IEMA 3rd Bulletin

ENERGY AUCTION BULLETIN

3RD EDITION

This is the third bulletin from the Institute of Energy and Environment (IEMA) regarding energy auctions in Brazil. The aim is to analyze the implications of competing projects in relation to system supply and environmental attributes. In this edition, the focus is on the capacity reserve auction that will take place on December 21, 2021.

Prior analysis of the Auction for Contracting Power and Associated Energy, December 21, 2021

1. Introduction

The Brazilian energy sector is currently undergoing a transition period. The predominance of hydroelectric power plants in the energy matrix, which has provided flexibility to the system (1), is being replaced by the introduction of variable renewable energies and an increasing participation of fossil fuel thermal power plants, mainly natural gas.

Thermal power plants are dispatchable (2) and provide security and reliability to the system, complementing hydroelectric generation. In contrast, renewable sources such as solar and wind power are generally considered non-dispatchable (3) (EPE, 2018b). Despite representing more than 27% of the installed capacity of the energy matrix, including distributed generation (Aneel, 2021a), they provide energy to the system only at specific times of the day or year. Nonetheless, these sources provide a significant amount of energy to the system and complement hydroelectric generation, especially when considering the portfolio (4) effect and complementarity between sources.

In recent hydroelectric power plant projects, the energy storage capacity and quick response to fluctuations in supply and demand have been reduced. This reduction is due to efforts to mitigate socio-environmental risks associated with the reservoirs of these projects, as well as their vulnerability to climate change. The most recent water crisis demonstrated the importance of addressing these concerns.

In light of the future need for power identified in the Ten-Year Energy Expansion Plan (PDE 2030), Law No. 14.120/2021 (BRAZIL, 2021a) proposed modifications to the legal framework to enable the contracting of a specific product of capacity reserve in the form of power. Therefore, in August 2021, Ordinance No. 20/GM/MME/2021 (BRAZIL, 2021b) was published, containing the guidelines for the "2021 Capacity Reserve Auction".

The auction's objective is to contract power and associated energy solely from new or existing thermal power plants (TPPs) with power supply beginning in July 2026 and energy supply commencing in January 2027. Two products will be negotiated: energy from TPPs with operational inflexibility of up to 30% (5), and power through flexible TPPs and winners of the energy product (BRASIL, 2021b). This is the first time power is being contracted to supply system needs during peak moments, and there is high anticipation regarding the bidding results.

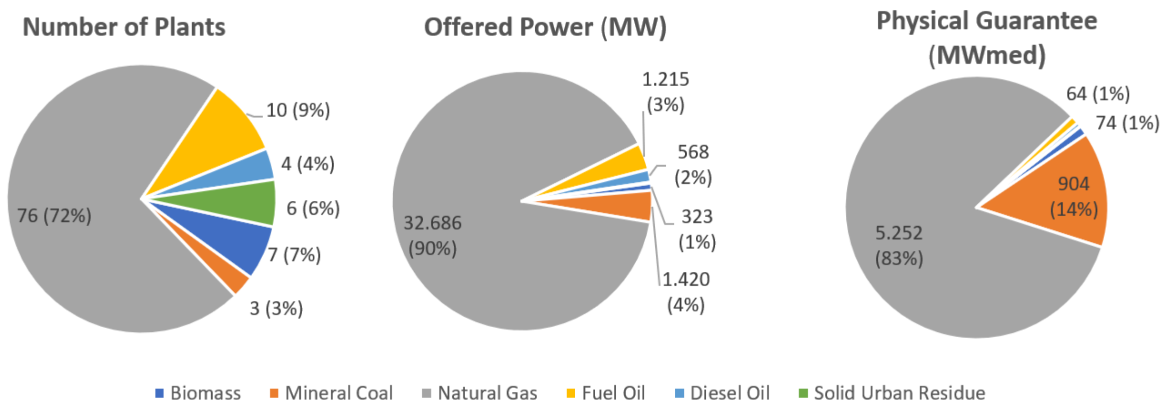
1. Capacity refers to the system's ability to meet demand at all times. Flexibility, on the other hand, refers to the controllable ability to vary generation in order to meet changes in the system's demand (EPE, 2018b).
2. Dispatchable power plants are those in which a primary natural resource, such as water or fossil fuels, is stored and can be converted into energy at any time.
3. Non-dispatchable power plants rely on primary natural resources with variable or cyclical supply to generate energy- such as the sun and wind.
4. The portfolio effect refers to the reduction in variability of generated energy when considering the generation of multiple projects or the combination of different sources, compared to the variability of isolated projects. For instance, the generation of a single wind farm has high variability. However, the simultaneous generation of parks spread throughout the Northeast Region has less variation (EPE, 2020b).
5. Operational inflexibility refers to the minimum energy generation of a project. In this auction, only projects that can generate energy at least 30% of the time are eligible.

The projects are compensated with a fixed cost component, similar to rent, to keep them available in the system, as well as a unit variable cost (UVC) that is only paid when the power plant is activated. In this auction, a ceiling of R$ 600/MWh was established for the UVC, which is higher than the ceiling set in previous energy auctions. According to the Energy Research Company (EPE, 2021a), the upper limit is justified because power plants with lower fixed costs are more attractive for power supply. These projects end up with either a higher UVC or a lower final cost, considering that their operating profile focuses on peak demand moments, using less fuel than power plants with full-time operation.

2. Overview of Participating Generating Units

According to Ordinance No. 1.098/SPE/MME, 106 generating units have been eligible, with a total offered power of 36.3 GW and a physical guarantee of 6.3 GWmean. These projects are powered by a variety of sources, including biomass (such as biogas and sugarcane bagasse), urban solid waste, natural gas, coal (national and imported), fuel oil, and diesel oil. Refer to Figure 1 for a breakdown of the generating units by number of plants, power, physical guarantee, and respective fuels.

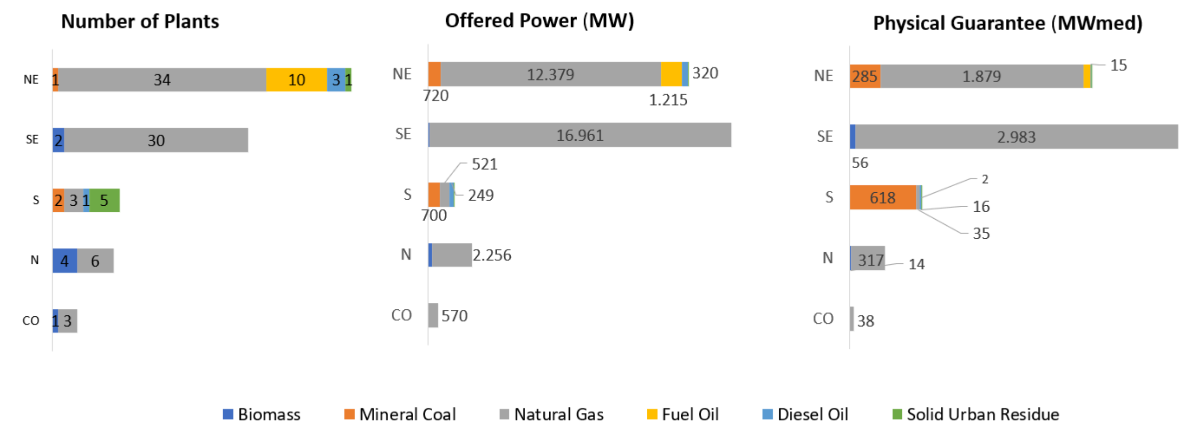
Figure 1 - Power plant distribution by fuel type

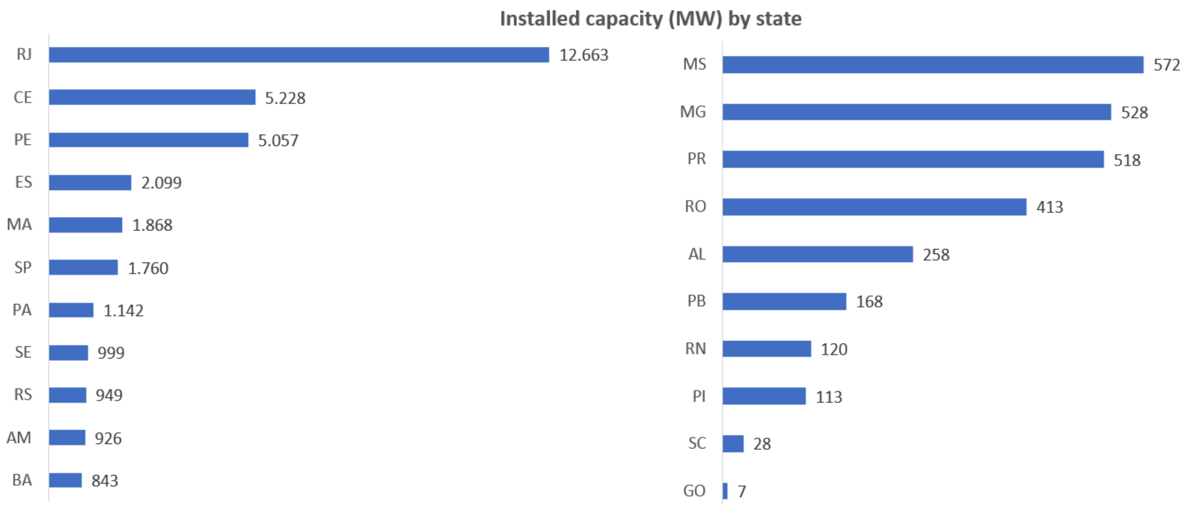


The relevance of natural gas projects is evident, with 90% of the offered capacity (32.7 GW) and 83% of the physical guarantee (5.2 GWmed) being attributed to them. Natural gas is also the most significant fuel in terms of the number of registered plants (76). The oil and diesel fuel generating units, which together represent only 13% of the total, have a greater participation in offered capacity (5%) than in physical guarantee (less than 2%), indicating that this type of generation is usually activated only during peak system moments. Although coal accounts for only 3% of the number of plants, it is more relevant in terms of physical guarantee (14%) than offered capacity. If contracted, this type of generating unit will operate more often and not only during peak moments. Biofuels and solid waste units together represent 12% of the number of plants, but are not significant in the auction regarding the offered capacity and physical guarantee, limited to less than 1.5% of the total in both cases.

Figure 2 shows that by territorializing the generating units, the Northeast Region offers the most projects, comprising almost half of the total (49). These projects have a total power of 14.6 GW and a physical guarantee of 2.2 GWmean. The Southeast Region, which has the second highest number of generating units (32), is the most relevant in terms of power and physical guarantee offered, with 17 GW and 3 GWmean, respectively. Both regions have a predominance of natural gas projects, but the Northeast Region presents greater fuel diversity, with generating units powered by all fuels except for biomass. The South and North Regions have the same number of projects(10), but differ in terms of installed power and physical guarantee. While the South Region proposes projects that operate for a longer period, such as coal projects, the North Region brings projects that are more concentrated in peak moments. Finally, the Midwest region appears with four projects, a total power of 0.6 GW and a physical guarantee of 0.04 GWmean offered.

Figure 2 - Power plants by Region and state





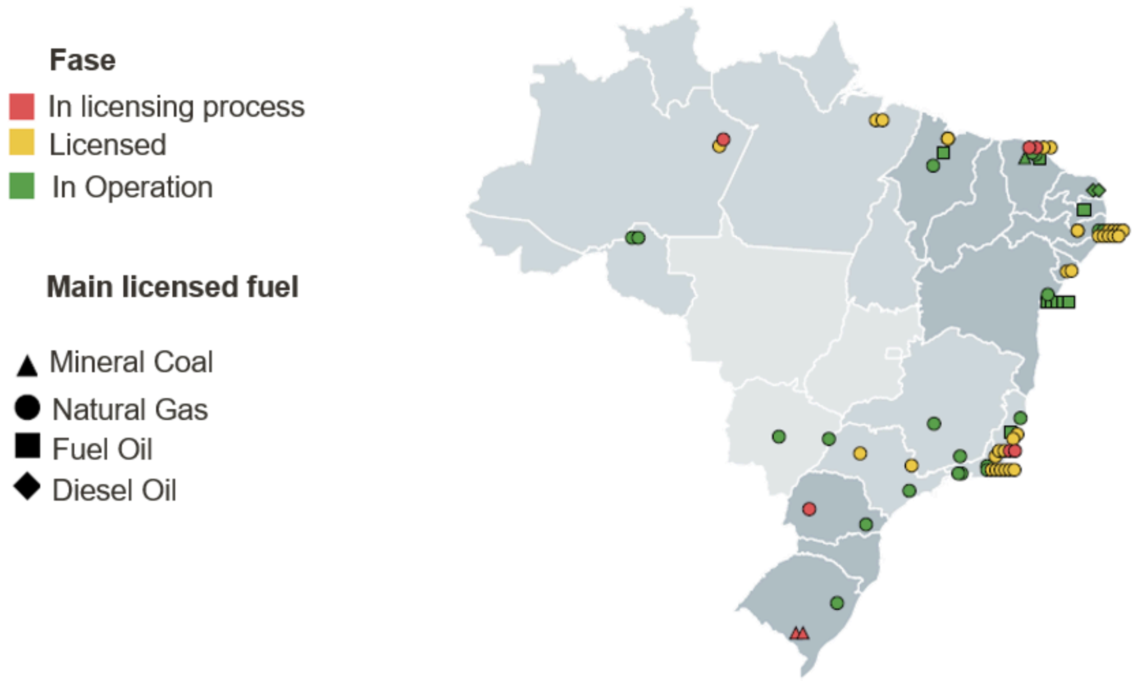
By analyzing the distribution of registered power, one can observe a tendency towards the formation of fossil fuel generation clusters, as previously noted in Pre-Auction Bulletins. For instance, Rio de Janeiro, with 35% of the offered power, has at least two large clusters in formation: Macaé and the Port Complex of Açu. Together, they have 20 power plants, with 11 of them registered for the auction. Similarly, in Ceará, which accounts for 14% of the registered power, there is the Port Complex of Pecém, located between the cities of Caucaia and São Gonçalo do Amarante. This complex comprises a total of 12 power plants, including operational units, licensed but not yet contracted, or in licensing. Seven of these units are competing in the Capacity Reserve Auction. Table 1 displays the main clusters in formation, as well as the generating units participating in the Capacity Reserve Auction.

Table 1: Number of plants by thermoelectric complex

		In the Auction					Not in the Auction					
City	State	In licensing process	Licensed	In Operation	No information	Total	Under construction	In licensing process	Licensed	In Operation	Total	Grand total
1. Macaé	RJ		6	2		8	1		6		7	15
2. Suape Port and Industrial Complex	PE		5	2		7		2	3	2	7	14
3. Pecém Port and Industrial Complex	CE	2	2	3		7			3	2	5	12
4. Barcarena Port and Industrial Complex	PA		2			2	1	3	2	1	7	9
5. Camaçari	BA			3		3	1		2	2	5	8
6. São Luís	MA		1			1		3		2	5	6
7. Açu Port and Industrial Complex	RJ				3	3	1			1	2	5
8. Barra dos Coqueiros	SE		2			2			2	1	3	5

It is important to note that the auction includes both generating units still in the project phase and operational power plants. Out of the 93 fossil fuel projects surveyed, information was obtained for 78 units. Of these, 33 are currently operational and 45 are still in the project phase. Among the latter, 34 have obtained at least a preliminary environmental license, while the remaining units are in the process of obtaining one. Figure 3 shows the geographical distribution of these fossil fuel projects across the country. It is worth noting that coordinates for the Ipojuca (PE) and Candeias (BA) plants were not found among the 78 power plants with licensing information.

Figure 3: Distribution of fossil fuel generating units competing in the auction.



In addition to the units registered in this auction, there are about 100 licensed or licensing thermal power plants projects throughout the country, according to an IEMA survey. This raises concerns about potential environmental impacts in the locations where these power plants can be installed. For instance, a natural gas power plant, which is the most common type of generating unit in the auction, of combined cycle with wet cooling, requires around 1000 liters of water per MWh. Furthermore, thermal power plants release greenhouse gases (GHG) and atmospheric pollutants that have negative effects on human health and the environment. These pollutants include particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), and sulfur oxides (SOx) (6), some of which participate in reactions in the atmosphere, giving rise to secondary pollutants such as tropospheric ozone (O_3). The Technical Note: Air Quality in Macaé (IEMA, 2021b) provides an analysis of the impact of thermal power plants and other projects on air quality in the city.

6. Particulate matter and sulfur oxides are pollutants that are more closely associated with coal-fired power generation. The other pollutants are concerns in power plants that use natural gas and coal as fuel.

3. Background

In 2002, shortly after the 2001 energy rationing, the majority of the energy matrix was generated by hydroelectric power plants, which accounted for 91% of the installed capacity. The expansion of thermal power plants in the following years aimed to reduce the system's vulnerability (EPE, 2018a). The recent push towards increasing the installed capacity of thermal power plants is due to a government decision motivated by the search for a market for the natural gas offered by Brazilian pre-salt wells, as well as for liquefied natural gas (LNG) offered in the international market. In 2020, although hydroelectric generation has grown, its share in the matrix has decreased to 71.1%. It is possible to perceive the diversification of sources, with wind, solar, biomass, and fossil fuel power plants contributing increasingly to the energy mix.

Historically, the operational characteristics of hydroelectric power plants (HPPs) allowed them to meet the requirements of power capacity and flexibility while adapting supply to meet the average energy demand. However, as the overall system load increases during peak hours, and variable sources without storage capacity become more prevalent, HPPs' relative participation in the energy matrix has decreased, along with their regulation capacity (MME, 2019). Although hydroelectric plants with reservoirs had the ability to control energy production or storage, the increase in energy consumption demand, combined with the rise of other types of renewable energy, has reduced the system's overall response power. Distributed energy generation (7) is another element that tends to influence the energy supply profile of the system.

To address the evolving landscape of the electrical grid, Brazil's energy sector has been undergoing a modernization process. This process is guided by principles of competitive access to electrical energy, sustainable expansion, market opening, and cost and risk efficiency. Discussions within the context of the Modernization of the Energy Sector (MME, 2019) have made progress on various topics, including the implementation of price formation mechanisms with greater temporal discrimination, updated supply criteria, integration of new technologies, and separation between physical guarantee and energy (8).

Regarding supply criteria, the planning of expansion and operation of the National Interconnected System (SIN, as in its Portuguese acronym) is now conditioned by energy parameters aligned with the system's new reality and explicit specifications for power supply. In other words, criteria that were previously considered non-restrictive have become significantly relevant for planning supply expansion (MME, 2019). The new energy and power supply criteria (9) for project qualification in auctions are presented in Table 2.

7. The use of distributed generation from renewable sources, particularly solar, is becoming increasingly important in reducing system load. This is mainly due to the compatibility between peak demand hours and the solar generation period, which reduces the need for generation from other sources to meet peak demand. As of 2021, the installed capacity of distributed generation in Brazil has exceeded 8 GW (ANEEL, 2021b).
8. Physical guarantee is a reliability indicator of the system that measures the average energy in MW that a generation project can provide (GOMES, 2017). Currently, physical guarantee and energy are marketed together as a single product. However, the separation between physical guarantee and energy aims to separately market and remunerate the supply of the two components.
9. Power is the rate at which energy is produced per unit of time. A power supply differs from an energy supply in that it meets specific moments of energy demand throughout the day or year. Energy supply, on the other hand, refers to an average supply over the year, without necessarily responding to specific peak demand moments.

In PDE 2030 (EPE, 2021b), the new supply criteria were considered, and it was identified that power needs to be added to the Brazilian system in the analysis horizon. Consequently, regulatory reform was deemed necessary to stipulate the procurement of power in the short term, in line with the guidelines for modernizing the sector.

However, the auction requires the power requirement to be met exclusively by natural gas-fired thermal power plants. This means that the reform of the electricity sector is not guided by technological neutrality in expanding supply, as it is in other countries. Instead, the sector could define supply based on the attributes that need to be met at a given moment, whether related to energy, capacity, or flexibility, rather than specific technologies or fuels. Additionally, it is important to emphasize that any expansion or reform must also be carried out in a way that avoids environmental and social impacts.

To gain a better understanding of the potential for the energy sector, this document presents current trends in other markets and a discussion of the technological options and regulatory designs that could have been taken into consideration.

4. Contracting Power in International Markets

Mexico has a Power Balance Market, which pays for power separately from energy. It does this through an annual payment for the power supplied to the system during the 100 critical hours of operation. This is the period in which the system has the lowest reserve margins. Despite discussions about the role of intermittent technologies, the Mexican market recognizes both thermal power plants and variable renewables as power suppliers.

Colombia is one of many international markets seeking to modernize its regulatory framework for the energy transition. The country already separates capacity and energy through a different mechanism for reliability valuation (CANAL ENERGIA, 2020). Recently, Colombia implemented an initiative to produce a roadmap of regulatory and institutional changes to improve the market environment for energy, gas, wholesale and retail markets, governance, and subsidies. PSR (PSR, 2020b), who participated in one of the roadmap fronts, reports that Colombia has hydropower resources that can provide flexibility to the system at low costs, facilitating the penetration of renewables and bringing resilience and robustness to climate change. This complementarity is seen as a factor of competitiveness and an interesting strategy for both the Colombian and Brazilian systems.

Chile is at the forefront of technical and regulatory discussions regarding the modernization of power systems in the face of new technologies (PSR, 2020a). The country has implemented measures to transition to renewable energy sources, resulting in a dynamic increase of intermittent renewable sources, distributed generation, storage and demand, as well as the decommissioning of coal and nuclear power plants (GOBIERNO DE CHILE, 2020). In light of this, measures have recently been launched to improve energy dispatch flexibility. These measures include: improving the power market design to consider flexibility in the choice of expansion technologies, updating regulations for energy storage and flexible technologies, including mechanisms for recognizing power contributions, and improving the programming of flexible technology operations.

The examples in this section demonstrate that international markets, such as Mexico, Colombia, and Chile, have created conditions that enable high rates of penetration of variable renewable sources in their systems. Key strategies for this include: ensuring isonomic treatment between sources, providing adequate remuneration for source attributes, using a combination of renewable sources, demand control mechanisms, and energy storage systems, and prioritizing flexibility over just power. However, it is evident that the mechanisms employed in Brazil are not aligned with these international trends.

5. Technological Options in the Brazilian Power Market

According to Energy Research Company (EPE, 2018b), the Expansion Plan should indicate an optimal generation matrix. This matrix should minimize future investment and operating costs while still being able to meet demand within established reliability criteria. These criteria relate to energy supply, capacity, and flexibility.

Under PDE 2030, the requirement for designed power was translated as the need to expand technologies such as flexible thermal power plants, modernize hydroelectric plants, and implement demand response (10) - technologies that can provide power, but not necessarily physical energy guarantee (11) to the system (EPE, 2021b). In other words, these are options that can supply power peaks in the system at specific moments. However, recent decisions in the power market have focused on increasing the exclusive participation of thermal power plants, while disregarding other sources and technologies that could contribute to the power attribute.

In Technical Note EPE-DEE-011/2020-r0 on Transition Measures (EPE, 2020a), EPE discusses the transition process to the new model, with a focus on capacity contracting, and highlights the technologies to be considered in the capacity auction.

The document identifies thermal power plants and hydroelectric power plants as the most suitable options for power supply in the short term. However, due to the time constraints involved in the environmental licensing process, new hydroelectric projects are not considered. Instead, the Repowering, Modernization, and Expansion (RME) of existing hydroelectric power plants is proposed as the best option in the short term. Regarding wind and solar sources, the document evaluates that while they contribute to the system's capacity in certain instances, their main contribution is to add more energy than power capacity. Therefore, the document does not recommend their participation in the auction (EPE, 2020a). Storage technologies, such as batteries and reversible hydroelectric plants, were excluded from the auction due to still-pending legislative and regulatory efforts.

In regards to solar power, a study conducted by IHS Markit (ABSOLAR, 2019, PORTAL SOLAR, 2019) discusses its potential to provide not only energy, but also capacity in the national context. This is due to the coincidence of the hourly generation profile with peak demand moments, as well as the predictability of generation. Therefore, compensation for capacity attributes could also apply to variable renewable energy projects, such as solar power.

In the Brazilian context, it can be argued that technological options for a power market extend beyond thermal power plants. Firstly, adding more power to the existing hydroelectric park in the country is both possible and economically viable. Secondly, variable renewable sources may have a greater capacity for supplying energy than power. By integrating these sources more effectively, their generation can displace some hydroelectric generation. This would transfer the role of large hydroelectric plants from energy supply to power supply, adding flexibility to the system.

10. Demand Response mechanisms (DR) enable consumers to manage their energy demand by reducing or shifting their consumption in response to supply conditions. Two types of consumer signaling are used: establishing hourly prices or providing financial incentives for reducing demand during critical system moments. The main technologies that allow for DR are smart grids, smart meters, and other enabling devices that allow consumers to understand their consumption profile, access energy prices in real-time, and control household equipment based on signals (EPE, 2019a).

11. Physical guarantee, also known as assured energy, determines the amount of energy that a power plant can supply as declared in energy commercialization contracts. The responsibility of calculating the Physical Guarantee of generation projects, as well as

its revisions, lies with EPE and follows methodologies and criteria defined by specific regulations (EPE, 2021c).

5.1 Integration of Renewable Sources in the Brazilian Market

There is already relevant literature on the integration of variable renewable sources into the Brazilian market. An example of such analysis is the project "Future Energy Systems: Integrating Variable Renewable Energy Sources into the Brazilian Energy Matrix" (Sistemas Energéticos do Futuro: Integrando Fontes Variáveis de Energia Renovável na Matriz Energética do Brasil). This project, a partnership between the Brazilian federal government and the German institution GIZ (GIZ AND MME, 2019), modeled the integration of high rates of variable renewable energy sources (VRE) into SIN. The study found that high rates of renewable sources could be integrated while maintaining the reliability requirements of the system. The methodology used combined elements of system operation and expansion with high temporal resolution, which allowed for the evaluation of the benefits of the portfolio effect. This effect can reduce the variability of sources, providing reliability gains and operating cost savings for the system.

The case study discusses the penetration of onshore wind and solar energy in a centralized and distributed manner. By the end of the planning horizon, they are expected to reach 41% of installed capacity and 36% of total energy generation, assuming future cost reduction of renewable technologies. Despite their reduced generation share, the integration of variable renewable sources is facilitated by hydropower plants, which provide essential system flexibility. For example, wind and hydropower sources in Brazil complement each other seasonally, as wind contributes mostly during the dry season, when the favorable wind regime helps reduce the use of reservoirs for hydropower generation. Consequently, the role of reservoirs in storing water during the wet season to meet demand in the dry season is altered. Wind generation reduces net demand, and the need for storage is reduced accordingly. The volume of solar generation during the dry season also contributes to energy security for the same reason.

If water resources run out, the system will rely on flexible gas-fired power plants and/or energy storage technologies. In summary, the document shows the importance of other energy sources to provide controllable dispatch requirements to mitigate the energy and electrical effects of variable renewable sources. The analysis also highlights the benefits of spatial complementarity of renewable resources in Brazil and the importance of expanding the transmission system to support regional energy transfers (GIZ and MME, 2019).

In PDE 2030 (EPE, 2021b), EPE also modeled a scenario of oversupply in the Brazilian system by changing the operative modality (12), while keeping the indicative reference offer. The simulation indicates that oversupply of energy reduces production in hydroelectric power plants, increases the possibility of storage, and contributes to a greater availability of power in the system.

12. The modeled changes involved increasing the inflexible thermal power supply to 80% inflexibility and lowering the UVC, without altering the reference installed capacity. This oversupply of energy reduces the energy load that must be met by HPPs, enabling greater power availability from them.

6. Conclusions

With the increasing participation of variable renewable sources and distributed generation in the power grid, the market and regulatory aspects of the sector have been undergoing updates. The solution adopted so far has been a temporary reform of the regulatory framework for power procurement for the short-term system, through the capacity reserve auction. However, despite several sources being capable of supplying power to the system, either directly or through synergy with other sources, only thermal power plants were included in the bidding.

Variable renewable sources like wind and solar can complement each other and hydroelectric generation in Brazil. However, these sources were not given due consideration, mainly due to the portfolio effect. Furthermore, some interesting options were not explored within the national context. These options include modernizing hydroelectric power plants, implementing storage systems (such as batteries or reversible hydroelectric power plants), and demand response programs for load reduction.

This auction contradicts what has been implemented in international power markets, which do not discriminate based on the type of energy source or its attribute remuneration. This approach aims to increase the participation of renewable energy and ensure system flexibility. In fact, several studies demonstrate the possibility of integrating variable renewable sources at even higher rates in Brazil.

Recent efforts by the energy sector to intensify the hiring of fossil fuel thermal power plants (IEMA, 2021a) are taking place despite significant growth of new renewable sources such as wind and solar. These sources have been consolidated as the two most economical sources of the energy matrix. In contrast, the hiring of more thermal power plants has negative impacts on the environment, climate, and national economy, as it contributes to the progressive rise of electric bills.

To improve the reliability and efficiency of the system, it is recommended to hold auctions based on expanding the integration of renewable sources. This can be supported by their cost-effectiveness and a market of attributes, with price signals that allow for adequate valuation of the services provided by each technology. This configuration can increase the resilience of the system to the variability of natural resources and to the eventual impacts of climate change on its availability.

In addition, auctions should be part of a broader strategy aimed at reducing dependence on fossil fuel-based thermal power plants due to their greenhouse gas emissions and local socio-environmental impacts. In this regard, it is worth reflecting on and questioning the suitability of the design of this capacity reserve auction, which will lead to an increase in reliance on these sources for the required power supply and flexibility of the Brazilian electrical system.

The predicted energy deficit cannot exceed 5% of the energy consumed annually, even in the 1% most critical simulated scenarios. The average of the 10% of scenarios with the highest marginal cost of operation (MCO) in each month cannot exceed BRL 800/MWh.

The power shortage in any given month must not exceed 5% of the corresponding maximum available demand, even in the worst-case scenario of the lowest 5% of demand. The probability of insufficient power during the 10 hours of maximum demand each month must not exceed 5%.

Source: EPE, 2020c.