Deloitte.

Brazil Infrastructure market study

March 2023

MAKING AN IMPACT THAT MATTERS since 1845

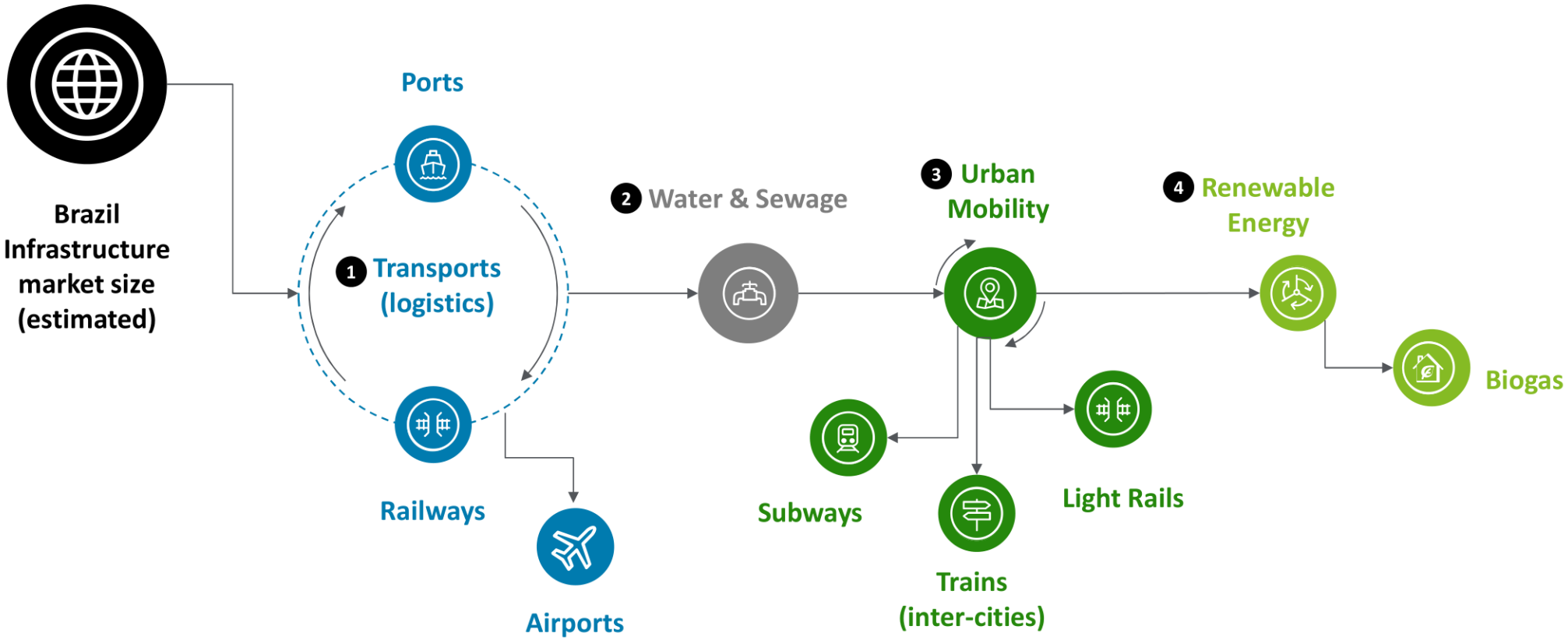
（再生可能エネルギー）バイオガス セクター　市場調査　エグゼクティブサマリ

ハイライト情報

重点調査対象	再生可能エネルギーの中でもバイオガスを重点的に調査している。バイオガスは都市交通（バス等）への利用可能性が高いこともあり、再生可能エネルギーの中でも注目されている。また、日本を含む海外企業の参画余地も多くあることから、バイオガスを掘り下げて調査を実施することとした。
バイオガスの法律と規制	政府は産業の規模を問わずバイオガスを再生可能エネルギーの活用を支援し、その為の機関としてANP／ANEELを設置している。その他に産業支援の為、Abiogás／Probiogás／ABBM／CIBiogás／EPE等の組織が設置されている。1998年に連邦法で環境汚染に関する罰則が設けられて以降、順次同産業に関する法律／規制が整備されている。
バイオガスのバリューチェーン	再生可能エネルギーの中でバイオガスは排出削減目標の達成、国のエネルギー危機、肥料不足への解決策として期待が高まっている。バイオガスは有機物を分解することにより生成し、同時に副産物としてバイオ肥料を生成する。2021年のバイオガス生産量は2.3 billion m^3だが、ポテンシャルとしては84.6 billion m^3と考えられている。
バイオガスセクター概観	バイオガスはその生成方法が衛生、農業、産業の3つに大別される。衛生では都市の固形廃棄物／果物の残滓／下水等、農業では動物の糞尿／死骸等、産業では産業廃棄物、廃液等の有機物を分解する。2011年から2021年までの10年間でバイオガス工場は56から102に増加し、バイオガス生産量は1.1billion m^3から2.3 billion m^3に増加している。
主要プレイヤー	ブラジルのガス販売事業者は27社ある一方で、2021年現在でバイオガスを販売している事業者は、CegasとGas Brasilíanoの2社のみである。今後バイオガスの販売を視野に入れているのはこの2事業者を含めて10事業者に上る。
政府の戦略	政府はバイオガスの社会経済および環境における戦略的期待役割を踏まえて産業に対してインセンティブを提供してきており、今後もその方針は継続されることが見込まれている。
投資プロジェクト状況	2023年に232の電力発電所が稼働開始予定であるが、そのうち11がバイオガスに関する施設である。2021年において稼働中の電力発電所が6,056ある中で、バイオガスの取扱があるのは300である。

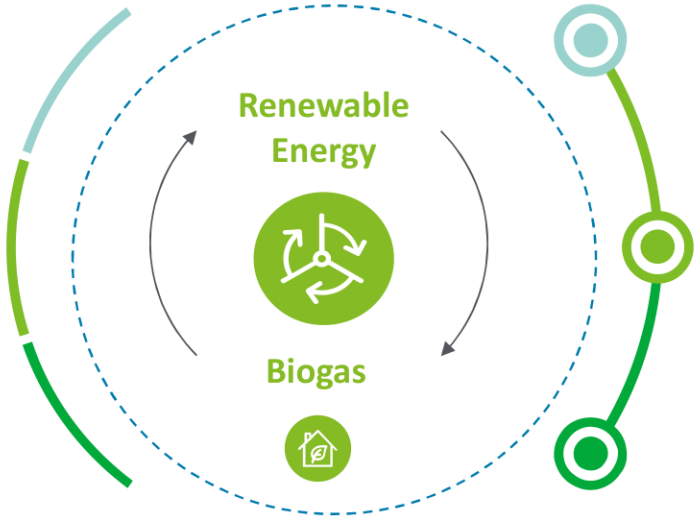
Brazil infrastructure market study

General Overview



Brazil infrastructure market study

Renewable Energy - Biogas



Brazil infrastructure market study

Transports – Ports – Agenda

Renewable Energy - Biogas

Laws and Regulations

Laws and Regulations

Current Legislations and Legal Framework - ANP and ANEEL are the regulatory entities for federal level.

The Brazilian Government supports and encourages, from the minigeneration to the greater industries, to use the biogas as a renewable and sustainable source.

There are two bodies responsible for the sector in Brazil:

- **ANP** (National Agency for Oil, Gas and Biofuel), which is responsible for the supervision and application of administrative and pecuniary sanctions regarding compliance with legal requirements, responsible for granting authorization to carry out the activity of production and/or distribution of biofuels in Brazil, and to encourage the electric energy generation from biomass and by-products of biofuel production, due to its clean, renewable source. ANP's responsibilities regarding the biofuel sector is described through the Law 9,478/1997 and complemented by Law 12,490/2011. According to the agency, the biogas results after stages of biogas purification, in a gaseous fuel with high content of methane in its composition. With this, it combines features to be interchangeable with natural gas in all its applications. As the qualified provenance biomethane may be mixed with natural gas and marketed by means of connection to the piped gas distribution network or in the form of compressed gas. The quality of biomethane is regulated by the ANP through Resolution ANP No. 8/2015. The specification of the product is found in ANP Technical Regulation 1/2015, an integral part of the before mentioned resolution.

- **ANEEL** (The National Electricity Regulatory Agency), an autarchy under a special regime linked to the Ministry of Mines and Energy, created to regulate the Brazilian electricity sector, through Law 9,427/1996 and Decree 2,335/1997. It has the following main attributions:

  i. Regulate the generation (production), transmission, distribution and commercialization of electric energy;
  ii. Supervise, directly or through agreements with state agencies, concessions, permits and electric energy services;
  iii. Implement the policies and guidelines of the federal government, regarding the exploitation of electric power and the use of hydraulic potentials;
  iv. Establish tariffs;
  v. Address divergences, at the administrative level, between agents and between those agents and consumers, and
  vi. Promote activities of granting concessions, permits and authorization of electric power projects and services, by delegation of the Federal Government.

Laws and Regulations

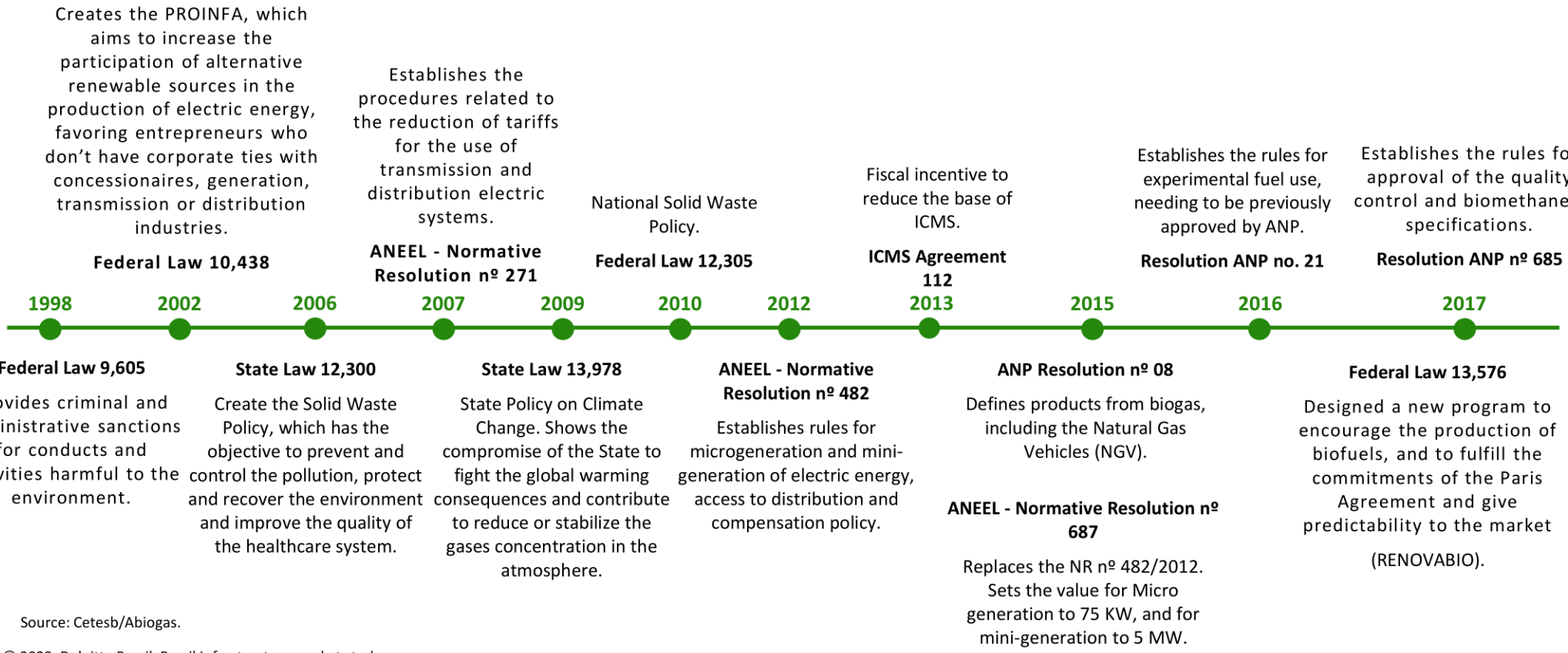
Current Legislations and Legal Framework - Some institutions, such as, Abiogás, Probiogás, ABBM, CIBiogás and EPE are created to support the sector.

- **ABiogás**, founded in 2013, brings together the interests of representatives of the civil society who are dedicated to the development of biogas and biomethane production and consumption, disseminating and promoting these energy sources, in order to enable their effective and significant participation in the Brazilian energy matrix. Thus, the Association works intensively with the regulatory agencies (Aneel and ANP), the Ministry of Mines and Energy (MME) and the National Congress, and also promotes a Working Group dedicated to the conclusion of a Proposal for a National Biogas and Biomethane Policy.
- **Probiogás** acts with public institutions to encourage the production of energy from biogas; promotes the approximation between Brazilian and German research, also with teaching institutions; and supports the national industry by promoting the development of local technologies and the transfer of German know-how and the training of professionals.
- **Brazilian Biogas and Methane Association (ABBM)** is a non-profit organization incorporated to defend the interests of Brazilian companies in the biogas and methane sector.
- **CIBiogás (International Center for Renewable Energies -Biogas)** is a scientific, technological and innovation institution, in the form of a private legal entity, constituted as a non-profit association; It has an administrative and financial autonomy, governed by a statute. The Center is made up of 22 institutions that develop and/or support projects related to renewable energies. Its structure has a biogas laboratory, in the Itaipu Technological Park (PTI) in Foz do Iguaçu, and it also has 11 biogas production units in Brazil.
- **EPE (Energy Research Company)** is a public company dedicated to provide services to the Ministry of Mines and Energy (MME) in the area of studies and research regarding energy sector, covering electricity, oil and natural gas and its derivatives and biofuels. Through its Superintendency of Natural Gas and Biofuels, EPE is responsible for preparing studies on the infrastructure, processing, transportation, storage, supply, sale and supply of natural gas and elaborate studies on the infrastructure, supply, production, transformation, commercialization and supply of biofuels. It is also its responsibility to prepare and/or evaluate studies of natural gas and biofuel infrastructure projects and to conduct studies on the national and international markets for natural gas and biofuels.

Laws and Regulations

Current Legislations and Legal Framework - Timeline of relevant **Laws** and legislations to the biogas sector.

A timeline describing the main rules and legislations that govern the manner that industries must act in the Brazilian biogas sector, as well as their brief description, is shown below:

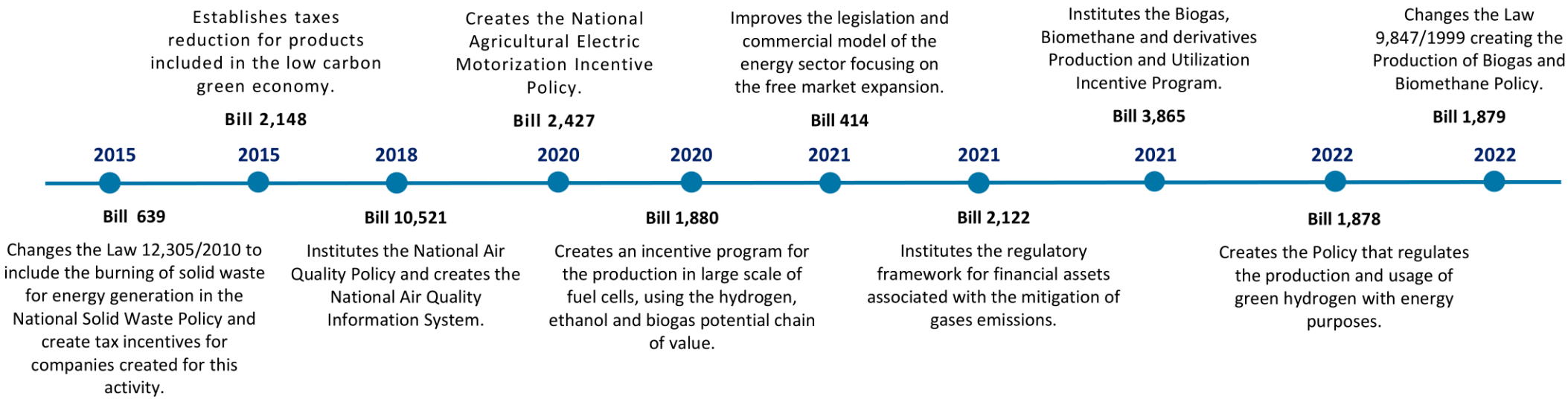


Source: Cetesb/Abiogas.

Laws and Regulations

Current Legislations and Legal Framework - Timeline of relevant **bills** for the biogas sector.

A timeline describing the main rules and legislations that govern the manner that industries must act in the Brazilian biogas sector, as well as their brief description, is shown below:



Source: Cetesb/Abiogas.

Laws and Regulations

Current Legislations and Legal Framework - Biofuel Decarbonization Credit in RenovaBio.

Biofuel Decarbonization Credit (CBIO):

- CBIO is the asset that supports the RenovaBio program and offers the solution for the low-carbon economy that large companies in the world are looking for. These are bonds issued by producers and importers based on your purchase invoices and sale of biofuels. One CBIO equals one ton of avoided emissions, which is seven trees in terms of carbon capture. By 2030, greenhouse gas emissions corresponding to the planting of 5 billion trees will be offset.
- For each current year, it is deployed individual targets, applied to all fuel distributors, proportional to their respective market share in the commercialization of fossil fuels in the previous year. This credit will be a financial asset. It will be traded on the stock exchange and issued by the producer from the commercialization of biofuels, in other words it will be another source of funding for entrepreneurs in the industry;
- According to the MME – RenovaBio Impact Scenarios, there are some sets that can show the influence of the decarbonization target and the oil price in the CBIO value, however, it is not the final method of calculation. An example with a decarbonization target of 10% is indicated below.

CBio Price (US$/ ton CO2 equivalent)				
Oil Price (US$/barrel)	Productive Efficiency (%)			
	0	10	20	30
20	50	37	23	9
40	29	14	1	0
60	11	0	0	0
80	0	0	0	0

Source: Gov.

Main impacts over CBio:

- The CBIO has no expiration date and will be valid until your holder requests the retirement of the credit. The achievement of goals of each distributor is based on the number of CBIOs in its retirees during the period.
- Arbitrage with other markets, 1 CBio = 1 ton of CO2 equivalent.
- Constitution of the Biofuels and Fuels Monitoring Committee.
- Amendment by the government of compulsory biofuels measurements.

Laws and Regulations

Licenses.

- Biogas production plants are regulated by several government agencies, and the degree of complexity and the requirements vary depending on the size of the enterprise, the types of substrates that are processed and the destination that will be given to products generated. In general, the main refer to the following topics:

i. Environmental Regularization: Refers to the control of aspects and impacts environmental licenses, involving the obtaining of environmental licenses, authorizations for suppression of vegetation and use of water resources, to the technical register federal and other legal obligations to environmental agencies;

ii. Technical regulations: These refer to the technical standards applied to the of projects, construction and operation of biogas plants;

   a) Agronomic aspects: Licenses and other obligations concerning the use and marketing of the material digested with purposes;

   b) Electricity and Biomethane: These are the regulations regarding the production, commercialization and / or distribution of electricity and biomethane;

   c) Health and Safety at Work: Occupational safety and risks associated with activities.

Regarding the Environmental Regularizations, there are two main bodies responsible for the monitoring and the regulatory requirements:

1) **IBAMA** (Brazilian Institute for the Environment and Renewable Natural Resources) was created by Law 7,735 of February 22, 1989, is a federal authority linked to the Ministry of the Environment (MMA). It is the executive body responsible for implementing the National Environmental Policy (PNMA) and carries out various activities for the preservation and conservation of natural heritage, exercising control and oversight over the use of natural resources (water, flora, fauna, soil, etc.).

In the biogas sector, IBAMA requires from the industry the following items:

i. Environmental Licensing;
ii. Federal Technical Registry (CTF);
iii. Annual Activity Report;
iv. Environmental Control and Inspection Fee (TCFA).

Laws and Regulations

Licenses.

Regarding the Environmental Regularizations, there are two main bodies responsible for the monitoring and the regulatory requirements:

2) The **Secretary responsible for the Environment** in its respective state. For example, in Minas Gerais State, SISEMA, has as its mission to formulate and coordinate the state policy of protection and conservation of the environment and management of water resources and articulate the policies of management of environmental resources, aiming at sustainable development in the State of Minas Gerais.

In the biogas sector, the secretariat requires from the industry the following items:

i. State Inventory of Industrial Solid Waste;

ii. Declaration of Pollution Charge;

iii. Rural Environment Registration (CAR).

And regarding the Technical Regulations:

In order to prepare biogas plant projects, the interested industry must look for the Brazilian Regulatory Rules (NBR) created by the Brazilian Association of Technical Standards (ABNT).

However, there are no NBRs which deal specifically with biogas, but it is possible to adopt the regulations of natural gas and combustible gases. Also, pay attention to the applicable regulations to waste, electrical installations, atmospheric discharges, atmospheric emissions, area classification, chemical substance identification, project criteria, among other items.

Public Value Chain

Public Value Chain

Renewable Energy and Biogas.

Renewable Energies

Renewable energy is a clean alternative to fuel fossil sources that don't generate major negative environmental impacts. Renewable energy sources are considered clean, as they emit less greenhouse gases (GHG) than fossil sources and, therefore, are achieving a good insertion in the Brazilian and world market. Brazil has a predominantly renewable Energy Matrix thanks to hydroelectric plants. The energy sources that belong to this group are considered inexhaustible, as their amounts are constantly renewed when used. Examples of the main renewable sources are:

- water (energy from river water),
- solar (energy from the sun);
- wind (energy from the wind);
- geothermal (energy from the Earth's interior);
- oceanic (energy from the tides and waves) and;
- **biomass** (energy from organic matter).

Biomass is a fundamental energy source to produce several biofuels, such as the **biogas.**

Biogas

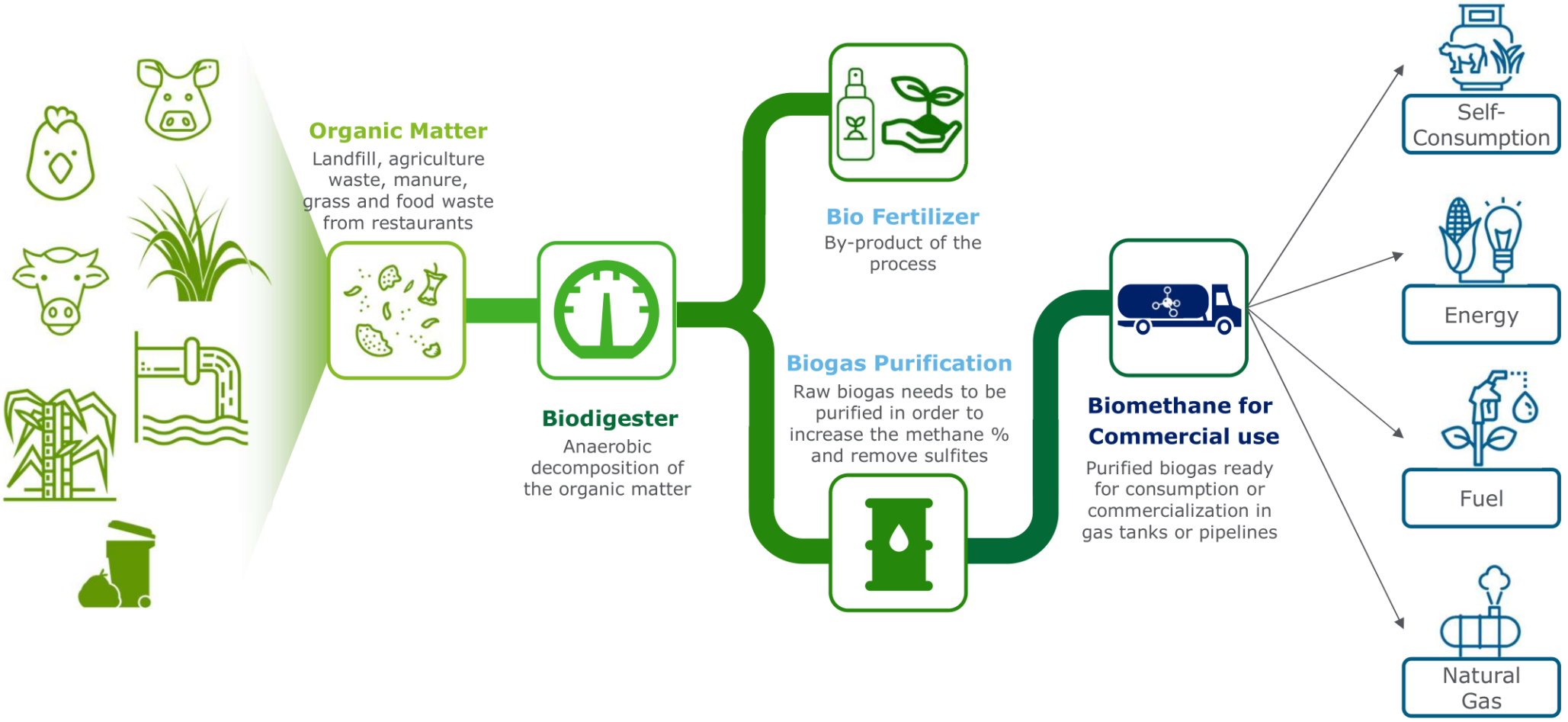
Biogas is an energy resource obtained from organic residues anaerobic bio digestion, from the sugar-energy industry (straw, bagasse, stillage and filter cake), from the animal protein chain (manure from animals, slaughterhouse and dairy waste), agriculture (bark soy, corn, cassava industry) and sanitation (waste urban solids and effluent treatment plants). Once produced, biogas can be used for different purposes: heat generation; electricity generation, operating from equivalent to a natural gas thermoelectric plant, 100% renewable, continuously, without intermittency; or, with its purification, transformed into biomethane which is equivalent to fossil natural gas.

Biogas is seen as an opportunity due to Brazil's adherence to the global commitment for the reduction of methane emissions, the energy crisis for which the country is going through, the growing dependency on imports of fuels and the shortage of fertilizers. Biogas can be part of the short- and medium-term solution for the decarbonization of key sectors of the Brazilian economy.

Source: EPE/Ecycle.

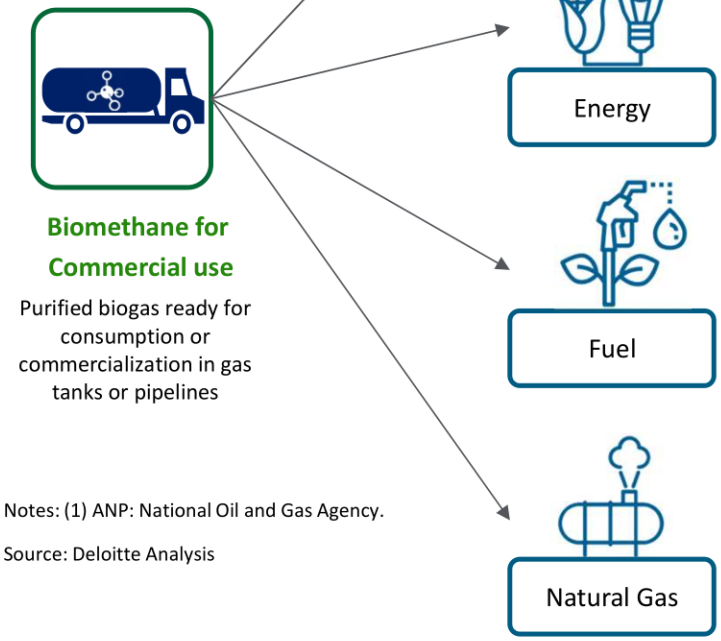
Public Value Chain

Biogas production is based on anaerobic decomposition of organic matter and yields bio fertilizer as by-product.



Public Value Chain

Usage - Biogas can be used to generate electric or thermal energy and can also be used as a replacement for fossil fuels.



Thermal energy transfer from biogas combustion.

Biogas utilization for electric energy in thermoelectric power plants.

Utilize biogas as replacement for fossil-fuel.

Use biogas as substitute for natural gas.

Minimum Purity Level Required

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For self consumption, little or no purification is required.

Although not mandatory, purified gas provides better efficiency and increase the durability of machines.

For commercial use as fuel, the biogas needs to be purified. For self consumption, some farmers use raw gas.

To be inserted in the pipeline, Biogas needs to be purified to ANP[1] standards.

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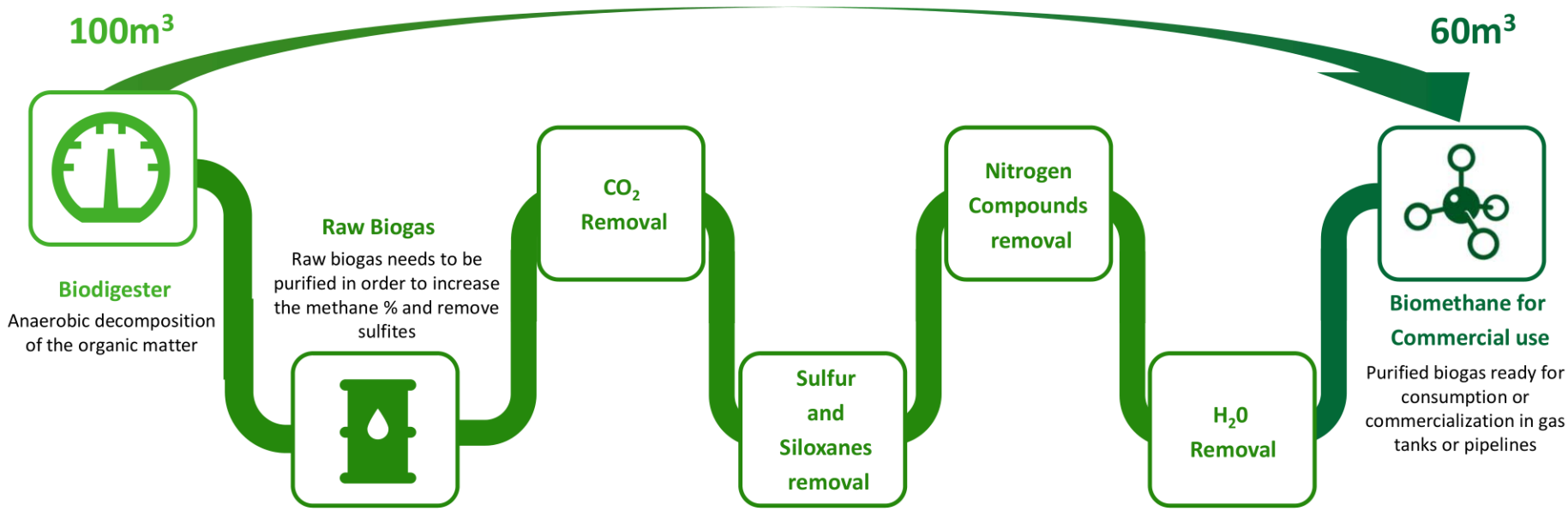
Notes: (1) ANP: National Oil and Gas Agency.

Source: Deloitte Analysis

Public Value Chain

Production Chain - Biogas purification yields biomethane in a proportion of around 60% depending on the methane content of the gas.



Biogas has **different applications**, which require **different levels of purity**. For **thermal or electric generation**, biogas can usually be **consumed in its raw state**. When using biogas as a **commercial fuel or supplying for a natural gas pipeline**, however, **purification is almost always a requirement**.

Source: Industry Experts,/Deloitte Analysis.

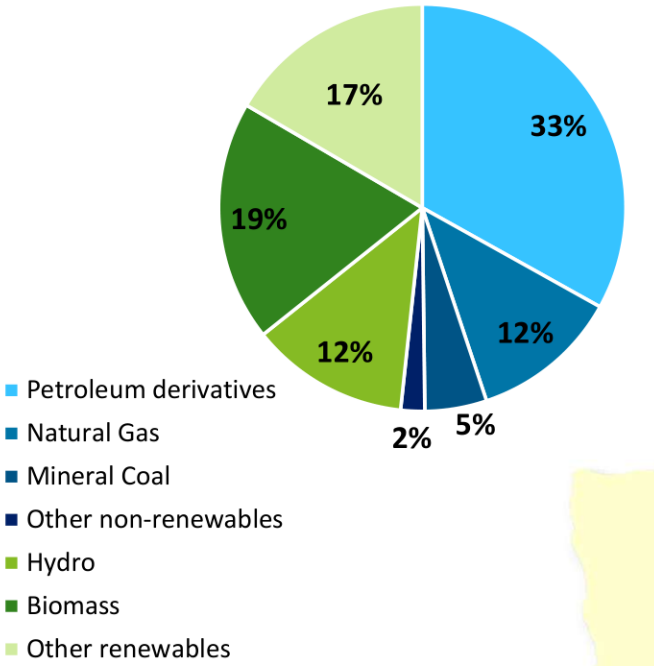
General Sector Overview

General Sector Overview

Brazilian Energetic Matrix Potential – From 2011 to 2020, the share of renewable sources in Brazil's Energy Matrix grew from 43.6% to 48.4%, while the share of non-renewables fell from 56.4% to 51.6%.

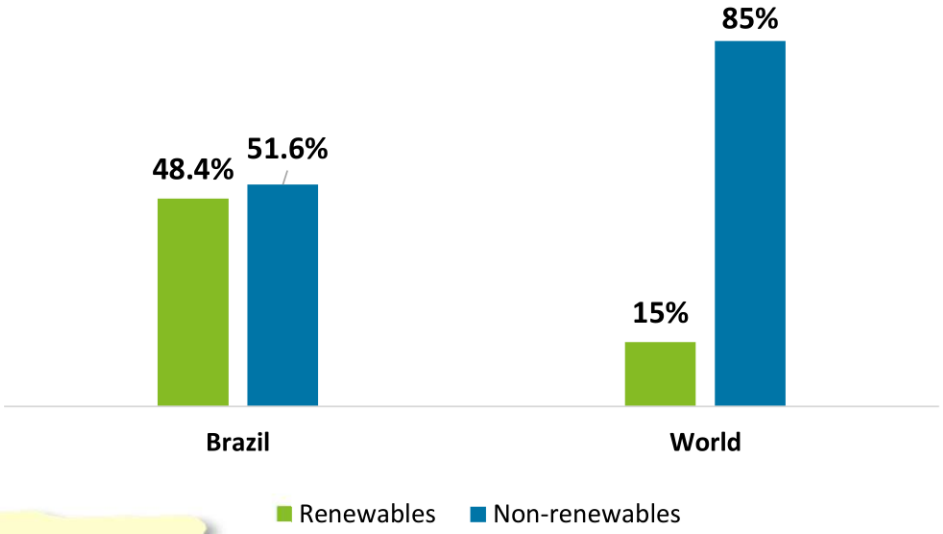
Brazilian Energetic Matrix

2020



World and Brazilian Energetic Matrix Comparison

2020

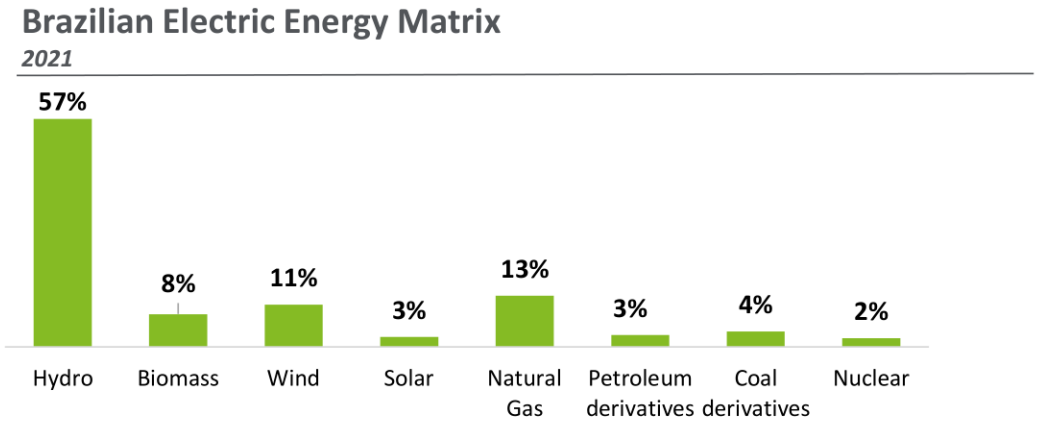


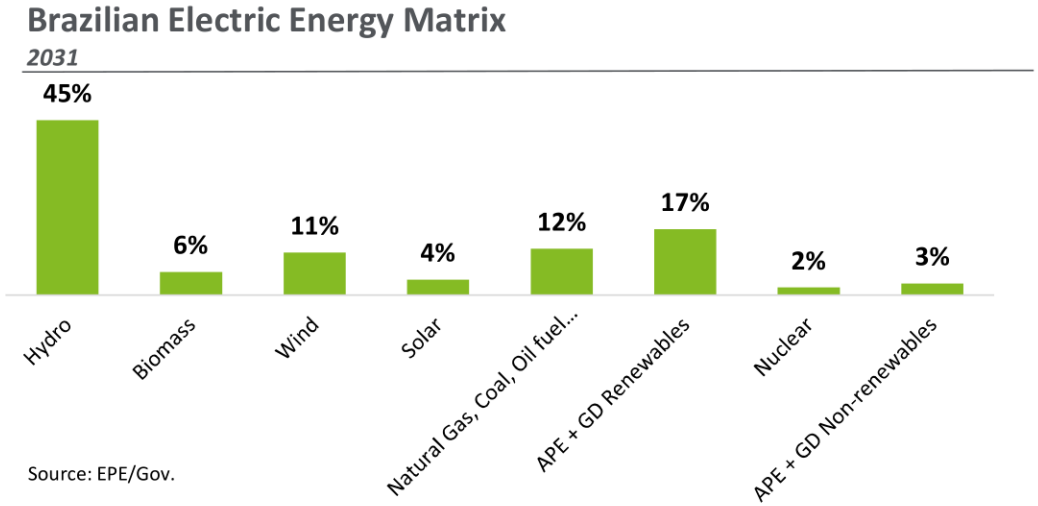
The energy matrix represents the set of energy resources used in a country to supply its energy demand. Brazil has one of the most renewable energy matrixes in the world.

Source: EPE.

General Sector Overview

Brazilian Electric Power Generation Potential - The overall Brazilian electric energy production is expected to grow 75 GW until 2031, from 200GW in 2021 to 275 GW, being the renewable sources responsible for most of it.





Source: EPE/Gov.

Main Sources	Current Power (200 GW)	2031 Power (275 GW)	Increase (GW)
Hydro	114	124	+10
Biomas	16	16.5	+0.5
Wind	22	30	+8
Solar	6	11	+5

The Brazilian electrical matrix is even more renewable than the energy matrix. Much of the electricity generated in Brazil comes from hydroelectric plants. Wind energy has also been growing significantly, contributing to our electricity matrix continuing to be mostly renewable.

General Sector Overview

Substrates used for biogas production in Brazil are divided into 3 categories as to their sources.

BIOGAS Potential:

84.6

billion m³/year

BIOGAS Current Production

- **Sanitation** — 1.7 billion m³/year in 2021 — 74%
- **Agricultural** — 0.23 billion m³/year in 2021 — 10%
- **Industry (including sugar and ethanol)** — 0.37 billion m³/year in 2021 — 16%

Source: ABIOGAS.

General Sector Overview

Plants in operation – Substrate Sources.

Agricultural

Animal manure, effluent from waste management, food's residues, dead animal's carcass, etc.

Industry

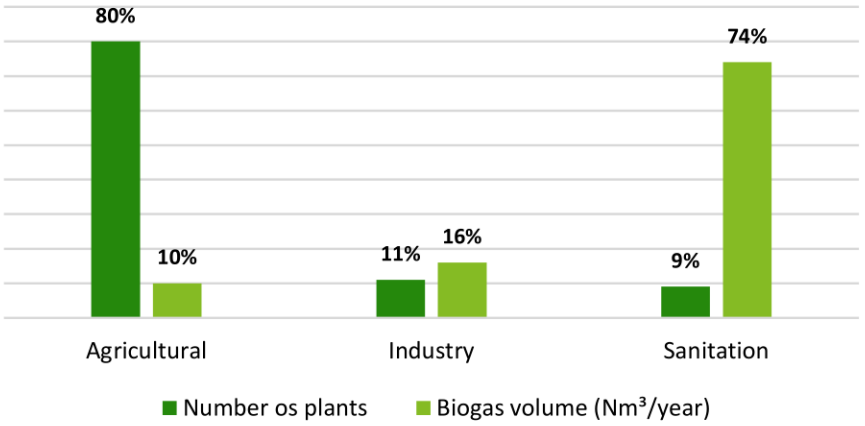
Industrial effluents and other organic waste from the industrial process.

Sanitation

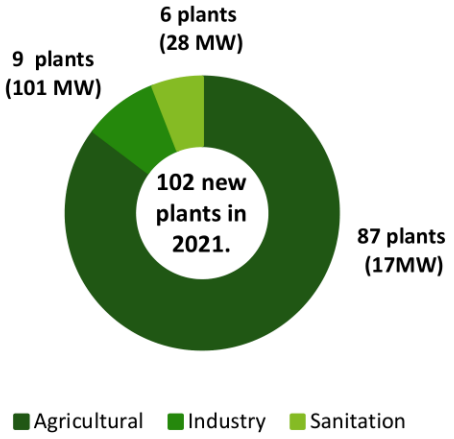
Urban solid waste fruit and vegetables residues, food leftovers, sanitary sewage, etc.

The agricultural sector was responsible for 80% of the biogas plants in operation in the country, in 2021. While the industrial sector and the sanitation sector contributed 11% and 9%, respectively, in the number of plants. As for the volume of biogas, the sanitation sector was responsible for 74% of the total volume produced, followed by the industrial (16%) and agricultural (10%) sectors.

Proportion between the number of operating biogas plants in 2021 (755 plants), by substrate source.



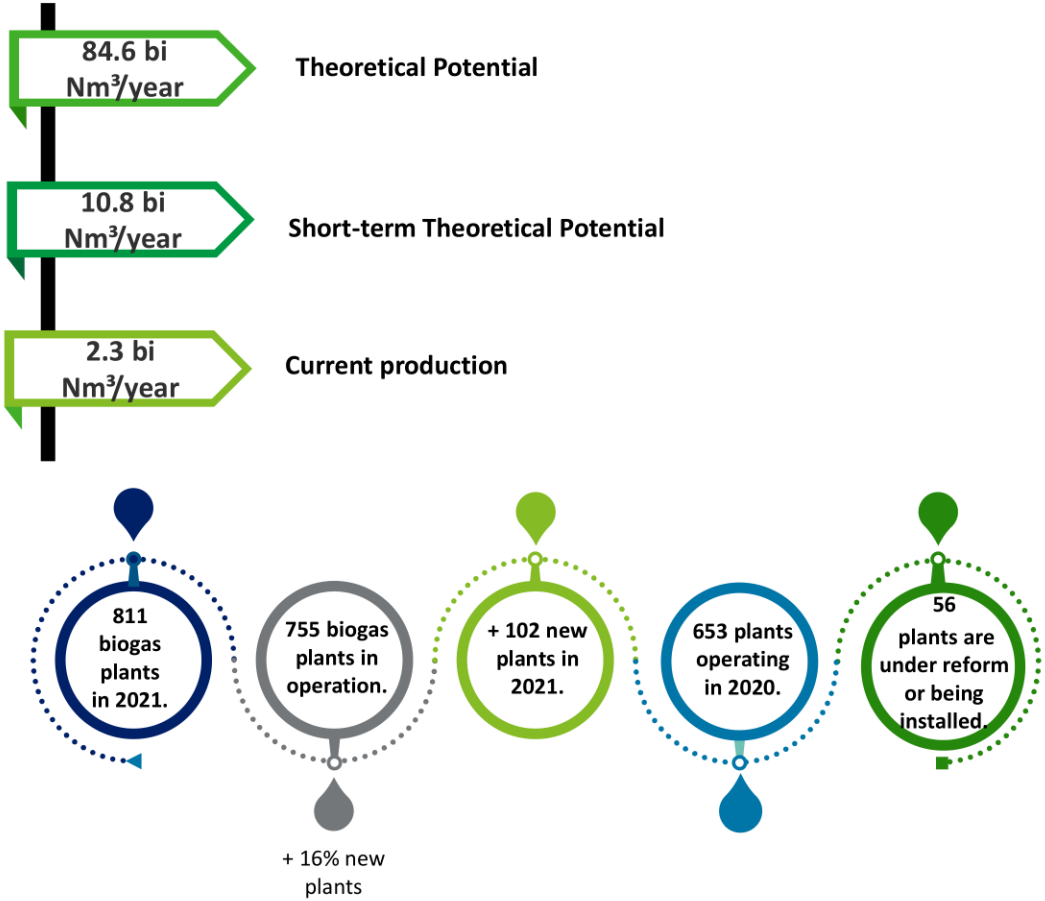
New biogas plants operating in Brazil and their installed capacity.

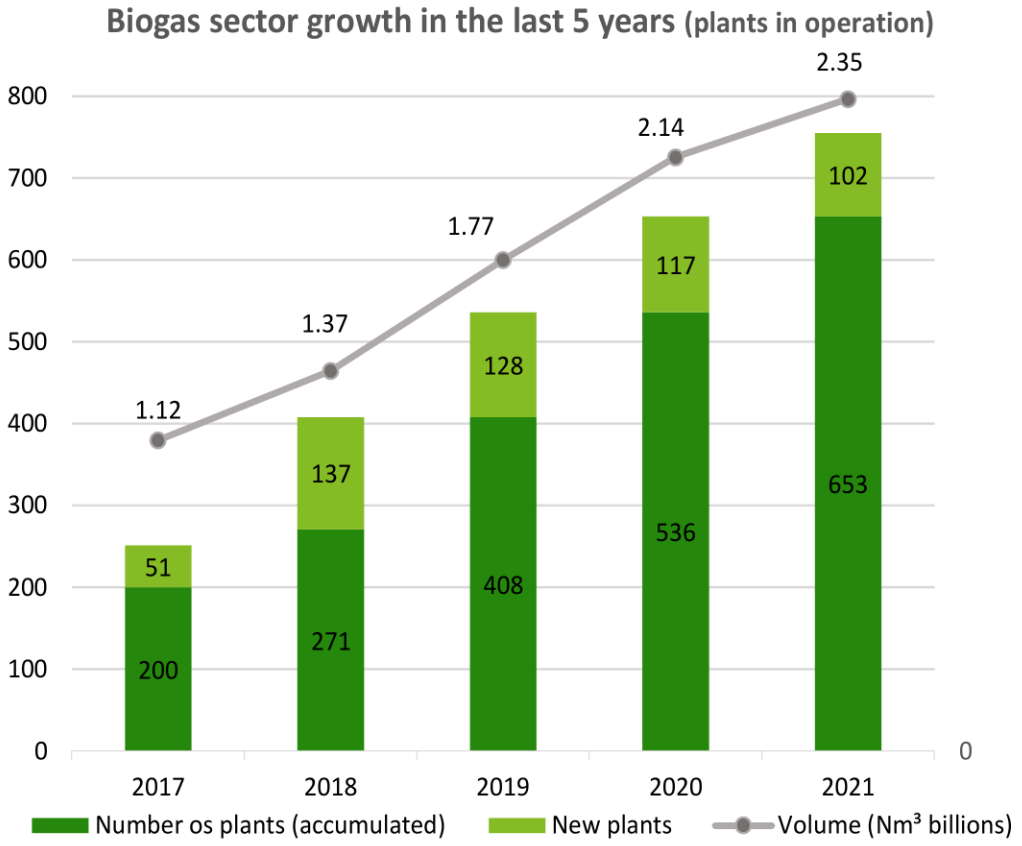


Source: CIBIOGAS.

General Sector Overview

Market Size Overview – There was a 16% increase in the number of plants in operation and a 10% growth in the biogas produced volume in 2021, compared to 2020. The theoretical potential production is 84.6 bi Nm3/year.





Source: CIBIOGAS.

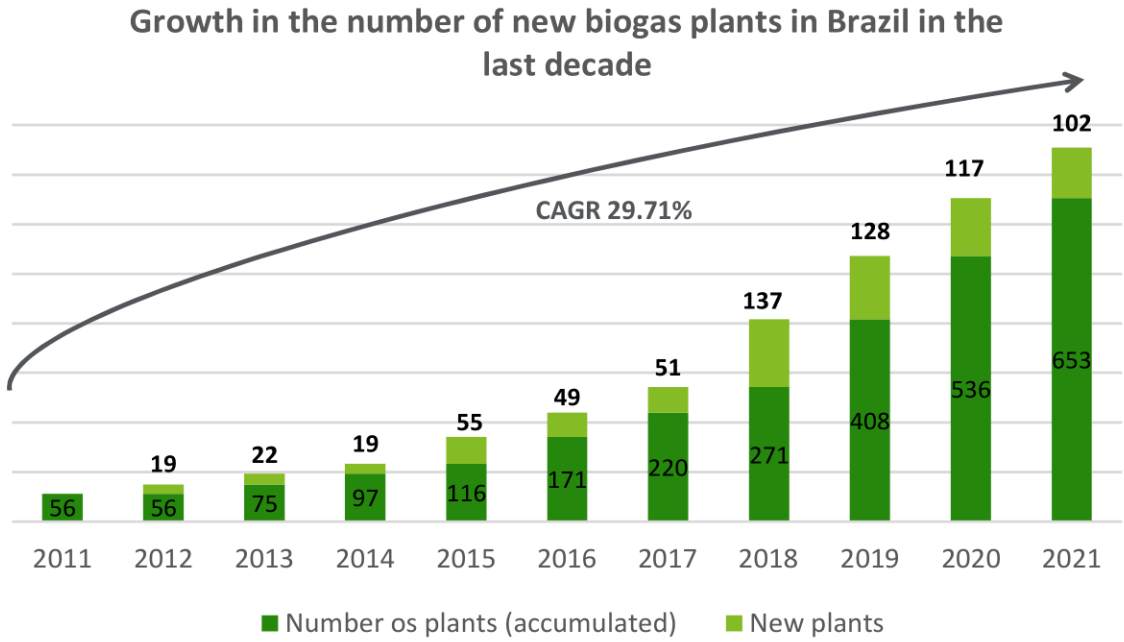
General Sector Overview

Market Size – Growth and exploited production potential analysis – Brazilian biogas plants have a 29.71% CAGR from 2011 to 2021.

The biogas sector continues to grow in Brazil, despite an unfavorable scenario, with an increase in fuel prices, water crisis and the COVID-19 pandemic.

According to the Brazilian Biogas Association (Abiogás), there has been a development of the national industry of suppliers of goods and services for the biogas sector, which has helped to reduce biogas plants and biomethane installation costs in the country. Therefore, the Brazilian biogas industry remains heated.

The number of units in operation went from 653, in 2020, to 755 in 2021. Representing a 16% growth in national level.

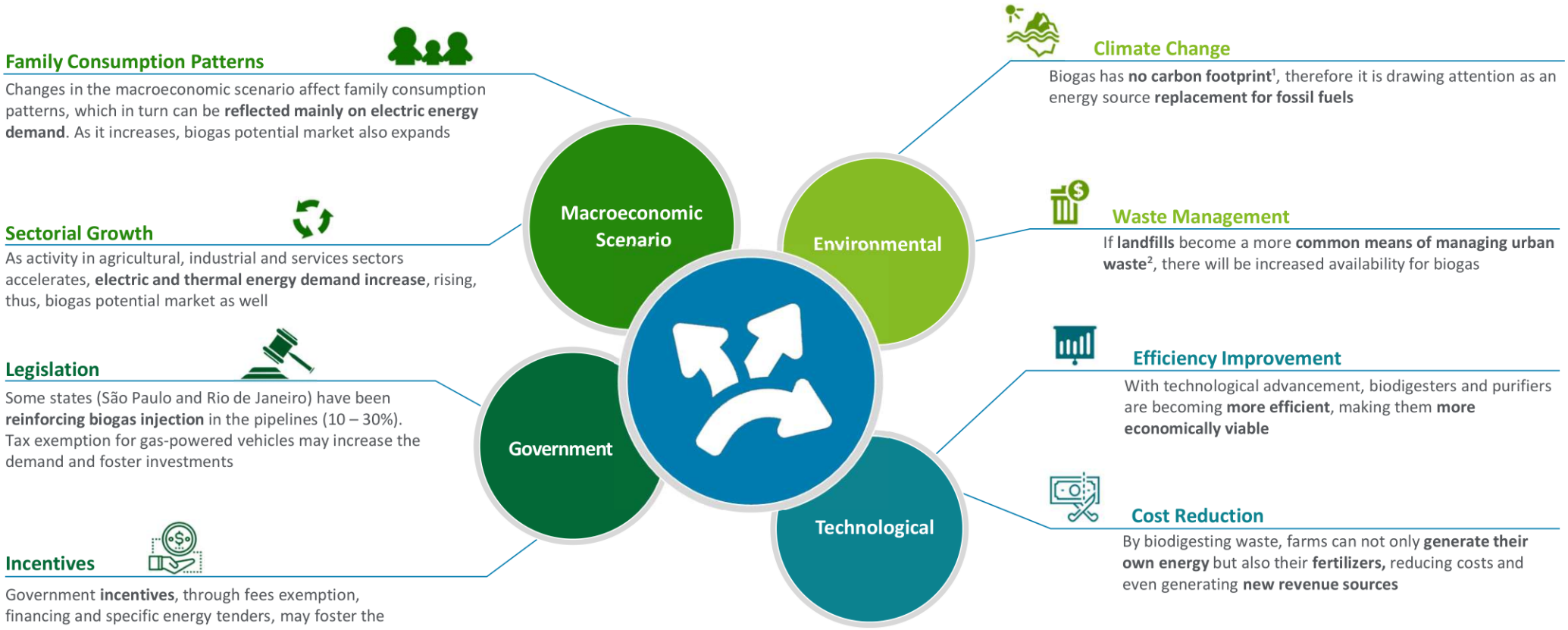


Since 2018, there has been a considerable increase in the number of biogas generating units with energy use, mainly incentivized with the ANEEL Resolution 482/2012, which opened paths for the generation of electric energy from biogas, in the distributed micro and mini-generation modalities.

Source: CIBIOGAS.

General Sector Overview

Growth Drivers - Several drivers may foster biogas production and consumption in Brazil.



Family Consumption Patterns

Changes in the macroeconomic scenario affect family consumption patterns, which in turn can be **reflected mainly on electric energy demand**. As it increases, biogas potential market also expands

Sectorial Growth

As activity in agricultural, industrial and services sectors accelerates, **electric and thermal energy demand increase**, rising, thus, biogas potential market as well

Legislation

Some states (São Paulo and Rio de Janeiro) have been **reinforcing biogas injection** in the pipelines (10 – 30%). Tax exemption for gas-powered vehicles may increase the demand and foster investments

Incentives

Government **incentives**, through fees exemption, financing and specific energy tenders, may foster the development of **biogas-based energy**

Climate Change

Biogas has **no carbon footprint**[1], therefore it is drawing attention as an energy source **replacement for fossil fuels**

Waste Management

If **landfills** become a more **common means of managing urban waste**[2], there will be increased availability for biogas

Efficiency Improvement

With technological advancement, biodigesters and purifiers are becoming **more efficient**, making them **more economically viable**

Cost Reduction

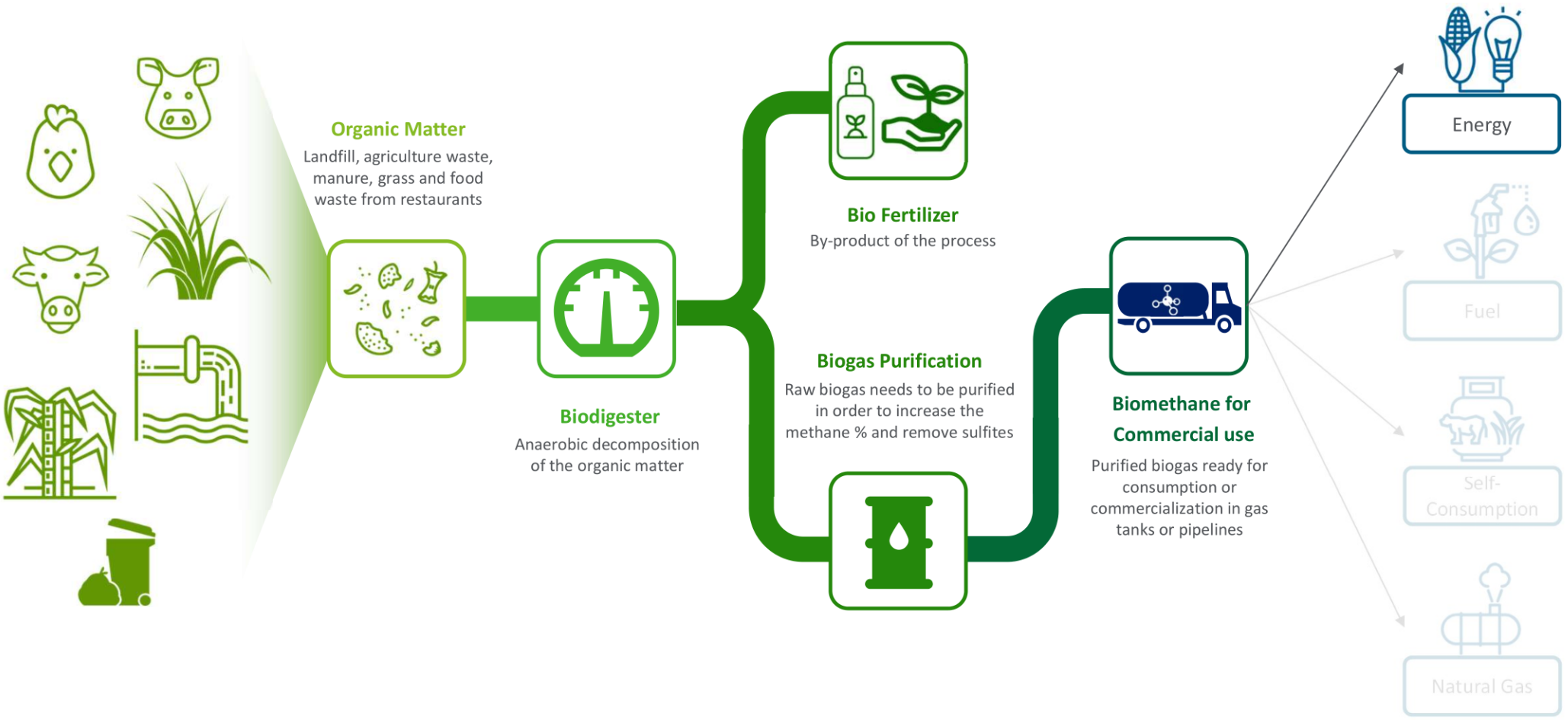
By biodigesting waste, farms can not only **generate their own energy** but also their **fertilizers,** reducing costs and even generating **new revenue sources**

Notes: (1) Although it produces CO_2, the carbon in biogas comes from plant matter that fixed this carbon from atmospheric CO_2; (2) As proposed in the National Solid Waste Policy.

Source: Mercosul Enery Report/EPE/MME/Fatec-JB/Clippings/Deloitte Analysis.

General Sector Overview

Biogas production is based on anaerobic decomposition of organic matter from the sugar-energy industry, animal protein chain, agriculture and sanitation.

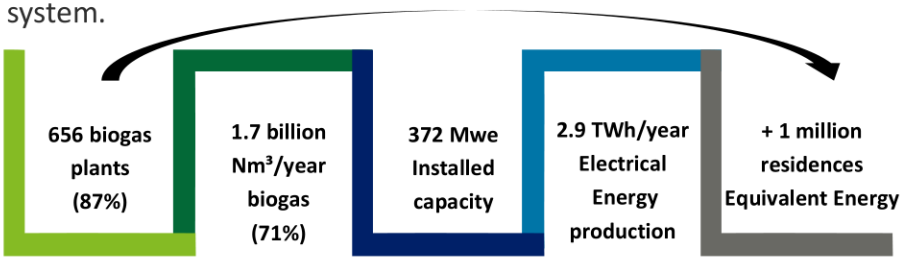


General Sector Overview

Brazilian Electric Power Generation Potential – About 87% of the biogas units were used for electrical energy generation and 11%, for thermal energy.

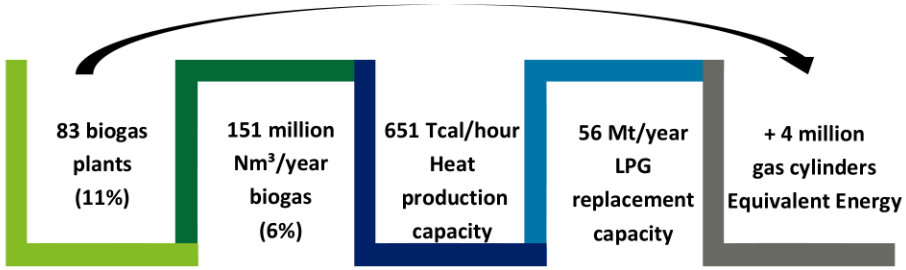
Electrical Energy

The use of biogas for electricity generation presents itself as the main energy application carried out in Brazilian biogas plants. In 2021, about 87% of the units in operation used this energy source to this purpose, resulting in the use of 71% of the volume of biogas produced for electricity generation. These biogas plants are on the regulated market (Regulated Contracting Environment - ACR), in the free market (Free Contracting Environment - ACL) and in isolated systems (off grid). Due to the simplicity in the process connection (compared to other options on the market), most plants are linked to the energy compensation system (net metering). Furthermore, It is worth noting that, there is also the option of isolated operation, therefore, many plants operating in this regime don't have a registration record ANEEL'S generation system.



Thermal Energy

The thermal use of biogas is done in 11% of the units in operation, for the most diverse utilities. Some examples are burning in a boiler to produce steam, the drying of grains to produce feed, the heating poultry houses and drying sewage sludge. In terms of volume, approximately 7% of biogas produced in 2021 was destined to the generation of thermal energy. Units that use biogas to produce mechanical energy to drive turbines, for example, add up to 6 plants, that is, 1% of the national total. In terms of volume, these plants correspond to 0.3% of the biogas produced in 2021.



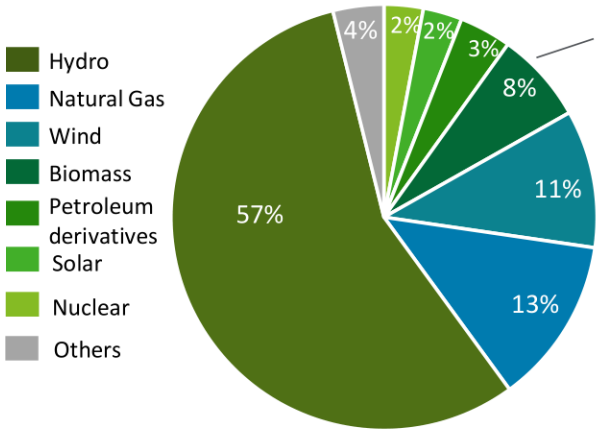
Source: CIBIOGAS.

Main Projects Portfolio

Opportunities on Power Generation - Biogas thermoelectric power plants have a marginal participation in Brazil's electric energy matrix, have a long tail, and use organic matter mainly from landfills.

Brazilian Electric Power mix

2021 %



Less than 0.1% of the total generation comes from **biogas**, and is generated by...

300
biogas power plants

Input Origin

Most of the biogas is derived from **solid urban waste.**

79% of the plants in operation are classified as small and produce **8%** of the total volume of biogas. In On the other hand, **82%** of the biogas produced in the country comes from large plants, which correspond to **7%** of units in operation. Medium-sized plants represent **14%** of the units in operation and **10%** of total volume of biogas.

Most of the biogas thermoelectric power plants **produce their own biogas and** transport it to the thermal generation unit **using their own internal pipeline**.
Some power plants purchase natural gas when biomass supply gets low.

Source: ANEEL/BEN 2022/Deloitte Analysis.

General Sector Overview

Power Generation Overview – Although Biogas currently represents a small portion of the Brazilian electric energy matrix, it is starting to find space, whether in energy generation or as fuel.

Current State

- Out of the 200 GW of the Brazilian electric power matrix, almost 60% is from hydroelectric power plants and approximately 22% is from other renewable sources;
- Only 0.0356% of the total electric energy comes from biogas, generating 71.2 MW generated from 300 power plants in 2021;
- In 2021, 71% of the biogas produced volume was used for electricity generation by 87% of the total units in operation;
- 3 biogas thermoelectric power plants generate the most part of all Brazilian biogas electric energy, 2 are in Southeast region and the other in the Northeast;
- Biogas thermoelectric power plants are concentrated in the Southeast area.

Change Agents

Area	As China, a traditional biogas energy user, Brazil disposes of an extensive area, which is favorable to biogas generation;
Industry	The agriculture-based economy can provide vast volume biogas production "raw material";
Infrastructure	Infrastructure deficiency fosters local energy generation, that can be supplied by biogas thermoelectric power plants;
Cultural	Popularization of electric micro and mini generation technologies as a reflection of an increased consumers' power of choice;
Economical	Price volatility and rising question related to fossil fuels open space for renewable energy sources, such as biogas;
Government	Government incentives through tax exemption, programs and higher electric energy fees comparing to inflation, among others;
Legal	Resolutions and laws, such as Resolution #08, #21, #482 and #687, specify, regulate and stimulate biogas use.

Future State

Electricity export potential from biogas (vinasse and filter cake) reaches an average of 2 GW in 2031 (based on power plant winner of the energy auction A 5 of 2016).

epe
Empresa de Pesquisa Energética

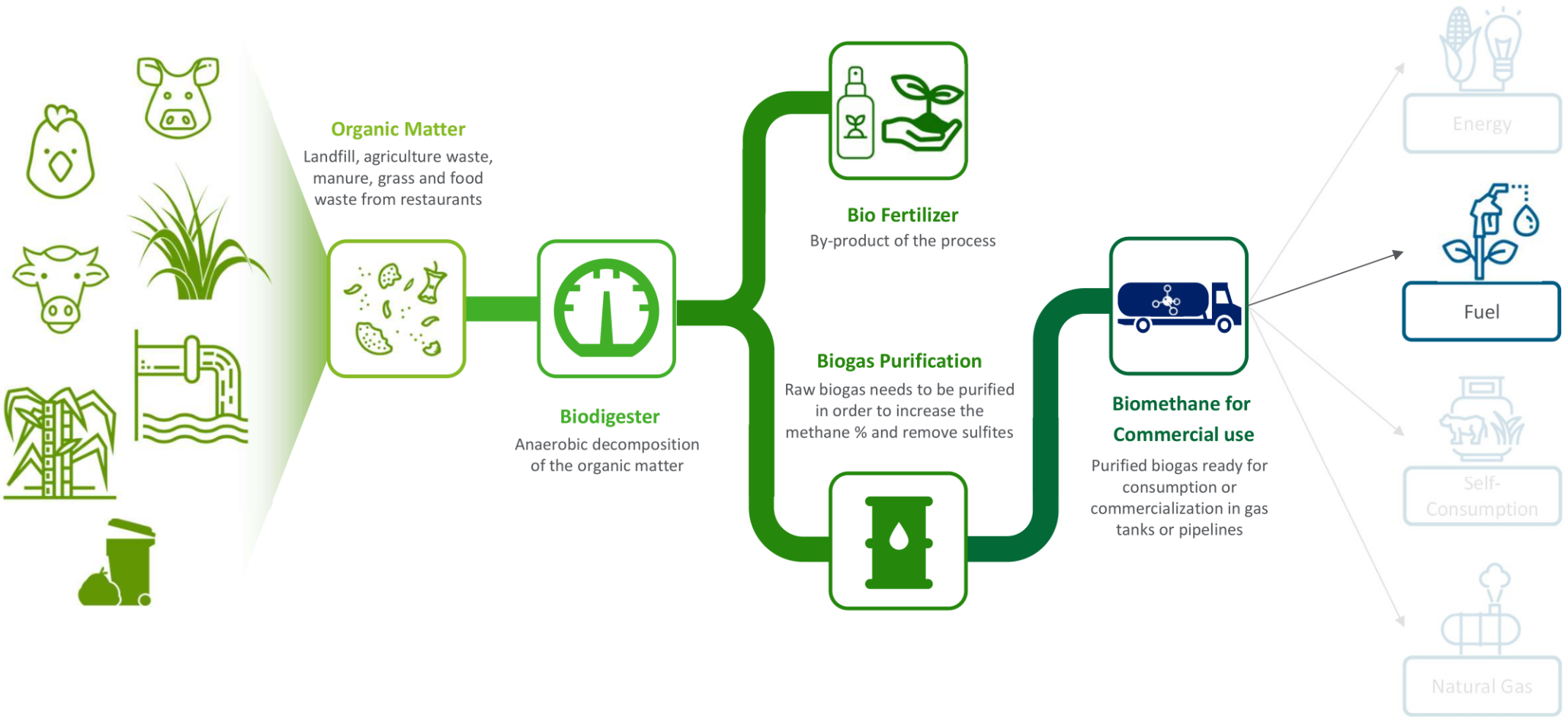
"It is expected a bigger government participation with subsidies and new projects financing. This scenario is very dynamic for positive changes in the short-medium term."

Fatec

Source: EPE/PNBB/TFatec/Deloitte Analysis.

General Sector Overview

Biogas production is based on anaerobic decomposition of organic matter and yields bio fertilizer as by-product.



General Sector Overview

Fuel - Research on Manufacture's Truck or Agricultural Machinery Adopting Biogas – Scania, New Holland and MWM are among manufactures moving to offer new biomethane solutions.

Current Situation

Companies are working to replace diesel with biomethane in their fleets.

Although still incipient, there are some cases of **biomethane powered vehicles** in the market:

- **Scania** has sold 600 units of gas and biomethane trucks in the Brazilian market since 2020;
- **New Holland,** manufacturer of agricultural machinery, launched, in 2022, the first tractor powered by biomethane, with 152 horsepower;
- **MWM**, the manufacturer of engines and generators, has also been betting on new biogas solutions on the market. In addition to the production of electricity generators powered by renewable gas, the manufacturer offers truck conversion services to replace diesel engines with biomethane engines.

Source: EPBR.

Future perspectives

Companies are Looking to use biogas as an alternative to fossil fuels

- **Scania** expects to launch one more gas and biomethane truck model, with 460 horsepower on biogas, in 2024. According to the company's director, the goal is for the number of vehicles of this type sold in the country to reach 2,500 in the coming years;
- **New Holland** is now starting to develop new biomethane machines below 100 horsepower and above 200. The forecast is that, by 2026, they will be ready to show something new to the market;
- **MWM** will focus on bringing solutions for agro costumers who want to decarbonize activities.

The **technology is promising**, however, the **lack of supply of biogas and the fossil fuel culture** are still **major challenges** to overcome before biogas vehicles become mainstream.

General Sector Overview

Urban Vehicles - Sweden is a benchmark in implementing a green fleet, biogas is increasing its percentage of the total fleet over the years.

Sweden's Visions

- Fossil Free Transportation by 2050
- 100% biomethane on pipelines

Incentives

- Free parking for biogas vehicles
- Special lanes for biogas taxis
- Tax incentives for biogas projects
- Bonus for manure-based biogas

Source: energigas.se/ SCG/Clippings/ Deloitte Analysis.

Sweden's Biogas Fleet (% of total fleet)

	47,000 (1%)
	2,300 (6%)
	800 (1%)

World's first Biogas Train

General Sector Overview

Urban Vehicles - Scania started circulating biomethane powered buses in Brazil – The Scania K280 powered bus is available for passengers in Foz de Iguaçu.

"This bus draws attention to the **reduction of operating costs per kilometer**, as well as noise pollution and emissions. In comparison to a diesel-like vehicle, in fact, it emits **85% less gaseous pollutants**, if supplied with biomethane, and 70% if it is with CNG. "

Silvio Munhoz
Scania Sales Director for Buses

Source: SCANIA/Clippings/Deloitte Analysis.

"According to Scania, the **average consumption of biomethane is slightly lower than of diesel** (2.02 km / m³ versus 2.2 km / L), but **costs about 30% less**."

Silvio Munhoz
Scania Sales Director for Buses

Scania Test[1] in São Paulo in 2016: Diesel vs. CNG

CNG		Diesel
700 km	Km	700 km
1.26 km/m³	Consumption	2.14 km/L
BRL 1.12/m³	Price	BRL 2.65/L
555m³	Total Consumption	327 L
BRL 621.60	Total Cost	BRL 868
BRL 0.89	Cost per km	BRL 1.24

Note: Diesel taxes in 2015 PIS/COFINS: BRL 0.2480/L, ICMS 25%, CIDE BRL 0.39/L

General Sector Overview

Urban Vehicles – CNG cars are becoming quite popular for people that desires to purchase a vehicle in 2022. One of the main reason is due to security factors.

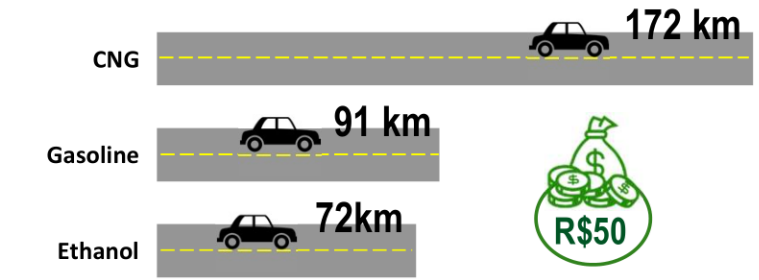
Astra Multipower: The first car in Brazil with CNG from the factory.

Example of 5 cars with CNG from the factory:

- Chevrolet Astra Multipower;
- Ford Ranger;
- Fiat Siena Tetrafuel;
- Volkswagen Santana;
- Toyota Etios.

Average Fuel Range with BRL 50 investment

Sergipe, km, 2022



CNG is more frequently used by uber and taxi drivers and fleet owners due to the fuel economy.

CNG adaptation kits can be purchased in several authorized car workshops – BRL 5,000 investment

For a car that covers 1,000 km/month, payback is around 32 months[3].

Advantages

- Safer (Lower risk of fire and explosions in leak cases due to its density)
- More economy
- Environment preservation

Disadvantages

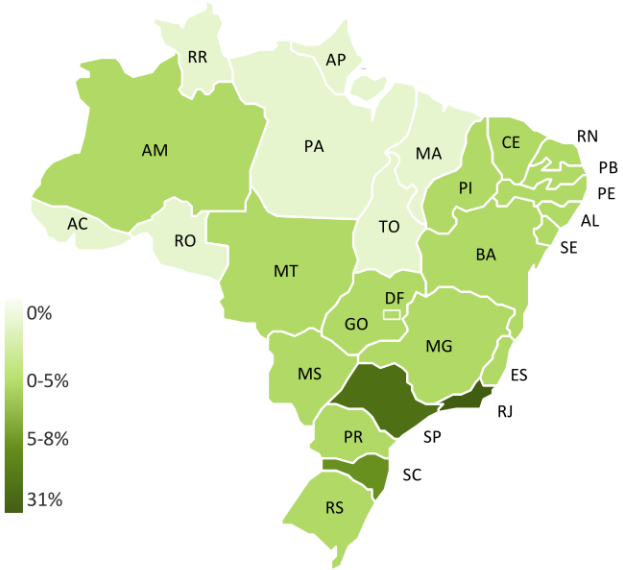
- Loss of vehicle warranty
- Reduced trunk space
- Reduced power

Source: Sergipegas/Webmotors/UOL/ Deloitte Analysis.

General Sector Overview

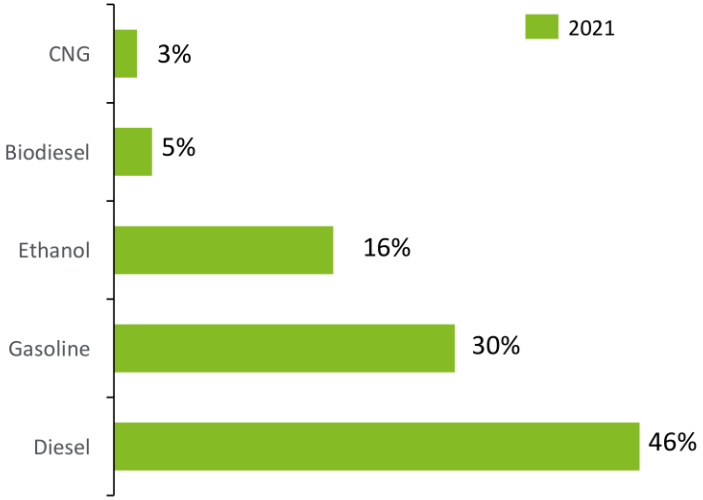
Urban Vehicles - One main factor hindering the adoption of CNG on vehicles is the lack of gas stations throughout the country.

Gas Stations Selling CNG



In 2022, only **1,593 gas stations sold CNG** in Brazil, only **4% of the 41,689 gas stations** of the country **29%** of these stations are in São Paulo and **33%** in Rio de Janeiro. The expectation is that the number of gas stations offering CNG will increase in the next years.

Vehicle Fuel Consumption

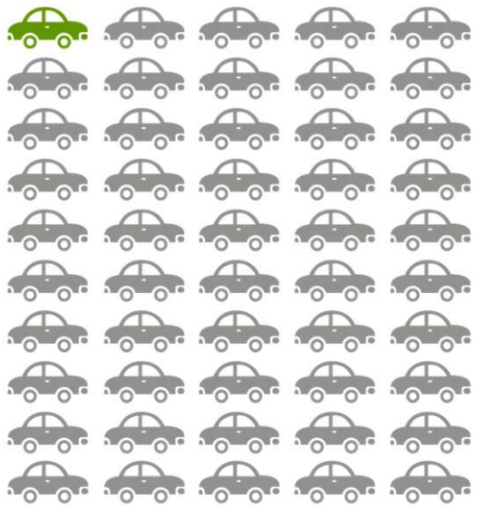


CNG is mainly used by taxi/uber drivers;

Cost of the conversion system and lack of gas stations are the main inhibitors of a major adoption;

The State of Rio de Janeiro is decreasing taxes on vehicles running by CNG to foster the market.

Fleet Fueled by CNG



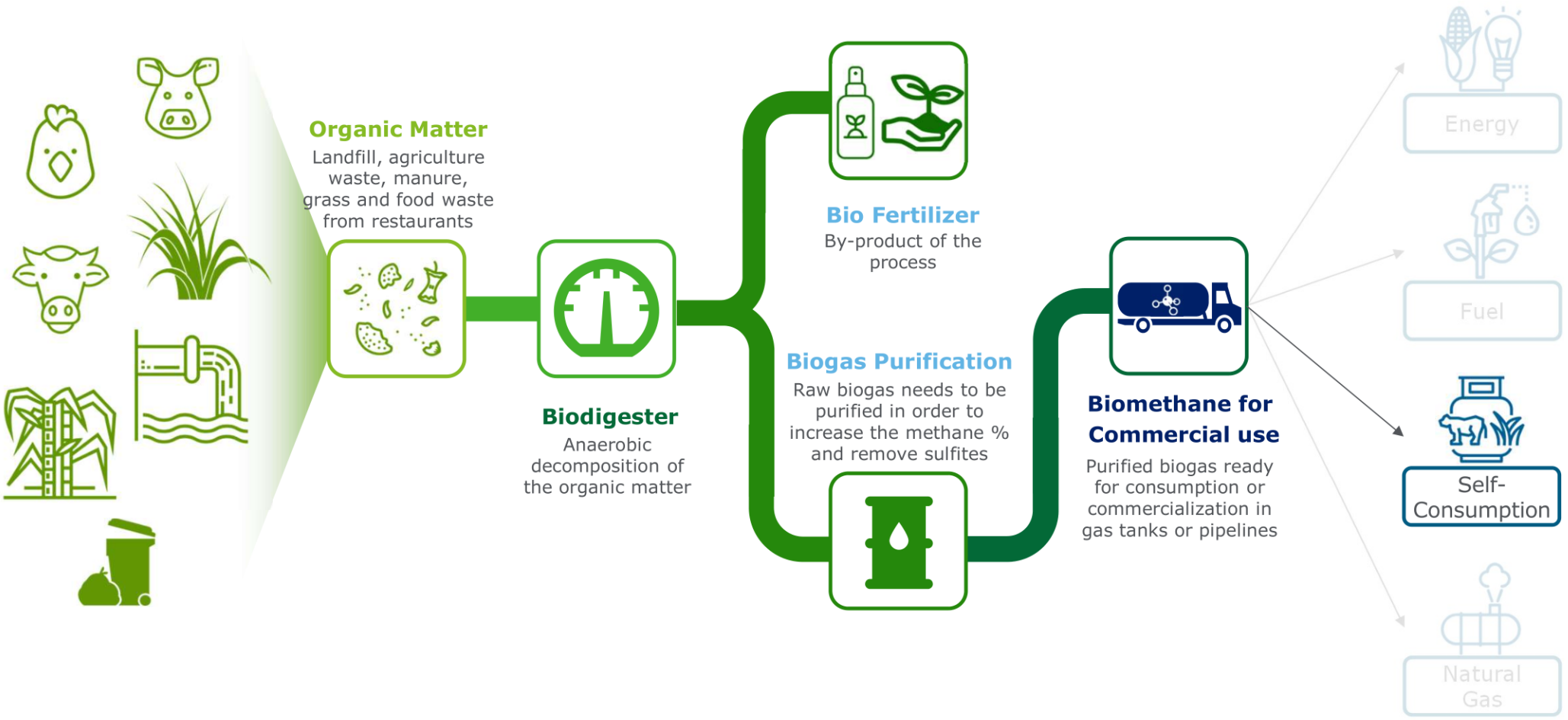
Only about **3%** (2.25 million vehicles) of the Brazilian fleet[1] runs on CNG.

Note: (1) Fleet includes all motorized vehicles registered at DENATRAN.

Source: Gasnet/ANP/IBP/Infomoney/UOL/Deloitte Analysis.

General Sector Overview

Biogas production is based on anaerobic decomposition of organic matter and yields bio fertilizer as by-product.



General Sector Overview

Self Consumption - The Marujo farm is a great example of the use of biogas for self consumption, mainly for thermal energy.

Marujo Farm generates 365 m³ of biogas every year, mostly from swine manure.

The farm plans to purify the gas and use it as vehicle fuel in the future.

- Heating for the maternity and nursery
- Grain drying
- Electric energy
- Biofertilizer
- Fuel – Plans for the future

Source: Marujo Farm website/FIEP/Deloitte Analysis.

General Sector Overview

Self Consumption - Ajuricaba, a condominium with 33 small farms, generates 266,000 m³ of biogas per year, was one of the first initiatives to see value on farm waste.

A 25km pipeline connects the 33 small biodigesters to a thermoelectric power plant.

Source: FIEP/ ITAIPU,/boaspraticas.org/Deloitte Analysis.

Heating:
Self sufficient on cooking gas and water heater. Also used to clean milking equipment.

Grain drying:
Thermic energy to dry the grain production.

Electric Energy:
Production of 24,000 kwh per month, connected to grid to sell excess production.

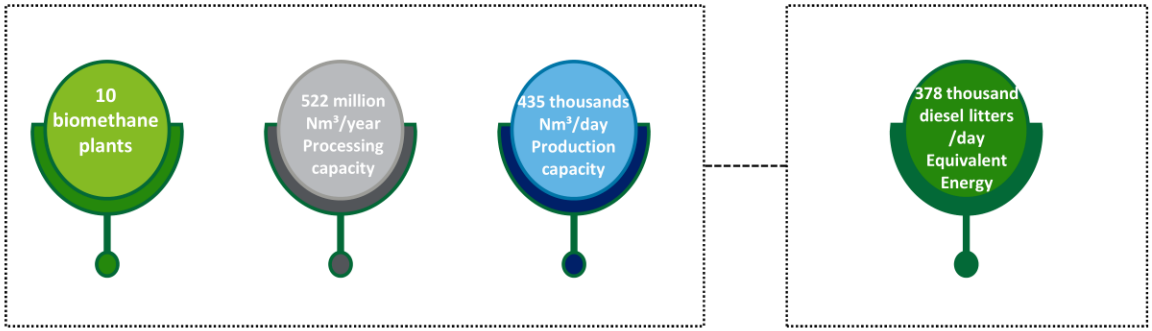
Biofertilizer:
Used on the crops and pasture to increase production.

Environment:
Reduction of greenhouse gases, odour, insects.

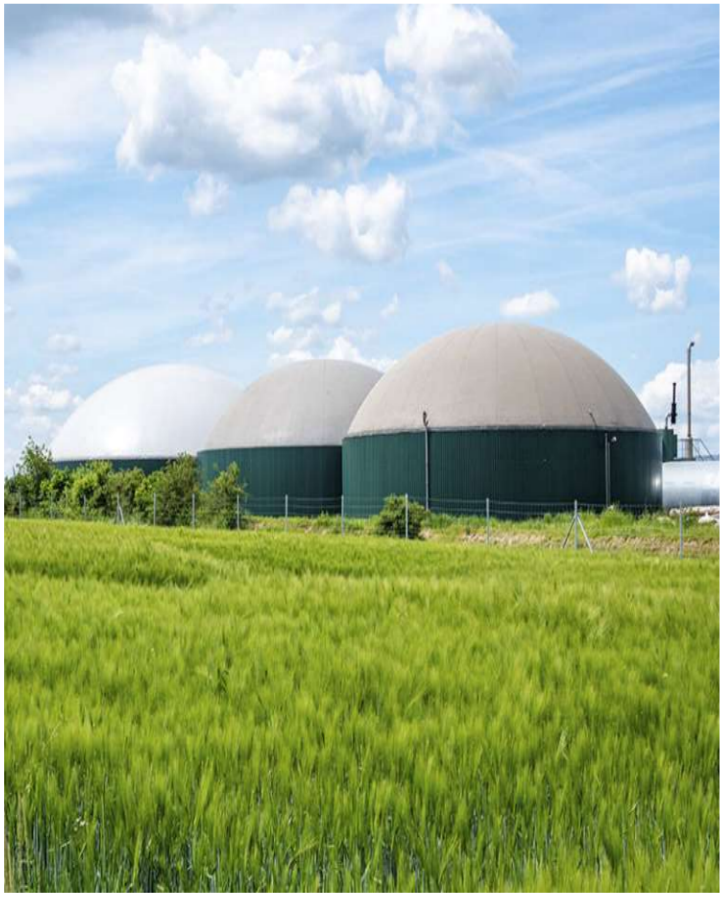
General Sector Overview

Self Consumption - Biomethane – Plants operating represent 23% of the total volume in 2021 – Energy application.

Units that have a biogas purification system with biomethane generation for self-consumption or commercial purposes, add up to 10 plants, which is equivalent to 1% of the national total. However, in terms of volume, such plants correspond to 23% of the total volume of biogas produced in 2021. According to the National Agency of Oil, Gas and Biofuels (ANP), in 2021 there were 4 plants authorized to produce and sell biomethane in the country and 2 in the authorization process. The production of biomethane for commercial purposes is regulated by the ANP.

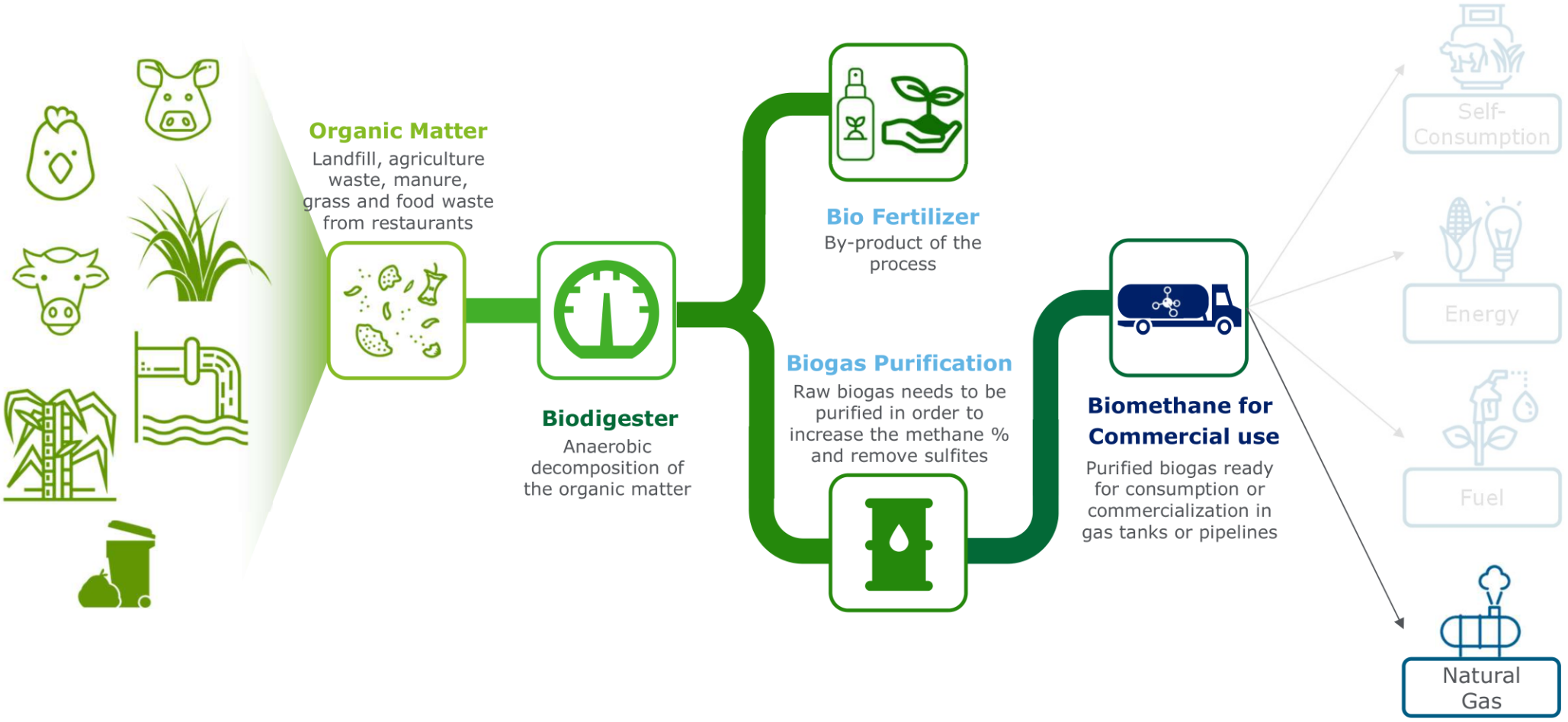


Source: CIBIOGAS.



Public Value Chain

Biogas production is based on anaerobic decomposition of organic matter and yields bio fertilizer as by-product.



General Sector Overview

Natural Gas - Thermal - Gás Verde: First project in the world that connects a landfill to a refinery through pipelines.

gás verde

Joint venture between Biogás, Synthesis e J. Malucelli to explore the methane produced in the Gramacho landfill in Rio de Janeiro. Gás Verde is the largest producer of biogas in Brazil and provides biomethane to Petrobras Duque de Caxias Refinery.

Investment

BRL 240 million were invested in the construction of **301 wells**, a **purification system** to convert biogas into biomethane and a **6 km pipeline** to connect the gas into a Petrobras Refinery.

Quality Standards

5 steps purification system in order to provide high quality biogas according to ANP (National Oil agency) and Petrobras standards.

Capacity

Supplies Petrobras with **70 million m³ of biomethane**[1] per year, 10% of the refinery consumption.

Source: Gas Verde website/ Deloitte Analysis.

Enough to supply all residential and commercial gas consumption in the city of Rio de Janeiro.

Note: (1) Biogas production is 160 million m³.

Main Players

Main Players / Production

Market Competitors in Brazil - Solví: Large waste management group operating thermoelectric power plants close to landfills.

Company Description

Waste management group with operations in the **public and private sector**. Solví has more than **13 thousand employees** and operations in Brazil, Bolivia, Argentina and Peru.

Solví's energy area operates **three thermoelectric power plants in Brazil.**

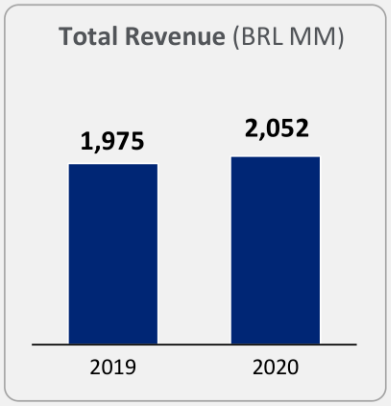
Products/Services

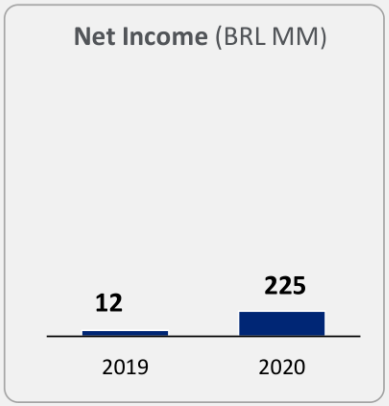
- Waste and disposal treatment;
- Industrial services;
- Concessions;
- Energy.

Biogas Destination

- **Biotérmica S/A** – Biogas thermoelectric plant using landfill as the source of organic matter. Currently has an installed power of 8.5MW with potential to reach 15 MW – enough to supply the demand of a city with 200,000 inhabitants;
- **Termoverde Salvador** – BRL 50 million were invested in this biogas thermoelectric plant that uses a landfill as the source of organic matter. Installed power of 19.73 MW – enough to supply the demand of a city of 300,000 inhabitants;
- **Termoverde Caieiras** - BRL 100 million were invested in the construction of the biogas power plant, substation and wells to capture the gas. Installed power of 29.5MW.

Financial Situation





Source: Company website/Clippings,/Deloitte Analysis.

Main Players / Production

Market Competitors in Brazil - Geo Biogas & Tech is focused on energy production using waste from the sugar cane and ethanol industry.

Biogas Destination

- **Geo Electric Tamboara:** The first large-scale commercial biogas production plant in Brazil to process filter cake, vinasse and straw. The plant operates from sugarcane residues and other agro-industrial residues. It currently produces 25,000 Nm^3/d of biomethane and has 10 MW installed;
- **Raízen Geo Biogas:** It is one of the largest biogas plants in the world, with 21 MW of installed capacity. The vinasse and filter cake, resulting from more than 5 million tons of cane crushed per year, allows the plant to generate 135,000 MWh/year of electricity.
- **Cocal Energy:** Its the first plant with a pipeline dedicated to biomethane in Brazil. With an installed capacity of 5MW of electricity and over 25,000 m^3/d of biomethane, Cocal Energy - Narandiba uses vinasse, filter cake and straw as raw material, resulting from the 5 million tons of cane crushed annually.

Company Description

GEO Biogas & Tech is a **100% Brazilian** company that has developed a **unique and innovative biotechnological process** to produce biogas from the reuse of waste from the agroindustry, tropicalizing the technology and bringing to Brazil the first biogas plant in the sugar-energy sector.

GEO Biogas & Tech has become a **leader in the development of the biogas chain in Brazil**, transforming organic waste into clean electric energy and advanced fuels.

The biogas produced by GEO can be used in the generation of electricity from a renewable source or in the production of biomethane for the replacement of diesel oil.

Products

GEO Biogas & Tech develops customized and economically viable solutions for the use of agro-industrial waste, with great economic, social and environmental benefits.

- Biomethane;
- Biofertilizers;
- Electricity.

Financial Situation

Notes: The financial information of Geo Biogas & Tech wasn't available, therefore, the information presented is from the Consolidated of the parent company Raízen Energia S.A.

Main Players / Production

Market Competitors in Brazil – Ecometano is the first biomethane project on a commercial scale in Brazil.

ecometano

Biogas Destination

Ecometano sells biomethane generated from its two active plants:

- **GNR Dois Arcos:** Is a pioneer in the production of biomethane on a commercial scale in Brazil. Inaugurated in 2014, the plant has the capacity to produce up to 15,000 m³ per day of biomethane, about 5.5 million m³ per year;
- **GNR Fortaleza:** Inaugurated in 2017, the plant captures and treats the biogas produced in the Sanitary Landfill in Fortaleza. It has the capacity to produce up to 85,000 m³ of biomethane per day, around 31 million m³ per year. Currently, it is being expanded to a total capacity of 108,000 m³ per day. The biomethane produced is sold by Cegás, through a long-term contract and injected directly into the gas pipeline.

cegás GÁS NATURAL

Company Description

Created in 2010, with the goal of **capturing and treating biogas generated from renewable sources** such as urban solid waste, organic waste and vinasse, for the production and distribution of biomethane.

Ecometano offers solutions in the biogas and biomethane sector by uniting production from renewable sources (urban solid waste, vinasse and agro-industry waste) with processes and consumer markets.

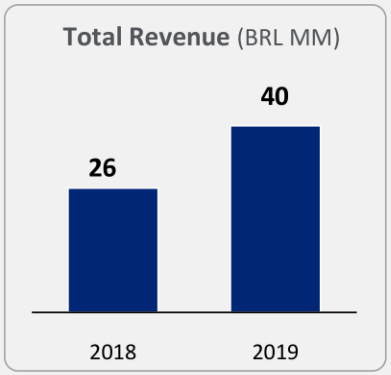
The company **belongs to MDC Group, a Brazilian group of investments in infrastructure**, created in 2006, with a strong presence in the energy market.

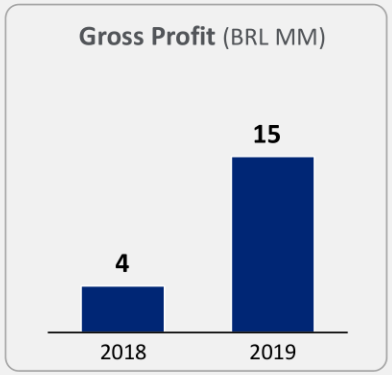
Business Lines

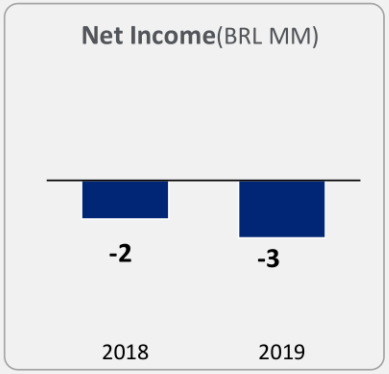
Currently, Ecometano produces biomethane by using three processes:

- **Landfill:** The decomposition of urban solid waste in sanitary landfills generates biogas;
- **The Effluent and Waste Treatment Plant:** The Plant transforms agrosilvopastoral, commercial and effluent waste into energy assets through anaerobic bio digestion. This process results in biogas and biofertilizers;
- **Vinasse:** Energetic use of vinasse, an aqueous by-product resulting from the distillation of sugarcane, as well as other residues from this industry, transforming them into energy actives and high-quality fertilizers.

Financial Situation







Source: Company website/Clippings,/EMIS/Deloitte Analysis.

Main Players / Production

Market Competitors in Brazil - Gás Verde S.A. is the largest biomethane producer in Brazil.

Company Description

Gás Verde S.A. produces and sells biomethane from biogas landfill. In addition, it issues CBIO, and BIORec.

Offers sustainable solutions by supporting the treatment of waste and the effective transition of companies to a cleaner energy matrix.

The company **invested BRL 240 MM** to build the biogas plant that has a processing capacity of **70 million m³ of biofuel per year**, sufficient to supply all residential and commercial consumption of gas in the city of Rio de Janeiro.

Products/Solutions

- **Biomethane:** Daily commercialization up to 175,000 m³ with delivery within 150km of the Seropédica Plant.
- **CBIO**: Gás Verde issues the CBIO's, decarbonization credit from the RenovaBio.
- **BioRec Certificate:** Biomethane from Gás Verde has the BioRec, the certificate that guarantees its origin from a renewable source.
- **Green CO2 (food grade):** In 2023, the company will start producing green C02, with a projection of 100 tons per day.

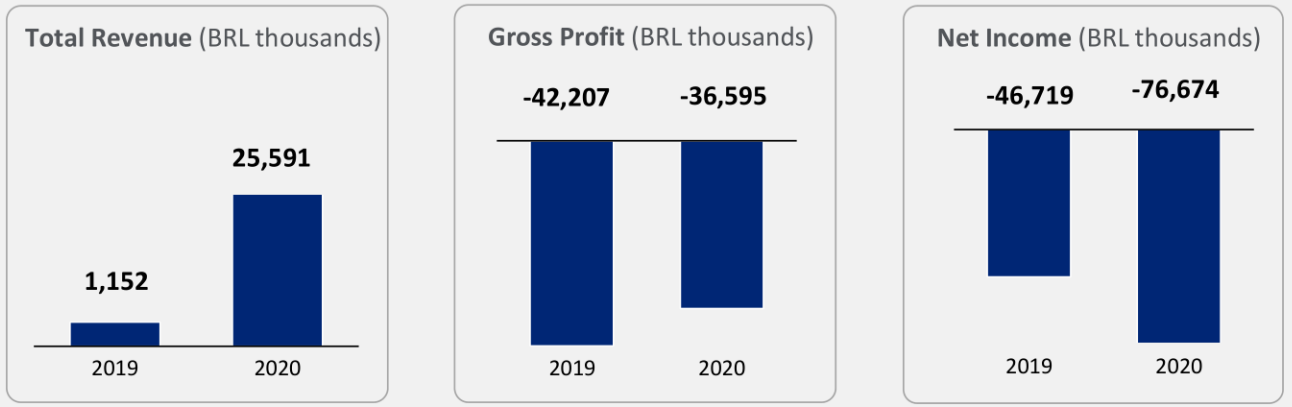
Biogas Destination

The company has three plants in Rio de Janeiro: Seropédica, Nova Iguaçu, and São Gonçalo.

Gás Verde offers an effective solution for fleets and production processes of companies that need to reduce emissions and meet ESG goals, in addition to supporting landfill managers and agribusiness companies in dealing with environmental liabilities.

Gás Verde has three clients that have already started the energy transition:

Financial Situation



Source: Company website/Clippings,/EMIS/Deloitte Analysis.

Main Players / Production

Market Competitors in Brazil - CS Bioenergia – The best organic waste treatment plant. Pioneer in large scale co-digestion.

Company Description

CS BIOENERGIA S.A. is a service provider and generator of energy from biogas. The purpose of the plant is the sustainable and environmentally correct treatment of organic waste from both the largest sewage treatment plant in Curitiba in the form of sanitary sludge and from the commercial and industrial generator in the form of solid or liquid organic waste.

The start of CS Bioenergia was achieved through the partnership between one of the CATTALINI Group companies and SANEPAR.

Products/Services

- **Receive**: Receives materials for the generation of Biogas;
- **Energy (Biogas):** Generated in motor generator units insided the Cs Bioenergia plant itself.

Projects in process:

- **Fertilizers;**
- **Fuel Derived from Waste (CDR).**

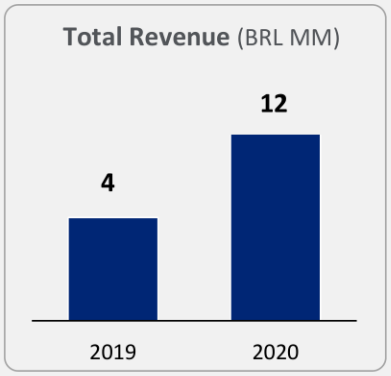
The company also provides services for organic waste with high polluting potential.

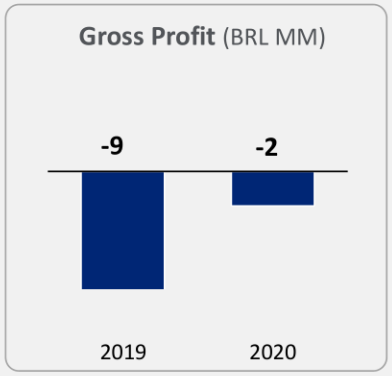
Biogas Destination

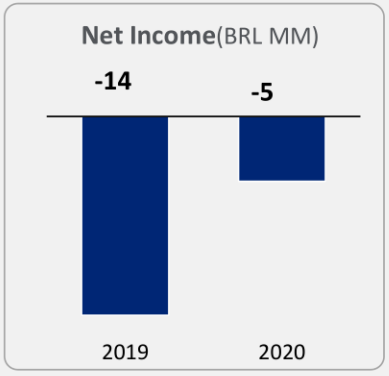
The biogas Plant installation is designed to process organic waste in solid, semi-solid and liquid form.

To be a CS Bioenergia customer, it is enough to be a "waste generator", that is, any industry or service provider that generates organic waste that is not collected by the public collection network and that is commonly sent to landfills and composters by outsourced companies or own collection and disposal of this waste.

Financial Situation







Source: Company website/Clippings,/EMIS/Deloitte Analysis.

Main Players / Distribution

Market Landscape in Brazil - There are 27 natural gas distributors in Brazil and, although only two companies are distributing biomethane, several have shown interest or are very close to distributing it.

Gas Concessionaires in Brazil

There are **27 natural gas concessionaires** in Brazil, all long-term concession granted, **regulated and audited by State Governments and Federal District.**

Only **Cegás (first biogas distributor) and Gás Brasilíano have started distributing biogas** through its pipeline – **all other companies only distribute natural gas.**

Some companies have **shown interest in the biogas market**, and some of them are **very close to begin the distribution of biomethane** through their pipelines.

Source: ABEGAS/Concessionaire's website/ Deloitte Analysi.s.

Main Players / Distribution

Market Landscape in Brazil - CEGAS currently was the first distributor of biomethane in Brazil because it was the first to obtain ANP certification and needs and extra gas supplier to fulfil the demand.

- Fuel is from biogas generated from solid waste at ASMOC (Municpal Sanitary Landfill West of Caucaia).

- Cegás invested BRL R$22 million in the construction of a custody transfer station and a 23 km long pipeline that transports renewable natural gas produced from biogas generated from solid waste at ASMOC.

- A Public-Private Partnership project. The Ceará government structured the operation and distributes renewable natural gas, through Cégas, the City Hall of Fortaleza facilitated the access to solid waste, GNR Fortaleza set up the production plant and Cerbras committed to initially consume the gas produced.

- The project complies with the National Policy on Solid Waste and the State Policy on Solid Waste, since the landfill daily receives around 3,000 tons of household solid waste, which are converted into biogas by bacterial action and purified in an industrial plant to generate Renewable Natural Gas – GNR.

- The 23km gas pipeline was built in Polyamide 12 and is considered the largest in the world using this material.

Legend:
- Concessionaires that already distribute biogas
- Concessionaires that showed interest in biogas

Source: ABEGAS/CEGAS/Deloitte Analysis.

Main Players / Distribution

Market Landscape in Brazil – Cocal acquired authorization from ARSEP for the biomethane purchase and sale agreement with Gas Brasilíano.

GAS BRASILIANO

energia responsável cocal

- The unit has capacity to produce 33.1 million Nm³ of biogas from sugarcane waste (filter cake, vinasse and straw) per year. Of this volume, a part is destined for distributed generation (becomes electrical energy dispatched on the grid) and the other is transformed into biomethane. As a result, around 4.4 million m³ of biomethane are distributed by GasBrasiliano. A third portion of the gas is used in Cocal's own fleet.

- The total investment in the project was BRL R$160 million, Cocal's part was R$130 million, to produce fuel and GasBrasilíano entered with R#30 million, destined for the construction of 65 km of distribution network.

- Cocal's initial goal is to consume 3 thousand m³ per day of biomethane. The demand is currently at 1.14 thousand m³ per day.

- The municipalities of Narandiba, Pirapozinho and Presidente Prudente, all in the interior of São Paulo, were the first to be supplied with biomethane in the region, serving industries, businesses, homes and light and heavy vehicles. (GNV)

- This production is also beneficial to the environment, as it offers a new source of clean and renewable energy for consumption, contributing to regional development and ensures noble destination for industrial waste.

Source: ABEGAS/CEGAS/Deloitte Analysis.

Legend:
- Concessionaires that already distribute biogas
- Concessionaires that showed interest in biogas

Main Players / Distribution

Market Competitors in Brazil - 10 of the 27 gas distribution companies have shown interest in the biogas market, some of them are very close to begin distribution of biomethane.

Company	Concession State	Interest in Biogas	Description
cegás GÁS NATURAL	CE	✓✓✓	• Cegás has started distributing biomethane through a dedicated pipeline, originated from the GNR Fortaleza plant, which produces biomethane from the waste of the Caucaia landfill.
ceg rio gasNatural fenosa	RJ	✓✓	• Ceg Rio is very close to incorporate biomethane originated from the Dois Arcos landfill into its gas pipeline in Rio de Janeiro, depending only on regulatory approvals.
SULGÁS	RS	✓✓	• Sulgás is very close to start commercializing biomethane originated from biomethane supply contract in RS with SebigasCótica.
SCGÁS	SC	✓✓	• SCGÁS has new public auctions for biomethane in progress.
POTIGAS COMPANHIA POTIGUAR DE GÁS	RN	✓	• Potigás is doing a feasibility analysis to produce and commercialize biogas from the Braseco Landfill, located in the city of Ceará-Mirim, in the Great Natal area.
Copergás	RN	✓	• Copergás has its first public auction for biomethane in progress.

✓✓✓ Already distributes biomethane ✓✓ Close to inject biomethane into pipeline ✓ Showed interest in biomethane

Source: ABEGAS/CEGAS/Deloitte Analysis.

Main Players / Distribution

Market Competitors in Brazil - 9 of the 27 gas distribution companies have shown interest in the biogas market, some of them are very close to begin distribution of biomethane.

Company	Concession State	Interest in Biogas	Description
COMGÁS	SP	✓	• Comgás wants to eliminate greenhouse gas emissions and starts to invest in biomethane.
COMPAGAS	PR	✓✓	• Compagás has new public auctions and market opening studies for biomethane in progress.
PBGÁS	PB	✓	• The company has shown interest in conducting a feasibility analysis of the use of the biogas generated in the landfill of João Pessoa (PB).
GAS BRASILIANO	SP	✓✓✓	• Gas Brasiliano and Cocal have acquired authorization from ARSEP for a biomethane purchase and sale agreement.
BAHIAGÁS	BA	✓	• The company has new public auctions for biomethane in progress.
SERGAS	SE	✓	• Sergás is currently analyzing the possibility of using Biogas.

✓✓✓ Already distributes biomethane ✓✓ Close to inject biomethane into pipeline ✓ Showed interest in biomethane

Source: ABEGAS/CEGAS/Deloitte Analysis.

Federal Government Strategy

Federal Government Strategy

Biodiesel Cost & Performance Comparison - The government has been creating incentives to biodiesel industry as it has an important strategic role to Brazil's social-economic and environmental landscapes.

Government Incentives to foster...

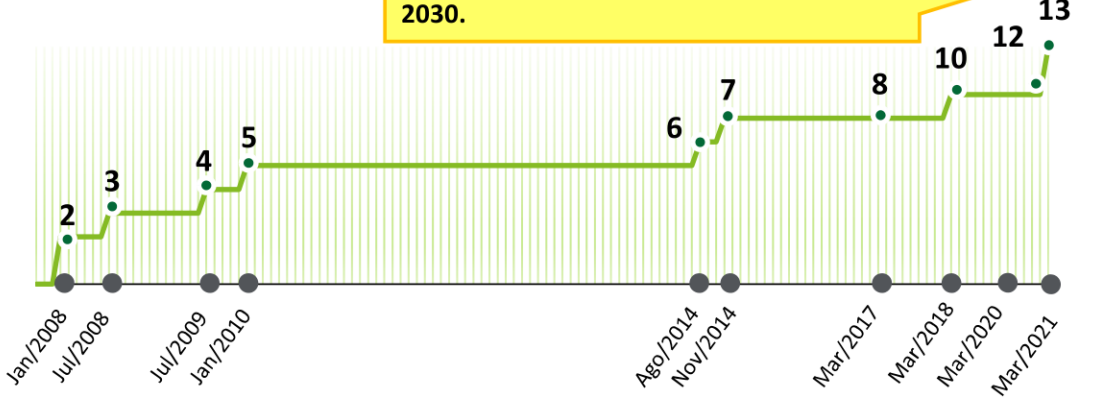
Biodiesel Consumption

The **National Program of Use and Production of Biodiesel** from **ANP** mandates that all diesel sold in national territory must have a **% of biodiesel included** in the regular diesel.

Biodiesel Mandatory %

Brazil, 2021

Regulatory compliance drives biodiesel demand. Current mandatory biodiesel mixture is 13% with plans to reach 20% by 2030.



Biodiesel Production

The government has been encouraging **both biomass and biodiesel** production by creating **social programs** to help family farming and granting rate reduction.

Social Fuel Certificate

Awarded by the Ministry of Agrarian Development to producers of biodiesel that **promote social inclusion and regional development through the generation of jobs and income for family farmers** that meet the criteria of PRONAF (National Program to Strengthen Family Farming). Producers with the certificate are **allowed to participate in ANP's biodiesel tenders and are granted tax benefits.**

Source: Law 13.033/2016 ,GOV.

Federal Government Strategy

Biodiesel Cost % Performance Comparison - The biodiesel incentive projects focus on a diversified and sustainable production.

Project Focus

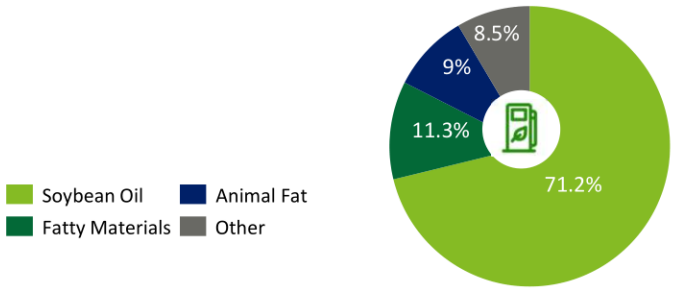
The Federal Government has defined as priority the expansion of **production and consumption,**in a **sustainable way**, focusing on social inclusion and regional development **through raw material and production regions diversification** to generate income and employment.

"In order to also **avoid a possible food crisis**, the biofuel production programs must stablish effective rules. As occurred in the National Program of Use and Production of Biodiesel in Brazil, which mandates biodiesel raw material producers to also **cultivate the same crops for food production**"

The National Program of Use and Production of Biodiesel

Brazilian Biodiesel Sourcing

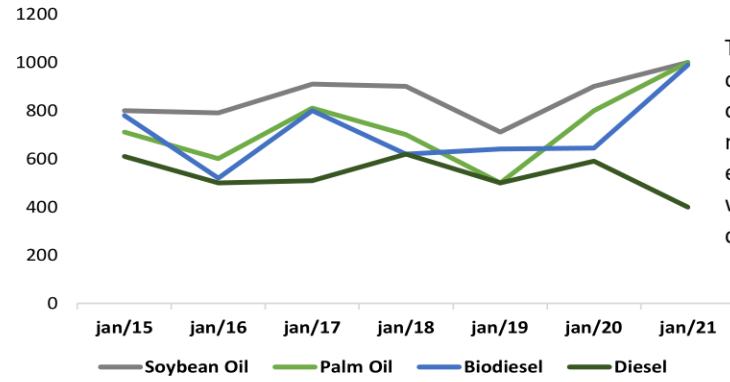
%, 2020



In 2020, the amount of Biodiesel grew by 9% when compared to the previous year, reaching the record volume of 6.43 million m³. The main raw material was the soybean oil (71.2%), followed by other fatty materials (11.3%).

International Standards Prices for biodiesel, diesel, soy and palm oils

US$/ metric tons (Approximate Values)



The raw material corresponds to about 80% of the total cost. For the next ten years, it is estimated that the price will follow the values of commodities in general.

Source: EPE/PDE 2031.

Laws and Regulations

Current Legislations and Legal Framework - What is RenovaBio?

RenovaBio is an acronym for National Biofuel Policy, which aims to expand the production and use of biofuels in the Brazilian Energy Matrix. This public policy defines the strategy to ensure the strategic role of biofuels, especially when it comes to energy security and reducing greenhouse gas emissions.

RenovaBio is a market driven incentive mechanism, based on the economic theory of "Coase Market" for pricing externalities. It transfers the social and environmental costs of using fossil fuels as an income to the production of biofuels. It values the service of GHG withdrawal from the atmosphere made by the biofuels. This mechanism brings incentives to the sustainable expansion of biofuels, based on efficiency. **RenovaBio** creates a "Carbon Credits" per unit of energy increasing efficiency in the production of biofuels, certified individually by producer.

RenovaBio creates an integrative agenda for a smooth transition on transportation of the energetic matrix. It values the great potential of energy production from biomass in Brazil (especially sugar cane, corn, soy, and residues - e.g., tallow). It allows the integration of different biofuels (ethanol, biodiesel and biomethane) in the Brazilian transportation matrix, which already has infrastructure (filling stations) and technology (flex-fuel engines, for example) to promote this transition very efficiently.

The central principle of **RenovaBio** is the calculation of the Energetic-Environmental Biofuel Index (NEEA), which is the difference in emissions (given in gCO2eq/MJ) between fossil fuel and substitute biofuel, through a Life Cycle Assessment "from well to wheel" approach.

The **RenovaCalc** is designed to account for GHG emissions across the entire biofuel life cycle and generate a Biofuel Carbon Intensity, that subtracted from the fossil fuel CI generates the Energetic-Environmental Biofuel Index (NEEA). The NEEA reflect the individual contribution of each production agent, vis-à-vis the mitigation of a specific amount of greenhouse gas, in relation to its fossil substitute (in terms of tones of CO2eq).

To convert the **Energetic-Environmental Biofuel Index** (NEEA - given in gCO2eq/MJ) into Decarbonization Credits (CBIO - given in ton CO2eq avoided), NEEA is multiplied by the eligible volume of biofuel. Another very important concept of the Policy, the Eligibility Criteria are requirements that link biomass production to sustainable land use, through LUC risk management mechanisms, which includes:

1) No native vegetation suppression (since November 2018). Zero deforestation in biomass production;
2) Comply local environmental legislation (like Brazilian Farm Environmental Registration - CAR);
3) Comply agro ecological zoning (if applicable).

The **Biofuel Decarbonization Credit** (CBIO) is a financial product backed by CO2 emissions, traded on the stock exchange, and issued by the biofuel producer, based on the commercialization of their certified production. Fossil Fuel distributors must meet the target (national emission reduction targets for the fuel mix, set for a 10-year period) by demonstrating the required amount of CBIOs on their property. Other agents (individuals and companies) will be able to buy and sell CBIOs on the stock exchange, as a way of bringing more liquidity to this market or a green bond abroad. It is a green economy road map for transportation transition to a low carbon economy.

Source: Gov.

Laws and Regulations

Current Legislations and Legal Framework - What is RenovaBio?

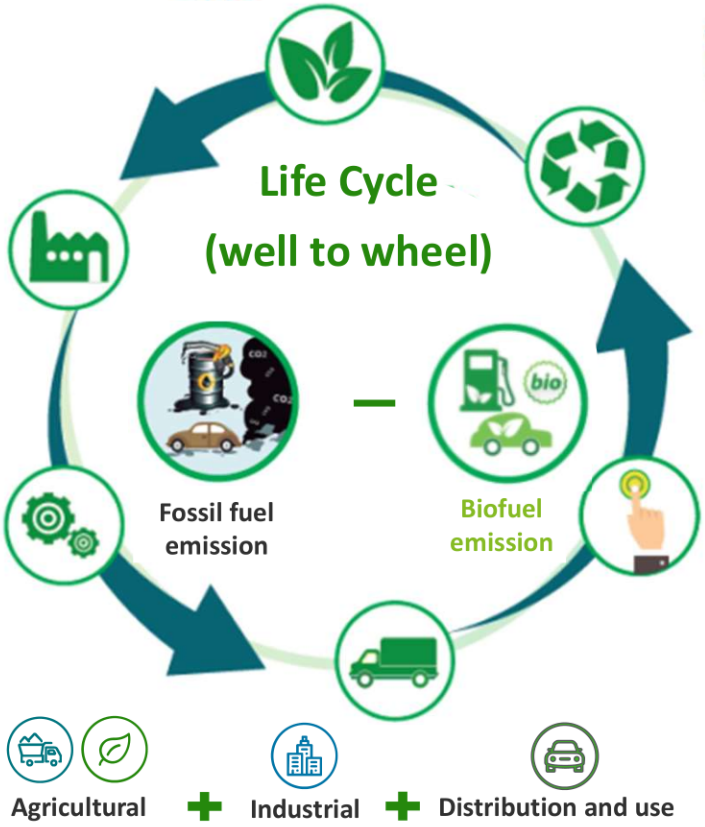
RenovaBio

RenovaBio

Brazilian Biofuels Policy

RenovaCalc

Efficiency incentives to sustainable expansion.

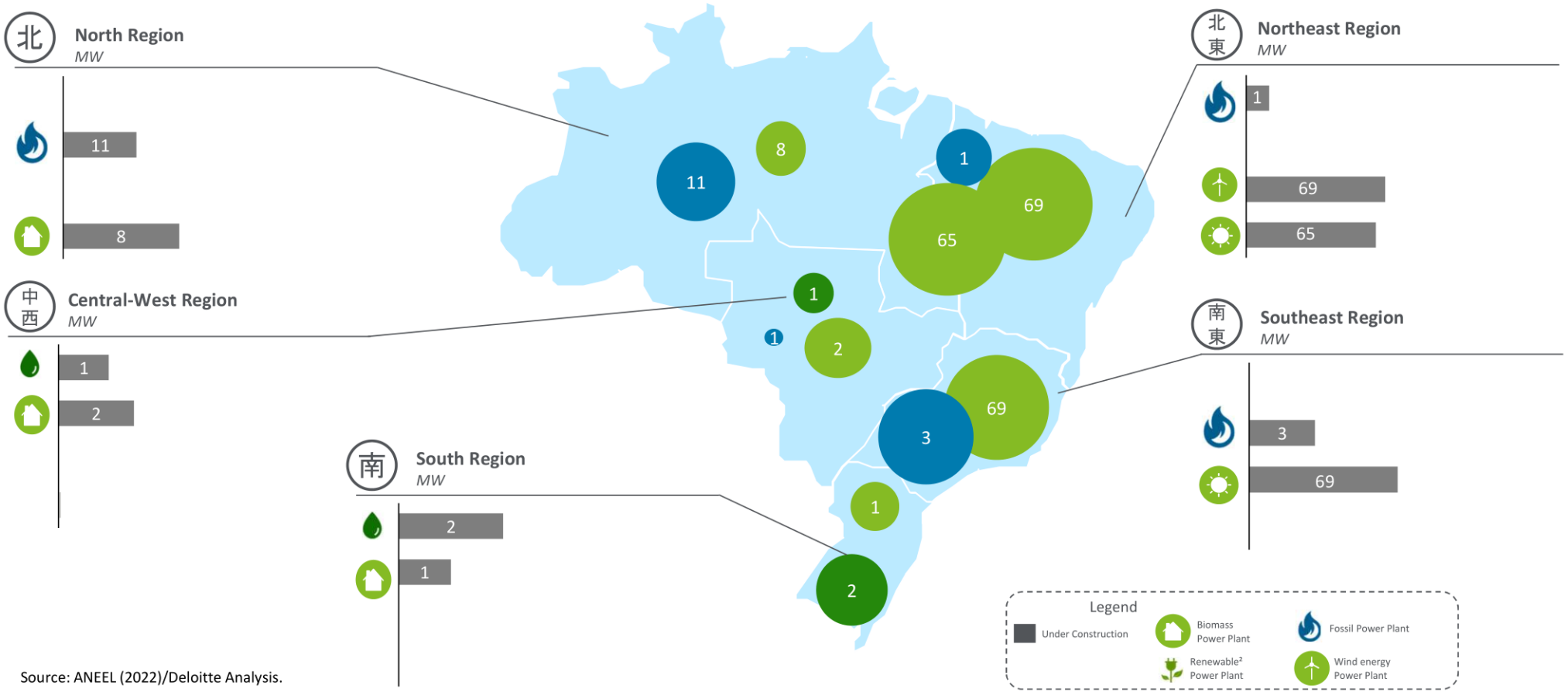


Source: Gov/Embrapa.

Main Projects Portfolio

Main Projects Portfolio

Opportunities on Power Generation – 232 power plants are under construction to start operating in 2023.



Source: ANEEL (2022)/Deloitte Analysis.

Main Projects Portfolio

Opportunities on Power Generation – There are 300 biogas power plants in 2021.

Biogas Power Plants
(Number of biogas plants by state)

Top 15 Biogas Thermoelectric Power Plants

Power Plant	City	State	Power (MW)	
Termoverde Caieiras	Caieiras	SP	29.5	
São João Biogás	São Paulo	SP	24.6	
Salvador	Salvador	BA	19.7	
Guatapará	Guatapará	SP	5.7	
Asja Sabará	Sabará	MG	5.7	
Tecipar	Santana de Parnaíba	SP	5.7	
Estre	Fazenda Rio Grande	PR	5.7	
Bandeirantes	São Paulo	SP	4.6	
CTR Juiz de Fora	Juiz de Fora	MG	4.3	
Novagerar	Nova Iguaçu	RJ	4.0	
Uberlândia	Uberlândia	MG	2.9	
Usitrar Eco Energy	Cabreúva	SP	2.7	
PCT Barueri Biogás	Carapicuíba	SP	2.6	
Arrudas	Belo Horizonte	MG	2.4	
Ambiente	Ribeirão Preto	SP	1.5	

Animal Manure Urban Solid Waste

Source: ANEEL/BEN 2022/Deloitte Analysis.

Main Projects Portfolio

Power Energy Tenders – Pioneer projects - Even though there were no tenders focusing only on biogas yet, biomass and biogas plants participate in energy tenders, Raízen was the first biogas plant to sell energy in a regulated auction.

raízen

UTE Biogas Bonfim - Tender A-5 of 2016

- 1st Biogas plant to win a tender
- Investment: BRL 130 MM
- Organic Matter: Vinasse
- Total Power: 21 MW
  Regulated Market: 14MW
  Price: BRL 251/MWh
  Open Market: 7MW

"In 2014, the A-5 Tender had a biomass price ceiling of BRL 209 per MWh. In 2015, this remuneration increased to BRL 281 and now it reduced by more than 11%, dropping to BRL 251 per MWh. We had hoped that the price for bioenergy would continue to improve, incorporating the benefits of this source into the system and stimulating a more robust return on investment"

Zilmar Souza – ÚNICA – Sugar Cane Industry Union.

UNIÃO DA INDÚSTRIA DE CANA-DE-AÇÚCAR
ETANOL · AÇÚCAR · ENERGIA SÃO PAULO · BRASIL

Source: Clippings/Deloitte Analysis.

Main Projects Portfolio

Power Generation Cases – Pioneer projects.

Project	Description	CAPEX	Production
Termoverde Caieras	Termoverde is the largest biogas thermoelectric plant supplied by a landfill in Brazil and one of the largest in the world, the plant was built and is controlled by Solví in the Caieiras landfill. BRL 100 million were invested in the construction of the power plant, substation and wells to capture the gas. It has an installed power 29.5 MW and generates around 250,000 MWh per year. Its annual biogas production is around 80 to 100 million Nm³/year. It is enough to fulfill the power demand of a city with 300,000 inhabitants. In July 2016, Termoverde was authorized by Aneel to start its operation. The plant is connected to SIN[1] (National Interconnected System). The generation of clean energy from biogas is sold on the open market and is also accredited to issue carbon credits.	BRL 100 MM	29.5 MW installed power; 250,000 MWh/year and 80-100 Nm³/year biogás production.
Dois Arcos	Dois Arcos was the first initiative to produce Biogas from a landfill in Brazil. It was a partnership between EcoMetano (gas exploration) and OSAFI (landfill) in São Pedro da Aldeia, Rio de Janeiro. BRL 18 million were invested in the Dois Arcos landfill in the construction of 50 wells and a biogas treatment plant. The landfill produces 5.5 million m³ of biomethane per year. Currently the gas is sold in tanks. Dois Arcos is ready to be connected into CEG Rio system by a 5km pipeline. National Gas Agency already certified the purity of the gas, but the distributor (CEG Rio) has not built the pipelines yet.	BRL 18 MM	5.5 MM m³/year of biomethane.
GNR Fortaleza	GNR Fortaleza was the first gas producing facility in Ceará. It is a Joint Venture between EcoMetano and Grupo Marquise. It is the second largest biogas production facility in Brazil. BRL 100 million were invested in the construction of 200 wells and a purification system. It produces 36.5 million m³ of biomethane per year. GNR Fortaleza is currently authorized by the ANP to inject into Cegás distribution network.	BRL 100 MM.	36.5 MM m³/year of biomethane.

Source: Companies' website/Deloitte Analysis.

Main Projects Portfolio

Self Consumption - Self Consumption Projects.

	Project	Location	Status	Biogas Production	Gas use
Urban	ETE Arrudas	Sabará - MG	In operation	9 million m³ of Biogas per year, 67% methane	Electric energy for self consumption (2.4 MW)
	Canhanduba Lanfill	Itajai - SC	Closed landfill	4.5 million m³ per year	Electric energy for self consumption and sales (800kWh)
	Sewage of Ribeirão Preto	Ribeirão Preto - SP	In operation since 2002, capacity of 1,450 l/s	2.9 million m³ of Biogas per year, 65% methane	Electric energy for self consumption (1.5 MW)
Agriculture	São Pedro Colombari Farm	São Miguel do Iguaçu – PR	Operational pig farm – 5,000 pigs	274 thousand m³ Biogas per year	Electric energy 1,000kw/h day Biofertilizer on pasture Gas for vehicles (own fleet)
Industrial	São Martinho	Pradópolis – SP	In operation – vinasse	9 million m³ of biogas per year, 70% methane	Electric energy (5,625 MW) and thermal to dry yeast
	Ecocitrus	Montenegro - RS	In operation – waste from citric juices and milk products	1 million m³ per year, 76% methane	Biomethane (96%) to be used in cars (own fleet)

Source: FIEP/ Deloitte Analysis.

Main Projects Portfolio

Some of 2022 projects - CAPEX for biogas installations varies greatly according to the production capacity, technology and purifying processes.

Project	Description	CAPEX	Production
Gás Verde (URCA Energia Group)	Urca Energia announced the construction of a plant that will produce green carbon dioxide (CO2) at the Waste Treatment Center (CTR) in Seropédica. It will be the first plant in Brazil to produce green CO2 by using biomethane generated from organic landfill waste. The expectation is that the plant will start operating in 18 months. The plant will generate around 100 tons of green carbon dioxide per day, which represents approximately 10% of daily consumption in Brazil, which is 1,100 tons.	BRL 45 MM	100 CO2 tons
RZK Energia	RZK Energia announced its funding of BRL 56 million for renewable plants (solar and biogas), from the issuance of green bonds. The company's forecast is to deliver nine more solar plants and one more biogas plant, also, expects to reach 29 plants by 2023.	BRL 56 MM	The company's forecast is to reach 43MW by 2023 with all biogás plants.
Uisa and Geo Biogás & Tech	Uisa and Geo Biogás & Tech signed an agreement for the construction of a plant attached to Uisa's industrial complex, located in Nova Olímpia - MT. The plant will convert liquid and solid residues (vinasse, filter cake and straw) resulting from the processing of sugarcane, other biomass and local agro-industrial residues into biogas, also serving as a platform for the treatment of organic effluents. The biogas obtained at the Uisa Geo Biogás unit will allow, in the first phase of the project, the generation of 32,000 megawatts per hour per year (MWh/year) and 64,000 MWh/year in its second phase. This energy is enough to supply, for example, a city with 40 thousand inhabitants. The project foresees a total production of 10.2 million cubic meters of biomethane per year (Nm3/year).	BRL 220 MM	64,000 MWh/year and 10.2 MM Nm^3/year.

Source: Companies' website/Deloitte Analysis.

Main Projects Portfolio

Some of 2022 projects - CAPEX for biogas installations varies greatly according to the production capacity, technology and purifying processes.

Project	Description	CAPEX	Production
Raízen Geo Biogás	Raízen, through Raízen Geo Biogás S.A., its Joint Venture with Geo Energética, announces the construction of its second biogas plant, the first dedicated to the production of renewable natural gas (biomethane). With an investment of approximately R$ 300 million, the plant attached to Bioparque Costa Pinto located in Piracicaba (SP) will have a production capacity of 26 million m³ of renewable natural gas per year, enough to supply approximately 200 thousand residential customers.	BRL 300 MM	26 MM m³
Geo Biogás and Crivelaro Group	Geo Biogás & Tech and Grupo Crivellaro, an industrial waste management company, announced the formation of a joint venture for the production of biomethane in São Paulo. The companies will invest BRL 70 million in a new plant for the production of biogas and biomethane from the treatment of organic waste from the food and consumer goods industries. The plant is scheduled to operate in 2023 and will be built in the municipality of Elias Fausto, in Greater Campinas. The unit will have the capacity to produce 15,000 m³/day of biomethane and generate 11,000 MWh of electricity from biogas.	BRL 70 MM	15,000 m³/day and 11,000 MWh.
Vivo and Gera Group	Vivo opens, in Santos, its first biogas distributed generation plant in the state of São Paulo. Built in partnership with Grupo Gera, the plant is installed in an area of 1,490 square meters, next to the Terrestre Ambiental landfill. The Terrestre Ambiental landfill plant will use between 2,500 and 5,000 Nm³/h (normal cubic meter per hour) of biogas with a high methane content (about 50% in its composition) to generate electricity and carbon credits	Not available.	5,000 Nm³/h

Source: EPBR/Energia e Biogas/Companies' website/Deloitte Analysis.

Financing Sources

Financing Sources

Subsidies and Incentives - There are no government incentives for the use of vinasse, filter cake or sugar cane bagasse in the generation of electric energy for self consumption.

Vinasse

- Residue after the distillation of the sugar cane;
- 10 – 18 liters of vinasse are produced for every liter of ethanol;
- Highly polluting if dumped into water;
- Can be used in moderation as fertilizer (rich in Ca, Mg and K) or to produce biogas.

Sugar Cane Bagasse

- Residue after milling the sugar cane;
- Can be used to produce 2nd generation ethanol – increasing ethanol production in 50% without increasing crop area;
- Usually used as biomass on thermoelectric power plants;
- 1kg of bagasse can be transformed in 250g of activated charcoal.

Filter Cake

- Residue after the filtration of the sugar cane juice;
- 30-40kg of filter cake for every ton of processed sugar cane;
- Can be used as fertilizer, rich in N,P,K, Cu and Zn;
- Helps in the control of roundworms.

Farmers utilize the residues of the sugar cane in their own crops to avoid incurring extra costs in the correct waste disposal, to create savings in the purchase of fertilizers or new revenue sources producing energy.

Notes: (1) Government incentives exists for plants that are not power generation plants, but use cogeneration to produce energy; however, these incentives are not related to the organic matter utilized.

Source: Novacana/UNIFESP/Raizen/UNICA/gestaonocampo/Revista Brasileira de Energia Renovável/Deloitte Analysis.

Financing Sources

Subsidies and Incentives - Public institution offers special loans for innovation and renewable energy projects.

BNDES

Low Carbon Agriculture Program

Interest: 7.0% - 8.5% year

Amount: up to BRL 5 MM

Terms: 5 years grace period
Up to 10 years payment

Source: Abiogás/BNDES/Deloitte Analysis.

Other Incentives

IPVA discounts: Tax benefits for cars running on CNG² (Rio de Janeiro)

REIDI: Special incentive for infrastructure development

PROINFA: Incentive program for alternative energy sources (wind, hydro, biomass)

Financing Sources

Biogas Funding – Main Financing Programs: Safra Plan

Safra Plan	
Financing Institution:	Ministério da Agricultura, Pecuária e Abastecimento
Target:	National rural producers.
Objectives:	The Safra Plan, established in 2003 by the federal government to encourage rural production company, annually allocates funds for investment or for funding, industrialization and commercialization of agricultural products. In the 2021/22 Safra Plan, the budget package allocated to the ABC Plan adds up to R$ 5 billion and expands the sustainability models contemplated, such as production of bio inputs and biofertilizer. Projects with biogas and biomethane benefit from financing of up to R$ 20 million per project – with possibility of being a collective project, that is, a consortium of producers. This kind of investment expands the options for producers who are not yet able to explore the entire potential of biogas and biomethane in its activities, such as sugar-energy plants, for example.
Interest rate:	3% a 12.5% per year.
Maximum loan value:	R$ 20 million (For biogas or biomethane projects).
Deadline:	up to 12 years.

Eligible items:

- For the 2021/22's Safra Plan, R$ 251.2 billion were made available for rural credit. Of this amount, R$ 177.8 billion will be used to finance the costing, commercialization and industrialization and for financing investments R$ 73.4 billion were made available. Of this total of R$73.4 billion in resources made available for financing of investments, R$ 17.6 billion are allocated for Pronaf, R$ 4.12 billion for PCA Program and R$5.0 billion for the *ABC Program.*

Source: Abiogás/GOV/Deloitte Analysis.

Financing Sources

Biogas Funding – Main Financing Programs: ABC Program – The Program allocated more than BRL R$17 billion between 2010 and 2019.

ABC Program (Low Carbon Agriculture)	
Financing Institution:	BNDES
Target area:	Whole Country
Objectives:	Financing projects aimed at reducing the emission of greenhouse gases and other environmental influences from agricultural activities, such as: – Implementation, maintenance and improvement of waste treatment systems from animal production for energy generation and composting (ABC Waste Treatment).
Interest rate:	7.0% - 8.5% per year
Maximum loan value:	R$5 million per customer, per agricultural year
Deadline:	up to 10 years, including grace period until 5 years

Eligible items:

The investment project may include the following items:

- Preparation of technical project and georeferencing of rural properties, including technical and administrative expenses related to the environmental regularization process;
- Necessary technical assistance until the project's maturation phase;
- Reallocation of internal roads of rural properties for environmental adequacy purposes;
- Purchase of supplies and payments of services for the implementation and maintenance of the projects financed;
- Payment of services destined to the conversion to organic production and its certification;
- Acquisition, transportation, application and incorporation of agricultural correctives (limestone and others);
- Marking and construction of terraces and implementation of soil conservation practices;
- Green manuring and planting cover crops;
- Acquisition of seeds and seedlings for the formation of pastures and forests; implementation of nurseries for forest seedlings;
- Disassembly operations;
- Implementation and recovery of fences; acquisition of fence energizers; acquisition, construction or refurbishment of drinking fountains and saltshakers or salt pans;
- Acquisition of cattle, buffaloes, sheep and goats, for reproduction, rearing and finishing; and semen, ova and embryos of these species, limited to 40% of the financed amount;
- Acquisition of machines, implements and equipment of national manufacturing - for the implantation of irrigation systems, for agriculture and livestock, biodigesters, machines and equipment for composting and for energy production and storage - limited to 40% of value of the financing. For items related to waste and animal waste treatment systems for energy generation and composting, the limit can be up to 100% of the value of the financing.

Source: Abiogás/BNDES/Deloitte Analysis.

Financing Sources

Biogas Funding – Main Financing Programs: Climate Fund – It's currently the main tool available for BNDES to finance the biogas sector. Since 2011, the Fund has financed more than BRL R$880 million in projects.

BRDE Energy	
Financing Institution:	BNDES
Target area:	Brazil
Objectives:	The Climate Fund is one of the instruments of the National Policy on Climate Change and constitutes an accounting fund, linked to the Ministry of the Environment with the purpose of guaranteeing resources to support projects or studies and financing of enterprises that have as objective the mitigation of climate change.. It supports the implementation of projects, the acquisition of machinery and equipment and technological development related to the reduction of greenhouse gas emissions and adaptation to climate change and its effects.
Interest rate:	Composed by the Financial Cost, the BNDES rate and the Financial Agent Rate or Credit Risk Rate.
Maximum loan value:	R$ 80 million
Deadline:	up to 16 years, with a maximum grace period of 8 years

Eligible items:

- Technological development of solar, wind, hydraulic, biomass, hydrotreated vegetable oils, urban solid waste and oceans or for the production and use of green hydrogen, and of the production chain for the dissemination of the use of solar energy and of the oceans, including energy storage;
- Projects for the generation of electricity or energy conversion from the use of biomass, including the production and use of biogas or hydrotreated vegetable oils for energy purposes, and urban solid waste;
- Support for electricity generation projects from renewable sources in distributed generation or energy self-production, up to 5MW;
- Projects involving solar thermal energy or the production or use of green hydrogen, including initiatives related to the fuel cell;
- Projects of renewable energy storage systems from intermittent sources in batteries;
- Projects for technological development and/or investment in expanding production capacity related to aviation biokerosene, green diesel, biomethane, second-generation ethanol, sustainable marine fuels, synthetic fuels derived from solid waste and electro fuels;
- Investment projects in carbon capture and storage associated with the production of sustainable and low-carbon fuels.

Source: Abiogás/BNDES/Deloitte Analysis.

Deloitte.