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BRAZILIAN DAYLIGHT SAVING TIME AND ELECTRICITY GENERATION

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ABSTRACT
Brazilian Daylight Saving Time consists of advancing the (official) Legal Time of certain states by one hour. It is adopted with a view to limiting the maximum load to which the electric system is subject in the period of the year with the highest consumption, increasing the reliability of the National Electric System. This article analyzes and discusses the electrical situation in Brazil to justify, or not, the adoption of daylight saving time. In addition, it discusses the economic, social, cultural and health effects resulting from the artificial alteration of clocks during the summer. Consumption data (load) recorded during the summer of 2024, and electricity generation data in this period were analyzed. These data were collected from the records of the institutional bodies of the country's energy sector: ANEEL, ONS, EPE, CCEE, and other similar bodies. To discuss social and cultural impacts, journalistic reports on the subject were analyzed, and to assess possible impacts on human health, scientific articles of related research were analyzed. It resulted that the application of daylight saving time this year does not bring benefits to the National Electric System and has no effect on the maximum demand that occurs during the afternoon. The level of the SIN reservoirs has improved and there is a contribution from wind and solar sources, generating significant amounts of energy, precisely at times of greater demand. The seasonal daylight saving time that affects people's circadian cycle, negatively impacting the health of the population, causing many disorders ranging from insomnia and hunger, to cardiovascular accidents, through tiredness, inattention, lack of energy and traffic accidents, is not justified.

Keywords: Electrical demand, Photovoltaic and wind generation, Daylight saving time, Circadian cycle, Public health.

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INTRODUCTION

Daylight saving time is the practice of advancing clocks one hour during the spring and summer months, with the aim of saving energy in regions that receive less sunlight outside of this time of year. The first suggestion to force people to get up earlier during the summer was put forward in 1784 by American politician and inventor Benjamin Franklin, before the invention of electricity. The idea of daylight saving time was proposed by the Anglo-New Zealander George Hudson in 1895 and by the Englishman William Willett in 1907, and was adopted for the first time in Germany in 1916 [STEPHENSON, 2022] and [FUNDASONO, 2024]. Daylight saving time anticipates human activities by one hour in this period by shifting the load curve. The early start of daily activities makes the day "longer" by taking advantage of sunlight for an additional hour in the late afternoon, delaying the time of turning on the lights in homes, streets, and shops by one hour.

Each country decides whether or not to adopt daylight saving time. Differentiated time is adopted in 70 countries around the world [JANNUZZI, 1999] reaching about a quarter of the world's population [LANGE et al, 2024], but it is not a global rule – several countries do not adopt it [DM, 2024]. Most of the countries that adopt the measure are located in the regions between the tropics and the poles. Daylight saving time is adopted in countries such as Canada, Greenland, Australia, most of Europe, New Zealand, Chile, etc. In most of the lands inhabited at high latitudes, winter is more severe, with the Sun setting very early and rising late. In summer the reverse occurs, it is common for the day to still be clear at 8 pm, or even at 10 pm. Therefore, in these places daylight saving time makes a big difference. In the U.S., it is called, perhaps erroneously, " *daylight saving time"* (DST).

In Brazil, daylight saving time was adopted for the first time on 10/01/1931, through Decree No. 20,466, covering the entire national territory, in force until 03/31/1932. It was applied in the country in irregular years until 1968, when it was revoked. It was instituted again in 1985, and until 2018 daylight saving time was adopted annually. Until 2007, the duration and geographic scope of daylight saving time were defined annually by decree of the Presidency of the Republic. On 09/08/2008, Decree No. 6,558 defined rules for the start and end dates of daylight saving time in Brazil [Brasil, 2008]. According to Brazilian law, on the third Sunday of October, the clocks in some states must be advanced by one hour, a change that must remain until the third Sunday of February, when the clocks are again put back. Over time, the scope (initially national) was reduced successively. Decree No. 9,242/2017 reduced daylight saving time by two weeks from 2018. Daylight saving time has been modified to start on the first Sunday in November. In its last configuration, daylight saving time was adopted in the South, Southeast and Midwest regions.

Brazilian Daylight Saving Time consists of advancing the (official) Legal Time of certain states by one hour. It is adopted at the initiative of the Executive Branch, with a view to limiting the maximum load to which the electric system is subject in the period of the year with the highest consumption, to increase the reliability of the National Interconnected System (SIN), consisting of transmission lines and generating plants. The adoption of Daylight Saving Time enables a certain energy saving for the country [MONTALVÃO, 2005].

The traditional load profile, in force in the second half of the twentieth century, popularly called the "duck curve", presented in the summer a "peak consumption" between 6 pm and 9 pm, a period in which lighting and the use of electric showers put pressure on electricity demand, a period called "peak hours" [EPE, NT-DEA-01, 2015]. According to the Ministry of Mines and Energy (MME), the main objective of adopting daylight saving time is to ensure the best use of solar energy in relation to electricity, that is, extending the period in which there is natural light, it is expected that there will be a decrease in energy consumption during peak hours. The MME recognizes that due to changes in the lifestyle habits of Brazilians, the time of highest energy consumption has moved from the night to the middle of the afternoon, changing the profile of electricity demand. In 2019, a decree was signed that ends daylight saving time. The end of differentiated hours aims to favor the biological clock and increase worker productivity. The topic is again under discussion.

OBJECTIVE

This article aims to discuss the social, cultural and health effects resulting from the artificial alteration of clocks during the summer. Additionally, analyze and discuss the situation of the electrical system in Brazil to justify or not the adoption of daylight saving time.

METHODOLOGY

To discuss social and cultural impacts, journalistic reports on the subject that have repercussions in the media were analyzed. To assess possible impacts on human health, scientific articles on related research were analyzed. To discuss the electricity situation, consumption data (load) recorded during the summer of 2024 and electricity generation data in this period were analyzed. These data were collected from the records of the institutional bodies of the country's energy sector: National Electric Energy Agency (ANEEL), National Electric System Operator (ONS), Energy Research Company (EPE), Electric Energy Trading Chamber (CCEE), and other related bodies.

RESULTS

SOCIOECONOMIC ASPECTS

- **Public opinion**

People's opinion of Daylight Saving Time is very individualized, and subjective, and does not take into account effects on individual and public health. Each one has their own reasons for liking, or disliking, the change in the official time. There is no consensus on the subject.

There are no public results of recent opinion polls. Old public opinion polls, dating from 2001, obtained the following results [EBC, 2012].

- 74% approved daylight saving time
- 25% disapproved of daylight saving time
- 1% did not know how to answer

The main argument of the interviewees in favor of daylight saving time is that the end of the working day still with daylight allows an additional hour of leisure during the day. For many, an hour of fraternization – "*happy hour*". There are reports of a reduction in crimes in this period during the time of leaving work, but we did not find public statistics to support this statement.

- **Sports and Leisure**

Some sports such as outdoor running, football and volleyball "peladas", golf, beach tennis and other activities that benefit from extended natural lighting. Daylight saving time favors afternoon activities; There are those who like it and there are those who don't. No conclusive results were found on this topic [ZICK, 2014]. Delayed dusk provides children with an additional hour to play outside.

- **Commerce and Tourism**

The retail trade looks favorably on the adoption of daylight saving time, which allows the population an hour with daylight and pleasant temperature after work to visit stores and shop. The volume of impulse purchases tends to benefit from circulation [Associação Comercial de São Paulo (ACSP), apud SANTOS, 2022].

Entrepreneurs in the tourism, bar and restaurant sectors claim the return of daylight saving time, claiming that the extra hour of daylight in the late afternoon positively impacts business [CARRANÇA, 2021]. For the tourism sector, daylight saving time is an important boost to business, especially in coastal cities. The restaurant sector will have an extra hour of light after office hours, the so-called "happy-hour" [SANTOS, 2022]. The Brazilian Association of Bars and Restaurants (ABRASEL) has expressed itself in favor of daylight saving time, arguing that it leverages the sector's revenue [SOLMUCCI, 2022]. The brewing industry also benefits from this increase in consumption. On the other hand, restaurants will have one hour less to serve dinner because it is not the habit of Brazilians to dine while there is still sunlight. Also, it can bring problems for evening entertainment.

ASPECTS RELATED TO HUMAN BEHAVIOR AND HEALTH

Chronobiology studies the rhythms and biological phenomena that occur in living beings with a certain periodicity. This branch of biology is responsible for the study of the "biological clock" of living beings. The life of almost all organisms is governed by various biological rhythms that are defined as physiological and behavioral oscillations. Circadian rhythms (lat: circa diem, around a day) are those that have a period of approximately 24 hours that have evolved in adaptation to the environmental day and night cycle [PANDA, HOGENESCH and KAY, 2002]. They are found in many organisms, from fungi and single-celled bacteria to higher organisms such as insects and mammals, including man. The bases of these oscillations are internal molecular clocks that maintain their rhythm even in the absence of external timing signals. The circadian clock has evolved to improve an organism's adaptation to its environment and to ensure timed coordination of life-sustaining activities such as feeding, sleeping, as well as the coordination of physiological and biochemical mechanisms [JUD, SCHMUTZ, HAMPP et al., 2005].

Several biological rhythms are generated at the cellular level, from molecular processes of gene expression, commonly called molecular clocks. Circadian rhythms are the most studied in this context, which also studies efferent genes, that is, those genes whose expression transmits the rhythmicity generated in molecular clocks to other cellular functions [CECON and FLORES, 2010] and [RIVAS, 2012]. In this way, the molecular clock

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can regulate the expression of rhythms in cells, organs, and, ultimately, in the physiology and behavior of organisms.

The circadian rhythm is the mechanism by which our body regulates itself between day and night. From it, our physiological processes are commanded so that our body can wake up, feel hungry, be active, stay sleepy, and so on. Changes in the circadian cycle in humans cause disorders such as insomnia; dysrhythmia (jet-lag) such as that caused by travel across time zones; mood disorders that can lead to conditions such as depression, bipolar disorder, and seasonal affective disorder; attention disorders and lack of concentration at work. Our body works according to a biological clock, a part of the nervous system that determines the times when the body feels sleepy, hungry, tired, and the moments of greatest physical and mental disposition.

A forced alteration in the biological rhythm of each one causes a series of physical problems [LIM, PARK, YANG and KWON, 2010]. Until the body synchronizes its habits to the new schedule, it is normal to experience difficulty sleeping and, as a consequence, sleepiness during the day, changes in mood and eating habits, malaise and difficulty concentrating. This causes a drop in concentration during the day, increasing the risks of accidents at work or in traffic.

Daylight saving time causes effects such as insomnia, tiredness and even hormonal changes such as the production of melatonin (hormone responsible for signaling the onset of the night) and cortisol (hormone released in the body before the individual wakes up that has the function of preparing him for the day's activities) [PARAGINSKI, 2014]. The changes caused by the start (\end) of daylight saving time sometimes complicate time measurement and can cause setbacks and inconveniences regarding travel, billing, record keeping, medical devices, heavy equipment and, above all, sleep patterns. They cause insomnia, increased stress, cardiovascular diseases and emotional disorders [SIPILA, RUUSKANEN, RAUTAVA and KYTO, 2016].

As some people feel its effects more intensely, especially in relation to daytime sleepiness, it is recommended to avoid driving for a long time in the first few days. It takes time for the body to get used to it. The adaptation period usually takes five to seven days, if there is prior preparation. Otherwise – the situation of the vast majority – sleep will be readapted in a maximum of two weeks. The medical recommendation is always the same, but many people have difficulties in following it: always sleeping at the same time

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[HAGGSTRAM, 2022] and [FUNDASONO, 2022]. By adopting the routine of having regular schedules, it will be easier to face daylight saving time [PARAGINSKI, 2014].

Switching from standard time to daylight saving time has been associated with increased cardiovascular morbidity, including risk of myocardial infarction [TORO, TIGRE, and SAMPAIO, 2015], [MANFERDINI, FABBIAN, GIORGI et al., 2018] and [JANSKY and LJUNG, 2020], stroke [SIPILA, RUUSKANEN, RAUTAVA, and KYTO, 2016], and hospital admissions due to the occurrence of acute atrial fibrillation [CHUDOW, DREYFUS, ZAREMSKI et al., 2020] and return visits to the hospital [ELLIS, LUTHER and JENKINNS, 2018], [FERRAZI, ROMUALDI, OCELLO et al., 2018]. An increase in mortality was observed in 16 European countries in the two weeks following the change in clocks due to daylight saving time [LÉVI, ROBINE, REY et al., 2020]. The American Academy of Sleep Medicine (AASM) has recommended that the U.S. should eliminate seasonal clock changes in favor of a fixed, year-round, national time. Current data better support the adoption of a year-round standard time, which better aligns with the daily biological cycle and offers distinct benefits for public health and safety [RISHI, AHMED, PEREZ et al., 2020].

There is evidence that traffic accidents increase when daylight saving time is introduced [SMITH, 2016]. In Canada, a study was carried out that showed that, the day after the implementation of daylight saving time and in the week following its end, there was a 7% increase in traffic accidents [OLALLA, 2020] and [FUNDASONO, 2022]. A study by the University of Colorado reports that traffic accidents increase by 6% in the week following the implementation of daylight saving time [UCB, 2020]. Among the costs generated by these accidents can be related to expenses with hospitals, and with delays to work and fuel, in the case of traffic jams caused by collisions, among others. There are suggestions to make daylight saving time permanent, [CUNNNINGHAM, NUÑEZ, HENTAI et al., 2022] to reduce traffic accidents between vehicles and wild animals in the USA, this study suggests that this measure can reduce expenses in the US in the order of US$ 1.2 billion annually. We did not find equivalent research in Brazil.

ASPECTS RELATED TO THE ELECTRICAL SYSTEM

The electricity sector publishes data on electricity generation and demand that allows a more detailed analysis of the influence of daylight saving time. In addition, savings in the electricity sector are the main institutional justification for the change in official time during the summer.

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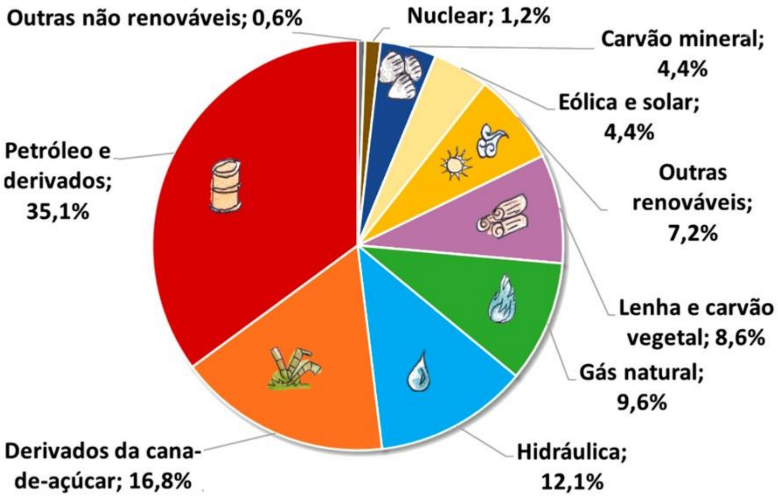
- **Electricity generation in Brazil**

Electricity is responsible for a good portion of the Brazilian energy matrix. During the second half of the twentieth century, and in particular after the world oil crisis of 1973, aiming at energy security, Brazil invested a lot in hydroelectric power plants (HPP). In the world energy matrix, still marked by a large share of coal, petroleum products and natural gas, 86% is from non-renewable sources.

In Brazil, although the consumption of energy from non-renewable sources is even higher than that of renewables, we use more renewable sources than in the rest of the world. Brazil's energy matrix is very different from the world's. The National Energy Balance [EPE-BEN, 2024] points out that: adding firewood and charcoal, hydraulics, sugarcane derivatives, wind, solar, and other renewables, we meet almost half of our energy matrix in 2023 – 49.1% of the total (Fig. 1).

FIGURE 1: ENERGY MATRIX – BRAZIL - 2021



Source: BEN, 2024

When looking at the electricity sector, the Brazilian matrix is even more renewable than the energy one, because much of the electricity generated in Brazil comes from HPPs. Hydraulics account for about 59% of the electricity matrix and only 17.4% is from non-renewable fossil sources, including nuclear (Fig. 2). Brazil has a well-diversified and balanced electricity matrix

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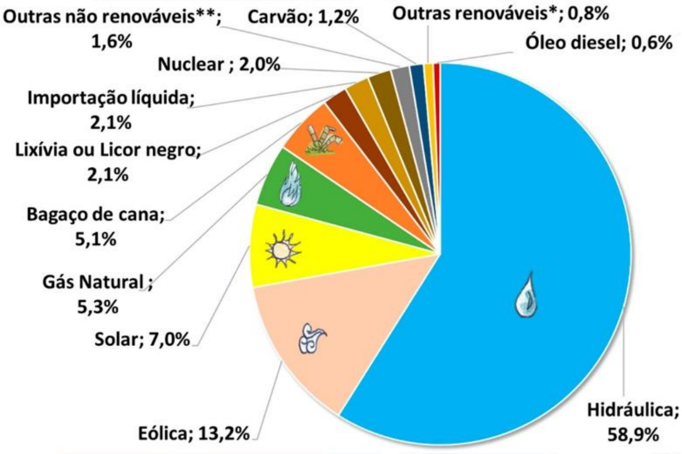
FIGURE 2: ELECTRICITY MATRIX – BRAZIL - 2023



Source: BEN, 2024

The problem is that there are many restrictions on the production of HPPs, mainly motivated by the variation of the hydrological cycle. The blackout that affected 18 states and affected 90 million Brazilians in November 2009 was considered the most serious in the history of Brazil and motivated the installation of a park of thermoelectric plants (UTE), using fossil fuels, to be activated when the HPPs do not meet demand.

Water restrictions make it necessary to dispatch the UTE in order of merit [ONS, 2020] which makes the generation model hydrothermal [EPE, 2021]. This form was used in the last decade due to the prolonged drought that affected the levels of the storage reservoirs of the National Interconnected Electric System (SIN). The low levels in the reservoirs were alarming of a possibility of a lack of electricity, if the UTE are unable to meet the peak demand in the SIN, causing new blackouts. One way to reduce the impact on the maximum load on the system was the implementation of daylight saving time, anticipating human activities by one hour during this period, thus changing the electricity demand profile, "flattening" the demand curve and reducing the nocturnal peak load in the SIN.

- **Current hourly demand**

The load on the SIN during the year 2024 had the behavior illustrated in Fig. 3. The maximum load exceeded 100 GWh/h on 6 hot days during the month of March, always in the afternoon.

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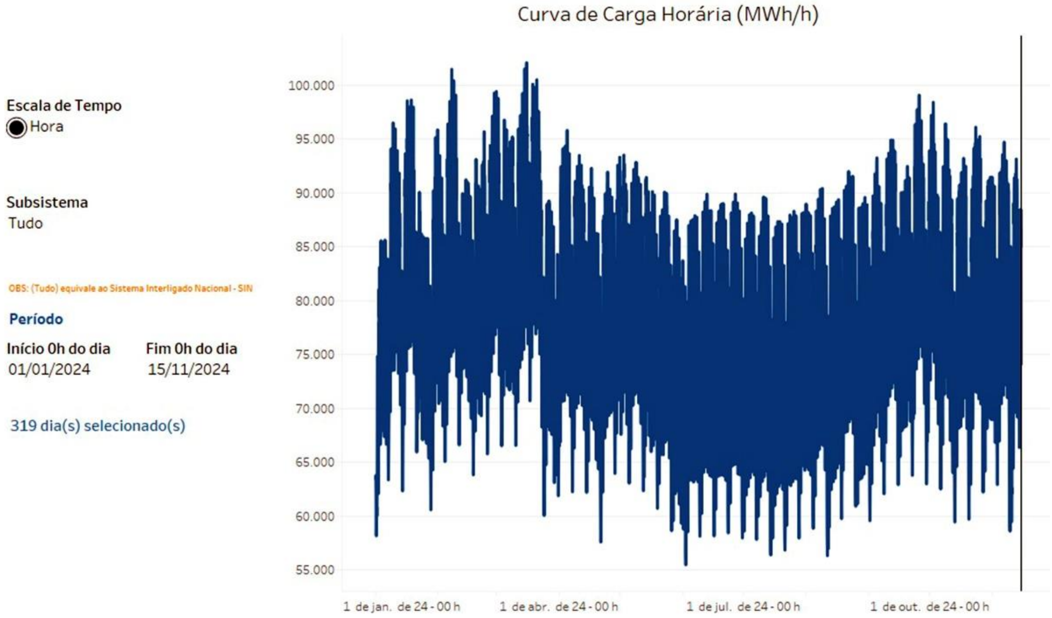
FIGURE 3: CHARGING NOT WITHOUT DURING 2024



Source: ONS – Operation results/Operation history

The highest electricity demands in Brazil are being recorded during the summer. In the summer of 2024, already recovered from the measures adopted to combat the Sars-Covid19 pandemic, the cargo records in the SIN between 12/21/2023 and 3/20/2024 are in Fig. 4. The highest demand recorded was 102,085 MWh/h on 03/15/2024 and constituted an all-time high. This summer, the lowest load occurred in just 9 days, in which, during the night, it did not reach 65,000 MWh/h. The typical profile of the daily load points to two daily peaks: one in the early afternoon, around 3 pm, and another during the traditional peak hours at 7 pm.

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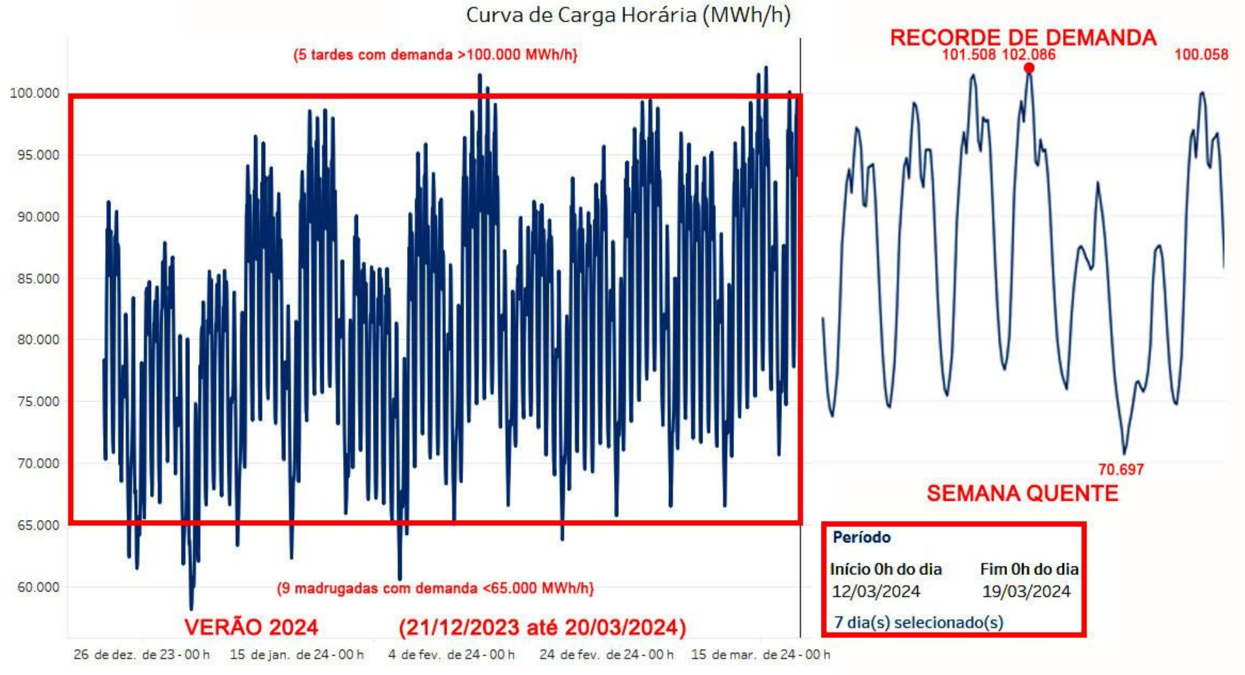
Figure 4: Cargo in the summer of 2024



Source: Adapted from ONS data

Highlighting the load profile on 03/15/2024 in which the highest demand was recorded (Fig. 5), the times of greatest load, the daytime peak and the night peak, are evident. The load was in the range of 77 GWh/h to 102 GWh/h, with the lowest load of the day occurring at 4 am. Fig. 5 also presents the contribution of each source to the generation of this electricity [ONS, 2022b]; of the total of 2,113 GWh generated, 215 GWh (10.2%) were from wind sources and 208 GWh (9.8%) were from solar sources. The energy generated by Mini and Mico Distributed Generation (MMGD) is not included in this calculation.

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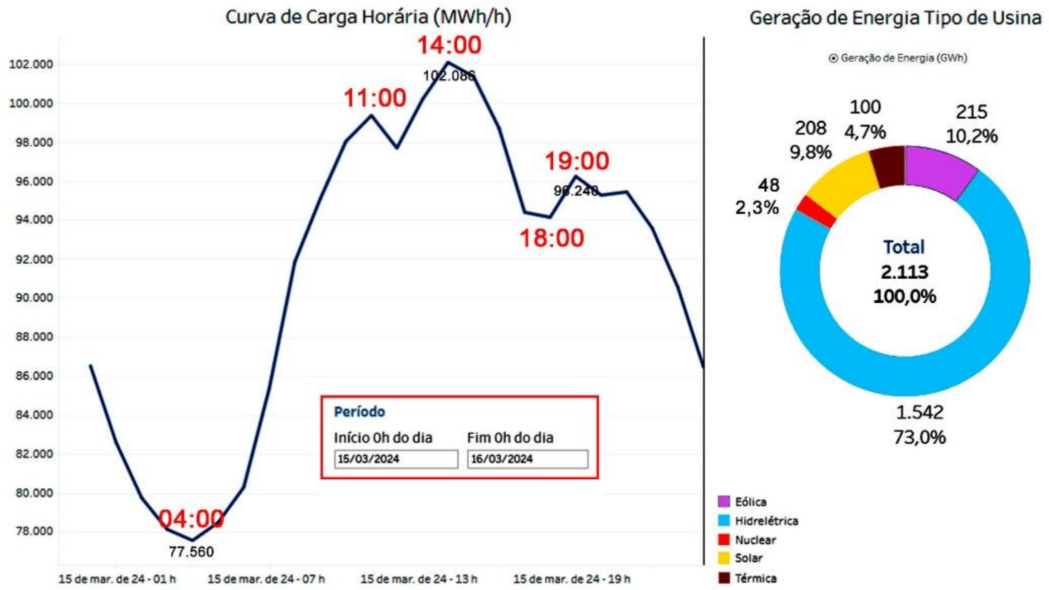
Figure 5: Day with the highest load in 2024



Source: Adapted from ONS data

- **Distributed Generation (MMGD)**

In Brazil, distributed generation, also called MMGD, is defined in Article 14 of Decree Law No. 5,163/2004 [BRASIL, 2004]. The Electric Energy Compensation System, regulating the "*net-metering"* model in the country, was instituted in 2012. This system was made official by ANEEL's Normative Resolution (REN) No. 482/2012 and was updated through REN No. 687/2015 [ANEEL, 2015]. 2 modalities of distributed generation of photovoltaic solar energy were regulated:

- microgeneration: electric power generating plant, with installed power less than or equal to 75 kW.
- minigeneration: electric power generating plant, with an installed capacity greater than 75 kW and less than or equal to 5 MW.

The MMGD Legal Framework, Law 14,300/22, definitively regulated this modality in Brazil.

The MMGD eases the burden of the SIN. This generation serves local loads. Only the surplus feeds the distributors' local network and is computed as an energy credit for the producer, therefore, the MMGD is not represented in the load profile of the SIN, while centralized generation is computed in the demand load profile.

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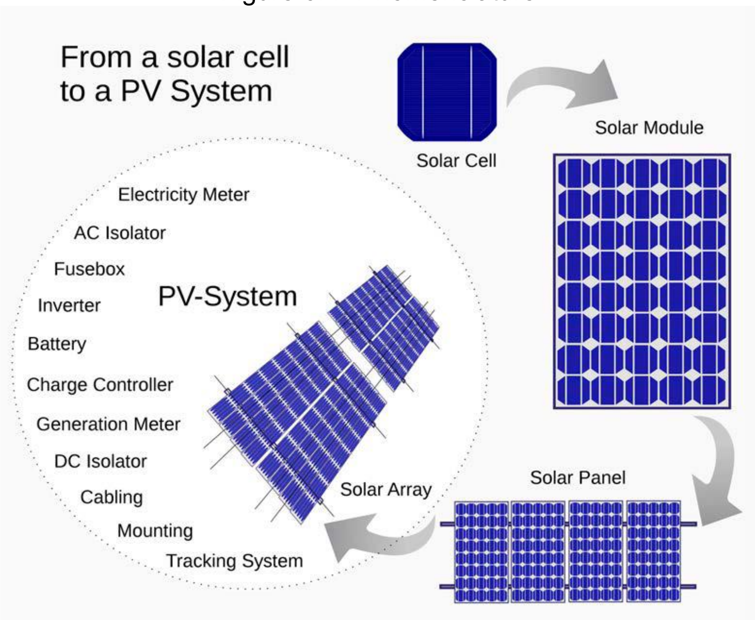
- **Photovoltaic (PV) generation**

The conversion of the energy contained in solar radiation into electricity can be done by photovoltaic cells exposed to sunlight. PV cells are assembled into modules that connected in series and in parallel form PV arrays. Photovoltaic arrays and other equipment necessary for the conversion, control and measurement of the energy generated form photovoltaic systems (Fig. 6).

Figure 6: PV nomenclature



PV generation in Brazil is divided into 2 categories:

- Distributed generation (MMDG ≤ 5 MW).
  Note: After February 7, 2023, distributed minigeneration is defined as all units with installed power above 75 kW and less than or equal to 5 MW for dispatchable source generating plants, or 3 MW for other sources not classified as dispatchable source generating plants

- Centralized generation that takes place in large solar PV plants (> 5 MW).

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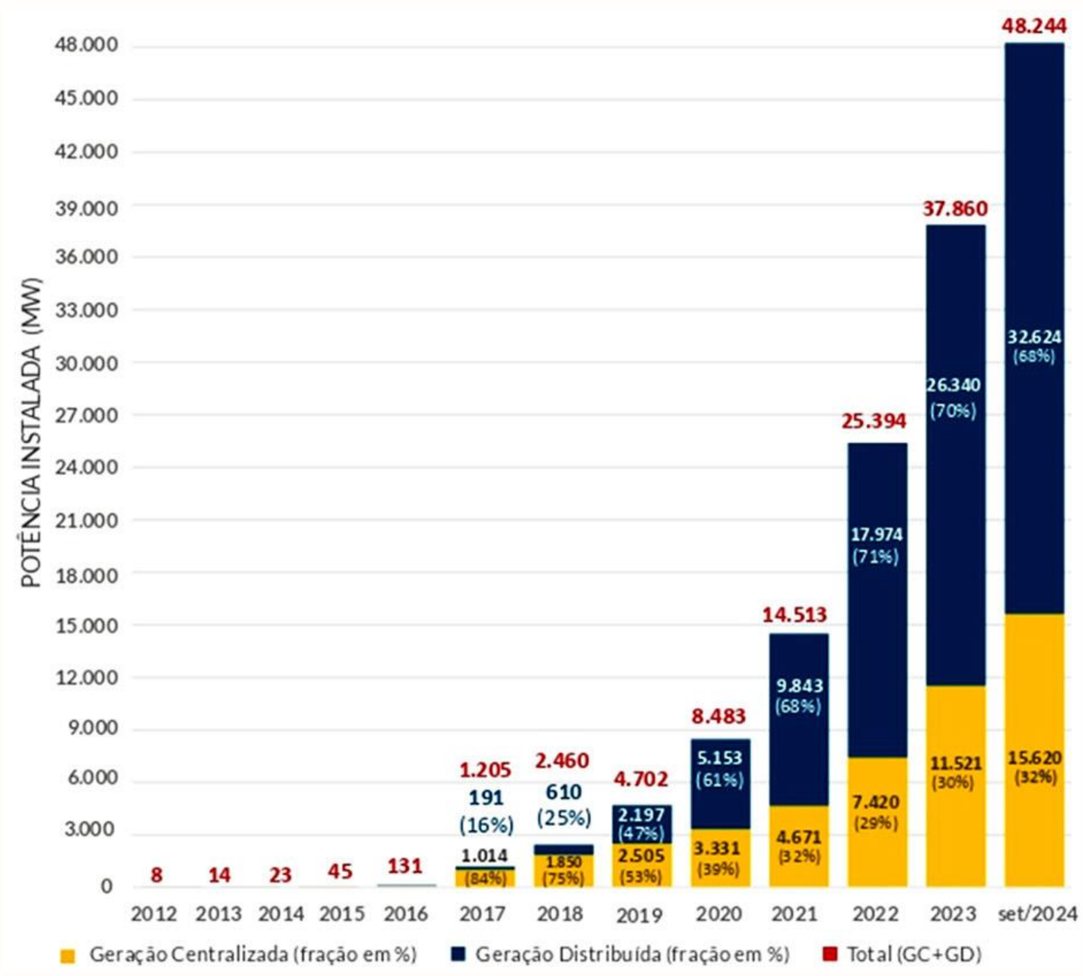
FIGURE 7: EVOLUTION OF THE PHOTOVOLTAIC SOLAR SOURCE IN BRAZIL



Source: ABSOLAR No. 72, 2024

PV generation in Brazil has significant growth since 2016. Fig. 7 illustrates the growth of PV generation in Brazil. The installed capacity of PV generation is close to 50 GWp, of which 33.5 GWp MMGD in about 4 million consumer units (of these, about 50% in the residential sector) [ABSOLAR, 2024] and 16.5 GWp of centralized generation from 18,450 PV plants in operation in the country. Another 134 PV plants are being built to increase the capacity of concentrated generation to 22.5 GWp [SIGA, 2024]. EPE, in its Ten-Year Energy Expansion Plan [EPE-PDE 2030], projected the installed capacity for 2030 when it expected the solar source to represent 6% of the 236 GW needed (Fig. 8).

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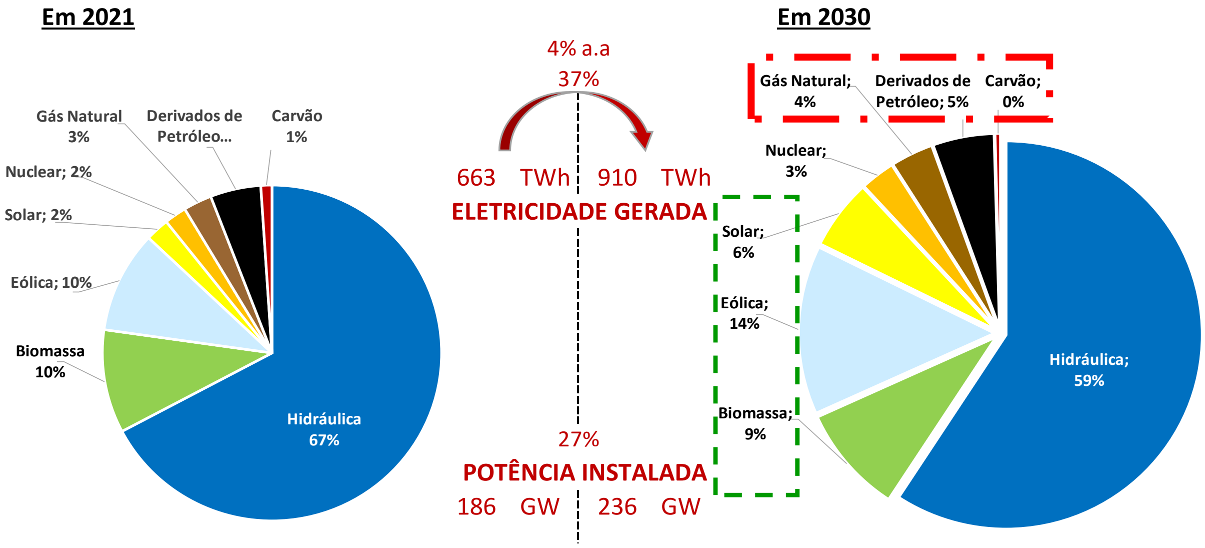
FIGURE 8: GROWTH FORECAST



Source: Adapted from EPE-PDE2030

The growth of the PV sector exceeded this projection. The PDE-2030 target was exceeded in 2023 when the PV source represented 7% [BEN, 2024]. The reduction in the prices of PV modules and other components of the system has caused the sector to grow at a very fast pace of expansion. Once the construction of all the photovoltaic plants in progress is completed, the centralized generation power of 22.5 GWp will meet the afternoon peak of the daylight saving time, limiting the need for generation from other sources to a maximum of 85 GW at this time. This power can be supplied, even considering water constraints, by the 214 existing hydroelectric plants with a nominal installed capacity of 103 GW [SIGA, 2024].

In the summer of 2024 there were about 30 GWp of MMGD-PV. There was also about 12 GWp of centralized PV generation that on 03/15/2024, the day of the highest peak demand, contributed to the SIN with about 208 GWh (9.8% of the daily total). By direct proportion, it is estimated that MMGD contributed with about 400 GWh of self-generation/local consumption not accounted for as load in the SIN. Fig. 9 shows the FV generation recorded in the SIN on that day [ONS, 2022b].

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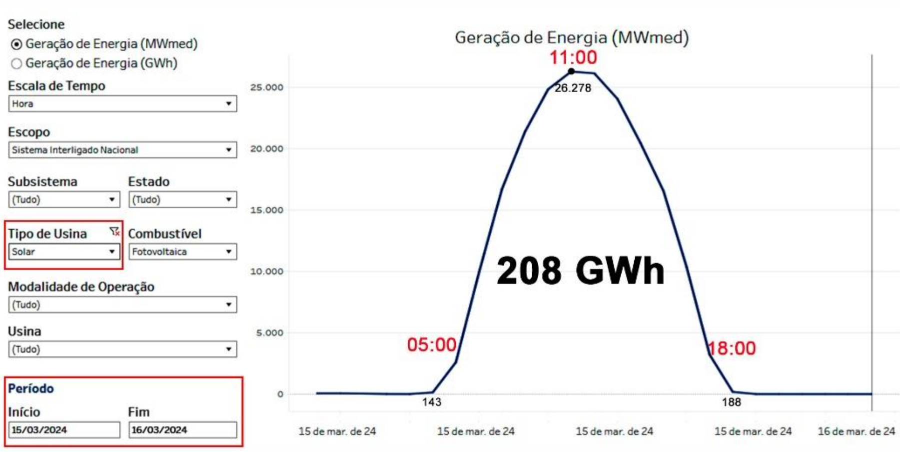
FIGURE 9: PV GENERATION



Source: Adapted from ONS

During the period in which the demand for the SIN exceeded 100 MWh/h, solar energy accounted for about 25% of the total, with a significant contribution to meet the peak demand. The linear extrapolation of the data in this graph allows us to project the generation results and suppose that, considering centralized installations of the same yield, if there were 20 GWp installed, the PV source would have generated 325 GWh, replacing 100% of the need for UTE dispatch, being able to operate the set of HPPs with the same daily flow that was turbocharged on this day, without exceeding the restrictions arising from the hydrological condition of the SIN reservoirs.

The aggregation of many plants that are distant from each other, distributed throughout the national territory, reduces the variability of joint production and extends the generation period, resulting in PV generation in the summer from 5 am to 6 pm as seen in Fig. 9

- **Wind Generation (EOL)**

Wind generation is the conversion of the kinetic energy of the winds into mechanical energy by the action of air on the blades, and later into electricity by a generator. The set of equipment for the conversion of wind energy is called Wind Turbine or Wind Turbine. Like solar energy, it does not emit greenhouse gases (GHG) during operation.

Wind energy is the fastest growing renewable energy technology in the world, with 1,021 GW installed in 2023, 32.5 GW in Brazil, and expected to reach 22% of the world's electricity matrix in 2030 [GWEC, 2024]. The large size of wind turbine blades limits the power of each turbine. Currently, the typical powers for onshore installation are 2.5 to 5 MW. Individual wind turbines can be installed, but "wind farms" with several turbines are

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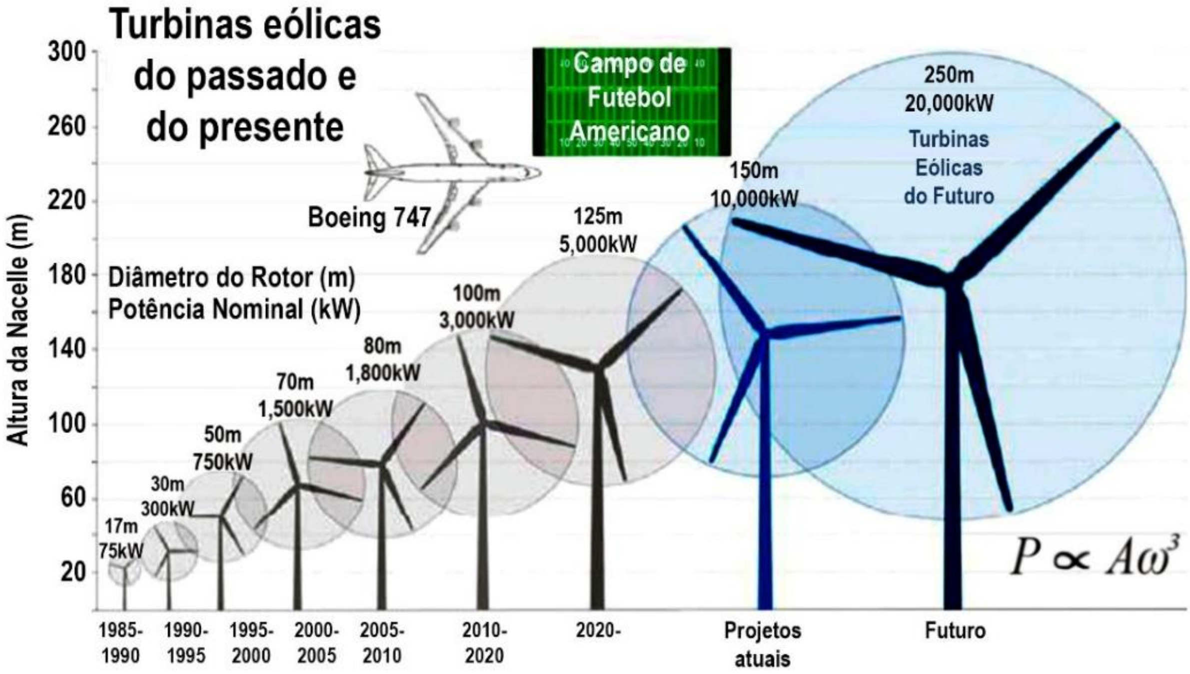
usually installed for substations with a nominal power of hundreds of MW. In the open sea, larger turbines can be installed, turbines up to 20 MW are projected with *offshore technology* developed by the oil and gas sector. Fig. 10 illustrates the evolution of the size of wind turbines.

Figure 10: Increase in the size of wind turbines



The random variability of the wind is, to a certain extent, compensated by the large number of wind turbines distributed over a large geographical area. When there is little wind in one place, in another place there may be a favorable wind. In this way, the contribution to the SIN is less random than the individual generation of each turbine

In Brazil, wind technology has been growing since 2005 and has already exceeded 32.5 GW of onshore installations [EPE-BEN2024, SIGA, 2024]. It was the 3rd country that installed the most wind farms in 2023 (4.8 GW of new installations) and, according to the *Onshore Ranking of the Global Energy Council* (GWEC), it ranks 6th in the world ranking of on-shore installations [GWEC, 2024]. Fig. 11 shows this spectacular growth.

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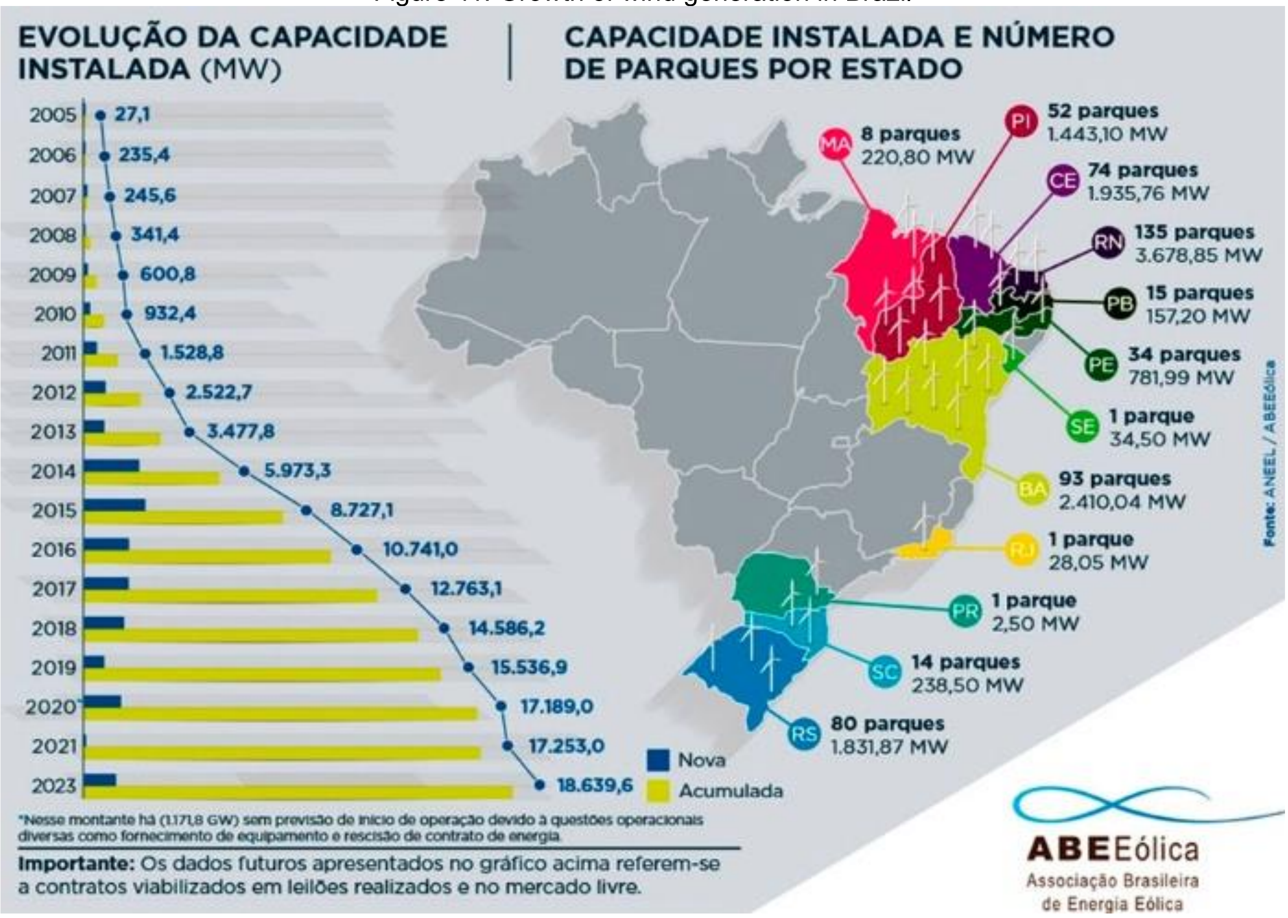
Figure 11: Growth of wind generation in Brazil



Source: ABEEólica

In the summer of 2024, the installed capacity of EOL plants was around 20 GW. However, on 03/15/2024 the maximum power recorded was 12 GW. Fig . 12 shows the EOL generation recorded in the SIN on that day [ONS, 2022b]. It is observed that while the FV generation occurs exclusively during the day, the EOL generation occurs all day, but is predominant at night. The lowest power (6,821 MW) occurred at 1 pm and the highest power (11,962 MW) was recorded at 4 am with a new peak (10,962 MW) at 8 pm. The energy contribution on that day was 215 GWh (10.2% of the daily total).

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FIGURE 12: EOL GENERATION

Source: Adapted from ONS

In the same way as solar energy, the Ten-Year Energy Expansion Plan [PDE 2030], projected the installed capacity for 2030 when it expected the EOL source to represent 14% of the 236 GW forecasted, as already seen in Fig. 8. Eighty new wind farms under construction will add another 3.3 GW to the installed capacity, reaching 36 GW – exceeding this target as early as 2025 (5 years earlier than planned).

The offshore wind potential along the Brazilian coast within Brazil's exclusive economic zone of 200 nautical miles, considering the various distances from the coast is: 0-10 km=57 GW; 10-50 km=202 GW; 50-100 km=255 GW and 100-200 km=1,266 GW [ORTIZ and KAMPEL, 2011]. With another view, regardless of the distance from the coast, but considering the depth of the sea, EPE studies point to a technical potential of 700 GW in places where the depth does not exceed 50 m [EPE, 2020]. Despite this immense potential, there is still no offshore electricity generation in Brazil, except for the self-generation of oil platforms. The first offshore EOL park projects are still in the licensing phase at the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA).

DISCUSSION

BEHAVIOR OF ELECTRICITY DEMAND

Even though some of the early proponents of the practice thought that it would reduce the use of artificial lighting in the late afternoon, in Brazil the geographic location, the moderate tropical climate and sociocultural patterns make the load profile have different characteristics from countries with temperate, cold or polar climates. The increasing use of air conditioning equipment at the time when temperatures are highest (a trend that may be enhanced by climate change and global warming) is of great importance.

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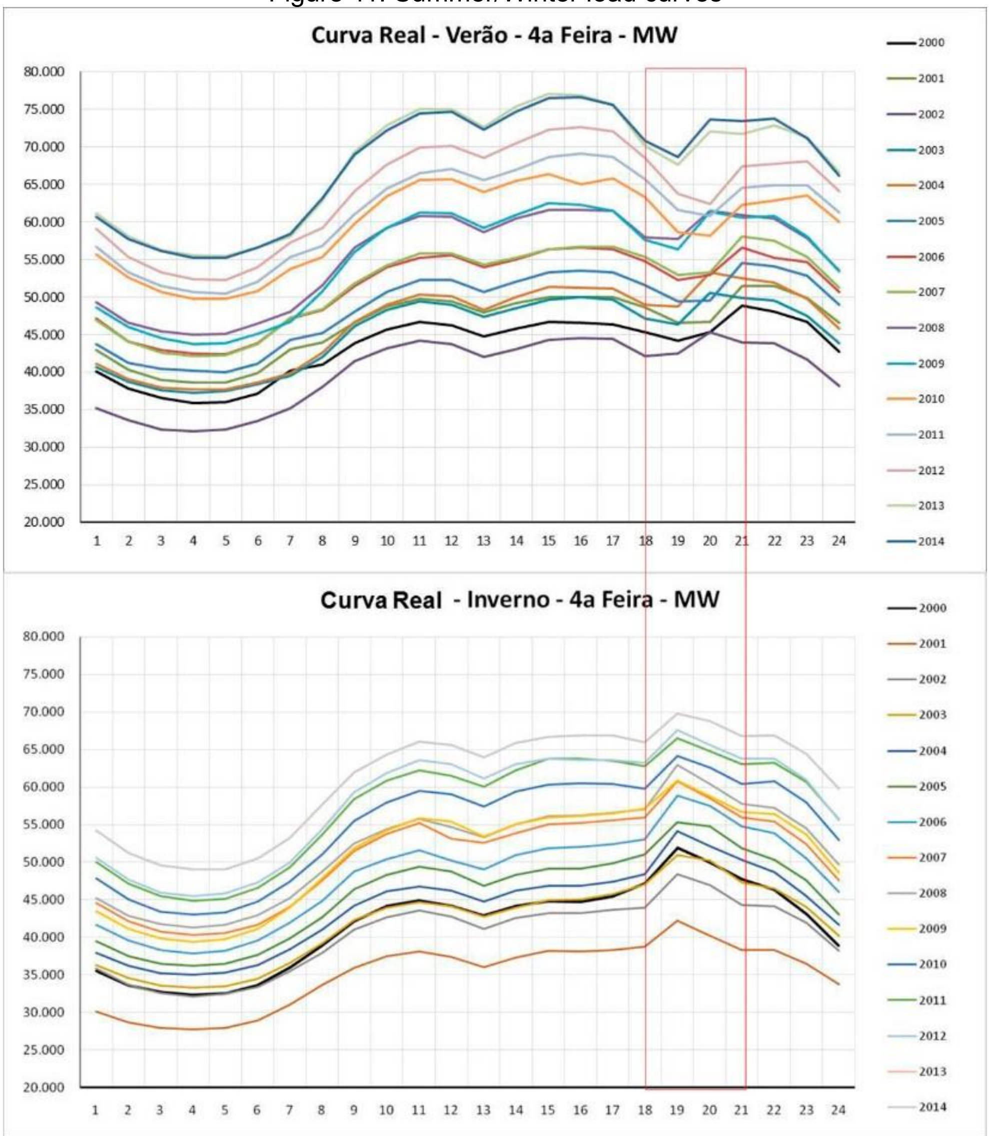
In Brazil, the fact that there are peaks in demand during the afternoon in the summer (Fig. 5) is highlighted, a fact that is repeated annually and can be observed in the measurements carried out since 2000 by the EPE and, later, from 2006 onwards by the ONS and CCEE. Fig. 13 shows the demand curves on the days with the highest annual load in the SIN, year by year, for summer and winter, showing the behavior at peak hours.

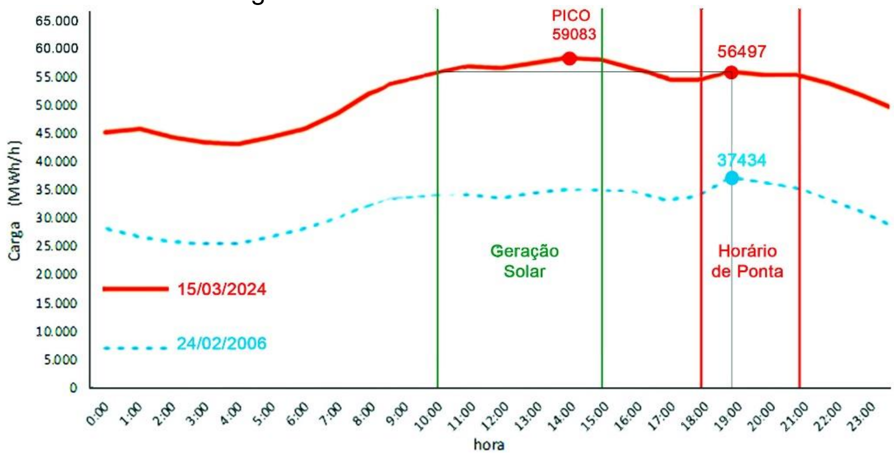
Figure 11: Summer/Winter load curves



Source: Adapted from ONS

In the Southeast/Midwest region, where most of the Brazilian population lives, where there is the highest energy consumption, the maximum instantaneous load recorded – historical peak, of 59,257 MW at 14:37 (without daylight saving time) on 03/15/20243. In this region, demand has the greatest growth, the historical maximum of 59,083 MWh/h occurred at 2 pm and on that day a second peak of 56,497 MWh/h occurred at 7 pm. Fig. 14 compares the load of the day of highest consumption in the Southeast/Midwest region in the years 2024 and 2006, the year in which the ONS began to record and publish the hourly demand in the country by region. The similarity of the profiles can be seen, however, in 18 years consumption increased 50% at peak hours and 70% at the new peak hours in the afternoon, surpassing the traditional peak hours from 10 am. It is evident that the maximum consumption at night was lower than that of 10 a.m. in the morning. The new peak in demand coincides with the time of highest irradiance of the day, between 9 am and 4 pm, pointing to PV energy as an alternative to mitigate the daily peak of this new demand profile in the summer.

Figure 12: Maximum load not SE/CO



The ONS's medium-term electrical planning is based on the forecast of the maximum load in the SIN. Fig. 15 shows the ONS forecast for the current period [ONS, 2018]. This forecast was not confirmed, but it is indicative of the growth rate of energy demand considered by the ONS for the expansion of the electrical system. The highest instantaneous demand ever recorded in the SIN slightly passed the 100 GW mark, but did not reach 106.5 GW in 2024. On the other hand, the installed capacity of EOL and PV sources grew above the forecast, easing fears of not meeting demand peaks.

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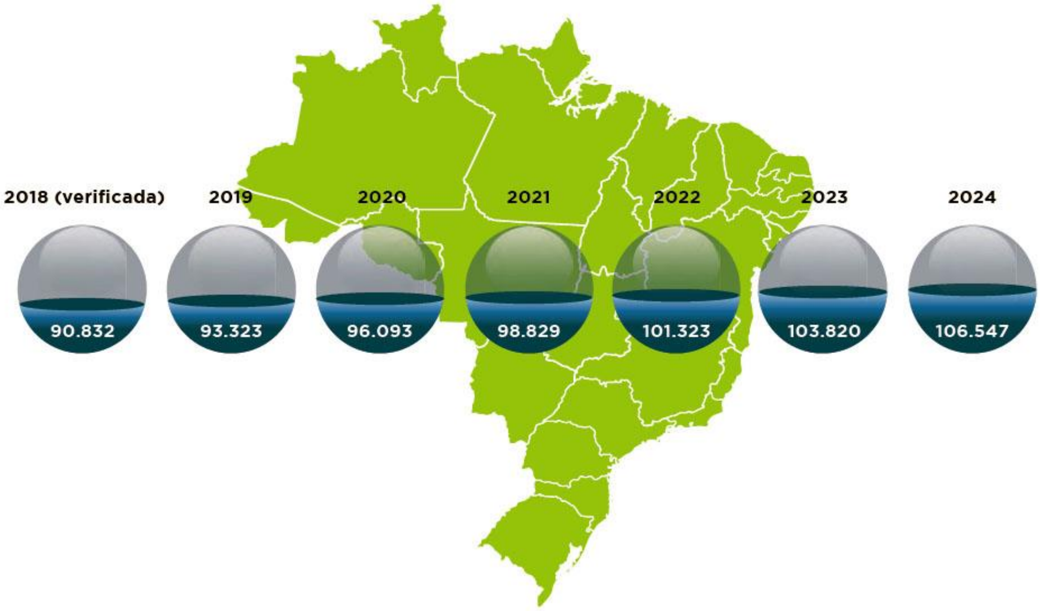
Figure 13: Maximum Load Forecast in the SIN (MW)



Cast iron: ONS – PAR/PEL 2020/2024

The PV generation curve does not move to follow the official time. Regardless of the time of the clock, the FV generation is governed by the position of the sun, remembering that in the summer period the day is longer and there are more daily hours of sunshine. Therefore, if there are no clouds, the solar PV contribution is greater than in winter. EOL generation also does not depend on the official time. Regardless of the time of the clock and human activity, during the period when the air is heated by solar radiation there are fewer winds and the EOL generation drops, when the air is colder, at dusk and during the night and early morning, the EOL generation is higher.

REGIONAL ASPECTS

In Asia it is not adopted. China, India and Japan, the engines of the Asian economy, no longer adopt daylight saving time. On the African continent, only Morocco and Egypt, which have geographical proximity and strong economic ties with Europe, adopt it; in South America, only Chile and Paraguay [DM, 2024].

SOCIAL, CULTURAL AND TECHNOLOGICAL ASPECTS

- Daylight saving time favors afternoon activities; There are those who like it and there are those who don't. Public opinion polls indicate that, apparently, most of the population interviewed looks favorably on daylight saving time.
- American research has not found conclusive evidence that daylight saving time

encourages the practice of sports [ZICK, 2014]. The research makes clear its regional limitation and suggests similar studies in other locations. No results of similar research were found in Brazil.

- Commerce benefits from daylight saving time, so much so that class associations in the sectors of commerce, bars and restaurants and tourism plead for the implementation of daylight saving time to leverage business.
- Public security recognizes the reduction in crimes when leaving work while still daylight, but there are no statistics on the increase in crimes when going to work, which is still dark.
- For astrology, the time of birth affected by the change in official time, distorts horoscope calculations.
- The civil registration of twins born before and after the move may be affected, with twins being registered with different birth dates.
- Religious practices and rituals may be affected.
- Many devices require manual adjustment with the official time change. The software of contemporary devices can often change the time by itself; however, changes in official time in various jurisdictions of dates and times can create confusion [EHLERS, DYSON, HODGSON, AND DAVIS, 2018].
- In the logistics of transporting passengers and goods, there can be confusion and inconvenience when departures and/or arrivals are in regions that adopt daylight saving time.

HUMAN HEALTH ASPECTS

In Brazil there are no public statistics on the damage caused by the maladjustment of the biological clock. In the justification of PLS 438/2017, the author argues that sleep deprivation caused by daylight saving time has several effects: irritability, cognitive impairment (learning), memory loss or lapses, impairment of moral judgment (which could lead to the commission of crimes), drowsiness, yawning, hallucinations, impairment of the immune system, worsening of heart disease, cardiac arrhythmias, reduction in reaction time (which can cause traffic accidents), tremors, pain, reduced accuracy (which can lead to work accidents), increased risks related to obesity and suppression of the growth process (in adolescents). The justification presented is that the benefits of reducing the maximum load of electricity at peak hours do not reach most citizens, while the damage to health

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does. It is also listed the fact that there are negative impacts on public safety that mainly affect people who need to wake up early to go to school or work, far from their homes, while the streets are still dark [BRASIL, 2017].

FISCAL AND BUDGETARY ASPECTS

There is a cost to debate, approve, decree and publicize the Brazilian Daylight Saving Time each year. When discussing the benefit to the electricity sector of changing the legal time, this cost (not foreseen in the budget) is not well quantified and is not taken into account when evaluating the economic justification for implementing daylight saving time, but it is paid by the population as a whole.

CONCLUSION

The profile, and composition, of the load on the SIN is changing so that peaks occur during the afternoon and no longer at peak hours between 6 p.m. and 9 p.m. Daylight saving time will have no effect on increasing the reliability of the SIN as it relates to transmission lines, if the SIN is sized for the loads predicted by the ONS medium-term electrical planning, since the maximum predicted loads are not being reached.

Studies by the ONS indicate that the application of daylight saving time this year does not bring benefits to the operation of the national electricity system and has no effect on the maximum demand of the day, which typically occurs in the afternoon in the months of October to March [CTA-ONS-DGL-1988/2021]. According to the ONS, their study:

> *"... did not identify significant energy savings, as the reduction observed in the night rush hour, that is, from 6 pm to 9 pm, is offset by the increase in consumption at other times of the day, especially in the early morning. In addition, according to the prospecting carried out, it would not have an impact on the power supply, as Daylight Saving Time does not affect consumption in the afternoon when the highest demand of the day is observed. Therefore, the gains in terms of relevant benefits for the National Interconnected System (SIN) are reduced..."*

What effectively reduces the load on the SIN is the MMGD, as it meets part of the demand with self-generation, not accounting for this portion in the SIN load curve. As 99.2% of the MMGD is PV [ABSOLAR, 2024], it occurs precisely at the time of highest consumption, directly affecting the peak recorded in the load curve during the summer.

Even considering the increase in the total demand for electricity, resulting from population growth and the economy, the growth in the share of renewable sources wind and solar, already exceeding 20% in the electricity matrix, allows for a more flexible operation of the HPPs, ensuring the availability of electricity at any time, even with the restrictions imposed by the hydrological regime. The energy generated by these sources occurs precisely at times of greater energy demand, during consumption peaks after noon (FV) and early evening (EOL). This allows better management of hydroelectric generation, even during periods of drought, modulating generation to complete the variable power of EOL+FV generation to the required levels, without dispatch of UTE. However, ensuring the availability of renewable energy in the region with the highest consumption (Southeast) requires ensuring the transmission of this energy generated predominantly in the Northeast, "debottlenecking" the grid, to allow the flow of all generation from renewable sources without cuts in energy generation for operational reasons of the ONS (*curtailment* or *constrained-off*).

Water scarcity in 2024 is not as critical as it has been in the past [SIQUEIRA, 2022] and [INMET, 2022]. The level of the SIN reservoirs at the end of the year will be close to 50%, unlike previous years (2017-23%, 2018-32%, 2019-24%, 2020-25%, and 2021-33%) in which the levels were low (EAR less than 100,000 MWh.month), and the drought imposed severe restrictions on the operation of the HPPs [ONS, 2022a]. Spring and summer are the rainy seasons in the SE/CO [MINUZZI, SEDIYAMA, BARBOSA and MELO Jr., 2007], a period in which the reservoirs of the SIN recompose their EAR. The installed capacity in the sum of the SIN's HPPs reached 103 GW, increasing availability, with the entry into operation of the Belo Monte, São Manuel, Colíder, Baixo Iguaçu and Sinop HPPs as of 2017 [ONS, 2022; SIGA, 2024].

From the angle of energy saving, or to avoid the dreaded blackouts, the annual implementation of daylight saving time is no longer justified, negatively impacting the health of the population. The vaunted benefits of energy savings are not sustained, as the reduction observed in peak hours is offset by the increase in consumption at other times of the day, especially in the early morning. The flattening of peak demand for daylight saving time represents no more than 3%, which is equivalent to a "saving" of approximately 3,000 MW – tiny compared to the social upheavals it causes. In the last year in which daylight saving time was adopted in Brazil, the ONS reported savings of only 0.5% [CONFEA, 2024]. The effort and resources applied in the debate on the implementation of daylight saving time would be better if applied to measures aimed at increasing energy efficiency and energy storage to ensure the stability and quality of the system.

Despite the fact that the commerce and tourism sectors plead for the implementation of daylight saving time to leverage business, research on how daylight saving time currently affects energy expenditure seems to indicate that this artificial time is counterproductive for energy savings during the period. The industry can face logistical challenges and often needs to adapt its processes to times of lower demand, which can increase operating costs and requires planning. Agribusiness represents about 21.8% of the Brazilian GDP in 2024 [CEPEA, 2024]. Agriculture favors morning light more than afternoon light. Agricultural activities are governed by the natural circadian rhythm and the annual rhythm of the seasonality of the seasons, regardless of the official time (clock). The agrarian sector does not benefit from the change in official time. The new schedule can bring challenges to rural workers, impacting their health and well-being due to changing sleep patterns, in addition to harming the logistics of transporting perishable products, increasing the risk of losses [CONFEA, 2024].

From the consumer's point of view, the direct financial impact of daylight saving time tends to be limited. The increasing use of household appliances and air conditioners tends to increase energy consumption regardless of natural lighting. Therefore, the impact of daylight saving time on the electricity bill is increasingly reduced. Daylight saving time can generate a slight reduction in energy consumption, especially in regions where artificial lighting is used intensively in the late afternoon, which can result in a small saving on the electricity bill, but will hardly be significant for most families or companies.

Medical research shows that the artificial alteration of the official time negatively affects people's circadian cycle, causing many disorders ranging from insomnia, and hunger, to cardiovascular accidents, through tiredness, inattention, lack of energy and traffic accidents. This harmful effect affects the entire population and has a socioeconomic cost that is not considered in the evaluations of the energy sector. The cost of the effects of the change in official time for the country's public health system is not clearly identified. Likewise, there is a lack of data on the cost to the public security system. Daylight saving time harms health and increases inequalities [JOHNSON et al, 2024]

If economic and/or political reasons indicate the anticipation/delay of the clocks, doctors recommend that this change in the official time be made only once, making the new time permanent and without new seasonal changes. American organizations, such as the American Academy of Sleep Medicine (AASM) and the Society for Research in Biological Rhythms (SRBR), recognize the growing scientific consensus that the abolition of the biannual time change may have several benefits for sleep health and circadian rhythm. Therefore, they suggest a permanent change to standard time, which can offer the maximum benefits of economy, health and safety [CARTER, KNUTSON and MOKHLESI, 2022].

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