

THE LEGAL FRAMEWORK FOR BIOGAS IN BRAZIL: PATHWAYS TO SUSTAINABLE AND EFFICIENT PRODUCTION

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ABSTRACT: Brazil is a signatory to international agreements that oblige it to meet decarbonization targets as good environmental practice. Thus, encouraging the generation of biogas, which originates from waste (biomass), such as agribusiness waste, through public policies and regulatory adjustments, is a priority. This article aims to understand whether legislation can influence the increase in biogas plants and production in Brazil, and consequently the expansion of this renewable energy source and the reduction of Greenhouse Gas Emissions (GHG). The hypothesis is that there is a correlation between public policies through regulations and the expansion of biogas in Brazil's energy matrix. This is an exploratory study based on documentary analysis. The results indicate that legislation impacts the growth in the number of facilities and biogas production, demonstrating the agribusiness sector's potential to lead renewable fuel production and contribute to mitigating GHG emissions.

Keywords - Agribusiness, biogas, energy sources, regulation

1. INTRODUCTION

Regulatory frameworks play a crucial role in the development of renewable energy, whether by initiating market operations or establishing regulations. Initially, the main purpose of legislation should be to encourage energy generation from renewable sources—such as biogas. Subsequently, once generation is relatively consolidated, the legislation shifts focus to regulating the related energy market.

In his seminal work, Alberto Venâncio Filho describes the origins of regulation as an expansion of police power, intended to limit individual rights through normative order and supervisory authority. Lighter and detached from the responsibility of spearheading development—which should preferably be led by the private sector—the Public Administration takes on the role of regulating, supervising, and sanctioning services performed by private entities. In the terms of Diogo de Figueiredo Moreira Neto, this constitutes an administrative definition of which specific interests (intensified regulation) should prevail in relationships subject to regulatory authority. These outcomes are not predetermined by law or regulation, but rather derived from facts through the qualified, negotiated, and balanced exercise of regulatory functions by public agencies (BRAGA, 2016, pp. 64–65).

Based on Braga's (2016) analysis, the State is understood as the main driver of energy generation development, particularly through public policy.

It is important to emphasize that every public policy implies a public expense for its implementation. Given limited resources, it is impossible to address all social demands simultaneously. Thus, prioritization is essential.

The decision of what and how much to fund is essentially a political decision (OLIVEIRA, 2010, p. 275), made by public administrators (GUIMARÃES, p. 10).

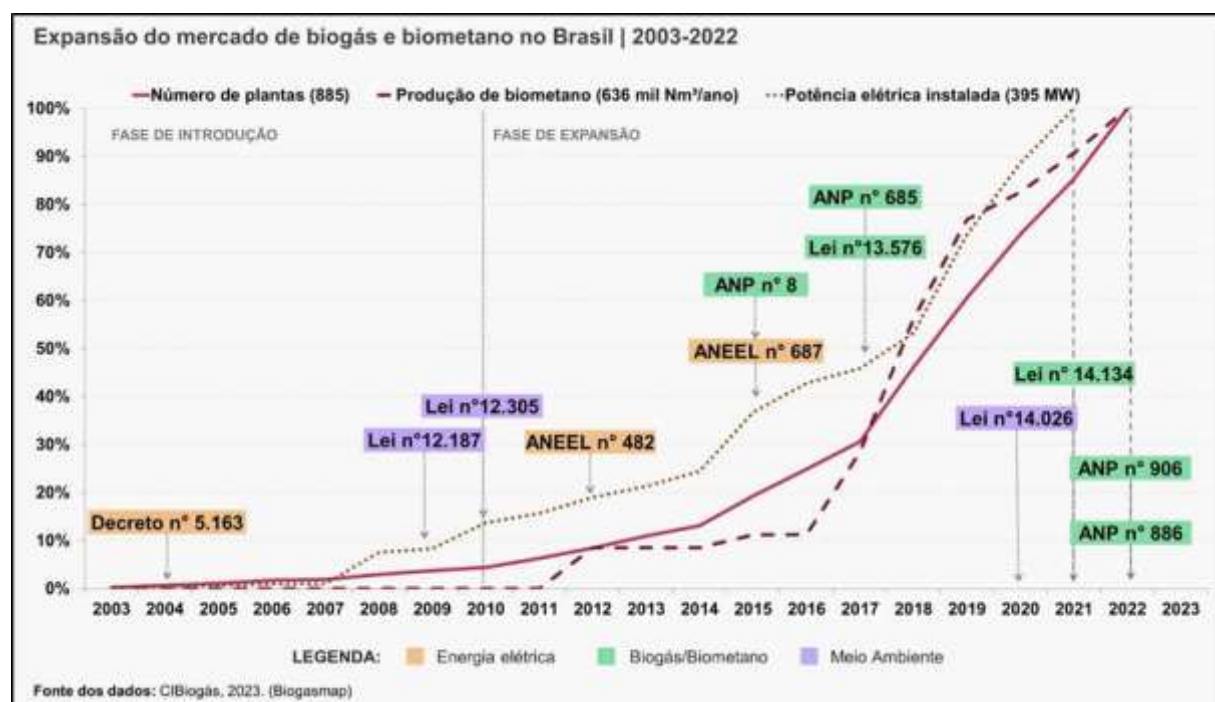
To meet its Nationally Determined Contributions (NDCs), Brazil is obligated to fulfill decarbonization targets. In this context, incentivizing biogas production from agribusiness biomass residues must be treated as a priority public policy. Through anaerobic digestion systems (which operate in the absence of oxygen), biomass is converted into biogas by using a biodigester that ensures efficient fermentation of organic materials (SHUBEITA, 2016, p. 21).

Biogas can be converted into electricity, heat (thermal energy), or it can be purified and upgraded to biomethane, which—when compliant with ANP (National Agency of Petroleum, Natural Gas and Biofuels) specifications—is considered analogous to natural gas and may be used as vehicle fuel.

Despite its wide range of applications, biogas accounts for only 1.4% of Brazil's energy matrix (EPE). In this context, it is crucial that public policies are aligned with market needs and its stakeholders—including suppliers, producers, consumers, and research centers—with the objective of fostering the development and deployment of this renewable energy source. This alignment is essential to ensuring national development in a more sustainable manner, as provided by Article 3, section II of the Brazilian Federal Constitution.

From this perspective, Brazil has enacted a number of laws specifically addressing the generation of energy from biogas, as illustrated in Figure 1.

Figure 1 – Relationship between the Enactment of New Legislation and the Increase in the Number of Biogas and Biomethane System Installations [Period: 2003–2023]



Source: Prepared by the author. Research data (2023). Adapted from the Technical Note on Biogas and Biomethane Systems: Market Perception in Brazil and Abroad. GEF Biogás Brasil, December 2020, and data from BiogasMap, 2023.

As illustrated in Figure 1, legislative measures have contributed to the increase in biogas plants, demonstrating the relevance of regulatory frameworks such as the Distributed Generation Regulation by ANEEL (Resolution No.

482/2012), which corresponds to a visible upward trend in the number of installations. Furthermore, legislation also plays a role in boosting biogas generation by mandating, for instance, the proper final disposal of waste, as seen in swine farming—where the construction of biodigesters becomes a necessary measure.

Within this context, a central research question emerges: Do legislative frameworks influence the increase in biogas production and the number of biogas plants in Brazil? The guiding hypothesis of this study is that there is a correlation between public policies—implemented through regulations—and the expansion of biogas within Brazil's energy matrix.

Accordingly, this study aims to assess whether legal frameworks can influence the growth of biogas installations and production in Brazil, as well as the broader expansion of this renewable energy source and the resulting reduction in greenhouse gas (GHG) emissions.

Moreover, this investigation is justified by its contribution to the ongoing debate on the correlation between the implementation of public policies—through regulation—and the expansion of Brazil's renewable energy matrix via biogas.

2. RESULTS AND DISCUSSION

In Brazil, renewable energy is closely linked to the country's abundant natural resources, including solar potential, wind energy, and a robust biofuels program, such as ethanol—where sugarcane bagasse is burned in boilers to produce steam and generate electricity (BRAGA, 2016, p. 299). Biogas derived from agribusiness residues also fits into this context. The generation of electricity from biogas allows for firm and dispatchable power production, meeting the needs of areas where the quality of electricity distribution is poor (UNIDO, 2022, p. 27). As such, this energy source does not suffer from the intermittency issues common to other renewables, making it a valuable ally in the energy transition.

In 2002, the Federal Government established the Program for Incentives to Alternative Sources of Electric Energy (PROINFA) through Law No. 10.438/2002. The program aims to contribute to the diversification of the national energy matrix and is regarded as one of the key drivers in the development of alternative energy sources in Brazil. Its main objective is to contract projects in wind power, biomass, and small hydropower plants (SHPs) connected to the grid, to be implemented by Independent Power Producers, whether or not affiliated with electricity concessionaires.

As shown in Figure 1, legislation has played a key role in increasing the number of biogas plants and overall biogas production. As noted, the timing of legislative milestones has supported this trend both in terms of electricity generation and the development of biomethane.

With regard to jurisdiction over energy regulation, both federal and state authorities share responsibilities, alongside regulatory agencies such as the National Electric Energy Agency (ANEEL) and the National Agency of Petroleum, Natural Gas and Biofuels (ANP). These agencies have their regulatory powers established under Laws No. 9.427/1996 and No. 9.478/1997, respectively.

In the case of biomethane—when considered analogous to natural gas—legislative authority is divided: the federal government holds the competence to regulate gas in general, while state governments are responsible for regulating local piped gas distribution services, as established in Article 25, §2 of the Federal Constitution.

In this context, the present study will examine selected regulatory milestones and their implications for increasing the production and use of biogas, particularly as an energy carrier derived from agro-industrial waste.

2.1 PROPER FINAL DISPOSAL OF WASTE

The 1988 Federal Constitution of Brazil was the first to address environmental protection directly and

systematically, establishing detailed rights and duties concerning the environment. It outlines the main principles of environmental law, which are further elaborated in infraconstitutional legislation.

The fundamental nature of the right to an ecologically balanced environment lies in its indispensability for a healthy quality of life—essential for ensuring dignified living conditions. This right is also recognized in international treaties and agreements, as previously discussed.

In Brazil, the responsibility for environmental protection is shared among the Federal Government, states, the Federal District, and municipalities.

The beneficiaries of the right to an ecologically balanced environment are all individuals (a diffuse right), while the duty to defend and preserve it for present and future generations rests both with public authorities and with society as a whole (Federal Constitution, Art. 225; JÚNIOR, 2011, p. 875).

In this context, environmental licensing emerges *as an administrative procedure whereby the competent environmental authority grants permission for the location, installation, expansion, and operation of enterprises and activities that utilize environmental resources, are deemed potentially or effectively polluting, or may cause environmental degradation in any form. This process considers relevant legal provisions, regulatory frameworks, and applicable technical standards* (CONAMA, 1997).

Law No. 6.938/1981, which establishes the National Environmental Policy (PNMA), aims to preserve, improve, and restore environmental quality. It also establishes penalties for environmental harm, consolidates the requirement for environmental licensing of potentially polluting activities, and institutes the National Environment System (SISNAMA)—a framework comprising federal, state, and municipal environmental bodies tasked with implementing the PNMA across the country.

CONAMA Resolution No. 01/1986 defines environmental impact as:

Article 1 – For the purposes of this Resolution, environmental impact is considered to be any change in the physical, chemical, and biological properties of the environment caused by any form of matter or energy resulting from human activities that directly or indirectly affect:

- I – the health, safety, and well-being of the population;
- II – social and economic activities;
- III – biota;
- IV – aesthetic and sanitary conditions of the environment;
- V – the quality of environmental resources. (CONAMA, 1986)

Accordingly, enterprises likely to cause environmental impacts—such as swine, poultry, and cattle farming—must be licensed. The licensing requirements, responsibilities, and regulated activities are defined by state laws, as the Federal Constitution grants such competence to the states (Art. 23, VI), and further guided by Complementary Law No. 140/2011, which outlines the specific objectives in the exercise of shared environmental competence.

Each state thus legislates on the polluting potential of specific activities. For instance, the state of Paraná— one of Brazil's largest swine producers—requires the use of biodigesters for the treatment of swine farming waste (IAT Resolution No. 31/1998).

Historically, the development of Brazil's biogas production chain was delayed, as the decomposition of organic waste through anaerobic digestion remained poorly understood for many years. As a result, such practices were rarely implemented, leading to improper waste disposal and environmental damage (ROSSONI, 2023).

In this context, particularly for swine farming, the implementation of biodigesters for biogas production— and consequently for energy generation—is seen as a more feasible solution, supported by legislative mandates for the proper final disposal of waste, including the use of biodigesters.

The southern states of Brazil are the country's largest swine producers, and therefore have the greatest potential for biogas production (IBGE, 2017). Not surprisingly, they are also the leading biogas producers (BiogasMap, 2022).

This biogas generation potential is understood to be directly linked to the legal mandates on proper waste disposal, including incentives for the installation of biodigesters to pre-treat swine waste, as outlined in the regulations of these states: Paraná (Resolução IAT nº 31/1998); Santa Catarina (Resolução CONSEMA nº 143/2019); e Rio Grande do Sul (Resolução CONSEMA nº 455/2021).

Thus, it is understood that there is a correlation between legislative mandates on the proper final disposal of waste and the increase in biogas production. These regulations not only fulfill environmental requirements but also benefit producers, who gain added value on their properties through energy generation—thereby promoting both economic development and sustainability.

2.2 LEGISLATION RELATED TO ELECTRICITY GENERATION FROM BIOGAS

In the electricity sector, regulatory and oversight activities fall under the responsibility of the Brazilian Electricity Regulatory Agency (ANEEL), which oversees agents involved in generation, transmission, distribution, and commercialization.

Distributed Generation (DG) is classified within the distribution stage, meaning that electricity generation occurs close to the point of consumption.

Ultimately, distributed generation refers to electricity produced by concessionaires, permit holders, or authorized agents whose facilities are located near load centers. This type of generation is directly connected to the buyer's distribution network, without the use of transmission infrastructure (BRAGA, 2016).

Decree No. 5,163/2004, which “regulates the commercialization of electric energy, the process for granting concessions and authorizations for electricity generation, and other provisions,” formally established the concept of Distributed Generation in Brazil, as defined in Article 14.

The same decree, regulating Law No. 10,848/2004, created two contracting environments: The Regulated Contracting Environment (ACR) and the Free Contracting Environment (ACL).

The ACR became the marketplace for distribution utilities. In this model, utilities—grouped into a purchasing pool—are required to procure electricity through auctions to fully meet their customers' demand, i.e., 100% of the load. The model allows little room for flexibility: accurate demand forecasting is critical, as any deviation—either surplus (overcontracting) or deficit (undercontracting)—leads to financial exposure. The regulations allow pass-through of procurement costs to tariffs up to 105% of the forecasted demand. Any amount beyond this threshold is settled in the short-term market, valued at the Settlement Price of Differences (PLD), and the revenue is assigned to the distribution utility. (...)

The ACL, which succeeded the former free market, is limited to: (i) generation agents; (ii) trading agents; (iii) importers and exporters; (iv) free consumers—those with loads above 3 MW served at voltages above 69 kV (pre-1995) or any voltage (post-1995); and (v) special consumers—those with loads above 500 kW served at any voltage, provided the electricity comes from incentivized sources.

The key feature of the ACL is the autonomy granted to agents to negotiate the terms of electricity purchase and sale through bilateral contracts, which define price, duration, volumes, guarantees, penalties, and more. Despite

the freedom of contracting, these transactions involve a regulated commodity, meaning that mandatory rules still apply, particularly regarding commercialization procedures, agent qualification, and balancing mechanisms. Both ACR and ACL contracts must be registered with the CCEE (Electric Energy Commercialization Chamber), which uses them to account for and settle short-term market differences. Total contracted volumes are settled bilaterally between agents under their contractual terms and outside the CCEE's operational environment (BRAGA, 2016, pp. 621–622).

As previously mentioned, Decree No. 5,163/2004 established Distributed Generation. In this context, users in the ACR may produce and consume their own electricity. A system was created whereby the distribution grid is used to “store” the electricity generated but not immediately consumed, making it available for future use.

ANEEL Resolution No. 482/2012 introduced a net metering scheme, allowing active energy injected by consumers with micro or mini distributed generation units to be credited by the distribution utility, which redistributes the energy to neighboring units. The consumer then offsets their electricity bill by using these energy credits either at the same unit or at another unit under the same ownership.

In short, an electricity consumer can install small generators (e.g., solar PV panels or small wind turbines) at their facility, using the generated energy to reduce their consumption. If generation exceeds consumption, the surplus energy is credited and can be used to offset consumption at another location or in a future billing cycle. These credits remain valid for 36 months. Additionally, consumers may allocate these credits to other units within the same concession area and under the same ownership.

With the net metering system, generators no longer require expensive batteries for energy storage, as the grid itself serves this purpose. For utilities, this model is also beneficial as it reduces energy loss costs—nearly consumers receive the distributed energy. This setup has lowered installation costs and encouraged the expansion of distributed generation from various sources, including biogas.

Resolution No. 482/2012 also enabled captive consumers to generate their own electricity through models such as on-site self-consumption and remote self-consumption, with credit sharing permitted between units under the same CPF or CNPJ. It set generation limits at 1 MW for mini generation and 100 kW for micro generation.

In 2015, ANEEL amended Resolution 482/2012 with Resolution 687/2015, improving the rules for Distributed Generation by expanding business models and introducing Shared Generation and Multiple Consumer Units (EMUC). It also raised the installed capacity limit for mini generation to 5 MW (3 MW for hydro sources) and for micro generation to 75 kW.

Despite initial intentions to revise net metering rules, these regulatory updates—particularly the expanded business models and capacity limits—sent a clear signal of encouragement to civil society, fostering investments and development in the electricity sector under the guidance of the regulatory agency (ARANTES, 2023).

As a result, under Resolution No. 482/2012, the following models for generation and compensation emerged: Local Self-Consumption (local energy credit compensation), Remote Self-Consumption (credits used across units under same ownership), Multiple Consumer Units (compensation among contiguous areas with different owners), and Shared Generation (energy credits shared among multiple stakeholders, e.g., cooperatives or consortia).

In 2021, after ten years of Distributed Generation in Brazil and extensive discussions, Law No. 14.300—the Legal Framework for Distributed Generation—was passed by Congress, the Senate, the Ministry of Mines and Energy, and major industry associations. This law brought greater legal certainty to emerging business models in the sector.

Among the existing biogas plants in Brazil in 2021, the primary application of this energy source was electricity generation, with a total of 605 plants. The Southeast region had the highest number (270), followed by the South (192), Central-West (135), North (5), and Northeast (3) (Biogas Map, 2022).

Figure 1 shows that following the publication of ANEEL Resolution 482/2012, there was a noticeable increase in both the number of biogas plants and installed electric capacity. This growth was further accelerated by Resolution 687/2015, which expanded DG modalities.

However, despite this growth, in 2021 biomass-based sources accounted for only 8.2% of total electricity supply in Brazil's energy matrix, indicating the continued need for public policies that further promote the use of such renewable resources (EPE, 2023).

For instance, the state of Minas Gerais has exempted solar photovoltaic energy credits from ICMS (state VAT) when generated and consumed through self-consumption or shared generation (Item 181, Part 1, Annex X, State Decree No. 48.859/2023). However, biogas is not included in this exemption, which hampers its broader adoption.

It is thus evident that the increase in biogas plants and installed capacity resulted from the consumer's ability to generate and use their own energy, enabled by ANEEL Resolutions 482/2012 and 687/2015. This confirms that regulations significantly impact the expansion of biogas and its integration into Brazil's energy matrix.

Nonetheless, further public policies—such as those enacted in Minas Gerais—are needed to stimulate even greater biogas adoption and utilization.

2.3 LEGISLATION RELATED TO BIOMETHANE

According to information published by the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP), biomethane is a gaseous biofuel obtained through the processing (refinement) of biogas. It is derived from essentially organic residues, which, for the purposes of this study, refer to residues from agrosilvopastoral activities or certain commercial activities (e.g., food waste from restaurants and bars), excluding landfill gas and gas from wastewater treatment plants, as these may contain non-organic waste (ANP, 2020).

Biomethane has a high methane content, making it fully interchangeable with natural gas in all its applications. It can also be transported as compressed gas using cylinder trucks (virtual pipelines) or as liquefied gas, known as Liquefied Biomethane – BIO-LNG.

As previously noted, the regulatory authority for the gas sector in Brazil is the ANP, which has issued the following resolutions related to the composition of biomethane derived from livestock and agro-industrial activities: ANP Resolution No. 08/2015 (now repealed); and ANP Resolution No. 906/2022 (currently in force).

According to Resolution No. 906/2022, ANP defines biomethane as “a gaseous biofuel composed essentially of methane, derived from the purification of biogas.” The specifications for biomethane originating from agrosilvopastoral and commercial products and residues are listed in the technical table provided in that regulation.

In 2021, according to BiogasMap data, there were only five biomethane plants in operation in Brazil: three in the South region and two in the Southeast.

2.4 NEW GAS LAW – LAW NO. 14.134/2021

Law No. 14,134/2021, known as the "New Gas Law," was enacted to open the Brazilian gas market, motivated

primarily by the principles of free enterprise, free competition, and the goal of increasing competitiveness in the sector.

Law No. 14,134/2021 and its regulatory Decree No. 10,712/2021 establish rules for the development of economic activities related to the transportation of natural gas through pipelines, as well as the import and export of natural gas, in accordance with items III and IV of Article 177 of the Brazilian Federal Constitution. The law also regulates the activities of collection, treatment, processing, underground storage, packaging, liquefaction, regasification, and commercialization of natural gas (Art. 1, Law No. 14,134/2021). In essence, it governs the transport of natural gas within Brazil, provided it is carried out through pipelines.

This legal framework applies to biomethane as well, as biomethane is considered analogous to natural gas, provided it meets ANP (National Agency of Petroleum, Natural Gas and Biofuels) specifications, as explicitly stated in Article 4 of Decree No. 10,712/2021. Thus, biomethane that complies with ANP specifications may be transported via pipelines and even blended with natural gas, as permitted under ANP regulations and Law No. 14,134/2021.

Since the New Gas Law governs activities conducted through pipelines (including dedicated pipelines), it does not apply to the transportation of natural gas by other means, such as land transport.

In cases of overland transportation via trucks (tube trailers), Resolution No. 5947/2021 of the National Land Transport Agency (ANTT) must be observed. This resolution updates the regulations for the road transportation of hazardous products and approves related complementary instructions.

Regarding pipelines, it is important to highlight that Article 25, §2 of the Brazilian Federal Constitution grants exclusive authority to the states to regulate local piped gas distribution services. Consequently, the federal government is responsible for legislating on the production, collection, processing, and transportation of natural gas, while the states are responsible for regulating distribution.

The New Gas Law, in its Chapter I, defines several key market agents, relevant to this discussion (Art. 3, IV, V, XIV, XV):

- a) Self-producer (Autoprodutor): An agent engaged in the extraction and production of natural gas who, under ANP regulations, uses part or all of their production as feedstock or fuel in their industrial facilities or those of controlled or affiliated companies.
- b) Self-importer (Autoimportador): An agent authorized to import natural gas who, under ANP regulations, uses part or all of the imported product as feedstock or fuel in their industrial facilities or those of controlled or affiliated companies.
- c) Captive consumer (Consumidor cativo): A natural gas consumer served by the local piped gas distributor through gas commercialization and transportation services.
- d) Free consumer (Consumidor livre): A natural gas consumer who, under state legislation, has the option to purchase gas from any agent engaged in gas commercialization.

Accordingly, states are responsible for regulating who may qualify as a free consumer, which means legislation on this matter may vary across states.

Moreover, the New Gas Law grants state regulatory agencies the authority to oversee the natural gas distribution and commercialization markets. Under Article 29, these agencies may establish tariffs for distribution activities (§1) and mediate negotiations between state gas distributors and other market agents (§3).

Table 1 presents an overview of state legislation concerning the concept of free consumers:

State	Law
Espírito Santo	Law No. 11,173/2020
Amazonas	Law No. 5,420/2021
Minas Gerais	SEDE Resolutions No. 17/2013 and No. 32/2021
Pará	Law No. 7,719/2013
Rio de Janeiro	Law No. 6,361/2012 and AGENERSA Deliberation No. 4068 of 02/12/2020
São Paulo	ARSESP Deliberation No. 744/2017
Mato Grosso do Sul	AGEPAN Ordinance No. 103/2013
Rio Grande do Sul	Normative Resolution No. 68/2023
Maranhão	Law No. 9,102/2009
Santa Catarina	ARESC Resolution No. 136
Paraná	Complementary Law No. 205/2017

Source: Prepared by the author (2023).

In this context, it is evident that the majority of Brazilian states have not yet enacted legislation defining the concept of free consumers. This legislative gap generates legal uncertainty for investors and may hinder the expansion of the biomethane market in the country. It is believed that the lack of such legislation is due, in part, to the limited availability of gas pipeline infrastructure in Brazil.

The New Gas Law (Law No. 14,134/2021) applies to the transportation of biomethane (considered analogous to natural gas, provided it meets ANP specifications) via pipelines. According to Article 1, the law governs the development of economic activities related to the transportation of natural gas through pipelines, as well as its import and export. Therefore, in terms of legal applicability, the law is effective and enforceable within the legal framework. However, in practice, it lacks full effectiveness across the national territory, as Brazil's pipeline infrastructure is not widely developed, as illustrated in Figure 5.

In this regard, the New Gas Law provides that users requiring natural gas transportation who cannot be served by the state piped gas distribution network may build and implement their own facilities and pipelines for exclusive use—referred to as dedicated pipelines.

Article 29. Free consumers, self-producers, or self-importers whose natural gas transportation needs cannot be met by the state piped gas distributor may construct and implement their own facilities and pipelines for their specific use, upon execution of a contract that assigns the operation and maintenance of these facilities to the state distributor. These facilities and pipelines shall be incorporated into state assets through a declaration of public utility and through just and prior compensation at the time of their full use (BRAZIL, 2021, Law No. 14,134/2021, Art. 29, caput).

As highlighted in the excerpt from Article 29 above, when such a pipeline is built by the user, it must ultimately be donated and incorporated into the state's assets, with just and prior compensation. Furthermore, tariffs related to the use of the pipeline will continue to apply; however, in these cases, investment, operation, and maintenance costs must be considered (Art. 29, §2, Law No. 14,134/2021).

It is understood that the New Gas Law represents a significant milestone for opening Brazil's gas market, a major step forward that could foster the expansion of biogas and, consequently, biomethane production. However, as of now, this expansion has not yet materialized, likely due to the scarcity of pipelines, as well as the high costs and lengthy timelines associated with their construction. Additionally, as the law is still relatively recent, it is expected that this market will expand more significantly in the future.

2.5 NATIONAL BIOFUELS POLICY (RENOVABIO) – LAW NO. 13,576/2017

Law No. 13,576/2017, which establishes the National Biofuels Policy (RENOVABIO), was created to support the Brazilian government in fulfilling the commitments undertaken with the ratification of the Paris Agreement in 2015.

As stated in the introduction of this work, the Paris Agreement aimed to reduce greenhouse gas (GHG) emissions, with the transportation sector being one of the major contributors, representing a significant bottleneck to be overcome in the energy transition and emissions mitigation process.

Additionally, Sustainable Development Goal (SDG) No. 7 aims to “ensure access to affordable, reliable, sustainable, and modern energy for all.” In this context, biomethane contributes to achieving this objective, given its renewable and firm (non-intermittent) generation potential.

RENOVABIO is a state policy that acknowledges the strategic role of all biofuels—including ethanol, biodiesel, biomethane, bio-kerosene, and second-generation biofuels—in Brazil's energy matrix, particularly in contributing to energy security, market predictability, and the mitigation of greenhouse gas emissions in the fuel sector. Biofuels thus enable a more sustainable, competitive, and secure energy supply (MME, 2023).

The policy is structured around three thematic pillars:

- a) Decarbonization Targets;
- b) Certification of Biofuel Production;
- c) Decarbonization Credits (CBIOs).

Under the first pillar, Decarbonization Targets, the Federal Government annually sets national targets with a ten-year horizon, which are then allocated to fuel distributors, the obligated parties under the policy.

In the second pillar, Certification of Biofuel Production, biofuel producers voluntarily certify their production and receive energy-environmental efficiency scores (based on Life Cycle Assessment – LCA). These scores are multiplied by the volume of biofuel marketed, determining the number of CBIOs that a given producer can issue and sell on the market.

The third pillar, Decarbonization Credits (CBIOs), involves environmental assets equivalent to one metric ton of carbon dioxide, traded in the over-the-counter market, regulated by Ordinance No. 419/2019 of the Ministry of Mines and Energy. One CBIO represents the avoidance of one ton of CO₂ equivalent emissions through the use of biofuels.

CBIOs are a mechanism to encourage the expansion of renewable fuels in the Brazilian energy matrix, considering that fossil fuel distributors are obligated under the policy to purchase Decarbonization Credits in proportion to their market share.

With the enactment of Law No. 13,576/2017 (RENOVABIO), there was an increase in the number of plants; however, the number of certified plants remains very low. According to research conducted in 2023 using the RENOVABIO Dynamic Panel on ANP's website, there are only six biomethane plants certified by ANP in Brazil, of which only one generates biomethane from agro-industrial waste.

Thus, it is concluded that the generation and use of biomethane in the agro-industrial sector are still not widespread, possibly due to the high cost of certification and the limited dissemination of knowledge about this energy source, which could replace diesel in rural properties, enable isolated energy systems, and primarily reduce production costs for farmers.

3 CONCLUSION

Regarding the use of biogas for electricity generation, it is understood that the increase in plants and installed

electric capacity resulted from the possibility granted to consumers/users to generate and consume their own energy, which became possible through ANEEL Resolutions No. 482/2012 and No. 687/2015. It is also concluded that further public policies are needed to encourage this energy source, following examples such as the policy adopted by the state of Minas Gerais, which exempted photovoltaic energy credits from ICMS taxation, thereby potentially further increasing the generation and utilization of biogas. As for biomethane, the new Gas Law (Law No. 14,134/2021) has not yet shown effectiveness throughout the national territory, given the scarcity of gas pipeline infrastructure in Brazil. Regarding Law No. 13,576/2017 (RenovaBio), only one registered plant belongs to the agro-industrial sector, leading to the conclusion that this energy source is still not widespread in that sector, despite its potential for replacing diesel, achieving self-sufficiency, and reducing operational costs. Therefore, it is confirmed that regulatory frameworks significantly impact the expansion of biogas and its greater integration into the Brazilian energy matrix.

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