Ministry of Foreign Affairs

Market Research:

BIOGAS AND BIOMETHANE CURRENT STAGE ANDOPPORTUNITIES FOR DUTCH COMPANIES IN BRAZIL

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ENERGIAS RENOVÁVEIS

P125/2019

MARKET RESEARCH

Biogas and Biomethane current stage and opportunities for Dutch companies in Brazil

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MARKET RESEARCH – P125/2019

BIOGAS AND BIOMETHANE CURRENT STAGE AND OPPORTUNITIES FOR DUTCH COMPANIES IN BRAZIL

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Executive Summary

BIOGAS AND BIOMETHANE CURRENT STAGE AND OPPORTUNITIES FOR DUTCH COMPANIES IN BRAZIL

WELKOM IN BRAZILIË - HET LAND VAN DE BIOMASSA!

One of the main obstacles in Brazil for the spread of new biogas plants is not biomass supply, which is abundant and mostly free of charge. Biogas is yet quite unknown and treated as a venture instead of a consolidated technique.

The increase of the biogas production in Brazil has the potential to drastically improve the energy matrix through electrical, thermal or vehicular use. **The current potential can supply 36 % of the Brazilian electrical demand or replace 70 % of the diesel demand.**

This report aims to support Dutch companies to help develop the brazilian biogas supply chain in a profitable, economically and environmentally sustainable manner. To this end, we studied the 5 main substrates available for biogas generation in Brazil (sugarcane, dairy products, swine, poultry and WWTP).

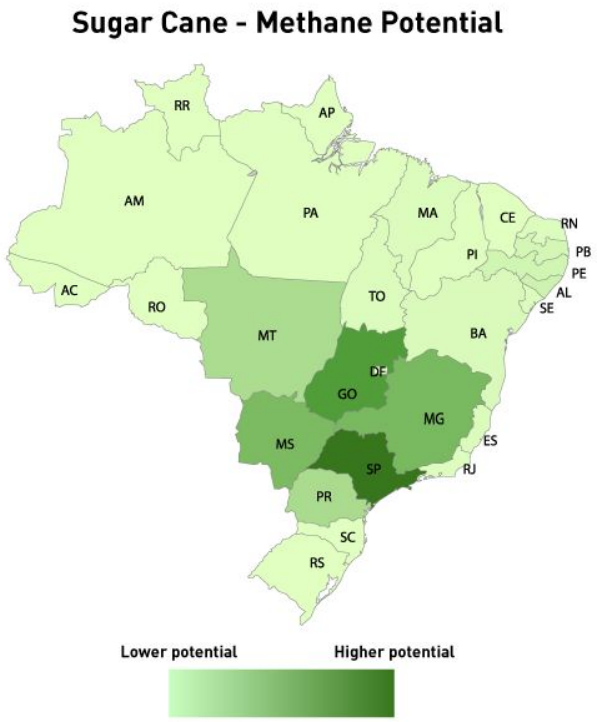
SUGAR CANE

Brazil is the world's largest producer of sugar and ethanol from sugar cane.

The main residues of the Sugar Cane industry are: bagasse, filter cake and vinasse. Bagasse and filter cake are produced either from sugar or ethanol production. Vinasse (figure) is exclusive for ethanol and registers the highest biogas potential.

Vinasse and filter cake, the main products available for biogas production, are generated inside the plant and can easily be directed to a bio digestion reactor. Bagasse are less

humid substrates than filter cake and vinasse and have a very high proportion of volatile solids. However, have a significant amount of lignocellulosic material that is difficult to degrade.



Sugarcane may not be stored and is harvested during 9 months per year. During this gap there is no residues production, which is a problem for the biogas plant. Ethanol production from corn might be a solution.

The state of São Paulo (SP) accounts for 50 % of the whole Brazilian production. The methane potential in this state represents 1,8 billion m^3 per year. The gas pipeline infrastructure in SP is the most attractive in Brazil for biomethane injection.

The high Brazilian knowledge in this sector, is related to the organization of sugarcane industries. In addition, it is notable that the high generation potential and the layout of the gas distribution lines support the production of biogas in this business.

DAIRY INDUSTRY

Cow milk production in Brazil is the third largest in the world with 33,5 billion liters of milk per year. In 2018 22 % was used by dairy companies, totaling 7,5 billion liters of milk.

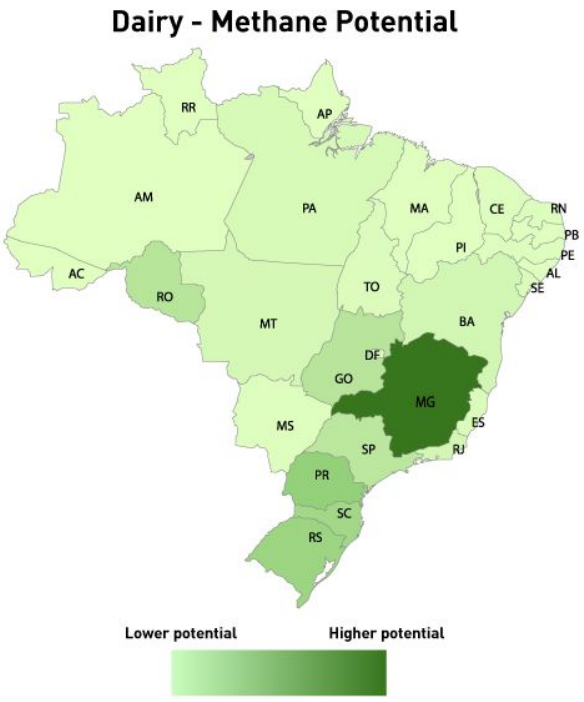
The dairy industry stands out for having a large generation of waste (figure[1]) rich in biodegradable organic matter. In the food processing sector, the dairy industry is

[1] **Picture source: Dairy WasteWater** http://efluenteslaticinios.weebly.com

considered the largest generator of wastewater.

For every liter of milk approximately 4 liters of organic effluent is generated, which must be treated and holds **strong biogas production potential.**

In addition to having high generation, biogas produced from residues from the dairy industry contains a high content of methane in its composition, reaching more than 60 % in its concentration.



The state of **Minas Gerais (MG) represents 25 % of the Brazilian potential for methane generation** from dairy waste equivalent to 67 million m^3 per year.

In spite of the leading role of MG in this branch of industry, the **potential of the southern region of Brazil** also deserves to be highlighted. Together, the states of PR, SC and RS represent 39 % of the national methane generation potential from this type of waste.

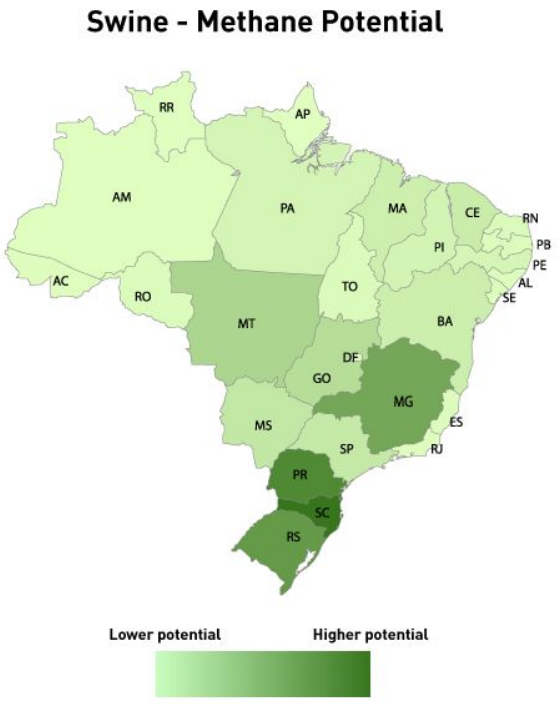
SWINE PRODUCTION

Brazil holds the 4th position on world swine herd with 24 million animals, behind China, EU and USA.

The residues from the swine termination units (figure) are the most appropriate for bio digestion, given the proportion of organic load, constant residue production and higher volume.

Confinement of the animals and the usually liquid consistency of the manure is favorable to the collection, transportation and treatment

of the residue. Consequently, it favours enterprises for the energetic recovery and biogas production. **Biogas production is significant**, recorded at a rate of 550 liters per kilogram of digested volatile solid.



75 % of all farming biogas plants benefits from swine production properties. Brazilian potential refers to an estimated herd of **23.5 million animals.**

The 3 states from South of Brazil (PR, SC and RS) account for 52 % of national production and registers a methane generation potential of 323 million m^3 per year.

POULTRY PRODUCTION

Poultry protein surpassed pork as the most consumed protein in the world. Brazil has 11 % of the export market share.

There are two main types of poultry production in Brazil: broilers and layers. The left figure shows the effluent from the poultry barn of commercial egg production, which consists of the water used to wash the conveyor belts plus the manure. On the other hand, the figure on the right shows a 1 m^2 and 30 cm thick cut of broiler litter bed and details of thickness and composition can be observed.

Egg production results an effluent that may trouble-freely inputed in biogas plants. Meat on the other side produces the Broiler Bed, which is still a challenge (market price of

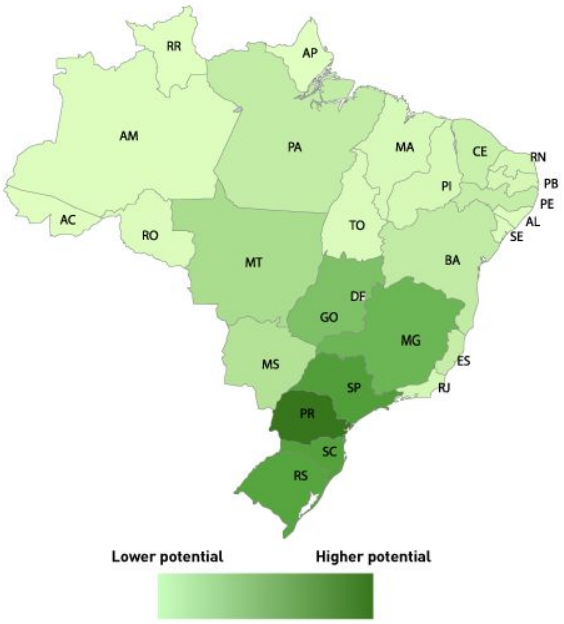
R$ 60 per ton and demands extensive pre-treatment). The national biogas potential from Broiler Bed is 18x larger than layers´ effluent.

The solution for highly efficient Broiler Bed biodigestion still does not exist.

The Brazilian potential for methane generation of broilers is 4.9 billion m³/year.

The potential of laying chickens corresponds to 270 million m³/year. The state of **Paraná (PR) is the largest producer of broilers while São Paulo (SP) concentrates the largest share of egg production yield**.

Poultry - Methane Potential

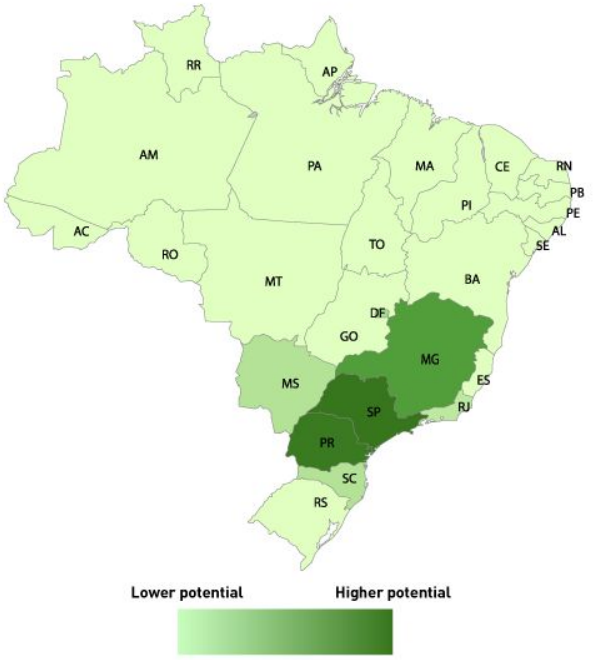


WASTE WATER TREATMENT PLANTS

Sanitation is still an issue in Brazil. In 2017 only 52 % of Brazil's total sewage was collected and, of this amount just 74 % was treated. Therefore, 38 % of the population has sewage treatment, and 62 % are improperly discharged.

Domestic sewage, or simply sewage, is the effluent generated when water is used to meet physiological needs and human hygiene, and sludge is the effluent generated during the treatment of domestic sewage; both can be used to biogas generation.

Waste Water Treatment Plant - Methane Potential



Two technical routes are suggested: UASB or CSTR reactors. Both have a weak spot. Effluent from a UASB may holds up to 40 % of the produced methane diluted in liquid form and

cannot be monetized. CSTR reactors work well on more extensive period of retention time and require extensive pre-treatment.

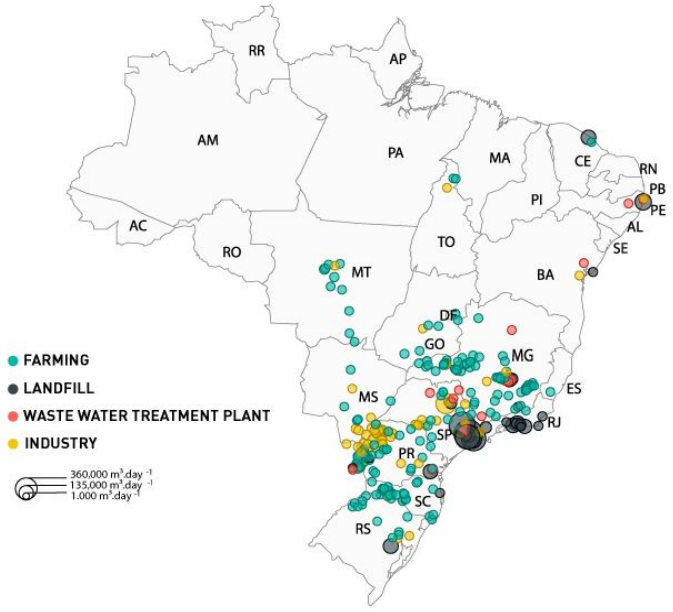
SP, PR and MG are the states with the largest sanitation infrastructure and consequently greatest biogas production potential. Only 14 WWTP in Brazil benefit from biogas.

The use of biogas in these facilities (figure[2]) is restricted to regions of the country where there is a higher rate of collection and treatment of sewage. In addition, it should be noted that the **UASB technology is a point to be explored**, due to the great knowledge already disseminated in the country.

MARKET ANALYSIS

There are only 366 biogas plants listed in Brazil (https://mapbiogas.cibiogas.org/). Concentrated mostly in MG, SP, PR, SC and RS. Firstly it is important to highlight the **very small quantity of biodigesters in Brazil, which reflects the huge not yet fully explored engineering market**. Secondly, also important to preview, the extreme difference between sectors and country regions.

Map with location, substrate type and volume of biogas produced per plant in Brazil

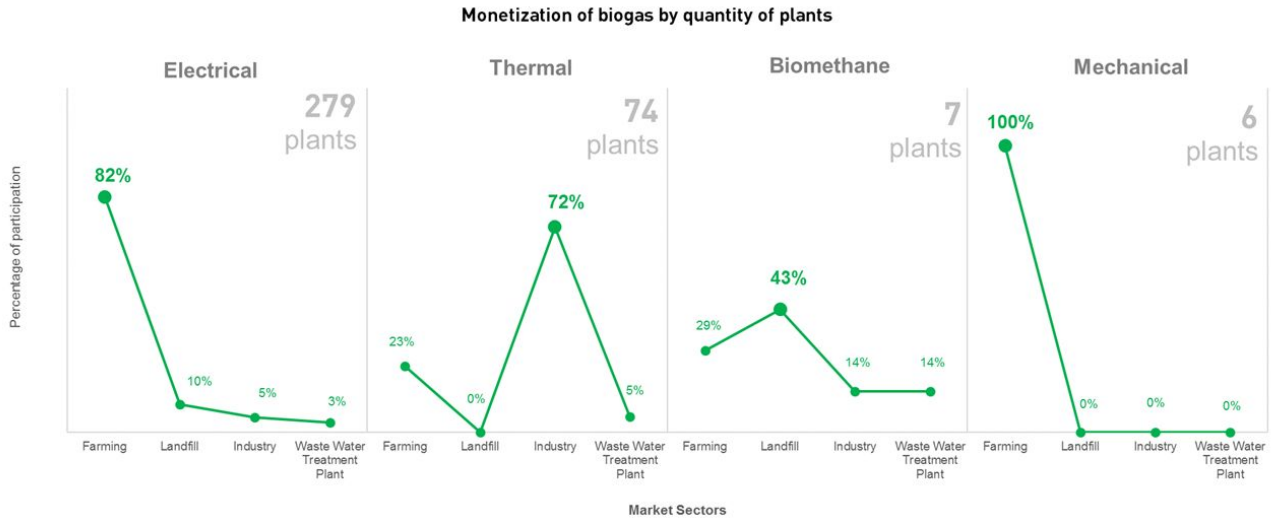


Farming sector benefits most from biogas. Concentration of plants where the agribusiness is strong. Very few plants on industries,

[2] **Picture source: WWTP - Ouro Verde/ SANEPAR - Foz do Iguaçu - Pr http://site.sanepar.com.br/**

landfills or WWTPs. **Main business model option overall is electric power generation.** In the industry sector, thermal generation is most common.

22 % of all plants are still under construction; of which 100 % are for power generation and 85 % are being built to treat swine waste.



Biomethane must be highlighted. There are only 7 biogas refineries operating. State regulation for biomethane pipeline injection is from 2018. Germany has 114 times more biodigesters per m^2 than Brazil. The cities of Castro and Carambeí in the state of Paraná (PR) are reference on cow milk production, have a strong presence of dutch families and very few bio digestors.

REGULATORY MILESTONES

Furthermore, the legal conditions for the use of biogas and its by-products are not very clear to all parties involved. The consequence of the lack of precise information is mainly insecurity, which inhibits the willingness of actors to invest in this market and, on the other hand, reduces the profitability of projects by increasing costs and the time for their evaluation and approval.

The production and use of biogas is generally framed as ancillary activities within the enterprise as a whole. In cases of small plants, environmental licensing is dispensed in

most states. Brazil does not have a unified environmental law, so it is suggested that the state environmental agency be consulted prior to installation.

According to the CIBiogás database, **the average size installed capacity on a brazilian biodigester is of 67 kW** (or 0,067 MW). This is considered by the legislation standards as insignificant or small and, therefore, do not require great efforts for licensing.

The most representative bureaucratic effort is the license to export electric energy to the regional utility company in turn of consume compensation, also called net metering.

Electric generation is commonly monetized on-gridly through net-metering.

There is no minimum capacity restrictions in order to supply it with selling contracts on the Free Chamber. The major challenge is economical.

Net metering regulation will face new rules from 1st semester 2020. It is yet unknown the impact of the regulatory changes. ANEEL has suggested 5 alternatives of grid use fee. Some of them may turn net metering unfeasible

Problems with environmental licenses for plants in farming is uncommon.

Brazil is Federative Republic. Each state has particularities. This report holds instructive tables, lists the most relevant pieces and recommendations.

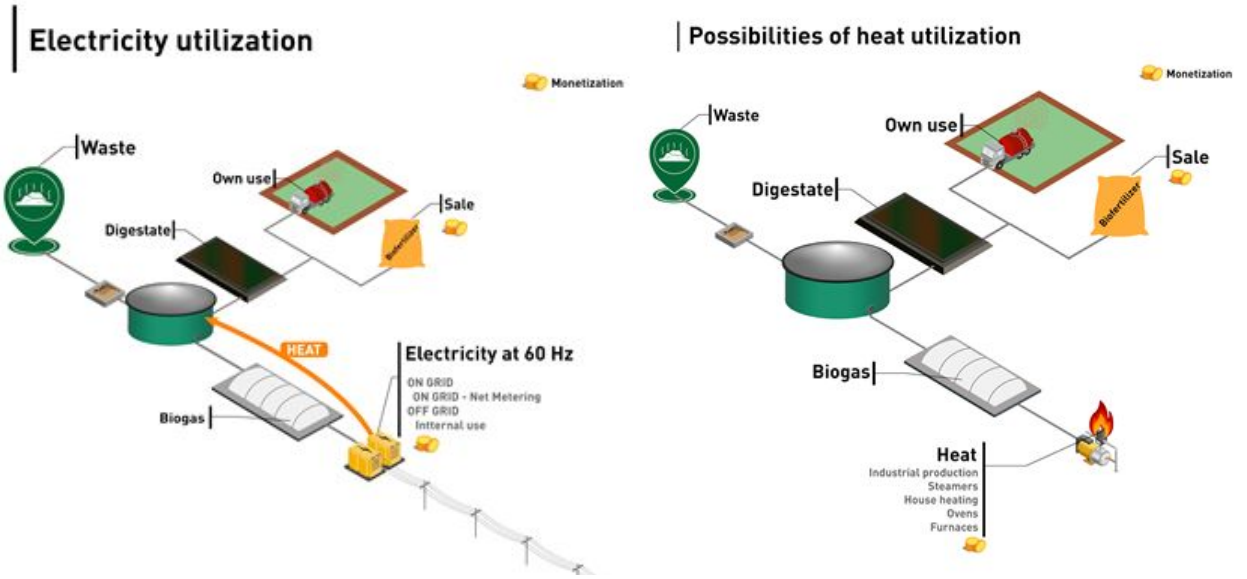
By 2021 it is expected to be implemented the free float of energy prices for residential consumption. This is a great opportunity for dispatchable plants.

By 2026 it is expected that there will be no demand restriction to buy energy from the Free Chamber. Today the minimum capacity is of 2.5 MW. Important to highlight, the Free Chamber of energy commerce shall not be affected by the new net metering regulation discussion by ANEEL.

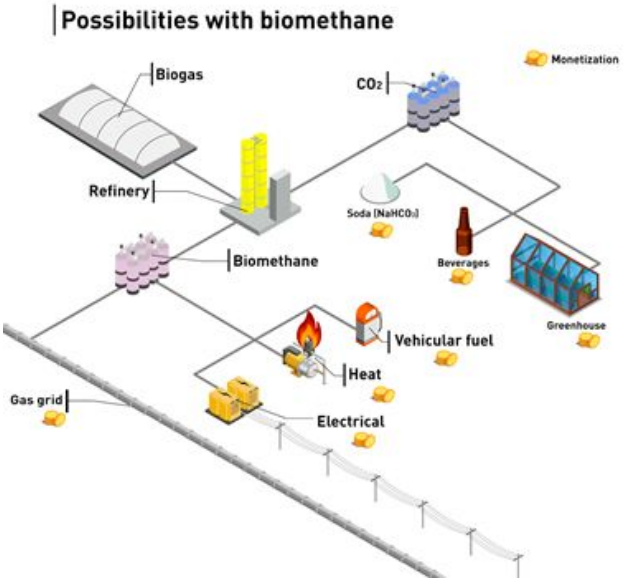
BUSINESS MODELS

In one of the studies on technical arrangements carried out by CIBiogás, **270** alternative arrangements for monetization of biogas with **electrical energy** and **405** for **thermal** use were identified.

Biogas plants include in the cash flow the monetization of **electrical or thermal energy or biomethane**. Avoided expenses with treatment is also expressive.



Electrical model involves a biodigester that produces biofertilizer and biogas, which in turn uses biogas as an energy source in a generator to produce electricity.



In some cases the monetization of biogas in the form of heat is more advantageous. This happens in enterprises that produce organic waste and that demand thermal energy in their production line, such as starch mills, sugarcane mills, dairy plants and poultry incubators.

The refining of biogas results in biomethane. Biomethane can be injected into the gas pipeline network or used as a vehicle fuel or even as an input for the production of thermal or electrical energy.

Biogas upgrading or refining produces by-products as CO_2 (carbonated beverages, soda or greenhouses).

Cerâmica Stein is a highly efficient farming biogas plant that works off-grid and should be used as an example of technical arrangement. See section 3.4.2 for details.

Some new energy surplus monetization is crypto mining and H_2 production.

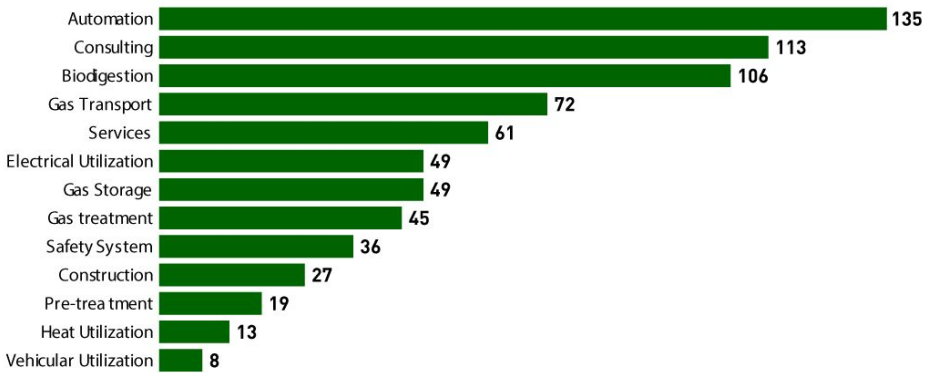
In order to “sell” energy through net-metering legislation the plant owner may construct a rent contract of the plant to the energy customer.

The first Microgrid is under construction by CIBiogás in PR and opens new markets.

SUPPLY CHAIN

This report contains a list of 418 companies with actuation branches and contact details. All of them had their fiscal status checked.

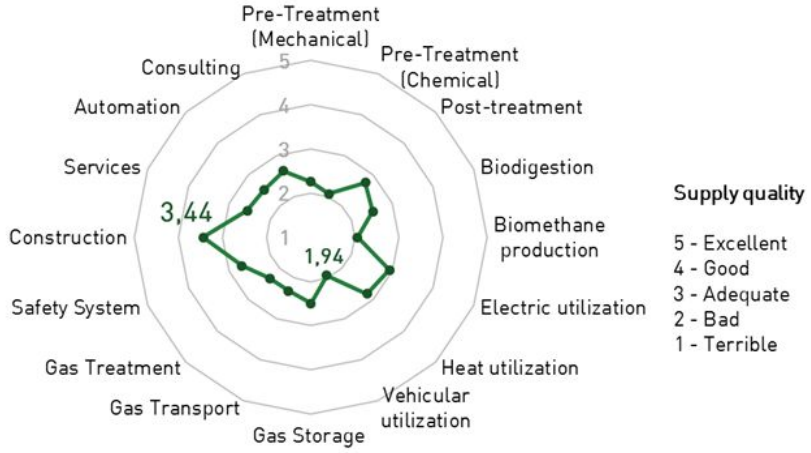
Many suppliers of services and products have been identified. The products with the largest number of suppliers in Brazil are of civil biodigesters works and consulting and maintenance services, while **the products with the greatest lack of options are related to vehicle and thermal use.**



The concentration is mainly in SP followed behind by PR, SC and MG.

This report brings up to date technical research results on the quality of national and international services and products for biogas in Brazil per step of the chain. The overall grade is of 2.5. An intermediate value between the classifications "bad" and "adequate".

The **best evaluated** sector was the **construction sector, reaching 3.44** (value between adequate and good), while the one with the **worst evaluation** was the **vehicular use sector, 1.94** (bad).



Shredders, refining, compressors and modern equipments are highly demanded.

One of the main technologies to be explored in the Brazilian biogas market is **refineries the biogas to biomethane**. The options currently available have configurations incompatible with the practical conditions found in Brazil, which implies the need for tropicalization of this technology.

Furthermore, currently, the Brazilian market of equipment in this field needs suppliers that ensure products and **after-sales services** with adequate quality.

BRAZILIAN BUSINESS CULTURE

"Brazil is not for amateurs", "Brazilian *jeitinho* (~shortcut)", "tons of bureaucracy" and "I know someone that will help" are common sentences when talking about doing business in Brazil.

The Embassy of the Kingdom of the Netherlands in Brazil and Dutcham have promoted two very interesting publications on the Brazilian Business Culture with testimonials of important dutch companies in Brazil as of Makro, ING, Heineken, Boskalis, KLM and AkzoNobel. See on references. Some tips on how to deal it with brazilians:

- **Personal contact** is essential to building a successful business relationship, so do spend some time on personal contact and don't jump straight to business.

- Brazilian(figure[3]) negotiate with people and not with companies. **Personal relationships take priority over institutions, laws and regulations.**
- Being too direct or avoiding the **usual small talk** may be seen as unpolite.
- Brazilians avoid conflicts. It is hard to hear a straight NO. More often a YES, BUT…
- Communication in Brazil has a strong presence of **non-verbal** or between the lines.
- Silence is also a communication and may be interpreted as lack of interest.
- Using a few words of Portuguese in a conversation generates a lot of goodwill. **Brazilian Portuguese** is different from Portuguese in Portugal. Brazilians do understand a bit of Spanish, but if possible, better speak in English.
- **Lack of punctuality** and **postponement of important decisions** and common.
- **Speech interruptions** may be interpreted as sign of interest and not of disrespect.
- Brazil has the **size of a continent.** There are many consumer cultures in it.
- **Appearance** is very important in the Brazilian culture.

[3] **Picture source: (DUTCHAM, 2019)**

Dear Dutch Companies,

hopefully this summary has awaken your interests on the Brazilian biogas market.

The full report contains many interesting data, pictures and tips gathered specially for You by effort of your Netherlands Business Support Office (NBSO) in Brazil.

Throughout this report You will be able to:

- identify the main regions and substrates for biogas production and suppliers;
- analyse supply gaps on equipment and services for national biogas industry;
- access a quick guide on electric sector regulation;
- get tips on how to deal business in Brazil;
- learn about successful and yet-to-be-built business models;
- explore the location and profile of every classified biogas plant in the country;
- identify CIBiogás as an international, neutral and optimal associate partner to support Your business venture in Brazil.

We will be glad to hear from You! Please contact us!

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RENEWABLE ENERGY

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LIST OF ABBREVIATIONS

ACL - Free Electricity Commerce Chamber

ACR - Regulated Electricity Commerce Chamber

ANEEL - National Electricity Agency

ANP - National Petroleum Agency

BPP - Biogas Production Potential

BOD - Biological Oxygen Demand

CC - Complete Cycle Swine Production

CH_4 - Methane

CHP - Combined Heat and Power

CNG - Compressed Natural Gas

CNI - National Confederation of Industry

CO_2 - Dioxide Carbon

COD - Chemical Oxygen Demand

COMPAGÁS - Paraná Gas Company

CSTR - Continuous Flow Stirred Reactor

EIA - Environmental Impact Assessment

K - Potassium

MPP - Methane Production Potential

N - Nitrogen

NaOH - Sodium hydroxide

NBSO - Netherlands Business Support Office

NG - Natural Gas

NREL - National Renewable Energy Laboratory

PLANSAB - National Primary Sanitation Plan

P - Phosphorus

RFB - Receita Federal do Brasil

RIMA - Environmental Impact Report

RT - Retention Time

SANEPAR - Paraná Sanitation Company

TS - Total Solids

TU - Termination Unit

UASB - Upflow Anaerobic Sludge Blanket

UHT - Ultra High Temperature

UPL - Swine Piglet Production Unit

VS - Volatile Solids

WWTP - Wastewater Treatment Plant

WELKOM IN BRAZILIË - HET LAND VAN DE BIOMASSA!

The climatic conditions, relief and continental vastness enabled Brazil to be one of the largest food producers in the world. It is also the 6th largest market for Rabobank, a Dutch bank that finances agribusiness in the world (RABOBANK, 2019).

In addition to feeding its 200 million inhabitants, much of the production of soy, corn, sugar and animal protein is exported and plays an important role in the Brazilian trade balance (ITC, 2019). This production also generates non-ordinary volumes of organic waste or biomass that can serve as input for biogas production. Biogas is the gas produced from the anaerobic digestion of biomass at mesophilic temperature, easy to store and rich in methane gas (CH_4), a fuel with high calorific potential that enables its use as a source of electric, thermal or vehicular energy (AL SAEDI, 2008).

Despite the significant supply of biomass for biodigestion and biogas production, this anaerobic digestion for energy purposes is in a late stage of development in Brazil compared to European countries. For example, in 2017 Germany had approximately 9,500 biodigestion reactors in operation, while Brazil registered less than 400 plants installed (CIBIOGÁS, 2018) (STATISTA, 2019). The reason for this delay is mainly due to the lack of knowledge about successful cases of biodigestion plants in Brazil by organic waste generators, investors or creditors. In addition, the high cost of constructing a latest-generation technical arrangement also contributes to the delay, since the equipment is of foreign origin and its import leads to high prices.

Taking this technological delay into account, CIBiogás appears with the mission of promoting the sustainable development of the biogas supply chain and other renewable energies. This report, entitled "Market Study of Biogas and Biomethane in Brazil" was produced especially for the Netherlands Business Support Office (NBSO), headquartered in Belo Horizonte, Minas Gerais and has as main objective to provide and guide Dutch companies interested in building biogas plants and provide equipment or services for the Brazilian biogas market that is growing at a rapid pace.

The specific objectives are divided into two items: 1) Survey of biogas production potential of 5 pre-defined substrates, and 2) Analysis of the Brazilian biogas market.

The content of item 1 covers the characterization and geographic concentration of the residues produced by:

- swine production;
- poultry production;
- sewage treatment plants (WWTP);
- dairy industry; and,
- sugar and ethanol industry (sugarcane).

Item 2 provides strategic and current material of the Brazilian biogas market, such as: i) analysis of current federal and state regulations and laws; ii) successful business models; iii) challenges and opportunities within the regulatory and supply chain environment; and iv) listing of the main public and private market players.

The expectation is that this material will contribute to Dutch companies to safely develop strategies in order to enter the Brazilian biogas engineering market, to tropicalize technologies, and together Brazil, the Netherlands and CIBiogás become partners in the common mission of developing the biogas value chain in a profitable, economically and environmentally sustainable manner.

1. SURVEY OF POTENTIAL FOR BIOGAS PRODUCTION

Brazil has one of the cleanest electric matrices in the world (IEA, 2018). This is partially due to the subtropical climate that does not require heating systems inside homes. It helps to reduce the consumption of coal and natural gas. Moreover, another reason is especially due to the enormous installed capacity of hydroelectric plants (61 % of total electric installed capacity). For instance, the Itaipu Binacional power plant in Foz do Iguaçu, state of Paraná in Brazil and Ciudad del Este in Paraguay, generates approximately 15 % of all electricity consumed in Brazil.

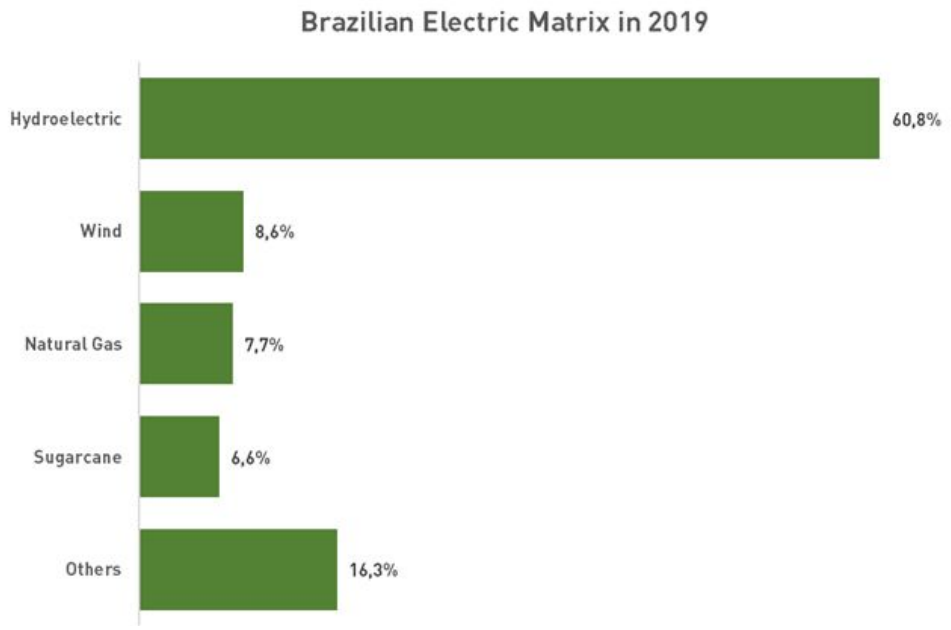
In addition, Brazil also has a significant share of energy generation from renewable sources, such as wind (9 %), biomass (8,5 %) and solar (1,3 %). Figure 1.1 brings the main sources of electric energy in Brazil and their representativeness compared to the total installed capacity of 174 GW. Almost 61 % of the energy comes from hydraulic plants. Furthermore, 6.6 % of the generated energy comes from the sugarcane mills (ANEEL, 2019).

By looking at the whole scenario, although Brazil counts with a quite clean electric matrix, its total energy matrix is still very dependent on fossil fuels. 37 % of all energy consumed in 2016 was used by the transport sector, while 35 % was used by the industry (IEA, 2016).

Biogas is still an incipient source of energy in Brazil. It has a huge potential to grow relevantly as it is in Germany. There, for example, the biogas production represents 2.2 % of the whole energy mix, yielded by more than 9,000 digesters with a total installed capacity of 4.2 GW (FACHVERBAND BIOGAS, 2017). Biogas can be easily stored and used to produce electric, thermal or vehicular energy. Therefore, it is considered a dispatchable energy source, because it can be turned on and off according to its availability. This is a feature highly valued and found only in hydroelectric and thermoelectric plants (coal, enriched uranium, natural gas, diesel, among others). The increase of the biogas production in Brazil has the potential to drastically alter the energy matrix, since it can contribute to the sources of electric and distributed energy generation. With this, it is possible to compete with fossil fuels, mainly in the form of biomethane,

which is removed from biogas and has the same qualities and efficiency of vehicular natural gas (CNG).

Figure 1.1 - Electric matrix of Brazil



Source: Adapted from ANEEL, 2019

This section brings the description and characterization of 5 sources of substrates with significant technical and economic advantages in biogas production. The selection criteria took into account the organic load, waste management, methanogenic potential and previous experiences of CIBiogás with them. They are: swine, poultry, sewage treatment plants (WWTP), dairy industry and sugarcane industry. Each one of them has its own section in this work, which contemplated for each substrate: i) operational details of the industry or sector, ii) characterization of the byproducts or residues allied to laboratory analyses of methanogenic potential, and iii) the geographic concentration. Moreover, an analysis of the Brazilian market was performed in order to give an overview of the Brazilian public policies and opportunities for investments regarding the mentioned substrates.

1.1. SUGARCANE INDUSTRY

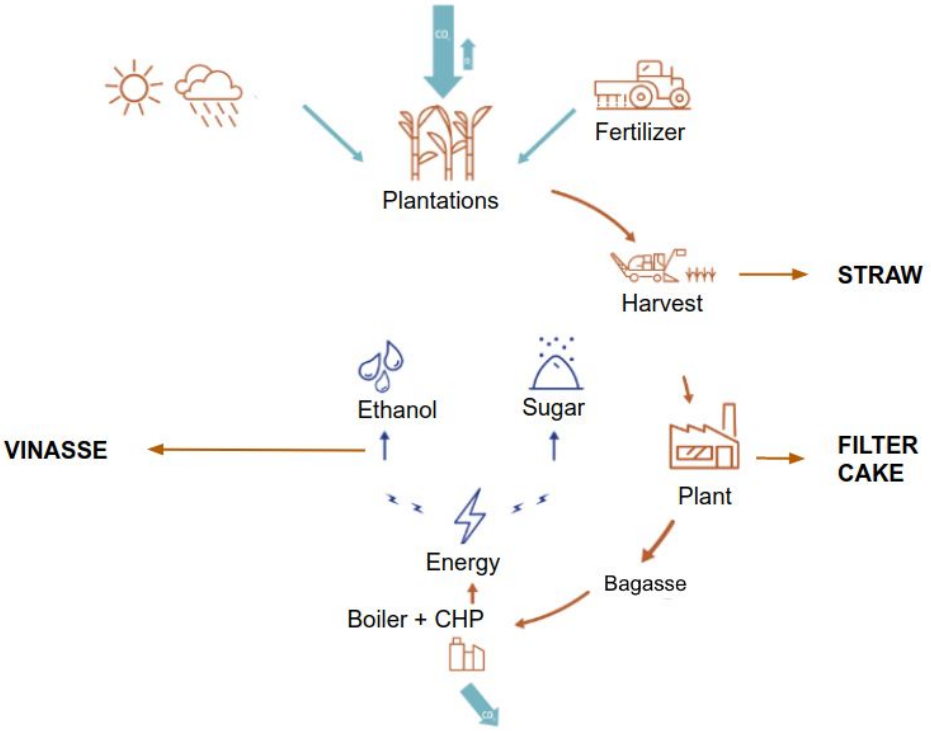
In this topic, the main characteristics of the sugar and alcohol industry, the types of waste and the potential for biogas and methane generation of each were detailed.

1.1.1. About the industry

Brazil is the world's largest producer of sugar and ethanol from sugarcane. This plant is also the country's main input for the production of this two products. The crop´s growth and harvest cycle is annual. Good planting conditions are found in south-central and northeastern territories of the country.

The harvest period is mainly between April and November in Southeastern Brazil and between September and April in Northeastern Brazil. In the first case, the mills close their operations between December and March. In the second case, they close their operations between May and August. These periods are used to maintain the equipment and to improve the technology used.

Figure 1.1.1 - Sugar and ethanol production process



Source: Adapted from ADECOAGRO,2019

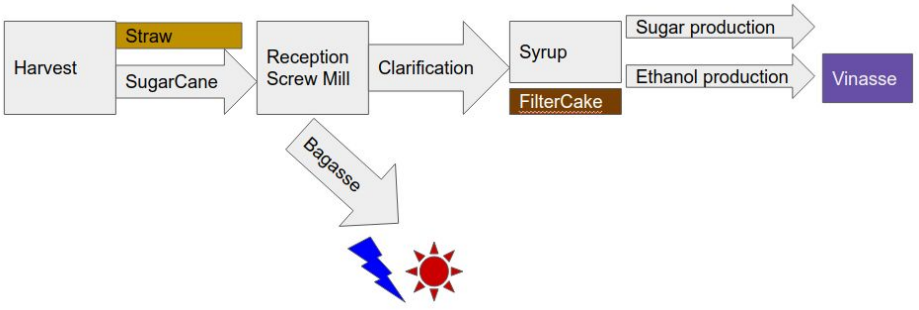
One important point of this industry is that the harvested sugar cane cannot be stored, because it perishes quickly. Therefore, the mills keep on harvesting and milling during the entire harvest period without stopping, including through the night (24 hours, 7 days a week during all harvest). However, when it rains, the harvest is suspended,

because the accesses to the crops are in bad conditions. Thus, trucks and harvesters have difficulty in reaching the extraction fronts. As sugarcane has a growth cycle of precisely one year, the rain season of each region determine the period between harvests.

The production process is illustrated in Figure 1.1.1. The first product is produced already by harvesting; the plant leaves, also called straw, are left in place for soil management. It is suggested to use 10 tons of straw per hectare after the harvest in order to maintain soil quality for the next cycle. Hence, this represents an average of 70 % of the straw generation. After harvesting, the sugarcane is transported to the sugar and ethanol mill. There, it will be treated and processed until the juice is formed, when the second product is generated: the filter cake. It is consisted of impurities, solids not used in the process, and even a small proportion of sugar crystals.

Figure 1.1.2 presents the flowchart of products generation by process. Firstly, the straw production is observed immediately after harvesting. Then, the sugarcane is sent to the reception screw mill. The sugarcane is crushed resulting in bagasse and juice. The bagasse is stored and is destined to the boilers in order to be burned, generating energy for the plant. It is common to find a significant surplus of bagasse in large plants without thermoelectric plants for energy export. In this case, the bagasse is burnt only for off-grid consumption. If so, the surplus of bagasse becomes an important source of income for the plant, since each ton is commonly sold at R$ 80. The buyers are normally plants that operate on shortage of this biofuel.

Figure 1.1.2 - Flow chart of the products generation



Source: Adapted from UDOP, 2018

Regarding the juice, it passes through a process of clarification, generating the filter cake and the syrup. The syrup is then directed to the production line of sugar (refining) or

ethanol (fermentation and distillation). When producing sugar, no residue or effluent suitable for biodigestion is produced, with the exception of straw and filter cake. However, when the alcoholic distillation process is followed, the vinasse is generated on the last stage of ethanol production. This is the third product. It is a turbid effluent of high humidity and organic load with characteristic odor.

Given the significant generation of products and the long production period, it is common for plants to register a surplus in the energy balance through the so-called "cogeneration". They produce all the electricity consumed and still export it to the utility concessionaire, either in the regulated market (ACR) or in the free market (ACL). Given the operation characteristics of the sugar plant and its energy matrix, only vinasse and filter cake will be considered as available substrates for biogas production, leaving bagasse and straw aside.

Vinasse and filter cake, the main products available for biogas production, are generated inside the plant and can easily be directed to a biodigestion reactor. Their current use is for soil nutrition as fertilizers by spreading or spraying. Fertilization with these products is important to return the macronutrients nitrogen, phosphorus and potassium to the soil, reducing, thus, the cost of chemical fertilizers.

Important to hence, the biodigestion will not eliminate this biofertilizer, since the nutrients nitrogen, phosphorus and potassium (N-P-K) are not consumed by the bacteriological action of fermentation. Instead, the result is a biofertilizer of higher quality and higher concentration of nutrients, including non-volatilized ammonia. It still has its organic load expressively consumed in biodigestion (approximately 80 %), which reduces environmental impacts, odors and proliferation of insects and diseases in the field.

Furthermore, the reduction of the organic matter through biodigestion contributes to the reduction of insects and bugs that may proliferate diseases for humans or animals. Nearby cattle production are often affected. Biogas production becomes, in this case, also a sanitary solution.

1.1.2. Byproducts characterization

Bagasse, straw and filter cake products are produced before the transformation into sugar or ethanol. Therefore, they are measured in kg per ton of processed cane. However, vinasse is an exclusive product of the fermentation and distillation of the syrup into alcohol. Thus, it is measured in liters per liter of produced ethanol. Table 1.1.1 shows the average production ratios of each product.

Table 1.1.1 - Sugarcane products production indexes

Product	un.	Quantity
Ethanol	L / t sugar cane	85
Vinasse	L / L ethanol	10
Filter cake	kg / t sugar cane	30
Straw	kg / t sugar cane	175
Bagasse	kg / t sugar cane	250

Source: Adapted from CONAB, 2018.

Yet, according to the data in Table 1.1.1, bagasse registers the highest production per mass of processed sugarcane, followed by the straw. This means that quasi half of the sugarcane (425 kg per ton) are plant fibers (bagasse and straw) rich on lignin and therefore not optimal for biogas recovery technique.

The volume of produced vinasse per liter of ethanol is also significant. Since each ton of the plant yields 85 L of ethanol, it is possible to calculate that for each ton of processed sugarcane, 850 L of vinasse are produced. This large amount of vinasse generation comes along with the water usage on the ethanol production process and it is important to be taken into account, since its scale of production is indeed striking.

For example, a medium size sugar and ethanol production plant visited by the Cibiogas team on the first semester of 2019 produces an average of 600,000 L of ethanol per day. This means that on each full day of production this plant produces around 6,000,000 L or 6,000 m³ of vinasse. In one month it is 180,000 m³ of this contaminant and

fetid residue. For comparison, a olympic swimming pool holds 2,500 m³ of water. Since this plant produces the volume of an olympic swimming pool of wastewater every two days, it needs also a correspondent infrastructure for the demanded treatment.

Figure 1.1.3 brings a satellite image of the plants complex. When one appraises this figure, it is possible to understand the magnitude of this environmental issue. The plant itself is located on the superior left corner of the figure, while the rest show either a green field (trees or sugarcane plantation) and vinasse storage lagoons from a wide range of sizes and formats.

Figure 1.1.3 - Visited sugar and ethanol plant visited by the Cibiogás team

Source: Google Earth

The characterization of substrates for biodigestion is given by the composition of total solids (TS), volatile solids (VS) and indexes of biogas production, methane (CH_4) and proportion of methane within biogas. From this, it is possible to value the biogas production on a case-by-case basis. Table 1.1.2 brings the characterization of bagasse, vinasse, filter cake and straw substrates.

From Table 1.1.2 it is possible to identify the main characteristics of the products. Vinasse is liquid and has an average proportion of VS. However, its VS is very powerful in biogas, because it registered the highest biogas production index and the highest concentration of CH_4 among all the listed residues.

Yet, the filter cake is a humid product. It also has, similarly to vinasse, an average proportion of VS. But, it does not has as much potential for biogas and methane production as vinasse. However, it is higher than the value of straw.

Table 1.1.2 - Methanogenic potential analysis of sugarcane byproducts

Residue	**TS [%]**	**VS / TS [%]**	**Biogas Yield [m³.biogas / kg.VS]**	**Methane Yield [m³.CH_4 / kg.VS]**	**CH_4 [%]**
Vinasse	2.8	74	0.607	0.393	65
Filter Cake	27.3	71.5	0.403	0.234	58
Straw	47	94	0.368	0.165	45
Bagasse	60	93	0.528	0.327	62

Source: Adapted from CIBIOGÁS and JANKE et. al, 2014

Regarding the others, both straw and bagasse are less humid substrates than filter cake and vinasse and have a very high proportion of volatile solids. However, both have a significant amount of lignocellulosic material that is difficult to degrade. Moreover, the tests were performed in laboratory conditions, where the challenge of lignocellulosic material is overcome. In normal conditions of a biodigester, an intense and costly pre-treatment is necessary to avoid clogging. Only doing this, the use of decomposition at the biogas production level is satisfactory

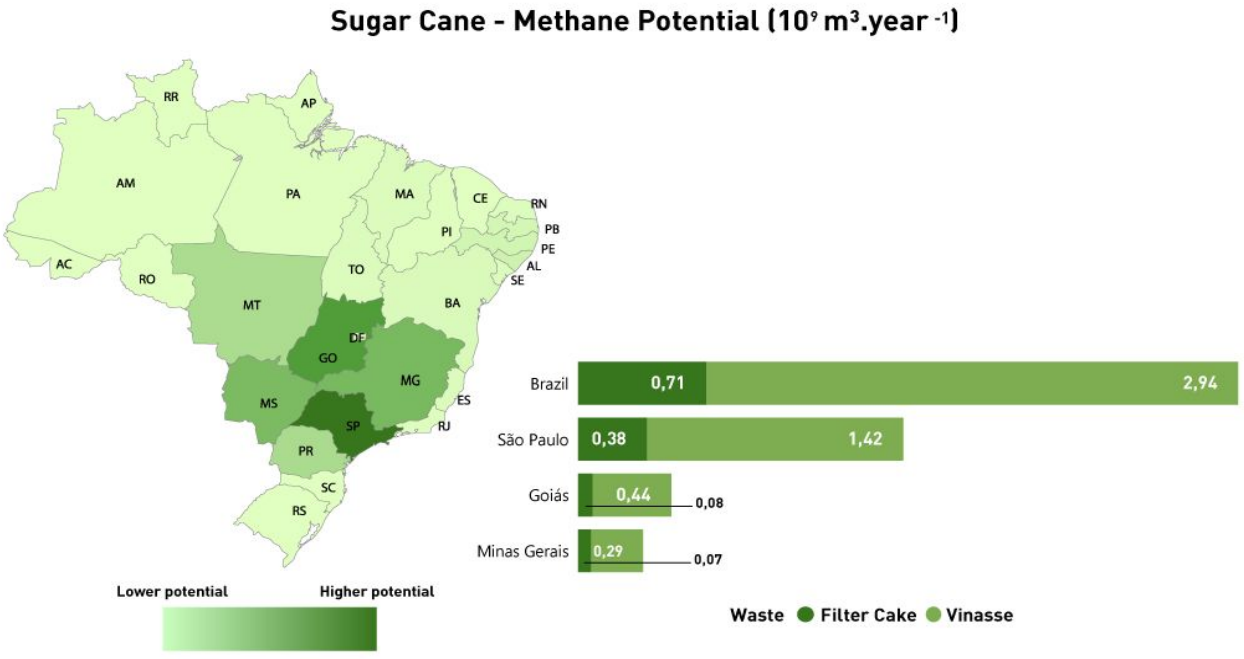
1.1.3. Geographic concentration

The estimated volume of methane production potential from sugarcane residues in Brazil considered the sugarcane milling and ethanol production survey for 2018/19 (UNICA et al., 2019). Figure 1.1.4 shows the statewide potential for annual methane generation,

related to the use of vinasse and filter cake. The generated volume of vinasse is 20 times greater in comparison to filter cake. Vinasse has a generation potential of approximately 2.94 billion m³ CH_4. São Paulo (SP) stands out as the state with the highest methane generation potential in Brazil from sugarcane waste, being responsible for 50 % of the Brazilian potential. SP is then followed by Goiás (GO) and Minas Gerais (MG).

In addition, another favorable factor to the use of biogas in this sector in the state of São Paulo is the proximity of the sugar-alcohol industries to the gas pipelines. This characteristic favors the distribution and use of biogas throughout the state. From Figure 1.1.5, it is possible to verify the concession area of the gas distributors, the main cities, the existing gas pipeline network, the natural gas delivery points for connection to the network and also the location of the power substations.

Figure 1.1.4 - Methane generation potential from sugarcane waste (10^9 m³.year^{-1})

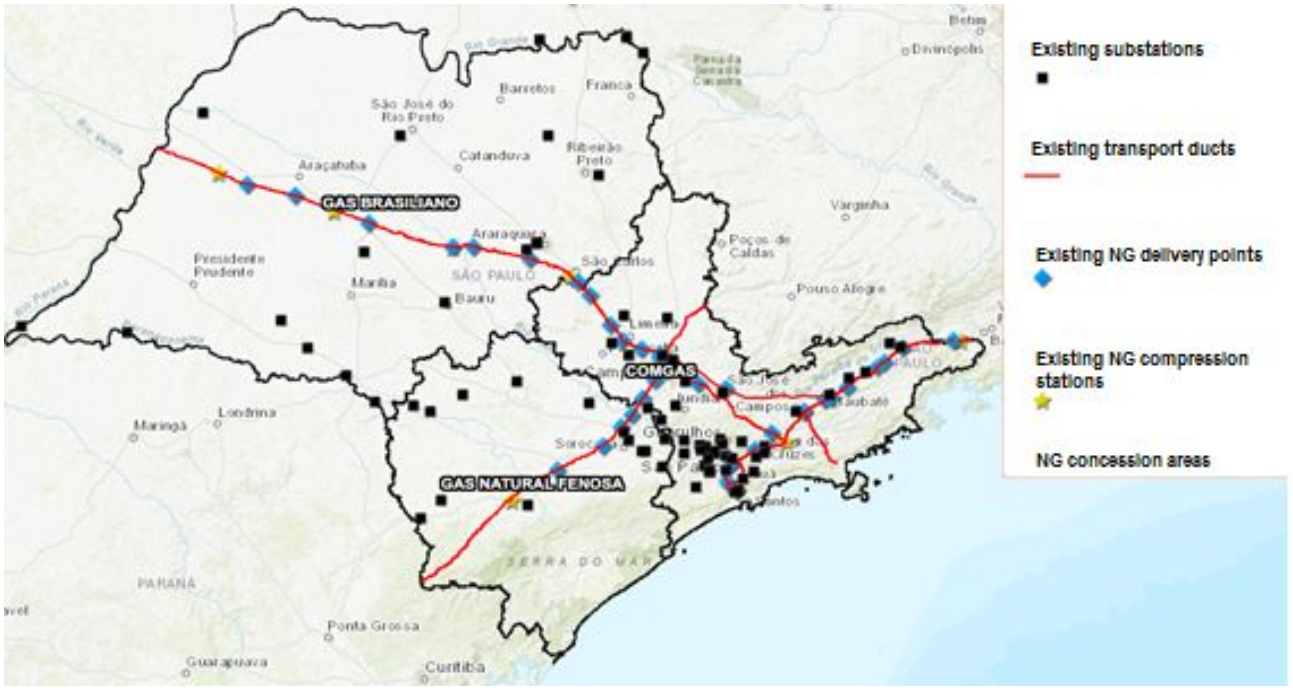


In São Paulo, the largest biodigester of vinasse and filter cake in Brazil and perhaps in the world is under construction. It is the project at the Bonfim Raízen Plant, located next to the city of Ribeirão Preto and which was the winner of the 2016 ANEEL A-5 energy auction, in partnership with the Italian company Sebigas-Cótica. The recent satellite image in Figure 1.1.6 illustrates the construction of this biodigester that will have 21 MW of installed capacity.

Firstly, it is possible to state that the biodigester will be of the type covered lagoon and not vertical (CSTR), as it is usually built in Europe. Covered lagoon reactors are horizontal and represent an economically less expensive option than a CSTR and are viable when the substrate does not exceed a 4 % concentration of solids.

By using Google Earth measurement tool, it was possible to measure the area of 12,000 m² for each of the three lagoons under construction. If each lagoon is 5 m deep, the complete system will have 180,000 m³ for the treatment of vinasse and filter cake only. With the premise that the waste remains in the biodigestion system for 15 days, it is estimated that this plant will produce approximately 12,000 m³ of waste (vinasse + filter cake) per day. This project is expected to be commissioned at the beginning of 2020 and the sale of energy in the regulated market (ACR) at the beginning of 2021.

Figure 1.1.5 - Infrastructure for biogas in the state of São Paulo and Brazil



(a) Source: IEE-USP, 2019

(b) Source: EPE, 2019

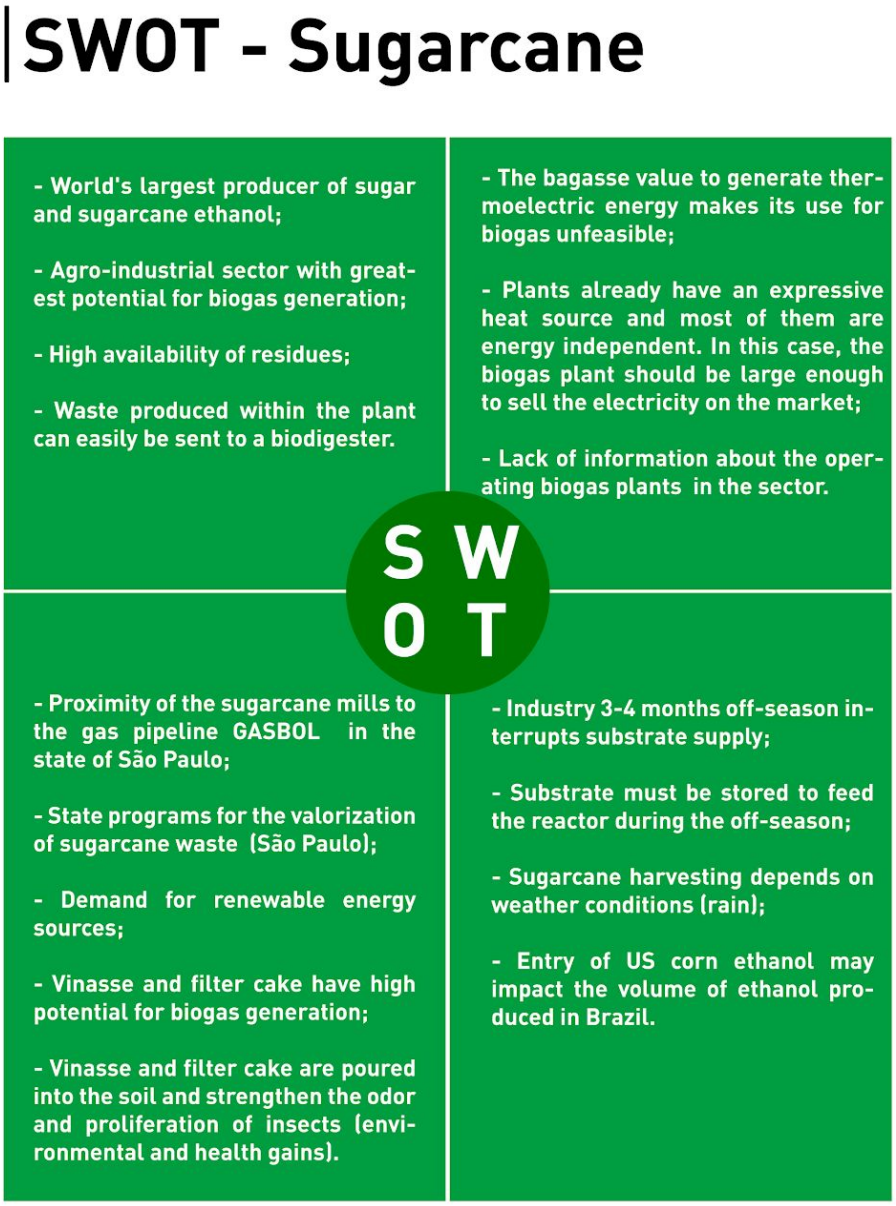
Figure 1.1.6 - Satellite image of the Bonfim Raízen Plant's biodigester project

Source: Google Earth

1.1.4. SWOT Analysis

The results of the analysis for the sugarcane mills are shown in Figure 1.1.7 The characteristics identified show the high Brazilian knowledge in this sector, a fact that is related to the organization of sugarcane industries. In addition, it is notable that the high generation potential and the layout of the gas distribution lines support the production of biogas in this sector.

Figure 1.1.7 - SWOT - Sugarcane



1.2. DAIRY INDUSTRY

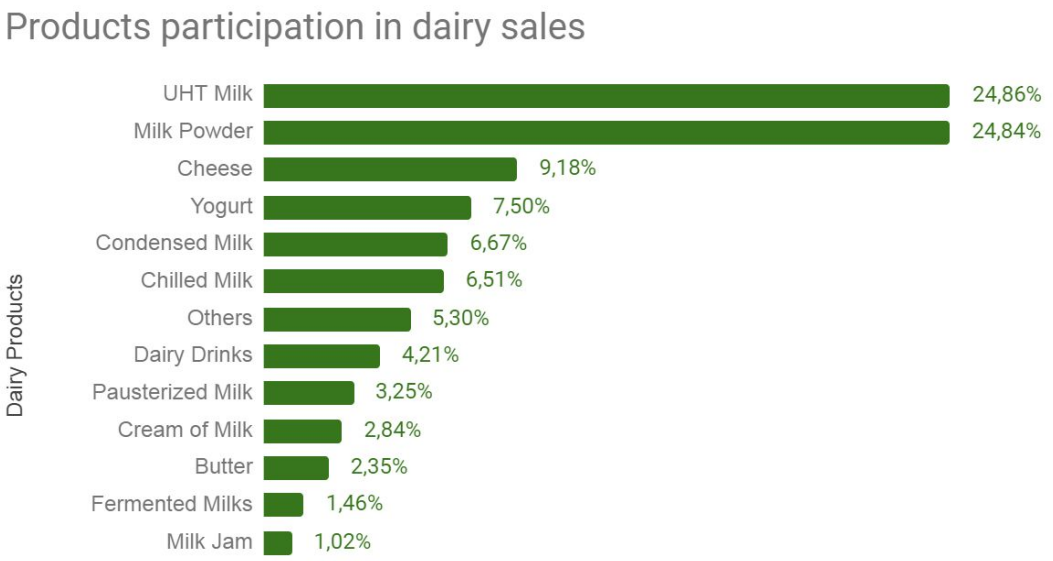
The dairy industry stands out for having a large generation of waste rich in biodegradable organic matter. In this topic the productive process of this industry and the characterization of the main residues generated were detailed.

1.2.1. About the industry

In Brazil, milk is predominantly produced by cows. Cow milk production in Brazil is the third largest in the world at 33.5 billion liters of milk per year, behind India (83,6 billion liters) and USA (97,7 billion liters).

A major consumer of brazilian milk is the industry of dairy products (milk products). According to a study conducted by Leite Brasil (2018), of the total volume of milk produced in Brazil in 2018, 22 % was used by dairy companies, totaling 7.5 billion liters of milk.

Figure 1.2.1 - Participation of each type of product in the sales value of dairy products



Source: Adapted from MAGYP/ Scot consultoria apud Embrapa, 2019

The dairy industry has a variety of products, systems and scale of production, which can be small industries up to large companies (MACHADO et al., 2002). The main products of the dairy industry are UHT milk (or long-life milk as it is popularly known in Brazil), cheeses, powdered milk, yoghurt, condensed milk, chilled milk, dairy drinks,

pasteurized milk, cream, butter, fermented milk and sweet milk. Figure 1.2.1 illustrates the share of each type of product in the value of dairy sales in 2016.

Because of the high variability of products that can be manufactured by the dairy industries, the effluents generated in this type of industry have their own characteristics of the production systems that are adopted in each case. However, in general, residues are generated with a high content of organic matter and consequent high polluting potential. It is possible to see that UHT milk, together with cheeses, were the best-selling dairy products in 2016. Together, they represent almost 50 % of the products sold.

1.2.2. Byproduct characterization

In the food processing sector, the dairy industry is considered the largest generator of wastewater (HUNG et al., 2006). According to Sarkar et al. (2006), the high volume of effluents generated in this type of industry is due to the fact that water is widely used in cleaning, sanitization, cooling and heating of the dairy production process.

Table 1.2.1 - Water consumption in different types of products in different countries

Product	Water consumed* ($L_{water}/L_{Processed\ Milk}$)			
	Sweden	**Denmark**	**Finland**	**Norway**
Milk and Yogurt	0.96 - 2.98	0.60 - 0.97	1.2 - 2.9	4.1
Cheese	2.0 - 2.5	1.2 - 1.7	2.0 - 3.1	2.5 - 3.8
Milk Powder and/or liquid products	1.7 - 4.0	0.69 - 1.9	1.4 - 4.6	4.6 - 6.3

* Including cooling water

Source: Nordic Council of Ministers, et al., 2001 apud (CETESB, 2006)

According to Saraiva et al. (2009), in Brazil the average water consumption in a dairy industry is approximately 3.2 $L_{water}/L_{Processed\ Milk}$. However, it is important to note that this volume may vary according to the type of product processed and technology used. Table 1.2.1 shows the variation in the volume of water consumed in the production of different types of products due to different technologies used in the different countries

listed. It can be seen that the average water consumption in dairy production in Brazil is close to the consumption range of the countries mentioned in Table 1.2.1. In addition, it is noted that the maximum water consumption rate values correspond to powdered milk and liquid products.

In Table 1.2.2 it is possible to verify the amount of waste generated by type of product produced. In addition to the high generation of effluents from dairy industries, they are known for their high organic load. In general, according to Hung et al. (2006), these types of residues have a high content of organic matter, and are predominantly composed of lipids and carbohydrates. In addition, they contain high concentrations of total suspended solids, chemical oxygen demand (COD), biological oxygen demand (BOD) and oils and/or grease. Thus, the high concentration of these compounds shows the need for a treatment for the adequate disposal of these effluents.

Table 1.2.2 - Volume of effluent generated by type of product

Product	**Effluent produced ($L_{effluent}/L_{Processed\ Milk}$)**
Milk, creams, Yogurt	3
Butter and Cheese	4
Whey or concentrate of milk and dehydrated milk products.	5

Source: European commission, 2006

According to Andrade (2011), the effluent treatment system of the dairy industry is typically composed of 3 phases, operated sequentially:

- Preliminary treatment;
- Primary treatment; and,
- Secondary treatment.

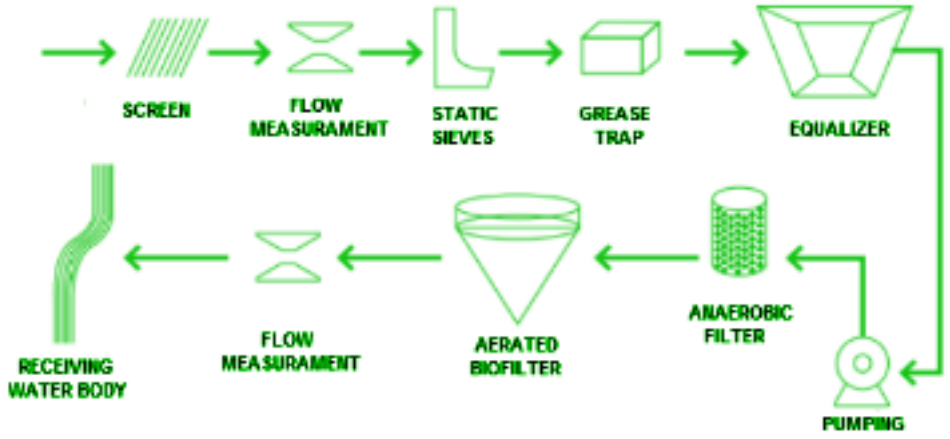
The preliminary treatment includes the removal of coarse solids (packaging waste and milk clots). Static sieves are generally used to remove larger solids, after which the waste is sent for primary treatment. The primary treatment represents the removal of solids, oils and/or greases. It can be carried out in different ways, the main ones being the grease trap and the one by dissolved flotation (flotation is a method used to separate the

solid and liquid phase of a residue by micro air bubbles), it should be noted that flotation is the most used method.

Finally, secondary treatment represents the step responsible for the removal of organic matter and nutrients dissolved in the effluent. Even with these phases, in some cases it may be necessary to have a subsequent treatment step in order for the effluent to be totally stabilized. In this treatment, biological treatments are generally used to stabilize the biodegradable organic material present in the waste (FIEMG, 2014).

Biological treatment can be carried out aerobically or anaerobically. Aerobic treatment is the most commonly used, and is generally performed by activated sludge systems, aerated ponds, and biological filters (FIEMG, 2014). Although aerobic systems are predominant in the treatment of dairy waste, the number of anaerobic treatments installed has been increasing (CAMMAROTA and FREIRE, 2006). These treatments are performed in reactors of the following type: anaerobic filter, fluidized bed, expanded bed or UASB (SCHOENINGER, 2005). Figure 1.2.2 shows the flowchart of a system that uses an anaerobic filter reactor.

Figure 1.2.2 - Flowchart of a treatment system using the anaerobic route



Source: FIEMG (2014)

In Figure 1.2.2 all the mentioned treatment steps are included. Additionally, the aerated biofilter is illustrated. This equipment is generally used with the purpose of complementing the removal of remaining organic matter from the anaerobic process before sending the treated effluent back to the ecosystem thru the receiving water body.

The wastewater produced by the dairy industry present high potential for degradation of organic matter. In another words: high potential for biogas production. This gas rich on methane is produced and collected on the anaerobic step of the technical arrangement shown on Figure 1.2.2. The potential for biogas generation from dairy waste may however vary according to its composition.

The physical-chemical characterization of the wastewater from dairy producers as well as its potential for biogas generation were analyzed in the Labiogás - Cibiogás laboratory. The results of the analyses are shown in Table 1.2.1. Table 1.2.2 shows that dairy effluents have high dilution, since effluent samples have less than 1 % of total solids (TS). On the other hand, the amount of volatile solids (VS) is high, indicating a high proportion of biodegradable organic matter. The potential for generation of analyzed biogas is expressive when compared to other biodegradable substrates, such as poultry and swine manure, also discussed in this study. In addition to having high generation, biogas produced from residues from the dairy industry contains a high content of methane in its composition, reaching more than 60 % in its concentration.

Table 1.2.3 - Fraction of solids and potential for biogas and methane from dairy industries effluents

Residue	TS [%]	VS / TS [%]	Biogas Potential [Nm³ biogás / kg VS]	Methane Potential [Nm³ CH4 / kg VS]	CH4 [%]
Waste Water	0.84	76	0.574	0.356	62
Whey	4.2	81	1.166	0.976	83

Source: LABIOGÁS, 2019

Although the dairy whey due to its protein content registers great potential for biogas and methane generation, in most cases it is sold as a protein supplement in within the milk production chain. However, the whey biogas potential is so expressive, that the biogas production might be feasible, even considering the isolated whey market price.

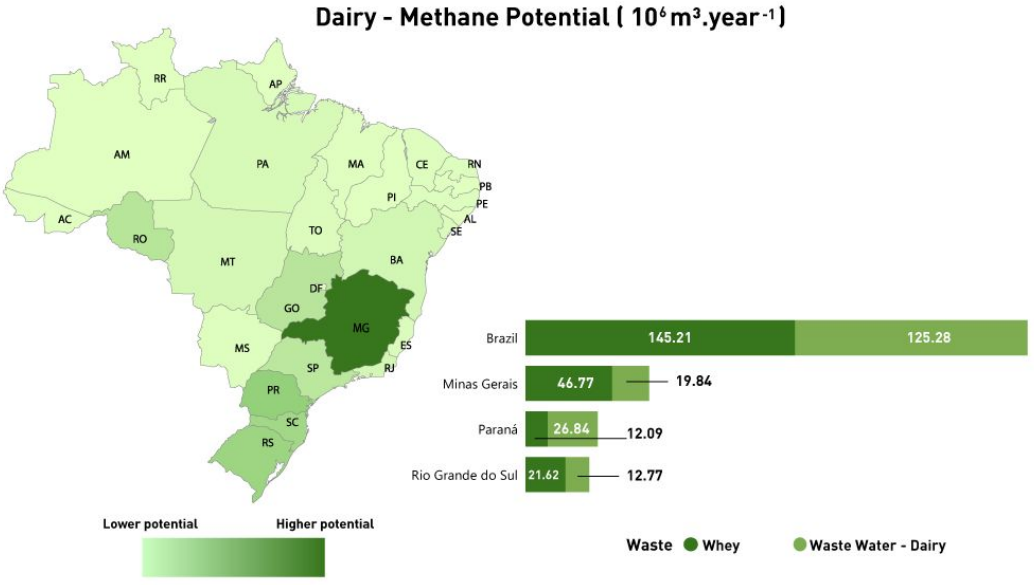
1.2.3. Geographic concentration

The composition of dairy waste can vary greatly according to the technology used and the product to be industrialized. Given these characteristics, in order to estimate the amount of effluents generated it was considered the volume of milk, milk powder and cheese industrialized in 2017, using as source the Annual Industry Survey - Product

(IBGE, 2017). The estimate of waste generation was limited to these three products due to their availability of production data at the state level.

Whey is a waste produced exclusively from cheese production and is a value-added substrate within the dairy market. In addition, it stands out for its high potential for biogas generation when compared to the wastewater from the different production processes of this branch of industry (Table 1.2.2). For these reasons, the potential of whey methane generation was analyzed in parallel to the other wastes. Figure 1.2.3 illustrates the Brazilian methane generation potential that can be obtained from dairy waste. From this, it is identified that the wastewater in face of the volume produced presents a higher estimate of methane generation in relation to the serum.

Figure 1.2.3 - Potential for methane generation from dairy waste in Brazil (10^6 m³/year)



Source: CIBiogás

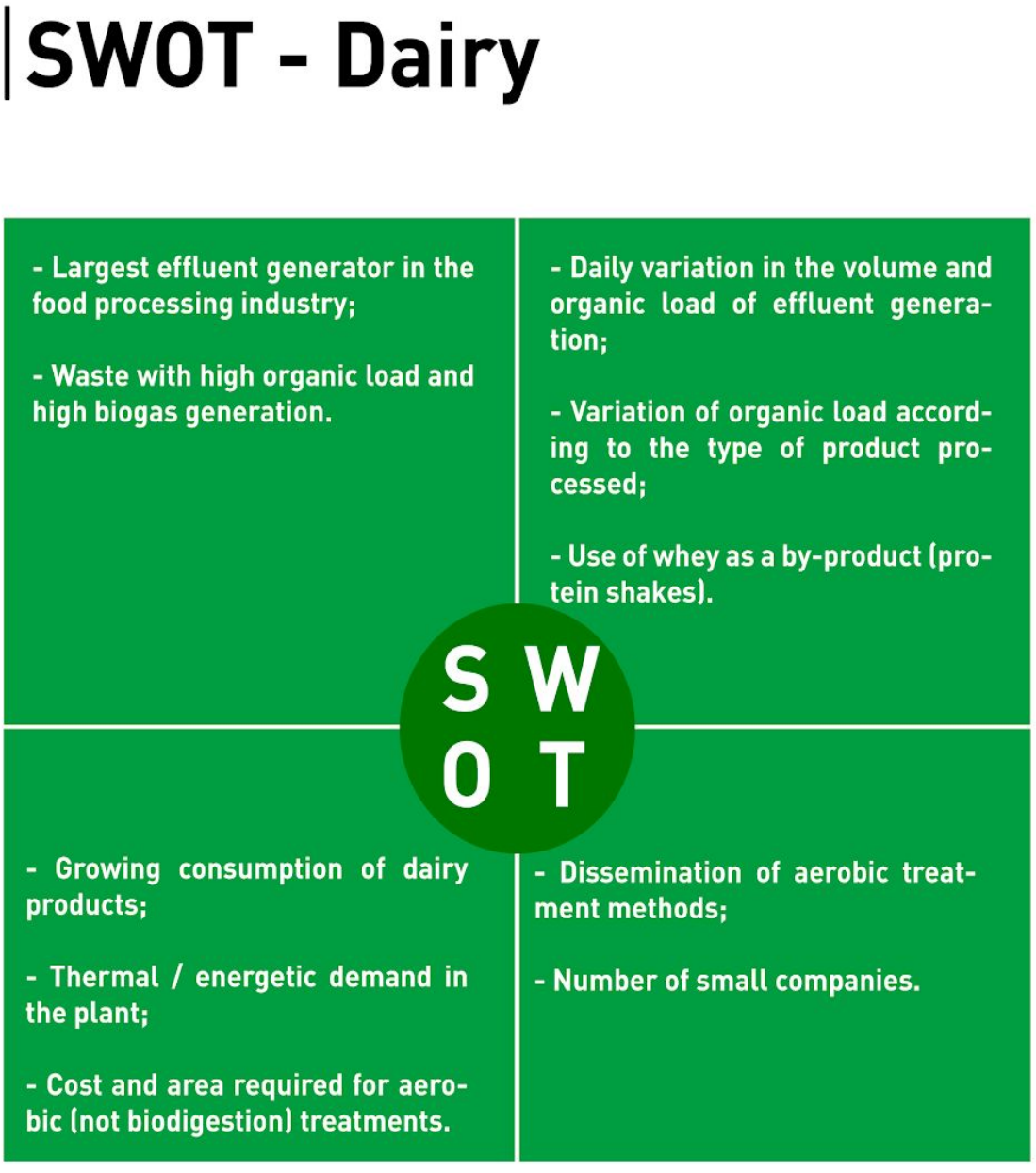
The states that most have methane generation potential for this substrate are Minas Gerais (MG), Paraná (PR) and Rio Grande do Sul (RS). In this context, the state of MG represents 25 % of the Brazilian potential for methane generation from dairy waste.

In spite of the leading role of MG in this branch of industry, the potential of the southern region of Brazil also deserves to be highlighted. Together, the states of PR, SC and RS represent 39 % of the national methane generation potential from this type of waste.

1.2.4. SWOT Analysis

From Figure 1.2.4 it is possible to verify that although the dairy industry has high effluent generation, the variation in the organic load of the residues can directly affect the generation of biogas. In addition, the treatment of this type of effluent is usually carried out by aerobic systems already widespread in the country.

Figure 1.2.4 - SWOT - Dairy



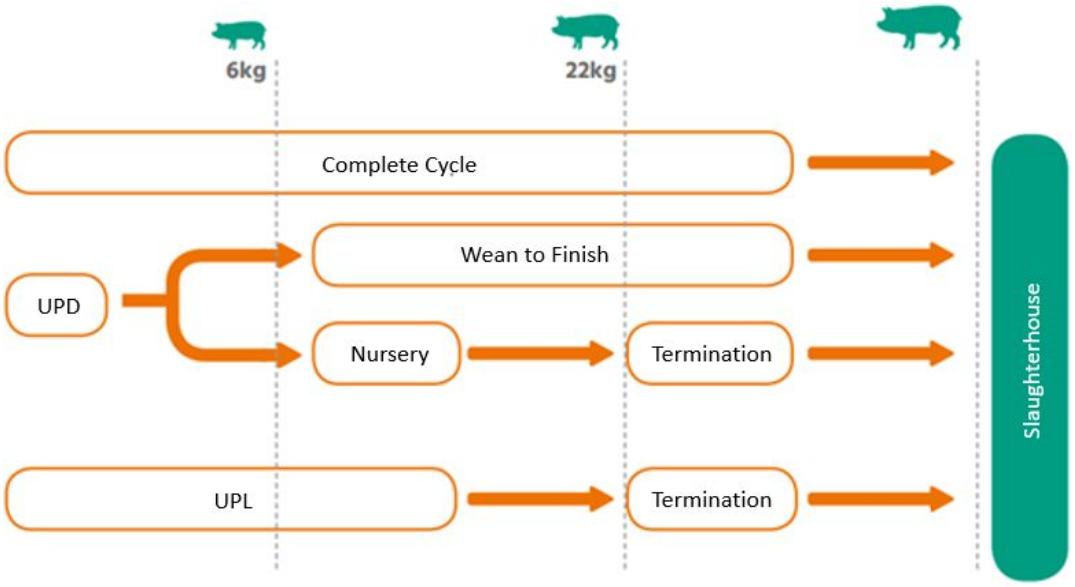
1.3. SWINE PRODUCTION

In this topic the main characteristics of the swine industry, waste byproducts and the potential for biogas and methane generation of each were detailed.

1.3.1. About the industry

In 2017 the number of swine in Brazil was equivalent to 4 % of the world's total herd, making it the holder of the fourth largest herd just behind China, European Union and United States of America (USDA, 2019a). Brazil is also the third largest exporter of pork in the world representing about 11 % of world exports in the sector, which is equivalent to a market of 1,41 billion USD in 2017. The three main markets are Russia (47 %), Hong Kong (15 %) and Argentina (7 %).

Figure 1.3.1 - Production routes in the pig industry



Source: (ABCS, 2016)

The swine meat production system in Brazil is characterized by the high technology and the extreme rigorous sanitary certification. Farms are commonly integrated into large cooperatives and intensive systems (Cardoso et al, 2015). Regarding this industry, there are five main types of units in the pig industry:

- Piglet Production Unit (UPL-*Un. de Produção de Leitões*);
- Weaning Production Unit (UPD-*Un. de Produção de Desmame, Berçário*);

- Termination Unit (UT-*Un.de Terminação*);
- Wean to Finish (WTF); and,
- Complete Cycle (CC).

Figure 1.3.1 shows the possible routes in the swine industry. In Brazil, the main profile of the swine producer is the combination of UPL and UT, which consists in the piglets production up to a weight of 22 to 26 kg in UPL, when are then transferred to UT and will fatten up to 145 kg and sent for slaughter. Then, there is the CC modality, which performs all stages of production: pregnancy, maternity, daycare, fattening and termination. The Weaning Production Units (UPD) have in their flocks pregnant and breastfeeding females in addition to piglets. The main characteristic of the UPDs is the sale of post weaning piglets.

Confinement of the animals and the usually liquid consistency of the manure is favorable to the collection, transportation and treatment of the residue. Consequently, it favors enterprises for the energetic recovery and biogas production. The production of biogas from this industry represented about 14% of the total volume of biogas produced in the country, being the third largest segment in generation, behind sanitary landfills (51 %) and industrialized food (25 %) (MILANEZ et al, 2018).

Figure 1.3.2 - Pig confinement at Colombari Farm in São Miguel do Iguaçu-PR

Source: CIBIOGÁS, 2019. Picture by Alexandre Marchetti

1.3.2. Byproducts characterization

The swine manure is produced in an expressive and constant volume, given the intensive characteristic (throughout the year) of the industry. The residues from the swine termination units (UT) - where the animals gain weight before the transport to the slaughterhouse - are the most appropriate for biodigestion, given the proportion of organic

load, constant residue production and higher volume, in comparison with the swine in the nursery (OLIVEIRA, 1993). Table 1.3.1 lists the average rate of waste production by pigs in termination stage

Table 1.3.1 - Swine manure generation in TU

Production stage	Manure generation [$m^3.animal^{-1}.day^{-1}$]
Termination unit (UT)	0.0046

Source: Adapted from CIBIOGÁS, 2018

Using the demonstrated value and the amount of animals housed in a given farm or region it is already possible to estimate the daily volume of waste to be produced. However, to estimate the volume of biogas or energy potential it is necessary to have other parameters, listed in Table 1.3.2. Checking this table it is possible to note that:

- the amount of total solids (TS) is only 3 % and of these, only 8 % are volatile solids (VS). Thus, 0.24 % of all waste produced is passive degradation and will produce biogas. It is an extremely humid waste;
- another indication that it is an effluent very similar to water is its density of 990 $kg.m^{-3}$; and,
- Biogas production is significant, recorded at a rate of 550 liters per kilogram of digested volatile solid, 60 % of which is composed of methane and can provide energy for combustion.

Table 1.3.2 - Physicochemical properties of swine manure produced in TU

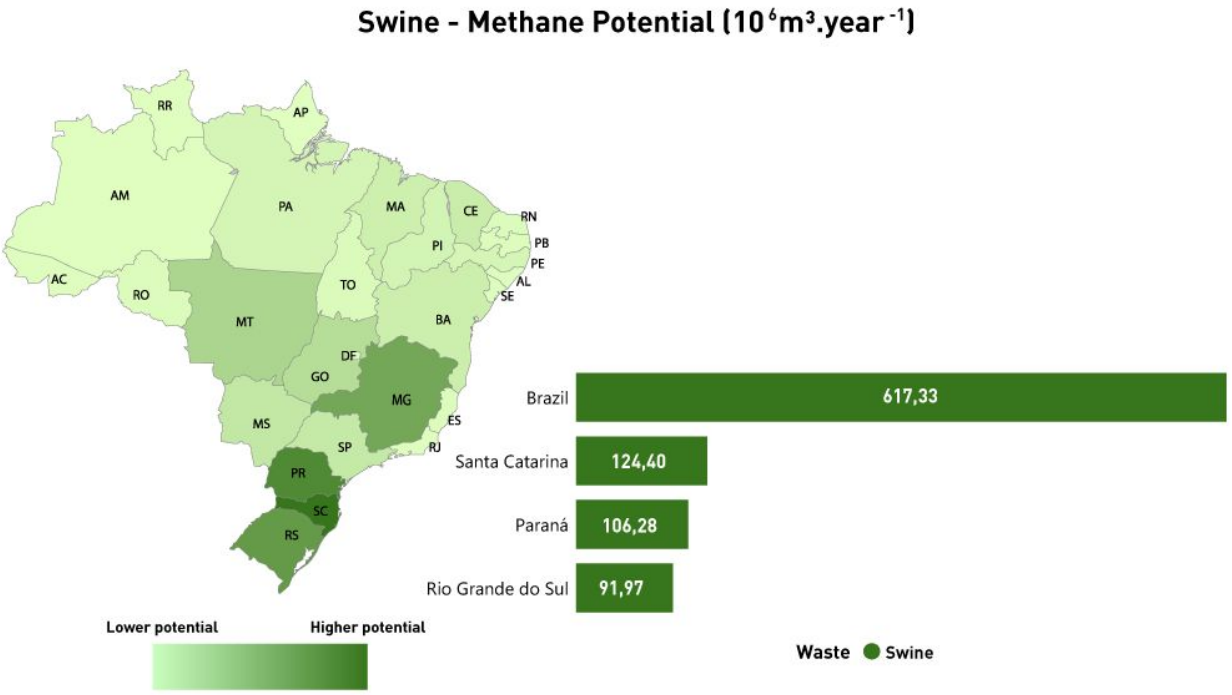
Residue	TS [%]	VS / TS [%]	Density [$kg.m^{-3}$]	Biogas Yield [m^3.biogas / kg.VS]	Methane Yield [$m^3.CH_4$ / kg.VS]	CH_4 [%]
Manure of UT	3	8	990	0.55	0.33	60

Source: Adapted from CIBIOGÁS, 2018

1.3.3. Geographic concentration

During the swine termination phase, the largest amount of waste per animal is generated (EMBRAPA, 2018b). Therefore, the population of this stage of production was used to estimate the generation of waste from pigs by state, shown on Figure 1.3.3.

Figure 1.3.3 - Methane generation potential per state (10^6 m³/year)



Source: CIBiogás

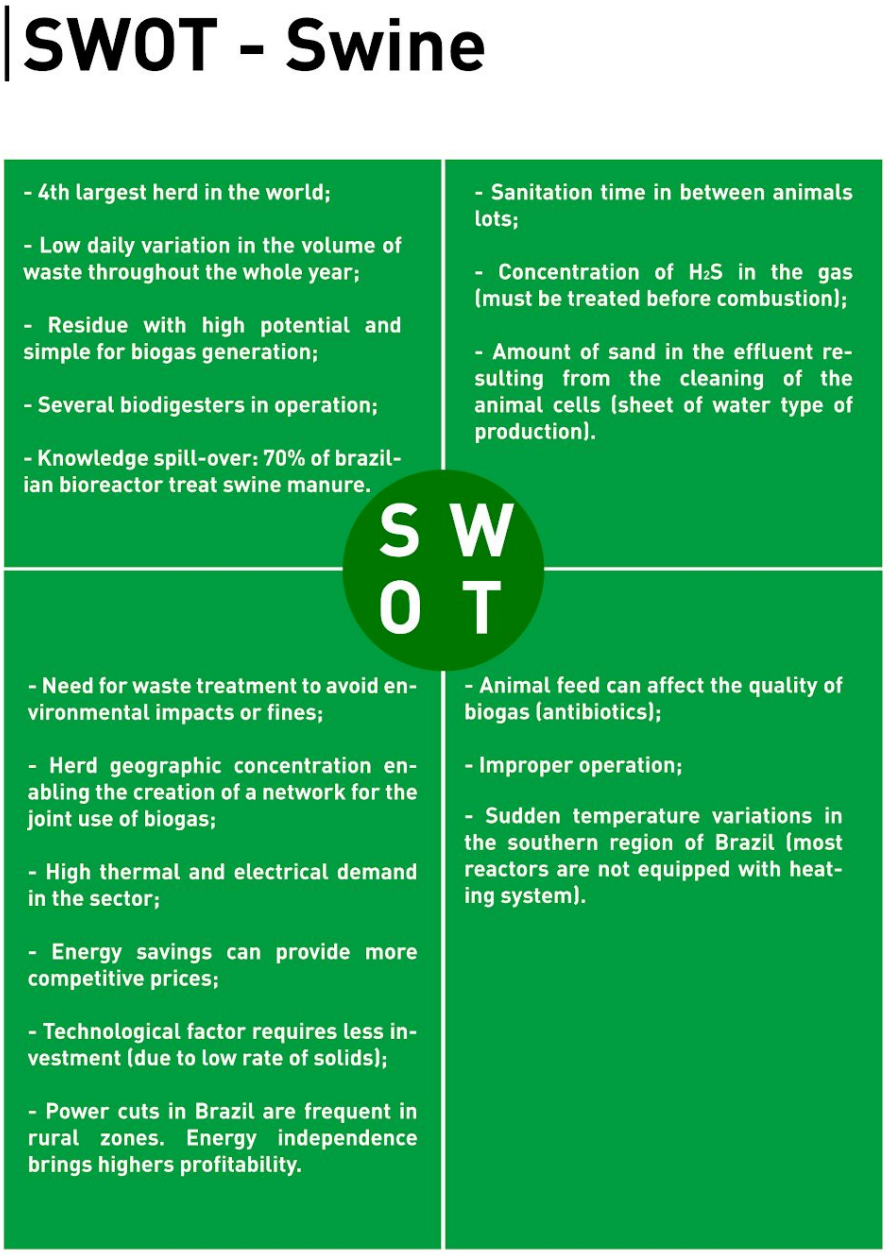
Figure 1.3.3 illustrates the potential of methane to be obtained from swine waste in the finishing phase in Brazil. This potential refers to an estimated herd of 23.5 million animals. The estimated potential of methane generation in Brazil is more than 617 million m³/year. As can be seen in the same figure, Santa Catarina (SC), Paraná (PR) and Rio Grande do Sul (RS) stand out as the states with the highest methane generation potential. Together, the methane generation potentials of these states represent 52 % of Brazil's total potential.

Besides the southern region of Brazil, the state of Minas Gerais (MG) also has a significant contribution to the national methane generation potential because it has more than 80 million m³/year, representing 13 % of the Brazilian potential.

1.3.4. SWOT Analysis

When well operated, pig production presents extraordinary potential for biogas generation, since it presents one of the largest herds in the world and production concentrated in specific regions of the country (Figure 1.3.4).

Figure 1.3.4 - SWOT - Swine



1.4. POULTRY PRODUCTION

In this topic the main characteristics of the poultry industry, waste byproducts and the potential for biogas and methane generation of each were detailed.

1.4.1. About the industry

The world ranking of most consumed animal protein has had a new leader since 2016. The consumption of poultry meat surpassed that of pigs, first place for many years, registering in 2018 a consumption of 118.5 million tons with a projection to remain in first place and still grow 18 % by 2027 (OECD-FAO, 2018). Brazil is a prominent participant in this industry. In 2017, it was responsible for the production of 11 % of the world's poultry meat, of which 67 % was destined for export (ABPA, 2018).

There are two main types of poultry production in Brazil: broilers and layers. On the one hand, the first one raises chickens in lots of approximately 42 days to be slaughtered and it has as final product chicken meat and derivatives. On the other hand, the second one has as its final product the egg product for the final consumer and it has longer batches of up to 18 months. Figure 1.4.1 shows both main types of production. The figure of the producing properties elucidate the handling of the animals and their residues. Broilers production in Figure 1.4.1(a), live and defecate on the bedding made of an absorbent material, while laying birds live in vertical cells, which wash the manure and collect the produced eggs regularly by conveyor belts, as illustrated in Figure 1.4.1(b). This absorbent material that covers the floor of broiler houses is commonly made from wood chips (shavings or maravalha), rice or peanut shells and it is called as “chicken bed”.

Figure 1.4.1 - Chicken production facilities types

(a)   (b)  

Source: CIBiogás. Authorized by the landowners: Mr. José Vilas Boas and Mr. André Haacke.

Figure 1.4.2 shows the profile of the two types of manure. Figure 1.4.2(a) is the effluent from the poultry barn of commercial egg production, which consists of the water used to wash the conveyor belts plus the manure. Figure 1.4.2(b) shows a 1 m² and 30 cm thick cut of broiler litter bed and details of thickness and composition can be observed. The absorbent material of this bed is the shavings, supplied by the LAR cooperative to its cooperative member, Mr. José Vilas Boas. The white material in Figure 1.4.2(b) is lime (NaOH), used to sanitize the shoes of visitors and also applied to the poultry bed every renewal of batch.

Figure 1.4.2 - Layer chicken manure and chicken bed (broilers manure)

(a)  (b) 

Source: CIBiogás. Disclosure authorized by the landowners

Brazil has very strict sanitary regulation and fiscalization on the food industry. One of the measures is to apply lime on the chicken bed every broiler batch renewal (every 42 days). This may affect the biodigestion, since lime kills microorganisms and sediments fast to the bottom of the reactor.

Regarding broilers bed, its composition has a high concentration of organic matter but also of lignocellulosic compounds and this brings both positive and negative points. A substrate of expressive potential for biogas production is formed, since it absorbs a lot of organic matter during the time - an average producer keeps the same chicken bed for up to 2 years.

However, the maximum use of this substrate is currently only made in the laboratory, since lignocellulosic compounds hinder biodigestion. Lignin is often found in vegetal fibers such as grass, leaves or even wood itself. Such types of substrates demand

more rigour in the stage of pre-treatment, heating inside the reactor, agitation and sludge management, since it has a high content of solids of difficult degradation. Cheng and Liu (2010) state that the limited generation of biogas from lignocellulosic residues is due to the recalcitrant[4] characteristic of components such as lignin, cellulose and hemicellulose. It makes the chicken bed a more challenging manure for effective anaerobic biodigestion and until the present date there is still no feasible technique that brings a simple, effective and economic solution (CIBIOGÁSc, 2019).

Additionally, the chicken bed has already a stable and formed market for biofertilizers. Although the organic matter is yet unstable (not fully degraded) farmers buy this solid and dry material to apply on the land for soil recover when changing crops. The chicken bed average price is of R$ 60 per ton (CIBIOGÁSc, 2019). For being a solid material and rich in nitrogen (N), phosphorus (P) and potassium (K), poultry litter is very well accepted as an input to increase the quality of the soil and consequently the production rates per area.

The production of commercial eggs in Brazil has not only a geographical concentration but also a significant concentration of animals. This represents currently a more attractive manure, compared to chicken litter of broilers, from a technical and financial point of view.

1.4.2. Byproducts characterization

Figure 1.4.2 shows the difference between the two types of waste in terms of consistency. Egg production has a liquid residue as a byproduct (Figure 1.4.2(a)), while broiler breeding produces a solid substrate similar to soil (Figure 1.4.2(b)). Table 1.4.1 shows the physical and chemical properties of both substrates that corroborate these characteristics. By analyzing Table 1.4.1 it is possible to first identify the high share of total solids (TS) in chicken litter (79 %), of which more than 70 % are volatile (VS). This means that they are degradable and produce biogas. In comparison, the manure from egg layers is much more liquid (73 % moisture) and also has a high share of volatile solids (63 %).

[4] Recalcitrant compounds are those that present low or no degradation index.

The biogas production potential and its calorific potential (% of methane) is then noted. Egg layers' waste produces 65 % more biogas and 82 % more methane per unit mass of digested VS. However, this does not mean that the chicken litter is less powerful. If we multiply the factors to 1000 kg, we get the result that the chicken litter would produce 105 m^3CH_4 [5], while the layer residue would register the production of 57 m^3CH_4 [6] or 45 % less from the same mass. This is because, despite the fact that the chicken bed produces less methane per VS unit, it has a much larger share of VS than the other, since water alone does not produce biogas.

Table 1.4.1 - Fraction of solids and potential for biogas and methane from layer chickens manure

Manure from	TS [%]	VS / TS [%]	Biogas Potential [Nm³ biogas / kg VS]	Methane Potential [Nm³ CH4 / kg VS]	Biogás quality [Nm³ CH4 / Nm³ biogas]
Layers	27	63	0.526	0.336	0.64
Broilers	79	72	0.318	0.185	0.58

Source: Adapted from CIBiogás, 2019[7]

However, it is important to remember that these are results of methane production potential (MPP) tests done in the laboratory. In the laboratory, the substrate is ground and prepared in small reactors in a controlled environment to assess the production and quality of biogas. This means that in the laboratory, the lignin structures from the maravalha in the bird litter have been particulate, which allows a more effective biodigestion. Another important point is that the laboratory in question is standardized by ABNT NBR ISO/IEC 17025:2005, which guides that the biodigestion is done with the addition of activated sludge, which serves as a source of microorganisms. In the end, when assessing the results, the portion of biogas produced from the activated sludge is deducted from the total to register the individual PPM of the substrate.

This reveals another obstacle that must be verified when building a biodigester to be filled with chicken waste (either litter or effluent): acidity, represented by the pH

[5] 1000 * 79% * 72% * 0,185
[6] 1000 * 27% * 63% * 0,336

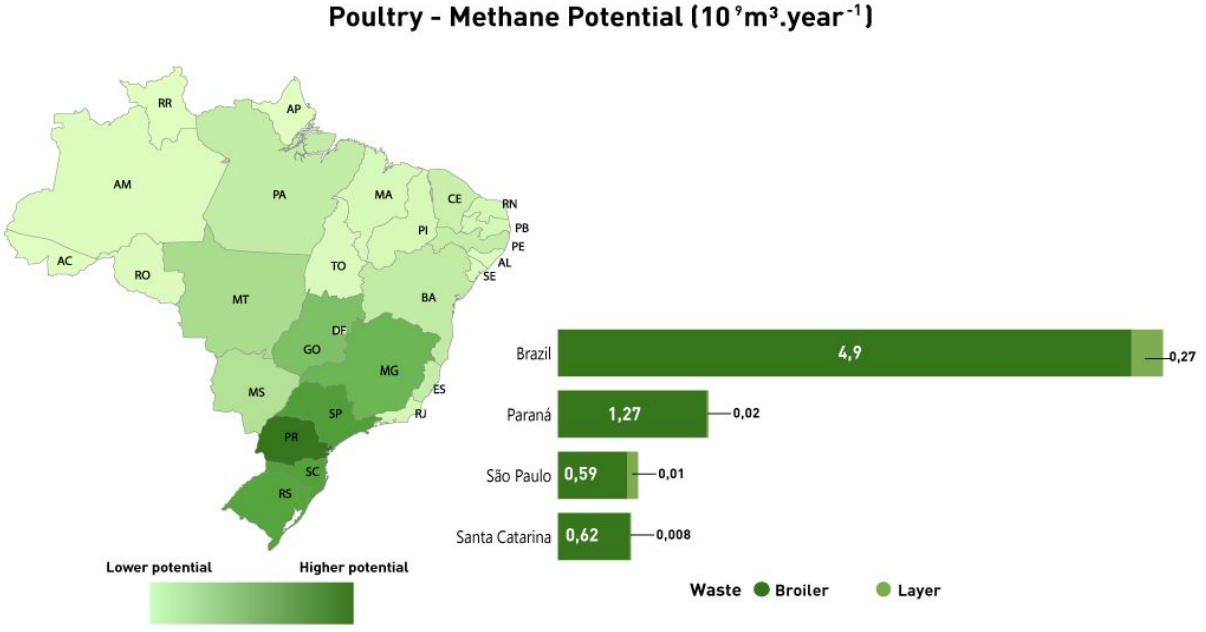
[7] The CIBiogás laboratory (LABIOGAS) is a replica of the laboratory of the Universität für Bodenkultur Wien (BOKU) located in Vienna-Austria. It is the first laboratory in Brazil to achieve the NBR ISO/IEC 17025:2005 seal. Currently LABIOGÁS has a very active operation, since it provides measurement service of PPM and PPB of various substrates throughout Brazil.

measurement index. These residues produce a very strong and unhealthy odor, as a result of the significant amount of nitrogen in the form of ammonia compounds (NH_3 or NH_4). The presence of large amounts of ammonia in the substrate causes a sharp decrease in the pH to levels of extreme acidity (pH < 5) that can impair the production of methane within the biodigestion reactor (SENAI, 2016). In order to overcome this problem, it is advisable to mix the residues with other organic substrates, such as residues from other animals (cattle, for example) or chemical pretreatment with basic compounds to balance the acidity (NaOH, for example).

1.4.3. Geographic concentration

Figure 1.4.3 presents the estimation of the annual methane production potential from chicken and egg production manure in Brazil. Based on this, it is possible to identify the great disparity in methane generation potential between these two production methods. This fact is due to the difference in population between the two herds, since the production of excreta is similar between the two. While the herd of laying chicken is little more than 271 million, the broiler herd is almost five times larger, reaching 1.3 billion animals.

Figure 1.4.3 - Potential annual production of methane from poultry waste in Brazil (10^6 m³/year)



Source: CIBiogás

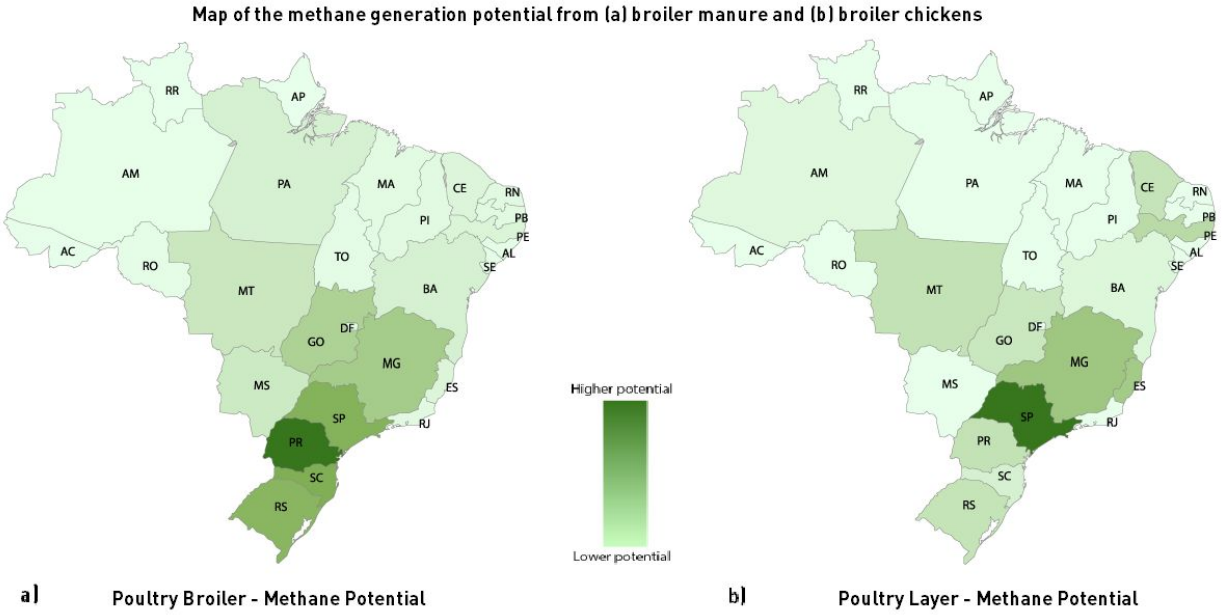
The Brazilian potential for methane generation of broilers is 4.9 billion m³/year. The potential of laying chickens corresponds to 270 million m³/year. Although the potential for

generating methane from broiler waste is 18x higher, it is important to emphasize that it presents operational difficulties due to the recalcitrant characteristics that interfere with the biodigestion process, as has been highlighted in the characterization of the substrate.

Also according to Figure 1.4.4, the states with the greatest potential for methane generation from the residues of the two types of birds studied here are: PR, SP and SC. The potentials of these three states together represent approximately 50 % of the total potential for methane generation in Brazil.

Due to this population difference between the chicken cultures, Figure 1.4.4 was prepared, showing a map for each culture, identifying the potential for methane generation at the state level by type of substrate. In Figure 1.4.4(a) it is possible to observe that methane generation from broiler poultry is accumulated mainly in the southern region of Brazil, with emphasis on the PR. On the other hand, Figure 1.4.4(b) shows that the potential for methane generation from poultry waste is concentrated mainly in the states of SP, MG and ES.

Figure 1.4.4 - Map of the methane generation potential from (a) broiler manure and (b) broiler chickens



Source: CIBiogás

1.4.4. SWOT Analysis

Considering the productive, operational and intrinsic differences to each type of chicken production, exclusive SWOT analyses were dedicated to broiler chicken - meat (Figure 1.4.5) and to laying chicken - commercial eggs (Figure 1.4.6).

The large herd of broilers in Brazil highlights the need to develop technologies that enable the generation of biogas from waste generated in this type of farming, since the options available in Brazil for treatment for this substrate are scarce. On the other hand, in spite of a smaller number of animals, the breeding of chickens for laying presents a higher level of technological automation that favors the generation of biogas from these substrates.

Figure 1.4.5 - SWOT Analysis - Poultry Broilers

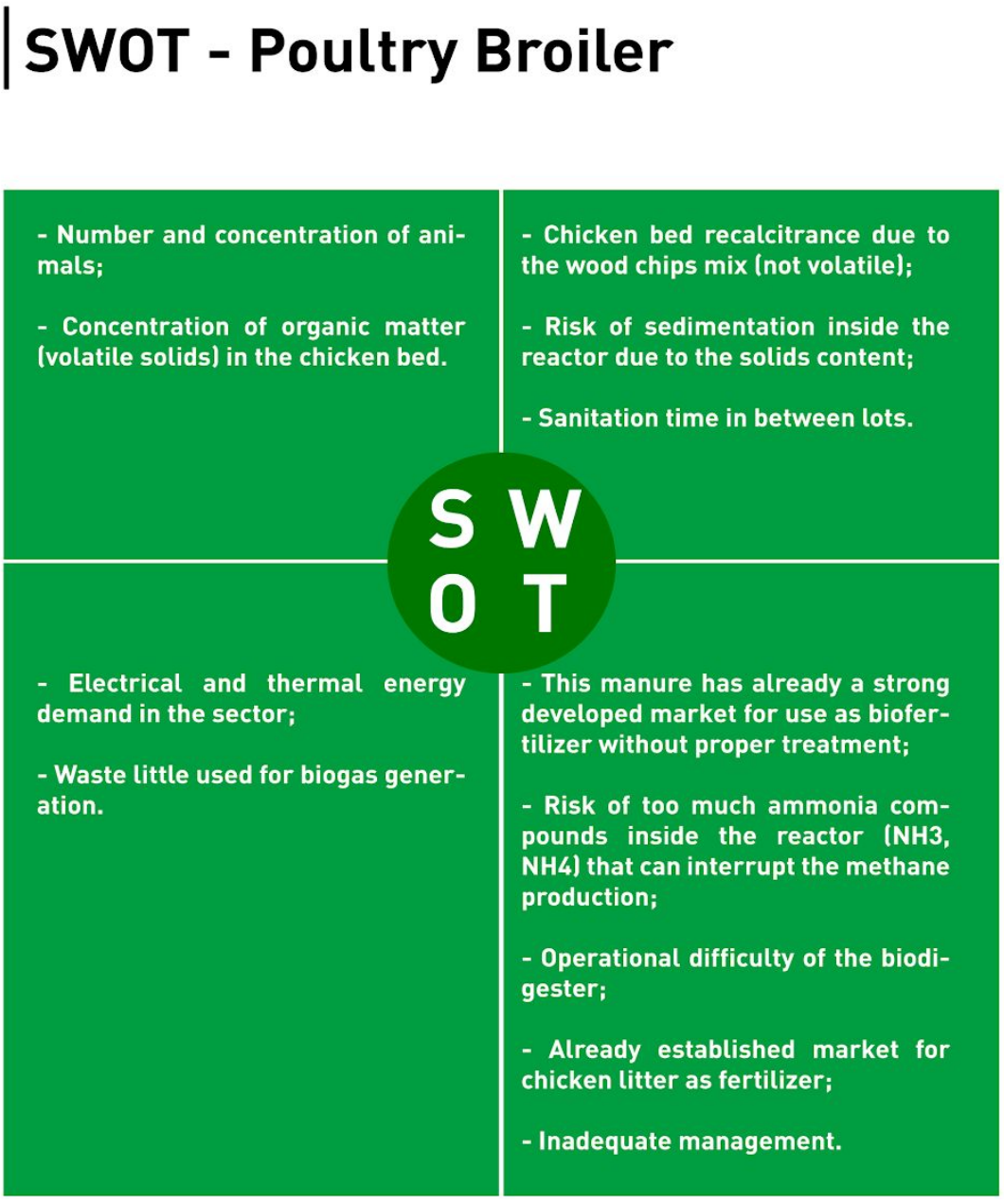
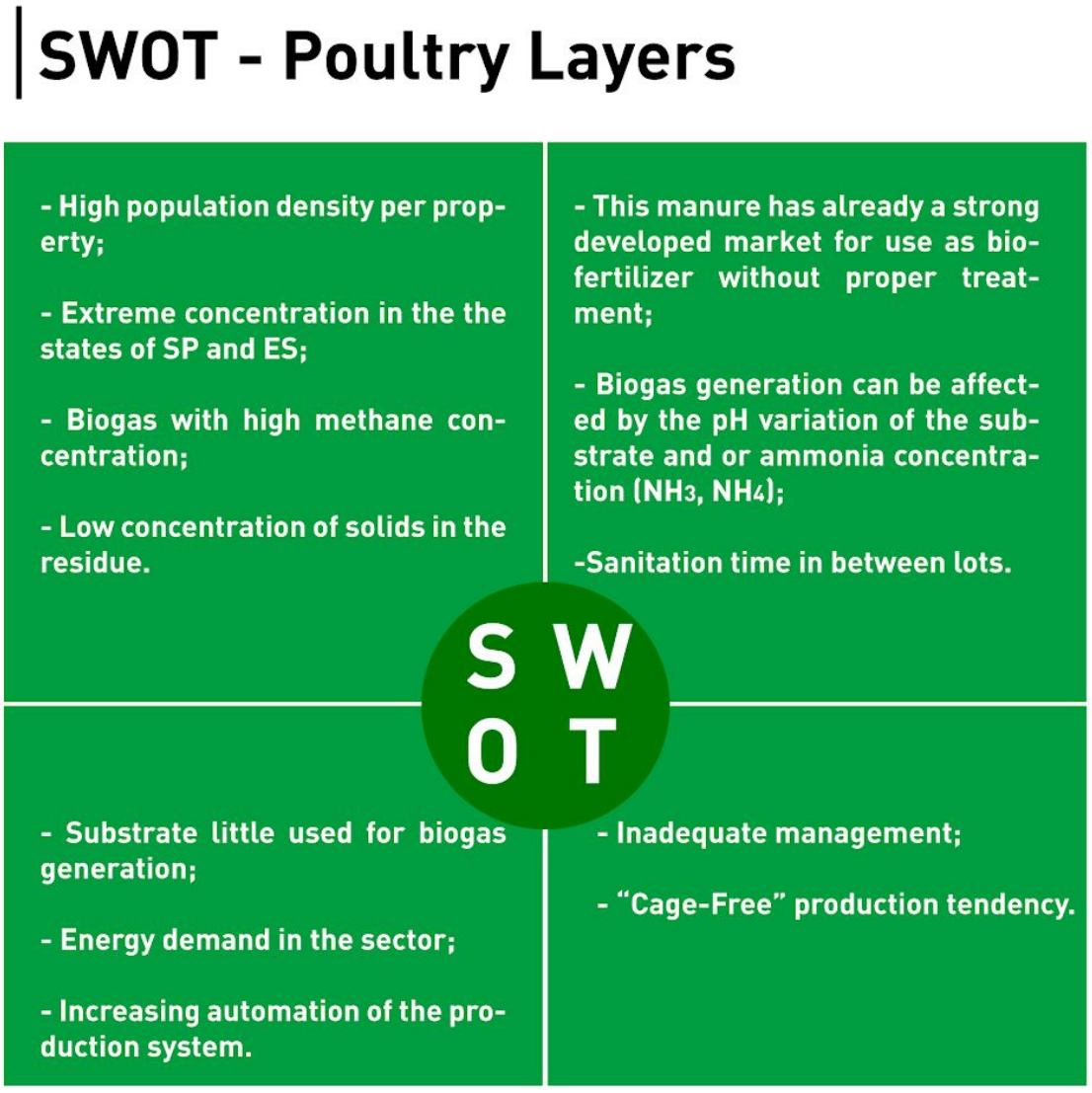


Figure 1.4.6 - SWOT - Poultry Layers



1.5. WASTEWATER TREATMENT PLANTS

In this topic the main characteristics of the sewage treatment plants (WWTP), the types of waste and the potential for biogas and methane generation of each were detailed.

1.5.1. About the collection area

The Brazilian government undertakes to invest more than R$ 500 billion in sanitation by the year 2033 (BRAZIL, 2013). However, according to a recent study conducted by the National Confederation of Industry (CNI), considering the decrease in current investments, the goal of whole access to sanitation will only be reached after 2050.

Sanitation is an area that needs to be developed in Brazil. According to the data from the National Sanitation Information System in 2017, only 52 % of Brazil's total sewage was collected and, of this amount, 74 % was treated. These figures confirm the need for investments in this sector. This means that only 38 % of the Brazilian population has sewage treatment, and 62 % are raw discharged into water bodies, compromising the quality of water in the country.

If we consider the decrease in investment in basic sanitation combined with the fact that the current treatment technologies need to increase the efficiency of pollutant removal, as well as update their method of management and disposal of byproducts, it becomes necessary to seek techniques that make these improvements financially feasible.

The anaerobic treatment of wastewater through biodigesters with storage and monetization of biogas can help to optimize the operation of treatment plants. Anaerobic digestion, also known as biodigestion or fermentation, is a process of biological degradation carried out in environments without oxygen, through which the treatment of organic waste can be performed and benefit from the production of methane. Under appropriate and controlled conditions, sewage sludge submitted to anaerobic digestion generates two byproducts: sludge and biogas.

Most of the Brazilian sanitation sector uses the generation of biogas only as an indicator of the efficiency of the anaerobic digestion processes used in the treatment of untreated sewage and sludge (PROBIOGÁS, 2015), since a constant generation of biogas is an indication of the stability of treatment. However, the aggregate energy potential of biogas should be highlighted so that it is no longer considered just an indicator, but it becomes a new source of revenue within a WWTP. Domestic sewage and sludge are the residues that can be used to generate biogas in a WWTP, so these substrates, as well as their respective treatment technologies, will be characterized in the following topics.

1.5.2. Byproducts characterization

Domestic sewage, or simply sewage, is the effluent generated when water is used to meet physiological needs and human hygiene (VON SPERLING, 2005). Sludge is the effluent generated during the treatment of domestic sewage, which can be aerobic or

anaerobic. Figure 1.5.1 brings two samples of domestic sewage (a) and sludge (b). Sludge has a highest content of total solids.

Figure 1.5.1 - Samples of sewage (a) and sludge (b)

(a)  (b) 

Source : Adapted from MEEC (2006) and Markham (2016)

Domestic Sewage

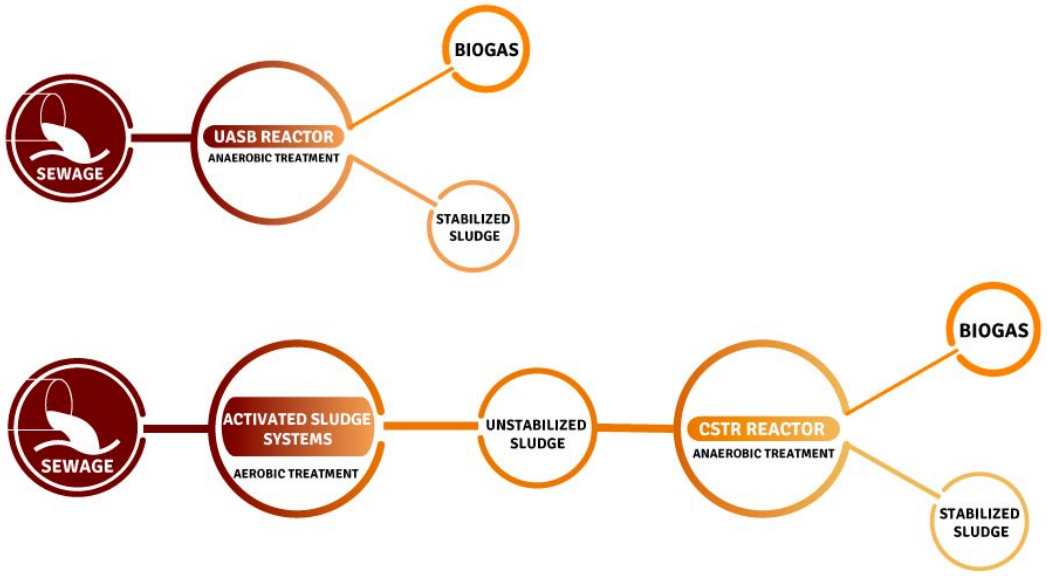
Sewage treatment can be performed aerobically or anaerobically. The treatment options and byproducts generated in each method are illustrated in Figure 1.5.2. Between the two forms of sewage treatment, biogas is obtained as a byproduct only in the anaerobic digestion of this substrate. Aerobic sewage treatment generates a sludge as a byproduct. This sludge can be used for biogas generation only if it is subsequently digested in anaerobic reactors.

Chernicharo et al. (2018) evaluated the main configurations of WWTP in the South, Southeast and Center-West regions of Brazil. The authors report that, regardless of size, most WWTP are composed of a technical arrangement with UASB (Upflow Anaerobic Sludge Blanket) type reactors, activated sludge systems and stabilization ponds. UASB-type reactors are an example of technique used for anaerobic treatment of domestic and industrial sewage in Brazil. The stabilization ponds and activated sludge systems are examples of aerobic treatments.

By analyzing the Figure 1.5.2, it is possible to visualize two types of technical arrangements in WWTP. The first is treatment by anaerobic treatment only and produces stabilized sludge and valuable biogas as byproducts. The second technical arrangement is a combination of the two types of treatment. Initially, the sewage goes through aerobic treatment, in which there is not a reactor, but rather an activated sludge system, that

produces a sludge already partially treated (non-stabilized sludge). This residue is still not considered sufficiently treated to return to the ecosystem. So, it must go through another stage of sanitization. This next step can be a biodigester, since the non-stabilized sludge registers expressive potential for biogas production in anaerobic conditions. However, this residue is much denser than primary sewage. That is, it has a larger portion of solids and therefore the UASB reactor is not the most adequate. Hence, it is common to find in this arrangement a reactor type CSTR (Continuous Flow Stirred Tank Reactor) to reach the treatment quality levels specified in legislation and also to increase the energy efficiency of the system when collecting and using the biogas produced.

Figure 1.5.2 - Arrangement options for sewage treatment



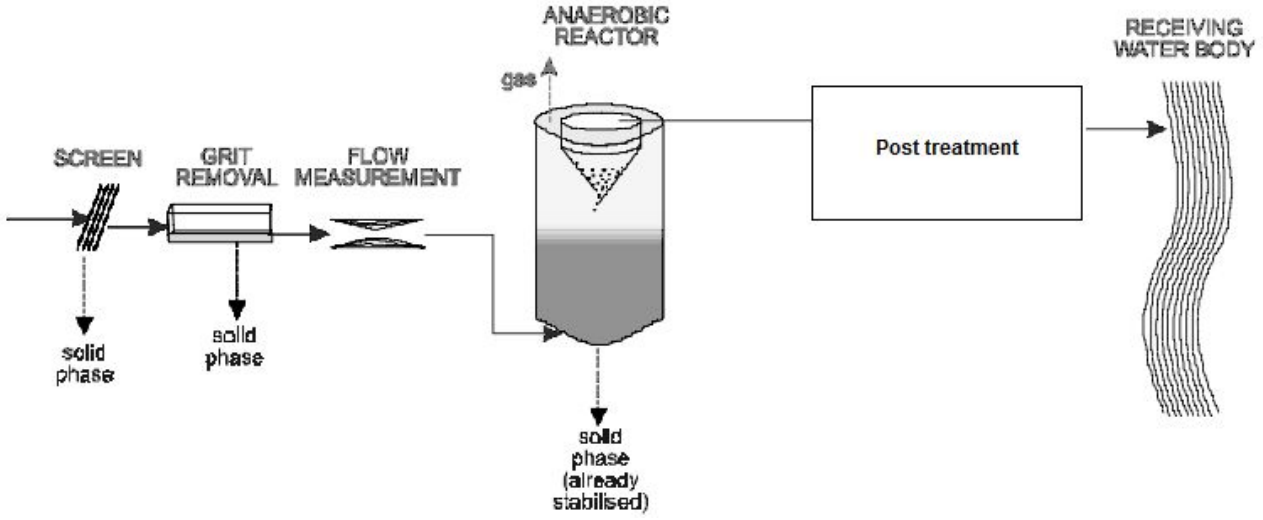
Source: Adapted from Valente (2015)

Currently, UASB reactors are a consolidated technology in Brazil. The vast number of this type of reactor is mainly due to advantages such as low area requirement, small energy demand and ease of operation (PROBIOGAS, 2015). Nonetheless, it has as a disadvantage the need for a post-treatment for the reactor effluent. This post-treatment is commonly used to meet the maximum contamination standards of release into water resources, as per the Brazilian legislation in force.

The structure illustrated in Figure 1.5.3 can be considered as a standard configuration for WWTP using the UASB reactor (Chernicharo et al., 2015). As shown in the figure, the UASB reactors require pre-treatment to remove sand and coarse solids

from the affluent sewage. The preliminary steps are composed of sieves or grids and sand boxes (desanders) (PROBIOGAS, 2015). There is also a biological and biomass digestion reactor. Besides them, the UASB has primary and secondary decanters (PROBIOGAS, 2015). These are characteristics that eliminate the need for structures for the prior thickening of affluent sewage. The previous thickening of the sewage, when necessary, can be carried out by means of a primary decanter, this decanter makes up a primary stage of treatment, in which the sewage resides for a period of 1 to 2 hours to decant the solids producing a sludge rich in organic matter (PROBIOGAS, 2015).

Figure 1.5.3 - Standard technical arrangement of WWTP using the UASB-type reactor



Source: Adapted de Chernicharo, 2006

For comparison purposes and due to the low content of total solids in the untreated sewage, the parameter used to measure the amount of organic matter in an effluent is the Chemical Oxygen Demand (COD), which corresponds to the amount of oxygen required to degrade a substrate by chemical means (PROBIOGÁS, 2015). The COD balance can be used to control the conversion of organic matter within the sewage biodigestion process. According to Chernicharo (2007), of the total COD affluent to an anaerobic reactor, 50 to 80 % are converted into biogas, 5 to 15 % are converted to sludge and 10 to 30 % are contained in its effluent.

Although much of the COD is converted into biogas, the UASB reactors still face challenges in their generation and collection. For example, the variation in sewage dilution (resulting from rainy periods) has a direct influence on biogas generation. In addition,

Chernicharo et al. (2018) points out that 30 to 40 % of the total methane (the main component of biogas) removed in a UASB cannot be used because it is diluted within the reactor effluent. It should also be noted that other types of losses may occur in the gas collection and transport system.

Taking into consideration the high variability of the sewage composition and the different losses that can occur during the digestion of this type of substrate in a UASB reactor, the most reliable method to estimate the potential for biogas generation from domestic sewage is through a mathematical model. A widely used model is the one proposed by Lobato (2011), because, among others, it considers the methane losses in the effluent and the other physical-chemical and biological phenomena that act in this type of reactor. Table 1.5.1 comprises average values of volume of biogas and methane estimated by the Lobato model (2011), using the assumptions proposed by Von Sperling (2005).

Table 1.5.1. Characterization and generation potential of biogas and methane from sewage

Residue	Per Capita Contribution [kg_{COD}/person.day]	Removal efficiency [%]	Biogas Yield [NL_{biogas}/person.day]	Methane Yield [NL_{CH4}/ person.day]	CH_4 [%]
Sewage Domestic	0.1	65	13.6	10.2	75

Source: Adapted from Von Sperling(2005), Chernicharo (2007) and Lobato (2011)

The Chemical Oxygen Demand (COD) removal efficiency considered here is an average value, because according to Chernicharo (2007), in UASB reactors, the COD removal efficiency varies between 60 and 70 %.

The value of 13.6 L_{biogas}/person.day obtained in this estimate of the potential for biogas generation from raw sewage in UASB reactors, allows us to conclude that sewage digestion presents lower potential for biogas generation in comparison with CSTR type sludge digesters. Andreoli, Sperling and Fernandes (2014) evaluated the potential for biogas generation from non-stabilized sludge and reported a value of 20 L_{biogas}/person.day. Additionally, it is important to mention that the methane production factor of 10.2 liters per person per day already takes into account the portion of methane diluted in the sludge, which is not used.

Sludge Treatment

In order to avoid environmental impacts resulting from the incorrect final disposal of sludge from sewage sludge, it is necessary to use a stabilization method. The most efficient method is the anaerobic treatment, because in addition to stabilizing the waste in a faster way than the aerobic treatment, it allows the exploitation of biogas. The anaerobic treatment of the sludge occurs by means of reactors also called sludge digesters, biodigesters or fermenters. They can be operated on a batch or continuous feed basis, where the substrate remains inside the digester for a period (ANDREOLI, SPERLING and FERNANDES 2014). Batch digesters are those that receive one substrate load for treatment at a time, while the continuous feed reactor operates with uninterrupted feeding and effluent production. In WWTP, due to the expressive volume and continuous reception for treatment, batch type biodigesters are not indicated.

For the treatment within a continuous digester to be adequate, the substrate must remain for a certain period of time so that its organic load can be satisfactorily reduced. This period of time is called the holding or retention time (RT). The RT is an important parameter to be analyzed in the design of the sludge digester. A low retention time (short period of time) can reduce the efficiency of the treatment because it implies a reduced period of bacterial activity or substrate digestion. For this reason, the RT generally used to project WWTP sludge digesters is approximately 25 days (ANDREOLI, SPERLING and FERNANDES 2014). Thus, the volume of the reactors are sized so that the sludge remains under treatment for 25 days before leaving the system.

According to Andreoli, Sperling and Fernandes (2014), the mixture performed by equipment is another important item in the configuration of these digesters. It is through it that the homogenization of the substrate occurs, which increases the performance of the digestion. The mixture can be made by pumping through the insertion of the biogas generated in the digester (pressurized) or by recirculation of the sludge or, still, through a mechanical mixer, which in turn can be fixed vertically in the center of the reactor or transversally with a kind of metal rod with a helix in the tip. In order to choose the best type of mixing system, the reactor dimensions and the specific characteristics of each substrate must be analysed. According to PROBIOGÁS (2015), the most commonly used digesters

for non-stabilized sludge digestion are of the CSTR type, also called the complete mixing method. It should be emphasized that, in reactors of complete mixture is allowed the treatment of waste with higher percentage of solids.

As illustrated in Figure 1.5.2, the sludge generated by aerobic sewage treatments (activated sludge system) is not yet stabilized, while the sludge from anaerobic sewage treatment (by means of a UASB reactor) is already stabilized. The types of sludge, its stabilization state and the volume generated can be seen in Table 1.3.2. The less biodegradable organic matter present in a substrate, the more stabilized it is and the lower the potential for biogas production (ANDREOLI, SPERLING and FERNANDES, 2014). The table shows that there is a high generation of non-stabilised sludge. Therefore, there is potential for biogas generation (PROBIOGAS, 2015).

Table 1.5.2 - Origin and per capita volume of sludge generated in the different WWTP configurations

Stabilization condition	**Treatment step**	**Type of sludge**	**Sludge per capita production [L_{Lodo}/inhab.day]**
Not stabilized	Primary decanter	Primary Sludge	0.66 - 2.2
Not stabilized	Conventional Activated Sludge System	Activated Sludge (Conventional)	3.1 - 8.2
Stabilized	UASB	Sludge from UASB	0.2 - 0.6

Source: Adapted from Andreoli, Sperling e Fernandes (2014)

In addition to being non-stabilized, the sludge must have another feature for the generation of biogas: the previous thickening (ANDREOLI, SPERLING and FERNANDES, 2014). The previous densification process is performed to increase the concentration of total solids in the studied substrate. This is an indispensable step, since it is directly related to the size of the sludge digester. For example, a sludge with 3 % of total solids requires a digester twice the size of what would be required to digest a sludge with 6 % of solids (PROBIOGAS, 2015).

With these two characteristics for the generation of biogas from sludge (with and without densification), Table 1.5.3 shows the results of the characterization and the respective potential for biogas and methane generation, from the different types of sludge previously presented. With these numbers it is confirmed that the biogas generation

potential of a sludge is related to its biodegradable organic matter content. Therefore, sludge from systems that remove high quantities of organic matter (such as UASB reactor sludge) are not ideal substrates for biogas generation (PROBIOGÁS, 2015).

Also according to Table 1.5.3, it can be seen that the highest volumes of biogas generation per capita are related to non-stabilized sludge. Sludge is non-stabilized when it has a VS/TS ratio greater than 70 % (PROBIOGAS, 2015). Therefore, due to the high remaining energy potential, the primary decanter sludge, the conventional activated sludge are considered the main types of sludge to be used as substrate for biogas generation, both are commonly found on aerobic treatment systems.

Table 1.5.3 - Solids and biogas and methane generation potential ranges for different types of sludge

Residue	**TS [%]**	**TS - Thickened [%]**	**VS / TS [%]**	**Biogas Yield [NL_{biogas}/ person.day]**	**CH_4 [%]**
Primary Sludge Decanter	2-6	4 - 8	75 - 80	15 - 20	60-75
Activated Sludge (Conventional)	0.6-1	2 - 7	75 - 80	16.5 - 25	-
Sludge from UASB	3-6	-	55 - 60	-	-

Source: Adapted of Andreoli, Sperling e Fernandes (2014) and Probiogás (2015).

Due to the lack of standardization of biogas generation potential quantification units, as well as the specificity of the studied substrates, there are no complementary data in Table 1.5.3 to compare the potential of biogas generation between the types of sludge.

1.5.3. Geographic concentration

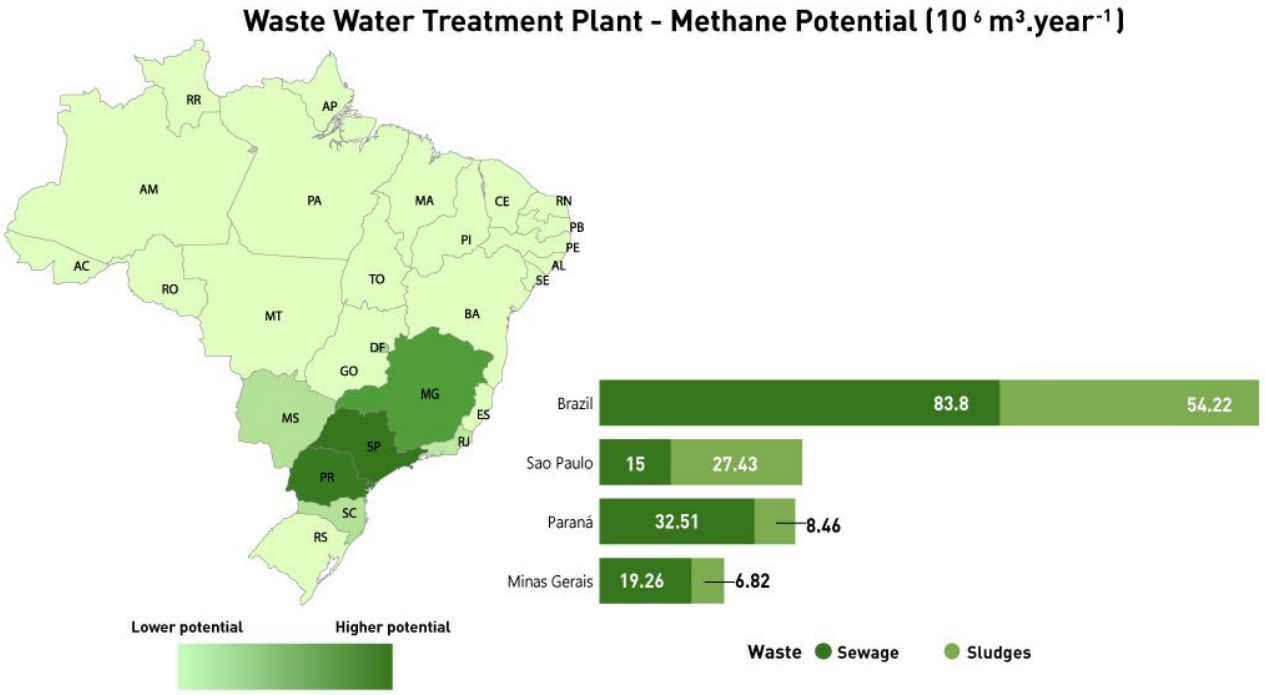
Unlike the other sectors, for wastewater treatment plants (WWTP) the total amount of the Brazilian population was not considered, but the portion of the population that is contemplated by the sewage collection and treatment system. This particularity was adopted due to the deficiencies of the Brazilian Basic Sanitation system and the lack of available information.

Thus, in order to calculate the population served by sewage collection and treatment, it was considered the population estimate of each state (IBGE, 2019) and the

percentage data of collection and treatment of sewage, obtained through the Diagnosis of Water and Sewage Services for the year 2017, available from the National Sanitation System (NHIS, 2017). The potential for methane generation from WWTP waste was estimated taking into account the population served by sewage collection and treatment in their respective states.

In addition, the installed sewage treatment capacity and the main technologies adopted by state, as reported by Chernicharo et al. (2018), were considered. It should also be noted that the scarcity of data on the configuration of WWTP in Brazil is a limiting factor in this study. For this reason, the methane generation potential was analyzed only in the states with available information, listed by Chernicharo et al. (2018) and shown by Figure 1.5.4. Although the study was restricted to only 7 states, it is important to highlight that these data are representative, since the selected states concentrate more than half of the Brazilian population.

Figure 1.5.4 - Methane generation potential from WWTP (10^6 m^3/year)



Source: CIBiogás

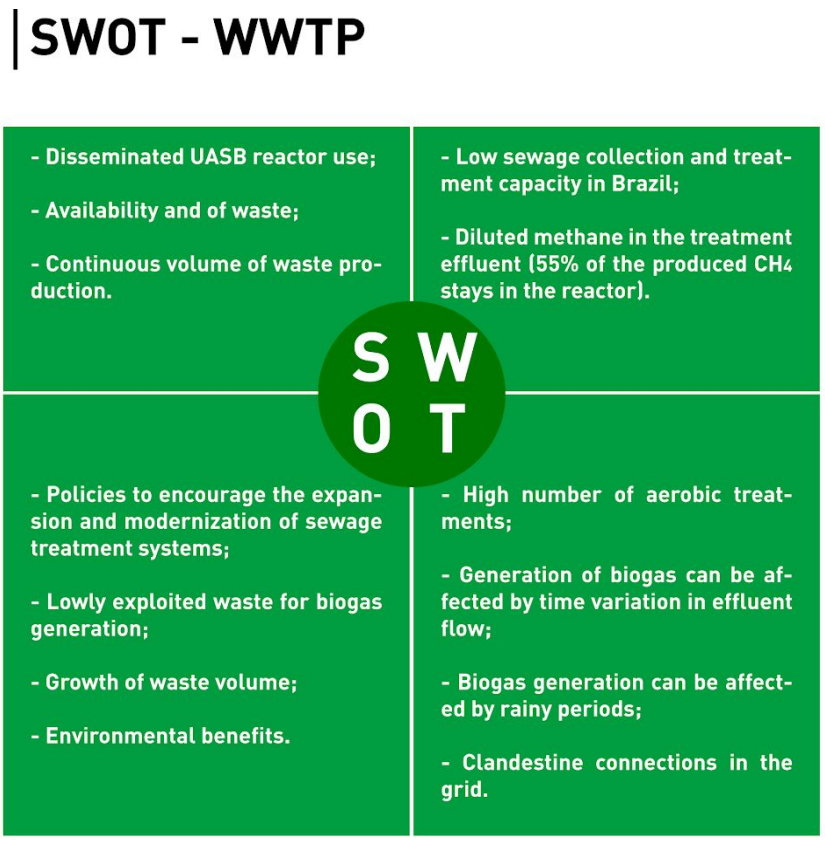
By analysing this map it is possible to identify that only the states of SC, PR, MS, MG and RJ had available information to calculate the indicator of methane production

potential. The states of SP, PR and MG are the states with the greatest methane generation potential. Although SP has a population 4x larger than PR, there is a proximity between the methane generation potentials. This characteristic is due to the high volume of sewage treated anaerobically in the state of PR (89 %) while in the state of SP only 12 % of sewage is treated by this method. Additionally, according to the methodology used in this study, the state with the lowest methane generation potential is RJ. The low rate of sewage collection and treatment (about 45 %) is fundamental for the low methane production capacity in this state.

1.5.4. SWOT Analysis

Figure 1.5.5 brings the SWOT analysis for the Wastewater Treatment Plants. When analyzing the characteristics of domestic sewage treatment plants in Brazil illustrated in Figure 1.5.5, it is possible to see that the use of biogas in these facilities is restricted to regions of the country where there is a higher rate of collection and treatment of sewage. In addition, it should be noted that the UASB technology is a point to be explored, due to the great knowledge already disseminated in the country.

Figure 1.5.5 - SWOT - Wastewater Treatment Plants

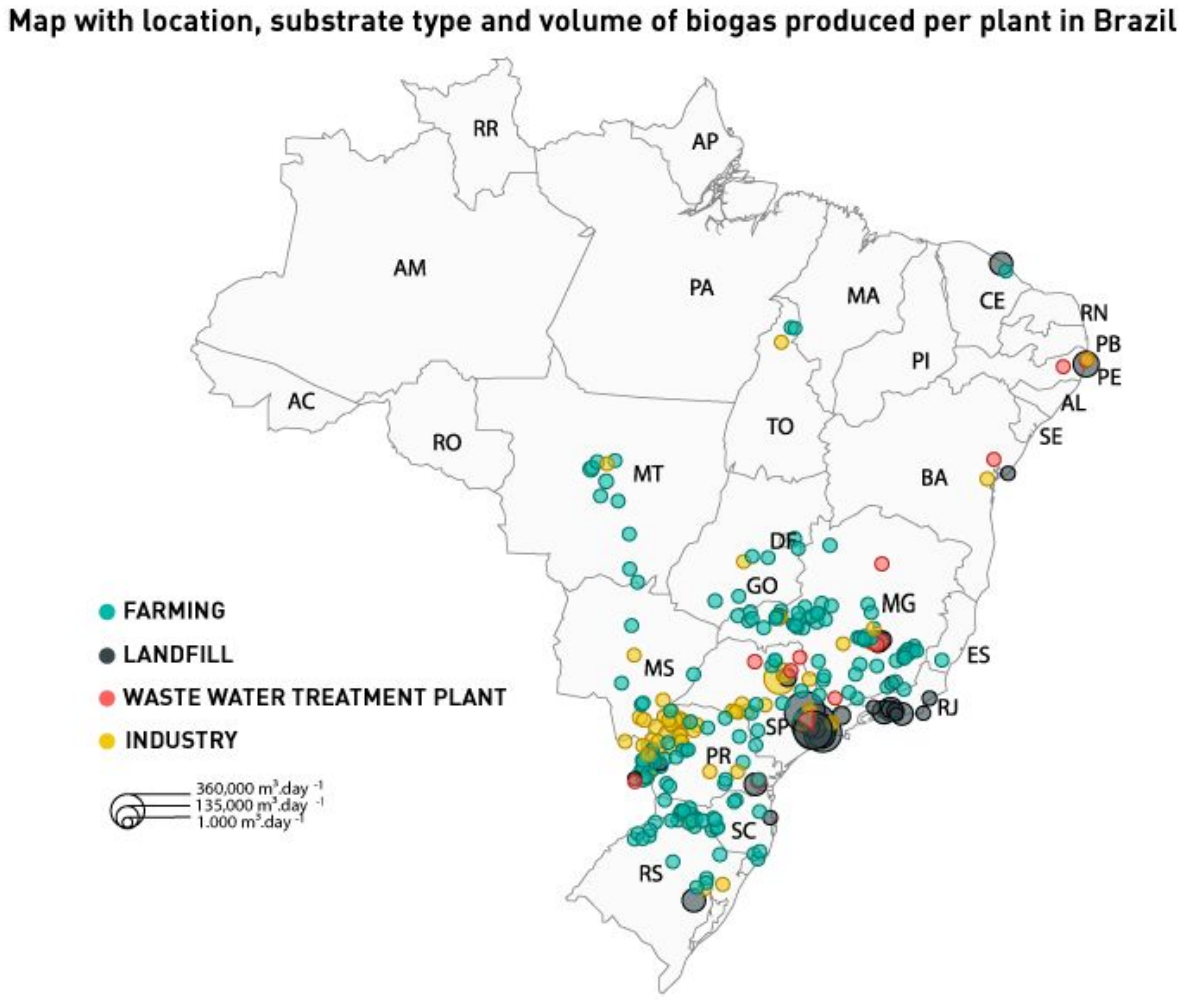


2. MARKET ANALYSIS

2.1. PANORAMA OF BRAZILIAN BIOGAS PLANTS

In order to characterize the profile of biogas plants in the Brazilian territory, the database of the web tool entitled "BiogasMap", developed by CIBiogás was used. This section shows maps and graphs that compare across the whole country the number of plants, their locations, sizes, substrates, the volume of biogas produced, the alternative of monetization of biogas and the situation of the plants. In total, the database has 366 registered plants, which together produce an average of 4.7 million m³ biogas per day.

Figure 2.1.1 - Map with location, substrate type and volume of biogas produced per plant in Brazil



Source: CIBiogás

Firstly it is important to highlight the **very small quantity of biodigesters in Brazil, which reflects the huge not yet fully explored engineering market**. Secondly, also important to preview, the extreme difference between sectors and country regions. This is brought up mainly by economic conjecture across this continental size country, where the highest concentration of agricultural and industry production is concentrated on the states of the south and center-east. Another factor is that for some the biodigester is a way of neutralize environmental fines, as of the swine producers. Therefore, one may notice the concentration of installed reactor in this activity.

Figure 2.1.1 shows a map of Brazil with data related to the plants location, origin of the substrate and volume of biogas produced. In this figure, each circle represents a biogas plant, the type of substrate is classified according to the color of the circle (green for agriculture, black for solid urban waste, red for sewage treatment plants and yellow for industry) and the size of the circle is directly proportional to the estimated volume of biogas produced.

The following points can be considered:

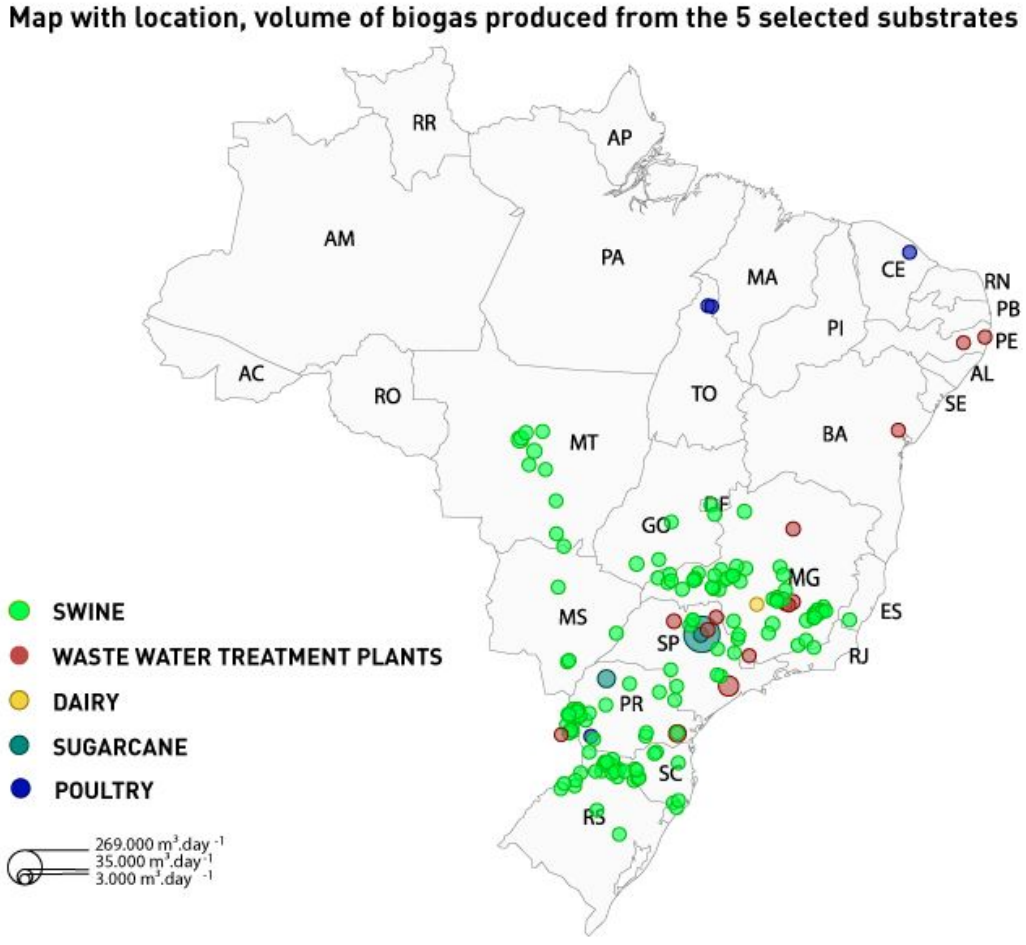
- highest concentration of biogas plants is found in the South and Midwest regions (MG, SP, PR, SC and RS). The North and Northeast together have less than 10 biodigesters;
- plants with the greatest potential for biogas production treat solid urban waste. In SP and RJ is the highest concentration. The states of CE, PE, MG, PR, SC and RS each have a biogas plant of this type of treatment;
- biodigesters of the industry are in higher density in the state of PR and also in MS and SP. Highlights include the biodigester under construction at Raízen's Bonfim Plant in the north of the state of São Paulo;
- biodigesters of farming residues, identified by the green circle, register expressive density in the west of the states of PR, SC and MG; and,
- sugar-energy industry (sugarcane) has only two plants in operation and one under construction.

Figure 2.1.2 below shows the location of the existing biodigesters supplied with the 5 substrates under study in this work; sugarcane and dairy industry, pig and poultry production and sewage treatment plants.

The highlights are:

- pig farming stands out in the number of biodigesters;
- there are very few biodigesters for the other 4 substrates, which indicates a very incipient market with a lot of opportunity for new projects; and,
- the biodigester with the largest biogas production (circle size) is in São Paulo and belongs to the Bonfim Raízen sugarcane plant - winner of the A-5 auction to generate 21 MW from vinasse and filter cake by 2021.

Figure 2.1.2 - Map with location, volume of biogas produced from the 5 selected substrates



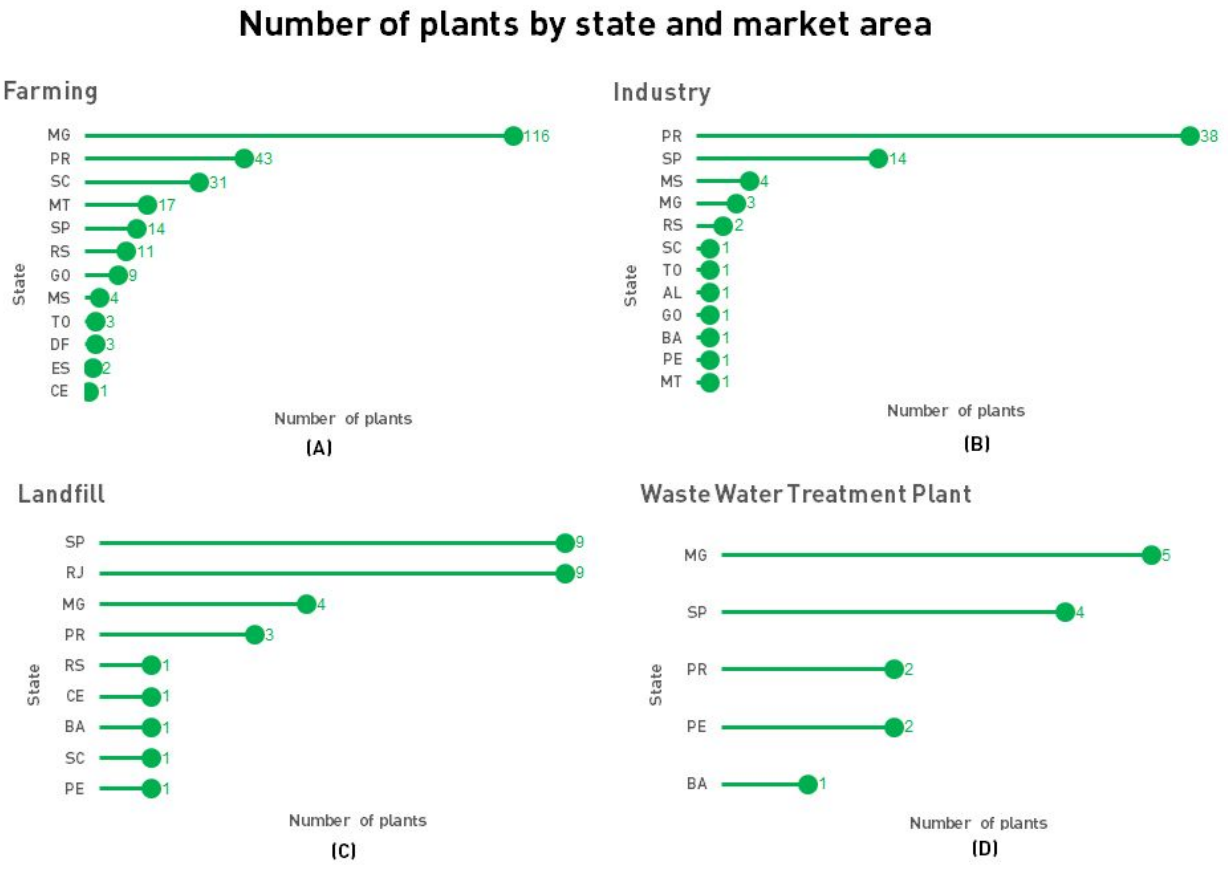
Source: CIBiogás

Figure 2.1.3 below crosses the number of plants per state according to the origin of the substrate that feeds the biodigester. It shows the plants installed by state and origin of the substrate.

As a result, it can be seen that:

- MG is the state with the largest number of biodigesters in Brazil, followed by PR, SP and SC;
- from these four, only in SP is the category farming not the most relevant. Here, the industry and sanitary landfill have several biodigesters;
- PR has a high number of biodigesters for farming. In addition, the western region stands out for the large number of biodigesters installed to treat industrial effluents;
- SC stands out almost unanimously for the presence of biodigesters in agriculture and livestock.

Figure 2.1.3 - Number of plants by state and market area

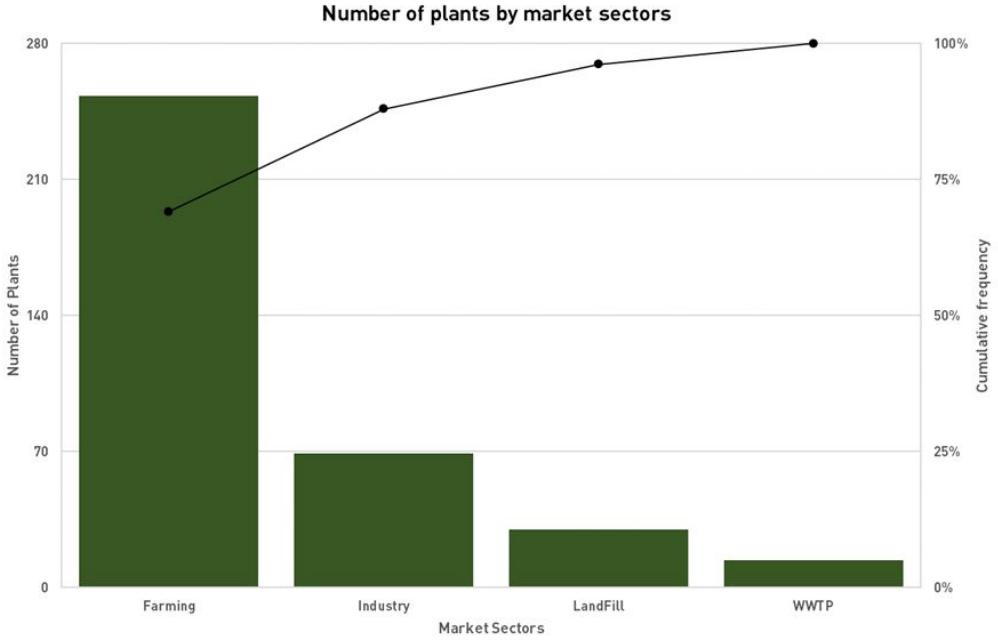


Source: CIBiogás

In order to interpret different variables analyses were performed using the **Pareto Diagram.** This type of graph is organized in such a way that the horizontal axis holds the market sectors. The left vertical axis contains the computed quantity of each variable (bars) and the right vertical one expresses the accumulated representativeness in percentage (line).

Figure 2.1.4 crosses the substrate category with the quantity of plants. In first place on the quantity ranking are the biodigesters for treatment of agricultural waste, followed by the industry sector. When analyzing this Pareto Diagram it is noted that approximately 70 % of the biodigesters are in the farms, while 25 % in the industries, leaving 5 % of the amount of biogas plants in landfills, WWTPs and co-digestion. Landfills are found in the third position with only 29 plants in Brazil. From the 5,570 Brazilian municipalities, only 14 % have sanitary landfills, which serve 63 % of the population. In other words, there are approximately 770 sanitary landfills that do not make use of the produced biogas (MMA, 2015).

Figure 2.1.4 - Number of plants per substrate category



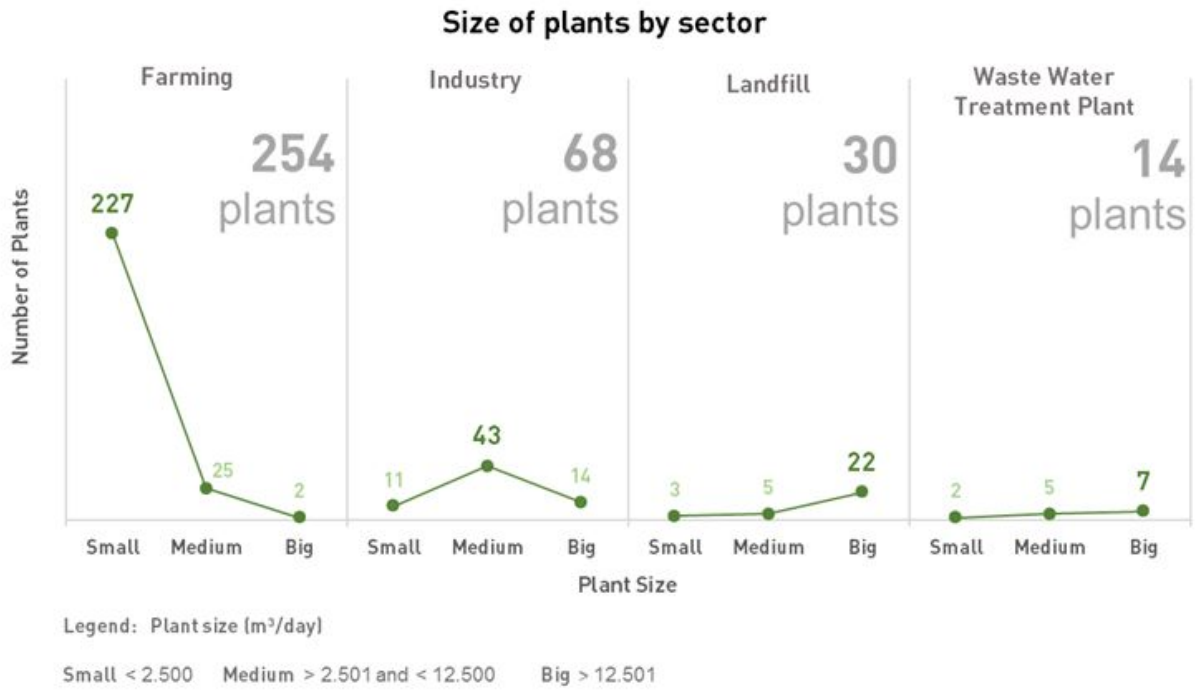
Source: CIBiogás

Next on Figure 2.1.5 one may check the distribution of biogas production scale per source of substrate.

The highlights:

- farming is the category with the largest number of plants, of which 89 % produce up to 2,500 m³ biogas per day;
- 10 % of sanitary landfills produces up to 500 m³/day of biogas, 17 % up to 12,500 m³/day of biogas and 73 % above 12,500 m³/day (some even produce more than 300,000 m³/day); and,
- industry's biodigesters are concentrated in 50 % in the production range of up to 12,500 m³/day and 50 % produce more than 12,500 m³/day of biogas.

Figure 2.1.5 - Size of biogas plants per sector



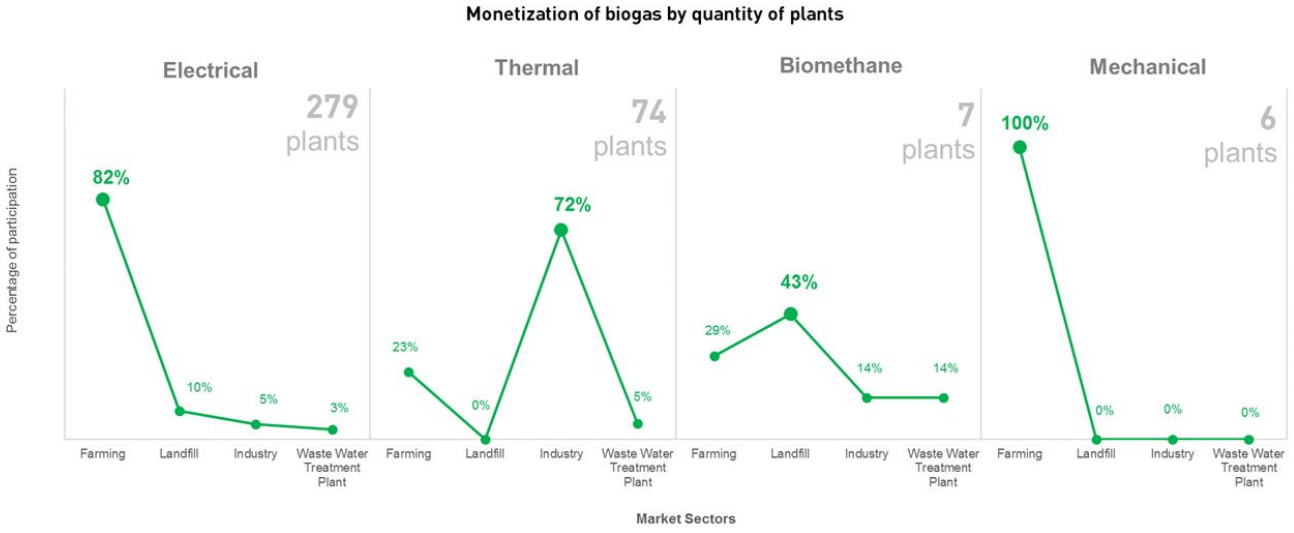
Source: CIBiogás

Figure 2.1.6 deals with the alternative of monetizing the biogas produced in these plants, such as for thermal, water pumping, biomethane or electricity generation.

The highlights:

- the main business model option for Brazilian biogas plants is electric power generation;
- only in the industry, the use of thermal energy is greater than electric energy; and,
- Biomethane is still almost non-existent in Brazil. There are only 7 plants in the whole country, and only one has a production greater than 100 m³/day (landfill in Fortaleza-CE). It is worth reminding that two of these are operated jointly by CIBiogás (Foz do Iguaçu and Santa Helena in PR).

Figure 2.1.6 - Form of monetization of biogas by quantity of plants



Source: CIBiogás

Refineries that upgrade biogas into biomethane are still pioneer in Brazil due to economic feasibility, regulation and national technique. The same obstacles that biogas itself and other renewable face in Brazil. The biomethane regulation in brand new (see item 2.2.2) and the early refineries that are installed today are the basis to the knowledge that formed the regulation.

CIBiogás strongly believes that biogas upgrading into biomethane will be good business in the future and, therefore, that will be many more plants installed. What supports this belief are the current political movements that combine privatizations on the gas and oil sector with large size biodigesters being built and the strong participation and interest of the automobile industry in this type of fuel.

On the other side, there is the technic bottleneck, which naturally has to do with investment expectatives. Currently, in Brazil there is yet no strong membrane supplier or specialized labor supply on biomethane or even a chain of laboratories able to test the biomethane according to the parameters established by the regulation.

It can be seen that:

- 75 % of all plants in the agricultural category produces biogas through the treatment of swine waste;
- in second place, with 6.5 % of the plants, is the confinement cattle culture; and,
- despite its expressive potential, the poultry substrate represents only 2 % of the biogas plants in this category.

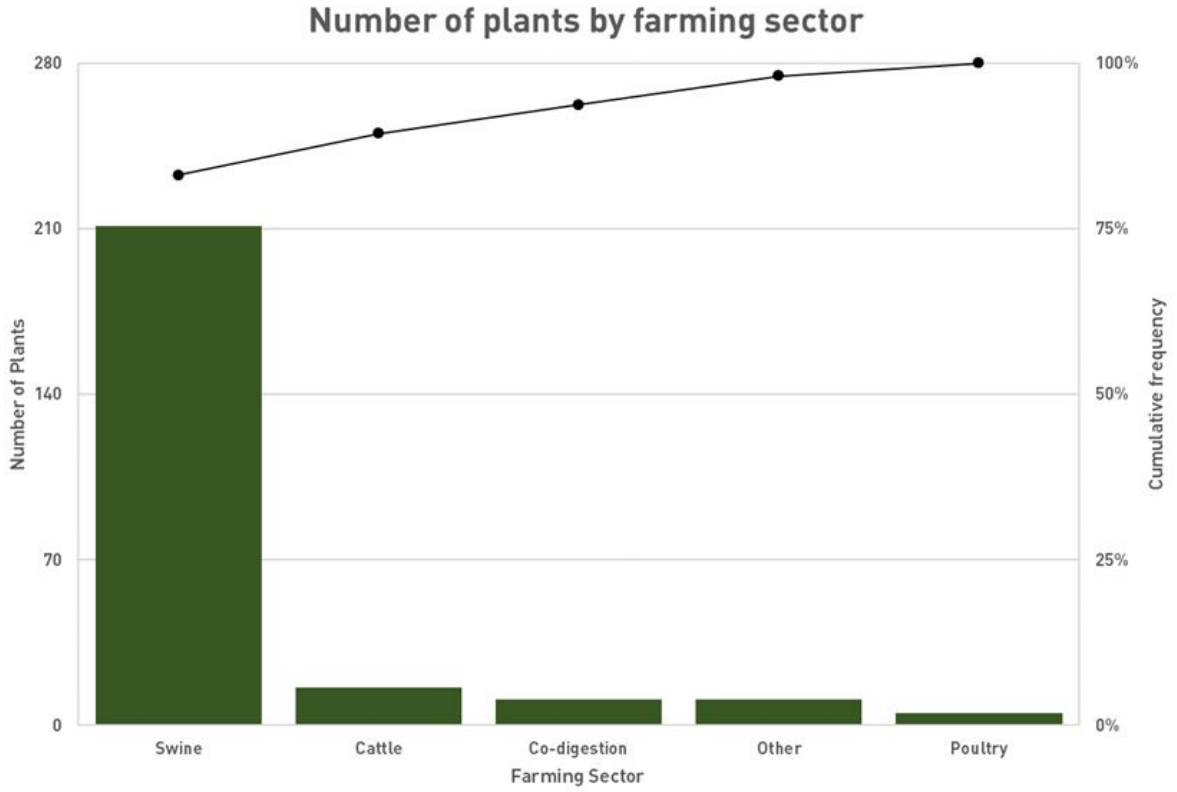
In relation to the Industry segment, it is seen in Figure 2.1.8 that:

- industry category also presents expressive concentration in a substrate, in this case food or beverage residues, with 88 %;
- despite the significant potential for biogas production, the Sugar and Alcohol Industry (sugarcane) has only 3 biodigesters in operation with 4.5 % of representativeness; and,
- similarly, the dairy industry has only one biodigester (owned by Embaré in Lagoa da Prata - MG).

Figure 2.1.7 shows a focus on the Agricultural category. A common question is: if the potential is so outstanding, why there are just a few installed reactors?

The core of the answer is qualitative and has to do with expectations. To begin with, biogas is yet unknown for the population and treated as a wild venture instead of being looked at as a technique with a consolidated industry supply chain that already creates value in Europe for the past 40 years.

Figure 2.1.7 - Agricultural Category by substrate source

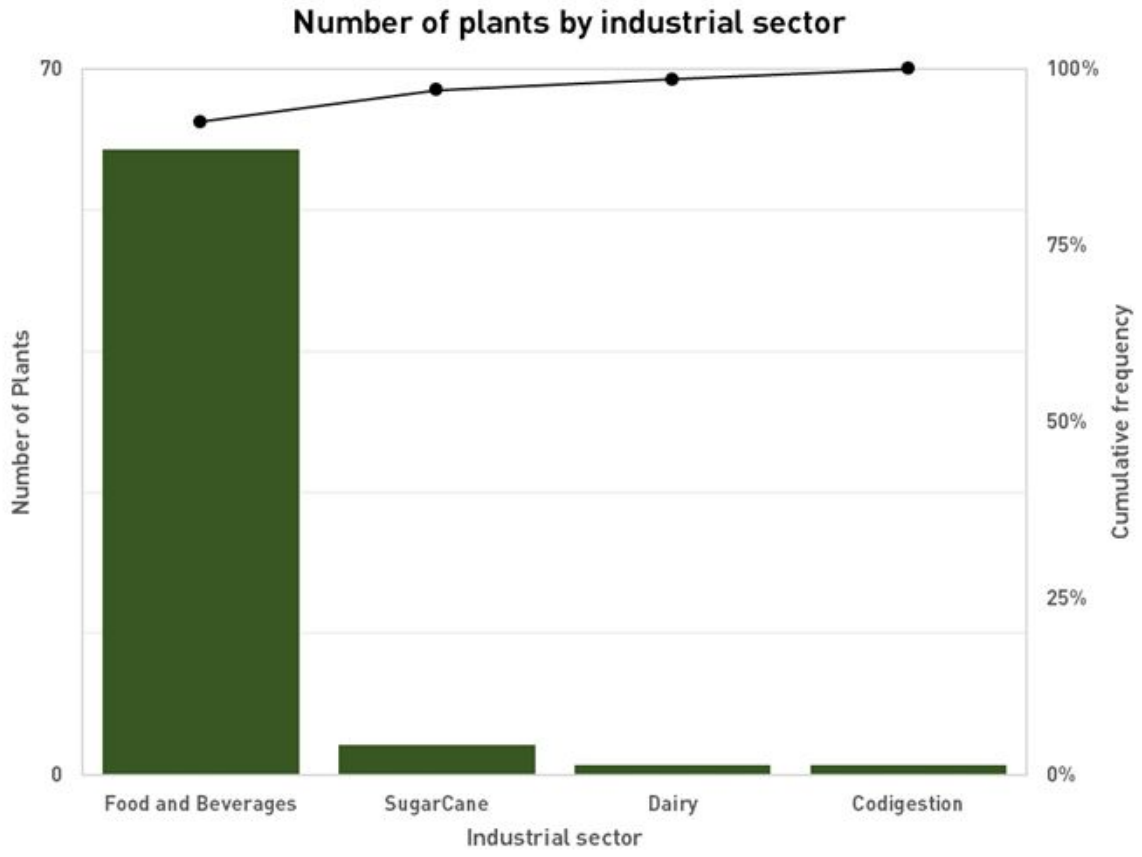


Source: CIBiogás

Embrapa made pioneer and quality efforts to encourage the construction of biodigesters on the 80s, same time when Germany started as well. The problem was that the constructed plants had not the vital equipments for a good operation (mixer, heater, pre-treatment etc.), they were in essence large covered lagoons. It is to expect that they did not last long. This event stained the biogas image for more than two decades.

Brazil is very complex in the sense of regulation and fines, therefore, farmers and businessmen rely a lot on “what my neighbor is doing”. This explain why there are so many installed reactors for swine producers and so little for sugar cane industry. There is still a lot of unanswered questions about the operation and success of biodigester on the sugar cane industry, since the few installed reactors do not share their data.

Figure 2.1.8 - Category Industries by substrate source

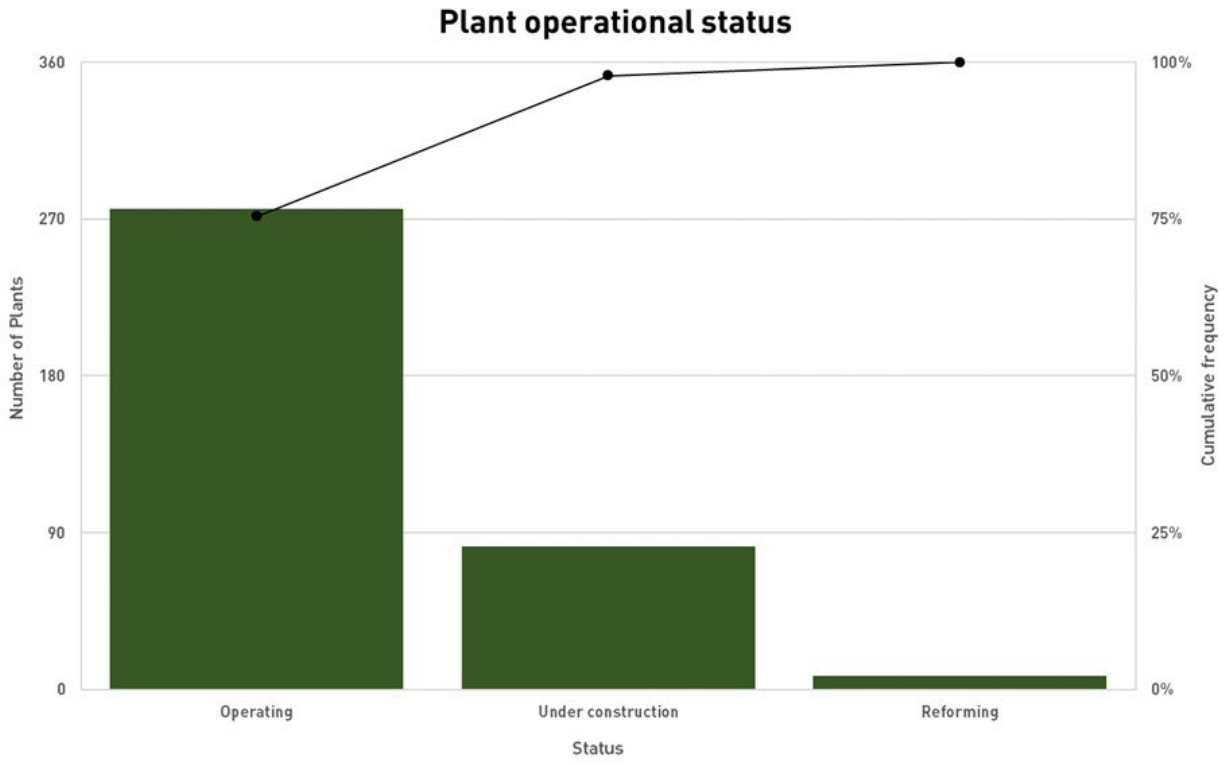


Brazil is very complex in the sense of regulation and fines, therefore, farmers and businessmen rely a lot on “what my neighbor is doing”. This explain why there are so many installed reactors for swine producers and so little for sugar cane industry. There is still a lot of unanswered questions about the operation and success of biodigester on the sugar cane industry, since the few installed reactors do not share their data.

In this sense, it is to expect that as soon as the “neighbors see it working” there will be an enorme demand for such reactors. We hope that Raízen ends up successful with its operation in order to promote the biogas technique on the whole sector.

There are many biodigesters that are still under construction and commissioning, as shown in Figure 2.1.9. Approximately a quarter of all plants in Brazil (22 %) are in the installation phase, of which 100 % are for power generation and 85 % are being built to treat swine waste.

Figure 2.1.9 - Distribution of plant status



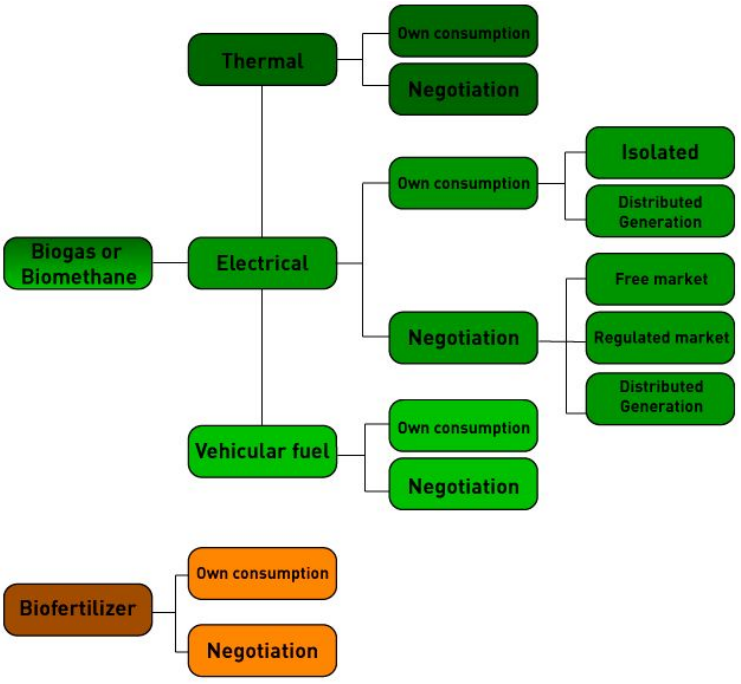
Source: CIBiogás

There are only 366 biodigesters in the entire Brazilian territory. If the number of biodigesters is divided by the area of the country, there is an index of $4^{-5}/km^2$. For comparison purposes, the same index in Germany is $3^{-2}/km^2$. In other words, Germany has 114 times more biodigesters per area than Brazil.

2.2. REGULATORY MILESTONES

The biodigestion process offered by biodigesters presents an alternative to sanitary treatment and, at the same time, a source of renewable energy resources. Biogas is easy to store and its calorific potential can be used in three main monetization routes; thermal energy, electrical energy and a combination of the two. In addition, another valuable product produced in this process is the biofertilizer. Figure 2.2.1 illustrates the economic alternatives of biogas.

Figure 2.2.1 - Alternatives for biogas monetization



Source: CIBiogás

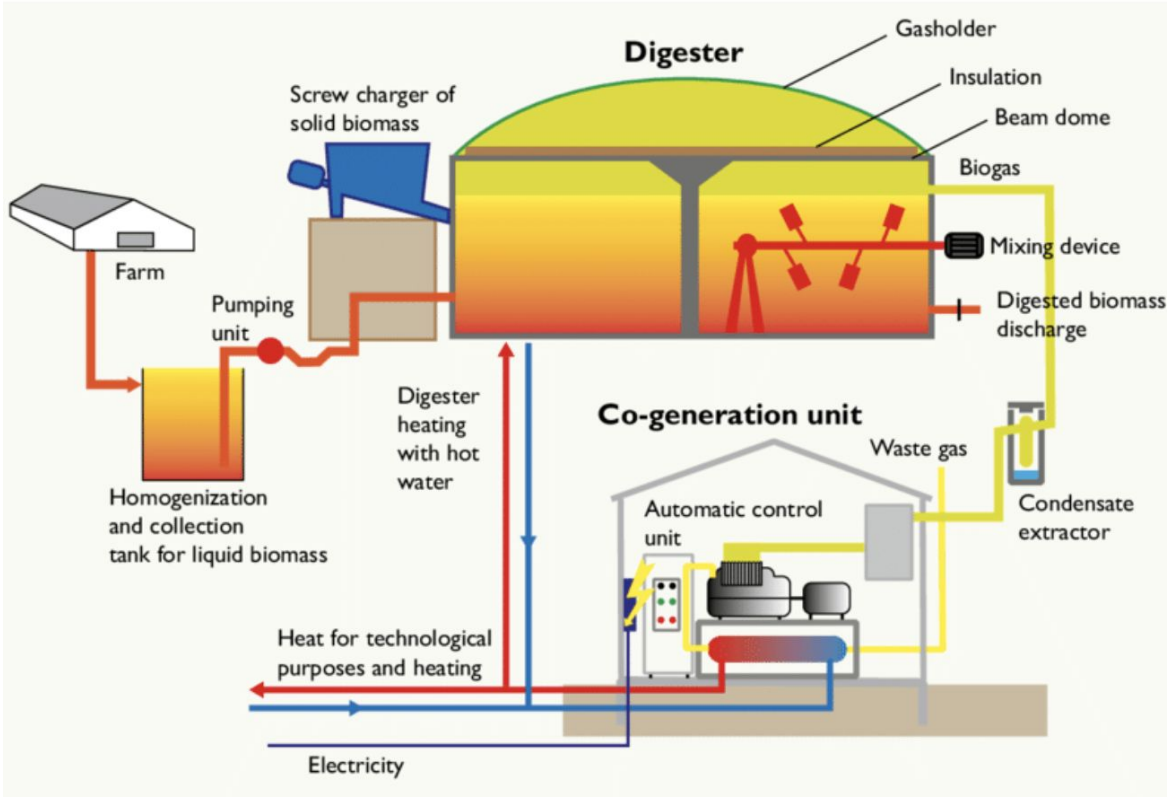
The exclusive use as thermal energy is a substitute for fuels such as wood chips in boilers or furnaces, or Compressed Natural Gas (CNG) in automobiles. In turn, the technical arrangement aimed at producing electric power is an additional activity that allows increasing the profitability of the business in an environmentally sustainable manner. This can be done through net metering (on-grid) or the direct use of electricity generated without involving the power utility (off-grid) and can fit as a new source of revenue by opting for commercialization. This can be done in the regulated or free market.

Electricity generation with biogas takes place from a generator (stationary gas engine coupled to a generator). If this equipment is a CHP (Combined Heat and Power) unit, it generates electricity and also uses the heat from the fuel gas to maintain the temperature of the reactor itself or heat a boiler, for example.

When analyzing Figure 2.2.2 it is possible to verify that the CHP unit (also called cogeneration unit) produces electrical and thermal energy simultaneously, which both

produce value for the investor, since, for example, if there were no other heat source to be found to keep the heating inside the reactor.

Figure 2.2.2 - CHP unit in biodigestion



Source: (BRACCO, 2018)

Therefore, the means by which a biogas plant acts, produces value and should fit the regulation are through the:

- sanitary treatment of organic waste;
- production of biogas (electric or thermal energy);
- upgrading to biomethane (possible use of CO_2);
- creation of stabilized organic biofertilizer; and,
- environmental benefits such as reduction of greenhouse gases, proliferation of insects, diseases and increased air quality.

It is known that the applied regulatory framework depends biogas monetization choice determined by the business model. For example, a biogas plant that produces electricity off-grid does not need to adjust to the state distributed generation rules.

As another example, a plant that upgrades biogas and produces biomethane for vehicular use also does not need to adjust to the state distributed generation rules, but it will have to adapt to the biomethane regulation and standards.

Therefore, this report will present a specific item for the main arrangements and models.

2.2.1. Introduction to the regulation

The feasibility of biogas projects depends directly on the regulatory conditions of the activity, in order to enable a solid development of the sector and the consolidation of markets for the effective flow of the byproducts of the process (electric and thermal energy, biomethane and biofertilizer).

Regarding the regulation, it is essential to identify and disseminate the norms and guidelines that apply from the licensing phase and environmental regularization of the installation because, due to the multidisciplinary nature of biogas projects, it can be applied many of the existing laws in other areas, such as the environment, sanitation, energy, infrastructure, agriculture, among others.

It is important to emphasize that the relevance of biogas projects in Brazil is justified in different spheres. Firstly, the current context of incentives for the diversification of the national energy matrix based on biomass sources fosters distributed and clean generation, in which biogas can assume a prominent potential due to the high availability of organic substrates in different productive sectors. And in a complementary way, methanization is positioned as a strategic technological alternative and solution for environmental sanitation, which also associates the generation of value-added byproducts, such as biogas and biofertilizer.

Furthermore, the legal conditions for the use of biogas and its byproducts are not very clear to all parties involved. Since it is relatively new sector, many of the old policies and regulations of other sectors are still applied, such as natural gas, environment and sanitation. The consequence of the lack of precise information is mainly insecurity, which inhibits the willingness of actors to invest in this market and, on the other hand, reduces

the profitability of projects by increasing costs and the time for their evaluation and approval.

What is needed to eliminate this bureaucratic insecurity is the finalization and publication of the Biogas Legal Mark, written as the Law Project 6.559\13, that has the power to bring some clear rules about what to expect from the biogas production and commercialization scenario in Brazil. Additionally to that, together with the privatization of the Natural Gas sector, the Biogas Legal Mark will also booster the biomethane market.

The strategic importance of biogas is not yet recognised in all its scope, a view reinforced by the lack of specific policies for the subject. The policy instruments, such as the regulatory framework, environmental licensing, financing lines, fiscal and tax incentives and specific energy auctions, should be adapted to this complexity with an integrated and strategic way.

Currently, while this report is being written, the Law Project 6.559\13 is being organized for discussion at national level in São Paulo. In Paraná, the public natural gas company Compagás together with the sanitation company Sanepar, CIBiogás, Paraná Investment Agency, Tecpar and the state environmental secretary formed a Thematic Cooperation Group to discuss and approve as soon as possible the Biogas and Biomethane Regulatory Mark for commercialization on the gas grid with support of the Paraná Governor.

When successful this work can be an example for application on other states. In the south of Brazil the state of Santa Catarina has already disclosed a state level biogas regulation. An example of such demands is the need for regulation of the transport of raw biogas at low pressure and by private pipelines.

2.2.2. Regulation

The production and use of biogas is generally framed as ancillary activities within the enterprise as a whole. In general, the plants are related to sanitation, energy production facilities or agro-industrial enterprises associated with the production and use of biogas. Therefore, in cases of small plants, environmental licensing is dispensed in most states. Brazil does not have a unified environmental law, so it is suggested that the state environmental agency be consulted prior to installation. Table 2.2.1 provides an

overview of the main state regulations that regulate the production and use of biogas for energy purposes in Brazil.

Table 2.2.1 - State regulations on biogas in Brazil

State	Normative	Year	Description
PR	Complementary Law nº 205	2017	Disposes about the services of distribution of canalized gas in the State of Paraná
RJ	Law nº 6.361	2012	Disposes about the State Renewable Natural Gas Policy - GNR
	Resolution INEA 32	2011	Use of biogas from sewage treatment plants with energy generation
			Burning of biogas from solid urban waste, with energy generation
			Generation of electrical energy from thermoelectric plants
SC	Law nº 17.542	2018	Establishes the Biogas State Policy
	Resolution CONSEMA 13	2012	Waste anaerobic biodigestion unit
			Thermoelectric energy production
			Gas and biogas production
ES	Ordinance SEAMA n° 01	1994	Thermoelectric energy production
			Gas and biogas production
BA	Decree n° 11.235	2008	Thermoelectric construction
			Centralised biological treatment plants
MG	Law nº 20.824	2013	Reduction of ICMS for projects, connections, transport and electric power generation from biogas
	Normative Resolution COPAM n° 74	2004	Biogas production
			Production of thermoelectric energy using natural gas and biogas
RS	Resolution FEPAM n° 002	2001	Thermoelectric energy production
SP	Decree nº 58.659	2012	Establishes the São Paulo Biogas Program and implements related measures

Source: BRASIL, 2016

At the national level, CONAMA Resolution no. 01/1986 establishes that electricity generation plants, from any primary energy source with production above 10 MW of installed power are subject to the presentation of environmental licenses (EIA, RIMA and

public hearing). Additionally, Table 2.2.2 lists all current regulations on biomethane in Brazil.

Table 2.2.2 - Regulations on biomethane in Brazil

State	Normative	Year	Description
Brasil	Resolution ANP nº 8	2007	Establishes the specification of biomethane
	Resolution ANP nº 21	2016	Provides about the use of Experimental Fuels throughout the national territory
	Resolution ANP nº 685	2017	Establishes the rules for quality control approval and specification of biomethane
	Resolution ANP nº 734	2018	Regulates the authorisation to engage in biofuel production activity and the authorisation to operate the biofuel production installation
PR	Law Project nº 19.500	2018	Disposes about the Biogas and Biomethane State Policy (waiting for approval and sanction)
RS	Law nº 14.864	2016	Establishes the State Biomethane Policy, the regional Program to Encourage the Generation and Use of Biomethane - RS-GÁS
SP	Resolution ARSESP nº 744	2017	Disposes about the conditions of biomethane distribution in the piped gas network

Source: BRASIL, 2016

In Santa Catarina (SC) enterprises smaller than 10 MW are requested only the preparation of the Simplified Environmental Study (EAS), or the Prior Environmental Report (RAP) for the composition of environmental regularization processes. Enterprises that process up to 0.5 t/d of MSW are considered insignificant, and up to 30 t/d are classified as small.

In Minas Gerais (MG) small enterprises are subjected only to the Environmental Authorization of Functioning (AAF), which does not require the presentation of an environmental study, being necessary, in general, the presentation of the Responsibility Term and the Technical Responsibility Note (ART) informing that the enterprise has all the necessary environmental control systems implemented and operates according to all the environmental conditions and parameters legally in force.

In Rio de Janeiro (RJ) licensing is facilitated through the issuance of the Simplified Environmental License (LAS), which is obtained in a single phase. The projects of

energetic use of biogas from sewage treatment plants with production of up to 200 m³/h and energetic use of biogas from urban solid waste, with treatment capacity of up to 100 t/d, are considered as of minimum size. For thermoelectric generation, enterprises with an installed capacity of up to 1 MW are considered small.

According to the CIBiogás database, the average size installed capacity on a brazilian biodigester is of 67 kW (or 0,067 MW). This is considered by the legislation standards as insignificant or small and, therefore, do not require great efforts for licensing.

The most representative bureaucratic effort is the license to export electric energy to the regional utility company in turn of consume compensation, also called net metering, which is deeply addressed on the next item.

Due to the high concentration of sugar-alcohol plants, the environmental agencies of the state of São Paulo have been proposing several measures to minimize the environmental impact caused by this industrial sector. In this context, the first solution proposed by the state of São Paulo to promote a healthier environment and decarbonize the energy matrix was an agreement of the Environmental Protocols signed in 2007 between the Secretariats of Environment (SMA), the Secretariat of Agriculture and Supply (SAA) and the sugar-alcohol industries. This agreement is important because from 2007 to 2015 the generation of electricity from bagasse thermoelectrics grew 2.75 times, reaching 5,125 MW of installed potential (RAMOS and NACHILUK - IEA, 2017).

Another state initiative that boosts the energy use of sugarcane byproducts is the creation of the "Greener Ethanol" program. This program is a continuation of the Environmental Protocols and aims to support the sustainable development of the sugar-alcohol industries in the state of São Paulo, through actions such as the reuse of byproducts (SMA/SAA, 2018).

2.2.3. Net Metering

In comparison with more developed economies Brazil has some particularities. First of all, the utility companies have total monopoly on their concession area. In general, there is one electric supplier per state. Most of them have free float shares but are still controlled by the government. That means that the captive consumers are not allowed to choose whom to buy the energy from.

Secondly, distributed generators are not allowed to sell the generated electricity. It is only possible to compensate the electricity consumed with the generated, the so called net metering. This restriction hinders the renewable energy matrix development. It makes it harder to achieve financial feasibility and protects the utility monopoly. However, on the positive side, the whole bureaucratic process is free of charge and for small plants (up to 75 kW), if needed, the utility company is even obliged to supply gratis grid reinforcements. The exception are for those with expressive power demand above 2 MW or supply above 3 MW, which are able to enter and trade on the free electric chamber (ACL).

The ANEEL Normative Resolution No. 482/2012 allows generating plants with installed power less than or equal to 5 MW to inject the energy generated to the local utility company. Doing this, they may offset their consumption of electricity from that same consumer unit or from another consumer unit of the same ownership of the unit in which the credits were generated, provided that they have the same individual tax number (CPF) or corporate (CNPJ) and that they are located on the same concession area.

The positive difference between the energy produced and compensated is the number of credits, which will be valid for 60 months for consumption. In this case of self-consumption through compensation on the electricity bill, it is not possible to sell the surplus energy.

Since 2016, it is possible to create the possibility of implementing distributed generation in condominiums (enterprises with multiple consuming units). Thus, the energy generated can be divided among the condominium members in percentages defined by the consumers themselves.

It was also created the figure of "shared generation", which enables that multiple stakeholders come together in a consortium or cooperative, implement distributed generation, and use the energy generated to reduce the bills of consortium members or cooperative members. In this case of shared generation and multiple stakeholders the given relationship of condominium or consortium must be proven.

There was also a simplification of the process for the connection of distributed generation to the distribution grid: the ANEEL created new rules that instituted standard forms for requesting access by the consumer, reduced the total time for the distributor to connect micro generations (up to 75 kW) from 82 to 34 days and, finally, instituted that the

request and monitoring of the request with the distributor can be done over the internet since 2017.

If the use of biogas is for injection into the Natural Gas (NG) network or use/marketing as fuel for automobiles, the regulations established by the Ministry of Mines and Energy (MME) and National Petroleum Agency (ANP) must be observed (ANP Resolutions 685 + 734). Alongside, projects larger than 75 kW of electricity generation need to consult the energy load in the network to the concessionaire and thus require expertise. If the investor does not have such knowledge in his team, they may hire a company to perform such bureaucracy, which may cost up to R$ 50,000.00.

2.2.4. Environmental licenses

According to the previous items, most of the biodigesters are considered as an additive to the investor's main activity. However, for those investors or producers that do not yet have the environmental licensing of their main activity, it is suggested that they regularize it with the correspondent environmental agency.

2.2.5. Tributation

The taxes that may be levied on electricity generation are ICMS (state tax) and PIS + COFINS (federal tax). For the former, the states that adhered to ICMS Agreement 16/2015, this tax is levied only on the negative difference between the energy consumed and the energy injected into the grid in the month, i.e., there is taxation on the energy consumption supplied by the power utility.

The energy generated or the credits generated are exempt. For those states that have not adhered to the new agreement, the previous rule is maintained, in which the ICMS is charged on all consumption, thus disregarding the energy injected into the grid by micro or mini generation. It does not apply to Consortia, Cooperatives or Condominiums nor to plants with an installed capacity greater than 1 MW.

For the PIS and COFINS, according to the publication of Law No. 13,169/2015 of October 6, 2015, its incidence follows the same rules as the ICMS. Given that PIS and COFINS are federal taxes, the rule established by law applies equally to all states of the country, while in ICMS the collection rate may vary among the states of the federation.

2.2.6. Actualities

This item holds three very possible and disruptive regulation changes.

- **Net metering remuneration review:**

Currently, ANEEL is discussing the distributed generation business model, in which the distributor holding the concession may charge for the electricity network service.

There are 5 possible scenarios that illustrate charging scenarios of different magnitudes. Today a micro (up to 75 kW) or mini-generator (up to 5 MW) is compensated by 100 % of the electricity exported to the grid.

5 alternatives were gathered. The first one suggests that the utility company reimburses the prosumer on 72 % of the exported electricity. The second one 66 %, the third 58 %, the fourth 50 % and the fifth only 38 % (ANEEL, 2018).

CIBiogás actively participates in the collaboration of the public calls for proposals in this discussion and presented projections that some scenarios made the growth of biogas in Brazil unfeasible. The CIBiogás defends that the renewable energy sector is not only formed by photovoltaic plants and that biogas should be treated according to its particularities.

On the CIBiogás point of view, there will be a raise on the contribution to the utilities company for the use of the electrical infrastructure, which will affect the operation similarly to a new tribute charged on the amount of electricity injected on the grid. Unfortunately, it is not possible to know for sure how large this bite will be. It is expected that the contribution will be up to 34 % of the produced energy. If so, for every 1 kWh injected on the grid the distributed energy producer will compensate 0,66 kWh on the energy bill. If the compensation is not on the same property where the energy is produced the expected contribution is of 62 %.

The new ANEEL resolution is to be disclosed on the first semester of 2020.

- **Free Contracting Chamber - Limit Reduction Schedule**

In Brazil one can only choose whom to buy energy from if the consumer unit has more than 2,5 MW of power demand for consumption from the grid.

Following a international electric sector trend, it is expected that this restriction will be gradually reduced, as seen on Figure 2.2.1.

Figure 2.2.1. Limit reduction schedule for independent energy booking

Source: CP 063/2018 - MME

This can be interpreted as a benefit, since biogas it is a encouraged source of energy and with the reduction of the minimum power demand more and more consumers will be able to contract electricity produced by biogas power plants.

However, biogas can be negatively impacted by the withdrawal of subsidies for generation of encouraged sources through the Draft Laws 1917 and 232 (scope of the working group for modernization of the electricity sector of the MME).

- **Electricity prices intraday oscillation**

Electricity is also a commodity and its prices follows the elasticity of the supply and demand curves. Brazil is preparing grounds for this big change on the electric sector. It is called in Brazil the introduction of the hourly PLD (differences liquidation price), which will affect not only industry but also dwellings.

Its start shall happen in January 2021.

Players shall prepare to commercialize and operate a biogas plant in order to maximize profits with the energy price exchange prices fluctuation.

This is a good news for the biogas value chain technical development. Since biogás is easily stored a simple automation online system can be installed onto a generator to start its work when the prices are higher and turn off when the prices are low. It is not well

known if there are expected limits on the oscillation, however, some say that the electricity prices may vary up to R$ 1.500 per MWh.

2.2.7. Possible improvements for the future

- Deduction of credits generated in Distributed Generation beyond the state border (by electric vehicles for example);
- Breaking the monopoly of energy distribution concessionaires;
- Simplified sale of electricity and from any installed capacity;
- Energy price fluctuation;
- Petrobras breaks its monopoly on the production, transportation and purchase of Natural Gas;
- Differentiated tariff for biogas generators for a certain period of time;
- Tax and fiscal incentives;
- Promotion of financing lines for biogas and access to federal public resources;
- To encourage the use of resources from the Sectoral or Electoral Funds for the implementation of reference projects in the area of biogas;
- Development of a sectoral structural policy for biogas;
- Structuring of incentives and subsidies for the electricity and natural gas sectors;
- Licensing and environmental regularization of biogas enterprises; and,
- Capacity building and training in the area of biogas.

3. BUSINESS MODELS

The business model is a key item in innovative ventures that do not follow a fixed pattern of replication. It involves public-private regulation and can last for a long period of time (more than a decade). Therefore, it is important to discuss business models applicable to biogas.

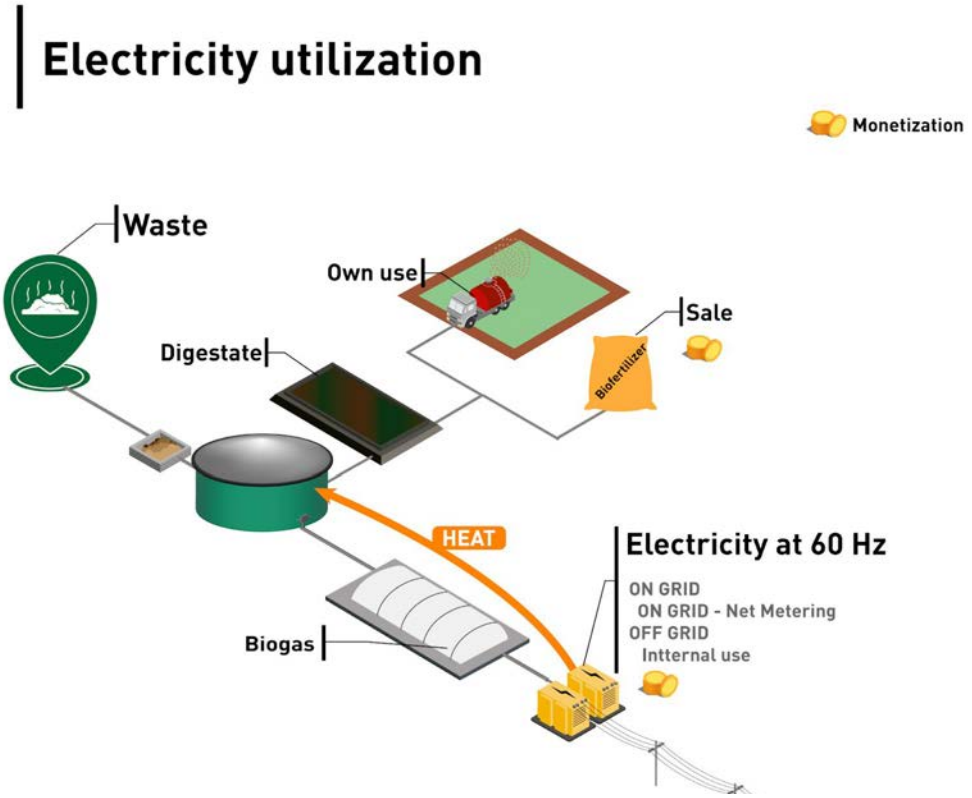
In one of the studies on technical arrangements carried out by CIBiogás, 270 alternative arrangements for monetization of biogas with electrical energy and 405 for thermal use were identified. This chapter illustrates alternatives of business models that can be compatible with hundreds of technical arrangements. Here are presented business models already widespread in Brazil, as well as some models that have not yet been tested, either for economic impracticability, stage of technical development or even for lack of initiative. Such models are classified into electricity, heat, biomethane and other

combinations. Additionally, some examples of successful biodigesters operating in Brazil are detailed.

3.1. ELECTRICITY

A general business model involving electricity is illustrated in Figure 3.1.1. It involves a biodigester that produces biofertilizer and biogas, which in turn uses biogas as an energy source in a generator to produce electricity. The biofertilizer can be used on the farm itself or sold. In addition to electricity and biofertilizer, the biodigester also generates revenue (avoided costs) through the sanitary treatment of organic waste.

Figure 3.1.1 - General model for electricity



The remuneration for electricity supplied to the grid (on-grid) is possible through two alternatives. The first is net metering, in which the prosumer is a captive consumer (buys energy only from the concessionary) and remunerated by reducing his expenses on the electricity bill, i.e., energy compensation and therefore the economic viability of the project depends directly on the investor's consumption profile.

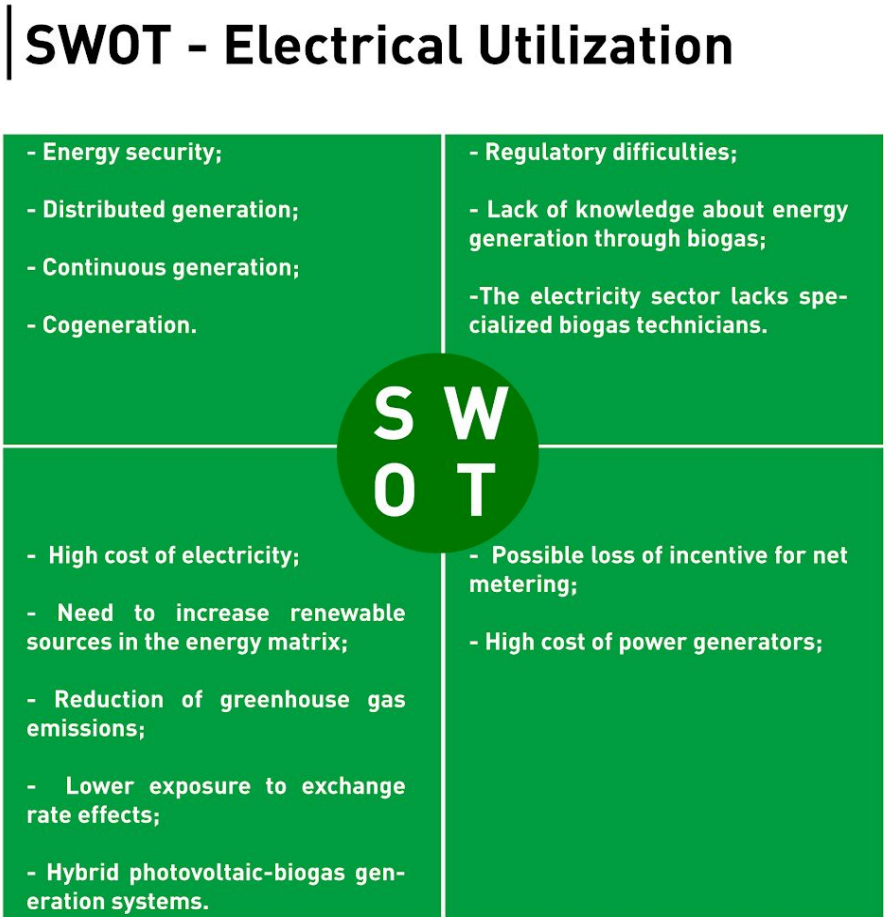
The second is through the sale of energy generated. This sale can take place in the free energy market (ACL) where prices fluctuate.

Finally, another constant source of income in all models of biodigestion is the digestate, also called biofertilizer. In continuous reactors this biofertilizer is always liquid, so it can generate positive cash flow by avoiding the purchase of chemical fertilizers (mostly imported) or it can be treated thru drying and pelletizing to transform into a commercial fertilizer.

In this context, the most common business model is found in pig farmers. The biodigester is usually a covered lagoon, also called a horizontal biodigester. The swine effluent is extremely humid (approx. 96%). The digestate is commonly spread on the soil. Finally, the monetization is thru electricity. The generator consumes biogas and produces heat and electricity. The heat returns to biodigestion through a heat exchanger and the electricity is injected into the distribution grids of the utility company (net metering).

Figure 3.1.2 shows the SWOT analysis performed to evaluate the use of biogas for electricity generation. Among the strengths the high potential of electricity generation from biogas should be highlighted.

Figure 3.1.2. SWOT Analysis - Electrical Utilization



3.2. HEAT

In some cases the monetization of biogas in the form of heat is more advantageous. This happens in enterprises that produce organic waste and that demand thermal energy in their production line, such as starch mills, sugarcane mills, dairy plants and poultry incubators.

In Figure 3.2.1 it is possible to identify that the only change between the generic electricity model is the use of biogas. In this case, biogas is used as a fuel to replace natural gas, wood chips, firewood or diesel and can be used in boilers, heat exchangers, furnaces or fluid heating. Therefore, the investment brings financial return through the avoided costs with other fuels.

Figure 3.2.1 - General heat model

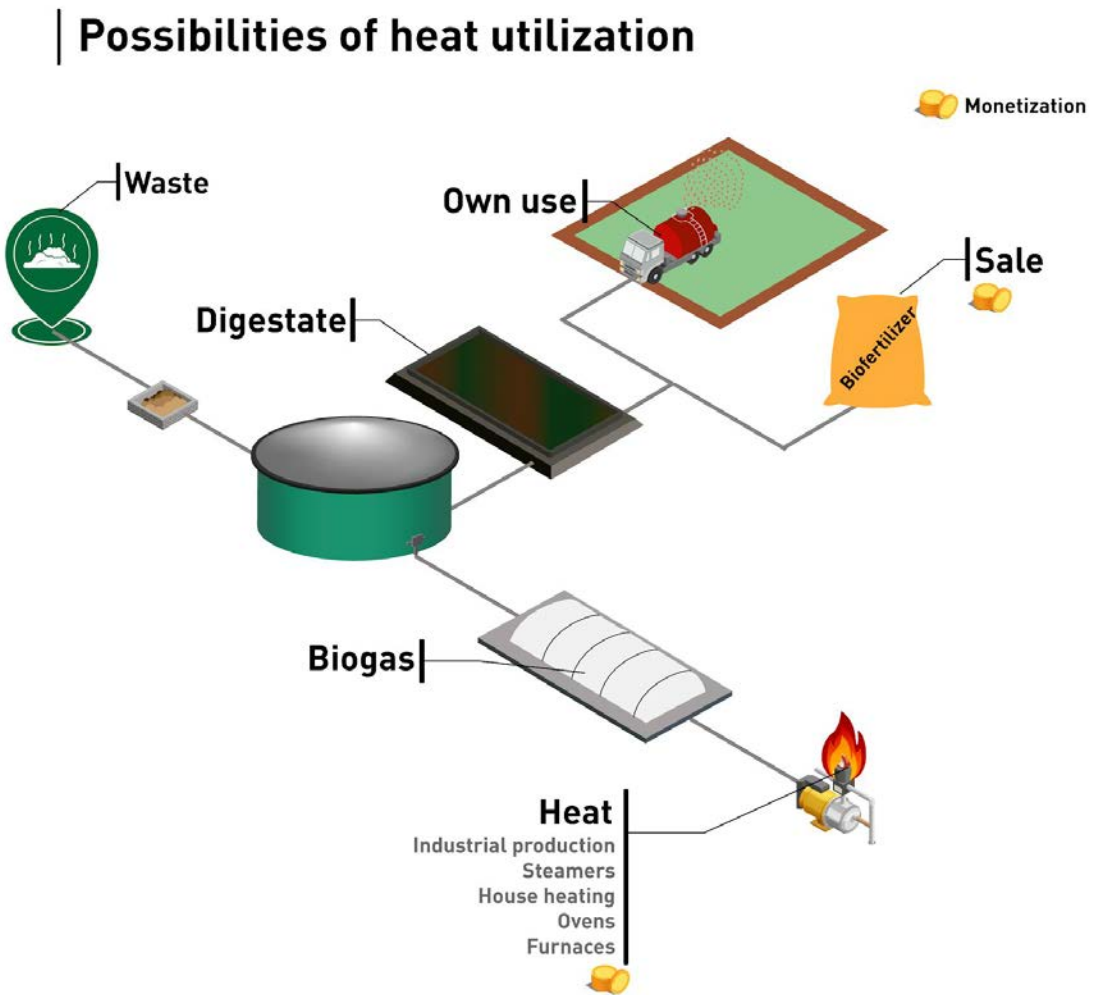
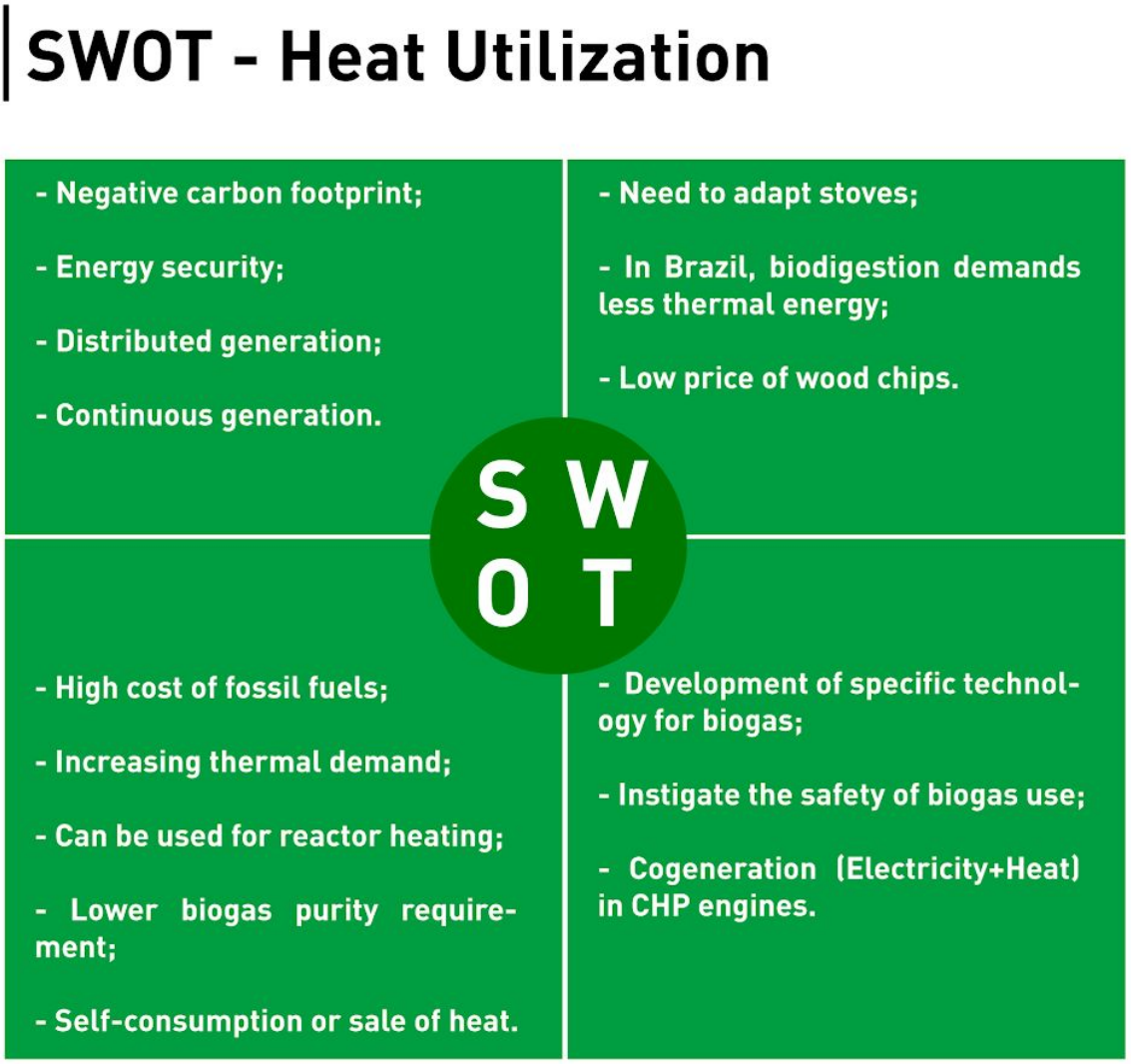


Figure 3.2.2 illustrates the SWOT analysis performed to evaluate the thermal use of biogas in Brazil. One may interpret that the main advantage of this business model is the use of a clean fuel that has a negative carbon footprint.

Figure 3.2.2. SWOT Analysis - Heat Utilization



3.3. BIOMETHANE

The refining of biogas results in biomethane. This process removes moisture, carbon dioxide, hydrogen sulfide and other compounds and produces a gas with physical-chemical properties similar to natural petroleum gas. In this way, biomethane can

be injected into the gas pipeline network or used as a vehicle fuel or even as an input for the production of thermal or electrical energy, as shown in Figure 3.3.1.

In addition to the various uses for biomethane, it is also possible to take advantage of the carbon dioxide accumulated during the refining of biogas. CO_2 can be used in the production of sodium bicarbonate (soda) and carbonated drinks, for example, as pop soda or soda water. In addition, it can be inserted into greenhouses, since it consumes a high consumption of carbon dioxide.

Also, unlike biogas that is stored in large gasometers, biomethane is compressed into cylinders (pink) at up to 200 bar. This allows the fuel to be transported over short or medium distances. By means of Figure 3.3.2, it is possible to verify the details of the SWOT analysis performed for biomethane.

Figure 3.3.1 - General model for biomethane

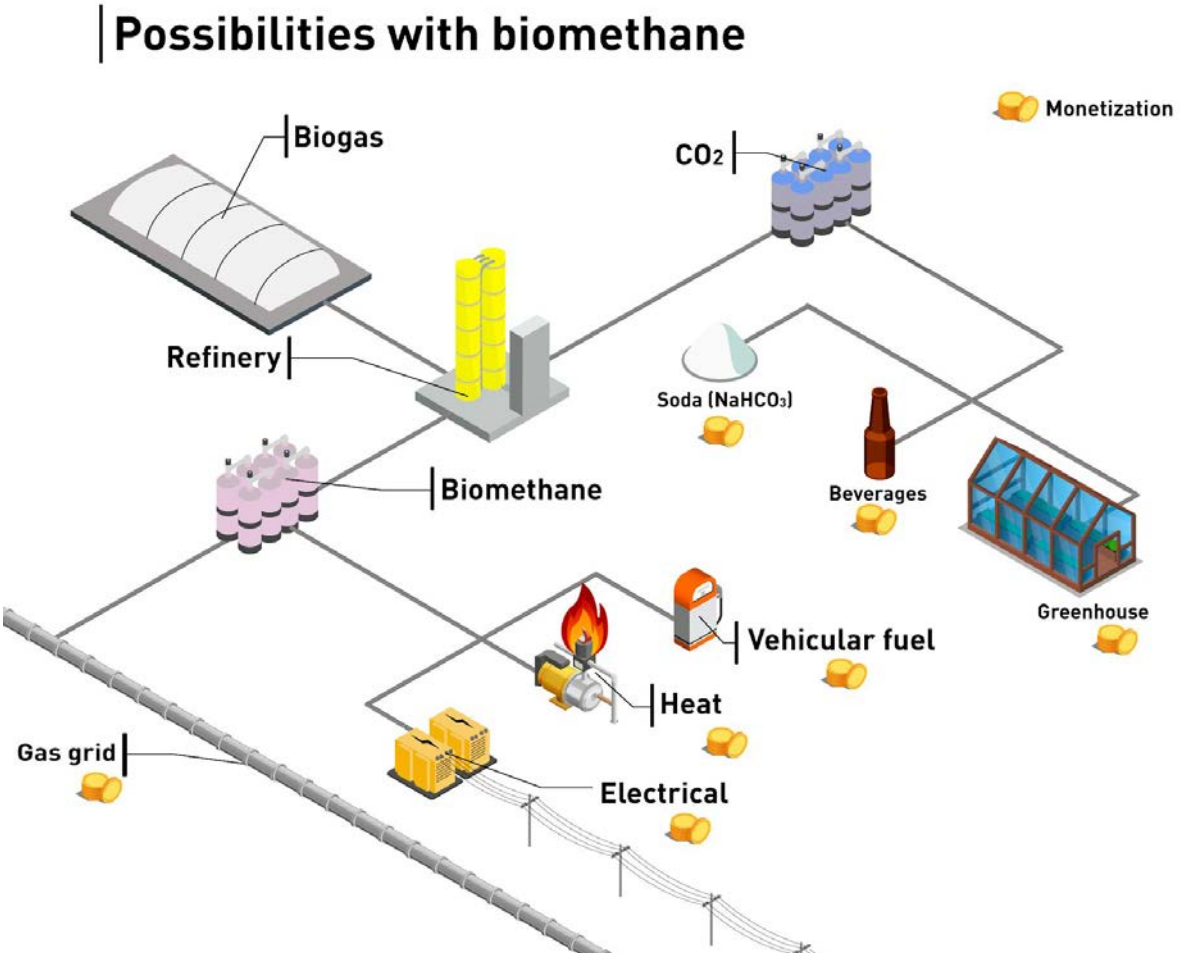
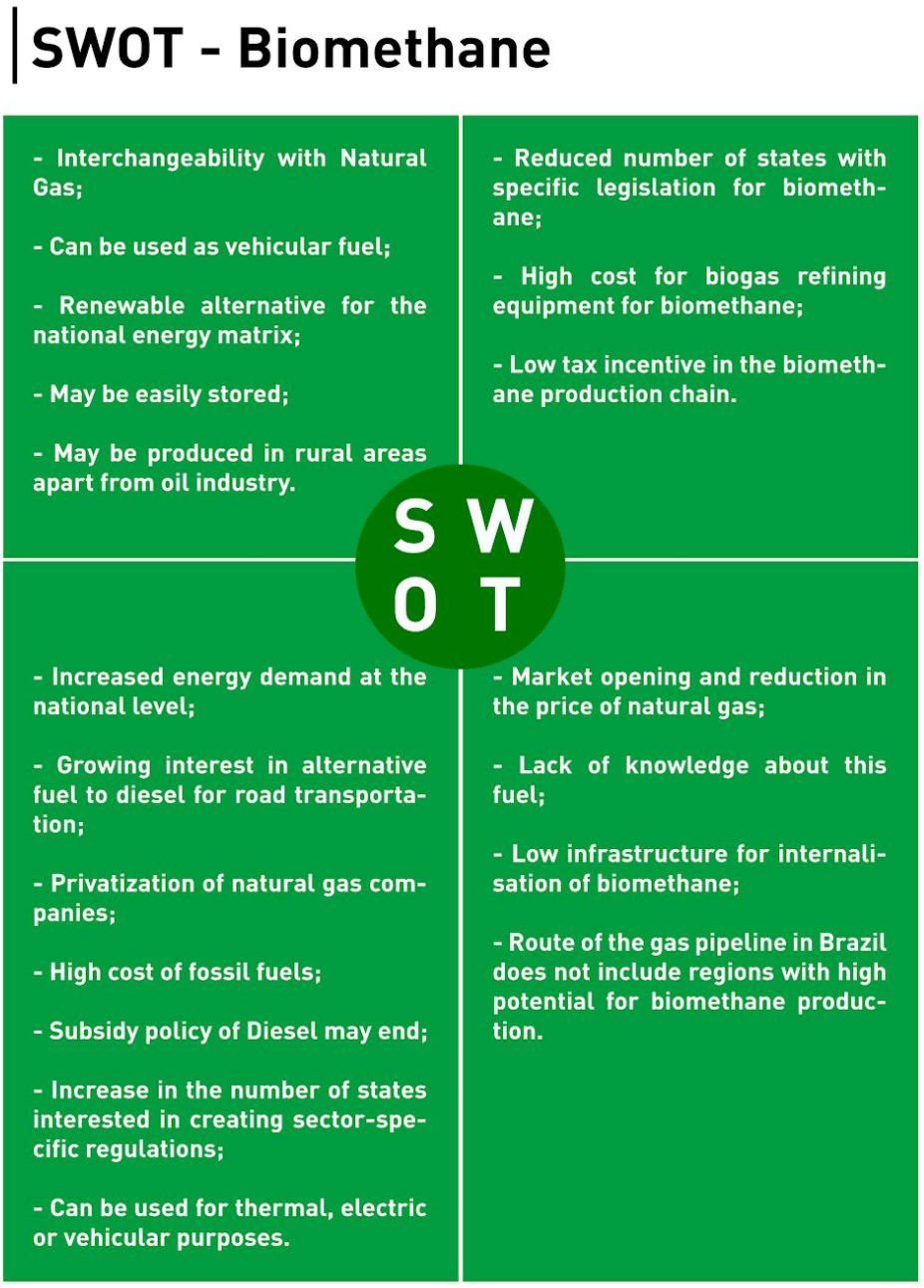


Figure 3.3.2. SWOT analysis



3.4. SUCCESS CASES

3.4.1. Fazenda Haacke

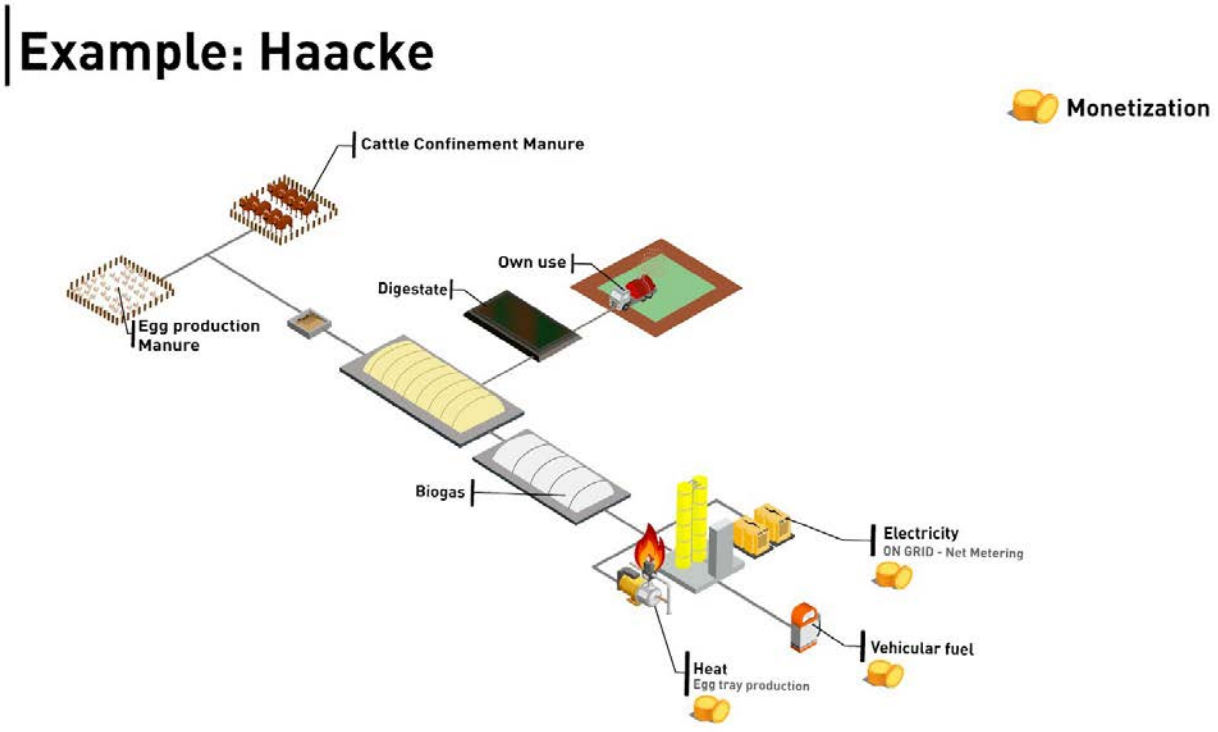
The Haacke's Farm, located in Santa Helena - PR has the capacity to confine up to 86 thousand laying poultry and 750 beef cattle. The animal waste is co-digested in a horizontal type biodigester (Figure 3.4.1).

Figure 3.4.1 - Haacke's Farm Facilities

Source: Marcos Lablanca

As shown in the business model on Figure 3.4.2, the biogas produced is monetized in three ways: electric, thermal and vehicular, while the digestate is applied on the land of the property to cultivate grains and pasture for cattle.

Figure 3.4.2 - Haacke's Farm Business Model



3.4.2. Cerâmica Stein

Stein's Ceramics, located in Entre Rios do Oeste - PR, has one of the most efficient biodigesters in Brazil (Figure 3.4.3). The biogas produced is destined 100% for off-grid electricity production, which in turn supplies the electric consumption of fully automated brick production line(Figure 3.4.4), a business model that can be seen in Figure 3.4.5.

Through a heat exchanger in the engine exhaust, the reactor is heated and the digestate produced is spread on the plantation for cultivation.

Figure 3.4.3 - Stein's Ceramics Facilities

Source: Bioköhler

On the right superior corner is the ceramics production facility. On the superior left side between trees is where the 4,000 pigs are taken care of. Below it one may check the round biodigester and the digestate lagoon to its left. On the right side of the reactor is the engine house and superior edge of it one may notice 3 round white and blue containers.

Part of the high efficiency of this reactor is accounted for its circular format, which helps the homogenization of the substrate and better control of temperature and pH.

Another interesting maneuver of this biodigester is the input of milk producing effluent delivered by a neighbor. It is a win-win situation for Stein Ceramics, since milk effluent has a high yield of biogas production and it is delivered at almost no cost. The two neighbors share the transport expenses which is non expressive since both properties are close to each other.

Figure 3.4.4 - Stein's Ceramics Biogas Plant Equipment (a) main digester SUMA mixer, (b) digestate lagoon SUMA mixer, (c) biogas desulfurization, (d) 75 kW generator (MWM engine + WEG magnetic generator) assembled by Biogas Motores and (e) heat exchanger (captures heat).


(a)

(b)


(c)


(d)

(e)

Source: CIBiogás.

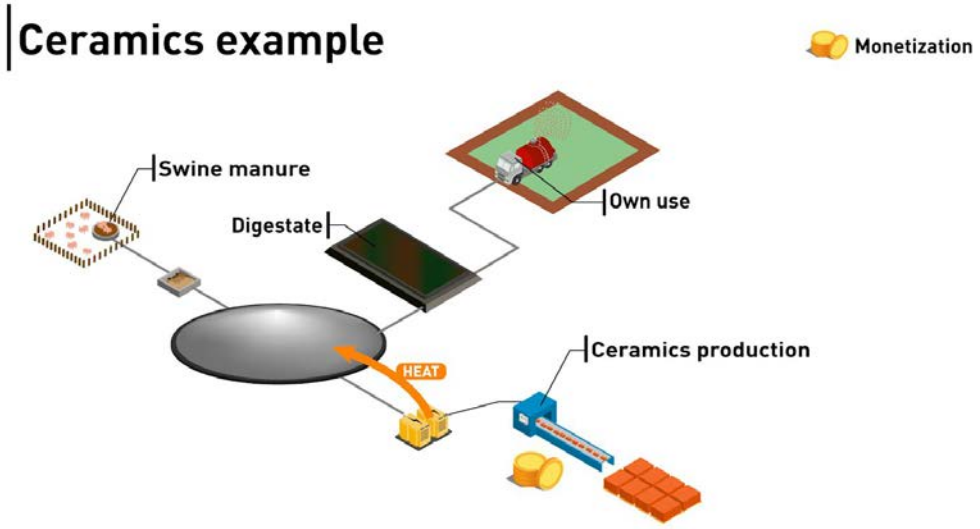
However, the input of milk has already brought some tough problems for this biodigestion system. Once a milk effluent with an unknown concentration of salt was used as substrate into the biodigester. Salt is a also a antibacterial substance (of which

antibiotika is made of), which resulted in the suspension of biogas production during 4 months, until the microorganisms colonies were organic established. It is now learned that expressive concentration of salt derivatives is not a good substrate for biogas production.

What makes this plant more efficient than others is the application of equipment normally found (in Brazil) only in vertical reactors, such as mixers (photos b and c), a heat exchanger (photo e) to keep the digester temperature constant by warming up the digestate on a closed circle plus the circular format of the reactor itself, which helps to prevent sedimentation and helps the homogenization.

What else makes it special is the fact that the owner of this plant, in order to reduce the cost of the plant's electricity bill, started the production of pigs in order to build the biodigester and not the other way around.

Figure 3.4.5 - Stein's Ceramics Business Model



This plant has a 266 kW power capacity installed by the utility company plus the 75 kW generator off-grid. The engine work at 70% of the time (capacity factor). **On an average, the biodigester supplies the ceramics plant with 21 MWh per month, which represents about 34% of all the energy consumed by the ceramics production plant.**

This generation yield data was not calculated, but measured by ERNEX®, a plant monitoring software developed by CIBiogás. This biogas plant costed around R$ 400.000

as a whole and the yielded electricity supports the owner with around R$ 16.000 of monthly avoided expenses (income).

3.4.3. Planta da Mantiqueira

The Mantiqueira's plant was conceived based on the research of the master's and doctoral degrees of Airon Aires (AIRES, 2012). It consists of a combination of a composting plant and biogas plant for treating chicken litter (waste from broiler production), as shown in figures 3.4.6 and 3.4.7.

Figure 3.4.6. Mantiqueira's Plant Facilities

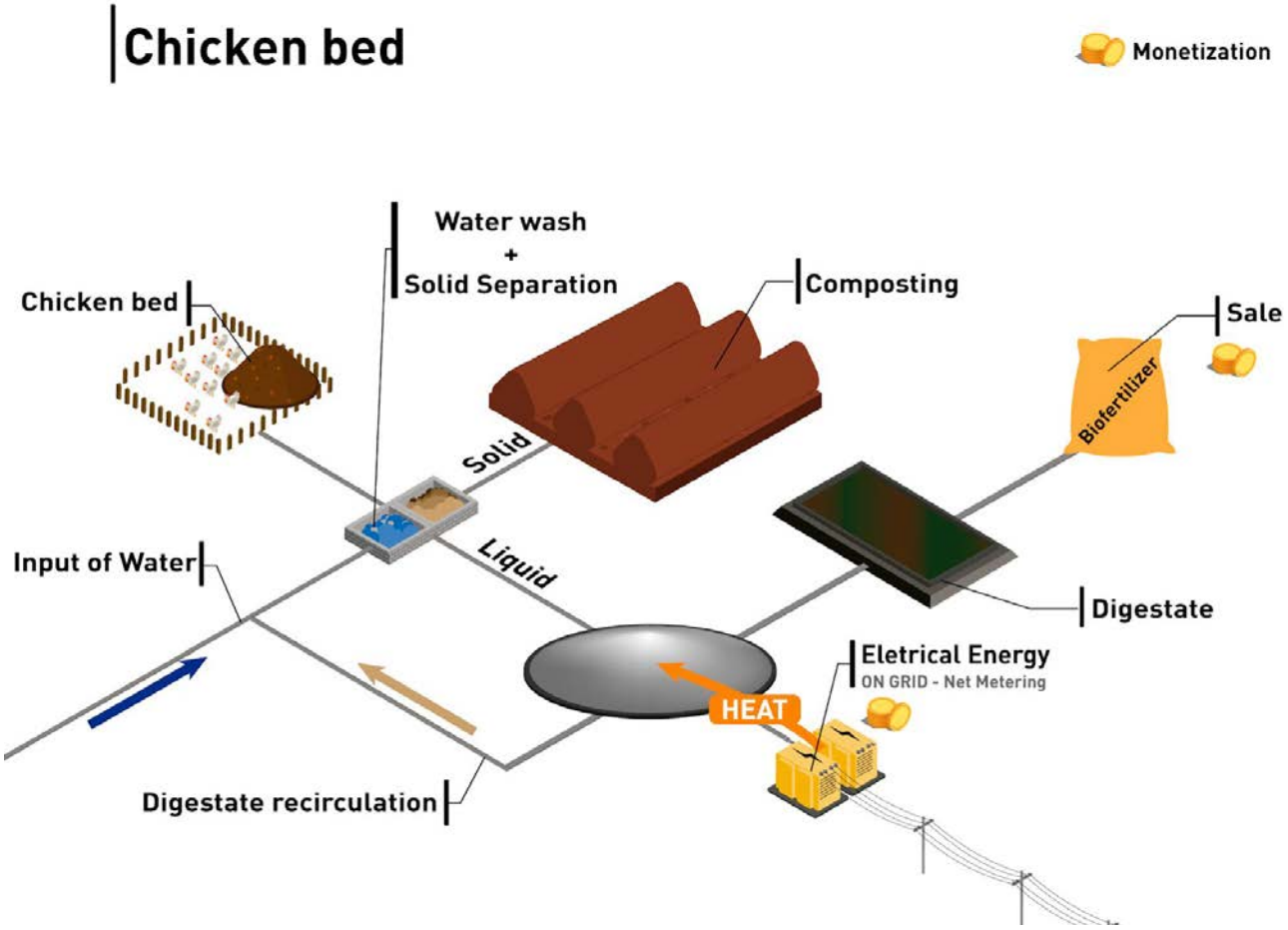
Source: Airon Aires

In order to work well, it has an expressive pre-treatment in order to separate the solids from the liquids. The solid portion goes to the composting line and produces organic fertilizer with low humidity, while the liquid portion is destined to the biodigester. The biogas generated is used as fuel for electricity production.

Positively, this plant offers a way to make an effective treatment of chicken litter, a substrate that, due to its expressive concentration of solids and lignocellulose, has operational difficulties in biodigestion. On to the other hand, most of the nutrients are kept in the solid part. Therefore, in this business model, biofertilizer is one of the pillars of economic viability.

In order to humidify the chicken bed the plant uses rain water. It does not apply the own digestate into de pre-treatment due to danger of lowering the pH of the mixtures, since chicken litter is characterized by very low pH yields.

Figure 3.4.7. Mantiqueira's Plant Business Model



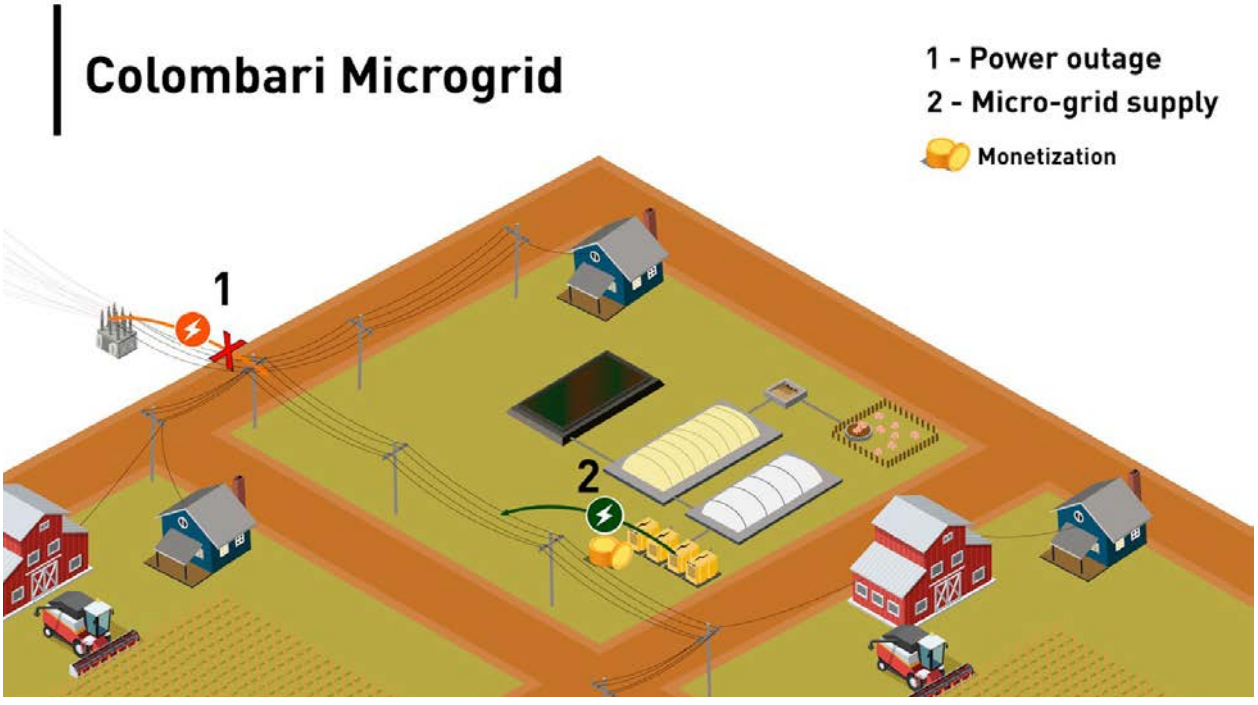
This plant has recently prohibited to commercialize its biofertilizer due to the absence of quality parameters. Therefore, it was learned that in order to make biofertilizer a part of the income expectations one must account for the necessary legal permissions also for this type of bio-product.

3.5. SUNDRY

In this item, some "out of the box" ideas for the use and monetisation of biogas are presented. As the Brazilian legislation does not allow the effective sale of energy to small energy generators, often the plants are sized well below the maximum potential. In this way, some of the alternatives presented here can make the monetization of surplus energy feasible.

The first is the microgrid illustrated in Figure 3.5.1, which consists of an electricity distribution system parallel to the distribution network. The CIBiogás is currently developing a pioneering project with this technique, which when concluded will allow a biodigester with 60 kW of installed power to supply electricity to 21 properties, when there is an interruption in power supply in the region. When the supply is restarted, the system will reconnect with the concessionaire's network. Such a microgrid structure has great value in regions where power interruption is frequent and the resulting losses are significant.

Figure 3.5.1 - Microgrid



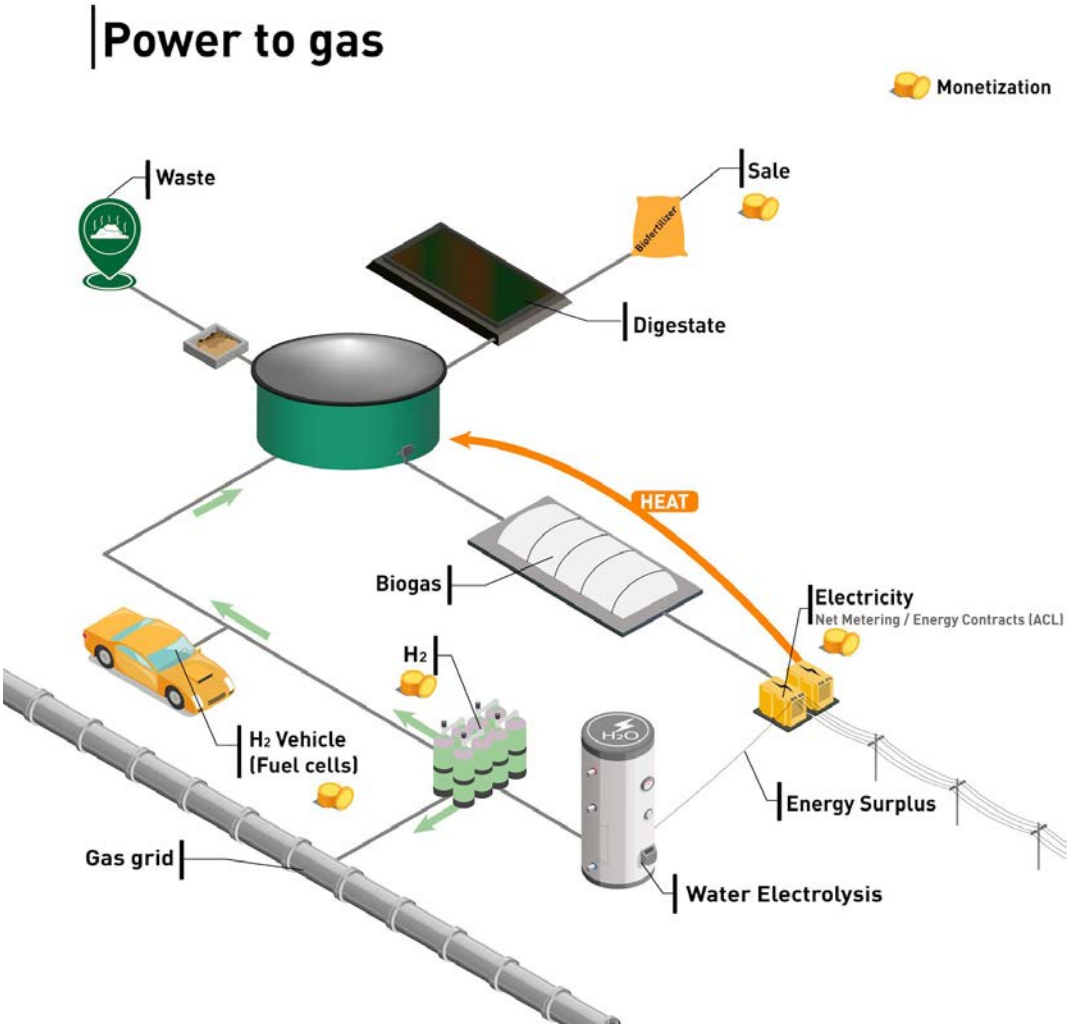
Another alternative is Power to gas, from which it is possible to produce methane using electricity, water and carbon dioxide. With the energy produced by the generator

(that which exceeds the consumption of the prosumer) it is possible to keep in operation an electrolysis reactor, which separates the molecules from water in hydrogen and oxygen, as can be seen in Figure 3.5.2.

Oxygen can be sold or accumulated and even (a small part of it) serve as a precipitator of hydrogen sulfide within the reactor, while hydrogen can also be destined into the reactor to produce methane by combining with carbon dioxide molecules.

In sum, the plant's production will increase as the concentration of methane in biogas will be higher, thus increasing the calorific value of biogas and consequently the production of electricity.

Figure 3.5.2 - Power to gas



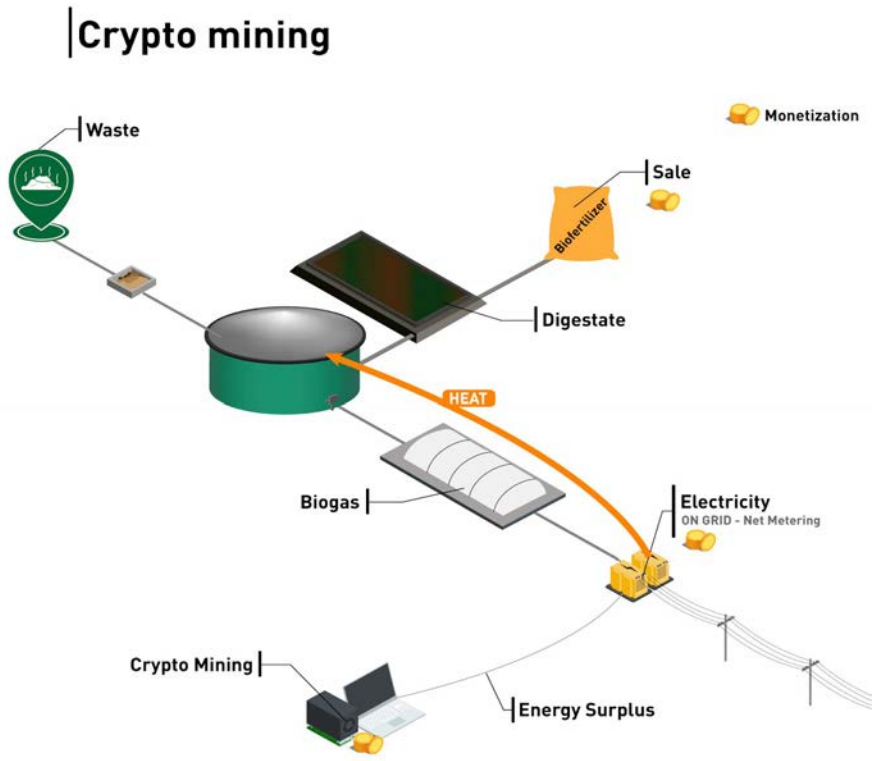
Hydrogen is flammable and has a calorific potential 50% higher than methane. Therefore, it would be possible for it to be destined directly to the natural gas pipeline

network. According to a review study done by the National Renewable Energy Laboratory - NREL in 2010, hydrogen (H_2) production and insertion on the natural gas grid is a way of mass delivering renewable energy. If implemented with relatively low concentrations, less than 5%–15% hydrogen by volume, this strategy appears to be viable without significantly increasing risks associated with utilization of the gas blend in end-use devices (such as household appliances), overall public safety, or the durability and integrity of the existing natural gas pipeline network.

This hydrogen delivery strategy also incurs additional costs, associated with blending and extraction, as well as modifications to existing pipeline integrity management systems, and these must be weighed against alternative means of bringing more sustainable and low-carbon energy to consumers (NREL, 2010).

Mining cryptocurrencies through the blockchain is also an alternative to using biogas` excess energy that cannot be harnessed by the prosumer can supply the mining computers, which consume a lot of electricity for cooling. Thus, the revenue comes from cryptocurrencies accumulated in foreign currency, such as bitcoin, ethereum, iota, lite, among others.

Figure 3.5.3 - Power to currency - Crypto mining



As Figure 3.5.4 shows, another economic activity that can benefit from a biodigester's surplus electricity is the cultivation of plants, fruits or vegetables. A greenhouse consumes a lot of carbon dioxide and electricity to simulate the irradiation of the summer sun during the winter, for example. Both can be offered by a biodigester with a running generator.

Figure 3.5.4 - Model of growing plants in greenhouses

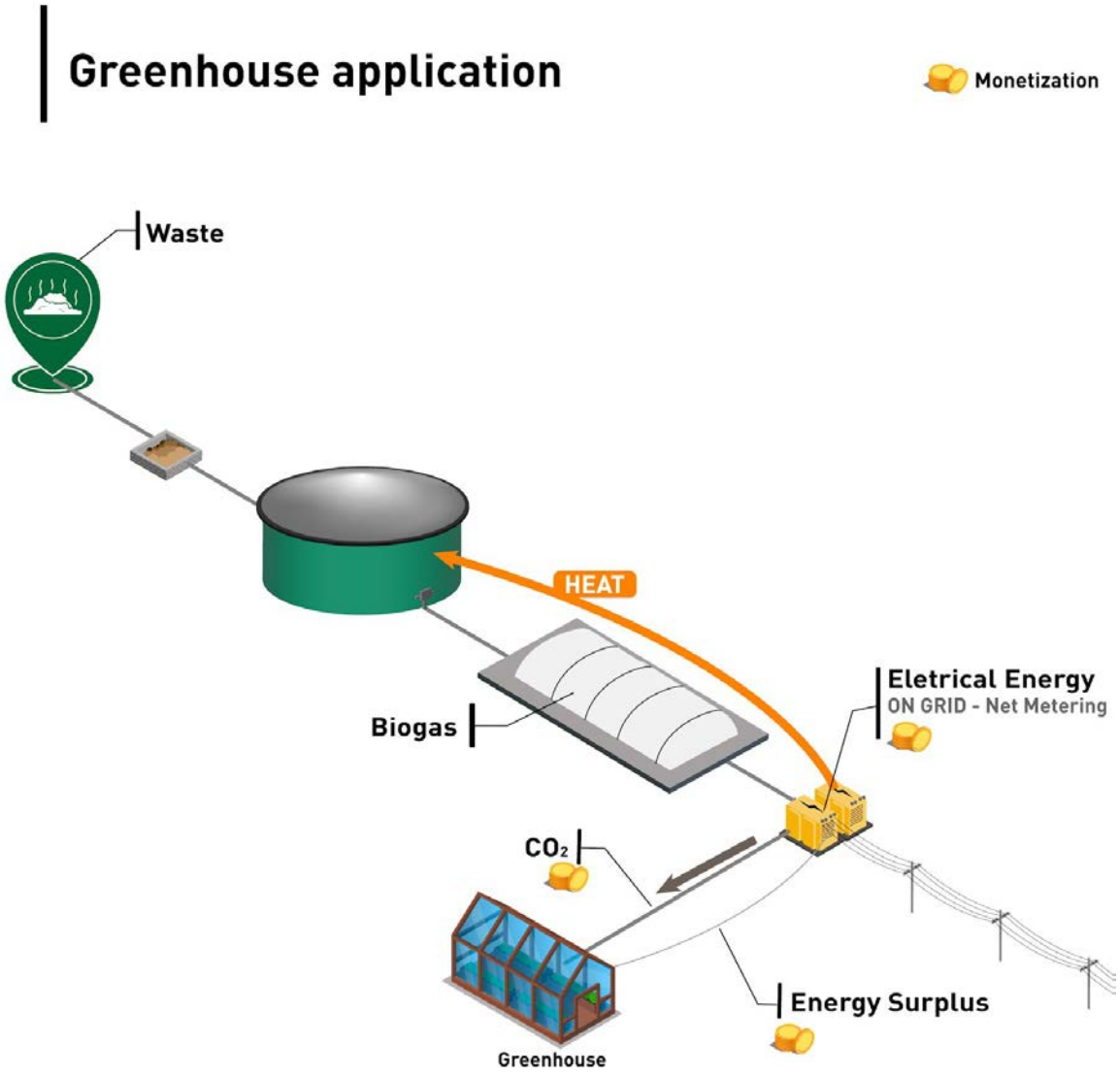
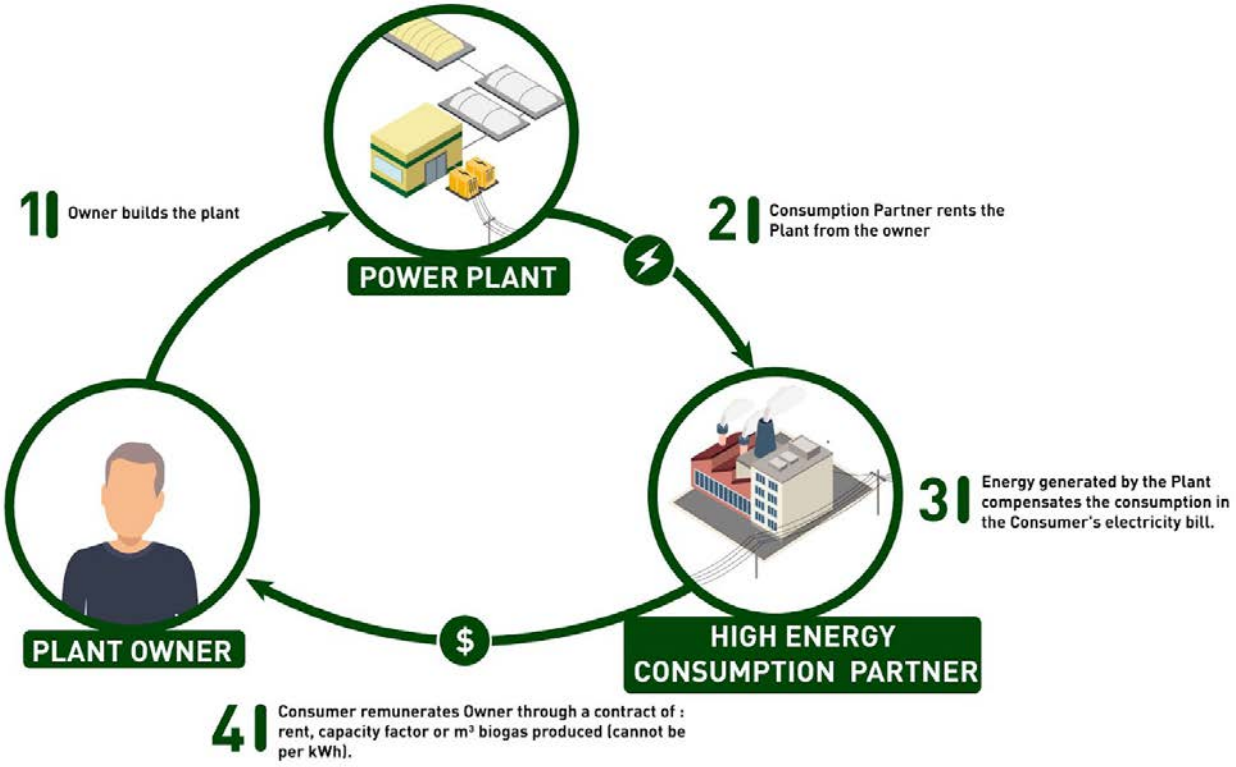


Figure 3.5.5, unlike the others, shows an alternative business model at the bureaucratic level. From the limitation of consumption to use the maximum potential for electricity generation, alternatives were sought in the regulations. An interesting alternative

is to rent the biogas plant to someone who wants to reduce the financial impact of the electricity bill.

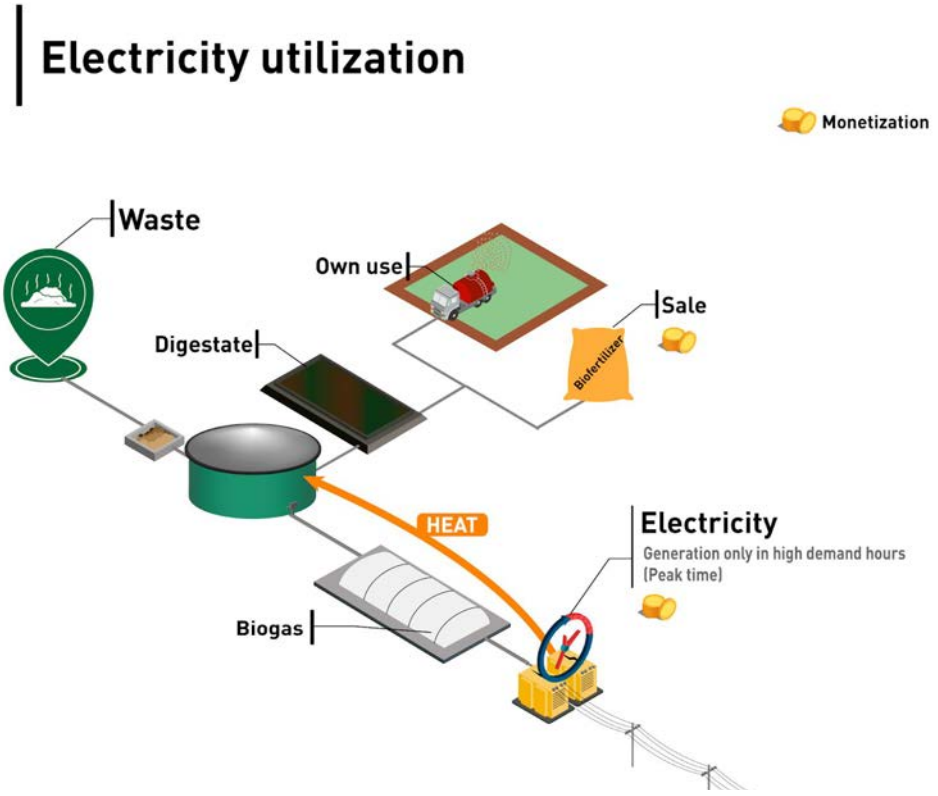
A new consumer unit (a new energy bill) is created for the plant by the distribution concessionaire on behalf of those who will compensate the energy. A contract is made with the owner of the plant for the consumer to pay for the energy generated. However, the trick is that the regulation does not allow the value of the periodic payment to be linked to the energy (kWh) produced. Thus, the contract must be for rent of property or sale of biogas or operation and maintenance.

Figure 3.5.5 - Biogas plant rental model



However, it should be noted that the electricity sector has developed with agility and is susceptible to many changes. Soon, the price of electricity is expected to fluctuate throughout the day according to the supply and demand in the Brazilian energy market.

Figure 3.5.6 - Generation model in times of high demand



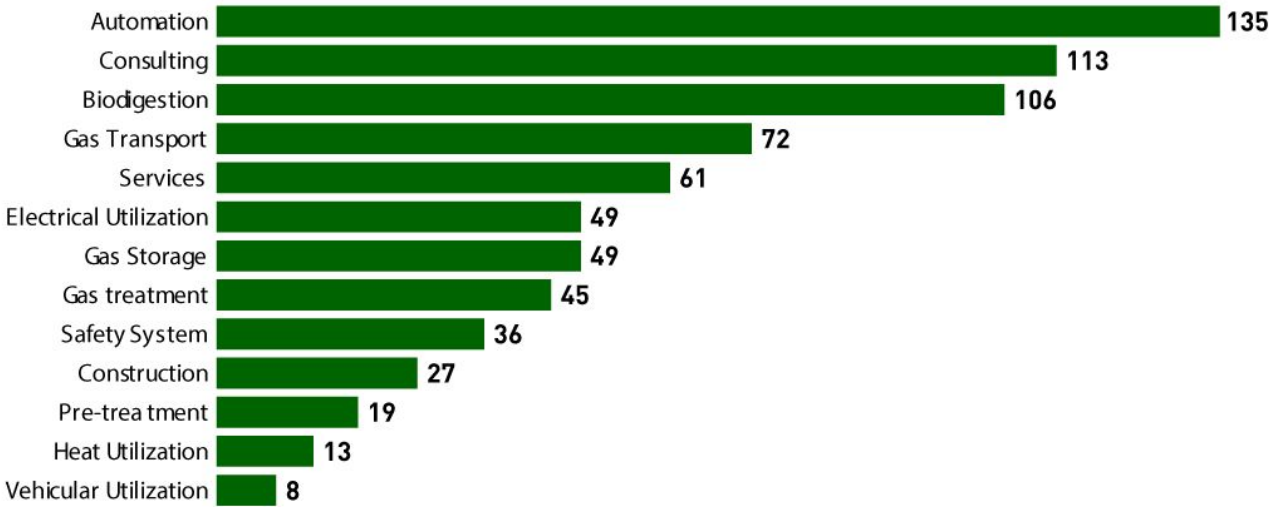
In this scenario, biogas is an excellent income generator, since the activation of the plant is fast and biogas or biomethane is easily stored. In other words, it is a dispatchable renewable decentralized source of energy.

Therefore, the plant can be programmed to produce electricity only when the price is attractive or when the gasometers are too full, as illustrated in Figure 3.5.6.

4. BIOGAS SUPPLY CHAIN IN BRAZIL

In order to identify the main members of the Brazilian biogas market, the CIBIOGÁS supplier database was consulted. Each one of them was consulted in the Brazilian fiscal agency (Receita Federal do Brasil - RFB) to confirm that they have an active registration status. A non-active cadastral situation may indicate institutional problems of the company's register with the State.

Figure 4.1. Number of companies by sector of operation.



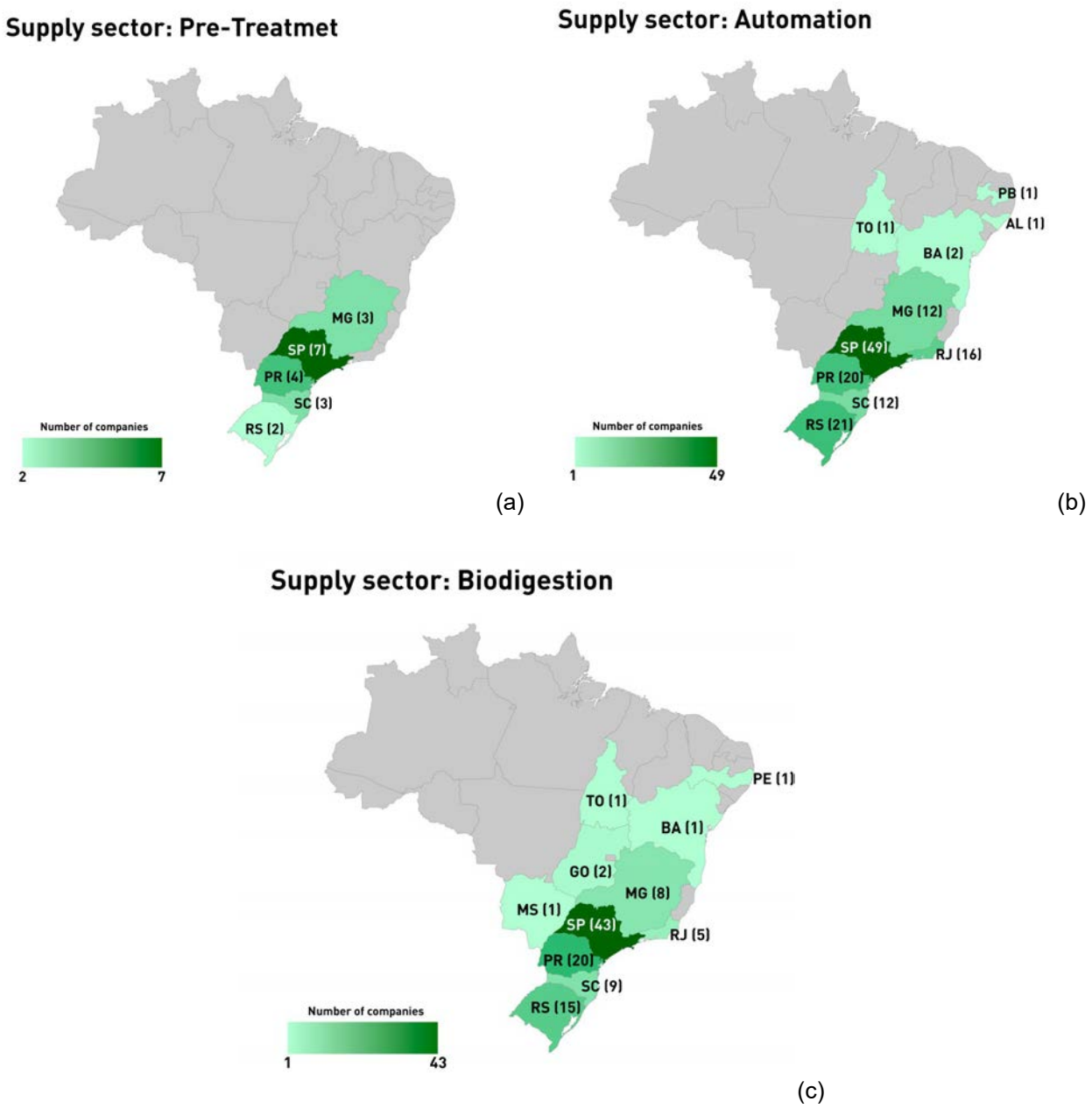
In addition, it was verified which companies have already done business in Brazil. The list contained many foreign suppliers. After these two filters, approximately 20 % of the companies were excluded from the study and there were 418 companies with active registration status with the Brazilian State that had already made business in Brazil in the biogas sector.

The list with ‘Company Name’, ‘CNPJ’, ‘Phone’, ‘Email’, ‘Website’, ‘City’ and ‘State’ is available in Appendix B. Subsequently, the companies were grouped according to their sector of operation (Appendix C), so that it is possible to identify their geographic disposition and the respective states with greater concentration of suppliers. It is important to note that the same company can operate in different sectors.

Figure 4.1 illustrates the number of companies by sector of operation, which is possible to verify that the areas of Automation, Consulting and Biodigestion stand out with the largest number of suppliers. **The list containing the products of each sector as well as the number of companies by type of product are available in Appendices D + E.**

The state concentration of suppliers in the sectors of Pre-Treatment, Automation and Biodigestion can be seen in Figure 4.2.

Figure 4.2. Concentration of suppliers in the sectors of (a) Pre-Treatment, (b) Automation and (c) Biodigestion.



By observing Figure 4.2 (b) and (c), it is possible to see that in the largest sectors, Automation and Biodigestion, the states of São Paulo (SP), Paraná (PR) and Rio Grande do Sul (RS) stand out for their high concentration, accumulating more than 66 % of suppliers in the Automation area and 73 % of Biodigestion. As in the areas already

discussed above, the companies that operate in the Pre-Treatment stage Figure 4.2 (a) are located mainly in the state of São Paulo (SP).

Figure 4.3. Concentration of suppliers in the sectors of (a) thermal , (b) electric and (c) vehicular.

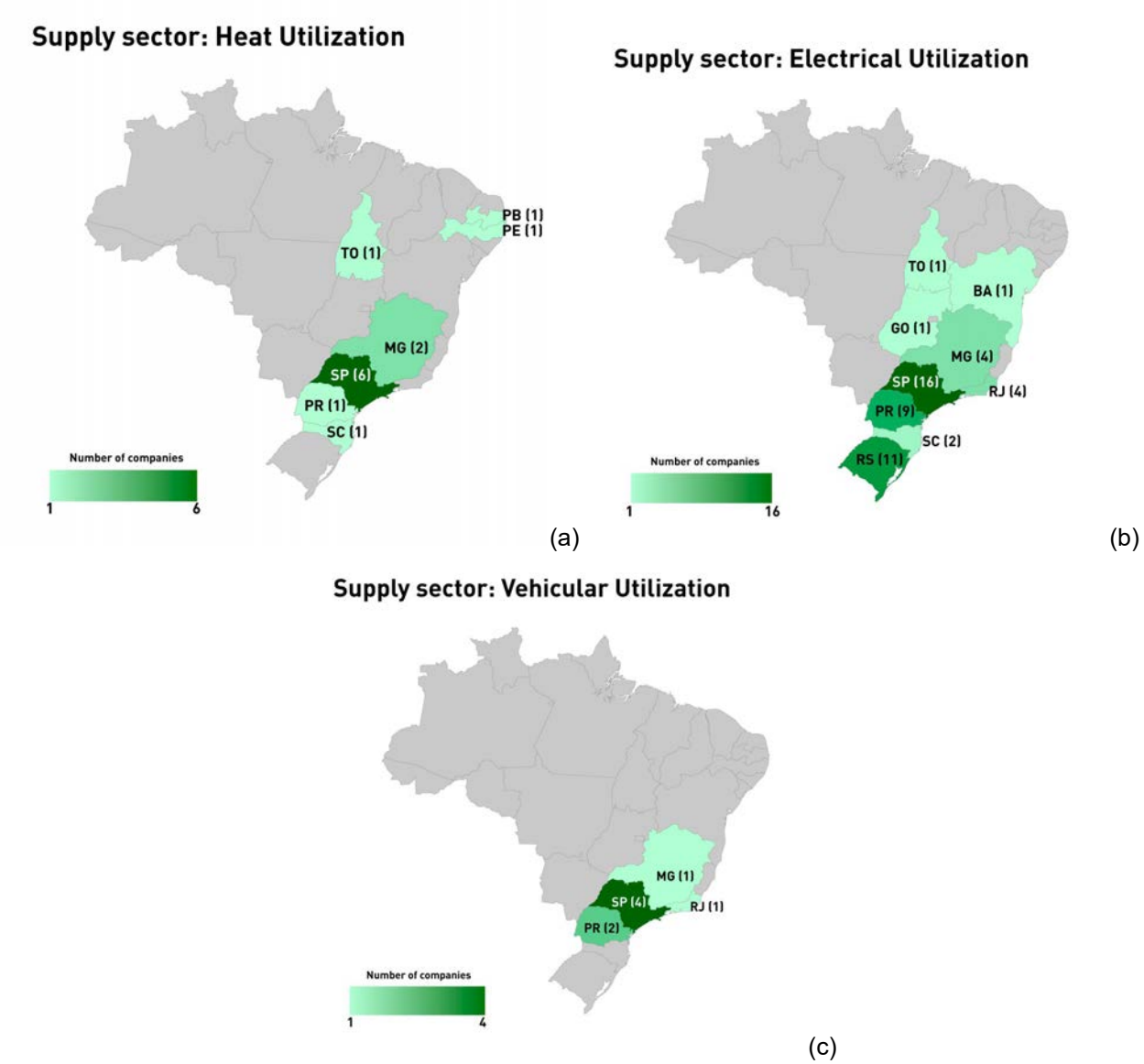


Figure 4.3 illustrates the national distribution of suppliers in the areas of electric and vehicular thermal utilization. When compared to other sectors, thermal utilization Figure 4.3 (a) and electrical Figure 4.3 (c), present the smallest number of suppliers. In spite of this, the state of São Paulo is a highlight because it concentrates most of the companies. The electric power companies are mainly concentrated in São Paulo (SP), Paraná (PR)

and Rio Grande do Sul (RS), accumulating in these states more than 73 % of the total of companies in this sector.

Figure 4.4. Concentration of suppliers in the sectors of (a) storage, (b) transport and (c) gas treatment.

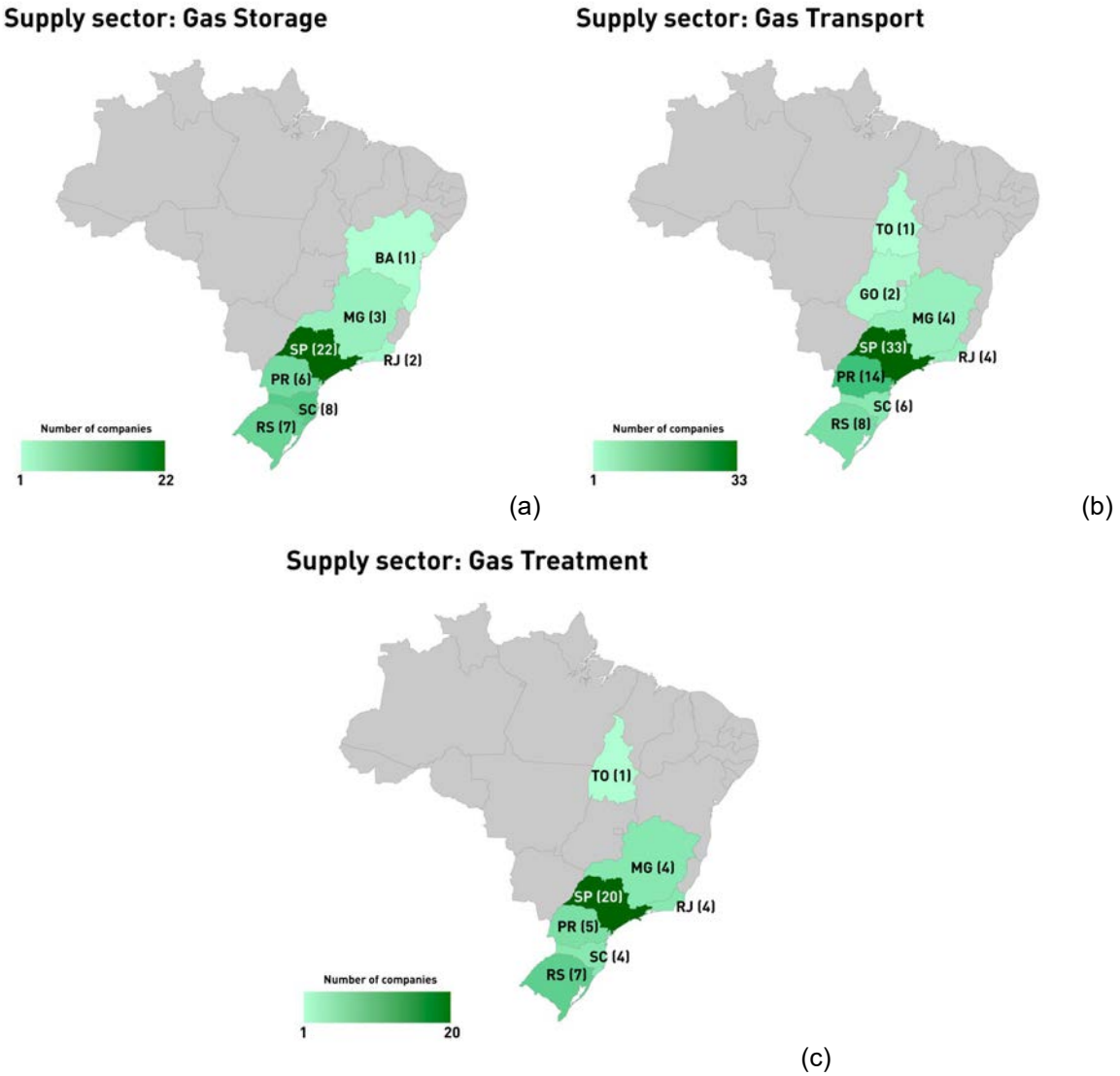
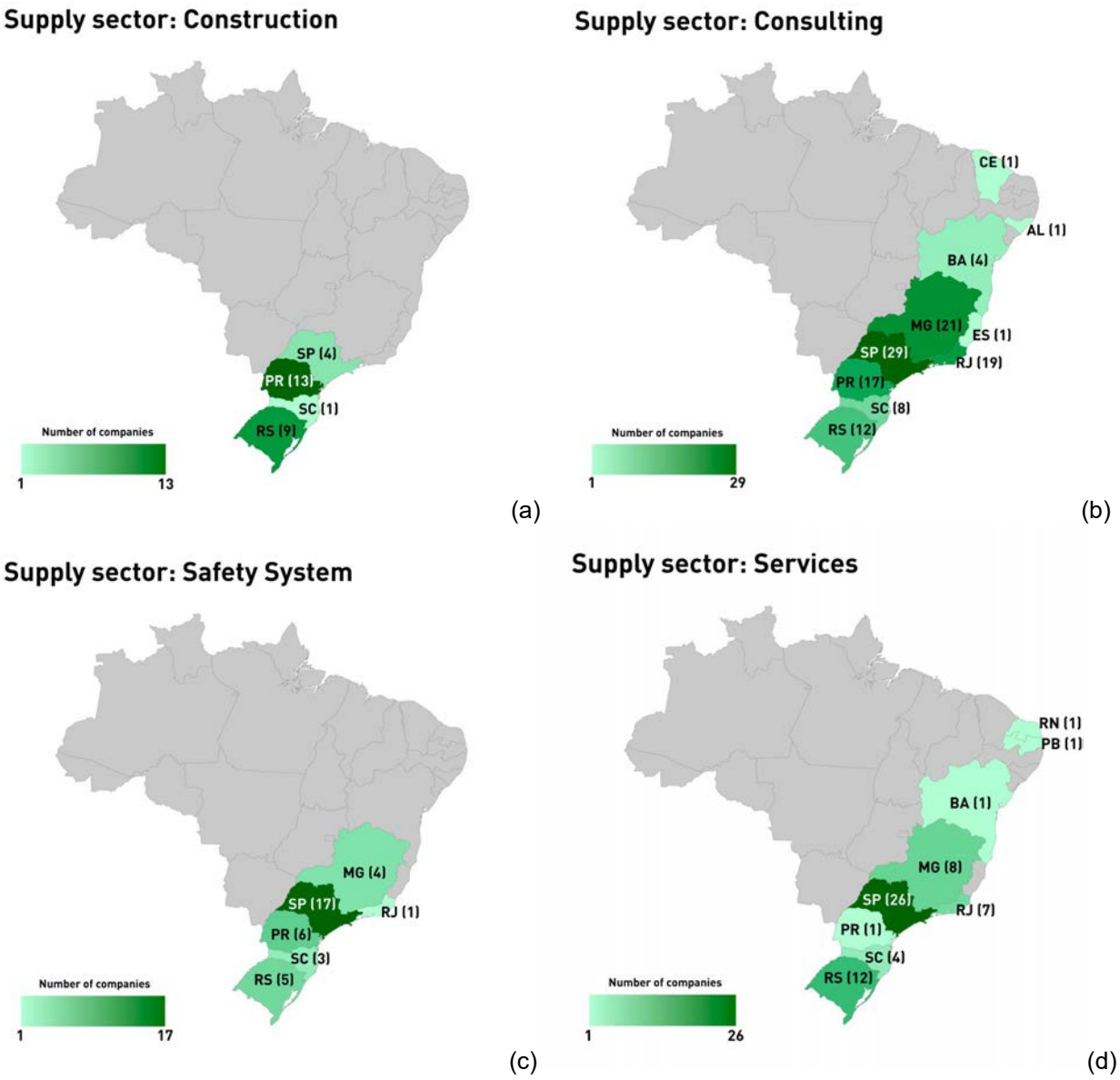


Figure 4.4 shows the location and the states that concentrate the largest number of suppliers in the area of gas storage, transportation and treatment. As in the previous figures, when observing Figure 4.4, it is possible to verify the large number of companies in the state of São Paulo (SP). If summed, they represent 37 % of the total number of companies that operate in the storage, transportation and treatment of gas.

Figure 4.5. Concentration of suppliers in the sectors of (a) construction, (b) consulting, (c) safety systems and (d) services.



Finally, the spatial distribution of suppliers in the sectors of construction, consulting, security systems and services can be observed in Figure 4.5. Suppliers in the construction area are mainly located in the state of Paraná, where approximately 50 % of Brazilian companies in this sector are located (Figure 4.5 (a)). In addition to the state of São Paulo (SP), the consulting firms, Figure 4.5 (b), are located predominantly in Minas Gerais (MG) and Rio de Janeiro (RJ). As in the rest of the sectors, the service and security systems

areas are concentrated in the southeast and south of Brazil, with only 3 % of the companies in these areas being in the northeast of the country.

4.1. ASSESSMENT OF THE SUPPLY CHAIN

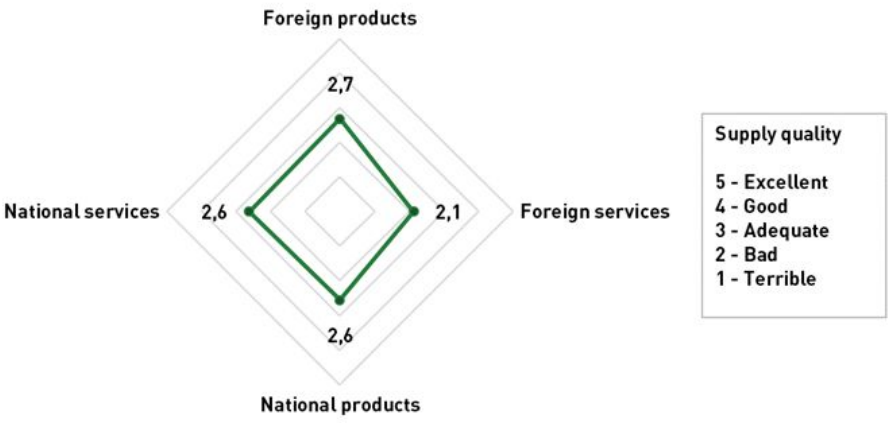
In order to evaluate the products and services currently available in the Brazilian biogas market, a form was applied to 16 CIBiogás´ employees with extensive knowledge of the topics. It is worth mentioning: 88 % of the participants in the survey are engineers and deal with the biogas technologies in a daily-basis.

Each question in the questionnaire addressed a specific sector, and the marks awarded ranged from 1 (Terrible) to 5 (Excellent). The results presented here are the arithmetic averages of the scores given for each question. The answers were divided into some groups for analysis of the gaps in the Brazilian supply chain:

- products and services in general (domestic and foreign);
- mechanical and chemical pre-treatment, biodigestion and after-treatment;
- security systems and gas refining, transport and storage;
- thermal, electrical, vehicular or biomethane production monetization; and,
- general services, consulting, automation and construction of biodigesters

Figure 4.1.1 illustrates the general assessment made of the supply of imported and domestic goods and services.

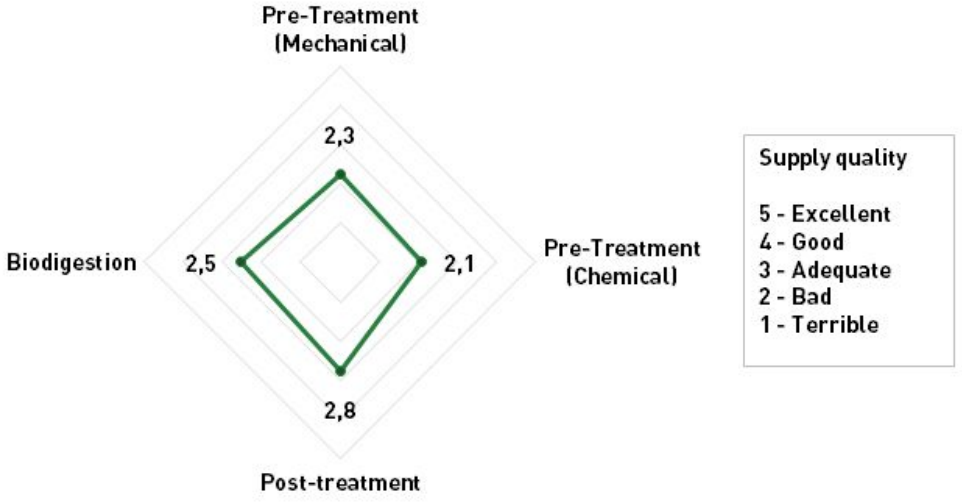
Figure 4.1.1. Evaluation of the quality of products and services of national or foreign origin



From Figure 4.1.1, it is possible to verify that the offer of Brazilian products have higher quality when compared to imported products. On the other hand, the services provided by companies outside Brazil were better evaluated by specialists.

The results of the quality survey of the areas of mechanical and chemical pre-treatment, biodigestion and post-treatment can be seen in Figures 4.1.2. Among the sectors of mechanical and chemical pre-treatment, biodigestion and post-treatment (Figure 4.1.2), the latter stands out as the one with the best quality of supply in Brazil. While the pre-treatment steps were evaluated with the lowest values of this group.

Figure 4.1.2. Evaluation of product quality in the pre-treatment, biodigestion and post-treatment sectors



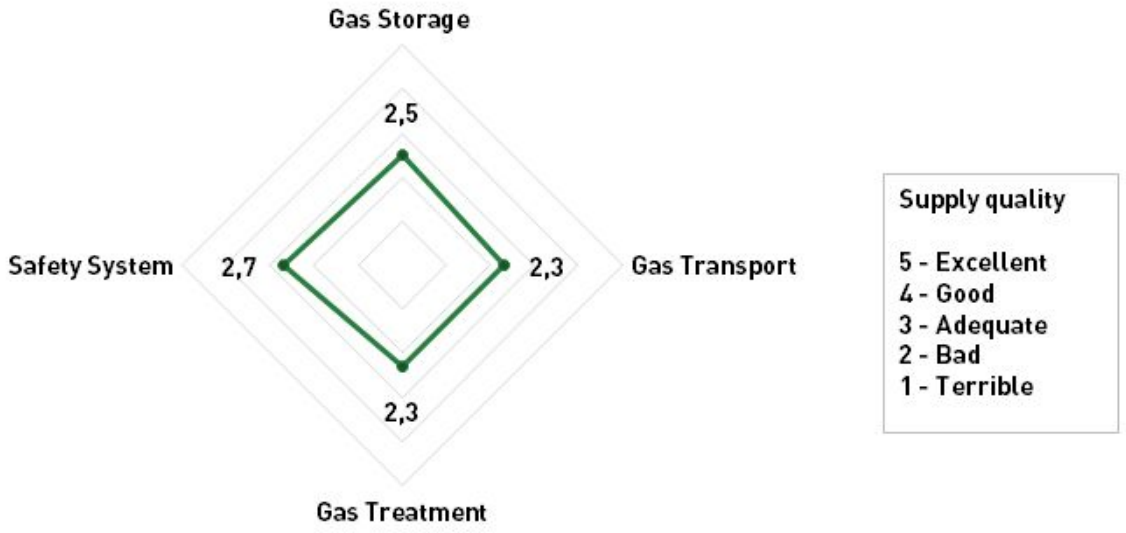
It should be noted that in order to evaluate the pre-treatment step in a more objective way, it was divided according to the most used methods in Brazil ("Mechanical" and "Chemical"). In this context, it is possible to verify that the pre-treatment method performed by chemical method presents lower grade of supply of products.

Figure 4.1.3 shows the evaluation of the quality of supply of products in the areas of transport, treatment and storage of gas, as well as safety systems. By observing Figure 4.1.3 it is possible to verify that the gas transport and storage systems recorded unsatisfactory evaluations, indicating a poor quality of the supply of products and services in these sectors.

The evaluations on the supply of products for electric, thermal and vehicular use, besides the production of biomethane, can be verified in Figure 4.1.4. The sector with the

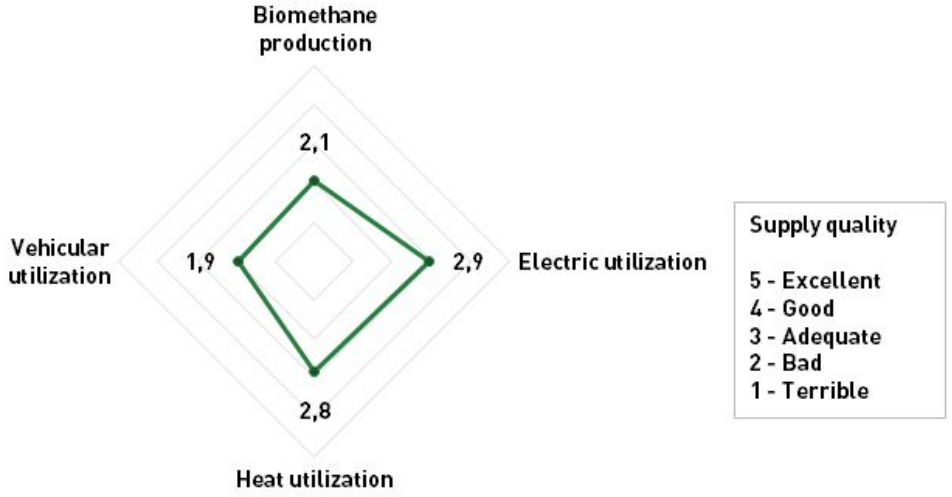
worst evaluation among all those evaluated here is the vehicle utilization sector (Figure 4.1.4). The low quality indicated by the specialists consulted is a reflection of the reduced number of suppliers in this sector, already reported in Figure 4.1.

Figure 4.1.3. Evaluation of the product quality in the sectors of transport, treatment and storage of gas, as well as safety systems.



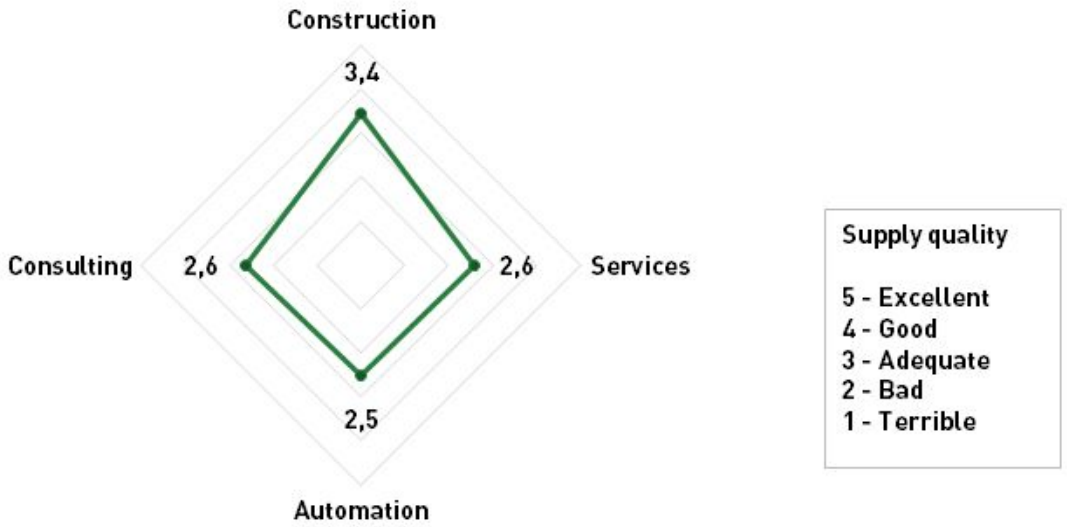
Finally, Figure 4.1.5 presents the evaluation of the products in the consulting, automation, construction and services sectors. When observing Figure 4.1.5 it is observed that the construction sector is the one that presents the highest evaluation among all the evaluated areas, being, therefore, the only sector evaluated with a higher score than the one considered as adequate here.

Figure 4.1.4. Evaluation of the quality of products in the sectors of biomethane production, electric, thermal and vehicular use.



It is important to highlight that the overall average score of the areas was 2.5, an intermediate value between the classifications "bad" and "adequate". According to one of the specialists consulted, this low score is due to the fact that "*(...) foreign products, when available, are very expensive, making their use unfeasible. And the Brazilian equipment, many times are adaptations and not developed exclusively to the Biogas market".*

Figure 4.1.5. Evaluation of the quality of products in the sectors of automation, construction, consulting and services.



It is worth to remind that Brazil states a 50 % import fee.

4.2. GAPS IN THE BRAZILIAN BIOGAS MARKET

In this topic the opportunities identified in the Brazilian biogas market will be presented, considering all the evaluations carried out so far. As in the previous items, the opportunities will be divided by sectors of the supply chain.

Pre-Treatment

The national pretreatment sector lacks specialized solutions, especially in the **physical pretreatment** of lignocellulosic materials and organic solid waste. The main pre-treatment technologies that can be applied in these cases are systems that use pyrolysis, grinding, crushing and grinding methodologies.

Additionally, the need for equipment for **separation and homogenization of substrates** in this stage of biogas production should also be highlighted.

Biodigestion

Brazilian biodigestion systems need more robust and practical solutions. In this context, **"Plug & Play" systems** are essential because, besides being easy to install and operate, in some cases they also serve small-scale waste generators.

Still in relation to small-scale systems, another technology that can be inserted in the Brazilian market are **small CSTR reactors**. Some of the advantages of systems of this type are the possibility of sizing the reactor according to the energy demand of the owner and the treatment of waste with higher solids content.

Post-treatment

Digestate post-treatment is one of the main opportunities in the biogas market in Brazil, considering that it is currently a byproduct with no commercial value. Thus, methods that allow the monetization of the **digestate as an organomineral biofertilizer**, for example, are essential to make the projects financially viable.

Biogas Treatment

Biodesulfurization from the insertion of oxygen into the reactor is a widely used method for removing H_2S from biogas. However, this is a technique still little diffused in Brazil due to the low number of suppliers present in the market.

Biomethane Production

Biomethane compression systems are essential for the storage and use of this renewable fuel. However, currently the compression equipment available in Brazil has not very competitive prices.

One of the main technologies to be explored in the Brazilian biogas market is **refineries the biogas to biomethane**. The options currently available have configurations incompatible with the practical conditions found in Brazil, which implies the need for

tropicalization of this technology. Membrane are common in Europe but not yet feasible in Brazil.

Automation

The monitoring of biogas plants is fundamental to optimize the production of biogas in quantity and quality, so **equipment for analyzing the quality, flow and pressure of biogas** are essential.

Moreover, currently, the Brazilian market of equipment in this field needs suppliers that ensure products and **after-sales services** with adequate quality.

Services

The fact that each biogas plant project involves a large number of suppliers, highlights another deficit branch in Brazil, that of **"Turn Key" type services**.

The stainless steel is fundamental for the production of products of all the chain of biogas due to its antioxidant characteristic, however, its high cost makes expensive the equipments that use it. Thus, the insertion of a **product with characteristics similar to those of stainless steel** is fundamental for the development of the biogas chain in Brazil.

APPENDIX A - ELECTRIC MATRIX OF BRAZIL

Table A.1- Electric matrix of Brazil

Energy source	Installed capacity [GW]	Participation [%]
Sugar cane bagasse	11.4	6.6
Natural gas	13.3	7.7
Wind	14.8	8.6
Hydro	104.5	60.8
Other	28	16.3
Total	172	100

Source: Adapted from ANEEL, 2019

APPENDIX B - LIST OF ACTIVE COMPANIES IN BRAZIL

COMPANY	CNPJ	PHONE	EMAIL	SITE	CITY	STATE
1STBEAM	Foreign	n.a	n.a	http://www.1stbeam.com/it	Foreign	-
3DI ENGENHARIA LTDA.	17906653000137	(45) 3029 3177 / 9931 6917	n.a	https://www.3diengenharia.com/	FOZ DO IGUACU	PR
A AQUECEDORES CALDEIRAS E QUEIMADORES ICATERM LTDA	4449663000149	(11) 2092-6300	contato@icaterm.com.br	https://www.icaterm.com.br/	SAO PAULO	SP
AB ENERGY DO BRASIL LTDA.	8542297000129	(11) 2970-1210 /(11) 98538-0187	n.a	http://www.gruppoab.it/pt-br/corporativo/	BARUERI	SP
ABI ENGENHARIA LTDA	24454952000143	(51) 9849-6167	n.a	n.a	PORTO ALEGRE	RS
ABILITY TECNOLOGIA E SERVICOS S/A	6127582000158	(19) 3405-3420/(19) 97130-3420	ability@ability.ind.br	www.ability.ind.br	OSASCO	SP
ABWASSERREINIGUNGS-INGENIEUR-GMBH	Foreign	n.a	n.a	https://www.sag-ingenieure.de/	Foreign	-
ACESA BIOENERGIA S.A.	9496326000126	(21) 3231-2082	n.a	http://www.acesabioenergia.com/	RIO DE JANEIRO	RJ
ADI SYSTEMS DO BRASIL PARTICIPACOES LTDA.	17601441000141	(19) 3565-6300	n.a	http://www.adisystemsinc.com/	LEME	SP
AERO MACK INDUSTRIA E COMERCIO LTDA	55078042000137	(11) 4178-7366/(11) 98964-7196	liliane@aeromack.com.br	http://www.gaiatecsistemas.com.br	SAO BERNARDO DO CAMPO	SP
AGE TECNOLOGIAS, MEIO AMBIENTE, SANEAMENTO & AMBIENCIA LTDA	1520686000104	(48) 3346-3005	n.a	http://agetec.com.br	SAO JOSE	SC
AGENTUR FUR ERNEUERBARE ENERGIEN	Foreign	n.a	n.a	https://www.unendlich-viel-energie.de/	Foreign	-
AGIMIX SOLUCOES E EQUIPAMENTOS INDUSTRIAIS LTDA	14295834000186	(16) 3664-0881/(16) 3664-0295	vendas@agimix.com.br	www.agimix.com.br	BRODOWSKI	SP
AGROBONA - INDUSTRIA DE EQUIPAMENTOS LTDA.	6333795000136	(45) 9145-0723 / (45) 8806-6620 / 3206-1900	juliano@agrobona.com.br	www.agrobona.com.br	MATELANDIA	PR

AIR LIQUIDE BRASIL LTDA	331788000119	(11) 2915-4702 /(11) 99980-2514	n.a	http://airliquideadvancedbusiness.com/	SAO PAULO	SP
AKGACHAUER KOMPOSTIERUNGS GMBH & CO.KG	Foreign	n.a	n.a	https://www.akg-bio.de/	Foreign	-
ALBRECHT EQUIPAMENTOS INDUSTRIAIS LTDA	79897849000160	(47) 99141-4807 / (47) 4009-3344 / (47) 4009-3300	n.a	http://www.albrecht.com.br	JOINVILLE	SC
ALFAKIT EIRELI	2297602000188	(48) 3029-2300	n.a	http://www.alfakit.ind.br	FLORIANOPOLIS	SC
ALFAMEC INDUSTRIA E COMERCIO LTDA	116471000160	(11) 4991-5000	n.a	http://alfamec.com.br/home	RIBEIRAO PIRES	SP
ALTATEC COMERCIO DE GASES LTDA	14078795000165	(49) 179 1150615	becher@altatec-germany.com	http://www.altatec-germany.com/index.php?id=14	RIO DE JANEIRO	RJ
ALTUS SISTEMAS DE AUTOMACAO S.A.	92859974000143	(51) 3589-9500	n.a	http://www.altus.com.br	SAO LEOPOLDO	RS
ALVAN BLANCH	Foreign	n.a	n.a	http://www.alvanblanchgroup.com/pt/	Foreign	-
ALVES PLASTIC LTDA	8670420000197	(55)(11) 4617-8000	comercial@alvesplast.com.br	http://www.alvesplast.com.br/	GASPAR	SC
AMBCORE SERVICOS AMBIENTAIS EIRELI	14595750000168	(51) 3421-3300	n.a	http://www.ambcore.com.br/	GRAVATAI	RS
AMBIENTAL ENGENHARIA E CONSULTORIA LTDA	22641641000168	(21) 3232-1850	n.a	http://www.ambientalconsult.com.br/default.asp	RIO DE JANEIRO	RJ
AMBIENTE GAIA CONSULTORIA E PROJETOS AMBIENTAIS E EDUCACIONAIS LTDA	8333498000116	(11) 3587-1993	n.a	http://www.ambientegaia.com.br/engenhariasanitariaeambiental.php	SALVADOR	BA
AMERICAN WELDING LTDA	52311255000411	(16) 3383-3800	sab@bambozzi.com.br ; vendas.alt@bambozzi.com.br	http://www.bambozzi.com.br/website/en/nossa_historia.php	SAO PAULO	SP
AMPERI IMPORTACAO E COMERCIO LTDA	19308851000124	19 3367-8775	n.a	http://www.amperi.com.br/	CAMPINAS	SP
AMR COMERCIO DE MANUFATURADOS LTDA	2991626000132	(45) 3523-1251 / 9976-1644	lucioriken@gmail.com	n.a	FOZ DO IGUACU	PR
ANDE MATERIAIS ELETRICOS LTDA	80342330000102	045 3528-9192	n.a	https://ande.com.br/	FOZ DO IGUACU	PR
APR INDUSTRIA DE MAQUINAS EIRELI	7509148000103	(51) 3695-1010	n.a	http://www.aprmaquinas.ind.br	HARMONIA	RS
AQUAVITA LABORATORIO DE ANALISES QUIMICAS E MICROBIOLOGICAS EIRELI	20656089000156	(48) 3258-3819	n.a	http://www.laboratorioaquavita.com.br	SAO JOSE	SC

ARCHEAANLAGENBAU	Foreign	n.a	n.a	https://www.archea-biogas.de/	Foreign	-
ARKA AMBIENTAL LTDA	29352077000102	(21) 3736-3808 (21) 99961-9464	n.a	http://www.arkambiental.com.br/	RIO DE JANEIRO	RJ
ASJA BRASIL SERVICOS PARA O MEIO AMBIENTE LTDA	7695457000107	(31) 3286-3311	infobrasil@aria-co2.com	http://www.asja.biz/	BELO HORIZONTE	MG
ASPMAQ FABRICACAO DE MAQUINAS E EQUIPAMENTOS EIRELI	22946484000107	(11) 4712-4112/	contato@aspmaq.com.br	www.aspmaq.com.br	SAO ROQUE	SP
ASPRO SERVICOS EM GNV LTDA	5508283000109	21 8133-5644//3231-2050	rsilva@aspro.com.br	http://www.aspro.com/index.php	RIO DE JANEIRO	RJ
AST SERVICOS SOLUCOES E TECNOLOGIAS EM MEIO AMBIENTE S A	19674481000149	(351) 220163277 / 220165486	office(at)ast-ambiente.com	http://www.ast-ambiente.com/index.php?id=1	NITEROI	RJ
ASTEN & CIA LTDA	60831104000170	(11) 2824-2952/-	vendas2@asten.com.br	http://www.gaiatecsistemas.com.br	SAO PAULO	SP
ATLAS SEIS	Foreign	n.a	n.a	http://www.atlasseis.com/	Foreign	-
AUGUSTO CLEMENTINO INDUSTRIA E COMERCIO LTDA	19018513000158	(31) 9608-4576 / 3201-4899/3271.5108	tritury@tritury.com.br	http://tritury.com.br/	BELO HORIZONTE	MG
AUSTEP	Foreign	n.a	n.a	https://www.austeplighting.com.au	Foreign	-
AUTOMATIC IND. E COM. DE EQUIP. ELETRICOS LTDA	76576198000118	(49) 3523-1033	n.a	http://www.automatic.com.br	LUZERNA	SC
AUTOMIND AUTOMACAO INDUSTRIAL LTDA	16119281000136	(21) 2460-0900	n.a	http://www.automind.com.br/index.php	SALVADOR	BA
AUTROTEC SISTEMAS ELETRONICOS LTDA	39181052000147	(21) 2568-6164	n.a	http://www.autrotec.com.br/index.php?pag=inicio	RIO DE JANEIRO	RJ
AVISERRA SOLUCOES AMBIENTAIS LTDA	4886943000114	(54) 3443-5665	n.a	http://www.aviserra.com.br/	GUAPORE	RS
AWITE BIOENERGIA E EQUIPAMENTOS ELETRONICOS LTDA.	1673507000179	(18) 4101-0016	n.a	http://www.awite.com.br	SAO PAULO	SP
BAKTRON MICROBIOLOGIA LTDA	39092598000121	(21) 3867-5530 /(21) 3867-5800	n.a	http://www.baktron.com.br/	RIO DE JANEIRO	RJ
BASE ENGENHARIA ELETRICA S/S LTDA	8398664000162	(51) 3062-4816/(51) 991240004	contato@engenhariabase.com.br	https://www.engenhariabase.com.br/	PORTO ALEGRE	RS

BECHTEL DO BRASIL CONSTRUCOES LTDA	34149328000196	(21) 2105-2400	n.a	http://www.bechtel.com/	RIO DE JANEIRO	RJ
BELBA ENGENHEIROS CONSULTORES LTDA	19293232000103	(31) 3291-0606	n.a	n.a	BELO HORIZONTE	MG
BERMO VALVULAS E EQUIPAMENTOS INDUSTRIAIS LTDA	82662263000120	(41) 2111-4344	bermocwb@bermo.com.br	http://www.bermo.com.br/produtos/1/Purgadores/	BLUMENAU	SC
BEST SUL COMERCIO E PRESTACAO DE SERVICOS LTDA	8748902000112	(51) 3398 3008	n.a	http://www.bestsul.com.br/	PASSO FUNDO	RS
BGS EQUIPAMENTOS AGROPECUARIOS LTDA	27227689000148	(41) 3024-2319	contato@bgsequipamentos.com.br	http://bgsequipamentos.com.br	CURITIBA	PR
BIO PROJ TECNOLOGIA AMBIENTAL LTDA	9542970000193	(16) 3416-7110	n.a	http://www.bioproj.com.br/index.html	SAO CARLOS	SP
BIOCATEC SUSTENTABILIDADE & CATALISADORES LTDA	9558654000100	(11) 5084-5929	n.a	n.a	SAO PAULO	SP
BIOCHAMA LTDA	13792074000150	(41) 3528-9723/(41) 98883-7485	engenharia@biochama.com.br	www.biochama.com.br	CURITIBA	PR
BIOEFICIENCIA ASSESSORIA E CONSULTORIA EM ENGENHARIA LTDA	17416898000186	(44) 9121-8441 /(45) 9107-0576	eng@bioeficiencia.com.br	www.bioeficiencia.com.br	MARINGA	PR
BIOGAS BIOENERGY SOLUTIONS MAXX	Foreign	n.a	n.a	http://www.biogasmaxx.com/english/about_us.html	Foreign	-
BIOGAS ENERGIA AMBIENTAL S.A	4131501000168	(11) 5506-999	energia@biogas-ambiental.com.br	n.a	SAO PAULO	SP
BIOGAS MOTORES ESTACIONARIOS EIRELI	6994667000133	(45) 3252-0833	administrativo@biogasmotores.com.br contato@biogasmotores.com.br	http://biogasmotores.com.br/index.html	TOLEDO	PR
BIOGASCLEAN A/S	12213749000104	(19) 99112-0266	n.a	http://www.biogasclean.com	EXTERIOR	EX
BIOKOMPAKT	Foreign	n.a	n.a	https://www.energy-xprt.com/products/biokompakt-model-awk-eko-series-biomass-boilers-256994	Foreign	-
BIOMETHANE TOTAL SOLUTION DO BRASIL - USINAS DE BIOMETANO EIRELI	30834661000183	n.a	n.a	http://www.ch4solution.com/empresa/	CASTRO	PR

BIOSOLAR COMERCIAL, PARTICIPACAO, ADMINISTRACAO E REPRESENTACOES LTDA	62148317000127	(11) 2157-2226	n.a	www.biosolar.eco.br	SAO PAULO	SP
BIOTER PROTECAO AMBIENTAL LTDA	2236436000100	(49) 3322-2061	n.a	http://www.bioter.com.br	CHAPECO	SC
BOBIG CONTATTO - EQUIPAMENTOS LTDA	5143214000130	(42) 3273-6620	n.a	http://www.hidrauflex.com/	TELEMACO BORBA	PR
BOLT SERVICOS E COMERCIALIZACAO DE ENERGIA LTDA	13700609000115	(11) 2626-1771 / 97500-3132	eevaristo@boltenergias.com.br	www.boltenergias.com.br	SAO PAULO	SP
BRANCO MOTORES LTDA	2526146000109	(41) 3381-8800 / 3381-8882	comercial@branco.com.br ; posvenda@branco.com.br	http://www.branco.com.br/	ARAUCARIA	PR
BRASIL CLEAN TECNOLOGIAS AMBIENTAIS LTDA	13475794000191	(47) 9990-1010 / (47) 3367-2176	n.a	http://brasilcleanenergy.com.br/	BALNEARIO CAMBORIU	SC
BRASIL H2 SOLUCOES ENERGETICAS E EDUCACIONAIS COM CELULAS A COMBUSTIVEL LTDA	8764964000118	(41) 3352-4032	n.a	http://www.brasilh2.com.br/brh2-tecnologiacac.html	CURITIBA	PR
BRASMETANO INDUSTRIA E COMERCIO LTDA	51412674000134	(19) 3424-4566	brasmetano@brasmetano.com.br	http://www.brasmetano.com.br/equipamentos/?lang	PIRACICABA	SP
BRASUMA COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA.	12336613000183	(45) 9978-4680	n.a	http://www.brasuma.com/index.php	MARECHAL CANDIDO RONDON	PR
BRAZIL COMERCIO E MANUTENCAO DE EXTINTORES EIRELI	24218850000129	(19) 3884-1011	n.a	http://www.brazilextintores.com.br/	PAULINIA	SP
BSDV BIOGAZ SYSTEM DÉPOLLUTION VALORISATION	Foreign	n.a	n.a	http://www.bsdv.com/	Foreign	-
BTS	Foreign	n.a	n.a	http://www.bts-biogas.com/	Foreign	-
BUHLER INDUSTRIA E COMERCIO DE EQUIPAMENTOS INDUSTRIAIS LTDA.	60885761000361	(47) 30278200/	contato pelo site	www.buhlergroup.com	JOINVILLE	SC
BUREAU VERITAS DO BRASIL SOC CLAS E CERTIFICADORA LTDA	33177148000155	(21) 2206-9400	n.a	http://www.bureauveritas.com.br/home/	RIO DE JANEIRO	RJ
BUYSOFT DO BRASIL LTDA	10242721000161	(44) 3041-8865	n.a	http://buysoft.com.br/	MARINGA	PR
C. G. LIMA COMERCIO DE MAQUINAS E DECORACOES EIRELI	644731000170	(45) 3573-5539	balancascglima@hotmail.com	n.a	FOZ DO IGUACU	PR

CAIB	Foreign	n.a	n.a	http://www.caib.es/conselleries/industria/dgener/user/portalenergia/pla_eficiencia_energetica/produccioenergia_1.es.html	Foreign	-
CALDEMA EQUIPAMENTOS INDUSTRIAIS LTDA	45372893000134	(16) 3946-2701	comercial@caldema.com.br	http://www.caldema.com.br/index_portugues_1024.html	SERTAOZINHO	SP
CANAA EQUIPAMENTOS DE COMBATE A INCENDIO LTDA	7271776000195	(19) 3407-2670	n.a	http://www.amcanaa.com.br/produtos.htm	MAGE	RJ
CASA HIDRAULICA TOLEDO EIRELI	5521160000108	(45) 3277-0174	contato@casahidraulicatoledo.com.br	http://www.casahidraulicatoledo.com.br/	TOLEDO	PR
CASTERS-AUTOMACAO COMERCIAL LTDA	84844596000104	(45) 3523-6012	casterautomação@hotmail.com	http://casters.com.br/	FOZ DO IGUACU	PR
CATERPILLAR BRASIL LTDA	61064911000177	(41) 2103-2211	elaine@pesa.com.br	http://www.catgaspower.com/AgricultureBiofuelFood.aspx?utm_source=google&utm_medium=sem&utm_cam	PIRACICABA	SP
CENTRO INTERNACIONAL DE ENERGIAS RENOVAVEIS-BIOGAS	18366966000102	(45) 3576-7166	n.a	https://cibiogas.org	FOZ DO IGUACU	PR
CEU AZUL - INDUSTRIA E COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA	6186268000146	(45) 9133-6975	n.a	http://www.debona.com.br/	CEU AZUL	PR
CHIAPERINI INDUSTRIAL LTDA	59064766000182	16 3954 9400	n.a	http://www.chiaperini.com.br/	SANTA ROSA DE VITERBO	SP
CHICAGO PNEUMATIC BRASIL LTDA	51609568000145	(45) 2101-2850/(45) 99137-0972	durval@arsulcompressores.com.br	www.arsulcompressores.com.br	BARUERI	SP
CHP BRASIL INDUSTRIA E COMERCIO DE GERADORES S/A	14238231000142	(48) 99968-2530/(51) 99977-9499	fabiano.lovato@chpbrasil.com.br	http://chpbrasil.com.br/	RIO DE JANEIRO	RJ
CIDELSA	Foreign	n.a	n.a	https://www.cidelsa.com/es/lp/biodigestores-productivos/	Foreign	-
CIENLAB EQUIPAMENTOS CIENTIFICOS LTDA	9019664000177	(19) 3308-1622/-	cienlab@cienlab.com.br	www.cienlab.com.br	CAMPINAS	SP
CLEAN ENVIRONMENT BRASIL ENGENHARIA E COMERCIO LTDA	628815000110	(19) 3794-2900 / (19) 3794-2901	n.a	http://www.clean.com.br/site/	VALINHOS	SP

CLOROFILA CONSULTORIA AMBIENTAL LTDA.	29720557000189	(45) 99933-6384	n.a	https://www.clorofilaconsultoria.com.br/biogas/	CASCAVEL	PR
COBRAPI GERENCIAMENTO CONSULTORIA E PROJETOS LTDA	9167020000126	(21) 2292-5499 /(31) 3349-1400	n.a	http://www.cobrapi.com.br/	VITORIA	ES
COMBUSTEC INDUSTRIA E COMERCIO DE QUEIMADORES LTDA	8179357000190	(35) 3851-3509	n.a	http://combustecqueimadores.com.br/index.php	BOA ESPERANCA	MG
COMERCIAL ELETRICA DW LTDA	5381281000193	(51) 3326-4010 /(51) 3326-4000	n.a	http://www.eletricadw.com.br/	CURITIBA	PR
CONAUT CONTROLES AUTOMATICOS LTDA	60659166000146	(21) 2220-7881	n.a	http://www.conaut.com.br/	EMBU DAS ARTES	SP
CONCERT TECHNOLOGIES S.A.	4732840000280	(31) 3194-0700 /(11) 3062-8663	n.a	http://www.concert.com.br/pt/	BELO HORIZONTE	MG
CONCREMAT ENGENHARIA E TECNOLOGIA S/A	33146648000120	(31) 3116-4400	n.a	http://www.concremat.com.br/	RIO DE JANEIRO	RJ
CONSOMINAS ENGENHARIA LTDA	7080673000148	(31) 3324-0880	n.a	http://consominas.com.br/	BELO HORIZONTE	MG
CONSTRUTORA ELABORE EIRELI	7726882000116	(45) 3029-6011	tecnico@construtoraelabore.com.br	http://www.construtoraelabore.com.br/site	SANTA HELENA	PR
CONSTRUTORA ELEVACAO LTDA	77167203000100	(41) 2106-9913 /(41) 9994-7890	n.a	http://www.construtoraelevacao.com.br/	CURITIBA	PR
CONSTRUTORA ICOPAN LTDA	78611688000133	(43) 91014627 /(43) 3327-1605	icopan@sercomtel.com.br	n.a	LONDRINA	PR
CONSTRUTORA METROSUL LTDA	1739467000110	(45) 3028 75 43	cq@construtorametrosul.com.br / orcamento@construtorametrosul.com.br	http://www.construtorametrosul.com.br/	FOZ DO IGUACU	PR
CONSTRUTORA POSSAMAI LTDA	73809790000124	(45) 3541 3400	construtorapossamai@hotmail.com	n.a	SANTA TEREZINHA DE ITAIPU	PR
CONSTRUTORA TAQUARUCU LTDA	75917955000107	(45) 3572-4490	n.a	https://construtorataquarucu.com.br/	FOZ DO IGUACU	PR
CONTECH INDUSTRIA E COMERCIO DE EQUIPAMENTOS ELETRONICOS LTDA	3206164000168	(11) 5035-0920	n.a	www.contechind.com.br	SAO PAULO	SP
COTERGAVI INSTRUMENTOS DE MEDICAO LTDA	51164671000129	(11) 3673-5020	donizetti@cotergavi.com.br	http://www.cotergavi.com.br/	SAO PAULO	SP

COTICA ENGENHARIA E CONSTRUCOES LTDA	88958673000108	(51) 3272-6600	n.a	http://www.sebigascotica.com.br	MARAU	RS
CS BIOENERGIA S.A.	20595947000108	(41) 3121-0995	n.a	http://www.csbioenergia.com.br/empresa.html	SAO JOSE DOS PINHAIS	PR
DAIMLER AG	05614604000141	n.a	n.a	https://www.daimler.com/career/about-us/locations/location-detail-page-5152.html	Foreign	-
DB2 ENGENHARIA LTDA	5158914000107	(21) 2421-3429	n.a	http://www.db2engenharia.com.br/home/7	RIO DE JANEIRO	RJ
DBFZ - DEUTSCHES BIOMASSEFORSCHUNGSZENTRUM	Foreign	n.a	n.a	https://www.dbfz.de	Foreign	-
DEDONATI & DEDONATI LTDA	9106665000159	(45) 3268-1294	comercial.metaza@hotmail.com posvendas@metaza.com.br	n.a	SANTA HELENA	PR
DELTA VINIL INDUSTRIA E COMERCIO LTDA	72027337000101	(11) 2119-0100	n.a	http://www.deltasaneamento.com.br/	ATIBAIA	SP
DIEFRA ENGENHARIA E CONSULTORIA LTDA	17579459000194	(31) 3319-6600	n.a	http://www.grupodiefra.com.br/	BELO HORIZONTE	MG
DISPARCO INDUSTRIA E COMERCIO LTDA	72954993000141	(12) 2138-9799	n.a	http://www.disparco.com.br/	SAO JOSE DOS CAMPOS	SP
DISTRIBUIDORA MERIDIONAL DE MOTORES CUMMINS S/A	90627332000193	(11) 2874-3511	n.a	http://www.cummins.com.br/cla/index.php	PORTO ALEGRE	RS
DUMONT COMERCIO DE EQUIPAMENTOS ELETRICOS LTDA	87158143000104	(51) 3346-3822/(51) 99701-6012	vendas@dumontmotores.com.br	http://www.dumontmotores.com.br	PORTO ALEGRE	RS
DW ENGENHARIA LTDA.	31906753000194	(21) 2439-3994(21) 2439-2628	n.a	http://www.dwengenharia.com.br/site/pages/home.php	RIO DE JANEIRO	RJ
DWYLER INSTRUMENTACAO E CONTROLE INDUSTRIAL EIRELI	12419133000186	011 2682-6633	n.a	www.dwyler.com.br	SAO PAULO	SP
E DE MORAES PIEGEL EMPREITEIRA	19759628000101	(51) 3325-5038/(51) 98061-3463	elmempreiteiraassessoria@gmail.com	https://www.elmempreiteira.com/	PORTO ALEGRE	RS
EATECNO ENGENHARIA E TECNOLOGIAS DE GESTAO LTDA	10845102000161	(41) 3244-0407	enon@eatecno.com.br	www.eatecnodobrasil.com.br	CURITIBA	PR

ECAM ENGENHARIA , CALDEIRAS E MAQUINAS - EIRELI	17382414000125	(34) 3322-6195(34) 3075-3390(34) 99143-7387	n.a	http://ecam.ind.br	UBERABA	MG
ECKERT REPRESENTACOES COMERCIAIS LTDA	13650631000106	(41) 3022-4848	marcos@eckert.com.br	www.eckert.com.br	MARAVILHA	SC
ECOAMB PESQUISAS AMBIENTAIS LTDA	442252000170	(31) 3532-3209	n.a	http://www.ecoamb.com.br/home.html	BETIM	MG
ECO-BIODIGESTORES E REVESTIMENTOS LTDA	15014093000180	(34) 3831-9153	n.a	http://www.ecobiodigestores.com.br/	PATROCINIO	MG
ECOGAS COMERCIO, REPRESENTACAO E SERVICOS LTDA	1352094000120	(35) 3851-1857	n.a	http://www.ecogas.com.br/	BOA ESPERANCA	MG
ECOMETANO EMPREENDIMENTOS S.A.	12826036000108	(21) 3177-5900	n.a	http://www.ecometano.com.br/ecometano/index.html	SALVADOR	BA
ECOTEC PRODUTOS E SERVICOS AMBIENTAIS LTDA	8404976000131	(11) 5181-6591	n.a	www.ecotecco.com	SAO PAULO	SP
ECOWORXX INTERNATIONALAG	Foreign	n.a	n.a	http://www.ecoworxx.de/	Foreign	-
ECR EQUIPAMENTOS DE MEDICAO E CONTROLE LTDA	95874657000194	(47) 3349-6850	vendas@ecr-sc.com.br	https://www.google.com.br/#q=ecr+manometro	ITAJAI	SC
EDRA OLEO GAS E BIOENERGIA INDUSTRIA DE COMPOSITOS LTDA	20773497000198	(19) 3576-9300	comercial@edra.com.br	http://www.edra.com.br/home/index.php	IPEUNA	SP
EFFICIENTIA S.A	4881791000167	(31) 3274-7529	n.a	http://www.efficientia.com.br/	BELO HORIZONTE	MG
EISELE EQUIPAMENTOS INDUSTRIAIS EIRELI	93722700000170	(51) 3342-6656	n.a	http://www.eisele.com.br/	PORTO ALEGRE	RS
EJC ENGENHARIA DE UTILIDADES LTDA	2822352000158	(21) 3685-9333	n.a	http://www.ejcengenharia.com.br/index.html	NITEROI	RJ
ELIPSE SOFTWARE LTDA	91213371000298	(41) 3332-0120	savio@elipse.com.br	www.elipse.com.br	CURITIBA	PR
ELITE GAS COMERCIO E MANUTENCAO DE EQUIPAMENTOS PARA GAS LTDA	10838714000127	(11) 4425-1827	elite.gas@hotmail.com	https://elitegas.com.br/	SANTO ANDRE	SP
EMP ENGENHARIA LTDA	18598692000187	(31) 3019-7671(31) 4109-0786	n.a	http://www.empengenharia.com.br	BELO HORIZONTE	MG

ENC ENERGY BRASIL PARTICIPACOES S.A.	29423638000117	11 4506-3192	info@enspower.com	http://www.encpower.com/pt/	JUNDIAI	SP
ENCIBRA S A ESTUDOS E PROJETOS DE ENGENHARIA	33160102000123	(11) 5501-1620	n.a	www.encibra.com.br	SAO PAULO	SP
ENDRESS + HAUSER CONTROLE E AUTOMACAO LTDA.	49423619000106	(11) 5033-4333	n.a	http://www.br.endress.com/pt	SAO PAULO	SP
ENEL GREEN POWER ESPERANCA EOLICA S.A.	19011517000104	(21) 2206-5600	n.a	http://www.enelgreenpower.com/en-GB/brazil/	NITEROI	RJ
ENERTEC KRAFTWERKE	Foreign	n.a	n.a	https://www.enertec-kraftwerke.de/en/	Foreign	-
ENGEBIO ENGENHARIA E MEIO AMBIENTE S/S LTDA	93287613000132	(51) 3333-6005	n.a	http://www.engebio.net	PORTO ALEGRE	RS
ENGENHO NOVE ENGENHARIA AMBIENTAL LTDA	71300693000186	(31) 3254-6900	n.a	http://www.engenho9.com.br/index.html	NOVA LIMA	MG
ENGEPOL GEOSSINTETICOS LTDA	93273985000100	(51) 3303-3935	n.a	http://www.engepol.com	CANOAS	RS
ENGEQUISA ENGENHARIA QUIMICA, SANITARIA E AMBIENTAL LTDA	25703935000165	(31) 3594-4677	n.a	http://www.engequisa.com.br/wp/	BETIM	MG
ENPROCON ENVIRONMENTAL TECNOLOGIES	Foreign	n.a	n.a	https://www.enprocon.com.au/	Foreign	-
ER-BR - ENERGIAS RENOVAVEIS LTDA.	10513886000120	(43) 3377-0100	claret@erbr.com.br	http://www.erbr.com.br/default/	LONDRINA	PR
ESCO GD TECNOLOGIA EM ENERGIA LTDA	21118050000148	(55) 3422-0940	n.a	http://www.esco-gd.com.br	ALEGRETE	RS
ESCO IGUASSU E ENGENHARIA LTDA	9542461000160	(45) 9922-9629	kleber@escoiguassu.com.br	http://www.escoiguassu.com.br/	MATELANDIA	PR
ESCOBAR ESTRUTURAS E FUNDACOES LTDA	7946915000133	(45) 3027 - 7199	celcio2007@hotmail.com	http://www.escobar.eng.br	FOZ DO IGUACU	PR
ESCOPOWER CONSULTORIA E SERVICOS EIRELI	8823359000170	(21) 2430-8825	n.a	http://www.escopower.com.br/index.html	RIO DE JANEIRO	RJ
ESSE ENGENHARIA E CONSULTORIA LTDA	41656372000158	(31) 3264-9535	n.a	http://www.esseengenharia.com.br/	NOVA LIMA	MG
ESTRE AMBIENTAL S/A	3147393000159	(11) 3709-2300	n.a	http://www.estre.com.br/index.php	SAO PAULO	SP

ETAENGE ENGENHARIA E COMERCIO LTDA	36453421000115	(21) 2437-7495(21) 3042-1397	n.a	www.odisbrasil/filtering(site em reforma) http://etaenge.wix.com/nuova-tubital	RIO DE JANEIRO	RJ
ETECK SERVICOS TECNICOS LTDA	12113634000130	(51) 3473-0982(51) 99138-5500	n.a	http://www.eteck.com.br	SAPUCAIA DO SUL	RS
EUROGEN POWER	Foreign	n.a	n.a	http://www.eurogenpower.com.au/	Foreign	-
EXCELENCIA ENERGETICA CONSULTORIA EMPRESARIAL LTDA.	5642927000149	(11) 3848-5999	n.a	http://www.excelenciaenergetica.com .br/pt-br/	SAO PAULO	SP
EXCENGE - EXCELENCIA EM ENGENHARIA LTDA	7603606000160	(21) 2610-0826	n.a	http://www.excenge.com.br/index.php	NITEROI	RJ
F F ARAUJO COMERCIO DE FERRAGENS FERRAMENTAS E PORTOES	13403034000179	(16) 3513.9800	n.a	https://www.gwsbrasil.com/	SAO PAULO	SP
F S INDUSTRIA DE BIODIGESTORES LTDA	15157080000160	(45) 3254-6222 / 3254-6222	n.a	http://planotec.ind.br/empresa.php	PALOTINA	PR
F.G.S. BRASIL INDUSTRIA E COMERCIO LTDA	2291486000190	(11) 4617-8000/-	michele@fgsbrasil.com.br / fgsbrasil@fgsbrasil.com.br	http://www.fgsbrasil.com.br/	CAJAMAR	SP
FABO BOMBAS E EQUIPAMENTOS LTDA	82369810000184	(41) 3286-1401	n.a	http://www.fabobombas.com.br/	CURITIBA	PR
FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.	Foreign	n.a	n.a	https://www.fnr.de/	Foreign	-
FARGON ENGENHARIA E INDUSTRIA LTDA	60815966000109	(11) 5545-2600	n.a	http://www.fargon.com.br/	SAO PAULO	SP
FAST INDUSTRIA E COMERCIO LTDA	771598000112	(49) 3555-7250	fast@fastindustria.com.br	http://www.fastindustria.com.br/	CAPINZAL	SC
FATOR 10-ENGENHARIA E CONSULTORIA LTDA	7304613000161	(71) 4103-5450	n.a	http://www.fator10engenharia.com.br/ contato	DIAS D'AVILA	BA
FAZIT - FABRICACAO DE SISTEMAS DE DETECCAO DE GASES LTDA	16554456000133	(51) 3649-2462	n.a	http://www.fazit.com.br	MONTENEGRO	RS
FCA FIAT CHRYSLER AUTOMOVEIS BRASIL LTDA.	16701716000156	n.a	n.a	https://www.fiat.com.br/	BETIM	MG
FIBRAENG EQUIPAMENTOS INDUSTRIAIS LTDA	76055482000149	(43) 3338-0110	vendas@fibraeng.com.br	http://www.fibraeng.com.br	LONDRINA	PR

FILIPPON ENGENHARIA SS	87818761000133	(51) 3331-6633/(51) 99712-4264	contato@filipponengenharia.com.br	http://www.filipponengenharia.com.br/	PORTO ALEGRE	RS
FIMACO DO BRASIL FABRICACAO DE MAQUINAS E EQUIPAMENTOS LTDA.	14656257000100	(47) 3525-1000	n.a	http://www.fimacodobrasil.com.br/	LONTRAS	SC
FLESSAK ELETRO INDUSTRIAL S/A	77804599000140	(46) 3520-1060	n.a	http://www.flessak.com.br/pt/	FRANCISCO BELTRAO	PR
FLOWMEC EQUIPAMENTOS E SISTEMAS LTDA	2812702000103	(51) 3475-0170	flowmec@flowmec.com.br	http://flowmec.com.br/site/	CANOAS	RS
FLUXO SOLUCOES INTEGRADAS LTDA	34213025000608	(11) 5098-6711	n.a	http://www.fluxosolutions.com.br/	SANTANA DE PARNAIBA	SP
FOCKINK INDUSTRIAS ELETRICAS LTDA	3021334000130	55 3375 9500	romulo@fockink.ind.br	http://www.fockink.ind.br/	PANAMBI	RS
FOKAL EQUIPAMENTOS INDUSTRIAIS LTDA.	64864127000131	(11) 4243 7200/(11) 991 537 359	info@fokal.com.br	http://www.fokal.com.br/index.php	COTIA	SP
FORJAFIX ELEMENTOS DE FIXACAO LTDA	3936142000153	(11) 2110-8000	n.a	https://www.forjafix.com.br/	ITAPEVI	SP
FRAGMAQ INDUSTRIA DE MAQUINA LTDA	44031631000143	(11) 4056-8057/	vendas@grupofragmaq	www.fragmaq.com.br	DIADEMA	SP
FROLING	Foreign	n.a	n.a	https://www.froeling.com/us.html	Foreign	-
FUND CENTROS DE REFERENCIA EM TECNOLOGIAS INOVADORAS	78626363000124	(48) 3239-2747	n.a	http://certi.org.br/	FLORIANOPOLIS	SC
G.V. EMPREITEIRA DE OBRAS EIRELI	13819444000103	(11) 2556-6052/(11) 99667-6976	0	http://www.gvconstrucao.com.br/index.html	SAO PAULO	SP
GAIATEC COMERCIO E SERVICOS DE AUTOMACAO E SISTEMA DO BRASIL LTDA	6176620000162	(11) 2207-1933(11) 2207-1986(11) 2207-1986	n.a	http://www.gaiatecsistemas.com.br	SAO PAULO	SP
GAS BRASILIANO DISTRIBUIDORA S.A.	3024705000137	(16) 3305-1818	n.a	http://www.gasbrasiliano.com.br	ARARAQUARA	SP
GCT GLOBAL CIENCIA E TECNOLOGIA BIO S/A	4508018000150	(31) 3245-7543	n.a	http://www.gctbio.com.br/	BELO HORIZONTE	MG
GE POWER & WATER EQUIPAMENTOS E SERVICOS DE ENERGIA E TRATAMENTO DE AGUA LTDA.	1009681000111	(21) 3548-3234	n.a	https://www.suezwatertechnologies.com.br/	SAO PAULO	SP

GENERAL ELECTRIC DO BRASIL LTDA	33482241000173	(11) 4873-7900	ge@agenciaideal.com.br	https://www.ge.com/br/	SAO PAULO	SP
GENESIS OIL & GAS BRASIL ENGENHARIA LTDA	29419512000179	55(21) 2586-6072	n.a	http://www.genesisoilandgas.com/	RIO DE JANEIRO	RJ
GEO ENERGETICA PARTICIPACOES S.A.	10323120000183	(43) 3025-5004	n.a	http://www.geoenergetica.com.br/	LONDRINA	PR
GEOKLOCK CONSULTORIA E ENGENHARIA AMBIENTAL LTDA.	51761351000156	11 5501-3777	n.a	http://geoklock.com.br/	SAO PAULO	SP
GESE - GESTAO EM SUSTENTABILIDADE ENERGETICA LTDA.	8092195000159	(31) 3312-4250	n.a	http://gese.com.br/site/	BELO HORIZONTE	MG
GICON	Foreign	n.a	n.a	http://www.gicon-engineering.com/en/gicon-biogas-technologies/the-gicon-process.html	Foreign	-
GNR DOIS ARCOS VALORIZACAO DE BIOGAS LTDA	17173460000114	(21) 3520-3900	n.a	http://www.doisarcos.com.br/	RIO DE JANEIRO	RJ
GREENLANE BIOGAS EUROPA SV	Foreign	n.a	n.a	http://greenlanebiogas.com/	Foreign	-
GREYLOGIX BRASIL MAQUINAS LTDA	12218713000105	n.a	n.a	https://www.greylogix.com.br/	MAFRA	SC
GS ENGENHARIA LTDA	13180842000114	(45) 3038.4110	n.a	http://phronesys.com.br/	CASCAVEL	PR
GSI BRASIL INDUSTRIA E COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA	1770039000150	(54) 3342 7500	gsi-brasil.contato@agcocorp.com	https://www.gsibrasil.ind.br/	MARAU	RS
GUASCOR DO BRASIL LTDA	1676897000130	(11) 3572-7000	n.a	http://www.guascor.com.br/website/br/contato/index.php	SAO PAULO	SP
GUTERRES PROJETOS LTDA	40445157000145	(21) 2233-9340	guterres@guterres-br.com	http://guterres-br.com/	RIO DE JANEIRO	RJ
GWE - GLOBAL WASTE ENERGY LTDA	18784709000190	(16) 3513-9800	n.a	n.a	SOROCABA	SP
HABTEC ENGENHARIA SANITARIA E AMBIENTAL LTDA	35808948000152	(21) 2533-0188	n.a	https://www.mottmac.com/pt-BR/brazil/brazil	RIO DE JANEIRO	RJ
HARRIS PYE BRASIL LTDA	4239291000126	(22) 2765-9950	n.a	https://www.harrispye.com	MACAE	RJ
HEATMAG INDUSTRIA E COMERCIO LTDA.	11662841000180	(37) 3323-2082 / 9988-4310	comercial@heatmag.com.br	https://www.heatmag.com.br/	PAINS	MG
HEIZOMAT	Foreign	n.a	n.a	https://www.heizomat.de/int/index.php	Foreign	-

HELENO & FONSECA CONSTRUTECNICA S/A	61573184000173	(11) 5504-5050 / 5505-4090	hfc@hfc.com.br	http://www.hfc.com.br/	SAO PAULO	SP
HELIBOMBAS - INDUSTRIA E COMERCIO DE EQUIPAMENTOS HIDRAULICOS LTDA.	1679707000139	16 3333-5252	n.a	https://helibombas.com.br/ptb/	ARARAQUARA	SP
HELIFER INDUSTRIA E COMERCIO DE EQUIPAMENTOS HIDRAULICOS LTDA	1003471000116	(11) 2783-6828	n.a	https://www.helifer.com.br/	SAO PAULO	SP
HERCULES COMPONENTES ELETRICOS LTDA	1964161000168	45 2101.8300	n.a	http://herculescomponentes.com.br/2018/	CASCAVEL	PR
HERMANN SEWERIN GMBH	Foreign	n.a	n.a	https://www.sewerin.com/pt/	Foreign	-
HEXIS CIENTIFICA LTDA	53276010000110	(11) 45892728/-	cotações@hexis.com.br	http://www.hexis.com.br	JUNDIAI	SP
HIDROMECANICA GERMEK LTDA	48613327000165	(19) 3682-7070	n.a	http://www.germek.com.br/	SAO JOSE DO RIO PARDO	SP
HIDROQUIMICA ENGENHARIA E LABORATORIOS SOCIEDADE SIMPLES LTDA	42114736000130	(21) 3293-7000	n.a	http://hidroquimica.ind.br/	RIO DE JANEIRO	RJ
HIDRUS TECNOLOGIA AMBIENTAL EIRELI	2927883000105	(67) 3341-1564	n.a	https://www.hidrusbrasil.com.br/pt/	CAMPO GRANDE	MS
HIRSA SISTEMAS DE AUTOMACAO E CONTROLE LIMITADA	27632330000156	(21) 3293-7001	hirsa@hirsa.com.br	http://www.hirsa.com.br/	RIO DE JANEIRO	RJ
HOISTERSUL EQUIPAMENTOS E SERVICOS INDUSTRIAIS LTDA	7238318000154	(51) 3403-2500	n.a	n.a	GUAIBA	RS
HOLZ WERT	Foreign	n.a	n.a	https://www.holz-wert.eu	Foreign	-
HS TUBULACOES INDUSTRIAIS LTDA	10336375000180	(53) 3278-3662	n.a	n.a	PELOTAS	RS
HUMANA QUALITY TREINAMENTO E DESENVOLVIMENTO LTDA	5267004000154	(11) 5641-7375	atendimento@humanaquality.com.br	n.a	SAO PAULO	SP
IBRAM INDUSTRIA BRASILEIRA DE MAQUINAS LTDA	47665559000102	(41) 3245-0367/(41) 98487-8930	eloirkaill@ig.com.br	https://www.ibram.ind.br/	SAO PAULO	SP
IMBIL INDUSTRIA E MANUTENCAO DE BOMBAS ITA LTDA	51482776000126	(19) 3843-9833	n.a	http://www.imbil.com.br/Imbil/Portugues/	ITAPIRA	SP
IMC SASTE-CONSTRUCOES, SERVICOS E COMERCIO LTDA.	67706853000114	(11) 3566-3200	comercial@imcsaste.com.br	https://www.imcsaste.com.br/	CAIEIRAS	SP

IMS - SOLUCOES EM ENERGIA LTDA	87723474000140	51 3382-2300	n.a	http://www.ims.ind.br/	PORTO ALEGRE	RS
INDUSTRIA E COMERCIO DE JUNTAS LGT SERVFLEX LTDA.	62714472000163	(11) 2641-7632	humberto@juntaslgt.com.br	http://www.juntaslgt.com.br/	SAO PAULO	SP
INDUSTRIAS BRASILEIRAS DE ARTIGOS REFRATARIOS - IBAR - LTDA	61442737000230	(11) 4634-6600	ibarvendas@ibar.com.br	http://www.ibar.com.br/	POA	SP
IN-HAUS INDUSTRIAL E SERVICOS DE LOGISTICA LTDA	5208211000138	(11) 3660-9704	n.a	http://www.in-haus.com.br/in-haus/empresa.html	SAO PAULO	SP
INOVAGRID ENERGIA LTDA	5870349000106	(11) 5070-1700	n.a	n.a	SAO PAULO	SP
INOX-TECH COMERCIO DE ACOS INOXIDAVEIS LTDA	49934250000783	(11) 4343-1920	velan@feital.com.br	https://www.feital.com.br/	CACHOEIRINHA	RS
INTECNIAL S.A.	89432702000158	(54) 2107-8000	n.a	https://intecnial.com.br/	ERECHIM	RS
INTEXX INTELIGENCIA E EXPERTISE AMBIENTAL LTDA	24511310000139	(19) 3704-6850(19) 97131-1963	intexx@intexx.com.br	http://www.intexx.com.br/	LIMEIRA	SP
IRRIGAOESTE SISTEMAS DE HIDROPONIA E IRRIGACAO EIRELI	17708901000135	(45)3268-3371/9931-4737	irrigaoeste@hotmail.com	https://irrigaoeste.com.br/	SANTA HELENA	PR
ISOCELL COMERCIO DE INSTRUMENTACAO LTDA	13162901000121	(19) 3704-6850(19) 97131-1963	n.a	https://www.isocellanalitica.com/	PORTO ALEGRE	RS
J. MALUCELLI AMBIENTAL LTDA	8767514000189	(41) 3351-5577	n.a	https://www.jmalucelli.com.br/	CURITIBA	PR
JANUS & PERGHER LTDA	95839000150	51 3330-4745	n.a	http://januspergher.com.br/	XANGRI-LA	RS
JIAS CONSULTORIA EM ENGENHARIA LTDA	7072880000150	(45) 9973-1671	n.a	n.a	RIO DE JANEIRO	RJ
JOSE ALBERTO DA MATA MENDES	20275432000112	(31) 3646-7421	n.a	n.a	BELO HORIZONTE	MG
KANAFLEX S/A INDUSTRIA DE PLASTICOS	43942598000140	(11) 3779-1670	n.a	http://www.kanaflex.com.br/novosite/index.jsp	COTIA	SP
KB CONSTRUCCIONES	Foreign	n.a	n.a	https://www.kbconstrucciones.com/	Foreign	-
KCE - CONSULTORIA EMPRESARIAL S/S LTDA	4354732000130	(11) 3501-9000	kce@kce.com.br	http://www.kce.com.br/contato.html	CAMPO LIMPO PAULISTA	SP
KEPLER WEBER SA	91983056000169	(45) 9947-1991	edson.ribeiro@kepler.com.br	https://www.kepler.com.br/	SAO PAULO	SP
KIRK ENVIRONMENTAL	Foreign	n.a	n.a	http://kirkenvironmental.ca/	Foreign	-

KOBLITZ ENERGIA LTDA	5964140000101	(19) 3421-0223	koblitz@koblitz.com.br	http://www.koblitz.com.br/	RECIFE	PE
KOHLER BIODIGESTORES LTDA	11364562000130	: (45) 3254-4897	n.a	http://www.biokohler.com/	MARECHAL CANDIDO RONDON	PR
KRIEG & FISCHER INGENIEURE GMBH	Foreign	n.a	n.a	https://www.kriegfischer.de/	Foreign	-
L M P ASSESSORIA E CONSULTORIA EMPRESARIAL - EIRELI	9442964000164	(45) 3524 3339	julio.meirelles.eng@gmail.com	n.a	FOZ DO IGUACU	PR
L. D. SOUZA FABRICACAO DE EQUIPAMENTOS HIDRAULICOS E PNEUMATICOS	30868584000182	(22) 2630-1043 (22) 98844-7236 (22) 99984-8707	n.a	n.a	CABO FRIO	RJ
LABOR OBRAS EIRELI	8431911000185	(45) 3028 4888 / 9990 7600	contato@laborobras.com.br	n.a	FOZ DO IGUACU	PR
LABORATORIO BIOLOGICO ANALISE QUIMICA E MICROBIOLOGICA EIRELI	4683974000178	(48) 3233-3013 (48) 3024-9013(48) 3233-3013 (48) 3024-9013	n.a	http://www.laboratoriobiologico.com.br/	FLORIANOPOLIS	SC
LABOREX	Foreign	n.a	n.a	http://www.laborex.ch/en/	Foreign	-
LANXESS - INDUSTRIA DE PRODUTOS QUIMICOS E PLASTICOS LTDA.	06176436000112	n.a	n.a	http://lanxess.com.br/	SAO PAULO	SP
LEAO ENERGIA INDUSTRIA DE GERADORES LTDA	10837578000150	(43) 3294-6444/-	antonio.oliveira@leaoenergia.com.bpaulo.bueno@leaoenergia.com.br glaucye.bento@leaoenergia.com.br	https://www.leaoenergia.com.br/	LONDRINA	PR
LIN-KA ENERGY	Foreign	n.a	n.a	https://www.linka.dk/en/	Foreign	-
LITE AUTOMACAO & SISTEMAS EIRELI	10769755000109	(48) 3626-4824	contato@liteautomacao.com.br	https://www.liteautomacao.com.br/	TUBARAO	SC
LMG NEGOCIOS INTELIGENTES S.A.	24034172000144	(51) 3017-1318	contato@luming.com.br	https://www.luming.com.br/turbinacapstone	PORTO ALEGRE	RS
LZ AMBIENTAL CONSULTORIA E SERVICOS LTDA	12461918000117	(11) 3192-0062 (51) 3097-0880	sp@lzambiental.com.br	http://lzambiental.com.br/	NOVO HAMBURGO	RS

M 3 H EQUIPAMENTOS HIDRAULICOS LTDA	37587920000168	62 3247-2900	n.a	http://www.m3h.com.br/	GOIANIA	GO
M. RESENDE & CARVALHO EQUIPAMENTOS AGROINDUSTRIAIS LTDA	4257086000193	(21) 2584-2701	felipegomes@alddistribuidora.com.br	http://www.alddistribuidora.com.br/	RIO DE JANEIRO	RJ
MADHELO CONSTRUCOES EIRELI	26656030000144	(45) 3306-4637/(45) 99127-6383	engenharia@madhelo.com.br	http://www.madhelo.com.br/	CASCAVEL	PR
MAGNA ENGENHARIA LTDA	33980905001287	(31) 3282-2507 (31) 3282-2504	contato@magnaeng.com.br	http://www.magnaeng.com.br	BELO HORIZONTE	MG
MAGNETROL INTERNATIONAL BRAZIL LLC	9402501000179	(15) 3033-8008/(15) 98106-3185	vendas.magnetrol@alutal.com.br	https://www.magnetrol.com/	EXTERIOR	EX
MAIA NOBRE ENGENHARIA LTDA	41162546000126	(82) 3326-3917 (82) 3336-1035 (82) 99661-1505	maianobre@maianobre.com.br	http://www.maianobre.com.br/sobre.html	MACEIO	AL
MAKROFER - COMERCIO DE METAIS EIRELI	10241616000108	(41) 3056-7005 (41) 3667-5051	contato@makrofer.com	http://www.makrofer.com.br/	PINHAIS	PR
MAN LATIN AMERICA INDUSTRIA E COMERCIO DE VEICULOS LTDA	06020318000110	n.a	n.a	https://www.vwco.com.br/produtos-man?utm_source=landingpage-header&utm_medium=Organic-All&utm_content=BR_VW_VWB_landingpage-header_ORG_ORG_ORG_OTR_MPU_AAF_ROS_CXD_ProdutosMAN-43749_PD_botao&utm_campaign=BR_AAF_SOC_LANCH_ND_NC_2019Q4OCT_VWB_Fenetran	SAO PAULO	SP
MAPDATA-TECNOLOGIA,INFORMATICA E COMERCIO LTDA	66582784000111	11 2615-2939	n.a	http://www.mapdata.com.br/quem-somos/	AMERICANA	SP
MAPNER	Foreign	n.a	n.a	https://www.mapner.com/	Foreign	-
MAQUINAS HIDRAULICAS HIDROSUL LTDA	87257135000115	(51) 3472-5066	diogo@hidrusbrasil.com.br	http://www.hidrosul.com.br/	CANOAS	RS

MARIO COELHO & CIA LTDA	3476019000105	(51) 3715-9542	n.a	http://www.ecoterra-bio.com.br/	SANTA CRUZ DO SUL	RS
MARPIE ENGENHARIA LTDA	19426059000174	(51) 3209-7837/(51) 9357-1678 / (51) 992115267	contato@marpie.com.br	http://www.marpie.com.br/a-marpie	PORTO ALEGRE	RS
MATORE CONSULTORIA, MANUTENCAO, MONTAGEM E CONSTRUCAO LTDA	21399462000101	(11) 2962-1149	n.a	http://www.matore.com.br/	MAUA	SP
MAX ASSESSORIA E CONSULTORIA LTDA	6234613000170	(41) 99018476	janaina@maxc.com.br	https://www.maxconsulting.com.br/	CURITIBA	PR
MAYSUL COMERCIO E DISTRIBUICAO LTDA	14457544000191	(51) 3059-7072	n.a	http://www.instalsystem.com.br/index	CANOAS	RS
METAL WORK PNEUMATICA DO BRASIL LTDA.	88041454000151	(51) 3590-7100	eng.aplicacao@metalwork.com.br	https://www.metalwork.com.br/	SAO LEOPOLDO	RS
METALURGICA CARDOSO EIRELI	85394690000244	(49) 3325-5050/(49)99167-2811	vendas@metalurgicacardoso.com.br	http://metalurgicacardoso.com.br/	CHAPECO	SC
METALURGICA TRAPP LTDA	83238832000178	47 3371-0088 /(47) 2107-8800	n.a	http://www.trapp.com.br/	JARAGUA DO SUL	SC
METHANUM ENGENHARIA AMBIENTAL LTDA	11181544000113	(31) 3024-1080 (31) 3024-0061	methanum@methanum.com	http://methanum.com/	BELO HORIZONTE	MG
METROVAL CONTROLE DE FLUIDOS LTDA	58762956000100	(19) 2127-9400	integridade@metroval.com.br	https://metroval.com.br/	NOVA ODESSA	SP
MICROPOWER EUROPE	Foreign	n.a	n.a	http://www.micropowereurope.com/	Foreign	-
MIGRATIO GESTAO E COMERCIALIZACAO DE ENERGIA ELETRICA LTDA.	15458171000136	(19) 3701-3476 (19) 3701-3486	n.a	http://www.migratio.com.br/	LIMEIRA	SP
MML IND E COM LTDA	25995291000126	(35) 3271-1657	vendas@mmlcaldeiras.com.br	http://www.mmlcaldeiras.com.br/contato	LAMBARI	MG
MOVIMATIC ENG AUTOMACAO INDL COMERCIO LTDA	65500886000188	(11) 5062-5222	movimatic@movimatic.com.br	http://www.movimatic.com.br/	SAO PAULO	SP
MS TECNOPON EQUIPAMENTOS ESPECIAIS LTDA	60160975000109	(19) 3434-1418/(19) 99801-1418	contato@tecnopon.com.br	http://www.tecnopon.com.br	PIRACICABA	SP

MT - ENERGY	Foreign	n.a	n.a	https://www.mtenergy.com.br/	Foreign	-
MUELLER ELETRODOMESTICOS LTDA	86375912000163	(47) 3281-21235(47) 3281-2121	anderson.schramm@mueller.ind.br	https://www.mueller.ind.br/	TIMBO	SC
MULTEE SERVICOS OPERACIONAIS AS EMPRESAS LTDA	23817176000136	(11) 3867-9502 WhatsApp:(11) 93119-1000	energia@biogas.agr.br	http://www.multee.com.br/	SAO PAULO	SP
MULTITECNICA INSTALACOES INDUSTRIAIS LTDA	1771125000188	(51) 3582-2727	Assistência: servicos2@multiarcomprimido.com.br Comercial: comercial@multiarcomprimido.com.br Projetos: gustavo@multiarcomprimido.com.br	n.a	NOVO HAMBURGO	RS
N NASCIMENTO DISTRIBUIDORA DE MOTORES ELETRICOS LTDA	55561252000181	n.a	n.a	https://www.nnascimento.com.br/	SAO PAULO	SP
NELCI FATIMA DE OLIVEIRA	30314450000110	(45)9827-2095 / 3523-2223	solarfoz@hotmail.com	n.a	FOZ DO IGUACU	PR
NEPIN ACESSORIOS INDUSTRIAIS LTDA	51598902000102	0800-774-3121	nepin@nepin.com.br	https://www.nepin.com.br/	SAO PAULO	SP
NETZSCH DO BRASIL INDUSTRIA E COMERCIO LTDA	82749987000106	(47)9269 – 7644	hederson.pedroso@netzsch.com	https://www.netzsch.com.br/	POMERODE	SC
NEUMAN & ESSER AMERICA DO SUL LTDA	53784443000187	(31) 2126-9590 (31) 2126-9578	n.a	https://www.neuman-esser.de/en/company/locations/brazil/	BELO HORIZONTE	MG
NEW ECO-TEC VERFAHRENSTECHNIK	Foreign	n.a	n.a	https://www.new-eco-tec.com/	Foreign	-
NEWTEC TECNOLOGIAS AMBIENTAIS LTDA	7557326000163	(49) 3433-4594	avesuy@avesuy.com.br	http://www.avesuy.com.br	XANXERE	SC
NORDSHIP MONTAGEM E CONSTRUCOES INDUSTRIAIS LTDA	24689064000100	(24) 2442-3684 (24) 99855-4139	n.a	n.a	BARRA DO PIRAI	RJ

NORGREN LTDA	46277349000176	(11) 5698-4000	norgrenexpressbr@norgren.com	https://www.imi-precision.com/br/pt/imi-norgren	SAO PAULO	SP
NOVUS - PRODUTOS ELETRONICOS LTDA	88176995000197	041 3244-0514	n.a	https://www.novus.com.br/	CANOAS	RS
NTC BRASIL COMERCIO DE MATERIAIS TECNICOS PARA CONSTRUCAO CIVIL EIRELI	8998928000119	(19) 3424-2325(11) 3522-9822	n.a	https://www.ntcbrasil.com.br/	PIRACICABA	SP
O.A.ENGENHARIA AMBIENTAL LTDA	3691975000100	(47) 3041-2840	n.a	http://www.oaengenharia.com.br/	BLUMENAU	SC
OBC INTERNATIONAL COURIER SERVICES	Foreign	n.a	n.a	https://cnwglobal.com/services/onboard-courier-obc/	Foreign	-
OBRA PRONTA - PROJETOS E EXECUCOES DE ENGENHARIA LTDA.	3095977000128	(51) 3028-8840/-	obrapronta@obrapronta.com.br	http://www.obrapronta.com.br/	PORTO ALEGRE	RS
OKO THERM	Foreign	n.a	n.a	https://www.oeko-therm.net/en/	Foreign	-
OLIVEIRA E MARQUES ENGENHARIA LTDA	65153470000130	(31) 3309-8367	n.a	http://www.oemengenharia.com.br/	BELO HORIZONTE	MG
OMEGA BRASIL SOLUCOES EM INFORMATICA, IMPORTACAO, EXPORTACAO E REPRESENTACOES LTDA.	8359052000160	(11) 2914-9899	n.a	http://www.omegabrasil.net/	SAO PAULO	SP
O-TEK TUBOS BRASIL LTDA.	2865153000127	(19) 3576-6000 (19) 3576-6020	O-TEK TUBOS BRASIL LTDA.	http://www.o-tek.com/	IPEUNA	SP
OTZ ENGENHARIA LTDA.	5016005000126	(21) 2224-8774	n.a	http://www.otzengenharia.com/	RIO DE JANEIRO	RJ
PAL ENERGY ENERGIA SOLAR LTDA	5979853000130	(54) 3446-1695	n.a	n.a	COTIPORA	RS
PAQUES BRASIL SISTEMAS PARA TRATAMENTO DE EFLUENTES LTDA	14666357000118	(19) 3429 0600	info@paques.com.br	https://br.paques.nl/	PIRACICABA	SP
PEAD BRASIL SOLUCOES EM TERMOPLASTICOS LTDA	12917935000116	(19) 3326-1186 / 9970	rafael@peadbrasil.com.br	https://peadbrasil.com.br/	CAMPINAS	SP
PENTAIR WATER DO BRASIL LTDA	4813867000117	(11) 3378-5400	n.a	https://www.pentair.com/	ATIBAIA	SP
PLANAVE S A ESTUDOS E PROJETOS DE ENGENHARIA	33953340000196	(21) 3232-8777	planave@planave.com	https://www.planave.com/	RIO DE JANEIRO	RJ
PLANET BIOGAS GLOBAL GMBH	Foreign	n.a	n.a	http://en.planet-biogas.com/	Foreign	-

PLANEX S/A CONSULTORIA DE PLANEJAMENTO E EXECUCAO	17453978000101	(31) 2105-0710 (31) 2105-0738	planex@planexconsultoria.com.br laboratorio@planexconsultoria.com.br	http://planexconsultoria.com.br/	BELO HORIZONTE	MG
PLANTFORT ESTUFAS AGRICOLAS	379513000155	(16) 3368-2011	priscila@plantfort.com.br	https://plantfort.ind.br/	SAO CARLOS	SP
PLASTOLANDIA HIDRAULICA E PLASTICOS INDUSTRIAIS LTDA	43235522000185	(11) 2168 8533	jurema@plastolandia.com.br	https://www.plastolandia.com.br/	SAO PAULO	SP
POLICON SOLUCOES INDUSTRIAIS LTDA	3813766000183	(11) 4479-2505/-	vendas@policon.com.br	https://policon.com.br/	SANTO ANDRE	SP
POLIERG INDUSTRIA E COMERCIO LTDA	45010717000152	(11) 2219 7700/-	marinho.comercial@polierg.com.br	http://www.polierg.com.br/	SAO PAULO	SP
POLIMATIC - EQUIPAMENTOS INDUSTRIAIS LTDA	1024722000149	(54) 3224-5007	polimatic@polimatic.com.br	http://www.polimatic.com.br/	CAXIAS DO SUL	RS
PROCKNOR ENGENHARIA LTDA	71927917000184	(11) 3898-1511	procknor@procknor.com.br	https://www.procknor.com.br/	SAO PAULO	SP
PROMINENT BRASIL LTDA	38875381000125	(11) 4176-0722	prominent-br@prominent.com	http://prominent.com.br/	SAO BERNARDO DO CAMPO	SP
PROSAN CONSULTORIA E PROJETOS DE SANEAMENTO LTDA	2572235000183	(31) 3267-8111	n.a	http://prosan.clocksistemas.com.br/	BELO HORIZONTE	MG
PROTEGO BRASIL VALVULAS E CORTA CHAMAS LTDA	14325185000119	(21) 2112-5700	office@protego.com	https://www.protego.com/pt/home.html	RIO DE JANEIRO	RJ
PROTONS SERVICOS INDUSTRIAIS, MONTAGENS, REFORMAS E COMISSIONAMENTO DE PAINES DE QUADROS ELETRICOS LTDA	17041550000151	(011) 4187-8109	n.a	http://www.eletronofx.com.br/quadro-de-transferencia.html	CARAPICUIBA	SP
REAL CENTER MATERIAIS E EQUIPAMENTOS ELETRICOS LTDA	93364974000569	(51) 3363-4700/(51) 999392915	realcenterpoa@realcenter.com.br	http://www.realcenter.com.br	PORTO ALEGRE	RS
RECOLAST EMPREENDIMENTOS E IMPERMEABILIZACOES EIRELI	50142819000161	(11) 3437-7450	Jeniffer@recolast.com.br	https://www.recolast.com.br/	GUARULHOS	SP
RENOVA COMERCIO DE MAQUINAS E EQUIPAMENTOS INDUSTRIAIS E DE APLICACOES AMBIENTAIS LTDA	10917285000183	(41) 3342-9268	n.a	n.a	CURITIBA	PR
RETIFICADORA DE MOTORES BARAO LTDA	10553937000148	(45) 3252-3941	n.a	n.a	TOLEDO	PR

RONDOTEC COMERCIO DE EQUIPAMENTOS DE INFORMATICA LTDA	461093000151	(45) 3254-7432	n.a	http://www.rondotec.com.br/	MARECHAL CANDIDO RONDON	PR
ROTARIA DO BRASIL LTDA.	5240491000161	(48) 3234-3164	info.br@rotaria.net	https://www.rotaria.net/	FLORIANOPOLIS	SC
ROTORTECH COMERCIO PECAS E SERVICOS LTDA	12780567000107	(51) 3078-5499	cleo.machado@rotortech.com.br	http://www.rotortechservices.com/	ESTEIO	RS
RS ACIONAMENTOS E MATERIAIS ELETRICOS LTDA	8294822000134	(51) 3029-0006/(51) 98345-0775	rsautomacao@rsautomacao.com.br	https://rsautomacao.com.br	PORTO ALEGRE	RS
RS GERADORES LTDA	17845824000165	(51) 3109-1266	rsgeradores@rsgeradores.com.br	http://www.rsgeradores.com.br/	PORTO ALEGRE	RS
RUBENS PIRO TERRAPLENAGEM E LOCACAO	10345358000100	(11) 2848-8082(11) 95 490-5139 (11) 99 740-1776(11) 99 470-8808 (11) 99470-1776	contato@terrasp.com.br	n.a	SAO PAULO	SP
RUCKEN INSTRUMENTOS DE MEDICAO LTDA	17080642000140	(11) 2061-9000	vendas2@rucken.com.br	https://rucken.com.br/	SAO PAULO	SP
SAACKE DO BRASIL LTDA	03411743000142	n.a	n.a	https://www2.saacke.com/	RIBEIRAO PRETO	SP
SANAG ENGENHARIA DE SANEAMENTO LTDA	19378942000136	(31) 3275-1388	contato@sanag.com.br	http://www.sanag.com.br/	BELO HORIZONTE	MG
SANEFLUX SOLUCOES AMBIENTAIS LTDA	18647142000100	(14) 3316-6407 (14) 3316-6408	n.a	https://www.gruposaneflux.com.br/	MARILIA	SP
SANEHATEM CONSULTORIA E PROJETOS LTDA	5065971000133	(31) 3271-7962	n.a	http://www.sanehatem.com.br/	BELO HORIZONTE	MG
SANETAL ENGENHARIA E CONSULTORIA EM SANEAMENTO E MEIO AMBIENTE LTDA	4779656000105	(48) 3346-9794	n.a	http://www.sanetal.com.br/	SAO JOSE	SC
SANSUY S/A INDUSTRIA DE PLASTICOS EM RECUPERACAO JUDICIAL	14807945000124	(11) 2139-2854	contato@sansuy.net / marcos@sansuy.net	https://sansuy.com.br/	CAMACARI	BA

SANTIAGO, ALBERTON & CIA LTDA	2860561000196	(45) 3028 99 81	rcconstrutora@uol.com.br	http://www.construtorarcengenharia.com.br/	FOZ DO IGUACU	PR
SATTLERAG	Foreign	n.a	n.a	https://www.sattler.com/home/	Foreign	-
SAUER AUTOMACAO LTDA	11837433000112	(51) 3490-7027	n.a	n.a	GRAVATAI	RS
SCANIA LATIN AMERICA LTDA	59104901000176	n.a	n.a	https://www.scania.com/br/pt/home.html	SAO BERNARDO DO CAMPO	SP
SCHAEFFLER BRASIL LTDA.	57000036000192	+55 15 3335 1500	n.a	https://www.schaeffler.com.br/content.schaeffler.com.br/pt/index.jsp	SOROCABA	SP
SCHEDULE HIDRAULICA E ELETRICA LTDA	54603089000100	(19) 4009-2744	schedule@schedule.net.br	https://www.schedule.net.br/	CAMPINAS	SP
SCHULZ COMPRESSORES LTDA	23635798000143	(47) 3451-6000	n.a	https://www.schulz.com.br/	JOINVILLE	SC
SDMO ENERGIA INDUSTRIA E COMERCIO DE MAQUINAS LTDA	5198319000197	(11) 3789-6000	vendas@maquigeral.com.br ;Alexandre.goncalves@maquigeral.com.br	http://br.sdmo.com/	EMBU DAS ARTES	SP
SEBIGAS DO BRASIL USINAS DE BIOGAS LTDA.	26442258000131	39 0331 428411	info@sebigas.it	http://sebigascotica.com.br/	PORTO ALEGRE	RS
SEMCO EQUIPAMENTOS INDUSTRIAIS LTDA	52225836000198	(11) 3576-2057/(11) 97200-2076	danilo.santos@semco.com.br	www.semcoequipamentos.com.br	SAO PAULO	SP
SEMI ENGENHARIA DE SISTEMAS LTDA	6307645000158	(11) 3079-7343	semi@semi.com.br	https://www.semiengenharia.com.br/	SAO PAULO	SP
SENERGAM SOLUCOES ENERGETICAS AMBIENTAIS LTDA	16836067000109	(63) 8475-3550 / 4101-2955	senergam@senergam.com.br	http://www.senergam.com.br/	PALMAS	TO
SENSORVILLE ELETRO ELETRONICA E AUTOMACAO LTDA	76589308000186	(47) 3422-5111/-	vendas@sensorville.com.br	http://www.sensorville.com.br/	JOINVILLE	SC
SERVICES EQUIPAMENTOS E SERVICOS LTDA	7469183000138	(16) 3513-4000	n.a	http://www.authomathika.com.br/index.php/pt-BR/	SERTAOZINHO	SP
SERVICO NACIONAL DE APRENDIZAGEM INDUSTRIAL	3784680000412	(84) 3204-8053	paulo.isabel@ctgas.com.br	www.ctgas.com.br	NATAL	RN
SERVICO NACIONAL DE APRENDIZAGEM INDUSTRIAL - SENAI	3776284000109	(41) 3271-7188 (41) 3271-7346 (41) 3271-7104	n.a	http://www.portaldaindustria.com.br/senai/	CURITIBA	PR

SIAM ENGENHARIA LTDA	3219872000133	(51) 3013-6848	contato@siamengenharia.com.br	https://siamengenharia.com.br/contato	PORTO ALEGRE	RS
SICES BRASIL S.A.	17774501000128	(11) 97301-7709/(11) 98030-4448	comercial5@sicesbrasil.com.br	https://sices.eu/pt/	ITAPEVI	SP
SIEMENS LTDA	44013159000116	(11) 3908-5683	atendimento.br@siemens.com	https://new.siemens.com/br/pt.html	SAO PAULO	SP
SISTEMAS DE FLUXOS BRASIL INDUSTRIA E COMERCIO - EIRELI	1510736000172	(16) 3306-6001 / 3306-6002 /3306-6003	contato@sfinternational.com.br	http://sfinternational.com.br/	SAO CARLOS	SP
SKYLAND BRASIL EXP. E IMP. ENERGIAS RENOVAVEIS LTDA	29786884000133	(34) 99103-7700	info@skyland.us	n.a	PATOS DE MINAS	MG
SLE DISTRIBUICAO INDUSTRIAL LTDA	24286667000160	(16) 3289-0500 (16) 3289-0600	n.a	http://sleindustrial.com.br/	RIBEIRAO PRETO	SP
SM7 ENGENHARIA, TECNOLOGIA E IMPORTACAO LTDA	10779721000103	(19) 3523-2321	n.a	http://tanksbr.com.br/	RIO CLARO	SP
SOLUTION ENGENHARIA & CONSULTORIA LTDA	10771257000109	(71) 3345-1406 (71) 98128-8043	n.a	https://www.engenharia-solution.com/	FORTALEZA	CE
SOLVI PARTICIPACOES S/A.	2886838000230	(11) 3124-3500	n.a	https://www.solvi.com/	SAO PAULO	SP
SOTECNISOL	Foreign	n.a	n.a	https://www.sotecnisol.pt/	Foreign	-
SPARK ENERGY IMPORTACAO E COMERCIALIZACAO DE MAQUINAS LTDA.	15007281000181	(19) 3115-5000	info@sparkenergy.com.br	https://www.sparkenergy.com/en/home/	INDAIATUBA	SP
SPIRAX-SARCO INDUSTRIA E COMERCIO LTDA	61193074000186	(11) 4615 9000 / 4615 9007	marketing.brazil@br.spiraxsarco.com	http://www.spiraxsarco.com/global/br	COTIA	SP
SPIRIT DESIGN - ATMOVE LIMITADA.	19687633000148	(43) 1 367 79 79-12	georg.wagner@spiritdesign.com	http://www.spiritdesign.com/pt	SAO PAULO	SP
ST ENGENHARIA E PROJETOS INDUSTRIAIS LTDA	5474791000105	(19) 3023-3631	n.a	http://www.stengenharia.com.br/	RIO CLARO	SP
STEMAC SA GRUPOS GERADORES	92753268000627	(45) 3222-1666	n.a	http://www.stemac.com.br/	PORTO ALEGRE	RS
SUNTECO BRASIL ENERGIAS RENOVAVEIS LTDA	21899027000138	(31) 3234-4018	n.a	http://www.suntecobrasil.com.br/	NOVA LIMA	MG

TAROBA CONSTRUCOES LTDA	95396115000153	(45) 3577-0006	adm@tarobaconstrucoes.com.br - engenharia@tarobaconstrucoes.com.br	http://www.tarobaconstrucoes.com.br/	FOZ DO IGUACU	PR
TEC - TECNOLOGIA EM CALOR LTDA	447339000130	(11) 2941-3454	n.a	http://www.teccalor.com.br/	SAO PAULO	SP
TECELAGEM ROMA LTDA	193273000108	(11) 4195-0100	n.a	http://www.roma.ind.br/	TATUI	SP
TECGEN COMERCIO E SERVICOS ELETROMECANICOS LTDA	8604528000181	(62) 3204-2529	sergio@tecgen.srv.br	http://tecgen.srv.br/	GOIANIA	GO
TECH-AR COMERCIO DE EQUIPAMENTOS PNEUMATICOS LTDA	7912390000115	(51) 3561-1414 (51) 3581-2988	n.a	http://www.tech-ar.com.br/	NOVO HAMBURGO	RS
TECNISUB INDUSTRIA E COMERCIO LTDA	2846684000172	(48) 3288-5555	n.a	http://www.tecnisub.com.br/	SAO JOSE	SC
TECNOFERRAMENTAS COMERCIAL IMPORTACAO E EXPORTACAO LTDA	9353055000150	(11) 3312-8090	vendas3@tecnoferramentas.com.br	https://www.tecnoferramentas.com.br/	SAO PAULO	SP
TECNOSANE TECNOLOGIA EM SANEAMENTO LTDA	10465673000170	(31) 3597-1060 (31) 3535-5769	n.a	http://www.tecnosane.com.br/	JUATUBA	MG
TECON	Foreign	n.a	n.a	https://www.tecon.biz/index_en.html	Foreign	-
TECSCAN INDUSTRIA E COMERCIO LTDA	5213508000191	(31) 34053420/	comercial@tecscan.com.br	www.tecscan.com.br	CONTAGEM	MG
TECWATER SYSTEM EQUIPAMENTOS PARA SANEAMENTO LTDA	5406559000130	(11) 3531-8080	n.a	https://www.tecwater.com.br/	SAO PAULO	SP
TEKNERGIA ASSESSORIA E CONSULTORIA LTDA	34392670000112	(11) 3129-3724	n.a	http://www.teknergia.com.br/	LAURO DE FREITAS	BA
TERCEL TERRAPLENAGEM E LOCACAO DE MAQUINAS LTDA	5971877000143	n.a	tercel@tercel.com.br	n.a	SAO PAULO	SP
TERMOAVES INDUSTRIA E COMERCIO LTDA.	1896194000118	(54) 3519-1687	Cristian@termoaves.com.br	https://www.termoaves.com.br/	ERECHIM	RS
TERRA CONSULTORIA AGRONOMICA PLANEJAMENTO AMBIENTAL LTDA	81900839000188	(41) 33389378	mlpsouza@hotmail.com	n.a	CURITIBA	PR
TESTO DO BRASIL - INSTRUMENTOS DE MEDICAO LTDA	3144465000104	(19) 3731-5800	n.a	https://www.testo.com/pt-BR/	CAMPINAS	SP

TEXIAN MANUTENCAO E MONTAGENS INDUSTRIAIS LTDA	714679000180	(51) 3341-9822 (51) 3457-1396	n.a	https://texian.com.br/	MONTENEGRO	RS
TOLEDO DO BRASIL INDUSTRIA DE BALANCAS LTDA	59704510000192	(44)3306-8400	n.a	https://www.toledobrasil.com.br/	SAO BERNARDO DO CAMPO	SP
TRIGAS - INDUSTRIA E COMERCIO LTDA	3811118000198	(54) 9113-2599	trigasbrasil@hotmail.com	http://www.trigas.com.br/	CAXIAS DO SUL	RS
TRIVELATO INDUSTRIA DE GERADORES LTDA	3061399000109	(34) 3213-6464(34) 3212-7100	n.a	http://www.trivellatoenergiarenovavel.com.br/	UBERLANDIA	MG
TS LOCACOES E SERVICOS LTDA	9463607000182	(45) 3574 2646	hsantos@naipi.com.br	n.a	FOZ DO IGUACU	PR
UNICARBO ENERGIA E BIOGAS LTDA.	8015177000173	55 11 4113-4222	mail@unicarbo.com.br	https://www.unicarbo.com.br/	SAO PAULO	SP
UNIFORTE AMERICANA ENGENHARIA E CONSTRUTORA LTDA	2426640000193	(19) 3469-5000/(11) 99656-6783	rvilar@uniforteam.com.br	https://www.uniforteam.com.br/	CAMPINAS	SP
UNION ENGINEERING LATAM LTDA	733268000132	(41) 3273-2087 /(41) 2169-0321 /(41) 8829-8142	n.a	https://union.dk/	CURITIBA	PR
US FIBER EIRELI	10381914000101	(11) 4148-8478	n.a	https://usfiber.com.br/	COTIA	SP
USINAZUL - ENERGIA SUSTENTAVEL E SERVICOS AMBIENTAIS LTDA	10908858000102	(11) 3042-8300	n.a	http://usinazul.com.br/	SAO PAULO	SP
VALDIR GEREMIA INDUSTRIA E COMERCIO LTDA	1315352000107	51 3579.8400	n.a	http://bombasgeremia.com.br/	SAO LEOPOLDO	RS
VALOR E FOCO CONSULTORIA EM ENGENHARIA S/S	5731785000196	(48) 9629-9389	charles@valorefoco.com.br	https://www.valorefoco.com.br/	FLORIANOPOLIS	SC
VALTEC VALVULAS E CONEXOES LTDA	12377846000124	(41) 3347-0505	vendaspr@valtecrobex.com.br	http://www.valtec.com.br/	CURITIBA	PR
VAN DER WIEL HOLDING BV	Foreign	n.a	n.a	https://vanderwiel.nl	Foreign	-
VIBROPAC INDUSTRIA E COMERCIO DE EQUIPAMENTOS LTDA	96228317000159	(11) 2108-5600	n.a	https://vibropac.com.br/	COTIA	SP
VINIFLEX INDUSTRIA COMERCIO E SERVICOS LTDA	2372161000131	(11) 4787-6003	n.a	http://www.viniflex.com.br/	TABOAO DA SERRA	SP
VLB ENGENHARIA E CONSULTORIA LTDA	9664782000138	(31) 3489-8100	n.a	https://www.vlb.com.br/	CURITIBA	PR
VOGELSANG	Foreign	n.a	n.a	https://www.vogelsang.info/	Foreign	-

WAM DO BRASIL INDUSTRIAL LTDA.	18253014000182	(12) 3933-5000	n.a	https://www.wamgroup.com.br/	SAO JOSE DOS CAMPOS	SP
WARTSILA BRASIL LTDA.	36176600000152	(21) 2206-2500	n.a	https://www.wartsila.com/bra/sobre/fale-conosco	RIO DE JANEIRO	RJ
WEBER SANTOS DUARTE EIRELI	20316767000131	(31) 3566-3488(31) 99566-0752	n.a	http://www.wbsuporte.com/home.html	BELO HORIZONTE	MG
WEG EQUIPAMENTOS ELETRICOS S/A	7175725000160	(47) 3276-4000	marciorc@weg.net	https://www.weg.net/institutional/BR/pt/	JARAGUA DO SUL	SC
WIKA DO BRASIL INDUSTRIA E COMERCIO LTDA	61128500000106	(041) 3888.7600 /	n.a	https://www.wika.com.br/	IPERO	SP
YC ENGENHARIA LTDA	1632626000183	(31) 3344-3817	n.a	http://www.ycengenharia.com.br/	BELO HORIZONTE	MG
ZANELLA ENGENHARIA E INDUSTRIA DE MAQUINAS LTDA	83780668000207	(41)2111-2300/	info@zanellamaquinas.com.br	zanellamaquinas.com.br	CURITIBA	PR
ZEECO DO BRASIL COMERCIO E SERVICOS DE EQUIPAMENTOS INDUSTRIAIS LTDA.	13633216000136	(11) 3063-1511	zeeco_brazil@zeeco.com	https://www.zeeco.com/brazil/	SAO PAULO	SP
ZETTECH SOLUCOES INDUSTRIAIS LTDA	19152429000122	(21) 2524-2085(21) 2226-2729	n.a	https://www.zettech.com.br/	RIO DE JANEIRO	RJ
ZORG BIOGASAG	Foreign	n.a	n.a	http://zorg-biogas.com/?lang=en	Foreign	-
ZURICH INDUSTRIA E COMERCIO LTDA	52898913000170	(11) 2020-8080	zurichpt@zurichpt.com.br	https://www.zurichpt.com.br/empresa.php	SAO PAULO	SP

APPENDIX C - LIST OF ACTIVE COMPANIES IN BRAZIL ACCORDING TO THEIR GROUP OF OPERATION

	Automation	Biodigestion	Conslting	Construction	Consulting	Electrical Utilization	Gas Storage	Gas Transport	Gas treatment	Heat Utilization	Pre-treatment	Safety System	Services	Vehicular Utilization
1STBEAM						■								
3DI ENGENHARIA LTDA.		■		■			■	■						
A AQUECEDORES CALDEIRAS E QUEIMADORES ICATERM LTDA										■				
AB ENERGY DO BRASIL LTDA.	■				■	■	■	■	■			■	■	
ABI ENGENHARIA LTDA	■				■									
ABILITY TECNOLOGIA E SERVICOS S/A											■			
ABWASSERREINIGUNGS - INGENIEUR - GMBH					■									
ACESA BIOENERGIA S.A.	■				■		■	■	■				■	
ADI SYSTEMS DO BRASIL PARTICIPACOES LTDA.	■	■			■									
AERO MACK INDUSTRIA E COMERCIO LTDA							■	■						
AGE TECNOLOGIAS, MEIO AMBIENTE, SANEAMENTO & AMBIENCIA LTDA		■			■		■		■		■			
AGENTUR FUR ERNEUERBARE ENERGIEN			■											
AGIMIX SOLUCOES E EQUIPAMENTOS INDUSTRIAIS LTDA		■									■			
AGROBONA - INDUSTRIA DE EQUIPAMENTOS LTDA.											■			

AIR LIQUIDE BRASIL LTDA	■								■					
AKGACHAUER KOMPOSTIERUNGS GMBH & CO.KG													■	
ALBRECHT EQUIPAMENTOS INDUSTRIAIS LTDA							■		■					
ALFAKIT EIRELI	■													
ALFAMEC INDUSTRIA E COMERCIO LTDA		■												
ALTATEC COMERCIO DE GASES LTDA					■	■								
ALTUS SISTEMAS DE AUTOMACAO S.A.	■													
ALVAN BLANCH													■	
ALVES PLASTIC LTDA		■						■						
AMBCORE SERVICOS AMBIENTAIS EIRELI	■				■									
AMBIENTAL ENGENHARIA E CONSULTORIA LTDA					■									
AMBIENTE GAIA CONSULTORIA E PROJETOS AMBIENTAIS E EDUCACIONAIS LTDA					■									
AMERICAN WELDING LTDA		■				■		■						
AMPERI IMPORTACAO E COMERCIO LTDA	■													
AMR COMERCIO DE MANUFATURADOS LTDA		■						■						
ANDE MATERIAIS ELETRICOS LTDA	■													
APR INDUSTRIA DE MAQUINAS EIRELI		■												
AQUAVITA LABORATORIO DE ANALISES QUIMICAS E MICROBIOLOGICAS EIRELI	■													
ARCHEAANLAGENBAU					■									
ARKA AMBIENTAL LTDA	■				■								■	
ASJA BRASIL SERVICOS PARA O MEIO AMBIENTE LTDA	■					■							■	

ASPMAQ FABRICACAO DE MAQUINAS E EQUIPAMENTOS EIRELI		■									■			
ASPRO SERVICOS EM GNV LTDA														■
AST SERVICOS SOLUCOES E TECNOLOGIAS EM MEIO AMBIENTE S A									■					
ASTEN & CIA LTDA							■	■						
ATLAS SEIS						■								
AUGUSTO CLEMENTINO INDUSTRIA E COMERCIO LTDA											■			
AUSTEP						■								
AUTOMATIC IND. E COM. DE EQUIP. ELETRICOS LTDA	■												■	
AUTOMIND AUTOMACAO INDUSTRIAL LTDA	■													
AUTROTEC SISTEMAS ELETRONICOS LTDA	■													
AVISERRA SOLUCOES AMBIENTAIS LTDA		■					■					■	■	
AWITE BIOENERGIA E EQUIPAMENTOS ELETRONICOS LTDA.	■				■				■				■	
BAKTRON MICROBIOLOGIA LTDA	■													
BASE ENGENHARIA ELETRICA S/S LTDA				■		■								
BECHTEL DO BRASIL CONSTRUCOES LTDA	■				■									
BELBA ENGENHEIROS CONSULTORES LTDA					■									
BERMO VALVULAS E EQUIPAMENTOS INDUSTRIAIS LTDA	■											■		
BEST SUL COMERCIO E PRESTACAO DE SERVICOS LTDA	■													
BGS EQUIPAMENTOS AGROPECUARIOS LTDA	■	■				■	■		■	■				
BIO PROJ TECNOLOGIA AMBIENTAL LTDA					■									
BIOCATEC SUSTENTABILIDADE & CATALISADORES LTDA	■				■				■					

BIOCHAMA LTDA												■		
BIOEFICIENCIA ASSESSORIA E CONSULTORIA EM ENGENHARIA LTDA					■									
BIOGAS BIOENERGY SOLUTIONS MAXX					■									
BIOGAS ENERGIA AMBIENTAL S.A													■	
BIOGAS MOTORES ESTACIONARIOS EIRELI		■				■		■	■					
BIOGASCLEAN A/S									■					
BIOKOMPAKT										■				
BIOMETHANE TOTAL SOLUTION DO BRASIL - USINAS DE BIOMETANO EIRELI		■												
BIOSOLAR COMERCIAL, PARTICIPACAO, ADMINISTRACAO E REPRESENTACOES LTDA	■	■			■								■	
BIOTER PROTECAO AMBIENTAL LTDA		■					■							
BOBIG CONTATTO - EQUIPAMENTOS LTDA						■								
BOLT SERVICOS E COMERCIALIZACAO DE ENERGIA LTDA					■									
BRANCO MOTORES LTDA		■				■		■						
BRASIL CLEAN TECNOLOGIAS AMBIENTAIS LTDA		■							■					
BRASIL H2 SOLUCOES ENERGETICAS E EDUCACIONAIS COM CELULAS A COMBUSTIVEL LTDA														■
BRASMETANO INDUSTRIA E COMERCIO LTDA		■			■	■		■	■					
BRASUMA COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA.		■									■			
BRAZIL COMERCIO E MANUTENCAO DE EXTINTORES EIRELI													■	
BSDV BIOGAZ SYSTEM DÉPOLLUTION VALORISATION													■	
BTS				■										

BUHLER INDUSTRIA E COMERCIO DE EQUIPAMENTOS INDUSTRIAIS LTDA.											■			
BUREAU VERITAS DO BRASIL SOC CLAS E CERTIFICADORA LTDA					■									
BUYSOFT DO BRASIL LTDA	■													
C. G. LIMA COMERCIO DE MAQUINAS E DECORACOES EIRELI	■													
CAIB						■								
CALDEMA EQUIPAMENTOS INDUSTRIAIS LTDA										■				
CANAA EQUIPAMENTOS DE COMBATE A INCENDIO LTDA		■						■						
CASA HIDRAULICA TOLEDO EIRELI		■						■						
CASTERS - AUTOMACAO COMERCIAL LTDA	■													
CATERPILLAR BRASIL LTDA		■				■		■						
CENTRO INTERNACIONAL DE ENERGIAS RENOVAVEIS - BIOGAS	■				■									
CEU AZUL - INDUSTRIA E COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA	■													
CHIAPERINI INDUSTRIAL LTDA							■	■						
CHICAGO PNEUMATIC BRASIL LTDA									■					
CHP BRASIL INDUSTRIA E COMERCIO DE GERADORES S/A	■					■								
CIDELSA		■												
CIENLAB EQUIPAMENTOS CIENTIFICOS LTDA	■													
CLEAN ENVIRONMENT BRASIL ENGENHARIA E COMERCIO LTDA	■						■	■					■	
CLOROFILA CONSULTORIA AMBIENTAL LTDA.	■													
COBRAPI GERENCIAMENTO CONSULTORIA E PROJETOS LTDA					■									
COMBUSTEC INDUSTRIA E COMERCIO DE QUEIMADORES LTDA												■	■	

COMERCIAL ELETRICA DW LTDA	■													
CONAUT CONTROLES AUTOMATICOS LTDA	■												■	
CONCERT TECHNOLOGIES S.A.	■													
CONCREMAT ENGENHARIA E TECNOLOGIA S/A	■				■									
CONSOMINAS ENGENHARIA LTDA					■									
CONSTRUTORA ELABORE EIRELI				■										
CONSTRUTORA ELEVACAO LTDA		■												
CONSTRUTORA ICOPAN LTDA				■										
CONSTRUTORA METROSUL LTDA				■										
CONSTRUTORA POSSAMAI LTDA				■										
CONSTRUTORA TAQUARUCU LTDA				■										
CONTECH INDUSTRIA E COMERCIO DE EQUIPAMENTOS ELETRONICOS LTDA	■											■		
COTERGAVI INSTRUMENTOS DE MEDICAO LTDA	■													
COTICA ENGENHARIA E CONSTRUCOES LTDA	■	■			■		■							
CS BIOENERGIA S.A.					■									
DAIMLER AG														■
DB2 ENGENHARIA LTDA	■				■									
DBFZ - DEUTSCHES BIOMASSEFORSCHUNGSZENTRUM					■									
DEDONATI & DEDONATI LTDA		■												
DELTA VINIL INDUSTRIA E COMERCIO LTDA		■												
DIEFRA ENGENHARIA E CONSULTORIA LTDA					■									

DISPARCO INDUSTRIA E COMERCIO LTDA												■		
DISTRIBUIDORA MERIDIONAL DE MOTORES CUMMINS S/A		■				■		■						
DUMONT COMERCIO DE EQUIPAMENTOS ELETRICOS LTDA	■			■		■								
DW ENGENHARIA LTDA.					■									
DWYLER INSTRUMENTACAO E CONTROLE INDUSTRIAL EIRELI	■													
E DE MORAES PIEGEL EMPREITEIRA				■										
EATECNO ENGENHARIA E TECNOLOGIAS DE GESTAO LTDA					■									
ECAM ENGENHARIA , CALDEIRAS E MAQUINAS - EIRELI	■	■			■	■	■	■	■		■	■	■	
ECKERT REPRESENTACOES COMERCIAIS LTDA	■				■									
ECOAMB PESQUISAS AMBIENTAIS LTDA	■				■									
ECO - BIODIGESTORES E REVESTIMENTOS LTDA		■												
ECOGAS COMERCIO, REPRESENTACAO E SERVICOS LTDA												■	■	
ECOMETANO EMPREENDIMENTOS S.A.	■				■									
ECOTEC PRODUTOS E SERVICOS AMBIENTAIS LTDA	■				■		■	■	■			■	■	
ECOWORXX INTERNATIONALAG													■	
ECR EQUIPAMENTOS DE MEDICAO E CONTROLE LTDA	■													
EDRA OLEO GAS E BIOENERGIA INDUSTRIA DE COMPOSITOS LTDA		■						■						
EFFICIENTIA S.A					■									
EISELE EQUIPAMENTOS INDUSTRIAIS EIRELI									■					
EJC ENGENHARIA DE UTILIDADES LTDA					■									
ELIPSE SOFTWARE LTDA	■				■									

ELITE GAS COMERCIO E MANUTENCAO DE EQUIPAMENTOS PARA GAS LTDA		■						■						
EMP ENGENHARIA LTDA					■									
ENC ENERGY BRASIL PARTICIPACOES S.A.	■	■			■	■		■					■	
ENCIBRA S A ESTUDOS E PROJETOS DE ENGENHARIA					■									
ENDRESS + HAUSER CONTROLE E AUTOMACAO LTDA.	■												■	
ENEL GREEN POWER ESPERANCA EOLICA S.A.	■				■									
ENERTEC KRAFTWERKE						■								
ENGEBIO ENGENHARIA E MEIO AMBIENTE S/S LTDA					■									
ENGENHO NOVE ENGENHARIA AMBIENTAL LTDA					■								■	
ENGEPOL GEOSSINTETICOS LTDA							■							
ENGEQUISA ENGENHARIA QUIMICA, SANITARIA E AMBIENTAL LTDA	■													
ENPROCON ENVIRONMENTAL TECNOLOGIES				■										
ER - BR - ENERGIAS RENOVAVEIS LTDA.	■	■			■	■		■	■			■		
ESCO GD TECNOLOGIA EM ENERGIA LTDA					■									
ESCO IGUASSU E ENGENHARIA LTDA					■									
ESCOBAR ESTRUTURAS E FUNDACOES LTDA				■										
ESCOPOWER CONSULTORIA E SERVICOS EIRELI					■									
ESSE ENGENHARIA E CONSULTORIA LTDA					■									
ESTRE AMBIENTAL S/A	■				■									
ETAENGE ENGENHARIA E COMERCIO LTDA		■			■				■					
ETECK SERVICOS TECNICOS LTDA	■	■			■			■	■		■	■	■	

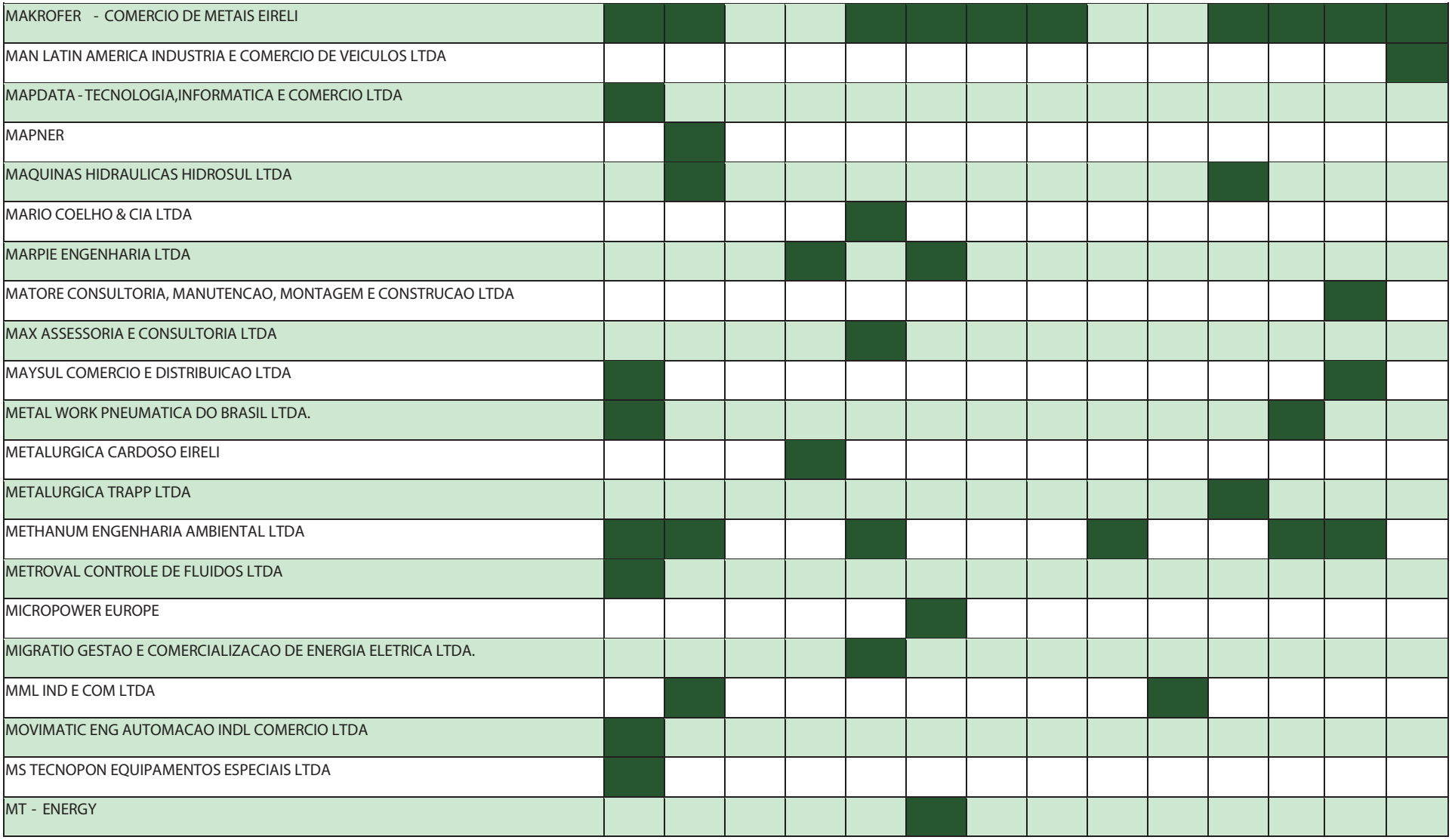
EUROGEN POWER						■								
EXCELENCIA ENERGETICA CONSULTORIA EMPRESARIAL LTDA.					■									
EXCENGE - EXCELENCIA EM ENGENHARIA LTDA					■									
F F ARAUJO COMERCIO DE FERRAGENS FERRAMENTAS E PORTOES		■												
F S INDUSTRIA DE BIODIGESTORES LTDA		■												
F.G.S. BRASIL INDUSTRIA E COMERCIO LTDA		■						■						
FABO BOMBAS E EQUIPAMENTOS LTDA		■						■						
FACHAGENTUR NACHWACHSENDE ROHSTOFFE E.V.													■	
FARGON ENGENHARIA E INDUSTRIA LTDA									■					
FAST INDUSTRIA E COMERCIO LTDA		■											■	
FATOR 10 - ENGENHARIA E CONSULTORIA LTDA					■									
FAZIT - FABRICACAO DE SISTEMAS DE DETECCAO DE GASES LTDA	■													
FCA FIAT CHRYSLER AUTOMOVEIS BRASIL LTDA.														■
FIBRAENG EQUIPAMENTOS INDUSTRIAIS LTDA		■												
FILIPPON ENGENHARIA SS				■		■								
FIMACO DO BRASIL FABRICACAO DE MAQUINAS E EQUIPAMENTOS LTDA.												■		
FLESSAK ELETRO INDUSTRIAL S/A	■	■			■	■		■						
FLOWMEC EQUIPAMENTOS E SISTEMAS LTDA		■												
FLUXO SOLUCOES INTEGRADAS LTDA	■					■	■	■					■	
FOCKINK INDUSTRIAS ELETRICAS LTDA	■	■				■		■					■	
FOKAL EQUIPAMENTOS INDUSTRIAIS LTDA.	■						■		■			■		

FORJAFIX ELEMENTOS DE FIXACAO LTDA													■	
FRAGMAQ INDUSTRIA DE MAQUINA LTDA											■			
FROLING										■				
FUND CENTROS DE REFERENCIA EM TECNOLOGIAS INOVADORAS					■									
G.V. EMPREITEIRA DE OBRAS EIRELI				■										
GAIATEC COMERCIO E SERVICOS DE AUTOMACAO E SISTEMA DO BRASIL LTDA	■	■			■	■	■	■	■			■	■	■
GAS BRASILIANO DISTRIBUIDORA S.A.					■									
GCT GLOBAL CIENCIA E TECNOLOGIA BIO S/A	■	■			■									
GE POWER & WATER EQUIPAMENTOS E SERVICOS DE ENERGIA E TRATAMENTO DE AGUA LTDA.						■	■	■				■		
GENERAL ELECTRIC DO BRASIL LTDA						■								
GENESIS OIL & GAS BRASIL ENGENHARIA LTDA		■						■						
GEO ENERGETICA PARTICIPACOES S.A.					■									
GEOKLOCK CONSULTORIA E ENGENHARIA AMBIENTAL LTDA.	■				■	■							■	
GESE - GESTAO EM SUSTENTABILIDADE ENERGETICA LTDA.	■				■				■					
GICON				■										
GNR DOIS ARCOS VALORIZACAO DE BIOGAS LTDA													■	
GREENLANE BIOGAS EUROPA SV									■					
GREYLOGIX BRASIL MAQUINAS LTDA	■													
GS ENGENHARIA LTDA	■													
GSI BRASIL INDUSTRIA E COMERCIO DE EQUIPAMENTOS AGROPECUARIOS LTDA				■										

GUASCOR DO BRASIL LTDA						■								
GUTERRES PROJETOS LTDA	■				■									
GWE - GLOBAL WASTE ENERGY LTDA						■			■	■		■		
HABTEC ENGENHARIA SANITARIA E AMBIENTAL LTDA					■									
HARRIS PYE BRASIL LTDA	■					■								
HEATMAG INDUSTRIA E COMERCIO LTDA.		■								■				
HEIZOMAT										■				
HELENO & FONSECA CONSTRUTECNICA S/A				■										
HELIBOMBAS - INDUSTRIA E COMERCIO DE EQUIPAMENTOS HIDRAULICOS LTDA.		■						■						
HELIFER INDUSTRIA E COMERCIO DE EQUIPAMENTOS HIDRAULICOS LTDA		■						■						
HERCULES COMPONENTES ELETRICOS LTDA	■													
HERMANN SEWERIN GMBH	■													
HEXIS CIENTIFICA LTDA	■													
HIDROMECANICA GERMEK LTDA		■				■		■						
HIDROQUIMICA ENGENHARIA E LABORATORIOS SOCIEDADE SIMPLES LTDA	■													
HIDRUS TECNOLOGIA AMBIENTAL EIRELI		■												
HIRSA SISTEMAS DE AUTOMACAO E CONTROLE LIMITADA	■						■						■	
HOISTERSUL EQUIPAMENTOS E SERVICOS INDUSTRIAIS LTDA	■	■			■				■				■	
HOLZ WERT		■												
HS TUBULACOES INDUSTRIAIS LTDA	■								■				■	
HUMANA QUALITY TREINAMENTO E DESENVOLVIMENTO LTDA					■									

IBRAM INDUSTRIA BRASILEIRA DE MAQUINAS LTDA							■	■						
IMBIL INDUSTRIA E MANUTENCAO DE BOMBAS ITA LTDA		■						■						
IMC SASTE -CONSTRUCOES, SERVICOS E COMERCIO LTDA.													■	
IMS - SOLUCOES EM ENERGIA LTDA	■													
INDUSTRIA E COMERCIO DE JUNTAS LGT SERVFLEX LTDA.		■						■						
INDUSTRIAS BRASILEIRAS DE ARTIGOS REFRATARIOS - IBAR - LTDA		■								■				
IN-HAUS INDUSTRIAL E SERVICOS DE LOGISTICA LTDA	■				■									
INOVAGRID ENERGIA LTDA						■							■	
INOX-TECH COMERCIO DE ACOS INOXIDAVEIS LTDA												■		
INTECNIAL S.A.					■									
INTEXX INTELIGENCIA E EXPERTISE AMBIENTAL LTDA	■	■			■				■			■	■	
IRRIGAOESTE SISTEMAS DE HIDROPONIA E IRRIGACAO EIRELI		■						■						
ISOCELL COMERCIO DE INSTRUMENTACAO LTDA	■												■	
J. MALUCELLI AMBIENTAL LTDA					■									
JANUS & PERGHER LTDA									■					
JIAS CONSULTORIA EM ENGENHARIA LTDA									■					
JOSE ALBERTO DA MATA MENDES					■									
KANAFLEX S/A INDUSTRIA DE PLASTICOS		■						■						
KB CONSTRUCCIONES				■										
KCE - CONSULTORIA EMPRESARIAL S/S LTDA		■					■							
KEPLER WEBER SA									■					

KIRK ENVIRONMENTAL					■									
KOBLITZ ENERGIA LTDA		■								■				
KOHLER BIODIGESTORES LTDA		■		■	■		■	■	■			■		
KRIEG & FISCHER INGENIEURE GMBH				■										
L M P ASSESSORIA E CONSULTORIA EMPRESARIAL - EIRELI					■									
L. D. SOUZA FABRICACAO DE EQUIPAMENTOS HIDRAULICOS E PNEUMATICOS		■						■					■	
LABOR OBRAS EIRELI				■										
LABORATORIO BIOLOGICO ANALISE QUIMICA E MICROBIOLOGICA EIRELI	■				■									
LABOREX													■	
LANXESS - INDUSTRIA DE PRODUTOS QUIMICOS E PLASTICOS LTDA.		■												
LEAO ENERGIA INDUSTRIA DE GERADORES LTDA		■				■		■						
LIN - KA ENERGY	■													
LITE AUTOMACAO & SISTEMAS EIRELI	■												■	
LMG NEGOCIOS INTELIGENTES S.A.		■				■	■	■						
LZ AMBIENTAL CONSULTORIA E SERVICOS LTDA					■									
M 3 H EQUIPAMENTOS HIDRAULICOS LTDA		■						■						
M. RESENDE & CARVALHO EQUIPAMENTOS AGROINDUSTRIAIS LTDA		■												
MADHELO CONSTRUCOES EIRELI				■										
MAGNA ENGENHARIA LTDA					■									
MAGNETROL INTERNATIONAL BRAZIL LLC	■													
MAIA NOBRE ENGENHARIA LTDA	■				■									



MAKROFER - COMERCIO DE METAIS EIRELI
MAN LATIN AMERICA INDUSTRIA E COMERCIO DE VEICULOS LTDA
MAPDATA - TECNOLOGIA,INFORMATICA E COMERCIO LTDA
MAPNER
MAQUINAS HIDRAULICAS HIDROSUL LTDA
MARIO COELHO & CIA LTDA
MARPIE ENGENHARIA LTDA
MATORE CONSULTORIA, MANUTENCAO, MONTAGEM E CONSTRUCAO LTDA
MAX ASSESSORIA E CONSULTORIA LTDA
MAYSUL COMERCIO E DISTRIBUICAO LTDA
METAL WORK PNEUMATICA DO BRASIL LTDA.
METALURGICA CARDOSO EIRELI
METALURGICA TRAPP LTDA
METHANUM ENGENHARIA AMBIENTAL LTDA
METROVAL CONTROLE DE FLUIDOS LTDA
MICROPOWER EUROPE
MIGRATIO GESTAO E COMERCIALIZACAO DE ENERGIA ELETRICA LTDA.
MML IND E COM LTDA
MOVIMATIC ENG AUTOMACAO INDL COMERCIO LTDA
MS TECNOPON EQUIPAMENTOS ESPECIAIS LTDA
MT - ENERGY

MUELLER ELETRODOMESTICOS LTDA										■				
MULTEE SERVICOS OPERACIONAIS AS EMPRESAS LTDA	■	■			■	■	■	■	■		■	■	■	■
MULTITECNICA INSTALACOES INDUSTRIAIS LTDA							■	■					■	
N NASCIMENTO DISTRIBUIDORA DE MOTORES ELETRICOS LTDA	■													
NELCI FATIMA DE OLIVEIRA		■						■						
NEPIN ACESSORIOS INDUSTRIAIS LTDA	■	■					■	■	■	■		■		
NETZSCH DO BRASIL INDUSTRIA E COMERCIO LTDA		■					■	■						
NEUMAN & ESSER AMERICA DO SUL LTDA							■	■						
NEW ECO -TEC VERFAHRENSTECHNIK						■								
NEWTEC TECNOLOGIAS AMBIENTAIS LTDA		■					■							
NORDSHIP MONTAGEM E CONSTRUCOES INDUSTRIAIS LTDA	■				■									
NORGREN LTDA												■		
NOVUS - PRODUTOS ELETRONICOS LTDA	■													
NTC BRASIL COMERCIO DE MATERIAIS TECNICOS PARA CONSTRUCAO CIVIL EIRELI		■												
O.A.ENGENHARIA AMBIENTAL LTDA					■									
OBC INTERNATIONAL COURIER SERVICES													■	
OBRA PRONTA - PROJETOS E EXECUCOES DE ENGENHARIA LTDA.				■										
OKO THERM										■				
OLIVEIRA E MARQUES ENGENHARIA LTDA					■									
OMEGA BRASIL SOLUCOES EM INFORMATICA, IMPORTACAO, EXPORTACAO E REPRESENTACOES LTDA.	■													

O-TEK TUBOS BRASIL LTDA.		■					■							
OTZ ENGENHARIA LTDA.					■									
PAL ENERGY ENERGIA SOLAR LTDA		■												
PAQUES BRASIL SISTEMAS PARA TRATAMENTO DE EFLUENTES LTDA		■			■				■					
PEAD BRASIL SOLUCOES EM TERMOPLASTICOS LTDA		■						■						
PENTAIR WATER DO BRASIL LTDA									■					
PLANAVE S A ESTUDOS E PROJETOS DE ENGENHARIA					■									
PLANET BIOGAS GLOBAL GMBH		■												
PLANEX S/A CONSULTORIA DE PLANEJAMENTO E EXECUCAO					■									
PLANTFORT ESTUFAS AGRICOLAS				■										
PLASTOLANDIA HIDRAULICA E PLASTICOS INDUSTRIAIS LTDA		■						■						
POLICON SOLUCOES INDUSTRIAIS LTDA	■													
POLIERG INDUSTRIA E COMERCIO LTDA		■						■						
POLIMATIC - EQUIPAMENTOS INDUSTRIAIS LTDA												■		
PROCKNOR ENGENHARIA LTDA	■				■									
PROMINENT BRASIL LTDA													■	
PROSAN CONSULTORIA E PROJETOS DE SANEAMENTO LTDA	■				■									
PROTEGO BRASIL VALVULAS E CORTA CHAMAS LTDA												■		
PROTONS SERVICOS INDUSTRIAIS, MONTAGENS, REFORMAS E COMISSIONAMENTO DE PAINES DE QUADROS ELETRICOS LTDA	■													
REAL CENTER MATERIAIS E EQUIPAMENTOS ELETRICOS LTDA	■			■		■								

RECOLAST EMPREENDIMENTOS E IMPERMEABILIZACOES EIRELI	■	■			■		■		■				■	
RENOVA COMERCIO DE MAQUINAS E EQUIPAMENTOS INDUSTRIAIS E DE APLICACOES AMBIENTAIS LTDA	■											■		
RETIFICADORA DE MOTORES BARAO LTDA						■								
RONDOTEC COMERCIO DE EQUIPAMENTOS DE INFORMATICA LTDA	■													
ROTARIA DO BRASIL LTDA.	■	■			■	■	■	■	■			■	■	
ROTORTECH COMERCIO PECAS E SERVICOS LTDA							■	■					■	
RS ACIONAMENTOS E MATERIAIS ELETRICOS LTDA	■			■		■								
RS GERADORES LTDA						■								
RUBENS PIRO TERRAPLENAGEM E LOCACAO	■												■	
RUCKEN INSTRUMENTOS DE MEDICAO LTDA	■													
SAACKE DO BRASIL LTDA										■				
SANAG ENGENHARIA DE SANEAMENTO LTDA					■									
SANEFLUX SOLUCOES AMBIENTAIS LTDA		■							■					
SANEHATEM CONSULTORIA E PROJETOS LTDA					■									
SANETAL ENGENHARIA E CONSULTORIA EM SANEAMENTO E MEIO AMBIENTE LTDA					■									
SANSUY S/A INDUSTRIA DE PLASTICOS EM RECUPERACAO JUDICIAL		■					■							
SANTIAGO, ALBERTON & CIA LTDA				■										
SATTLERAG							■							
SAUER AUTOMACAO LTDA	■													
SCANIA LATIN AMERICA LTDA														■

SCHAEFFLER BRASIL LTDA.		■						■						
SCHEDULE HIDRAULICA E ELETRICA LTDA												■		
SCHULZ COMPRESSORES LTDA							■	■						
SDMO ENERGIA INDUSTRIA E COMERCIO DE MAQUINAS LTDA		■				■		■						
SEBIGAS DO BRASIL USINAS DE BIOGAS LTDA.	■	■			■				■				■	
SEMCO EQUIPAMENTOS INDUSTRIAIS LTDA		■									■			
SEMI ENGENHARIA DE SISTEMAS LTDA	■													
SENERGAM SOLUCOES ENERGETICAS AMBIENTAIS LTDA	■	■				■		■	■	■				
SENSORVILLE ELETRO ELETRONICA E AUTOMACAO LTDA	■													
SERVICES EQUIPAMENTOS E SERVICOS LTDA	■												■	
SERVICO NACIONAL DE APRENDIZAGEM INDUSTRIAL													■	
SERVICO NACIONAL DE APRENDIZAGEM INDUSTRIAL - SENAI	■				■									
SIAM ENGENHARIA LTDA					■									
SICES BRASIL S.A.	■													
SIEMENS LTDA	■													
SISTEMAS DE FLUXOS BRASIL INDUSTRIA E COMERCIO - EIRELI												■		
SKYLAND BRASIL EXP. E IMP. ENERGIAS RENOVAVEIS LTDA	■					■			■					
SLE DISTRIBUICAO INDUSTRIAL LTDA					■								■	
SM7 ENGENHARIA, TECNOLOGIA E IMPORTACAO LTDA		■					■							
SOLUTION ENGENHARIA & CONSULTORIA LTDA					■									
SOLVI PARTICIPACOES S/A.	■				■									

SOTECNISOL													■	
SPARK ENERGY IMPORTACAO E COMERCIALIZACAO DE MAQUINAS LTDA.		■						■						
SPIRAX - SARCO INDUSTRIA E COMERCIO LTDA												■		
SPIRIT DESIGN - ATMOVE LIMITADA.													■	
ST ENGENHARIA E PROJETOS INDUSTRIAIS LTDA					■									
STEMAC SA GRUPOS GERADORES						■								
SUNTECO BRASIL ENERGIAS RENOVAVEIS LTDA	■				■		■	■						
TAROBA CONSTRUCOES LTDA				■										
TEC - TECNOLOGIA EM CALOR LTDA							■	■	■	■		■		
TECELAGEM ROMA LTDA							■							
TECGEN COMERCIO E SERVICOS ELETROMECANICOS LTDA		■				■		■						
TECH - AR COMERCIO DE EQUIPAMENTOS PNEUMATICOS LTDA							■	■	■				■	
TECNISUB INDUSTRIA E COMERCIO LTDA							■	■						
TECNOFERRAMENTAS COMERCIAL IMPORTACAO E EXPORTACAO LTDA	■													
TECNOSANE TECNOLOGIA EM SANEAMENTO LTDA		■												
TECON							■							
TECSCAN INDUSTRIA E COMERCIO LTDA											■			
TECWATER SYSTEM EQUIPAMENTOS PARA SANEAMENTO LTDA							■							
TEKNERGIA ASSESSORIA E CONSULTORIA LTDA					■	■							■	
TERCEL TERRAPLENAGEM E LOCACAO DE MAQUINAS LTDA		■												
TERMOAVES INDUSTRIA E COMERCIO LTDA.		■												

TERRA CONSULTORIA AGRONOMICA PLANEJAMENTO AMBIENTAL LTDA					■									
TESTO DO BRASIL - INSTRUMENTOS DE MEDICAO LTDA	■													
TEXIAN MANUTENCAO E MONTAGENS INDUSTRIAIS LTDA	■												■	
TOLEDO DO BRASIL INDUSTRIA DE BALANCAS LTDA	■													
TRIGAS - INDUSTRIA E COMERCIO LTDA		■												
TRIVELATO INDUSTRIA DE GERADORES LTDA		■				■		■					■	
TS LOCACOES E SERVICOS LTDA				■										
UNICARBO ENERGIA E BIOGAS LTDA.	■				■								■	
UNIFORTE AMERICANA ENGENHARIA E CONSTRUTORA LTDA				■										
UNION ENGINEERING LATAM LTDA	■						■	■	■					
US FIBER EIRELI		■												
USINAZUL - ENERGIA SUSTENTAVEL E SERVICOS AMBIENTAIS LTDA	■				■								■	
VALDIR GEREMIA INDUSTRIA E COMERCIO LTDA		■						■						
VALOR E FOCO CONSULTORIA EM ENGENHARIA S/S					■									
VALTEC VALVULAS E CONEXOES LTDA							■					■		
VAN DER WIEL HOLDING BV						■								
VIBROPAC INDUSTRIA E COMERCIO DE EQUIPAMENTOS LTDA							■	■						
VINIFLEX INDUSTRIA COMERCIO E SERVICOS LTDA		■					■							
VLB ENGENHARIA E CONSULTORIA LTDA					■									
VOGELSANG													■	
WAM DO BRASIL INDUSTRIAL LTDA.	■										■			

WARTSILA BRASIL LTDA.	■					■							■	
WEBER SANTOS DUARTE EIRELI	■												■	
WEG EQUIPAMENTOS ELETRICOS S/A	■	■				■		■						
WIKA DO BRASIL INDUSTRIA E COMERCIO LTDA	■													
YC ENGENHARIA LTDA					■									
ZANELLA ENGENHARIA E INDUSTRIA DE MAQUINAS LTDA											■			
ZEECO DO BRASIL COMERCIO E SERVICOS DE EQUIPAMENTOS INDUSTRIAIS LTDA.												■		
ZETTECH SOLUCOES INDUSTRIAIS LTDA	■												■	
ZORG BIOGASAG				■										
ZURICH INDUSTRIA E COMERCIO LTDA	■													

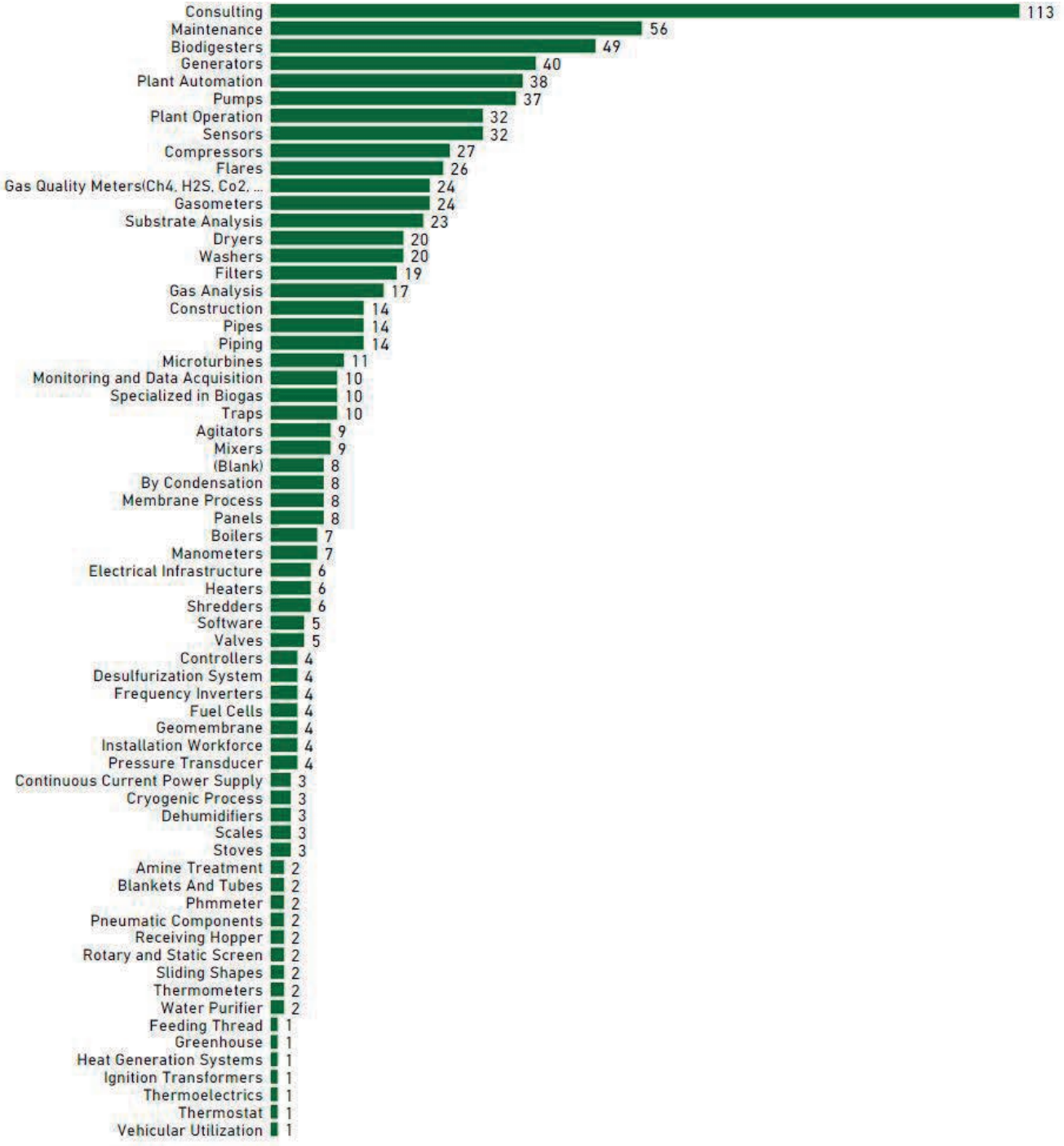
APPENDIX D - LIST OF PRODUCTS FOR EACH SECTOR

Automation	Biodigestion	Construction	Electrical Utilization	Gas Storage	Gas Transport	Gas treatment	Heat Utilization	Pre-treatment	Safety System	Services	Vehicular Utilization
Controllers	Agitators	Construction	Continuous Current Power Supply	Compressors	Compressors	Amine Treatment	Boilers	Feeding Thread	Flares	Maintenance	Fuel Cells
Frequency Inverters	Biodigesters	Electrical Infrastructure	Electrical Infrastructure	Gasometers	Pipes	By Condensation	Heat Generation Systems	Mixers	Ignition Transformers	Specialized in Biogas	Vehicular Utilization
Gas Analysis	Blankets And Tubes	Greenhouse	Generators	Valves	Pumps	Cryogenic Process	Ignition Transformers	Receiving Hopper	Traps		
Gas Quality Meters(Ch4, H2S, Co2, H2O, Etc)	Geomembrane	Installation Workforce	Maintenance			Dehumidifiers	Stoves	Rotary and Static Screen	Valves		
Manometers	Heaters	Sliding Shapes	Microturbines			Desulfurization System	Thermoelectrics	Shredders			
Monitoring and Data Acquisition	Piping					Dryers					

Panels	Pumps					Filters					
Phmmeter						Membrane Process					
Plant Automation						Washers					
Plant Operation						Water Purifier					
Pneumatic Components											
Pressure Transducer											
Scales											
Sensors											
Software											
Substrate Analysis											

Thermometers											
Thermostat											

APPENDIX E - NUMBER OF COMPANIES BY TYPE OF PRODUCT



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