



# **BRAZIL'S** ACTION PLAN FOR RAPID DECARBONIZATION OF POWER SECTORS



## BACKGROUND

A collaborative report from the Clean Energy Ministerial (CEM) on [Lessons Learned for Rapid Decarbonization of Power Sectors](#) was delivered to energy ministers and presented at the CEM13 in the United States in September 2022. In light of these lessons learned and discussed at CEM13, several jurisdictions signaled intent to develop Action Plans for power sector decarbonization. The [first cohort](#) of Action Plans was released at CEM14 in India in July 2023. The second cohort of action plans will be presented at CEM15 in Brazil.

The Action Plans, supported by the [21st Century Power Partnership](#), and other CEM workstreams via direct technical assistance and capacity building, are intended to focus on select implementation actions, given each country's existing power sector goals and activities, and are an opportunity for countries to display leadership in power sector decarbonization. The Action Plans are organized in a framework for Planning, Building and Operating, as well as Stakeholder Engagement where appropriate based on country priorities. They complement, but are differentiated from, other international power sector initiatives such as the Breakthrough Agenda (whose broad purpose is to raise collective ambition) and the Global Power System Transformation Consortium (whose goals are to convene power system operators to accelerate research innovations and foster peer learning).

**These Action Plans are voluntary, developed by each country individually, not comprehensive of all activities within the jurisdiction, and are living documents that are subject to change**



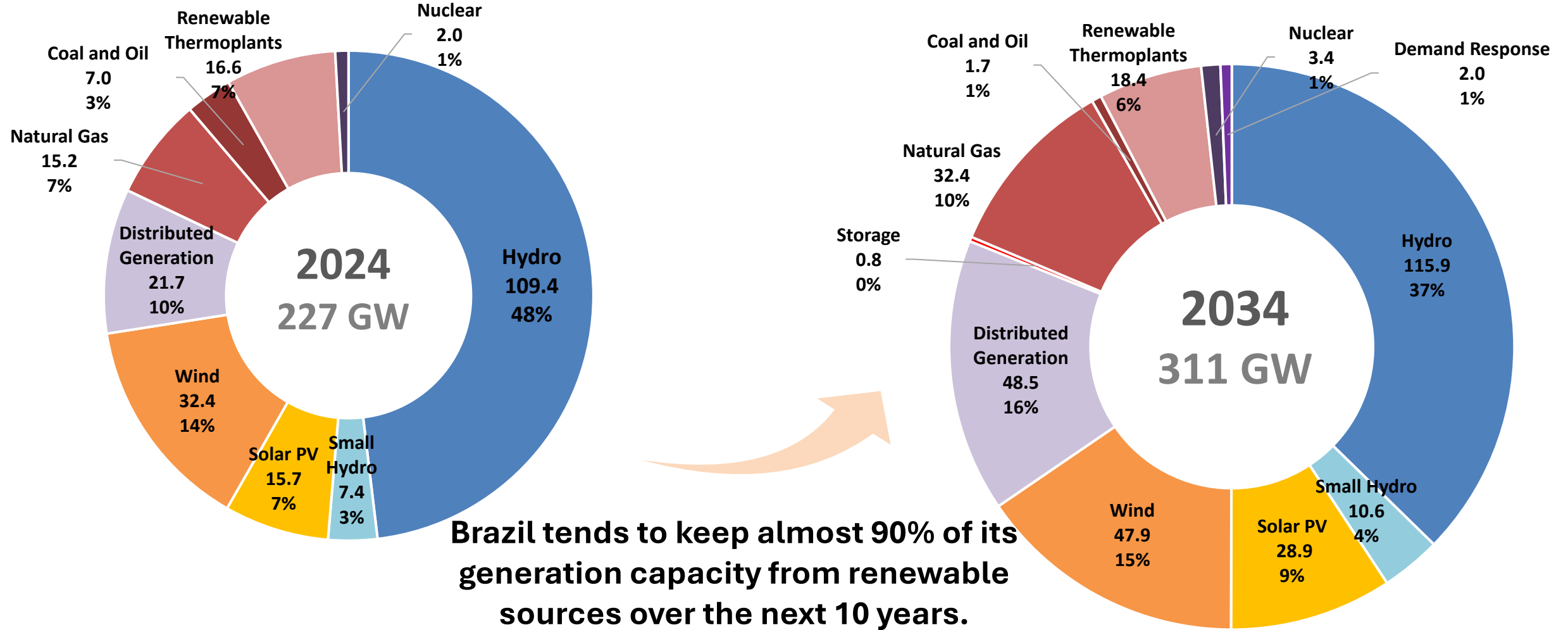
**Brazil**

# BRAZILIAN ACTION PLAN IN AN ENERGY TRANSITION CONTEXT

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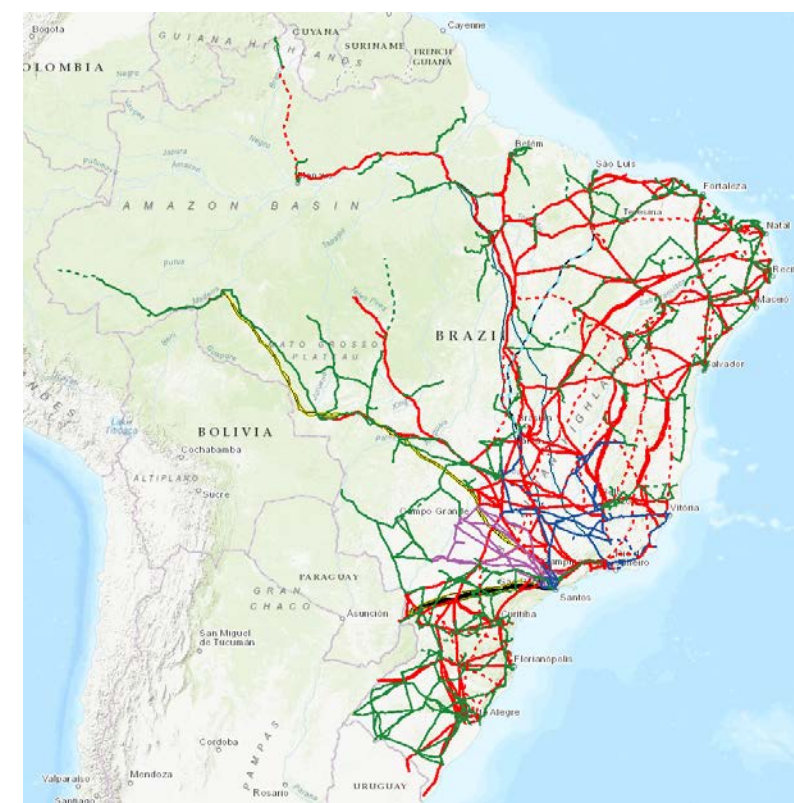
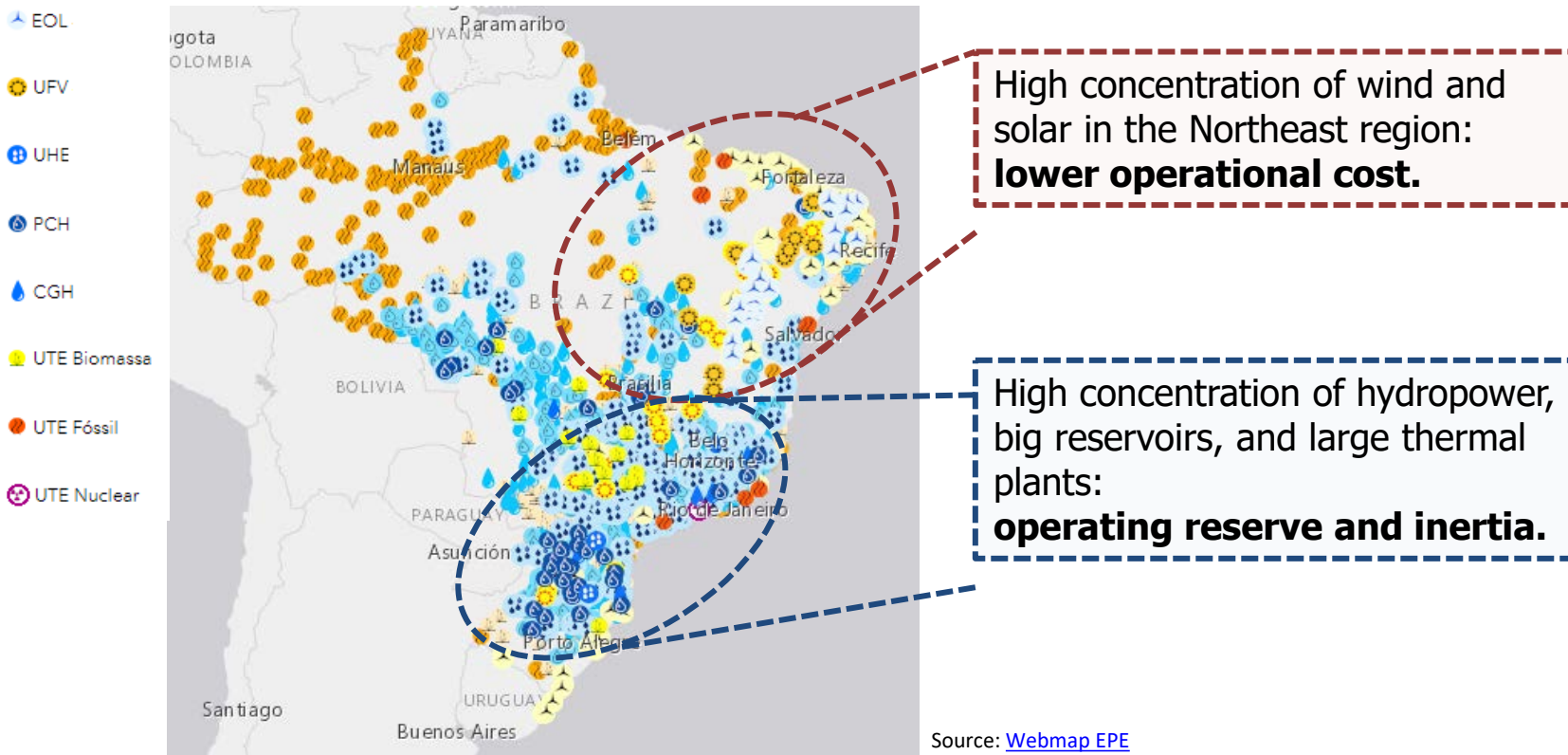
# BRAZIL: A RENEWABLE CONTINENTAL-SIZE POWER SYSTEM





Brazil

# BRAZIL: A RENEWABLE CONTINENTAL-SIZE POWER SYSTEM



Source: [Webmap EPE](#)

**A robust and reliable transmission system is necessary so that all available resources can be optimally and globally utilized.**



## LAUNCH OF THE NATIONAL ENERGY TRANSITION POLICY

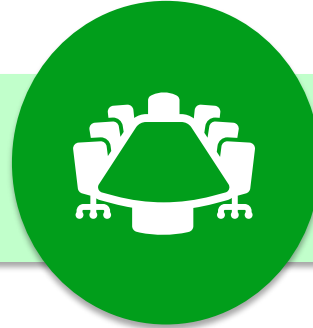


### December 2023

The **creation** of the National Energy Transition Policy is debated in the National Energy Policy Council (CNPE).



The National Energy Policy Council (CNPE), chaired by the Minister of Mines and Energy, comprises 17 state ministers and serves as an advisory body to the President of the Republic for the formulation of energy policies and guidelines.



### Jan/Jul 2024

Rounds of **discussions** with members of the CNPE and the National Office for Social Participation of the General Office of the Presidency.



### August 2024

**Approval** of the Resolution establishing the **National Energy Transition Policy** (PNTE) and its two instruments: the **National Energy Transition Plan** (PLANTE) and the **National Energy Transition Forum** (FONTE).



## NATIONAL ENERGY TRANSITION POLICY

### Objetives

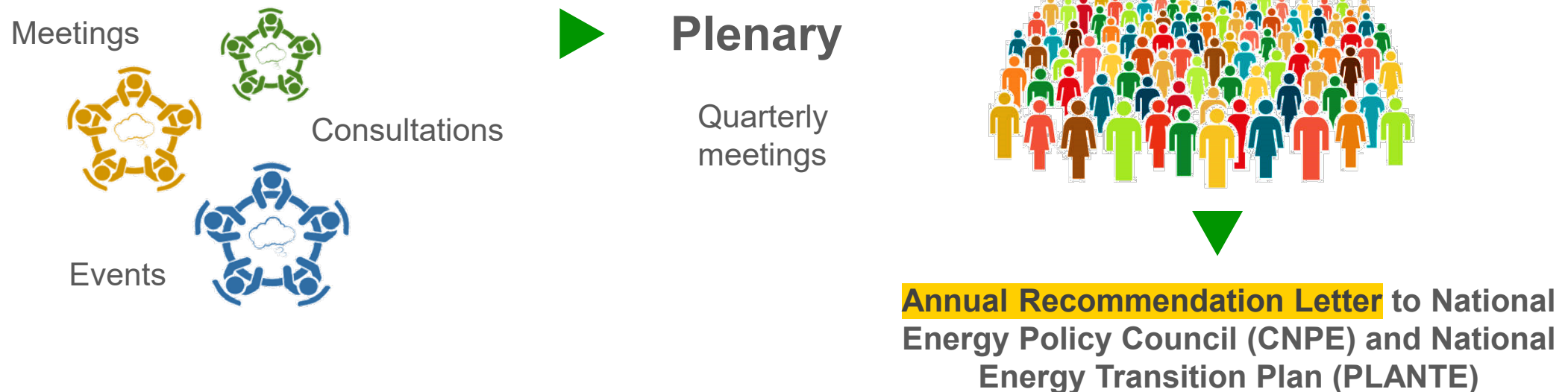
- ❑ Clearly articulate **Brazil's ambition** for an energy transition, guiding the country's efforts.
- ❑ Support the **alignment** of energy policy with other public policies.
- ❑ Increase the country's capacity to **attract investments** in the strengthening of energy transition supply chains, generating jobs and income.
- ❑ Establish a foundation for dialogue with society and **greater social participation**.
- ❑ Influence the development of the global energy sector, promoting opportunities for Brazil's **economic and geopolitical integration**.



## INSTRUMENTS OF THE NATIONAL ENERGY TRANSITION POLICY

### National Energy Transition Forum (FONTE)

- A permanent and **consultative instrument**, aimed at stimulating, expanding, and democratizing discussions on energy transition between the Federal Government, civil society, the productive sector, and subnational entities.







## INSTRUMENTS OF THE NATIONAL ENERGY TRANSITION POLICY

### National Energy Transition Plan (PLANTE)

- **Long-term action plan** that aligns with energy transition scenarios, supports economic and social development needs, and aims for net-zero greenhouse gas emissions in Brazil.

#### **I - Sectoral Approach**

Covering actions to promote energy transition within each economic sector, tailored to the relevance, complexity, and specific characteristics of each sector.

- Energy in Industry
- Energy in Transportation
- Decarbonization of Oil and Gas
- Electric Power Sector
- Mining Sector

#### **II - Cross-cutting Approach**

Addressing aspects such as the legal-regulatory framework, investments and financing, and the social dimension of the actions.

- Legal-Regulatory Agenda
- Promotion of Investments
- Energy Inclusion
- Supply Security
- Others



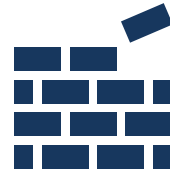
## CHALLENGES AND OPPORTUNITIES FOR BRAZIL IN AN ENERGY TRANSITION CONTEXT

Despite Brazil's current clean power generation mix, challenges remain to **enhancing the security of supply**, promoting a **fair and inclusive transition**, and keeping the **renewability of the power system**.



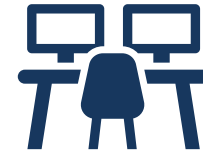
### Planning

Actions that are starting and under construction, and for which the result will be seen in the medium and long term (years ahead).



### Building

Actions that are already in discussion and can be implemented in the mid-term horizon.



### Operating

Actions and analyses that can be implemented and bring results in the short term.



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# I. PLANNING

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Action Plan for Rapid Decarbonization of the Power Sector



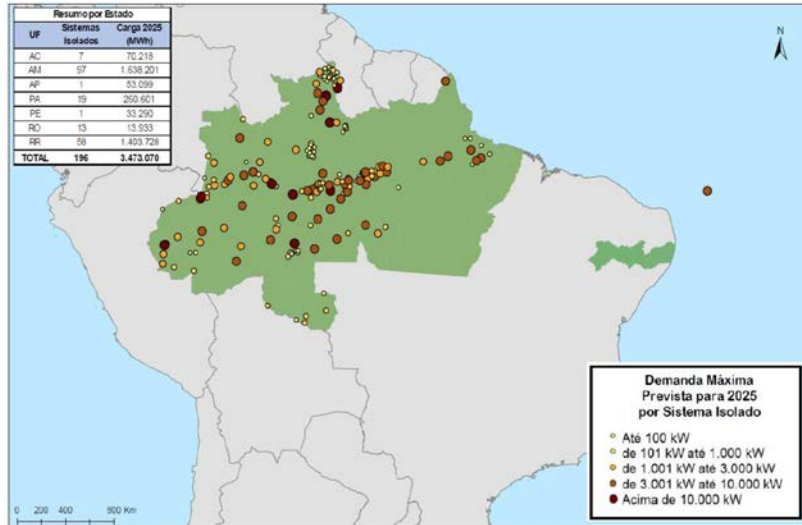
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# DECARBONIZE OFF-GRID (AND REMOTE) SYSTEMS

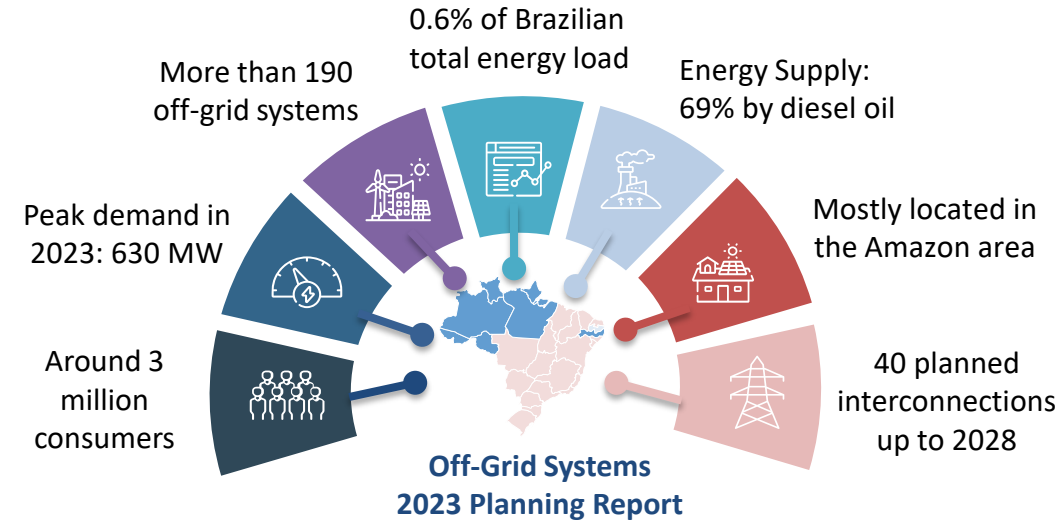
**Off-grid (remote) systems:** Power systems not electrically connected to the National Interconnected System (SIN), due to technical or economic reasons. In Brazil, they are mainly concentrated in the North Region.



City of Afuá (Peak demand: 2.3 MW)



Brazilian off-grid systems



Brazilian Office (EPE) publishes the **Systems Supply Report** based on data provided by companies. Research annually publishes the **Off-Grid Planning Report** based on data from distribution companies.



Source: EPE. "Sistemas Isolados" (2024).



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## DECARBONIZE OFF-GRID (AND REMOTE) SYSTEMS



**Amazon Energies Program:** Launched by the federal government in 2023, this program aims to reduce power generation from fossil fuels and energy costs in the Amazon region's isolated systems.



### Actions and Projects eligible for the program:



#### Interconnections

- Promote interconnections of isolated systems to the SIN through new electricity transmission or distribution networks
- 40 planned interconnections up to 2028 and 30 more projects under evaluation.



#### Energy Auctions

- Improve the auction guidelines to increase the competitiveness of renewable sources, including storage
- New energy auction will be held in 2025.



#### Energy Efficiency and Loss Reduction

- Implementation of electrical loss reduction, energy efficiency, and demand response projects or programs
- The electrical losses in some isolated systems are greater than 70%.



#### Funding

- Program for Structural Reduction of Energy Generation Costs in the Legal Amazon (Pro-Legal Amazon)
- About \$300M USD for the next 10 years.



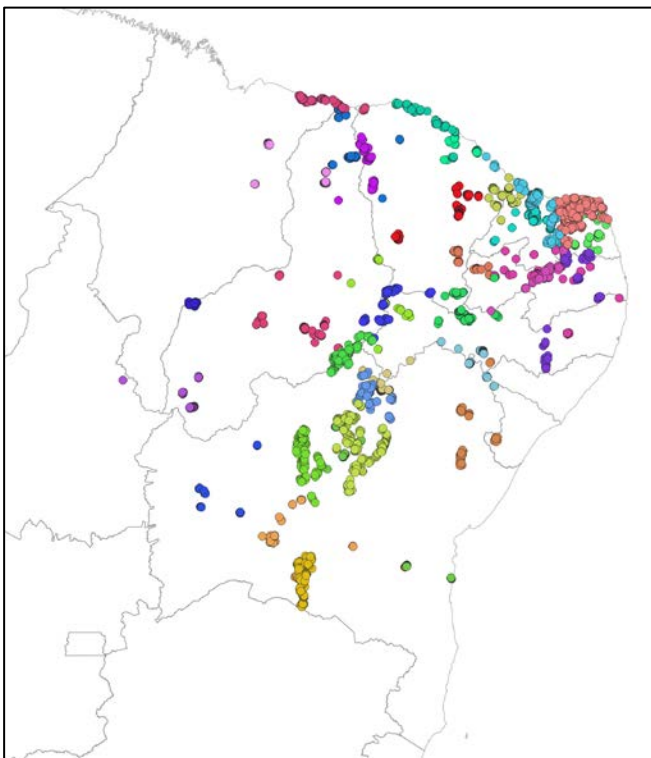
#### Data Quality and Transparency

- Promote the quality and transparency of information on electricity supply and fuel consumption within isolated systems
- Isolated System Data Dashboard ([PASI](#)) launched in March 2024.

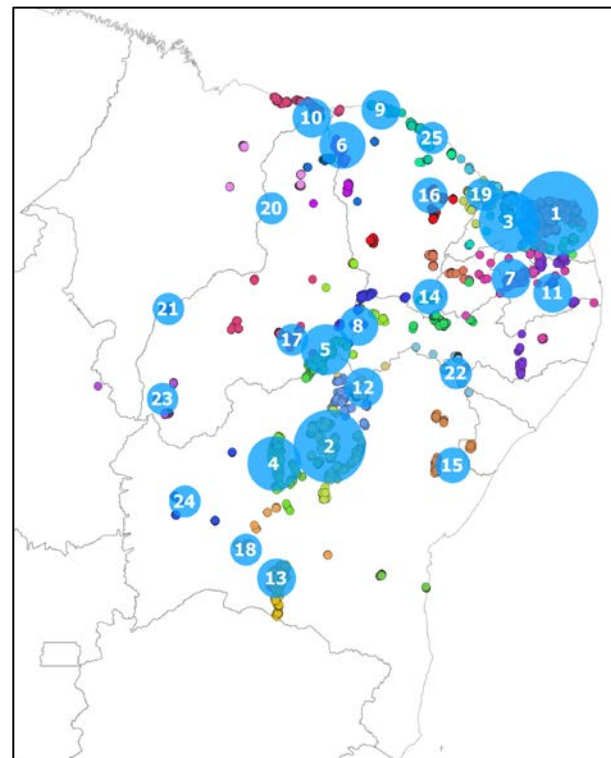


## PROACTIVE TRANSMISSION PLANNING

Location of renewable projects (wind and solar)



Database: SIGEL (ANEEL), AEGE (EPE)  
1,845 projects; total installed capacity: 70 GW  
Reference: May 2021



Results from the clusterization process.  
Approx. 14-GW cluster size is proportional  
to the installed capacity.

- Transmission planning studies are using different strategies to deal with the challenge of integrating wind and solar photovoltaics (PV) to the grid.
- Most of the challenges are associated with the uncertainty of the connection of future generation projects and the required time for the transmission assets to be operational (about 7 years).
- To deal with these uncertainties, it was necessary to map the expected location and the installed capacity of potential projects.
- By using clusterization methodologies based on the k-means methods, it was possible to identify the most promising areas for renewables expansion.

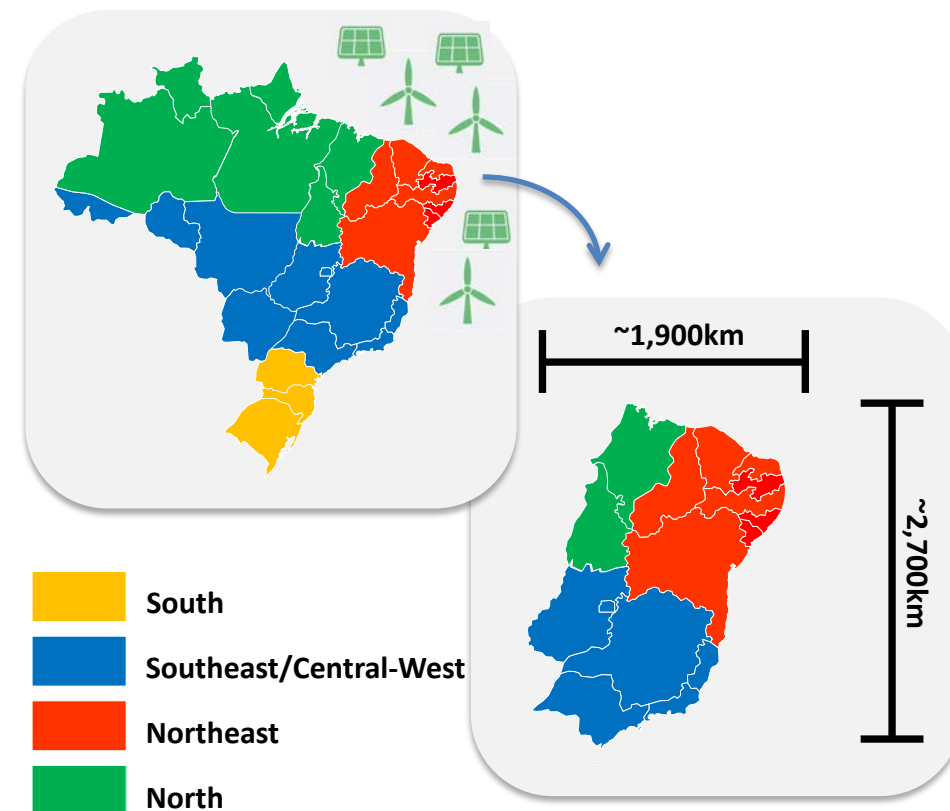


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## PROACTIVE TRANSMISSION PLANNING

- The prospective studies being carried out at EPE have brought a new perspective for the future expansion of the transmission grid in Brazil.
- Not only do these studies consider the location of future generation projects, but they also take into consideration future system needs, such as an adequate load growth supply and an increase in reliability and resilience levels.
- These studies have recommended **more than 15,000 km of new transmission lines** (500 kV and 230 kV), including 12 new substations (500 kV), 1 embedded 5-GW, 800-kV high-voltage DC Link (1,500 km) connecting the North and Southeast/Central-West regions.
- The total required **investments** for these new transmission assets is around **\$10 billion USD**.
- When these assets become operational, they will allow safe integration of the generation indicated in the 10-year energy plan and provide enough capacity and resilience to cope with future system needs.

*Brazilian electric regions*

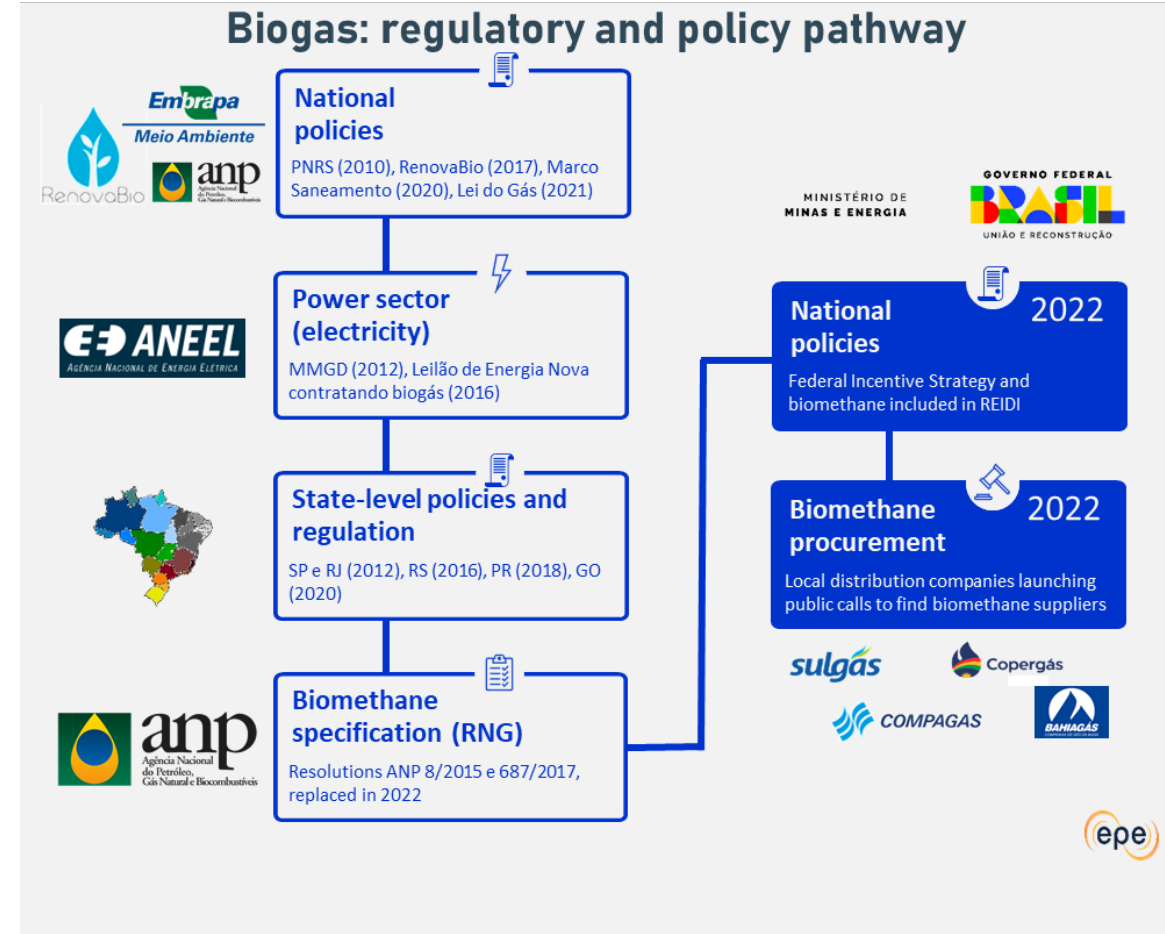
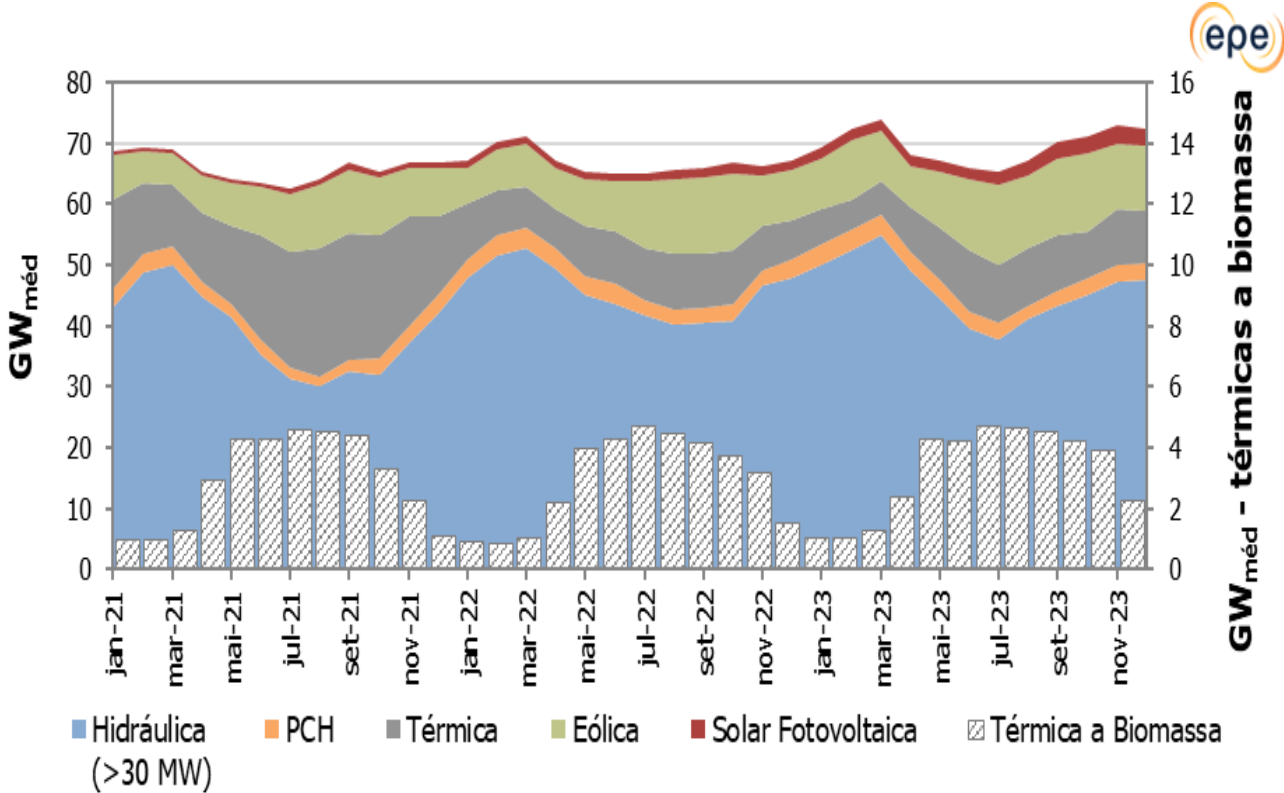




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# BIOENERGY PARTICIPATION IN POWER GENERATION

**Biomass seasonal profile is complementary to hydropower production**



Fonte: EPE (2023) – Análise de Conjuntura dos Biocombustíveis



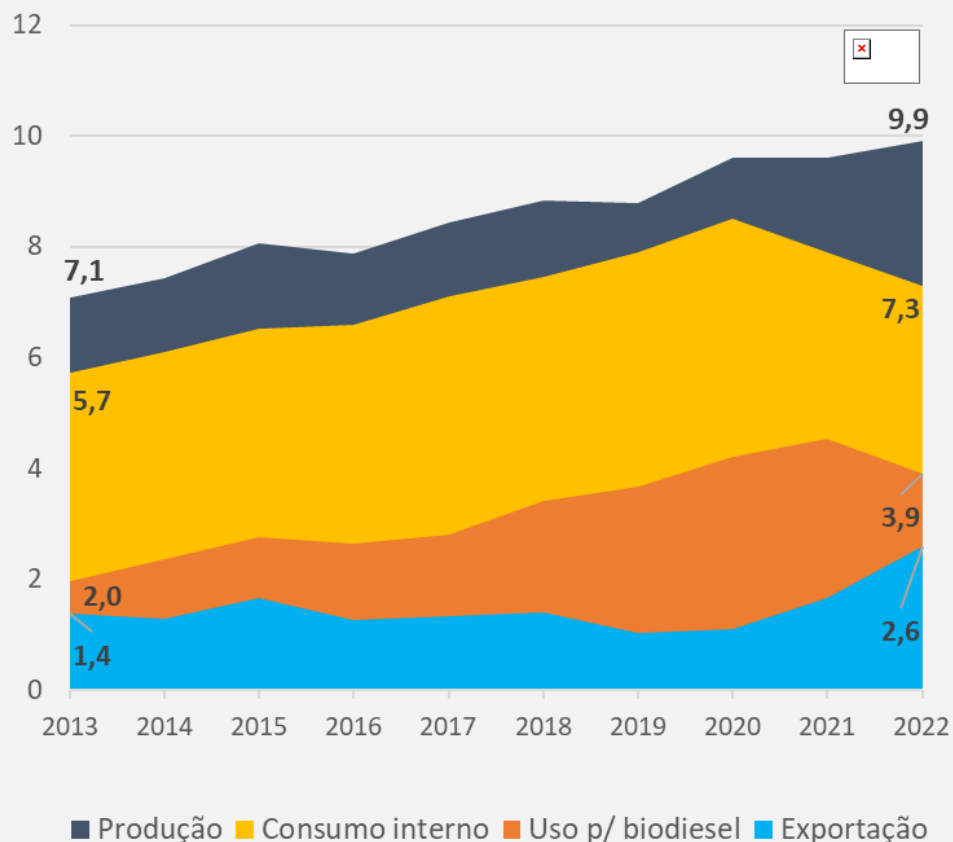


# BIOFUEL PARTICIPATION IN POWER GENERATION

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Mercado de óleo de Soja

Milhões de toneladas



## BIODIESEL FOR THERMOELECTRICITY

### CAPACITY

- Today, there are already plants operating with 100% biodiesel.
- The 10-year projection of idle capacity in biodiesel plants makes it possible to meet 53% of the maximum demand of thermopower plants in the Northeast exclusively with biodiesel.
- Considering those dedicated to diesel, there are 0.52 GW that could be fully supplied with biodiesel, with surplus, operating at full load.

### FEEDSTOCK

- The soybean oil and beef tallow now exported can be redirected to the production of biodiesel.
- This also applies to exported soybeans, given the idle extraction capacity.
- Other fatty sources can be used for the production of biofuel, but with an incipient production scale (sewage fat, fatty acid sludge, macaúba, babassu).

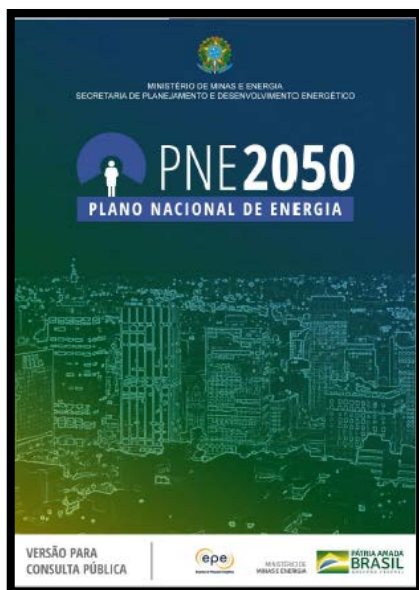


# OPPORTUNITIES AND CHALLENGES FOR SMALL MODULAR REACTORS

## Nuclear Energy in Brazilian National Plan 2050

### Recommendations:

*Standardize projects to get scale and learning economies; and seek synergies in public policies.*



*After 2030, new projects may be based on PWR technology, small modular reactors, and fourth-generation reactor technologies, if the latter reach technological maturity and competitiveness.*



### Small Modular Reactor

**Opportunities:**  
Standardization, simplicity, security and safety, construction time and cost reduction, flexibility of supply, etc.

**Challenges:**  
Technological uncertainties, many reactor concepts being proposed, diverse range of technological alternatives, comparisons, etc.

International Atomic Energy Agency (IAEA) - Coordinated Research Projects (CRP)  
“Economic Assessment of the Potential for Small Modular Reactors on a National Level”

Brazilian Association for the Development of Nuclear Activities Permanent Forum on Small Modular Reactors

U.S.-Brazil Energy Forum Study on Small Modular Reactors



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## II. BUILDING

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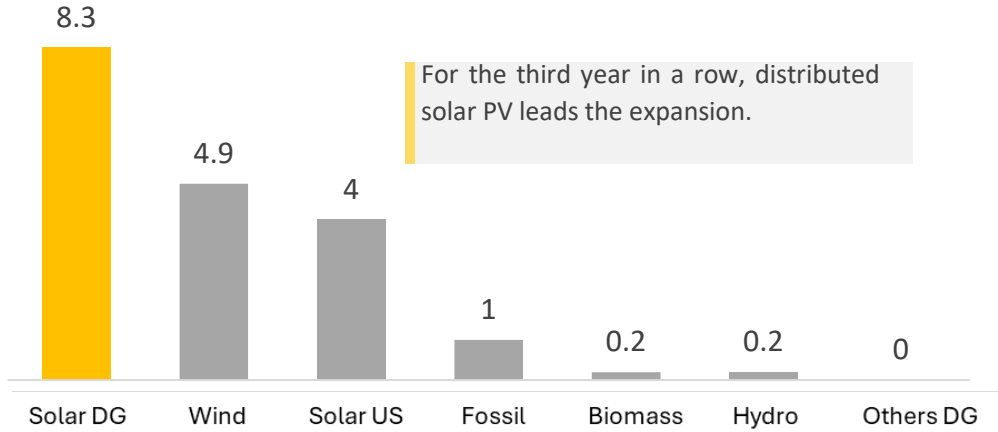
Action Plan for Rapid Decarbonization of the Power Sector



# MANAGING THE DISTRIBUTED GENERATION BOOM

## In recent years

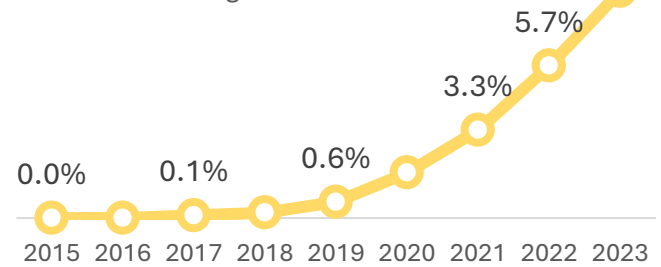
New capacity of power generation in 2023 [GW]



For the third year in a row, distributed solar PV leads the expansion.

Data from ANEEL

Share of electricity supplied by Distributed Generation on regulated market

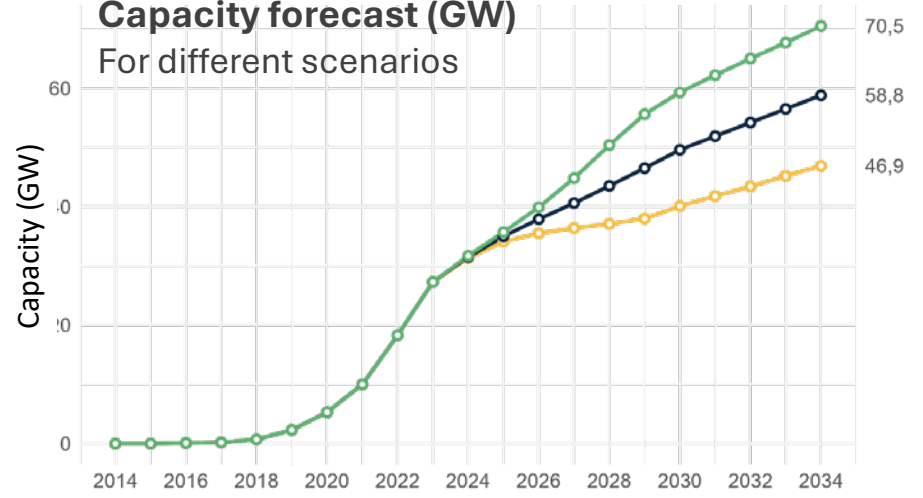


Data from ANEEL EPE. "Painel de Dados de Micro e Minigeração Distribuída." <https://dashboard.epe.gov.br/apps/pdgd/>

## In the future

### Capacity forecast (GW)

For different scenarios



Scenarios: Lower (orange), Reference (black), Upper (green)



Data: EPE. "Plano Decenal de Expansão de Energia 2034." [www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034](http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034).



## CHALLENGES OF IMPLEMENTING DISTRIBUTED GENERATION

- Quantifying costs and benefits of distributed generation: Starting in 2029, compensation for energy contributed to the grid will be based on a cost-benefit analysis. However, the methodology for this analysis remains undefined. The challenge is to develop a comprehensive and transparent approach that addresses the complex spatial and temporal dimensions of costs and benefits for distributed generation.
- Aligning distributed generation with the free electricity market: The current net-billing scheme for distributed generation in Brazil does not fit with the rules of the free electricity market. Given the trend of expanding the free energy market to more customers in Brazil, it is crucial to reconcile these two markets to ensure seamless integration.
- Ensuring equitable expansion of distributed generation: Currently, the adoption of PV systems is occurring mainly among affluent households, resulting in uneven distribution of costs and benefits. Implementing inclusive policies is crucial to broadening access to solar energy and ensuring more equitable benefits across society.



Source: EPE. “Plano Decenal de Expansão de Energia 2034.” [www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034](http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034).



# IMPROVEMENTS TO THE BRAZILIAN ELECTRICITY MARKET DESIGN

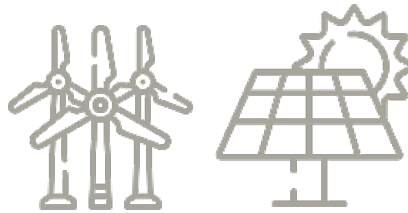
## Past



Expansion was based on **firm energy**, and it was sufficient to meet all system requirement due to hydropower plants.



## Present

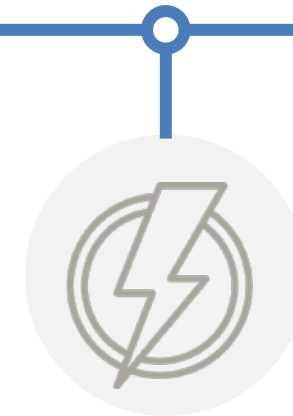


Today, considering new technologies and changes in generation mix, it is necessary to hold auctions to contract **capacity and** ensure supply security.



## Future

As the system continues to change, other improvements are needed to better address system needs, **consider new requirements** (like flexibility), and **modernize legal and regulatory frameworks**.





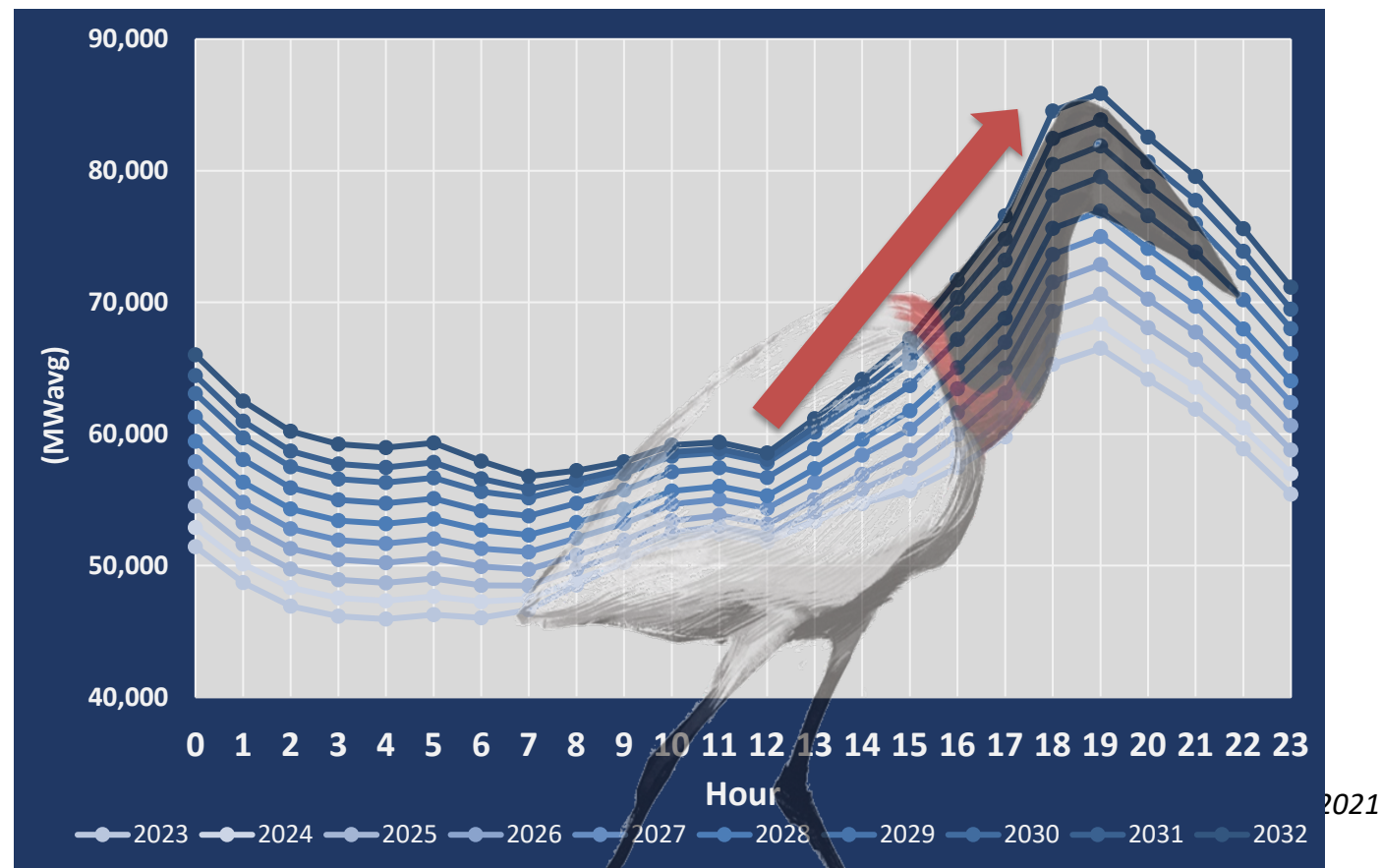
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## FLEXIBILITY REQUIREMENTS ASSESSMENT

As the energy mix changes to include more variable renewable energy, it is important to monitor not only **average energy** and **capacity**, but also the variations on system needs: the **flexibility requirements**.

In the planning horizon, the hourly **net load** (total energy demand – variable renewable energy generation) tends to have more intense intraday variations, the so-called energy ramps.

Brazilian system hourly net load evolution



[Flexibilidade: Estimativa de requisitos e recursos \(epe.gov.br\)](http://epe.gov.br)

Tuiuiú Curve



# WHICH RESOURCES CAN PROVIDE FLEXIBILITY IN BRAZIL?

## Hydropower Plants



- ❖ Provide fast ramps with low operational costs
- ❖ Challenges in modeling and detailing operational hydraulic constraints.

## Thermal Power Plants



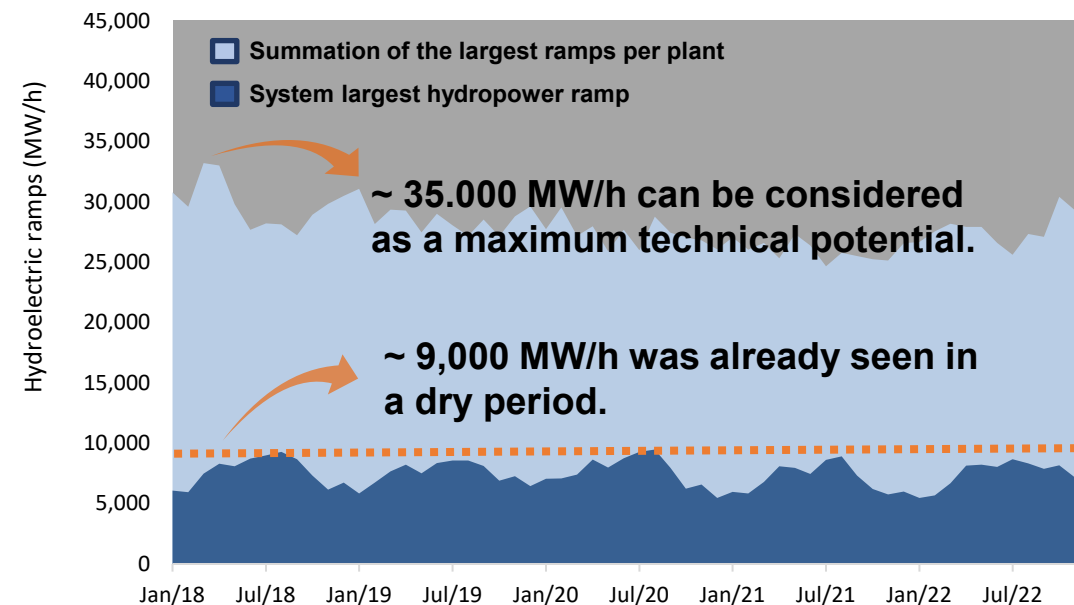
- ❖ Can provide capacity and flexibility
- ❖ Limited by unit commitment restrictions, among other things.

## Additional Resources



- ❖ Potential resources for Brazilian grid flexibility: small hydro, biomass, demand response, batteries, and pumped storage hydro
- ❖ Regulatory improvements are necessary to unlock their potential.

Existing hourly hydro flexibility resource



Source: ONS (Brazilian National Grid Operator). Open Database. <https://dados.ons.org.br/dataset/geracao-usina-2>





# LEGAL AND REGULATORY FRAMEWORK IMPROVEMENTS TO ALLOW NEW TECHNOLOGIES

## Offshore Wind

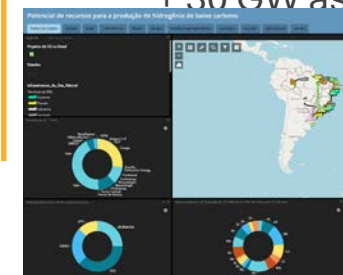
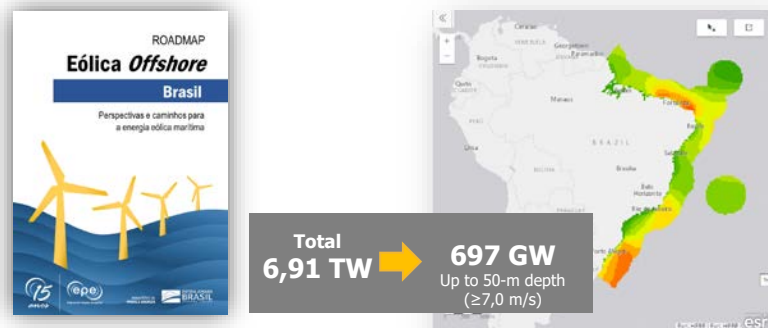
- Legal framework to be approved ([Bill # 576](#) in Congress)
- [Decree # 10.946/22](#)  
Rules for seabed leasing
- **Several developers and players**  
97 projects (234.2 GW) so far.  
From: [lbama](#)
- **Great potential: ~700 GW**  
in shallow waters (up to 50 m) and wind speed >7 m/s. From: [Roadmap](#)

## Storage

- [Regulation](#) under discussion
- **Pumped hydro storage**
  - Large experience on hydro power plants
  - Three studies and a tool for site identification: [1](#), [2](#), [3](#)
  - Roadmap under development.
- **Batteries: multiple uses**
  - [Behind the meter](#)
  - Utility scale: flexibility and capacity
  - As [transmission assets](#)
  - Isolated systems: increase renewable penetration and replace diesel. From: [1,2,3,4](#)

## Hydrogen

- **National Hydrogen Program (PNH2) in place**
  - [3-year work plan](#)
  - Technology neutrality
  - Recent legal framework: [Law #14.948/2024](#).
  - **Several studies on different routes and uses:** [Green](#), [Blue](#), [Gray](#), [Turquoise](#), [Refineries](#).
  - **Great potential: 1.8 Gt/year**  
Remaining technical potential until 2050: 96% from renewables From: [PDE 2031](#).
  - **Green hydrogen**  
Impact on load and new generation + 30 GW asked for [grid connection](#).



H2 dashboard

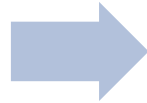




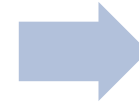
# DEVELOPMENTS IN COMPUTATIONAL MODELS

## Brazilian Power Generation Mix and Computational Model Improvements

PAST



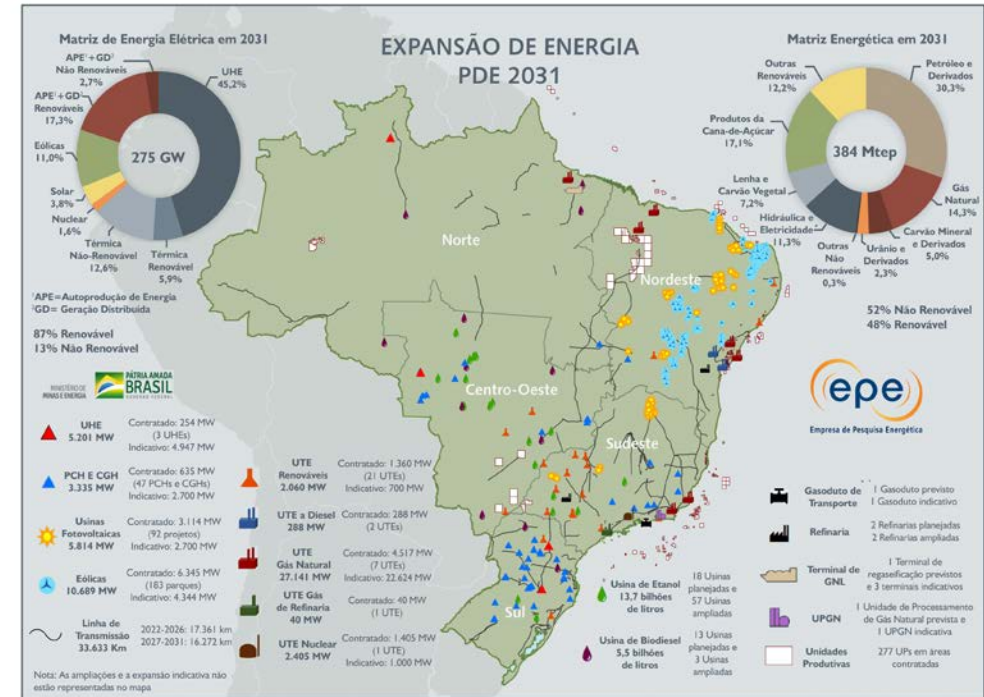
PRESENT



FUTURE

Increasing the participation of variable renewable sources and more decentralized decisions requires:

- ✓ More time and spatial details in modeling
- ✓ More data to better understand the resources and their correlations, including with load

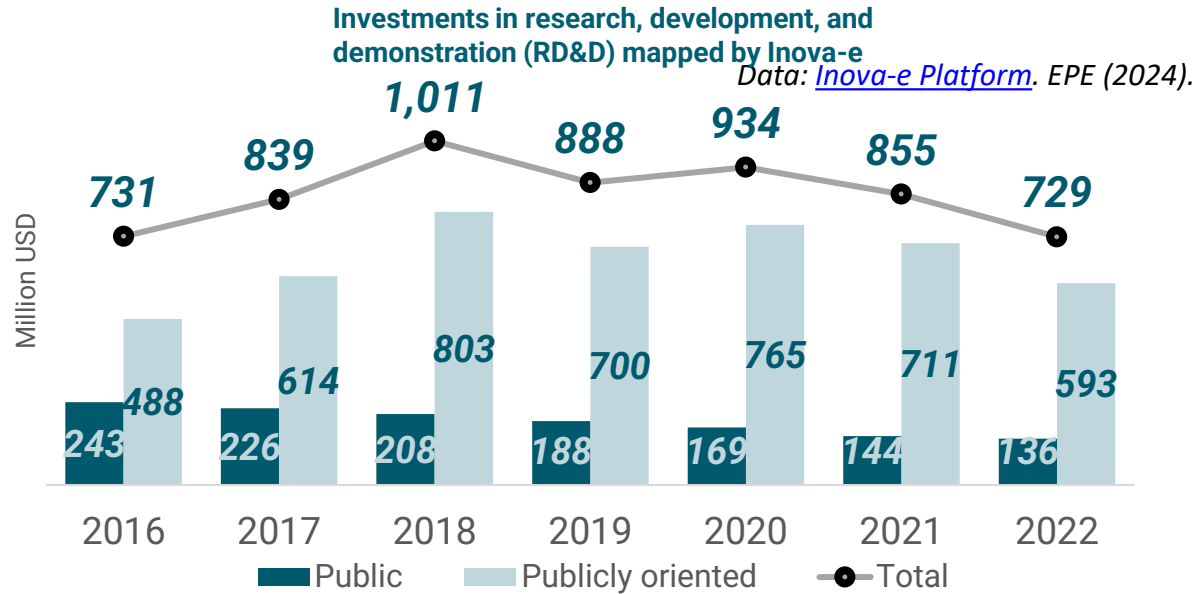




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## R&D PROGRAM

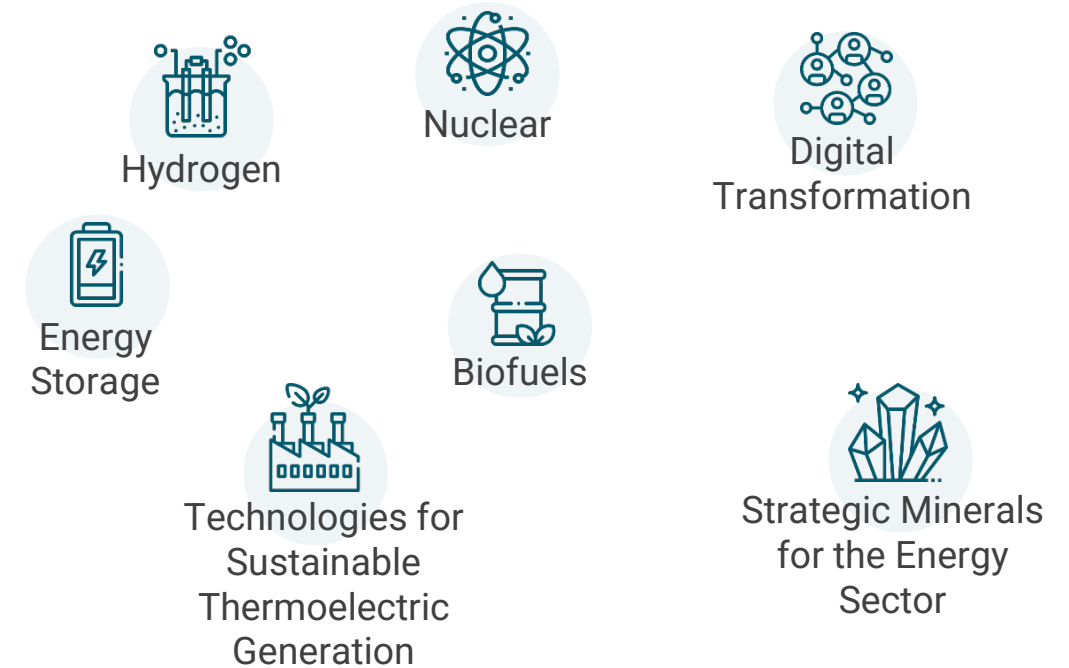
Brazil has been able to maintain annual R&D investments between 700 million and 1 billion US dollars per year in the energy sector.



**Publicly oriented investment:** Private investment derived from legal obligations with the purpose of inducing companies to make investments in RD&D.

**Public investment:** Expenditure on reimbursable and non-reimbursable RD&D projects carried out through public institutions that promote innovation in Brazil.

The National Energy Policy Council has prioritized publicly oriented resources for seven strategic themes in the energy sector (Resolution 02/2021).





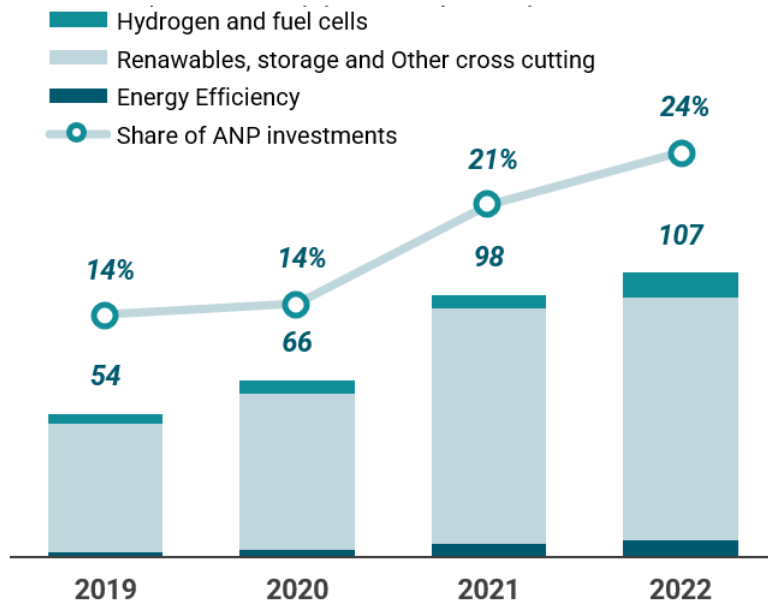
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## R&D PROGRAM

### Some other insights on the Brazilian RD&D investments database

#### The migration of expertise and diversification in the oil and gas sector.

Data from RD&D regulated by the Brazilian Oil & Gas regulator suggest that in recent years there has been a diversification of projects, with investments in technologies aligned with the energy transition. In 2022, almost one-quarter of regulated resources were allocated to non-fossil technologies.

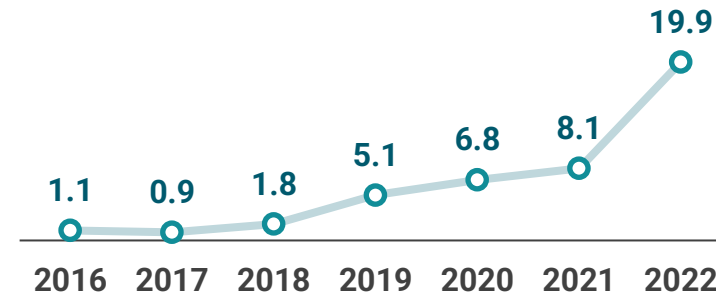


Data source: EPE. 2024. Inova-e Platform.  
<https://dashboard.epe.gov.br/apps/inova-e-eng/dashboard.html>

#### The growing investment in innovation in the hydrogen chain.

Inova-e data points to growing investment in innovation in the hydrogen chain. The expectation is that, in the coming years, investments in low-carbon hydrogen will gain even more importance, both due to the influence of National Policy Council resolution n°02/2021 and the development of PNH2.

#### Hydrogen and fuel cell RD&D investments, from 2016 to 2022 (U.S. million)



PNH2 seeks to strengthen the market and industry for hydrogen with low-carbon emissions as an energy vector in Brazil.

Data: EPE. 2024. Inova-e Platform.

<https://dashboard.epe.gov.br/apps/inova-e-eng/dashboard.html>



The first version of PNH2, launched in 2023, proposes increasing annual investment in R&D to 200 million reais by 2025 (equivalent to \$40 million USD on 2023 exchange rate).



**Brazil**

## III. OPERATING

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Action Plan for Rapid Decarbonization of the Power Sector



# OPERATING HYDROPOWER RESERVOIRS IN A VARIABLE RENEWABLE CONTEXT

What is the role of hydropower plants (especially those with large reservoirs) in a more variable renewable system?

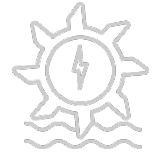


- More variable renewable sources in generation mix, such as wind and solar PV
- Significant expansion of distributed generation, especially solar PV
- Technological development and cost reduction tends to intensify this scenario.

## Diversifying Power Generation Mix

## Institutional Governance

- Needs coordinated actions between power sector and other water users, such as the **Reservoir Recovery Plan**, lead by Ministry of Mines and Energy
- Operational constraints related to multiple uses of water.



- New hydropower plant operation strategies, aiming to preserve reservoir levels
- Optimization of hydro reservoirs to meet capacity and flexibility requirements
- Enhanced security of supply.

## New Role of Hydropower Plants



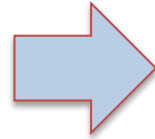
# RESILIENCE CHALLENGES IN SPECIFIC REGIONS



Rio Madeira tem menor nível em 56 anos, diz Agência Nacional de Águas

## Water scarcity in the North region in 2023:

- Low inflows of the Madeira River
- Generation loss at Santo Antonio Hydroelectric Power Plant
- Challenges to ensuring energy and power supply
- Risks to the transmission network.

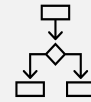


## Action Plan

Assess critical scenarios and propose solutions for the resilience of the electric system in the face of extreme climate events.



Characterize vulnerabilities associated with critical scenarios in the analyzed region



List possibilities for increasing resilience



Assess benefits and indication of the main impacts and challenges

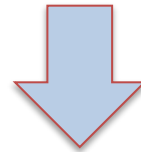


Create timelines and sequence solutions



Map routes and next steps

Scope



## Roadmap for Strengthening the Resilience of the Power Sector in Response to Climate Change





# PROMOTING FLEXIBILITY IN EXISTING POWER PLANTS

● Planning and Operation

● Regulatory

Effort

<ul style="list-style-type: none"> <li>● Development of integrated generation and transmission analyses.</li> <li>● Regulation of technologies and programs that can contribute to increased grid flexibility.</li> </ul>	<ul style="list-style-type: none"> <li>● Technological development of metering and review of tariff design.</li> <li>● Improvements in the temporal and spatial price signal.</li> <li>● Mapping of operational challenges that limit grid flexibility.</li> <li>● Review of the generator revenue structure.</li> </ul>
<ul style="list-style-type: none"> <li>● Inclusion of new reliability evaluations in mid- and long-term planning studies.</li> <li>● Improvements in the demand response and energy efficiency programs.</li> </ul>	<ul style="list-style-type: none"> <li>● Enhanced input data for operational and planning models to better represent short-term constraints.</li> <li>● Definition of criteria and continuous monitoring of flexibility requirements.</li> <li>● The startup and shutdown of thermal plants should be subject to the energy spot price.</li> <li>● Development of methodologies and computational tools to perform simulations with appropriate temporal granularity.</li> </ul>

Impact





## INCREASE CONSUMER PARTICIPATION IN POWER SYSTEM: DEMAND RESPONSE

### Actions developed in demand response in Brazil's electrical system



- Since 2018, new actions have already been taken to develop the demand response in Brazil, mainly for industrial consumers. A pilot project was created with significant participation of industry stakeholders in 2018, with low consumer participation.

- In 2021, during the water scarcity in Brazil, the Voluntary Demand Reduction program for industrial consumers had important results, which contributed to improving the situation of the national energy system. Several industrial sectors participated, which translates to significant cost savings for both energy providers and consumers.

- In 2024, the first specific auction for demand response will take place, which will be prepared by system operator and regulatory agency.



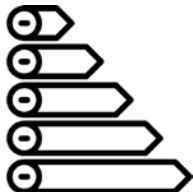
## INCREASE CONSUMERS PARTICIPATION IN POWER SYSTEM: ENERGY EFFICIENCY



One of the programs with the best results in energy efficiency is **the Procel Seal**. The Procel Seal of Energy Efficiency is a certification program in Brazil designed to promote **energy-saving practices and technologies** across various sectors.



One of the primary outcomes of the Procel Seal initiative has been a significant reduction in energy consumption across the country. For instance, products with the Procel Seal are often up to **30% more efficient** than their non-certified counterparts.



**240 billion kWh** have been saved since 1986.



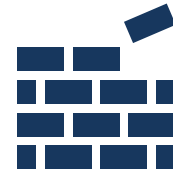
## CHALLENGES AND OPPORTUNITIES FOR BRAZIL IN AN ENERGY TRANSITION CONTEXT

Although Brazil already has a clean power generation mix, some challenges remain to **enhancing security of supply**, promoting a **fair and inclusive transition**, and keeping the **renewability of the power system**.



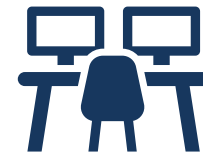
### Planning

- Implement and monitor Energias da Amazônia program
- Increase biofuel participation
- Deploy infrastructure to ensure the best use of renewable potential.



### Building

- Manage distributed generation boom
- Improve the market design and legal and regulatory framework
- Develop and improve software used in the power system.

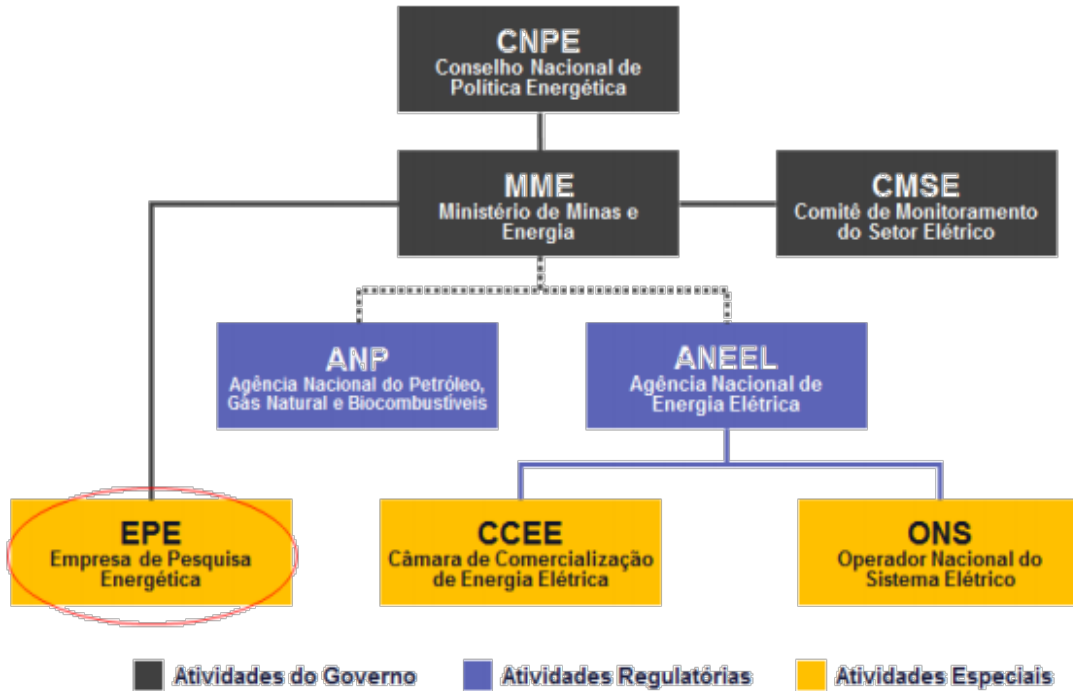


### Operating

- Rethink the role of hydropower plants and reservoirs
- Promote flexibility
- Increase consumer participation.



# STAKEHOLDER ENGAGEMENT AND INCLUSION: ENERGY SECTOR GOVERNANCE



Public consultations and social participation are important parts of the government decision process in the Brazilian energy sector.

## Official institutions



## Private sector associations and civil society





## REFERENCES

### Planning

Off-grid systems planning: <https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/sistemas-isolados>

Off-grid System Data Dashboard: [PASI](#)

Brazilian National Plan 2050: [Relatorio Final do PNE 2050.pdf \(epe.gov.br\)](#)

### Building

Brazilian Ten Years Plan 2034: [www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034](http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2034)

Brazilian Ten Years Plan 2034 – Distributed Generation and Batteries behind the meter: [Apresentação do PowerPoint \(epe.gov.br\)](#)

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Power System Flexibility: Requirements methodology and resources in Brazil: [Flexibilidade: Estimativa de requisitos e recursos \(epe.gov.br\)](#)

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Decree # 10.946/22: [D10946 \(planalto.gov.br\)](#)

Isolated systems batteries studies: [Publicações \(epe.gov.br\)](#), [Publicações \(epe.gov.br\)](#), [Publicações \(epe.gov.br\)](#), [Microsoft Word - NT Acre Lote III v9 GP.docx \(aneel.gov.br\)](#)

Pumped-hydro storage studies: [EPE-DEE-NT-006\\_2019-r0.pdf](#); [Publicações \(epe.gov.br\)](#); [Usinas Hidrelétricas Reversíveis \(UHR\): Desafios para inserção em mercados de energia \(epe.gov.br\)](#)

National Hydrogen Program: [PNH2](#)

Baseline to support the Brazilian Hydrogen Strategy: [NT Hidrogênio EN revMAE \(1\).pdf \(epe.gov.br\)](#)

### Operating

Roadmap for Strengthening the Resilience of the Power Sector in Response to Climate Change: [Publicações \(epe.gov.br\)](#)



**Brazil**

# BRAZIL'S ACTION PLAN FOR RAPID DECARBONIZATION OF POWER SECTORS