ENERGY AUCTION BULLETIN
4TH EDITION | SEPTEMBER 2022

The fourth issue of the Institute of Energy and Environment (IEMA) bulletin on energy auctions in Brazil addresses the environmental implications of the projects competing for the capacity reserve auction held on September 30, 2022.

Prior analysis of the Auction for Contracting Power and Associated Energy, September 30, 2022.

1. INTRODUCTION AND BACKGROUND

The capacity reserve auction (LRCE, as in its Portuguese acronym), Auction No. 8/2022-ANEEL, is exclusively dedicated to contracting new thermal power plants (TPPs) based on natural gas. Following the guidelines of Ordinance nº 46/GM/MME of June 23, 2022, negotiated in the Power Commercialization Chamber (CCEE, as in its Portuguese acronym) platform on September 30, 2022 (MME, 2022).

The auction follows the determination of Law 14.182/2021, referring to the privatization of Eletrobras[1], which foresees contracting thermal power plants between 2026 and 2030. Except for specific projects, such as Belo Monte, Santo Antônio, and Jirau hydroelectric power plants, this is the first time the power plants must be contracted in pre-established regions. Thus, up to 1,000 MW will be contracted in the North Region, 300 MW in Maranhão, and 700 MW in Piauí for supply starting at the end of 2026, in the first case, and at the end of 2027, in the last two cases.

The marginal cost of reference (MCR[2]) set at the auction's beginning will be R$ 440.00/MWh. According to the Energy Research Company (EPE, as in its Portuguese acronym), which resulted in the registration of 37 plants totaling 11,889 MW that must meet the requirement of having a unit variable cost (UVC[3]) less than or equal to R$ 450.00/MWh (ANEEL, 2022a).

Although it bears the same name as the capacity reserve auction held in 2021, the objectives and characteristics of this auction are different. The 2021 auction aimed to contract electrical power (installed capacity of the plants, such as MW or GW) and associated energy (generation capacity of the plants, such as MWmed, MWh) to serve the system in specific periods. The current auction seeks to contract thermal power plants in a full operation regime. Traditionally, most thermal power plants complement the system's generation in periods when the reservoir levels of the hydroelectric power plants are low or meet hourly peaks. The full-time operation of thermal plants breaks this rule and reduces the space for the participation of other energy sources.

The 2021 auction provided operational inflexibility up to 30% power through flexible TPPs (without the contractual requirement of minimum generation) in different regions of Brazil. This auction restricts the thermal power plant installation regions to Piauí, Maranhão, and the North Region from a price ceiling again higher than the stipulated R$ 400/MW in the last electrical

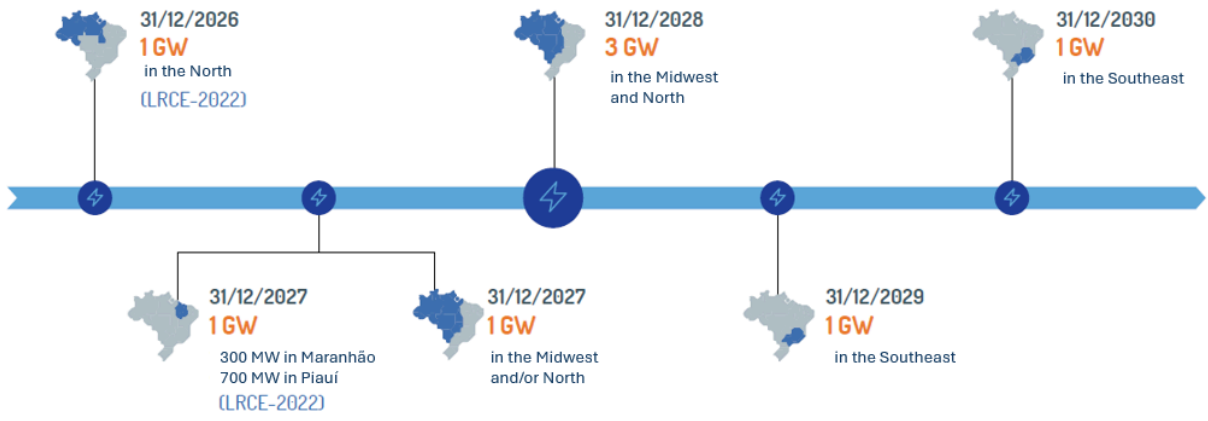
power auctions (EPE, 2021a). Another condition for participating projects is their location in regions without gas pipeline structures and Liquefied Natural Gas (LNG) terminals necessary to supply the thermal power plants.

The discussion in Congress and the consequent approval of Law 14.182/2021 have been among the most debated subjects in the electricity sector since 2021; not much about the privatization of Eletrobras itself but primarily because of the appendixes included in the final text, dealing with distinct matters. The points of contention were the creation of a market reserve for small hydroelectric power plants (SHPPs) and, mainly, the expansion in the medium term of gas-fired power plants in the energy matrix.

The final version of the text determines the contracting of at least 50% of the demand of the A-5 and A-6 auctions for SHPPs and a total of 8 GW for gas-fired power plants. Besides the 2 GW auctioned in the LRCE-2022, another 1 GW should be produced in 2027, 3 GW in 2028, 1 GW in 2029, and 1 GW in 2030 (Figure 1). Altogether, 2.5 GW should be contracted in the North Region, 2.5 GW in the Center-West Region, 2 GW in the Southeast Region, and 1 GW in the Northeast Region (contemplated in this LRCE).

The document, however, does not consider the infrastructure necessary to bring natural gas to these future plants, contradicting the ten-year plans published annually by the EPE. These state that there will be no expansion of pipeline infrastructure and liquefied natural gas (LNG) terminals in the 2022 to 2031 horizon (EPE, 2022a). This information shows that the auctions lack technical and regulatory grounds since not even the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP, as in its Portuguese acronym), which among many roles, regulates the natural gas sector, has applied for authorization to build new pipelines and LNG terminals. Therefore, there is no planned prospect for the service of thermal power plants for these regions.

Figure 1 - Schedule for the start-up of operations of the plants contracted under Law 14,182



Note: Law 14,182 does not identify the location of the 1 GW to be deployed in 2027, in addition to 1 GW to be allocated in the Northeast, contracted in this LRCE. It is only defined that the plants should be located in the North and/or Midwest regions of the country.

2. TECHNICAL AND ECONOMICAL IMPACTS

2.1. DISPLACEMENT OF RENEWABLE SOURCES AND HIGHER COST TO THE SYSTEM

Adding 8 GW of thermal power plants in the coming years will bring side effects by the increased thermal energy generation, such as additional greenhouse gas (GHG) emissions, local pollutants, and, depending on the cooling system to be adopted by the plants, increased water demand in the affected regions, as detailed in previous technical notes (IEMA, 2021b, c) and discussed in more detail in the following items. It will also have technical impacts on the energy matrix, increasing system operation costs and future electricity tariffs due to the cost of the contracted energy.

The large-scale insertion of natural gas in the energy matrix is harmful because it uses infrastructure and energy that could be directed to more renewable sources. In this context, besides reducing the contracting space for more economical renewable sources such as centralized solar and onshore wind, the mandatory contracting of inflexible thermal power plants reduces the generation of plants in operation, as pointed out in the 2030[4] and other technical studies.

Reducing the dispatch of renewable sources has already represented a challenge in recent years for regulators and the National Electric System Operator (ONS, as in its Portuguese acronym) in situations where energy demand is lower than supply. In such cases, it was opted for waste wind and solar energy, even though they were better economical sources5. The PDE 2030 simulation has pointed out that including 8 GW of thermal power plants in an inflexible regime would decrease 12 GW of wind power plants and 3.5 GW of photovoltaic power plants (EPE, 2021b). The analysis is supported in the PDE 2031, which shows that inflexible thermal power plants compete directly with variable renewable energy sources (VRE), reducing the potential to deploy new plants (EPE, 2022a).

The last Bulletin, referring to the Capacity Reserve Auction (IEMA, 2021c), pointed out that expansion planning should indicate an optimal generation matrix, minimize future investment and operating costs, and be capable of meeting demand within established reliability criteria related to energy supply, capacity, and flexibility. Another study conducted by the PSR Consultancy shows that expanding gas-fired power plants wide-distributed in the national territory, as foreseen in this auction, results in operating and investment costs 16% higher than in a scenario with plants concentrated in the South Region (Werlang, 2022).

4 The PDE 2030 (The Ten-Year Energy Expansion Plan) also suggests that the projected power demand requires the expansion of technologies such as flexible thermal power plants and modernization of hydroelectric power plants in response to the demand - a mechanism that allows consumers to manage the use of energy from technologies that provide power, but not necessarily electrical energy -, i.e., they are options that can supply demand peaks of the system at specific times. Moreover, in the Technical Note EPE-DEE-011/2020-r0 on Transitional Measures (EPE, 2020), the EPE discussed the transition process to the new model, focusing on capacity contracting, and indicated technologies to be considered in the capacity auction.

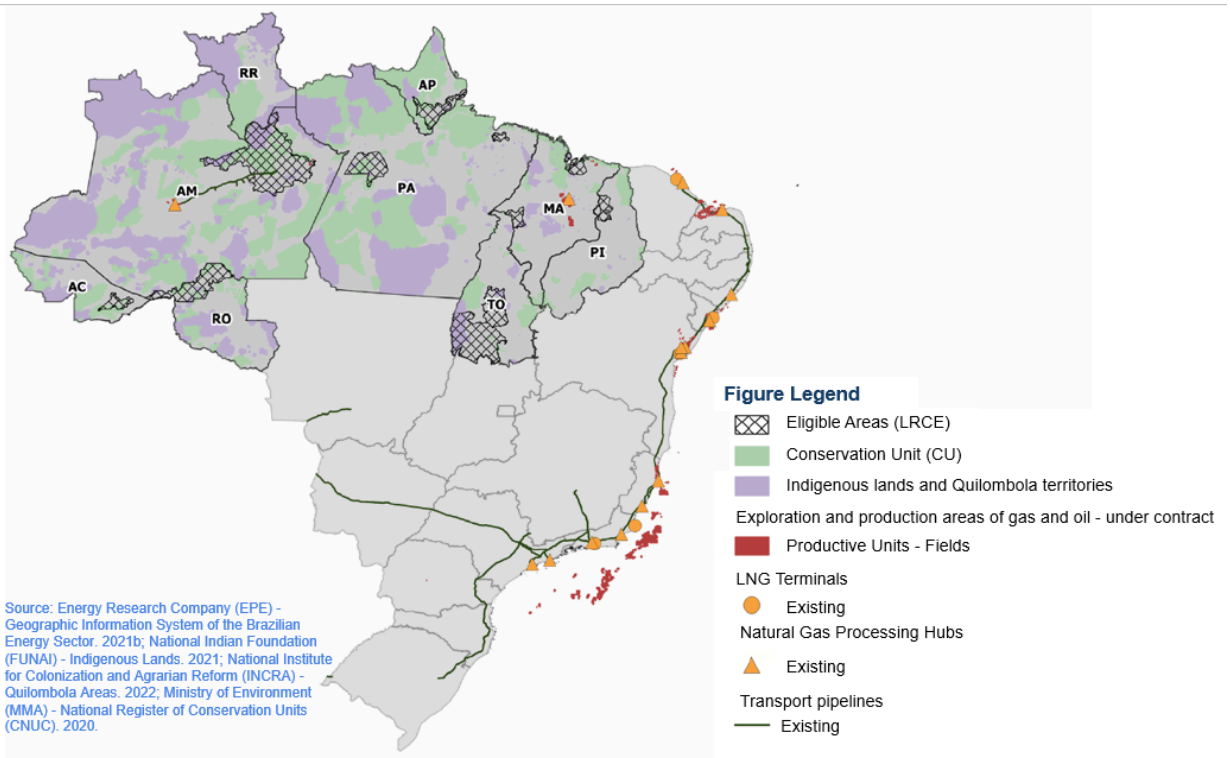
5 The project "Energy Systems of the Future: Integrating Variable Sources of Renewable Energy into Brazil's Energy Matrix" (Sistemas Energéticos do Futuro: Integrando Fontes Variáveis de Energia Renovável na Matriz Energética do Brasil, do Ministério de Minas e Energia), by the Ministry of Mines and Energy, in partnership with the German institution GIZ (German Agency for International Cooperation) and other consultants, modeled the integration of large installed capacity of variable renewable energy sources in the National Interconnected System and demonstrated that it would be possible to expand the insertion of onshore wind and solar energy, centralized and distributed, by up to 41% of installed capacity and 36% of the country's total energy generation, given the future reduction in costs of renewable technologies. The hydroelectric plants would be the great facilitators of the massive insertion of variable renewable sources because they can provide flexibility to the system due to the seasonal complementarity between wind and hydroelectric sources, which occurs mainly in the dry season when it rains less in the basins that feed the reservoirs of the hydroelectric power plants, and it is windier in the regions with installed wind farms. Also, the system could use flexible gas-fired power plants and energy storage technologies, or both, if water resources were exhausted. As such, the study points out the importance of other energy sources to provide controllable dispatch requirements to mitigate the energy and electrical effects of variability in VREs (GIZ, 2019).

2.2 LOCATION OF FUTURE POWER PLANTS AND COSTS RELATED TO PIPELINE EXPANSION

As previously stated, the Capacity Reserve Auction of 2022 only allowed the qualification of plants located in specific cities of the North and Northeast Regions; in the latter, only the states of Maranhão and Piauí were eligible. The complete list of eligible cities can be consulted in EPE's Technical Report EPE-DEE-IT-046/2022-r0 (EPE, 2022b).

Figure 2 summarizes the eligible regions survey and the existing infrastructure[6] for natural gas (transportation pipelines, processing terminals and hubs, and oil and gas production fields).

Figure 2 - Existing natural gas infrastructure and areas eligible for power plant contracting



The planned gas pipeline expansion[7] (Figure 3) to supply natural gas to the North and Northeast regions (orange dashed lines) totals 7,476 km, almost doubling the length of the country's current network[8]. If fully implemented, this infrastructure will require investments of almost R$ 57 billion[9] and a right-of-way strip [10] of approximately 150 km² (more than 18 thousand soccer fields), directly impacting land uses and increasing greenhouse gas (GHG) emissions from these projects.

6 Existing offshore infrastructure has been excluded.

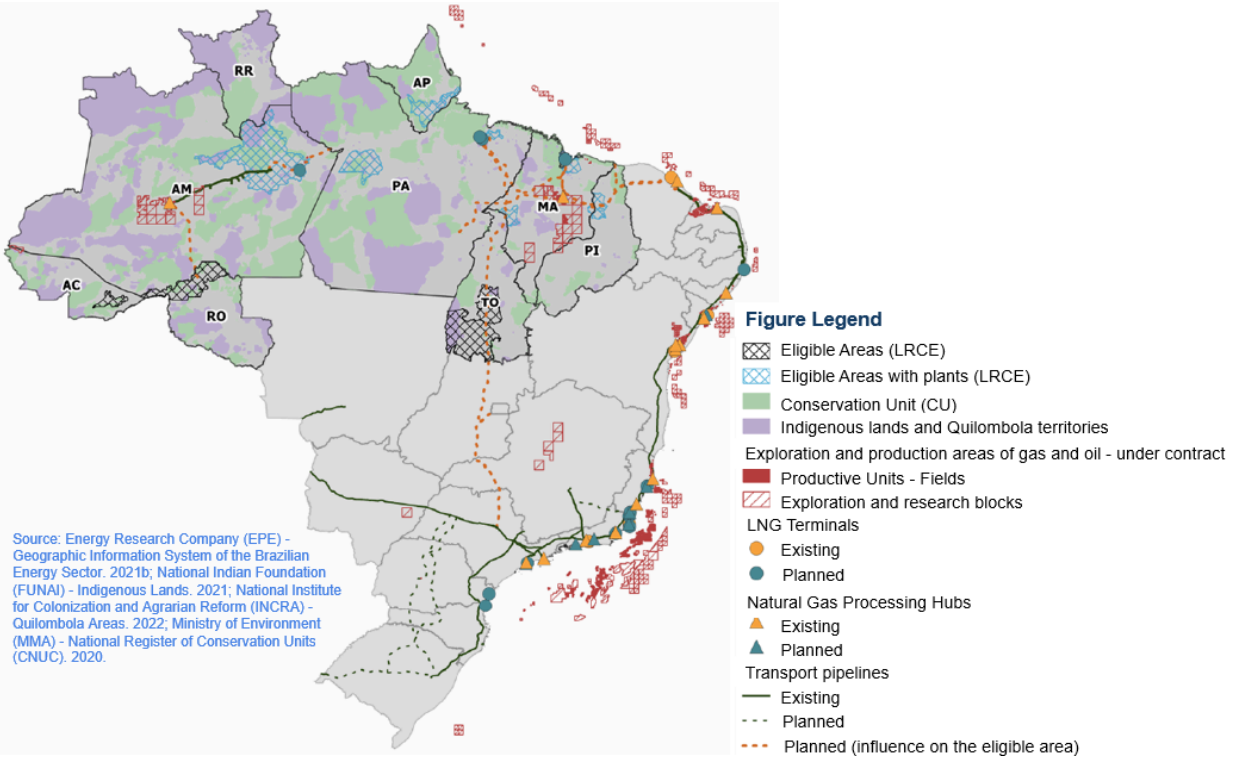
7 Among the pipelines categorized by EPE, the indicated, authorized, and studied pipelines were also classified as planned.

8 The length of gas pipelines, currently in operation, in Brazil is 9,409 km (MME, 2021).

9 The calculation considers the average cost of US$80.00 per meterpol (meter x inch) of the pipeline system [EPE, 2014; EPE, 2019] and an exchange rate of R$/US$5.1705 (BCB, 2022).

10 Landing stripping of 20 meters long along the axis of the gas pipeline (Brazil, 1996).

Figure 3 - Infrastructure expansion of the gas pipeline network, LNG terminals and natural gas processing hubs in Brazil



Considering only the gas pipelines foreseen to supply the priority areas of the State of Piauí, it would be necessary to build a 186 km extension line with an investment of approximately R$ 615 million and a right-of-way strip of 3 km². In the case of the State of Maranhão, the investment depends on where the thermal power plant is located and may vary from R$ 2.2 billion to R$ 5.6 billion, with a right-of-way strip between 8.1 and 13.6 km².

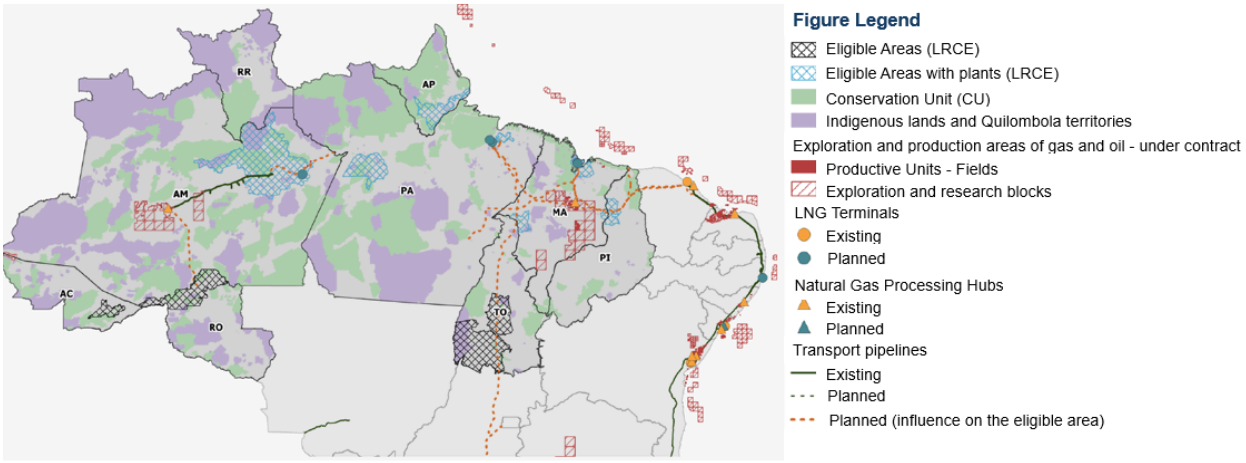
In the North Region, the estimate varies from state to state. The minor investment, R$ 2.9 billion, would supply Rondônia areas through the state's interconnection to the Urucu exploration area (AM). The most significant investment would supply the Tocantins areas, requiring the implementation of a gas pipeline from the state of São Paulo, at approximately R$7 billion, or a gas pipeline from the Northeastern states, by up to R$10.4 billion. In this case, the pipeline could also supply priority areas in Maranhão and Piauí. Amapá, Acre, and Pará priority areas also have no gas pipelines planned. Except for Acre, due to economic restrictions, the other two states can be supplied by LNG terminals installed on the coast, as is planned for Pará.

The last Ten-Year Energy Plan (PDE, 2031) does not foresee the expansion of the present gas pipeline network or compressor stations in the planning horizon. This information is essential because although the PDE simulates scenarios with new thermal power plants, it does not foresee the gas pipelines expansion.

Concerning the planned pipeline routes, there is an attempt to avoid passing through areas of Conservation Units (green spots in Figura 4), Quilombola Territories, and Indigenous Lands (purple in Figure 4) that have already been demarcated. However, in some stretches of land, the

invasion would be inevitable, and the socio-environmental impacts would be significant, especially implementing the planned pipelines in the states of Amazonas, Maranhão, and Tocantins (Figure 4).

Figure 4 - Existing and planned natural gas infrastructure in the North and Northeast regions of Brazil



Source: Energy Research Company (EPE) - Geographic Information System of the Brazilian Energy Sector. 2021b; National Indian Foundation (FUNAI) - Indigenous Lands. 2021; National Institute for Colonization and Agrarian Reform (INCRA) - Quilombola Areas. 2022; Ministry of Environment (MMA) - National Register of Conservation Units (CNUC). 2020.

Based on this observation, superimposing forecast data for the implementation of new LNG terminals, from exploration and production fields (E&P) of natural gas onto the areas selected for the implementation of these projects, it is possible to infer that the priority areas near the planned LNG terminals or E&P fields, as occurs in the metropolitan region of Manaus and São Luís, have priority in the auction, given the lower intensity of investments to ensure the supply of natural gas permanently, essential for the operation of thermal power plants with the inflexibility of 70%.

In any case, little or nothing has been said about who will bear the costs of implementing the infrastructure associated with the thermal power plants. This lack of definition increases the burden on all of Brazil's regulated market consumers. It also intensifies investor risk, especially in areas far from the existing gas pipeline network and LNG terminals, due to regulatory uncertainties (qualification and authorization to build new infrastructure) and the lack of definition of new consumer markets that will sustain the volume of natural gas in the medium and long term to compensate for the high investments in this type of project.

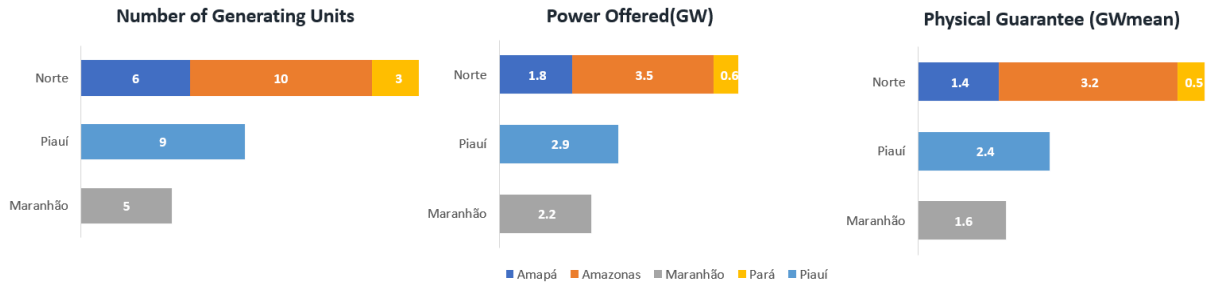
3. REGISTERED POWER PLANTS AND ENVIRONMENTAL IMPACTS

3.1 PARTICIPATING GENERATING UNITS OVERVIEW

Following the locational criteria, 33 of the 37 registered generating units[11] were qualified to dispute the 2 GW auctioned in the LRCE-2022. Together, these projects total 11 GW of offered power and 9 GWmean of physical guarantee[12] (MME, 2022b). In general, the generating units applying for this auction are located in only five states: Amazonas, Amapá, Pará, Piauí, and

Maranhão[13] (Figure 4). The winners should install 1 GW in the North Region, 700 MW in Piauí, and 300 MW in Maranhão (Figure 5).

Figure 5 - Generating Units by Auctioned Products



11 The term "Generating Unit" was adopted since some registered projects are blocks of a larger licensed plant. A plant X, for example, may have registered in the auction with "Plant X part A," "Plants X part B" and "Plant X part C" although, for licensing purposes, there is only the license issued for plant X.
12 Physical guarantee is the amount of energy a plant can supply to the system. It is a factor used to determine the maximum amount of energy that a plant can commercialize (MME, 2022).
13 In the Northeast region of Maranhão, the plants should be located in the city of São Luís or the metropolitan regions of Greater São Luís and Southwest of Maranhão. In the Northeast region of Piauí, the plants should be located in Teresina or the Integrated Development Region (Ride) of Greater Teresina. In the North region, the implantation must occur in the cities of Belém, Manaus, Macapá, Palmas, Porto Velho, or Rio Branco or in the metropolitan regions of Belém, Santarém, Macapá, Manaus, Palmas, Gurupi, and Porto Velho.

It is important to note that these generating units are registered for different products, then producing units of the Northeast Product Piauí are out of direct dispute with producing units of the Northeast Product Maranhão or North Product and vice versa since the plants of the same Product only dispute among themselves. Thus, 19 generating units (5.8 GW) are in dispute for the 1 GW in the North Region, of which more than half are located in the state of Amazonas. In Piauí, nine generating units (2.9 GW) dispute the 700 GW auctioned, and in Maranhão, five generating units (1.6 GW) compete to fill the auctioned power of 300 MW.

Unlike other auctions covered by IEMA, there was a predilection by the entrepreneurs to register generating units with less power. Of the 33 competing generating units, only six have installed capacity greater than 300 MW, and 22 are in the 280 to 299.9 MW range. In general, the median power of the plants is 295 MW, which is a relevant characteristic since, according to presidential Decree 8.437, IBAMA is in charge of licensing plants with power above 300 MW and, in cases of lower power, the licensing is the responsibility of the State Environmental Agencies (OEMAs, as in its Portuguese acronym) (BRASIL, 2015).

3.2 OBSTACLES TO INFORMATION ACCESS ABOUT LICENSING, TECHNOLOGIES EMPLOYED, GENERATING UNITS LOCATION AND THEIR ENVIRONMENTAL IMPACTS

Another critical and worrying factor is the difficulty in finding technical and licensing information about the participating generating units in an easy and accessible way. We searched the State Environmental Agencies (OEMAs) and the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA, as in its Portuguese acronym) for information on the licensing of the generating units or the corresponding power plants of which they are part, in addition to searching online platforms, direct contact via e-mail or portals for access to information.

When this bulletin was completed on September 22, 2022, it was impossible to find information on the licensing of seven of the 33 generating units that qualified for the auction. Even for those where the licensing process was found, and there is an indication of an issued document, only the Environmental Licenses of 13 units are available for download.

Some of the licensing processes started in May 2022, and in some documents, it is mentioned that the license was granted exclusively for project participation in the LRCE. The speed at which the licenses were granted puts at risk the environmental impact evaluations these projects may cause, including the requirement of documents such as the Environmental Impact Study and Environmental Impact Report (EIA-RIMA, as in its Portuguese acronym). Among the participating projects, only five have EIA-RIMA available, of which three are part of a single licensed plant, and the other two are part of a second plant. In some cases, the Preliminary License explicitly states that this document does not exist and will only be required if the enterprise wins the LRCE and applies for the installation license.

Generating units or corresponding power plants were also identified in the initial licensing process without acquiring the preliminary license. These plants' status contradicts § 3 of chapter II of Normative Rule No. 46/GM/MME, according to which the environmental licenses should have been delivered until August 19, 2022, to the EPE for project qualification (MME, 2022a).

In the same context of information accessibility, only six projects were located through their name or CEG ANEEL in the Georeferencing Information System (SIGEL/ANEEL, as in its Portuguese acronym), where it would be possible to find location information (geographical coordinates and precise city) and ownership of the projects (ANEEL, 2022b).

Accessing most of the generating units' documents with a more detailed description of the project and the technologies employed was impossible. The absence of information, such as the thermodynamic cycle, type of cooling technology, water collection site, geographical coordinates, water consumption, and existing and predicted pollutants emissions, makes the environmental impact assessment challenging and incomplete on the part of both public authorities and civil society.

Depending on the technology and location of the plant, the demand for hydric resources (used in thermal power plants cooling systems) is a sensitive point for discussion of the projects' local impacts. For most plants participating in the auction, information was not found related to

hydrographic basins, technology applied, and possible sources of capture since half of the contracted power is destined for the Northeast, a region of Brazil with critical water availability.

In the case of the Integrated Development Region (Ride) of Greater Teresina, qualified to participate in the auction with 700 GW, 65% of the region's basins are classified as very critical, critical, or worrisome considering the Quantitative Water Balance made available by the National Water and Sanitation Agency (ANA, as in its Portuguese acronym).

Regarding the emissions of air pollutants by the power plants that eventually win the auction, the little attention given by the institutions to the risks to public health draws attention since none of the areas qualified for the contracting of the plants has air quality monitoring stations in operation. Without monitoring the concentration of pollutants in the air, it is impossible to identify the pre-existing conditions and, consequently, to monitor changes in concentrations with the operation of new projects and the health impacts to which citizens will be subjected.[14]

3.3 GREENHOUSE GAS EMISSIONS ASSOCIATED WITH THE ENTRY OF CONTRACTED ENERGY INTO THE ENERGY MATRIX

Differently from the auctions held until now, in the LRCE-2022, the maximum power to be contracted is already known even before the auction takes place. In this context, it was estimated the greenhouse gas emissions associated with the entry of 2 GW, the object of the auction, as well as the total 8 GW foreseen in Law 14.182/2021.

For this, a capacity factor of 70% was considered, as defined by Normative Rule no. 46/GM/MME. An average emission factor was adopted for gas-fired combined cycle power plants, a technology that is understood to be the most likely for the construction of new plants, of 422 tons of equivalent carbon for each GWh produced (tCO_2e/GWh), available on the Inventory of Atmospheric Emissions in Thermal Power Plants, published by IEMA in June 2022 (IEMA, 2022).

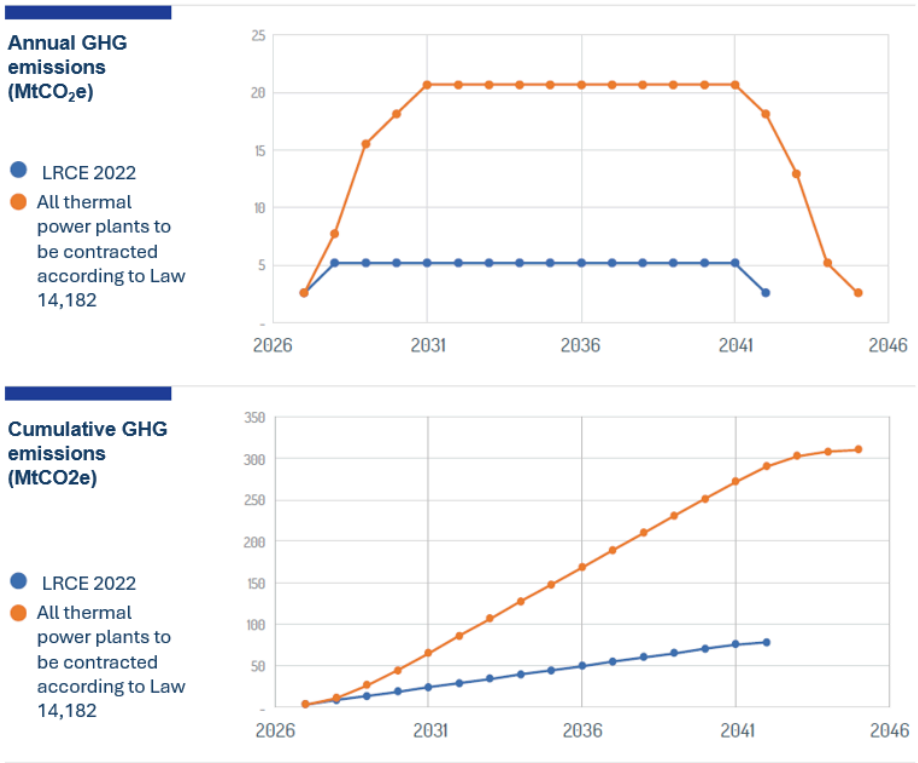
The first gigawatt is scheduled for 12/31/2026 with the delivery of the LRCE-2022 North Product power plants. By 12/31/2027, the plants of the Northeast Products Piauí and Maranhão should be ready to operate. With this, it is estimated that as of 2028, these plants will generate about 12 GWh of electricity and emit about 5.2 million tons of tCO_2e annually. For instance, this is equivalent to almost 30% of everything emitted by gas-fired power plants in 2020 or 17% in 2021. With 15-year contracts, it is expected that by 2042 the power plants contracted in the LRCE-2022 will release about 77.6 million tons of tCO_2e into the atmosphere, of which 38.8 are predicted for the North Region, 27.2 for Piauí and 11.6 for Maranhão.

14 Because of fuel burning, thermal power plants emit a variety of gases and particles, especially particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_x), and sulfur oxides (SO_x). Some of these pollutants participate in reactions in the atmosphere, giving rise to secondary pollutants such as tropospheric ozone (O_3). The presence of high concentrations of these pollutants in the atmosphere has

proven to have adverse effects on human health and the environment. The degradation of air quality has been associated with the aggravation of respiratory, cardiovascular, and neurological diseases, as well as different types of cancer.

Figure 6 illustrates the annual and cumulative emissions for the power plants contracted only in the LRCE-2022 and for the entire set of plants that must be contracted according to Law 14.182/2021.

Figure 6 - Annual and cumulative emissions for LRCE-2022 and totals according to Law 14.182



Analyzing the emissions of the whole set of thermal power plants to be contracted according to Law 14.182, between the entry of the first 1 GW in 2026 and the final GWs in 2045, the thermal power plants will emit an accumulated total of 310 million tCO_2e. This amount equals what has been emitted in the last 50 years by the Brazilian polluting coal-fired thermal power plants (SEEG, 2021). The annual emissions may reach 20.7 million tons, equivalent to an increase of 36% in the energy sector emissions registered in 2021.

4. CONCLUSIONS

In past decades, natural gas generation was considered a decarbonizing energy option to replace fuel oil, diesel, and coal, contributing to reducing emissions in many countries and

regions. In Brazil, wind and solar energy sources are already assuming a prominent role, present in second and third place among the sources with the largest installed capacity in the country, behind only hydroelectric generation. Meeting demand in strategic periods can be made by dispatchable sources such as biomass, energy storage options, or even the use of thermal power plants to meet peak periods, as the plants contracted in the 2021 capacity reserve auction.

According to the considerations of the technical note regarding the privatization law of Eletrobras (IEMA, 2021a), it is reiterated that contracting the planned volume of fossil thermal power plants, especially in an inflexible operation regime, is conflicting with the planning and modernization of the energy sector.

Besides wasting energy that could be injected into the system, the restrictions on the operation of variable renewable energy sources, such as wind and solar, will imply increased energy costs that could be directed to consumers' electricity tariffs or other public budgets. It is worth mentioning that the rates of economic growth and, consequently, the growth in energy demand have been lower than projected in official planning documents, resulting in the cancellation of auctions scheduled for the second half of 2022, such as the A-6 and the capacity reserve auction that was supposed to be held in December. The current scenario of low demand allied to the insertion of inflexible thermal power plants tends to accentuate the restriction of the operation of renewable plants and the energy cost in the medium term since fewer renewables would be contracted.

There is also the risk of making the energy matrix more dependent on imported fuel, as is the case of LNG, which is subject to international price variations and indexed to the dollar. The consequences of this choice were already felt by energy consumers in 2021 when LNG importation tripled to meet the demand for fuel from thermal power plants, which increased 22% over the previous year due to a 62% expansion of this type of power generation (EPE, 2022c).

The investment in power plants that will operate in the system for at least 15 years will represent a potential increase in pipeline costs, in addition to the need for new transmission lines and subsections, compared to other energy options closer to the country's largest load centers. Besides the increase in costs, the subordination of the energy sector planning to the natural gas industry expansion policy currently underway in Brazil compromises the necessary decarbonization of the Brazilian energy matrix. With different technical studies demonstrating the integration of wind, solar, biomass, and hydroelectric plants, the expansion of fossil fuel power generation shows itself to be against the global energy transition scenario.