WHAT ARE THE REAL COSTS AND BENEFITS OF ELECTRIC POWER GENERATION SOURCES IN BRAZIL?

instituto Escolhas

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Escolhas Institute is a think tank that develops studies and analyses on economy and the environment that contribute to allow sustainable development.

Andre Nery

PRESENTATION

Referred study was designed by Instituto Escolhas aiming at assessing the costs and benefits of electric power generation sources, carried out through analysis of their different attributes. With that, it aims at providing data that qualify the debate on the feasibility to increase participation of the new renewable (aeolian, solar, biomass) in our electric matrix with reliability, economicity, and sustainability.

Escolhas, thus, entered-into a partnership with PSR Soluções e Consultoria em Energia, one of the most acknowledged expert consultants in the country's electric segment, to set up an inedited methodology to valuate the attributes of the sources.

THE MAIN RESULTS ARE:

Brazil, by 2026, may increase the participation of renewable in its electric matrix without this resulting in significant costs to operate the electric system.

An inedited methodology to calculate the real costs and benefits of electric power generation sources, which allows for the effective valuation of their attributes, providing discussion of the manner how costs are allocated among the agents in the Brazilian electric segment.

Subsidies are a component of energy costs that potentially cause distortion upon pricing of the sources.

Brazil, in 2035, may increase in 68% the participation of wind, solar, and biomass energy in its electric matrix, in relation to the forecast in the Energy Decennial Plan of 2026, totaling 44% of the matrix's composition. This change can occur without affecting the competitiveness and attractiveness of the megawatt-hour (MWh) of these sources for consumers.

Not every MWh is economically equal and this study shows the actual cost of each one of them to society. However, once the attributes valuation realized in this study considers the complementarity between the generation sources operating jointly, the optimal expansion plan for the system should not necessarily select only the option with the lowest cost.

The attributes taken into account in this assessment are presented below and the inedited methodology set up to calculate the real costs and benefits of generation sources, which is fundamental for planning an efficient composition of our electric matrix.

ASSUMPTIONS

The energy sources have proper attributes, which are their characteristics and differentiate one from another. This causes each one to have a different role and, at the same time, complement the Brazilian electric matrix. Wind energy, for example, is clean and renewable, but its production is variable, because there is no way to operate if there is no wind. A thermal power plant emits greenhouse gases, but can be engaged at any time. That is, no single source has all the features necessary for optimal operation of the electrical system, or is self-sufficient, coming hence the complementarity among these.

Obviously, to the extent that technology advances, as, for example, the evolution of batteries, the most restrictive attributes of new renewable sources tend to suffer modifications, such as the ability to store the energy generated by solar and wind plants.

The greatest challenge in electricity supply of any country is to ensure the demand with quality, reliability, sustainability and in the most economical way possible. Thus, several objectives must be taken into account, analyzed simultaneously:

1. **Minimize *rates* to the consumer, taking into account the sum of generation and transmission costs;**

2. **Ensure the *reliability* of supply, that is, reduce the likelihood of power supply (rationing) and power (interruptions) failures;w**

3. **Ensure *robustness* of supply, which means resist the occurrence of low probability events, but of great impact, such as a catastrophic failure (and of long term) in a large hydroelectric plant or natural gas supply halt due to geopolitical crisis;**

4. **Ensure that *energy policy requirements* of the country are fulfilled, such as limiting greenhouse gases emissions in the energy segment, commitment undertaken by Brazil as a result of the Paris Agreement[1].**

[1]Agreement entered-into at the 21st Conference of the Parties (CoP-21) of the United Nations Framework Convention on Climate Change (unFCCC), in 2015.

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The expansion of electricity supply in Brazil, takes place mainly through auctions set up by the government. Referred auctions exclusively took into account the power production capacity of participating companies - volume of megawatts per year (MWh/year) distributed throughout the months -, without considering what the power generation source is, and to the detriment of other characteristics, such as reliability, robustness, greenhouse gas emissions and others.

This means that the comparison between different bids at the auctions was carried out only through the price of energy or expectation of cost to the consumer. As a consequence, other features related to the total services - called attributes - that each generation source can provide to a system were not valued explicitly. In addition, there are subsidies and tax, financial, and fiscal incentives to generators that affect the final price of energy and the outcome of auctions.

As of 2013, Brazil started to carry out auctions separated by source, thus allowing contracting of a generation type to the detriment of another, even if the energy price of same is higher. Such segmentation of the auctions implicitly considers the attributes of generators. Nonetheless, there is no official method of valuation of such features or to define the amount to be contracted from each source.

UPON NOT VALUING THE ATTRIBUTES OF SOURCES, THE FINAL PRICE DOES NOT REFLECT ALL THE REAL COSTS AND BENEFITS TO SOCIETY.

The previous model made no sense because the main generation source in the country were hydroelectric plants. The mix of generation sources changed over time, mostly with the presence of fossil-fuels thermoelectric plants and most recently, with the massive arrival of aeolian generation.

Such fact started to cause impacts that were not present before. An example is the use of thermal power to compensate for the problems of reduced generation capacity of hydroelectric plants in the Northeast region, caused by successive droughts in recent years. The result was the increased costs because of the high prices of fossil fuels and increased greenhouse gas emissions.

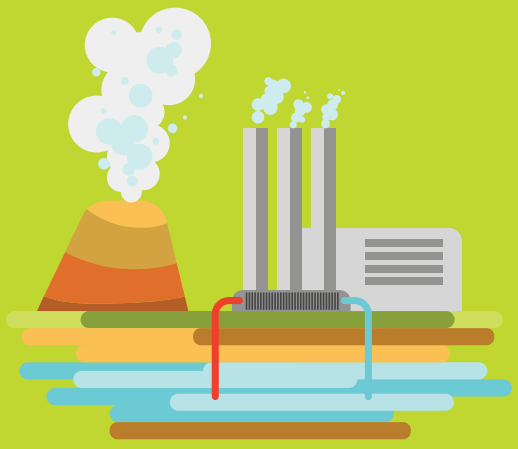
In addition, with climate change — that can impact the supply of energy from various sources-, it is even more important to consider the mix as a whole and not just the sources alone. This is because the sustainability of the electric matrix needs to be deemed as a primordial factor, as well as its safety and reliability.

In summary, the simplified contracting model, upon not being updated, carries inefficiency for the economy. In addition, same does not explicit for managers and society the true trade-offs of decisions on changes in the electric matrix, such as for example, defending massive construction of solar plants or the need to build more gas-powered thermal plants.

ANALYZED SOURCES

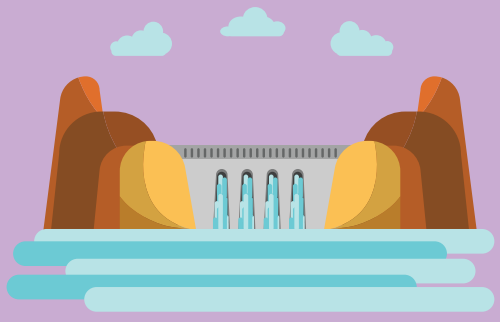
Empresa de Pesquisa Energética - EPE (Energy Research Company) sets up the Energy Expansion Decennial Plan (PDE), document that guides the government's selections and those of private agents to meet the local energy demand. This study is part of the last of these plans, which indicates in which sources and in what proportions the country will invest up to 2026 (PDE 2026).

ENERGY SOURCES FORESEEN IN PDE 2026[2]:



Natural gas thermoelectric plant[3]:

Operates through combustion of fuel gas in turbines.

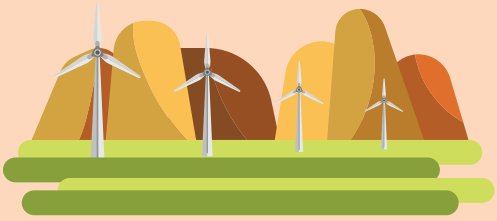


Hydroelectric plant:

Water stream: No water storage capacity for drier periods.

Small Hydroelectric Central: small-size hydroelectric plant and without water storage.

[2]PdE 2026 does not foresee power generation from hydroelectric plants with reservoir and nuclear plants.
[3]The study considered different alternatives for efficiency of plants (combined cycle and open cycle), for the operating inflexibility level (0% and 50% inflexible) and for origin of natural gas (local and imported).

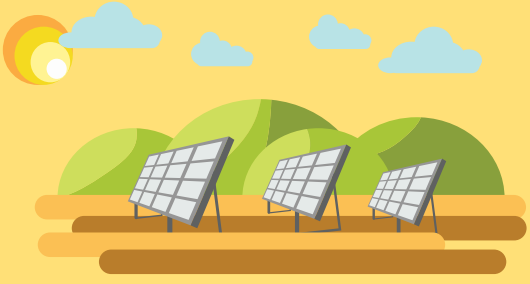


Aeolian plant:

Transforms wind energy into electric power.

Biomass plant:

Operates through combustion of organic material.



Photovoltaic solar plant:

Transforms energy of the sun into electric power.

METHODOLOGY

The study methodology calculates the total cost of power generation in Brazil through the assessment and valuation of attributes (characteristics) of five components for each generation[4] source foreseen in the PDE 2026 expansion plan.

The developed models analyze aspects not considered currently in official planning tools for operation and expansion of the matrix, such as: schedule, lead demand restrictions, detailing of the transmission grid, variability in aeolian and solar production and greenhouse gas emissions.

In addition, the costs and benefits were analyzed considering the synergy among the sources referred to in PDE 2026, which means that the results presented are strongly influenced by the configuration of the planned generation plant. For example, the benefit of solar generation time complementarity was analyzed (production concentrated during the day) as well as aeolian in the interior of the Northeast (greater production at dawn) in relation to thermoelectric plants, in the 2026 matrix, as well as the one projected for 2035.

Matyas Rehak

[4]Specific techniques were developed for assessment of each attribute, which are set out in summary in the main report (escolhas.org/biblioteca/estudos-instituto-escolhas/).

ANALYZED ATTRIBUTES

1 Investment and operation costs

Annual cost to recover the investment and operate the plant throughout its lifetime.

The new renewable sources are those with the lowest cost of investment and operation in relation to the others.

2 Services provided by the source in addition to energy production itself

Modulation: Generator's capacity to comply with energy demand throughout the month.

Seasonality: Generator's capacity to comply with demand throughout the year.

Robustness: Generator's capacity to produce energy beyond what was planned.

Reliability: Generator's capacity to inject power into the system to avoid interruption in supply.

The thermal source is the one with the best outcome. Hydroelectric plants have problems with seasonality, and wind and solar plants with the variability in energy production.

3 Infrastructure costs caused (or avoided) by the generator

Investments in infrastructure for the proper functioning of the electrical system (generation and/or transmission grid equipment) caused or avoided by each source.

Among the renewables, biomass is the one that has the lowest cost of infrastructure.

4 Subsidies and exemptions

Cost paid by society due to various incentives and exemptions offered by the government to the various energy sources. Tax exemptions, financing at differentiated rates by public financial institutions and regulatory incentives were taken into account in this study.

Subsidies may be used by the government to increase or decrease the participation of a certain source in the matrix, with consequences such as increase or decrease in the cost of energy to consumers and/or allocation of additional costs to other generators. Furthermore, depending on the source with incentive, it may reduce greenhouse gas emissions.

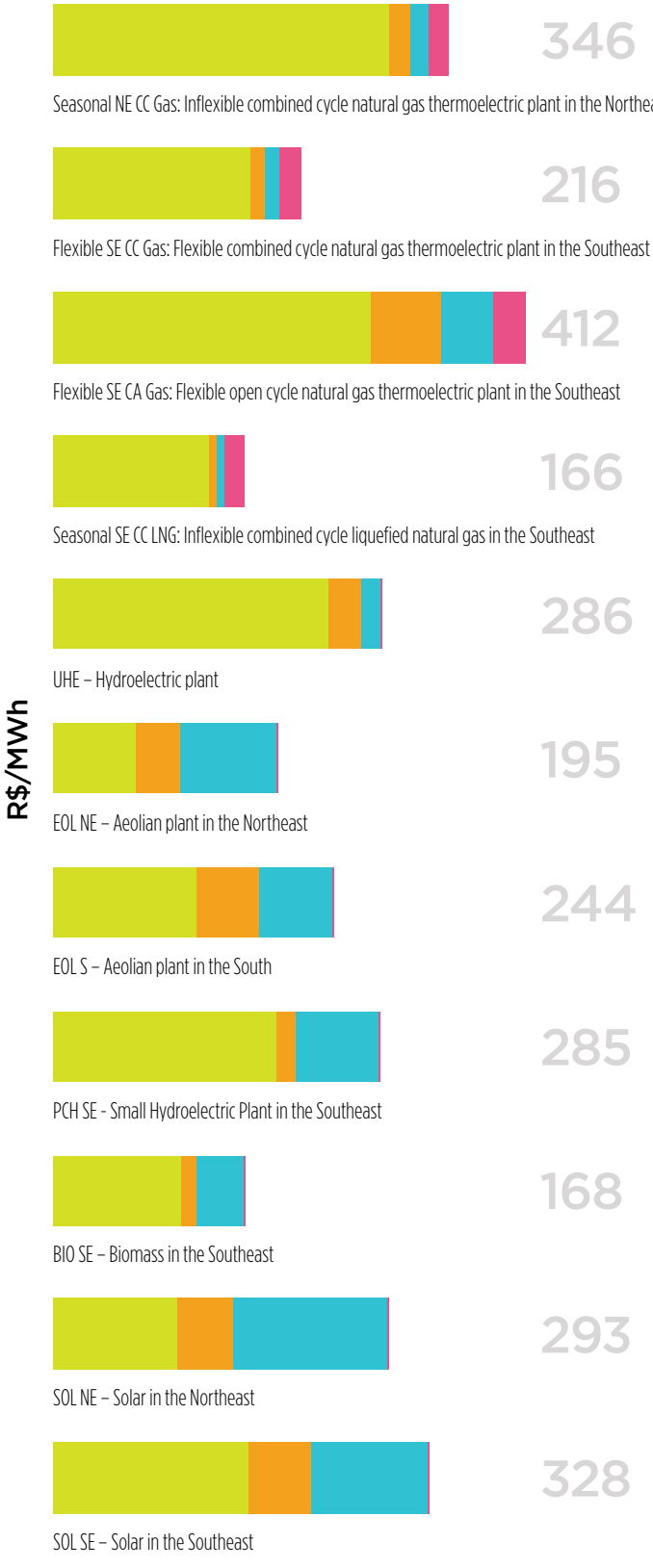
The sources that most receive subsidies and exemptions are solar, wind and small hydroelectric plants.

5 Environmental costs:

Costs to society relating to greenhouse gas emissions from each power generation source.

Once this study analyses the cost of emissions, it provides the opportunity to include one of the features of environmental attribute into the debate of pricing the energy sources. Other aspects of this attribute are to be incorporated into further unfolding of this study. The source with the highest cost of emission is the thermoelectric plant.

FINAL COST OF ENERGY FOR ALL OF PDE 2026 EXPANSION SOURCES



1 – Investment and Operation Costs

2 – Services provided by the source in addition to power production itself

3- Infrastructure costs caused (or avoided) by the generator

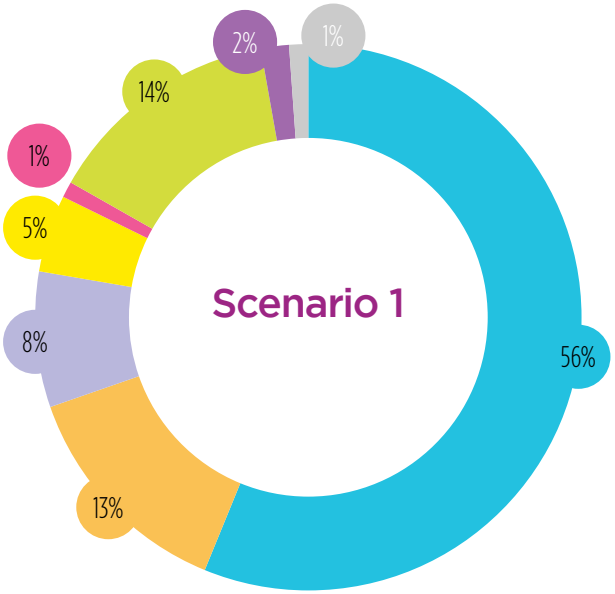
4 – Subsidies and exemptions

5 – Environmental (10 US$/$tCO_2e$)

SCENARIOS

Beyond the valuation of attributes in the base scenario (PDE 2026), the study counted with sensitivity analyses for another three scenarios with progressive expansion of new renewables. In these cases, only the attributes of modulation, seasonality and probabilistic reserve according to the projected electric matrix's mix, were assessed.

These three attributes are relevant to test the ability to ensure a stable supply of energy. The results indicate that the expansion in participation of new renewables (44%) may be carried out without significant impact to the system's cost. See the scenarios in which this is possible:



Participation of sources in the electricmatrix - base scenario PDE 2026 Total power - 211 GW

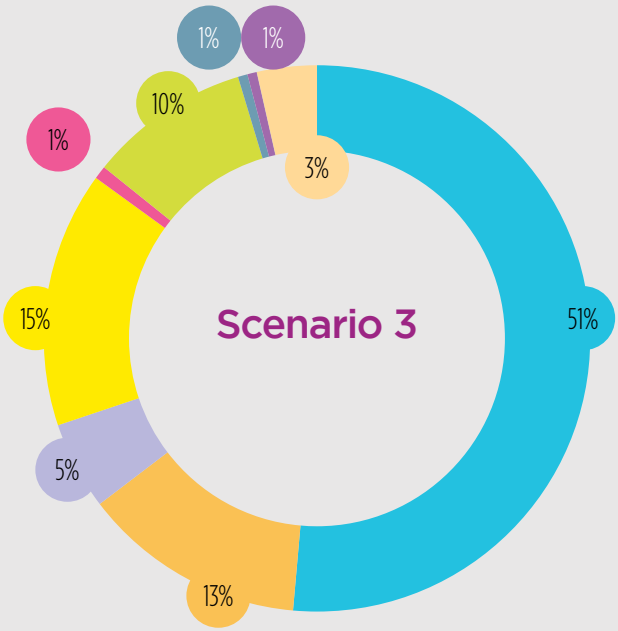
Supply on the last year of PDE 2026.

2026

Participation of sources in the electric matrix – base scenario 2035 - proper estimate Total power – 255 GW

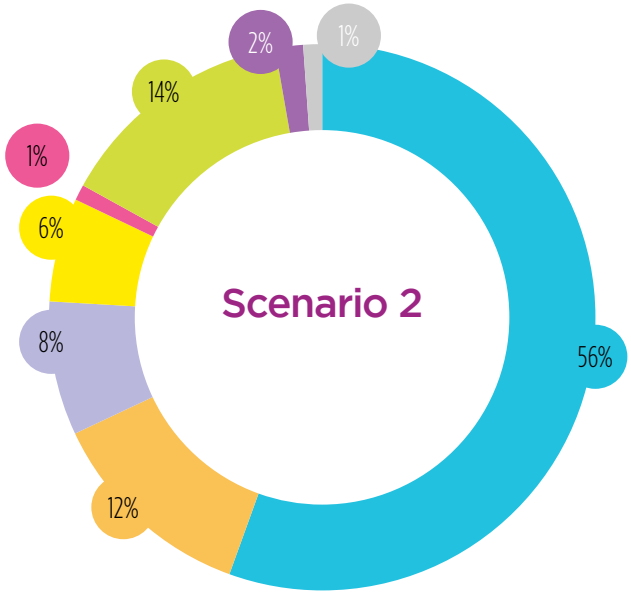
Demand projection for 2035, which foresees installed capacity expansion with solar, wind, natural gas and some hydroelectric projects. Thus a GDP growth of 2,9% per year was considered between 2027 and 2030 and of 3% per year between 2031 and 2035. This mix has an installed capacity of approximately 72 GW for new renewables (wind, solar and biomass).

2035



UHE + PHC | Aeolian | Biomass | Solar
Nuclear | Gas | Imported coal | Coal
Diesel/fuel oil | | | Others

Participation of sources in the electric matrix – scenario of greatest insertion of renewables of PDE 2026 Total power - 214 GW

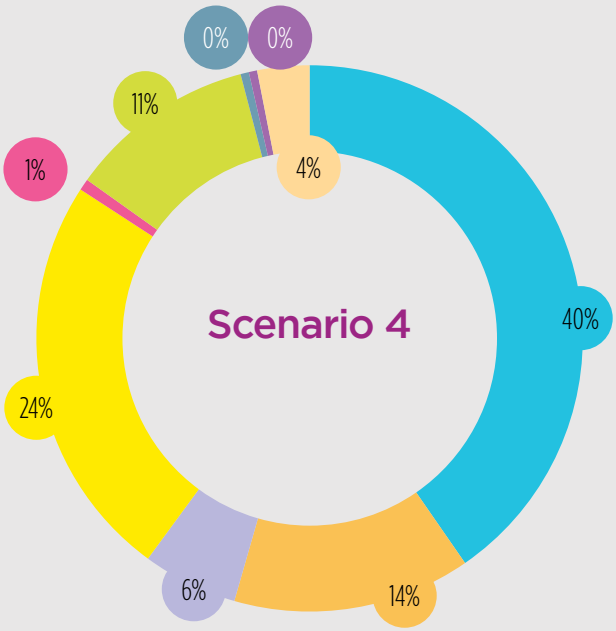


Foreseen an investment of over R$94 billion in renewable by 2026 due to a reduction in the cost of solar power investment, resulting in an increase of about 4 GW in the installed capacity from this source. Of this amount, 11.6% will be allocated to biomass, 56.4% for wind, 32% to solar.

2026

Participation of sources in the electric matrix – scenario of greatest insertion of renewables 2035 proper estimate Total power - 293 GW

Projection with larger renewable insertion for 2035, considering an expansion of the generation Park with higher concentration of wind, solar and biomass and, consequently, less participation of natural gas in the electric matrix. In this framework, new renewables reach 128.4 GW installed, reflecting a 44% participation in the energy matrix's total.



2035

see the full survey at: **http://escolhas.org/biblioteca/estudos-instituto-escolhas/**

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