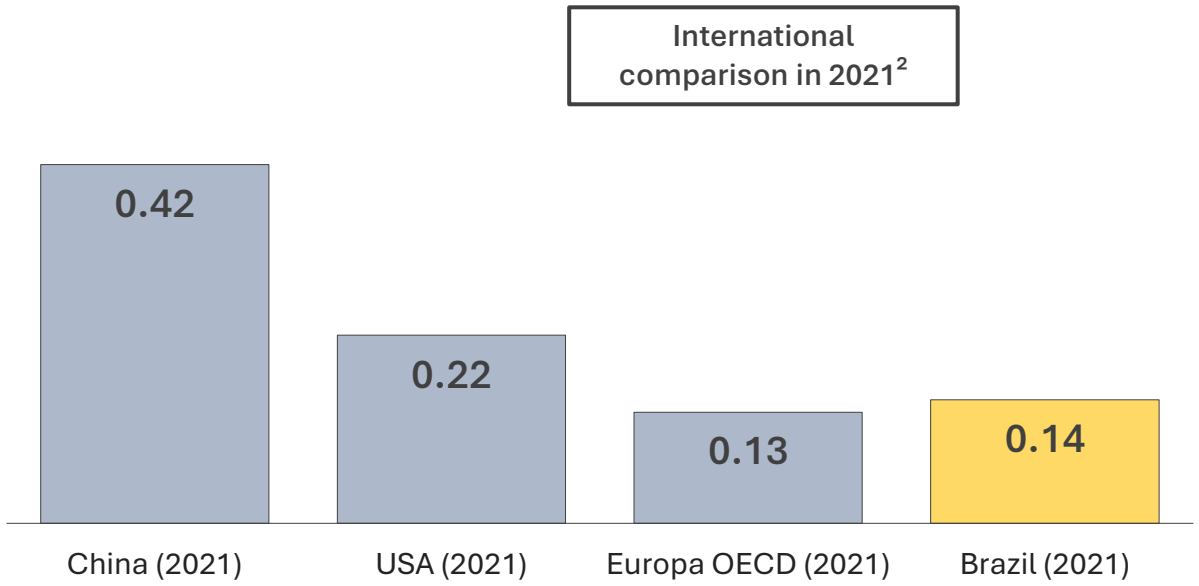
On average, in energy production and consumption, **each Brazilian emits the equivalent of 14.5% of what a US citizen emits, 36% of what an OECD European citizen emits and 26.2% of what a Chinese citizen emits**.

[1] Data in 2021 for international comparison due to the availability of data from the International Energy Agency for the USA, China and Europe OECD.

Carbon intensity in the economy

[1] **Carbon intensity (2021) in kg CO_2/US$$_{ppc\ [2015]}$**

Source: International Energy Agency. Prepared by EPE



Brazil in 2023

Carbon intensity in the Brazilian economy

0.13 kg CO_2-eq/US$$_{ppc\ [2015]}$

Source: EPE

To generate a unit of product, **the Brazilian economy emits**, in energy production and consumption, the equivalent of **34% of the Chinese economy, 66% of the US economy and practically the same level as the economy of the European OECD countries**.

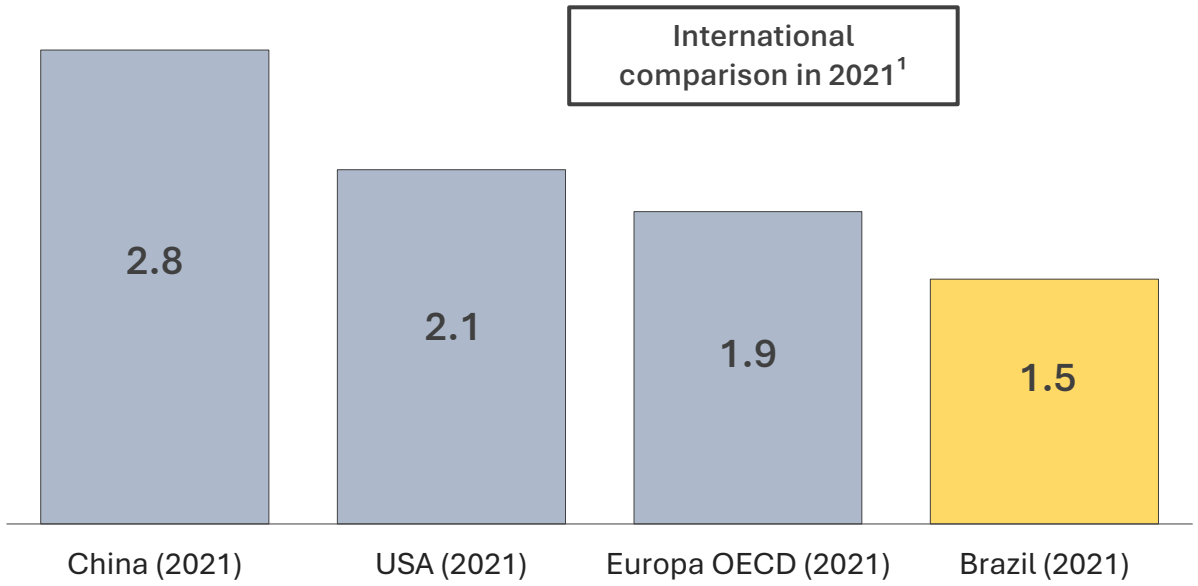
[1] US$$_{ppp\ [2015]}$ refers to the value in constant 2015 dollars in purchasing power parity

[2] Data in 2021 for international comparison due to the availability of data from the International Energy Agency for the USA, China and OECD Europe.

Emissions per unit of Total Energy Supply

CO_2 emissions (t) per toe (2021)

Source: International Energy Agency. Prepared by EPE



Brazil in 2023

Emissions associated with total energy supply

1.4 t CO_2-eq/toe

Source: EPE

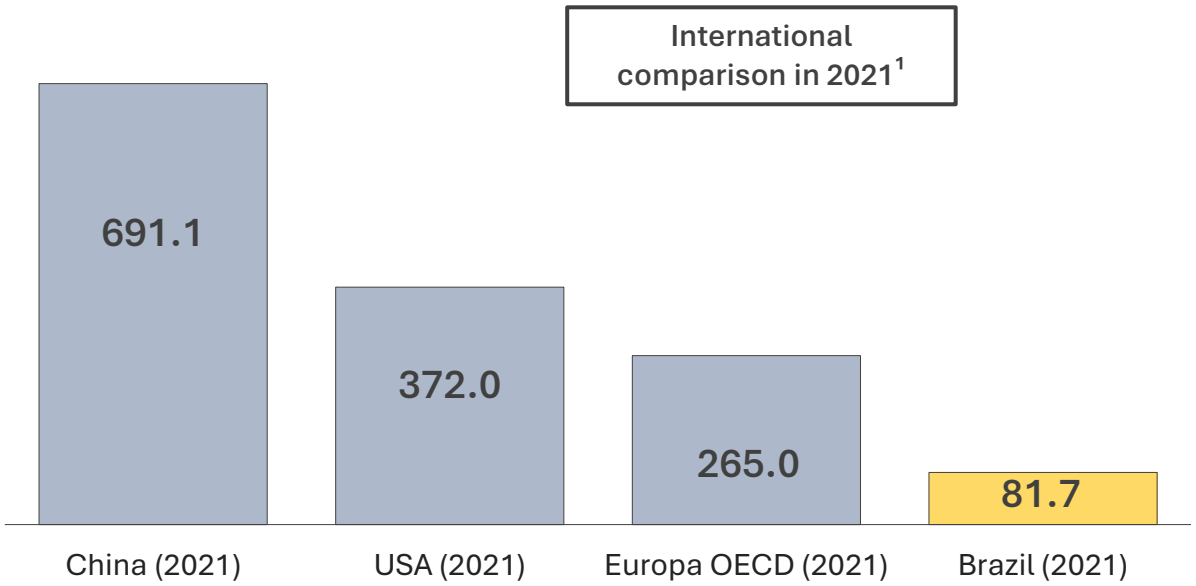
For each ton of oil equivalent (toe) made available, Brazil emits the equivalent of **78% of what European OECD countries emit, 69% of what the United States (US) emits and 52% of what China emits**.

[1] Data in 2021 for international comparison due to the availability of data from the International Energy Agency for the USA, China and OECD Europe.

Emissions in electricity production

CO_2 emissions (kg) per MWh (2021)

Source: International Energy Agency. Prepared by EPE



Brazil in 2023

Carbon emissions in Brazilian power generation

55.1 kg CO_2-eq/MWh

Source: EPE

To produce 1 MWh, the Brazilian electricity sector emits around **31% of the amount emitted by European OECD countries, 22% of what is emitted by the American electricity sector and 12% of what is emitted by the Chinese electricity sector**.

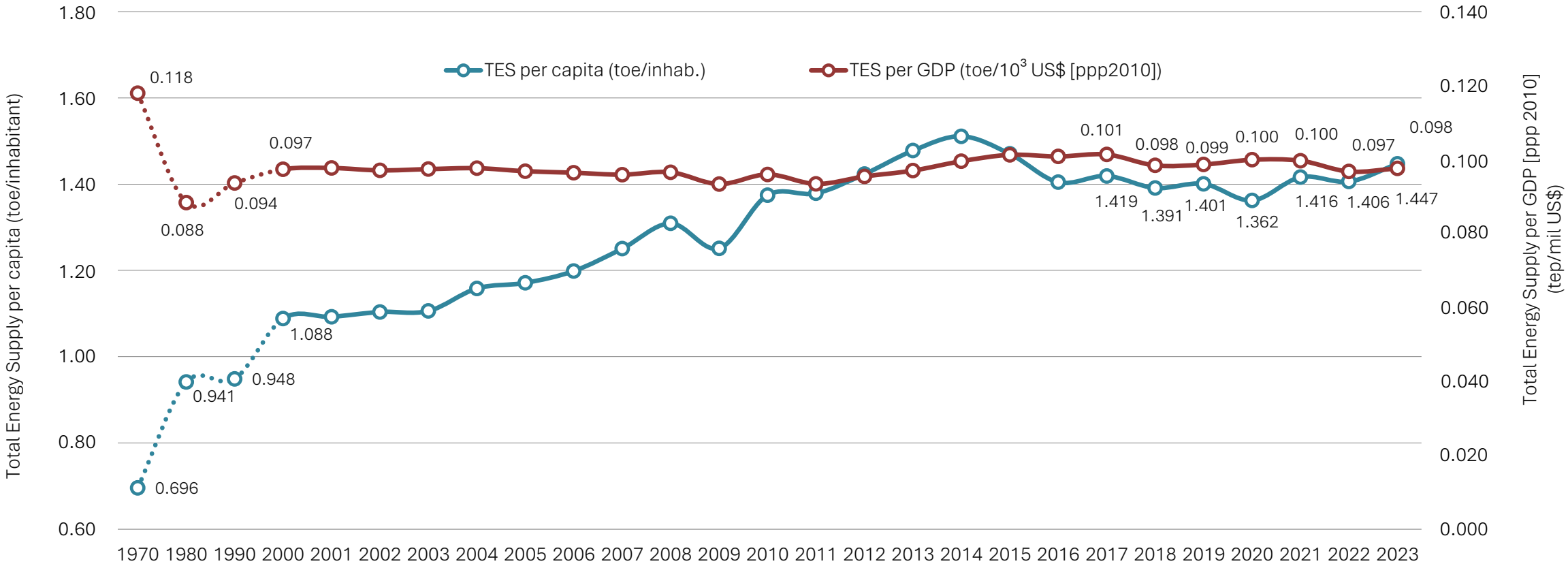
[1] Data in 2021 for international comparison due to the availability of data from the International Energy Agency for the USA, China and OECD Europe.

Annexes

Evolution of indicators: energy

Total Energy Supply per capita vs. Total Energy Supply per GDP

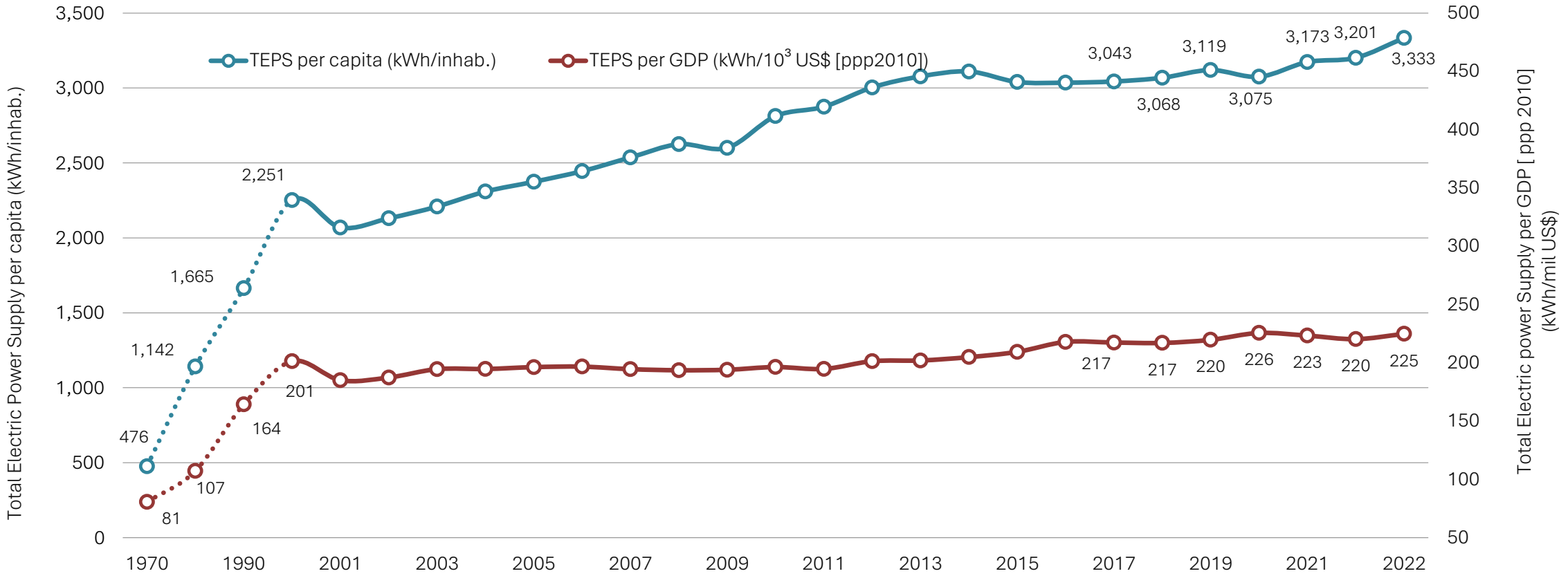
Source: EPE



Evolution of indicators: electricity

Total Electric Power Supply per capita vs. Total Electric Power Supply per GDP

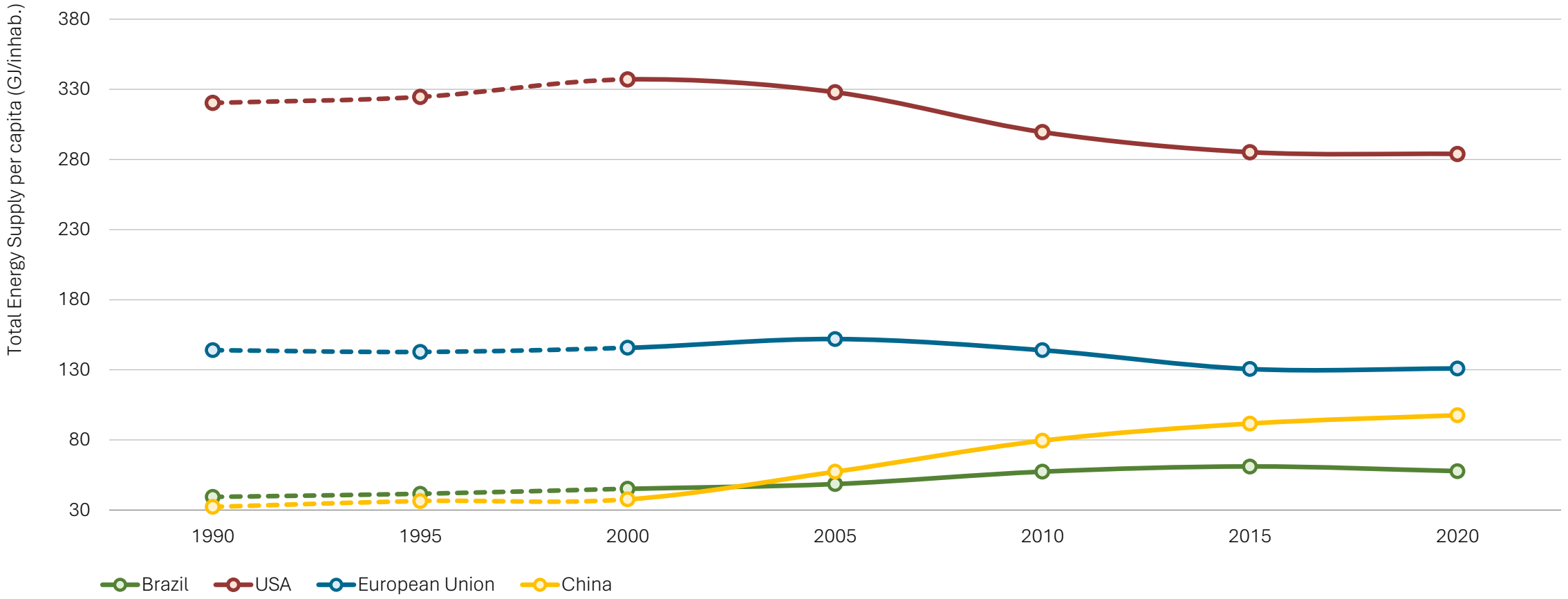
Source: EPE



Evolution of indicators: Brazil and the World

Total Energy Supply per capita

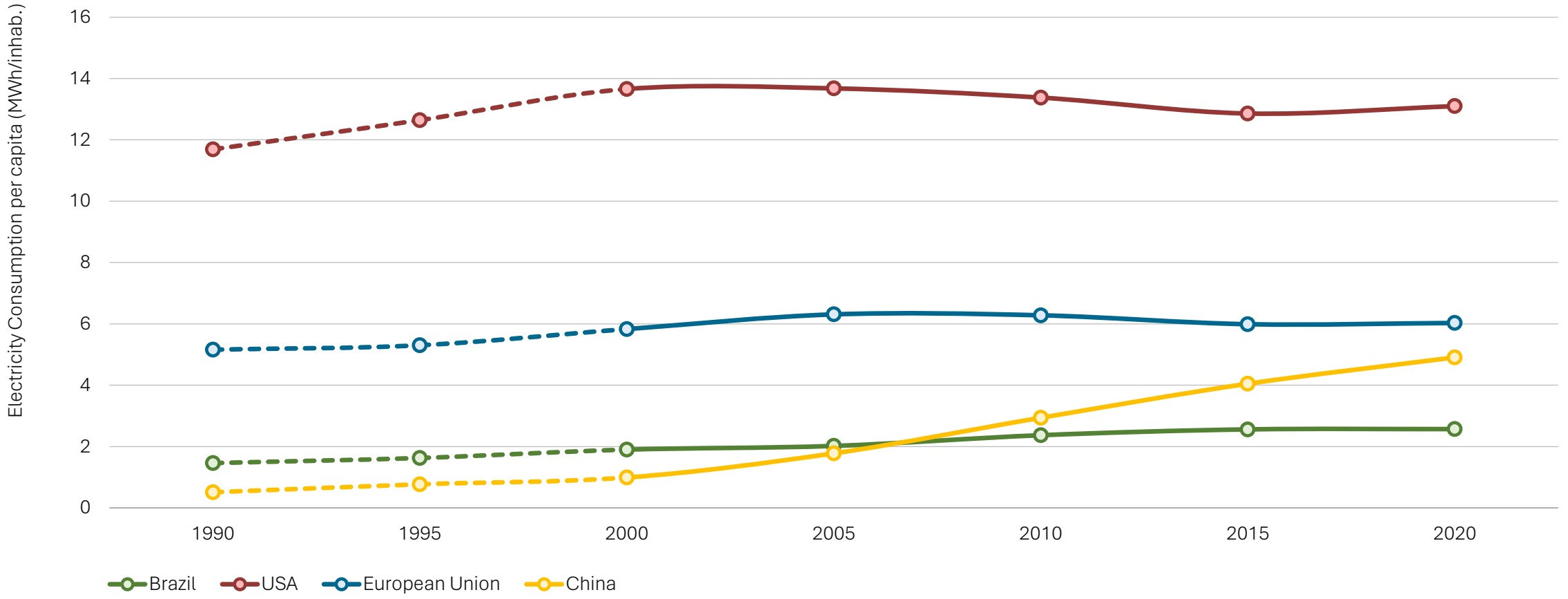
Source: International Energy Agency. Prepared by EPE



Evolution of indicators: Brazil and the World

Electricity Consumption per capita

Source: International Energy Agency. Prepared by EPE



Key Statistics

Source	Unit	2022	2023	Δ% 23/22
Oil Production[1]	10^3 bbl/day	3,024.6	3,404.4	12.6%
Natural Gas Production	10^6 m^3/day	137.9	149.8	8.6%
Electric Power Generation	TWh	677.2	708.1	4.6%
Consumption of Liquid Fuels	10^6 l/day	393.0	411.2	4.6%
Electric power consumption	TWh	586.1	616.3	5.2%
Total Energy Supply (TES)	10^6 toe	303.1	314.0	3.6%
Total Electric Power Supply (TEPS)[2]	TWh	690.1	723.2	4.8%
Population	10^6 inhab.	215.6	217.0	0.7%
GDP [2010][3]	10^9 US$	3,126.9	3,217.8	2.9%

[1] bbl = barrel; includes liquids of natural gas and LPG
[3] Includes import and autoproduction
[3] Values in constant 2010 reais converted to dollars in 2010 purchasing power parity (ppp).

Final energy consumption by source[1]

Unit: 10^3 toe

Source	2022	2023	Δ% 23/22
Diesel Oil[2]	53,091	55,218	4.0%
Electricity	50,403	53,003	5.2%
Sugarcane Bagasse	28,018	33,537	19.7%
Gasoline[3]	24,227	25,906	6.9%
Natural Gas	16,103	14,974	-7.0%
Firewood	18,422	18,704	1.5%
Ethanol	15,165	16,115	6.3%
LPG	8,211	8,240	0.3%
Black liquor	8,039	7,816	-2.8%
Fuel oil	2,431	2,255	-7.2%
Kerosene	3,132	3,296	5.3%
Other Sources[4]	28,326	27,408	-3.2%
TOTAL	255,567	266,471	4.3%

[1] Exclusive non-energy final consumption;
[2] Includes biodiesel; [3] Includes gasoline A and aviation gasoline;
[4] Includes refinery gas, coal coke and charcoal, among others

Selected indicators

Indicators	Unit	2022	2023	Δ% 23/22
GDP per capita	US$/inhab.	14,506	14,830	2.2%
TES per capita	toe/inhab.	1.406	1.447	2.9%
TES per GDP [2010]	toe/10^3 US$	0.097	0.098	0.6%
TEPS per capita	kWh/inhab.	3,201	3,333	4.1%
TEPS per GDP [2010]	kWh/10^3 US$	221	225	1.8%

Evolution of indicators

Parameters	Unit	1970	1980	1990	2000	2010	2022	2023
Total Energy Supply (TES)	10^6 toe	66.9	114.7	141.9	190.1	268.8	303.2	314,0
Total Electric Power Supply (TEPS)[1]	TWh	45.7	139.2	249.4	393.2	550.4	690.1	723,2
Population	10^6 inhab.	95.7	122.2	148.1	174.7	196.4	215.6	217,0
GDP [2010][2]	10^9 US$	567.3	1,297.7	1,517.1	1,953.0	2.,03.6	3.126.9	3.217,8
Indicators	**Unit**	**1970**	**1980**	**1990**	**2000**	**2010**	**2022**	**2023**
GDP per capita	US$/inhab.	5,928	10,619	10,244	11,179	14,275	14,506	14,830
TES per capita	toe/inhab.	0.699	0.939	0.958	1.088	1.369	1.406	1.447
TES per GDP [2010]	toe/10^3 US$	0.118	0.088	0.094	0.097	0.096	0.097	0.098
TEPS per capita	kWh/inhab.	478	1,139	1,684	2,251	2,802	3,201	3,333
TEPS per GDP [2010]	kWh/10^3 US$	81	107	164	201	196	221	225

[1] Includes import and autoproduction
[2] Values in constant 2010 reais converted to dollars in 2010 purchasing power parity (ppp)

Matrices

The matrices are available on the EPE portal by clicking on the QR code below or by clicking on the following link: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/BEN-Series-Historicas-Completas

The matrices can be obtained directly by going to:

Matrices and Time series

BEN

Summary Report 2024

Reference year 2023

Ministério de Minas e Energia

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