

IMPACTS OF THE ENERGY MATRIX ON BRAZILIAN SUSTAINABLE DEVELOPMENT

IMPACTOS DA MATRIZ ENERGÉTICA NO DESENVOLVIMENTO SUSTENTÁVEL DO BRASIL

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ABSTRACT

Objective: Analyze the impacts of the energy matrix and its relationship with Sustainable Development.

Methodology: The study is classified as descriptive composed of mixed methods, based on the results of ANEEL 2020, disclosed in the Generation Information Systems of ANEEL SIGA, and the results of EPE from the years 2015 to 2019, disclosed in the Energy Balance National.

Results: As main results, it stands out: that the energy matrix of Brazil has been going through changes, especially in the last five years, taking into account the main renewable energies consumed and emerging in the market, the renewable energies in the period between 2015 and 2019 had a growth around 12%, while non-renewable energies decreased by 8.4%, however the world energy matrix is unlike the Brazilian matrix, where non-renewable energies had an increase of 0.1% and renewable energies had a reduction of about 0.8%.

Originality/value: With the increasing demand for energy consumption and considering environmental problems, such as global warming, the search for a cleaner energy matrix has become the focus of several research. This study aims to propose that both the Brazilian case - which is already treated as an example - as well as the world case can be explored in a more satisfactory way its energy reserves, thus adopting a diversified and efficient energy matrix, consequently reducing the environmental impacts.

Keywords: Energy matrix, renewable energies and sustainable development

RESUMO

Objetivo: Analisar os impactos da matriz energética e sua relação com o desenvolvimento sustentável.

Metodologia: Classifica-se o estudo como descritivo, composto de métodos mistos, tendo como base os resultados da ANEEL 2020, divulgados no Sistemas de Informação de Geração da ANEEL SIGA, e os resultados da EPE dos anos de 2015 a 2019, divulgados no Balanço Energético Nacional.

Resultados: Como principais resultados, destaca-se que a matriz energética do Brasil vem passando por mudanças, especialmente nos últimos cinco anos, levando em consideração as principais energias renováveis consumidas e emergentes no mercado. As energias renováveis no período de 2015 a 2019 tiveram um crescimento em torno de 12%, enquanto as energias não renováveis tiveram uma redução de 8,4%, contudo a matriz energética mundial mostra-se de modo contrária à matriz brasileira, na qual as energias não renováveis tiveram um aumento de 0,1% e as energias renováveis tiveram uma redução de aproximadamente 0,8%.

Originalidade / valor: Com o aumento da demanda de consumo de energia e considerando problemas ambientais, como o aquecimento global, a busca por uma matriz energética mais limpa tornou-se o foco de diversas pesquisas. Assim, este estudo visa propor que, tanto no caso brasileiro – o qual já é tratado como exemplo – quanto no caso mundial, pode-se explorar de maneira mais satisfatória suas reservas energéticas, adotando-se uma matriz energética diversificada e eficiente, de modo a reduzir os impactos ambientais.

Palavras-chave: Matriz energética. Energias renováveis. Desenvolvimento sustentável.

1 INTRODUCTION

The growing and constant demand for natural resources has environmental problems consequently. Parallel to this scenario, it is known that climate change interferes considerably in the energy matrix of a given region, caused largely by the emission of gases from the burning of fossil fuels, putting in evidence, and even generating, the energy crisis (Silveira, 2018).

This matrix is understood as the set of available energy sources that meet the country's demand - renewable or non-renewable (Law, 2014). With the increased demand of global energy consumption, the energy matrix has allowed for several studies in favor of advancements and implementations of renewable sources, with the focus of enabling a more efficient matrix (Weber et al, 2019). Among these studies, the search for a sustainable future through the implementation of a clean energy matrix is heavily addressed (Elrahmani et al, 2021). Renewable energy sources such as solar, biomass, and wind point to strategies for a viable development (Vivek et al., 2021).

Energy plays a key role in society and organizations, and each year its potential is becoming more competitive due to growing demand and increased consumption of goods and services. Recent studies on several continents address the issue of energy efficiency, seeking to improve and make energy sources more efficient (Silveira, 2018). Research involving feasibility studies of the implementation of renewable energy sources stands out. Approaches carried out in countries such as Turkey, (Taner; Dalkilic, 2019) and Iran (Jamshidi; Pourhossein; Asadi, 2021), where the feasibility of deploying a clean energy matrix has been proven.

The development of solar and wind energy sources as well as new optimized models appears promising for sustainable development. However, the cost limitations and technological requirements associated with them hinder the implementation of renewable sources (Vivek et al., 2021). In contrast, according to some projections, the use of renewable energy in Brazil, mainly energies from wind (Raimundo et al. 2018) and solar sources, tend to grow a lot (De Andrade Guerra et al. 2015).

Given the above, the best way to achieve sustainable development, in which economic growth is aimed without harming the environment, diversifying the energy matrix is the best strat-



egy, that is, implementing and making renewable energy sources more efficient (Kang, 2020). The current Brazilian scenario presents promising perspectives with regard to achieving a cleaner energy matrix. However, it is not feasible to carry out the substitution of one energy source for another if there is no awareness in its consumption, thus achieving a rational use of energy (Silveira, 2018). An energy source can be classified as renewable when it is made up of natural resources, and energy from the sun, water, wind, biomass, among others, can be considered inexhaustible (Jurasz, Canales, Kies, Guezgouz, & Beluco, 2020).

In Brazil, there are several programs to encourage investment in renewable energy, such as the Program for the Development of Distributed Generation of Electric Energy (ProGD), aiming to decrease the emission of gases by 2030, thus improving the environment and promoting greater productivity in the electricity sector (Santos, 2018). Another example is the Incentive Program for Alternative Sources of Electric Energy (PROINFA), which aims to increase the participation of clean energy sources by taking advantage of the resources available in the region, achieving this goal by facilitating the creation of markets for energy from renewable sources through private initiative (Torres & Moreira, 2020). These incentive programs are extremely important, since approximately 80% of the energy consumed by humans globally comes from the burning of fossil fuels such as coal, oil, and natural gas (Johnsson et al., 2019).

The massive use of these resources, besides causing the depletion of these energy sources, is most responsible for the emission of toxic gases and pollutants, which alter the global climate, acidify waters, and cause damage to health (Aya, Inatomi, Edgar, & Udaeta, 2012). In this sense, obtaining electricity through fossil fuels is the main source of sulfur oxides (SO_x, SO₂), nitrogen oxides (NO_x, NO and NO₂), carbon dioxide (CO₂), methane (CH₄), carbon monoxide (CO) and particulates, among them, lead (Pb). (Goldemberg & Villanueva, 2003).

According to Goldemberg & Villanueva (2003), 85% of the sulfur released into the atmosphere comes from burning fossil fuels, as well as 75% of CO₂ emissions, the main culprit for the greenhouse effect. The emission of gases thus generates major environmental impacts, such as water acidification and global warming.

This study, of innovative character, regarding the thematic aspects of the 2030 agenda, sustainable development, of the energy matrix, will contribute to an analysis of the world energy matrix and of Brazil (2015-2019). This research has as central problem, to evaluate the energy matrix of Brazil and the World, which presents indicators that concern sustainability, also allowing an analysis of the indicators of the last 5 years. Contributing to the field of science, to organizations and to society. Thus, the following objective was outlined: to analyze the impacts of the Brazilian and world energy matrix over the period from 2015 to 2019 and its relationship with sustainable development. The following sections present: the theoretical aspects of the energy matrix, renewable energy, and sustainable development; the study method; the analysis and results; and the final considerations.

2 ENERGY MATRIX

The energy matrix can be considered as a certain amount of energy sources available in a region (Mantovani, Neumann, & Edler, 2016), thus being composed of the local energy resources. Through the analysis of the energy matrix, it is possible to plan the energy sector, which is responsible for ensuring the production and proper use of all energy produced. In this process, among all the information obtained, the most important is the amount of natural resources that are being used, thus verifying if these are used rationally (Mantovani et al., 2016), being of extreme importance for the establishment of policies that promote quality of life for the population.

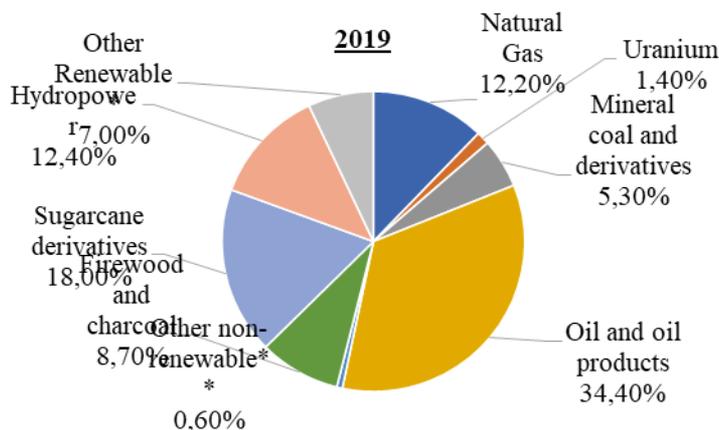


Considering the large generation capacity of fossil fuels, Brazil, as well as other countries, takes advantage of energy production through electricity (Janeiro, 2008). Due to a greater presence in Brazil with the use of alternative energies, the Brazilian electric matrix has been undergoing several modifications in recent years, being still largely dominated by hydroelectric power, which is the largest generating source in Brazil, corresponding to about 70% of the installed power (Kang, 2020). Thus, the electric matrix is also composed of other renewable energies, such as solar, wind, biomass and hydro, as mentioned earlier, which are the most exploited in Brazil (Pacheco, 2006).

The current energy scenario, analyzed from a global perspective, is still based on the consumption of non-renewable sources, fossil fuels such as oil, coal, oil and natural gas. However, because they are non-renewable energies, most of them have a limited reserve, and, with a greater demand for these energies, supply decreases dramatically. Moreover, during their consumption, these resources emit harmful gases into the atmosphere (Marques, Silva, & Vellutini, 2019). On the other hand, it is estimated that by 2040, the sector involving renewable energy will account for almost half of the world's electricity matrix (International Energy Agency [IEA], 2016).

The strategy for the following years focuses on the pursuit of a so-called clean energy matrix, which generates all or most of its energy through renewable sources. This will promote the more efficient use of energy in different sectors of society and also the diversification of its energy matrix (Kang, 2020).

Figure 1 - Diversification of the Energy Matrix for the year 2019.



Source: EPE (2019).

From the data in figure 1, it is possible to observe that the Brazilian energy matrix is composed of renewable and non-renewable energy sources. Non-renewable energy sources make up about 53.9%, with energy sources derived from petroleum and natural gas being the most prominent in this sector. In turn, renewable energy sources make up the remainder of this matrix, making up 46.1%, with energy sources derived from sugar cane and water standing out.

2.1 Renewable Energies

Renewable energy sources are considered inexhaustible sources because they are constantly renewed, i.e., they do not become extinct as they are used (Empresa de Pesquisa Energética [EPE], 2019). These energies are derived from the natural cycle of the sun, the primary source of virtually all energy on planet Earth, and because of this, they are endless and do not alter the thermal balance.

Taking into consideration the evidence presented for a developed nation, the supply and demand for clean energy becomes indispensable. In view of these factors, international organizations directed at serving sustainability promote discussions between energy and sustainable development.

Accelerating global warming trends, evidenced by storms and ice melt, drought and famine, unrest and migration, increasingly demand greater urgency regarding the need to rapidly end the age of fossil fuels. A growing consensus now perceives the transition to renewable energy systems, often understood as a process of fuel substitution as a key strategy to address the climate crisis (Burke & Stephens, 2018).

According to the Brazilian Energy Review (2017), the energy matrix of Brazil and other blocks of the world has presented significant structural changes in the last 44 years, which aim to adapt to the global climate scenario.

According to ANEEL 2020, Brazil has 82.76% of its energy matrix coming from renewable sources, these being: biomass, hydropower, solar energy, wind energy, and undi-electric energy (energy from sea waves). Conceptualizing them, we have:

Table 1 - Classification of the types of energy

Type of energy	Concepts
Hydropower	Hydroelectric or hydraulic energy is obtained through the use of gravitational potential energy, related to the unevenness between the dam and the generator. For this process to be carried out, it is necessary to build plants on rivers that have a high volume of water and that present unevenness in their course. It is worth pointing out that hydroelectric energy is the main component of the Brazilian electricity matrix.
Wind energy	It is the kinetic energy contained in the masses of air in movement. Its use is possible through the conversion of the kinetic energy of translation into the kinetic energy of rotation.
Biomass	Chemical energy obtained through plants, in the form of carbohydrates obtained in photosynthesis. It should be noted that animals and plants, as well as their derivatives, are biomass, an abundant resource on planet Earth. Biomass can be used as fuel in its raw form or from its derivatives. The use of biomass as an energy source helps to slow down the harmful effects of global warming.
Solar energy	It is considered the indirect source of all other types of energy. However, when we refer to solar energy, we take into consideration its direct use, that is, solar radiation as a source for heating environments and generating mechanical or electrical power.
Ondomotor energy	It is the energy that comes from the kinetic energy contained in sea waves. An important point about wave energy is that there is a wide range of technologies that can be employed in the process of conversion to electrical energy, the appropriate technology for each type depends on the characteristics of the site: depth, geology, among others. In 2012, the Port of Pecém Plant was installed in Ceará, being the first wave power plant in Latin America. According to data from ANEEL, the Porto do Pecém Plant has a generation capacity of 50 KV. It is worth remembering that Wave Energy is an energy on the rise, which is increasingly taking space when it comes to renewable sources.

Source: Authors.

It is understood that alternative energy sources present a fundamental role for the growth and service of society. From this perspective, it is important to highlight the use of this resource in the global, socioeconomic and environmental scenario (Jarlita, Silva, Maria, Sales, Veloso, & Soares, 2019).



2.2 Sustainable Development

Sustainable development can be understood as development that meets present needs without affecting the ability of future generations to meet their own needs. This process occurs by optimizing natural resources and studying the product life cycle, aiming for economic growth without environmental degradation (Corona, Shen, Reike, Carreón, & Worrel 2019).

An important point when it comes to sustainable development is energy. Energy is primarily addressed by Sustainable Development Goal 7, whose main objective is to “Ensure access to affordable, viable, sustainable and modern energy for all.” After all, the impacts of energy extraction, conversion and consumption activities on other sectors may predate their reach - these have economic, social and environmental impacts on nature (David L McCollum et al 2018).

The economic, social and environmental aspects within sustainable development forms the triple bottom line or triple bottom line as shown in figure 2. The term triple bottom line was introduced by Jonh Elkington who defined sustainability as “a principle that ensures that our actions today will not limit the range of economic, social, and environmental options available to future generations” (Da Silva, 2013).

Figure 2 - Sustainability tripod



Source: Adapted from Elkington (2020).

Allied to this, the green economy should be further explored, since it aims to reduce the emission of pollutants into the atmosphere, employing sustainable technology and relating concepts such as renewable energy and energy efficiency (Almeida, 2018).

In this context, seeking alternatives to the current environmental problems requires actions that generate long-term effects, thus achieving economic development in a way that does not harm the environment. Thus, investing in renewable energy, promoting the replacement of fossil fuels by green sources, is an excellent option to achieve sustainable development (Hargrave, & Economy, 2014).

It is known that energy resources, such as fossil fuels, are finite, while renewable energy sources are sustainable for a relatively longer period. Thus, seeking to develop and implement a sustainable energy sector is of fundamental importance in defining and creating a sustainable society. Renewable and eco-friendly energy, a term used to define something environmentally friendly, should be studied, encouraged, promoted and implemented (Simas, & Pacca, 2013), such as wind, hydro, photovoltaic energy can be used in place of energy from non-renewable sources.

There is a strong relationship between energy efficiency and environmental impact. For societies to achieve or attempt to achieve sustainable development, environmental concerns must be taken into consideration, as sustainable development requires the use of energy resources that cause as little environmental impact as possible (Santos, 2017). Many energies conservation and efficiency improvement programs have been and are being developed to reduce and make more efficient the current energy consumption (Kang, 2020).

One can also highlight the 17 Sustainable Development Goals (SDGs), among them, goal number 7 - Affordable and Clean Energy -, as shown in figure 3, which is part of a global agenda adopted during the United Nations Summit in 2015, which must be achieved by 2030. Goal 7 of the SDGs is to ensure reliable, sustainable, modern, and affordable access to energy for all. Thus, this theme is relevant to the extent that renewable energy sources provide greater environmental preservation, in addition to its inexhaustible nature, unlike non-renewable sources and harmful to the environmental balance, such as oil (Medeiros, 2018).

Figure 3 – SDG 7



Source: United Nations Organization.

According to a study done by the UN, energy is the dominant contributor to climate change, accounting for around 60 percent of all greenhouse gases emitted. For many decades, fossil fuels such as coal, oil or gas have been important sources of electricity production, but burning carbon produces large amounts of greenhouse gases that cause climate change and have harmful impacts on people's well-being and the environment (Serviço Social da Indústria [SESI], 2019).

Given this scenario, several governments around the world have been determining goals to reduce gas emissions, and, within this goal, organizations and the population have been motivated to adopt renewable sources, whether for electricity and fuel generation or for chemicals.

Besides the points mentioned related to climate and the population's health, fossil sources are concentrated in certain regions of the planet, which leads to social and economic inequality that generates tensions, or even wars, between different nations. Renewable energies, on the other hand, because they are obtained locally - through the sun, wind, tides, the potential energy of rivers,

thermal sources, or biomass - help reduce the inequalities introduced by the economy derived from fossil sources, generating energy security and income (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2018). Thus, inserting renewable sources as a primary form in energy matrices is to think about the sustainable, socioeconomic, and environmental development of the planet (Jarlita et al., 2019).

Brazil actively participated in the construction of the SDGs, having composed working groups and committees for the elaboration of the Goals within the UN in the years before the institution of the 2030 Agenda (Furtado, 2018). Currently, the country has been working on SDG 7 with some government actions, such as the Plans for clean energy incentives and the National Alcohol Program (Proálcool), which was started many years ago. A special highlight can be given to the promising National Biofuels Policy (RenovaBio), which aims to provide contributions to the fulfillment of the commitments determined in the Paris Agreement. This policy also aims to promote the development of biofuels in the energy matrix, focusing on the regularity of safe and effective supply and ensuring predictability for the fuel market, with a view to energy efficiency gains and, consequently, reduction of greenhouse gas emissions (SESI, 2019).

3 STUDY METHOD

This article is classified, as to objectives, as descriptive exploratory research as it sought a better understanding of the subject matter, still little known (VERGARA, 2006), primarily as to the effects that the energy matrix presents along with its impact on Brazil's sustainable development.

As for the form of approach to the problem, a qualitative and quantitative research was chosen, seeking to understand the phenomena in a deeper way, considering the data obtained during the research.

As for the means, it was a secondary data research, which were by means of the protocol for documentary study of the National Agency of Electric Energy - ANEEL 2020, disclosed in the Generation Information System of ANEEL (www.aneel.gov.br), and the results of the Energy Research Company - EPE (www.epe.gov.br/pt) of the years 2015 to 2019, disclosed in the National Energy Balance.

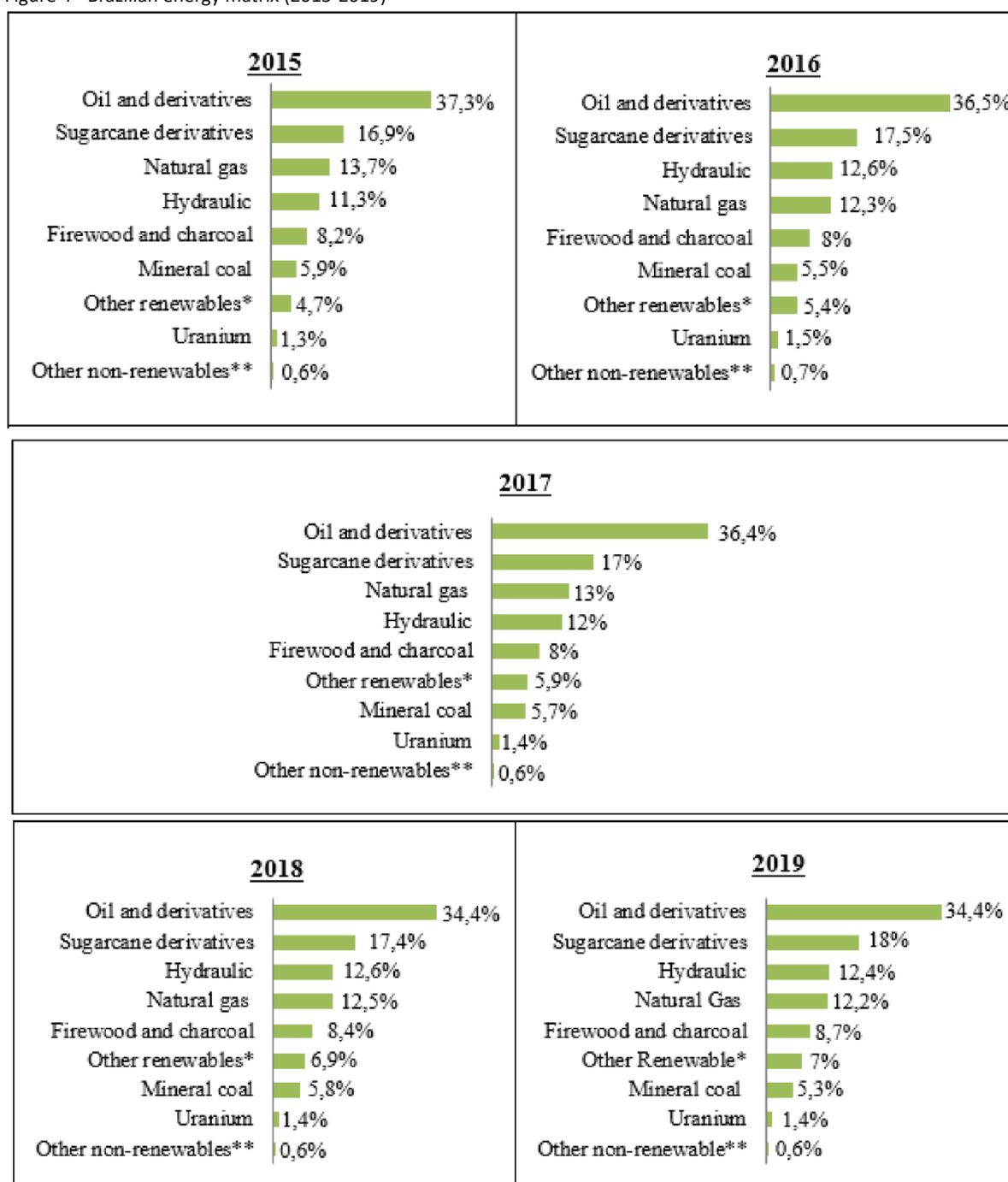
For data analysis, simple descriptive statistics (mean and frequency) were applied, following the precepts of Hair et al. (2014), Montgomery (2001), and Pereira (1999). Quantitative data were analyzed using SPSS - Statistical Package for the Social Sciences software. The results and analysis are presented below.

4 ANALYSES AND RESULTS

In view of the changes that have occurred over the past few years in the world energy sector, with a common goal of reducing the environmental impact caused by the exploitation of energy sources, there has been a major change in the profile of the energy matrix of several countries. By observing the data about the Brazilian energy matrix, great changes can be observed both in relation to renewable energy sources and in relation to non-renewable sources. Below are annual graphs of the composition of the Brazilian energy matrix, between the years 2015 and 2019.



Figure 4 - Brazilian energy matrix (2015-2019)



Source: Empresa de Pesquisa Energética.

*Renewables include lye, biodiesel, wind, solar, rice husk, biogas, wood waste, charcoal gas and elephant grass.

**Non-renewable include blast furnace gas, steel mill gas and sulfur gas.

The Brazilian energy matrix still consists largely of non-renewable sources, derived from oil or minerals, which can cause serious consequences for the environment, however, it has been falling over the years, with a reduction of 2.94 percentage points. With this, the uses of renewable energy have increased significantly over time, and based on this scenario, the diversification of the composition of the energy matrix is important, as well as the feasibility of using clean energy sources

(Marques, Silva, & Vellutini, 2019).

Renewable energy sources are directly interconnected with climate change - for example, it is possible to analyze a hydroelectric power plant that is directly dependent on rainfall condition. In Brazil, with the high incidence of droughts in some regions and in view of constant climate change, new renewable energy alternatives have been developed and implemented, such as hydropower, biomass, wind power, and photovoltaics (Bozio, 2018).

Hydropower corresponds to a large portion of the electricity matrix and is the most exploited energy source in the country and the largest electricity generating source, reaching a share of 60.7% of the Brazilian electricity matrix, according to a survey conducted by ANEEL in 2018. The energy from hydroelectric plants shows a growth, between the period from 2015 to 2019, of 9.6%; with this advance, it has become a consolidated type of energy in Brazil's energy matrix.

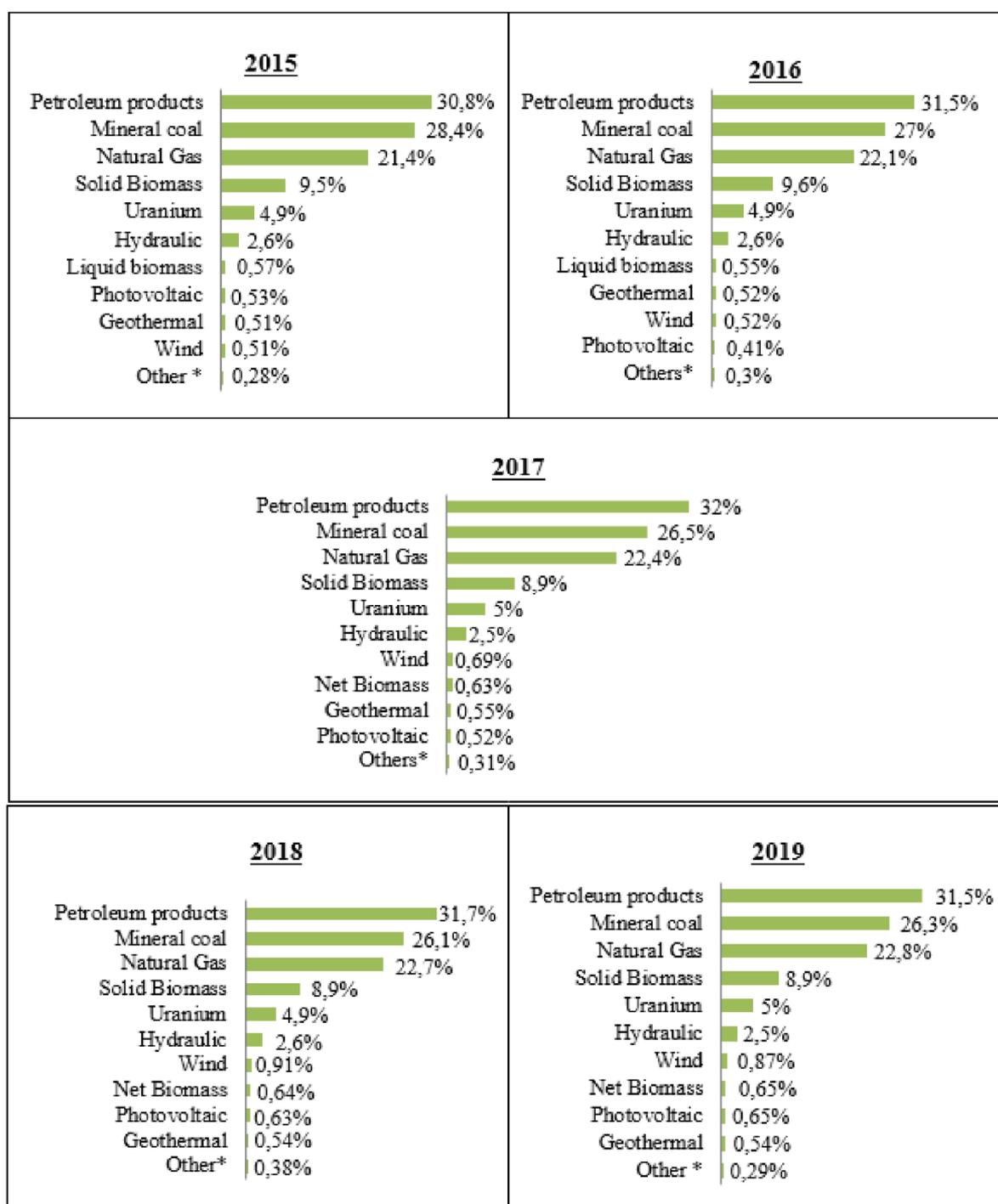
Another main source of energy is biomass and considering the need to use renewable sources aiming at environmental well-being, the use of biomass ends up being beneficial, mainly because it is a way to reduce the emission of pollutant gases, besides minimizing the disposal of waste in landfills. The country has favorable conditions for the use of biomass as a renewable source (Ministério de Minas e Energia [MME], 2007b, p. 199). About electricity generation, the main biomass used is sugarcane bagasse, originating from the production of sugar and ethanol (EPE, 2015, p. 137). Biomass meets about 8.4% of the Brazilian electricity matrix, according to the National Energy Balance report (EPE, 2020).

Renewable energy, between the period 2015 and 2019, had an increase of 12%, among which is photovoltaic energy, coming from sunlight, which is very promising, because Brazil has regions with high incidence of the sun's rays and wind energy, coming from the force of the winds. Being considered stable and rising, Brazil shows promise in the growth of this energy source, especially in the Northeast, with its apex in 2019, with the expectation that it will continue to grow.

It is still worth noting that these renewable energies need research aimed at reducing the costs for implementation, because currently the investments are exorbitant (Jarlita et al., 2019).



Figure 5 - World energy matrix 2015-2019



Source: Ministry of Mines and Energy.

The world energy matrix is composed mainly by non-renewable energy sources composing about 86% world energy matrix, predominantly oil derivatives, and these energy sources have a finite reserve and contribute with several impacts to the environment. There is a prospect of further increasing exploration and decreasing supply (Marques, Silva, & Vellutini, 2019), such as mineral coal, which has the forecast between the years 2018 and 2030 to achieve an annual growth of 2.5%,

with China being the main dependent on this energy source (Kang, 2020), however, between the years 2015 to 2019 there was a decrease in about 7.4%.

Renewable energy has also been growing over the years, making up about 14% of the world energy matrix in 2019 - with a scenario of increasing this percentage of energy in the coming years. Between the period 2015 and 2019, we can observe a growth in the production of renewable energy, mainly from wind and solar sources. Wind energy increased 70% and had its apex of growth in 2018, while solar energy increased, in the same period, 22.6% and had its highest growth in 2019.

Making an analysis between figures 4 and 5, it can be concluded that renewable energy sources in Brazil correspond to about 46.1%, bringing a benefit to the country with regard to the environment, in relation to the emission of greenhouse gases, because the use of renewable energy in Brazil is still superior it's to the use in other countries of the world, so the emission of greenhouse gases is also lower, since the largest emitters of these gases are fossil fuels (Marques, Silva, & Vellutini, 2019).

In this way, Brazil puts itself ahead of many other countries, projecting itself to the achievement of the SDGs. The SDGs are part of Agenda 2030, created in 2015 at the UN. This document proposes a set of seventeen goals to be achieved by signatory countries, called Sustainable Development Goals (SDGs), to promote human development in harmony with economic, environmental, etc. development, since they are undeniably connected (Souza, 2020).

Considering the countries that make up the Association of Southeast Asian Nations (ASEAN), which have an energy matrix composed predominantly of fossil fuels, it is expected that there will be an increase in electricity consumption in the coming decades, thus increasing its contribution to carbon emissions (Effendi & Resosudarmo, 2021). However, the ASEAN region has a large untapped renewable energy potential that can be used as an alternative for clean energy generation. Considering this utilization of clean energy generation capacity, it is estimated to increase the use of renewable energy sources by 23% by 2025 (Effendi & Resosudarmo, 2021). Like Asia, the European Union also aims to have a greater focus on sustainable development, aiming to use renewable energy to decrease carbon emissions and achieve sustainable development goals (Nazari et al., 2021).

Africa has several renewable energy sources that are in constant progress and development, constituting a large part of the continent's current energy matrix. This energy mix has favorable characteristics and a huge potential for renewable energy generation, as well as being an important condition for economic development and social and environmental development (Fortes et al., 2020). In contrast to Africa, Australia is a country that has the highest incidence of solar energy per square meter and therefore has an energy availability that has allowed a greater commitment to the use of solar energy (EL et al., [s. d.]).

The share of renewable energy sources in global electricity consumption has been increasing, following the goals of SDG 7, regarding achieving clean and affordable energy for all on this path, with the goal by 2030 (PLAF, 2021).

The use of certain fossil sources negatively affects the environment, causing irreversible social and environmental losses and impacting the quality of life of many populations, especially people in vulnerable situations, since these people usually live in the most remote places and in precarious conditions of basic sanitation, having little or no access to energy. If we consider that renewable sources are inexhaustible and found everywhere, along with the very low environmental impact compared to fossil sources, their use is indeed a key strategy for a sustainable and harmonious human development. Thus, in a study done on the island of Marajó in the state of Pará, where renewable sources were deployed for power generation, it was concluded that the implementation of these projects favored the standard of living of local communities and were also used as a factor

of socioeconomic insertion, contributing to the well-being of the population.

Finally, electricity is the key factor for industrialization, urbanization, and economic growth. In this sense, sustainable planning of the use of electricity generation sources can foster the expansion of the quality of life of populations (Borges, Baraúna, & Chotoe, 2015).

5. FINAL CONSIDERATIONS

According to studies, energy production from fossil sources contributes directly to global warming. Considering this fact, obtaining energy from renewable sources is a strategy of paramount importance when it comes to sustainable development and climate change mitigation.

Through this study we were able to analyze Brazil's energy matrix on the world stage, considering the indicators presented and the current Brazilian scenario.

If we analyze the behavior of the world energy matrix, the numbers are disappointing, because in the year 2019, 85.89% of the matrix was composed of fossil sources, having an increase of 0.11% compared to the year 2015. One can negatively highlight the year 2017, in which the share of fossil sources reached 86.21% of the energy matrix.

On a national level, Brazil is well ahead of the world average, with 46.1% of its matrix composed of renewable sources, which is a positive point. Thus, one can give special emphasis to wind and solar energy, which, despite not showing significant numbers in the Brazilian energy matrix, are showing great growth.

Brazil has a great renewable energy potential because it is a country with great diversity and abundance of natural resources. Based on this, the numbers should be more expressive. In this sense, although there are studies aimed at the use of renewable sources, more efficient strategies and more structured public policies are needed to reduce costs for the implementation of these research, along with an awareness of their consumption, thus enabling Brazil to take advantage of all its renewable energy potential, contributing to a diversification in the energy matrix in a sustainable way and achieving energy security.

Therefore, for future studies, it is suggested to carry out the correlation of the energy matrix of other continents versus the world matrix, verifying its degree of investment and government initiatives. To relate the impacts of the energy matrix versus the progress of the Sustainable Development Goals (SDGs), and to verify the sensitivity of the matrix to the changes caused by the SDGs. Another study suggestion is to analyze whether the increase in energy efficiency in products and processes is causing a decrease in consumption in the energy matrix. It is also possible to perform through future studies the projection of the energy matrix in a period of 10 years, analyzing how the energy matrix tends to behave, verifying the participation of renewable sources, giving special attention to two sources that currently show a high growth: solar and wind sources. Another future study is about the triple bottom line energy indicators, analyzing the developing countries, and how these indicators are behaving and how they tend to behave. One can also analyze the strategic planning of the use of renewable sources, analyzing climate change and how these renewable energy sources can adapt. Another future point to be studied is how the changes in the world energy matrix contribute to the mitigation of climate change, analyzing which are the points of greatest interest and sensitivity. It is also possible to analyze which are the renewable sources that are not yet part of the energy matrix, but that present a growing degree of investment and show promise in the future, as well as to study the degree of investment versus the growth potential of renewable energy sources, being able to analyze which path the energy matrix intends to follow, and which sources are already becoming obsolete.

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2. Development of hypotheses or research questions (empirical studies)	√	√	√
3. Development of theoretical propositions (theoretical work)	√	√	
4. Theoretical foundation / Literature review	√	√	√
5. Definition of methodological procedures		√	√
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