
2024
SUSTAINABILITY
Report
Eletrobras
Cepel

Contents

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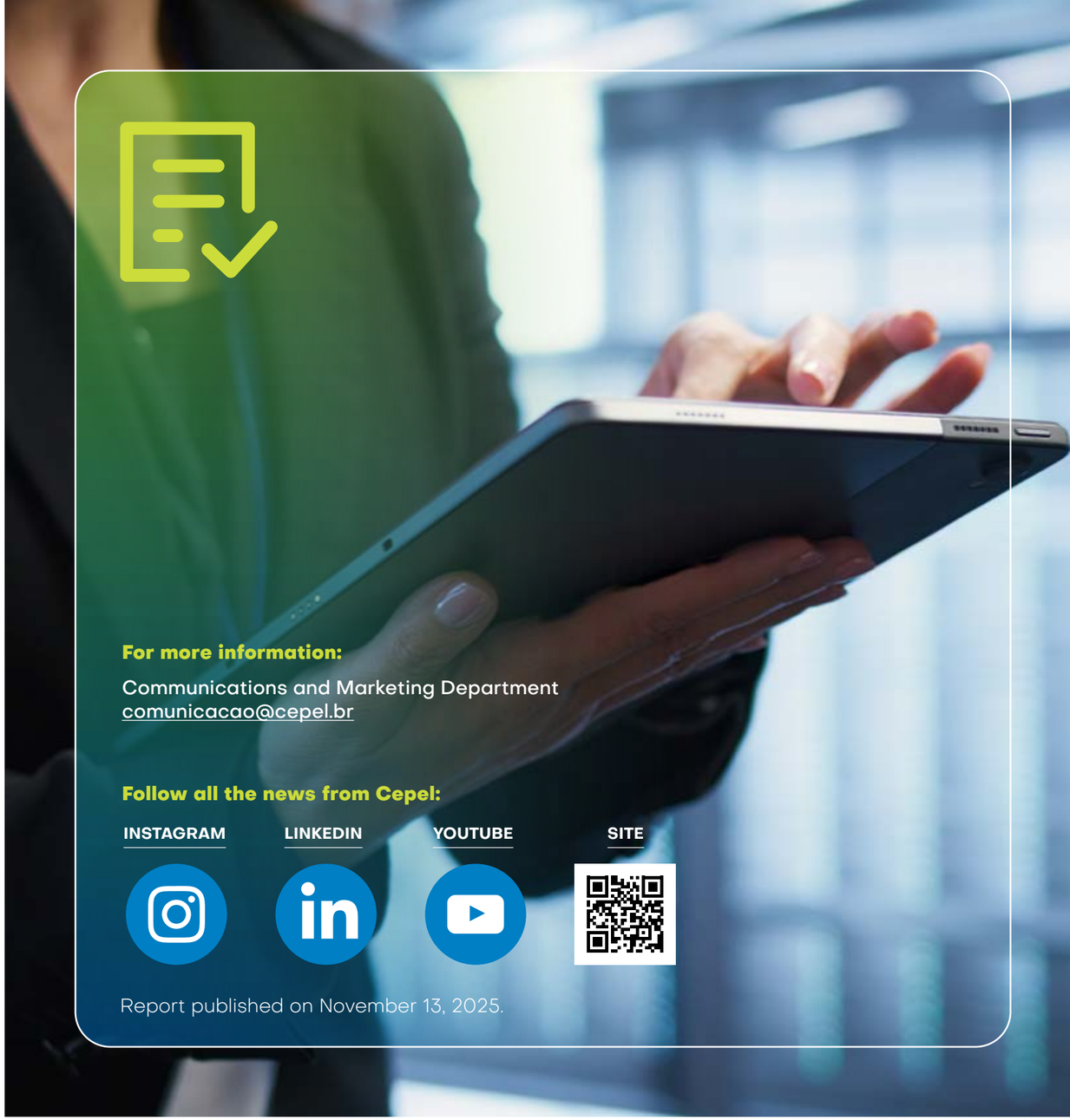
About the report

Welcome to the *Centro de Pesquisas de Energia Elétrica* (Electric Power Research Center) 2024 Annual Report, in which we **present a portrait of a Cepel under transformation.**

In 2024, the year of our 50th anniversary, we underwent a number of profound transformations: we updated our lines of research and operating areas to meet the new needs of the energy sector, thus generating even more value and impact for our customers, partners and society as a whole. We have also begun a process of cultural and organizational change to ensure the sustainability of the Center and have continued with our mission to be a technological leader in making the energy transition viable in Brazil and around the world.

This publication includes a complete set of disclosures, based on the 2021 version of the Global Reporting Initiative (GRI) standards, in line with our practice of publishing annual sustainability reports, using what is the world's most widely respected and employed methodology for this type of reporting.

We hope you enjoy the report!



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Report published on November 13, 2025.

A message **from the CEO**

GRI 2-22

A milestone year for Cepel, 2024 presented us with a great many challenges and opportunities. Changes in the energy market, an increased integration of intermittent renewable sources that require storage solutions, and challenges regarding controllability, and energy security and accessibility, have led us to reflect on our purpose and redesign the future of the Center. In our 50th anniversary year, we consolidated our mission for the coming decades: to lead a fair and sustainable energy transition in Brazil through knowledge and technology.

This objective is replete with challenges which require extensive integration between areas, greater operational efficiency, and a new mental approach, to generate value by combining established solutions with innovation and excellence in applied research. After all, this is Cepel's greatest feature: the development of products and solutions that are used by all the players in the Brazilian electricity sector, including companies, regulatory bodies and research centers, from generation and transmission, to energy distribution and trading.

That is why 2024 was such an important year for us, since it marked the beginning of a process of transformation on several levels. By analyzing our various areas of activity, we have initiated fundamental changes designed to strengthen Cepel from an economic-financial perspective, thus allowing us to expand the Center in its role as an agent of innovation, an aspect that is essential for the energy sector and other industries. Following the path taken by other companies in the Eletrobras group, our founders and main associates, we have turned our focus towards applied research and innovation as a means of generating value, in line with market demands, in order to contribute even more to the reliability, safety, and sustainability of energy in the country.

2024 marked the beginning of a **process of transformation** at Cepel on several levels

We obtained **sustainable certification** from the CCEE for our hydroelectric plant in Itumbiara (GO).

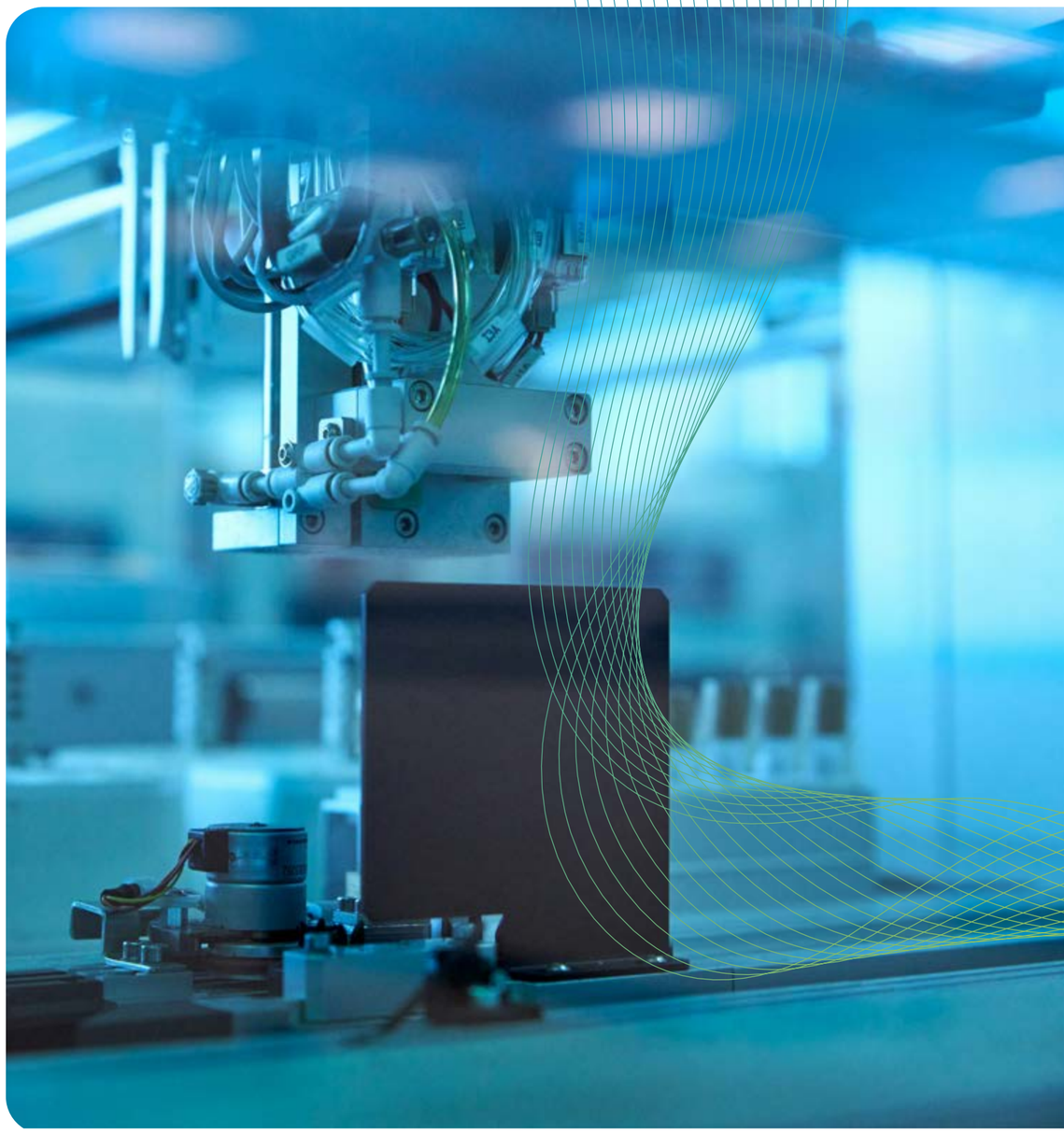
During this period, we increased the integration of areas, laboratories and teams, made alterations to the physical spaces, and invested in key skills for the market. Due to the breadth of our operations, we are considered to be a benchmark for electrical energy research in South America, with our unique digital solutions – which cover the entire energy value chain – and our laboratory infrastructure, which is unmatched anywhere on the continent.

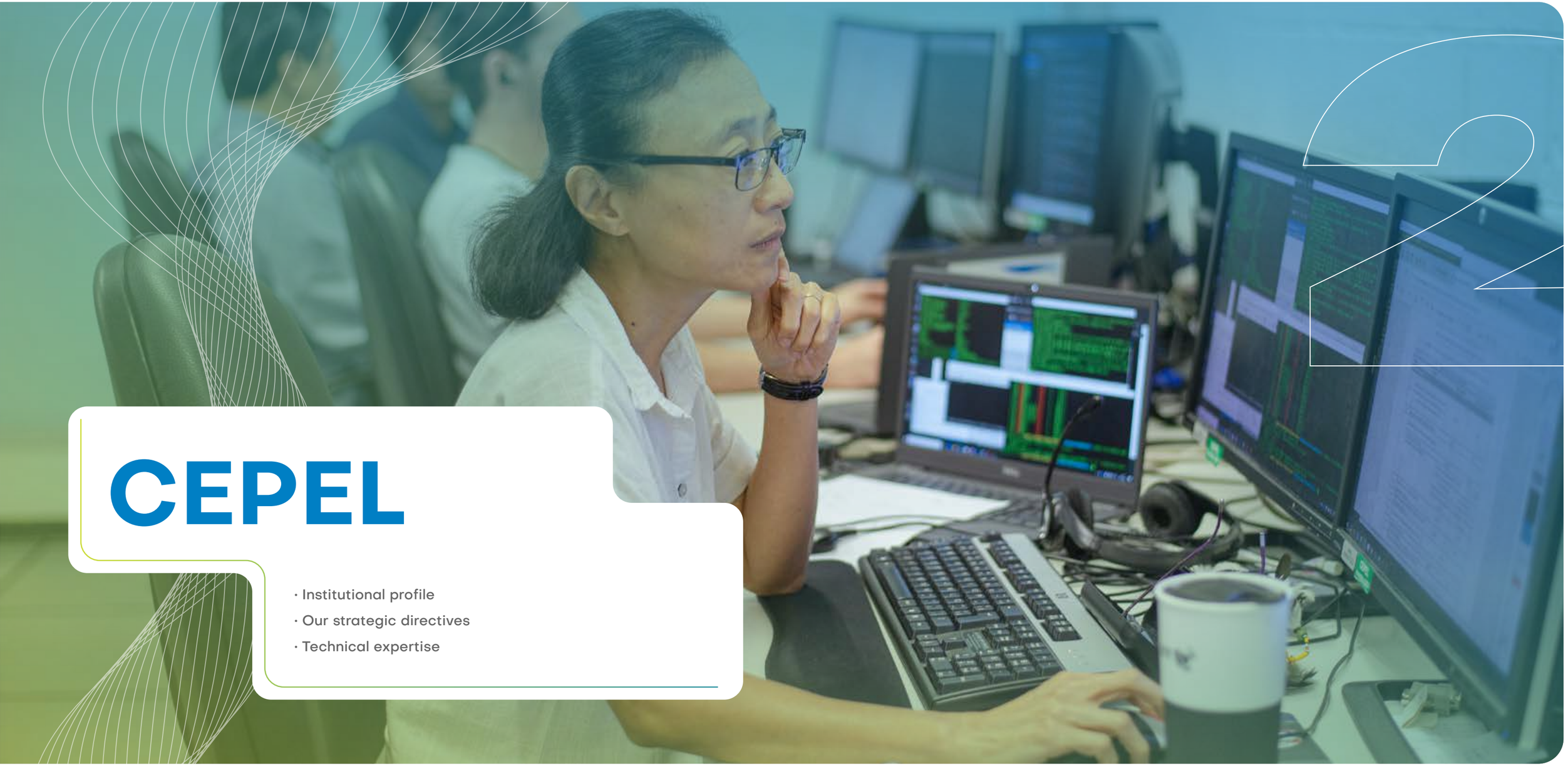
Among the many highlights of the year were the inauguration of the *Espaço NZEB* (NZEB Space), a benchmark for the country in the construction of buildings offering low-emissions in their operations, and the Itumbiara Hydroelectric Power Plant's (GO) receipt of sustainable certification for the production of green hydrogen (H2V) from the Chamber of Electricity Trading (CCEE). Internationally, we celebrated the use of Cepel solutions in ten countries and participated in the Cigre Paris Session 2024, where one of our researchers was recognized with the Technical Council Award, one of the organization's most prestigious prizes.

In addition to our consolidated participation in the *Sistema Interligado Nacional* (National Energy Grid / SIN), we remain dedicated to the research and development of technologies that will define the future of energy, including energy storage systems, high performance computing capacity for artificial intelligence, cybersecurity, and establishing the green hydrogen economy as a viable option. We see the present moment in time as an opportunity to surpass the achievements of the last 50 years with determination, innovation, and responsibility.

Our commitment remains as firm as ever: to lead the energy transformation, delivering innovations that enable a more sustainable, efficient, and globally-connected society.

Dr. Alexandre Orth,
CEO of Cepel





CEPEL

- Institutional profile
- Our strategic directives
- Technical expertise

Institutional **profile**

The Electric Power Research Center (Cepel), founded by the companies making up the Eletrobras group in 1974, is one of the most widely-respected Research and Development (R&D) institutions in the electricity sector in Latin America. With more than five decades of experience, it is considered a benchmark as a non-profit Scientific, Technological and Innovation Institution (STII), combining a top-level technical staff with a world-class laboratory infrastructure.

Bringing together intellectual and technological capital, we are uniquely positioned in the energy ecosystem as a link between the academic community and the market, applying research and innovation to meet the real needs of the sector, providing a complete platform of solutions in energy generation, transmission, distribution and use.

We combine applied research, agile experimentation, transversality and data-driven decisions to make innovation our competitive differential and establish ourselves as protagonists in the country's energy transition.

Laboratories

In the area of laboratories, we are accredited by Inmetro (National Institute of Metrology, Quality and Technology) to carry out a wide variety of tests. In our laboratory infrastructure at the Adrianópolis Unit, the only one in Latin America, we carry out **a number of tests on electrical equipment for class systems up to 800 kV**, the highest voltage level used in electrical transmission in Brazil, bearing in mind that the laboratory can reach voltage levels of up to 1,300 kVac and 1,000 kVdc, currents of up to 250 kA, and interruption tests of up to 750 MVA. In addition, we can make adjustments on high voltage and current measurement systems, develop technical reports, and carry out power equipment failure analyses. Our facilities for materials analysis and mechatronics are located at the Fundão Unit, located in Cidade Universitária (Rio de Janeiro), allowing for gains in the **quality control, technical inspection, diagnosis, and prognosis of assets**, thus reducing the likelihood of failures and operational interruptions.

Our main attributes,
widely recognized in the energy sector, are:

1. Technical excellence with the ability to solve complex problems;
2. An internationally recognized laboratory infrastructure;
3. Vast experience in developing digital solutions;
4. A commitment to integrity and scientific methodology;
5. Well-established cooperation with various players in the sector.

Mission

To develop technology-based energy solutions for society.

Vision

To be an international benchmark in groundbreaking energy solutions.

Values

We share our values with Eletrobras.

Life first

Our commitment is to life and the environment.

Our energy comes from people

Learning is always simple: knowledge is the basis for our people.

Integrity always

We act in accordance with the highest ethical standards in all areas of the company.

Our excellence makes the difference

We are committed to the highest quality standards.

Innovating to create value

We are constantly looking for solutions to build the future.

Our members

Founding members

Eletrobras

Eletrobras Chesf

Eletrobras Eletronorte

Eletrobras CGT Eletrosul

Special members

BR Petrobras

Eletronuclear Energia Limpa

Itaipu Binacional

ONS Operador Nacional do Sistema Elétrico

epe

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Facts and figures

Personnel

196 employees
100% of whom are university graduates

43 interns and undergraduate and graduate scholarship holders

15% hold PhDs

28% hold master's degrees

36 scientific articles published in 2024 (see the list in the relevant annex)

Units

Fundão Unit
Rio de Janeiro - RJ

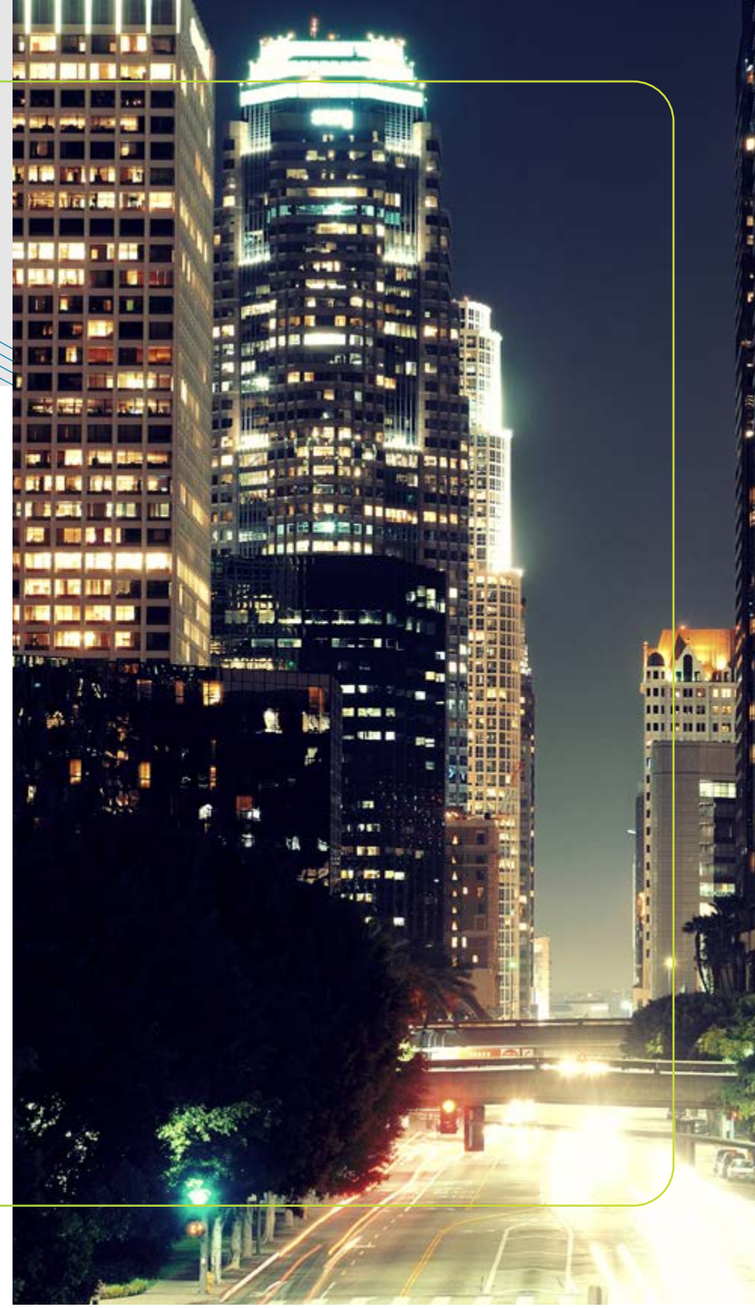
More than 68,000 m² of land and 26,000 m² of constructed area

AdrianópolisUnit
Nova Iguaçu - RJ

More than 233,000 m² of land and 23,000 m² of constructed area

Solutions used in 10 countries:
Germany, Bolivia, Brazil, Chile, Spain, USA, Mexico, Paraguay, Peru, and Portugal.

Main customers



Contribution to **Eletrobras**

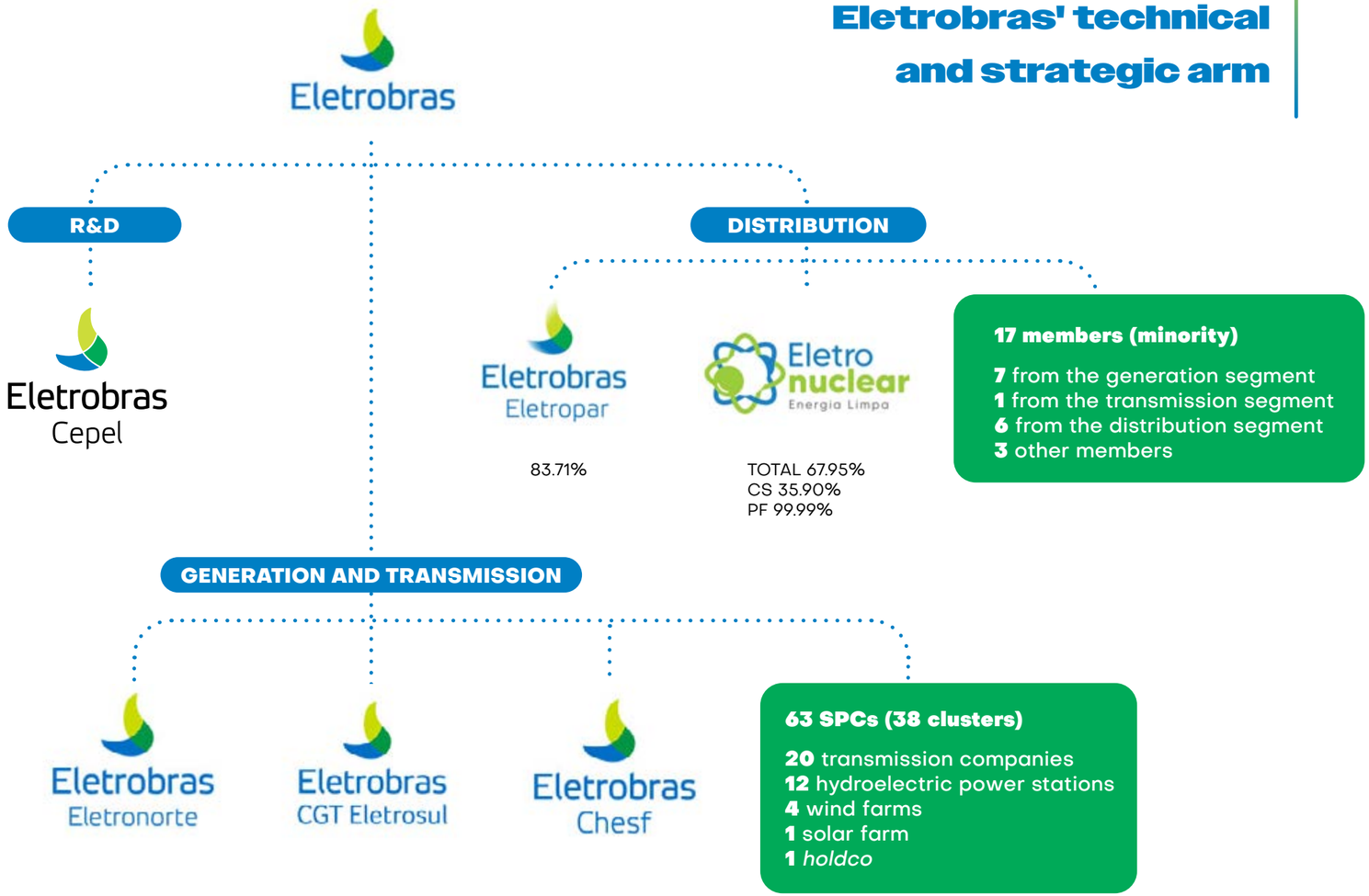
As a leading Scientific, Technological and Innovation Institution (STII) in the construction of the Brazilian electricity network, the Electric Power Research Center (Cepel), has played a strategic role in the development of Eletrobras' main technology and innovation projects, known as "value delivery", as well as in the implementation of those topics considered to be priority to the company and the segment. These operations have focused on the energy transition and the continuous improvement of the company's products and services, which are widely used by a range of different players in the electricity sector throughout the country. The diagram opposite shows how the Center acts as the research and technological development arm of the Eletrobras group.

Cepel was created by the companies forming the Eletrobras group as an autonomous legal entity under private law, organized as a non-profit civil association aimed at meeting the sector's demands for excellence in research and development. The Center's institutional relations, both with Eletrobras and its other associates, are in full alignment with Cepel's Bylaws.

FIND OUT MORE
For more information, visit Cepel's Bylaws

Organization of the Eletrobras Group

Cepel has always acted as **Eletrobras' technical and strategic arm**



Source: Eletrobras Sustainability Report

Areas of activity

Cepel is a platform offering solutions for energy generation, transmission, distribution and trading, and our portfolio contains products that help meet our clients' demands, from strategy to operation. Throughout our history, we have evolved in terms of our expertise and areas of activity, making us an STII with one of the most complete portfolios for the Brazilian electricity sector.

Innovating energy supplies for more than **50 years**

Amongst our areas of operation, the following are worthy of special attention:

- Control and supervision of systems
- Asset management and monitoring
- Electrical energy models for energy optimization, power grid analysis, and distributed energy resources
- Energy efficiency
- Meteorology
- High performance computing capacity for artificial intelligence
- Security of people, and physical and digital assets, such as cybersecurity
- Renewable energies and sustainability
  - Land and floating solar energy
  - Onshore and offshore wind farms
  - Reversible hydroelectric power stations
  - Industrial electrification using H2V green hydrogen
- Hybridization with intelligent storage

- Testing and technological services
  - High, extra-high and ultra-high voltages (which operate from distribution class voltage ranges up to the unique ultra-high, direct-current voltage levels already used in Brazil, 800 kVdc, and up to the highest alternating-current voltage class currently used in the country, 765 kVac, although the laboratory can reach levels of up to 1300 kVac and 1000 kVdc)
  - Reference laboratory for the adjustment of high-voltage systems, capable of adjusting measuring systems up to 900 kV AC or DC, and up to 2,500 kV impulse test
  - High-current area, capable of reaching short-circuit electrical currents of 250 kA, lasting seconds, and steady state current of 50 kA
  - High-power area, capable of reaching currents of 50 kA combined with voltages of up to 100 kV, resulting in powers of up to 750 MVA
  - In power laboratories, tests are carried out involving short-circuits in equipment, with or without the formation of electric arcs, normal or overload requests for electrical currents
  - Chemical analysis and corrosion
  - Metallography and mechatronics, with Internet of Things (IoT)
  - Smart Grids (smart grid and digital twins)
  - Digital substations
  - Cyber security

Our strategic **directives**

- Results-oriented financial management, with a focus on efficiency and sustainability
- Operations focused on the customer
- Organizational streamlining
- Human capital as a strategic asset
- Integrated innovation involving strategic partnerships

Customer **focus**

As well as meeting the requirements of Eletrobras, Cepel has also diversified its activities, concentrating its efforts on market demands, and encouraging entrepreneurship among its various teams. Each area has to consider the organization's strategy, the budget available, the basic needs involved, and the financial viability of the projects in its decisions.

Without making any reduction in the excellence of the cutting-edge scientific knowledge produced – a hallmark of Cepel – the new guidelines are clear: to respond to the real challenges faced by those operating in the sector, by providing innovative and sustainable solutions. As a non-profit Science and Technology Institution (STII), we look to the market with a view to meeting society's emerging energy needs. Financial sustainability is a means for the Center to have increasingly more resources to be reinvested in research and innovation, which, in turn, promote technological progress and quality of life for the public.

An entrepreneurial mindset, operational efficiency, a culture focused on data and results, integration between areas, and the professionalization of management. These are the foundations we are laying to guarantee a sustainable future for Cepel. We combine all this with the technical excellence that is already an accepted standard for all that we deliver. This is how we will be addressing the internal and external challenges to be able to fulfill our mission to contribute to technological leadership in the energy transition of Brazil and the world.

Technical **expertise**

From planning to operation, our energy solutions combine innovation, quality and versatility. We operate throughout the electricity sector chain – generation, transmission, distribution and use – as well as in other energy and industry segments, always offering customized products and services developed by highly-qualified and multidisciplinary technical teams. We are constantly seeking new solutions to meet the most diverse energy challenges and generate value for our customers, partners and, above all, society in general.

With a history of strategic contributions to the Brazilian electricity system, Cepel is a benchmark in technical and laboratory capabilities. Our scientific output is robust – with articles, theses and registered patents – and our R&D activities have resulted in an extensive portfolio of digital solutions, specialized consulting, and laboratory services.

Cepel is a reference in technical and laboratory capabilities for the Brazilian electricity grid

Digital Solutions

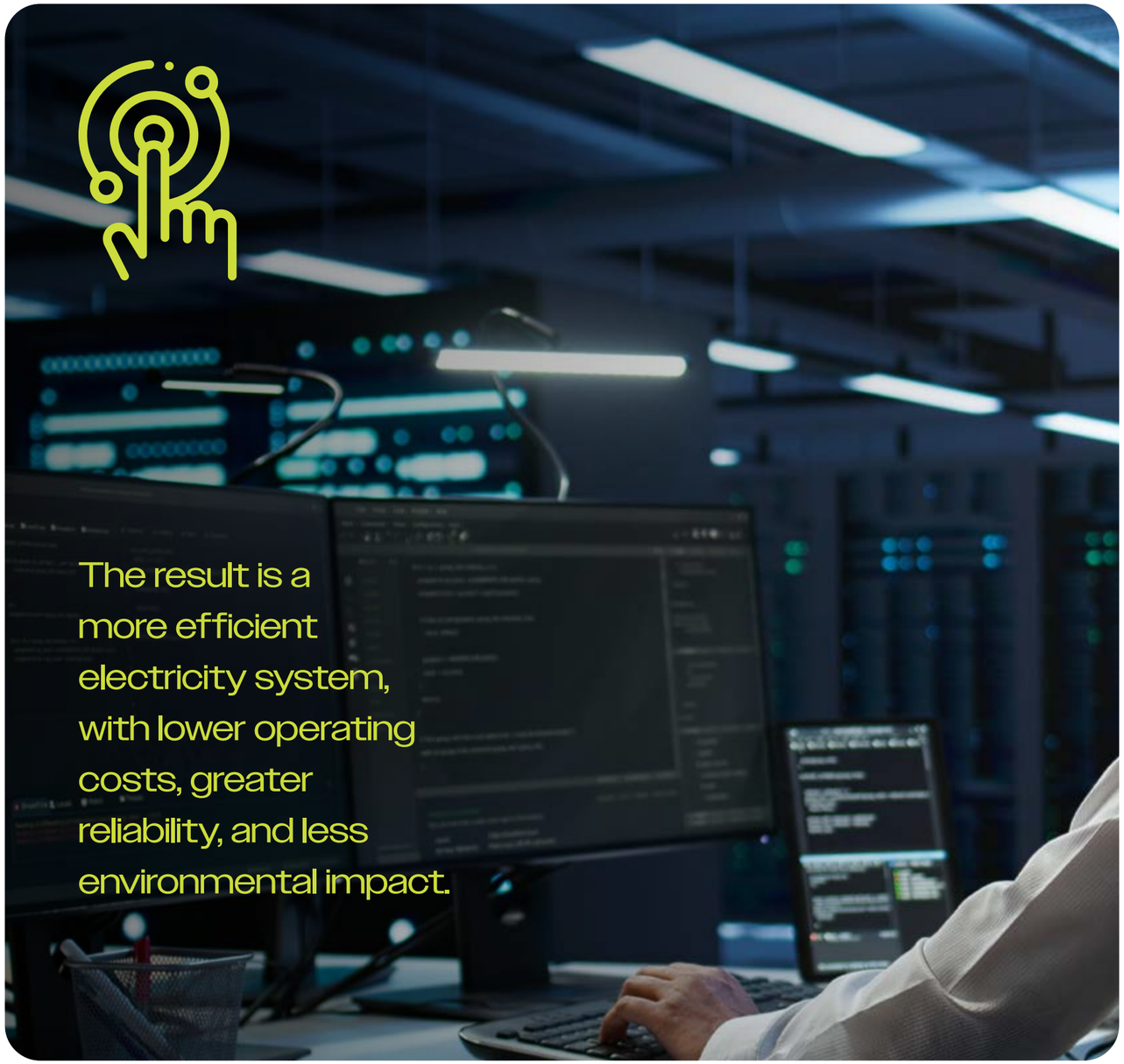
Our softwares and systems keep pace with, and often anticipate, market needs in asset monitoring and management, system control and automation, energy optimization, power grid analysis, prediction and security, and environmental and financial sustainability, among other topics.

With technological solutions developed in Brazil, Cepel contributes to the digital transformation of the operating technology (OT) infrastructure of Eletrobras and many other companies in the sector, promoting the intelligent and integrated management of assets including generators, transformers, reactors, circuit breakers, and transmission towers.

Our technologies make it possible to collect, process and analyze data in real time, enabling the early detection of faults and the consolidation of KPIs (key performance indicators) as reliability indexes in asset health cards, thereby optimizing maintenance and contributing to more strategic decision-making. The result is a more efficient electricity system, with lower operating costs, greater reliability, and less environmental impact.

More than half of our researchers are currently working on developing innovative and sustainable technological solutions to meet the market demand for digitalization. The computer models developed by Cepel have been adopted as the official tools used in the planning and operation of the National Energy Grid (SIN), and are essential for ensuring the safety and reliability of the electricity sector. Together with the Open Energy Management System (**Open EMS),** which serves the National Electric System Operator (ONS) and the largest energy companies in Brazil, we provide technologies that make a substantial contribution to the national and international electricity sectors.

FIND OUT MORE
Find out more about **SAGE** and other solutions, systems, and models on page 57.



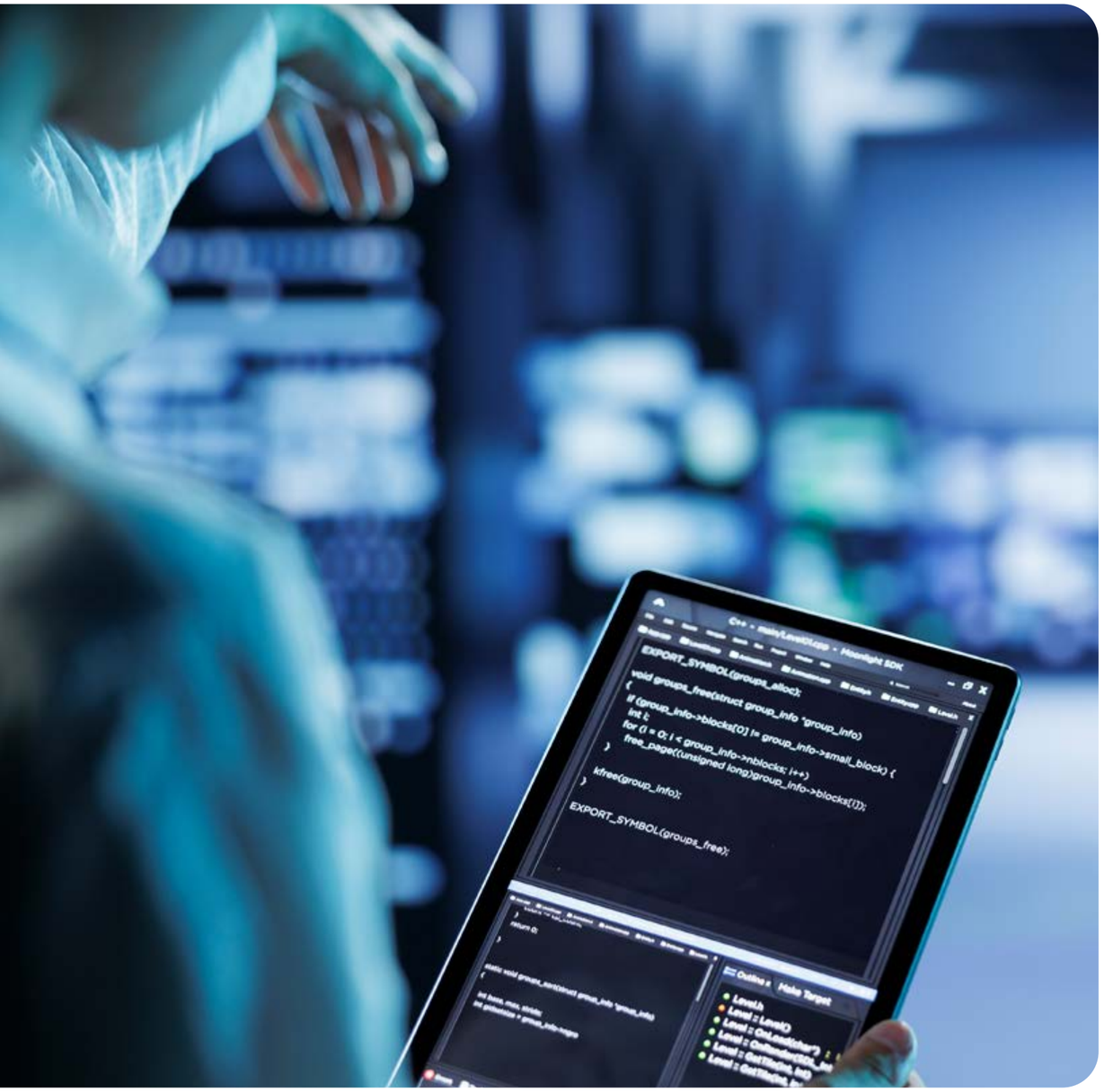
An overview of **2024**

- Software systems
- Projects
- Laboratories
- Technical publications
- Cultural transformation
- Energy transition, renewable sources, and sustainability
- Financial results

Over the course of the year, we made important technical contributions to driving both the energy transition in Brazil and the technological development of the Brazilian electricity sector: we improved our digital solutions used by various companies and institutions in the sector, advanced research on innovation issues that are crucial to sustainable energy, and updated our portfolio of laboratory and technological services.

To continue to perform our role as a benchmark in energy technology innovation, we decided to combine our undisputed technical potential with a more efficient structure, aligned with the most modern management and business practices. This is precisely why we started a process of organizational and cultural transformation.

On the following pages, you can read about the main technical achievements and corporate actions we have been involved in over the last year in detail.



Software systems

Digitalization is one of the pillars of the modernization of the electricity sector, and Cepel is one of the main developers of software systems for this sector in Brazil. Among the greatest advantages of digital solutions are the possibility of customization and constant improvement. In 2024, our solutions gained new functionalities to meet the most recent demands of our customers and partners on various fronts.

Our systems allow clients to be able to **customize our solutions**.

Asset **management**

Cepel's Asset Management and Monitoring area is one of the foundations of modernization and sustainability in the Brazilian electricity sector. With technological solutions developed entirely in Brazil, Cepel contributes to the digital transformation of the infrastructure of Eletrobras and various other companies in the sector, promoting the intelligent and integrated management of assets such as generators, transformers, reactors, circuit breakers, and transmission towers.

Our technologies allow for the collection, processing and analysis of data in real time, thus enabling the early detection of faults, and the consolidation of KPIs such as reliability indexes in asset health cards, thus allowing for the optimization of maintenance and more strategic decision-making. The result is a more efficient electricity system, with lower operating costs, greater reliability, and less environmental impact.

By acting on this front, Cepel is reaffirming its commitment to innovation, technical excellence, and the development of solutions that drive the electricity sector towards a more sustainable and intelligent future.

In 2024, our field teams took the technology of our laboratories to the four corners of the country, carrying out predictive diagnoses on hundreds of critical assets for the generation, transmission, and distribution sectors. Among the assets evaluated, it was possible to identify where a number of malfunctions could be avoided, turning these actions into savings of hundreds of millions of reais for Brazilian society.

One of the technologies employed was the **IMA-DP** system, which monitors insulation in high-voltage equipment and can be used to measure generators, transformers, cables, and substation equipment, using sensors and specific diagnostic algorithms in each case. Installation of the **IMA-DP** significantly increased in 2024, with sales growth of over 100%, boosting the area's financial results.

In 2024, we also made progress in the development of our performance asset management system **GAMMA**, which was adopted by Eletrobras at its Asset Monitoring Center **LIGA**, producing KPIs for the efficient administration of more than 94,000 assets throughout the company, integrating strategic, tactical and operational levels in asset management. The **LIGA** Monitoring Center was inaugurated in February 2025, and is already a national benchmark in terms of technology for the predictive management of electrical equipment.

At a more strategic level, it allows Eletrobras' top management to monitor the overall health of the company's assets from a macro perspective, while at a tactical and intermediate level, it offers a detailed history of each asset, enabling analysis of

The **IMA-DP** experienced sales growth of more than **100%,** boosting the area's financial results

its performance over time. At an operational level, meanwhile, it allows specialized areas to access detailed diagnostics and specific indicators for each asset.

In addition to Eletrobras, other companies in the distribution, and oil and gas sectors, including thermal power plants, have adopted our predictive management and on-line condition monitoring solutions. Implementation of the **GAMMA Online - SOMA** system, for example, was contracted by the largest oil and gas company in Brazil.

The **GAMMA Predictive Management - DIANE** system, responsible for predictive maintenance management and calculating the health indexes of physical assets, has been expanded to the distribution sector and is now marketed as 'SaaS' (Software as a Service).

Another highlight in Asset Management was the use of the **Elektra** system (Technical and Economic Optimization of Transmission Line Projects) in EPE studies carried out prior to transmission auctions, thus defining safer and more economical projects for expansion of the Brazilian electricity network.

The GAMMA Online System – SOMA was implemented in Brazil's largest oil and gas company.

FIND OUT MORE
Learn more about the **Gamma System** on page 57

Asset Management clients

EPE, Eletrobras, Petrobras, Itaipu Binacional, Eletronuclear, Cemig, Equatorial Energia, TAESA, Light, ISA Energy, SEFAC, Tijoá Energia, COPEL, Acelor Mittal, SINOP Energia HPP, Teles Pires HPP, and Belo Monte HPP.

***GAMMA* software components**

GAMMA Online - SOMA (Asset Monitoring-Oriented System): data acquisition, processing, and monitoring based upon artificial intelligence (AI) applications, the Internet of Things (IoT), and digital twins. (Read more on page 57).

GAMMA Predictive Management - DIANE: creation of records with operating and maintenance history, and calculation of asset health indexes. It allows recurring problems to be identified quickly and helps to manage predictive maintenance.

GAMMA Reliability: detailed analysis of the criticality of assets, with positioning in a risk matrix of economic, operational, safety, environmental, and reputational impacts.

Control and supervision **of systems**

Cepel's Systems Automation and Control area develops technological solutions that are essential for the supervision, control, and operational safety of the Brazilian electricity system. This has been strategic for the modernization of the national energy infrastructure, promoting greater reliability, efficiency, and resilience in the transmission, generation, and distribution networks.

Our solutions reflect Cepel's commitment to innovation, technological sovereignty, and the operational sustainability of the electricity sector. The Center's work makes a decisive contribution to mitigating risks, optimizing resources, and building a safer and smarter electricity system that is prepared for the challenges of the energy transition.

THE THREE MAIN SYSTEMS

SAGE

This system enables real-time monitoring, control, and analysis of electricity grids and concentrates data such as voltage, current, phase angle, and other synchrophasor data.

It can be found in more than

Used by more than **300** customers

Found in more than **2,500** installations in Brazil and Latin America

Found in more than **60%** of the SCADA (Supervisory Control and Data Acquisition) market in substations in Brazil

Used by ONS and Eletrobras in the Brazilian electricity system (SEB) for more than **25 years**

TOPSIM

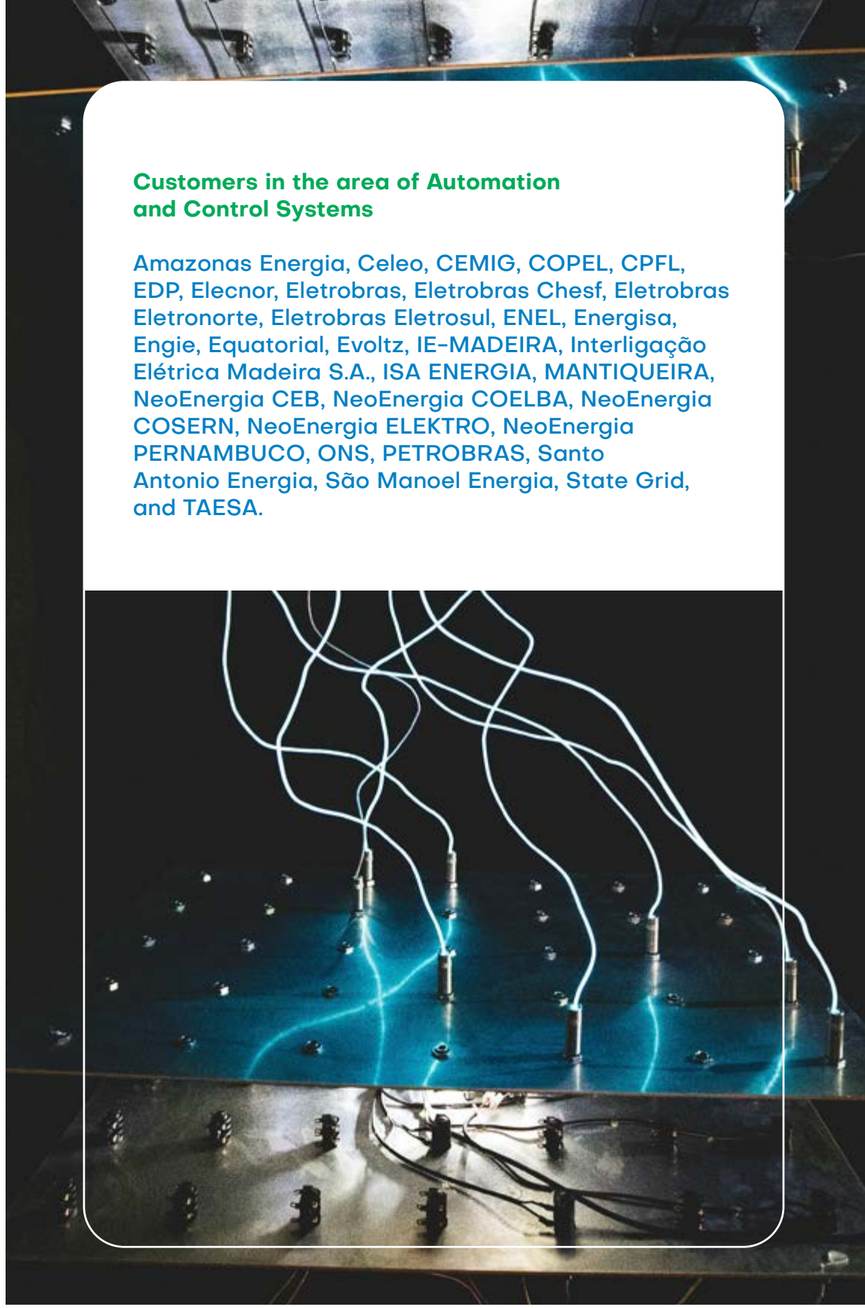
This **SAGE** module allows operator training by simulating electrical networks.

SINAPE

The solution speeds up the identification of the causes of unscheduled shutdowns (faults) in electrical systems, enabling faster and more effective action by the operations and protection analysis teams, with the main benefit being a reduction in operating costs and increased electrical safety in the power system.

Customers in the area of Automation and Control Systems

Amazonas Energia, Celeo, CEMIG, COPEL, CPFL, EDP, Elecnor, Eletrobras, Eletrobras Chesf, Eletrobras Eletronorte, Eletrobras Eletrosul, ENEL, Energisa, Engie, Equatorial, Evoltz, IE-MADEIRA, Interligação Elétrica Madeira S.A., ISA ENERGIA, MANTIQUEIRA, NeoEnergia CEB, NeoEnergia COELBA, NeoEnergia COSERN, NeoEnergia ELEKTRO, NeoEnergia PERNAMBUCO, ONS, PETROBRAS, Santo Antonio Energia, São Manoel Energia, State Grid, and TAESA.



In **2024**

In 2024, our flagship solution for network supervision and control, **SAGE**, was improved as follows:

Customization for green hydrogen production, storage, and use systems (SAGE H2)

Modernization of the system interface, thus optimizing usability.

In 2024, **SAGE** was implemented in all facilities operated by Eletrobras' companies. Main applications:

- **Supervision and control** of all control centers, substations and power plants
- **Use of the TOPSIM simulator** as the company's standard program for training operators who use **SAGE** as their operating platform.
- **Implementation of SAGE** in the H2V green hydrogen plant at the Itumbiara Hydroelectric Power Station (GO)

At this project, located in Itumbiara, there are also plans for the installation of a solid-state hydrogen storage system, coupled to solid oxide fuel cells (SOFC), which will be monitored by the **SAGE**.

In addition to Eletrobras, Copel has also established **SAGE** as its standard system for the supervision and control of its transmission system facilities.

There has also been an expansion of use outside the country. Celeo, a Spanish transmission company in Brazil, has also implemented **SAGE** in its first control center in Peru. Multinationals such as Siemens and GE Vernova, which use the **SAGE** system in their operations in Chile and Mexico, also expanded its use in 2024.

In the programs involving SINAPE in 2024, the main highlights were the completion of two important initiatives: a value delivery project with Eletrobras, and an R&D project by the Brazilian Electricity Regulatory Agency (ANEEL), in partnership with the Advanced Institute of Technology and Innovation (IATI), for Evoltz Participações. Important features have been introduced in SINAPE. Net and COLETOR, such as integration with **SAGE** to read operational data and send alarms; the creation of a situational dashboard to monitor the oscillography data collection process; introduction of new techniques for locating faults on transmission lines; interfacing with georeferenced data providers (in particular lightning strikes and fires); and access to long-term oscillography for the analysis of systemic incidents, among others. We have also implemented these SINAPE.Net tools in several companies, thus broadening our range of customers.

Electrical energy models

Cepel's Electroenergy Models area develops advanced computational tools that support the planning, operation, and expansion of the Brazilian electricity grid. These models are fundamental to guaranteeing the sector's energy security, economic efficiency, and environmental sustainability, especially in the current context of transition to a cleaner, more diverse, and decentralized grid.

The solutions developed by Cepel make it possible to simulate the behavior of the electricity system over different time periods and in different scenarios, taking into account variables such as hydrology, demand, renewable sources, and operating restrictions. Used by institutions such as ONS, CCEE, EPE, ANEEL, and various other companies in the sector, these models support strategic and operational decisions based upon science and technology.

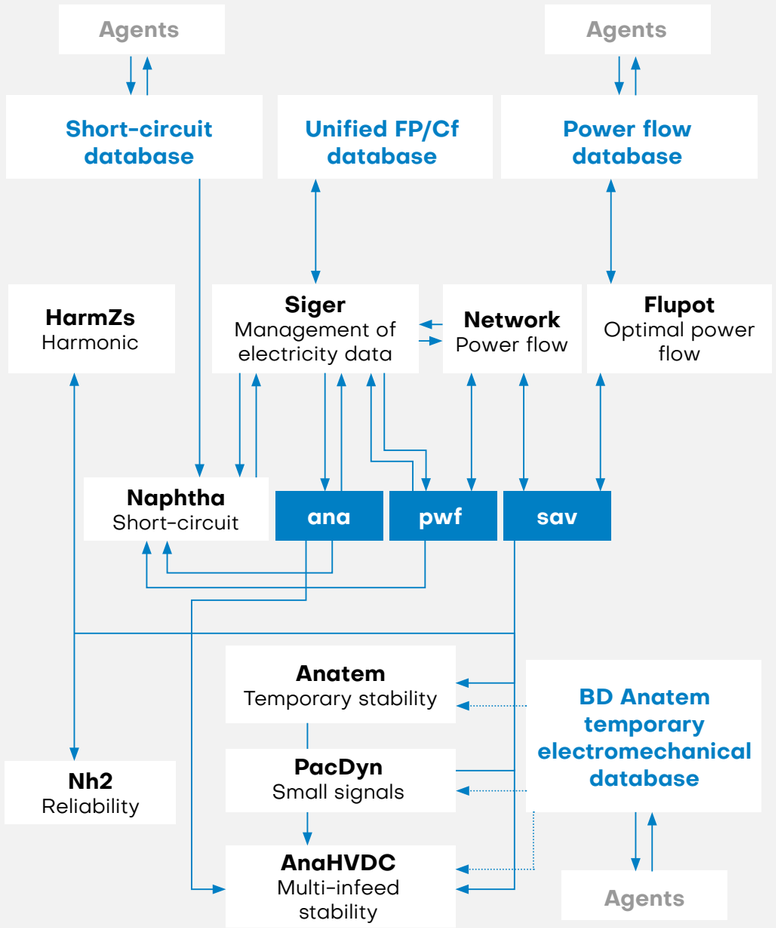
The non-experimental versions follow a formal governance process involving sectoral institutions and agents from the electricity sector. Methodological improvements and developments are discussed and decided upon in specific technical forums, guaranteeing transparent and representative decision-making. Once the priorities have been defined, the updates go through annual validation and approval cycles with the regulatory bodies, ensuring that the versions made available reflect best practices and are in line with technological and regulatory advances in the sector.

Cepel's Electrical Energy Models area has the technical capacity to develop and improve computer models according to the demands of the national electricity sector. These models faithfully represent the various parameters of interest associated with the physical aspects of electrical systems, and are applied extensively to the Brazilian grid. This expertise has consolidated Cepel as a national benchmark in innovation, planning, and technical-scientific support for the electricity sector.

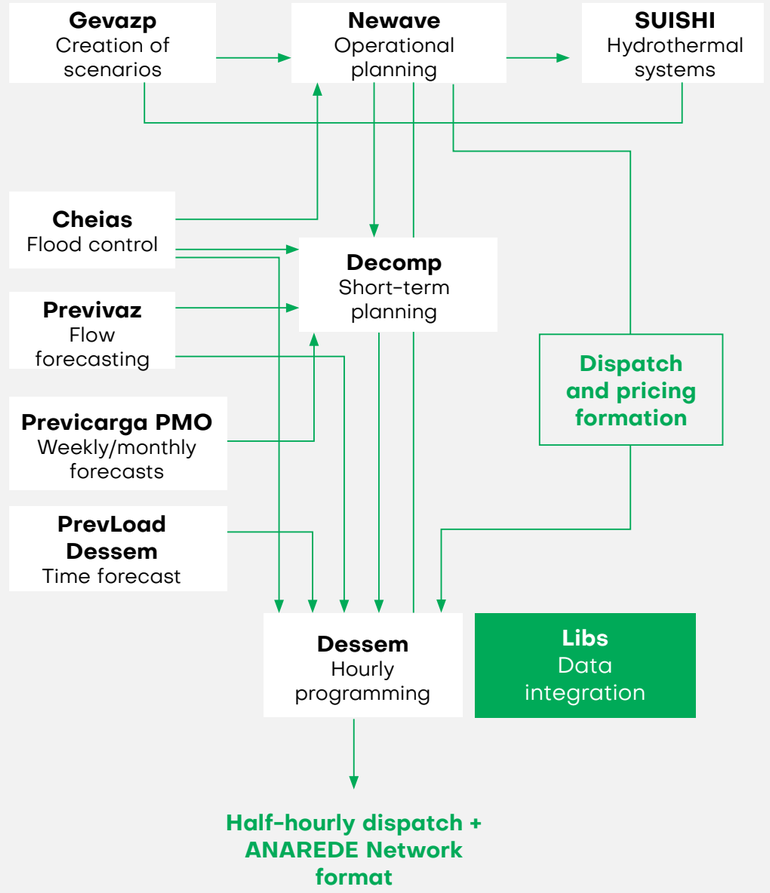
Strategic partnership

Cepel has been contributing to the ONS' strategy of increasing its autonomy in the development and maintenance of computer models for the operation of the electricity system, in line with the Memorandum of Understanding signed between the institutions in October 2023. A working group has been created to foster this partnership.

Electricity models



Energy models



Electricity models

These are used to guarantee the viability of the generation program defined by the energy models, ensuring that the load is met with a high level of quality, while respecting the operational limits of the generating units and the transmission system. They are also used to analyze the need and feasibility of connecting new projects to the electricity grid.

Two electricity models are Anarede, a set of computer applications that enables the analysis of electrical power systems, and Anatem, an app that generates information on system stability, busbar voltages, and transmission line currents.

In 2024

Development of static and dynamic models in the Natural Saturation Reactor (NSR) for voltage control, using the Anafas, Anarede and Anatem programs.

Updating of the Bipole I Model of the Direct Current Transmission System installed at the Madeira River (RO) Power Plants is underway for Eletronorte. This model is already used by the ONS in electromechanical stability analyses and the definition of North-Southeast and Northeast-Southeast interchange limits, and by EPE in expansion planning studies, using the Anatem program.

This equipment has been developed by the R&D area at Eletrobras Chesf and offers an economical alternative to linear reactors and static compensators. There are several linear reactors at the end of their useful life in the institution's concession region and the alternative of replacing this equipment with RSN is only viable if computer simulation models are available for the studies conducted by the EPE and the ONS.

Development of an Anatem model with battery energy storage for studies of electromechanical transients, developed for Eletronorte, which will allow for the evaluation of the systemic behavior of battery-based energy storage installations.

Validation of the wind turbine model for CGT Eletrosul is underway. As a result of the August blackout in the SIN, the ONS asked power generators to deliver and approve PSCAD and Anatem models for wind and photovoltaic generators. Cepel, CGT Eletrosul and Eletrobras Chesf have formed a task force to validate the Woben E-82 wind turbine models, which operate at the Cerro Chato (RS) I, II and III wind farms.

Cepel's individualized generator model allows computer simulations to reproduce the allocation strategies for generating units in the National Interconnected System.

The individualized generator model in network analysis programs

Throughout 2024, the set of electricity grid simulation programs developed by Cepel was equipped with an individualized generator model that allows for the reproduction, in the form of computer simulation, of the generation unit allocation strategies used in the National Power Grid. As well as bringing computer simulations closer to the reality in the field, this model will, in the near future, also enable integration with energy planning models, also developed by Cepel, at the daily operation programming level.

NH2

Updating the model for calculating and allocating the power reserve for the ONS, taking into account the insertion of wind and photovoltaic plants and the exchange between the system's regions. The correct consideration of the exchange between the areas is of paramount importance for the daily programming of the operation, especially considering the proportion of wind and photovoltaic generation that is concentrated in the Northeast.

AnaHVDC

Implementation of the direct current link model with harmonics. By doing so, the program is able to take into account the dynamic effect of direct current links, which are increasingly present in the Brazilian electricity system, bringing the expansion and operational planning studies developed by the EPE and the ONS closer to becoming a reality.

Energy models

Optimization tools that support planning, operation and price formation in the Brazilian electricity sector. These tools determine the optimum use of hydroelectric, thermal, and wind resources, guiding the efficient use of water in multi-annual regularization reservoirs, reconciling supply security with environmental sustainability.

Hybrid Newave
aims to meet the electricity sector's demand for a more accurate representation of how the system operates

Hybrid Newave

The **Hybrid Newave** is the new version of the software used for the strategic planning of generation and transmission in the Brazilian electricity system. It allows for:

- Individualized and more detailed representations of hydroelectric power stations;
- Analysis of the impact of each plant on the electricity system as a whole;
- Consideration of water restrictions, such as shipping and flood control.

This development is in response to the sector's demand for a more accurate representation of how the system operates.

Decomp and Dessem

The **Decomp** (short-term, up to two months) and **Dessem** (very short-term, up to one week) models are used by the ONS for short-term planning and system dispatch, and by the CCEE to determine the Settlement Price for Differences (PLD) for the Brazilian electricity system. It is also used for economic planning by agents in the electricity sector, based on water availability.

Estimated benefits:

- Savings of around 10%, with an estimated impact of around four billion BRL annually, for society.
- Greater expected thermoelectric generation in systems low reservoir level, thus improving system predictability.

The use of the **Hybrid Newave** software was made official by the EPE, ONS and CCEE in January 2025.

Operation:

- Both use data generated by **Newave**.
- They incorporate additional aspects according to the temporal and spatial granularity required, such as: representation of the electricity grid, consideration of the allocation of thermal and hydroelectric generating units (unit commitment), power reserve restrictions, and detailed electrical and water restrictions, among others.

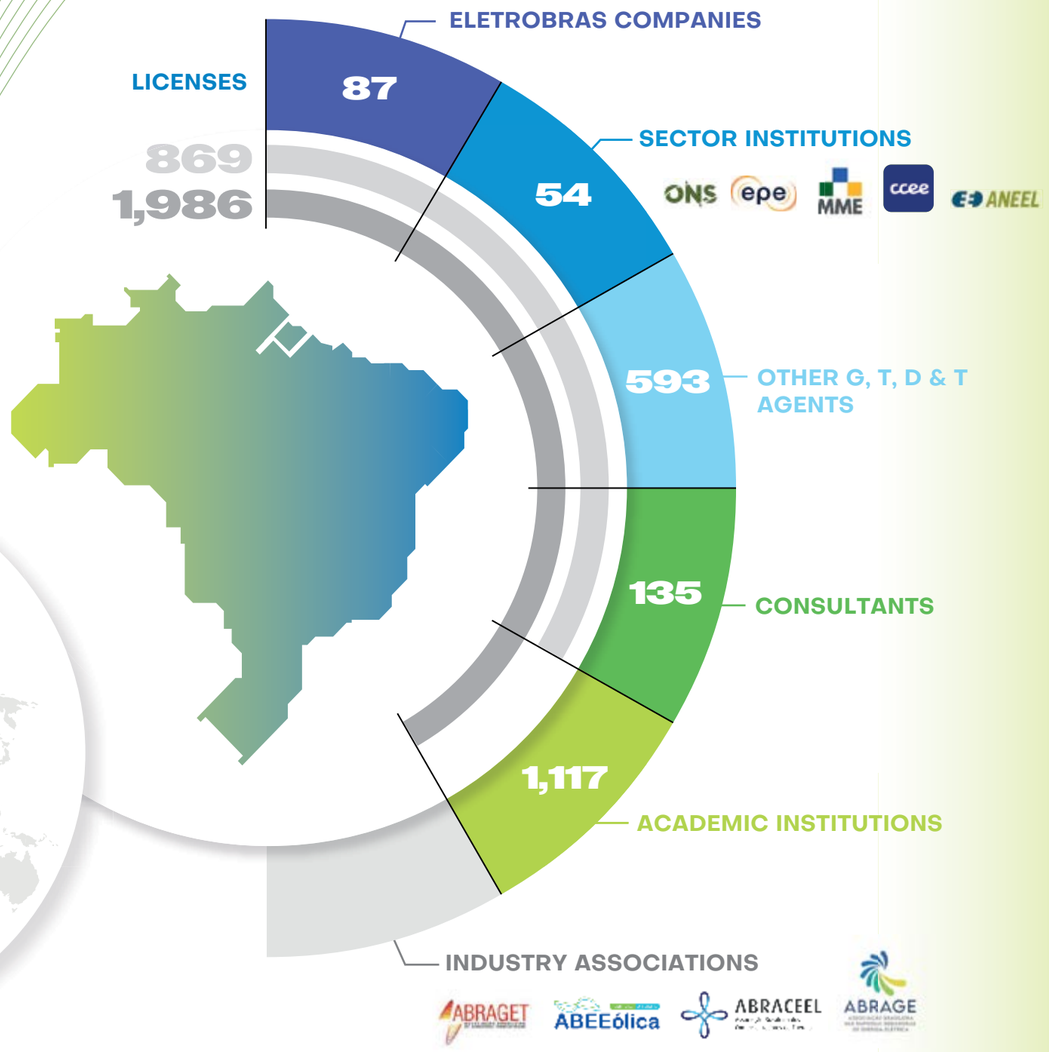
In 2024

Improvement in the modeling strategy of the unit commitment restrictions of the thermal units in **Dessem**, thus reducing processing time.

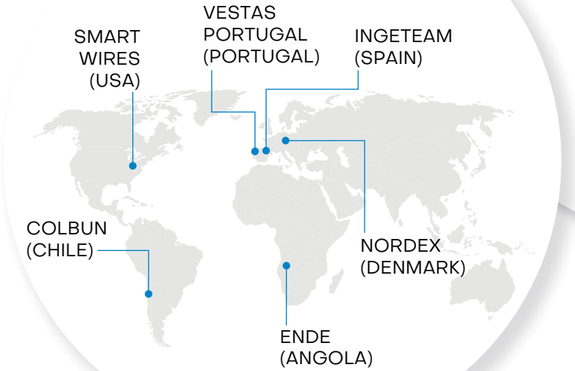
Adaptation to water resource management guidelines (average water limit and variation restrictions) in accordance with the requirements of the National Water and Sanitation Agency (ANA) for multiple water uses.

Electrical energy models

CUSTOMERS



OVERSEAS CUSTOMERS



ELETROBRAS COMPANIES

- CHESF
- ELETRONORTE
- ELETROBRÁS
- FURNAS
- ELETROSUL

SECTOR INSTITUTIONS

- MME
- ANEEL
- ONS
- CCEE
- EPE

OTHER G, T, D & T AGENTS

- COSERN
- CEA
- CELPA
- CEMAR
- BOAVISTA
- AMAZONAS
- BANDEIRANTE
- COELCE
- COSERN
- ENERGISA
- ELETRONUCLEAR
- CEPISA
- CELPE
- CEAL
- CELTINS
- ENERGIPE
- CEMAT
- CEB
- COELBA
- ESCELSA
- PETROBRAS
- CELG
- LIGHT
- ENERSUL
- CFLCL
- AMPLA
- DUKE
- CEMIG-D
- CEMIG-GT
- CAIUÁ
- CESP
- CTEEP
- EEB
- ELEKTRO
- ELETROACRE
- COPEL
- AES-TIETÊ
- CELESC
- TRACTEBEL
- ELETROPAULO
- CERON
- ITAIPU
- CPFL
- CEEE-D
- CEEE-GT
- ENDESA
- RGE

CONSULTANTS

- ENGEPOWER
- PSR
- POWER SOLUTION
- VIRTUS
- DALBEN
- BRASELCO
- MARTE
- ALUMAR
- CPE
- SÁ & LOPES
- BIO ENERGIAS
- ANDESA
- GSI
- BAKHITA
- CPE
- ISESC
- CEFET/GO
- POWER CONS
- BMG
- ABB
- SENIOR
- MOURENTE
- A&C
- EEB
- LT
- ATIVA
- UTP
- FURB
- WOBBEN
- GRAMEYER
- JORDÃO
- ENGEVIX
- CON ENERGIA
- TOOLS
- EMBRAE

ACADEMIC INSTITUTIONS

- UNFC
- UFMA
- FDTE
- UFGC
- UFU
- UNIFOR
- UCP
- UNIVASF
- UNIFOR
- UFC
- UNI
- POLITÉCNICA
- UFMG
- UNIFEI
- FURB
- UFBA
- UFRN
- UNB
- EMBRAE
- UFF
- UCP
- UFES
- USU
- ETEHL
- FOA
- UFRJ
- UNESP
- UNICAMP
- UPM
- UFSM
- UTFPR
- UFPR
- CEFET/SP
- SOCIESC
- UFSC
- UNISUL
- UFERSA
- UNISINOS
- SENAI
- UFJF
- UFSM
- ULBRA
- UNISUL
- UNIOESTE
- UFG
- IFES
- UFRGS
- UNIPAMPA

Energy Planning, **Trading and Regulation**

Cepel's Energy Planning, Energy Trading, and Regulation department acts as a strategic link between technical knowledge, market intelligence, and decision-making in the electricity sector. Its mission is to support Eletrobras and other customers in formulating robust strategies for the expansion of generation, efficient trading of electricity, and regulatory compliance.

With a highly qualified team, it develops studies and tools that enable:

- Energy price forecasts;
- Analysis of the economic viability and venture risks;
- Weather and hydrological forecasts;
- Planning for energy expansion and diversification of the energy mix;
- Support for trading in the Free Contracting Environment (ACL);
- Electrical studies of transmission margins for new loads and generation in the Brazilian electricity system.

In 2024, the highlight in this area was the **ATMOS** climate monitoring project, developed by Cepel and Eletrobras.

ATMOS is a hand-held, flexible, and integrated solution that uses meteorological data focused on those regions where Eletrobras has assets to support the company's decision-making regarding operations and maintenance. Its goal is to:

- Facilitate access to meteorological data;
- Improve the quality of climate forecasts;
- Support strategic decisions in the management and maintenance of assets and energy production;
- Ensure operational efficiency, human safety, and sustainability.

The solution is part of Eletrobras' Meteorological Monitoring and Intelligence Center.

FIND OUT MORE
Click here to access the content in the standards supplement

Decision-making support models for energy trading

Eletrobras used various models developed by Cepel throughout 2024:

ANAFIN

Support for investment decisions in generation and transmission projects, helping to identify the most profitable investment opportunities for the company.

Evaluates the economic and financial viability of generation and transmission projects.

Analyzes the risks associated with each investment in new assets.

Applicable to hydrogen production projects, whether coupled to generation plants or not.

PLDPro

Prospecting the Settlement Price for Differences (PLD), meaning the price of electricity on the spot market, providing support for energy trading strategies. In 2024, the price matrix sensitivity feature was incorporated, providing a more comprehensive analysis of energy prices.

Automatically carries out prospective PLD studies.

Links all the energy models involved in the formation of the PLD – **Newave, Decomp, Dessem** and **Gevazp**.

Replicates the models execution procedures in order to guide dispatch and price formation (PLD) carried out by the ONS and CCEE.

Presents results in an easy-to-analyze format.

SazOpt

Definition of the seasonality of the physical guarantee of energy from the hydroelectric plants, in order to maximize energy production.

Optimizes the seasonality of the physical guarantee of hydroelectric power plants (UHEs) for the Energy Reallocation Mechanism (MRE), which is a set of rules designed to mitigate hydrological risk in energy production.

Maximizes revenue in the Short-Term Market.

Incorporates risk aversion via Conditional Value at Risk (CVaR) modeling, which is a statistical metric for managing a company's financial risk.

Considers minimum monthly revenue restrictions and physical energy guarantee seasonality ramps.

Includes aspects such as the renegotiation of hydrological risk.

SIPMV project

The aim of this project is to develop a system that:

- Provides relevant weather information for the energy market;
- Uses this information to forecast inflows to the reservoirs used by the HPPs centralized by the ONS;
- Supports energy price analysis and forecasting.

The project includes:

- Development of a computer system;
- Meteorological research and flow modeling phases.

Artificial intelligence applications

PrevIA: this solution supports the operation of Eletrobras with the forecasting of inflows into four Chesf reservoirs – Sobradinho (BA), Itaparica (PE), Pedra (BA), and Boa Esperança (PI). In 2024, the model's first test window took place in the wet season, from November to April.

Other systems and models developed by the area are **MELP, Matriz, Confint, Cheias** and **Previvaz**.

The PrevIA solution forecasts inflows into four Eletrobras reservoirs

FIND OUT MORE
See more details in the annex on page 57

Projects

Offshore electrification

Cepel has developed a conceptual study for the electrical interconnection of offshore oil and gas production platforms by means of underwater cables.

The project, called Offshore Microgrid, proposes:

- The creation of its own independent power grid;
- Adaptation to the adverse conditions of the offshore environment;
- The potential to save millions of *Reais* and reduce emissions.

In view of the promising initial results, a more detailed study has already been commissioned by one of the leading companies in the sector.

Artificial intelligence

Cepel has joined an international consortium to conduct the 'Deep integration between machine learning approaches and renewable energy optimization' project.

The project is coordinated by SINTEF Energy Research, of Norway, and involves:

- European companies and universities;
- Research into the application of artificial intelligence in models for planning and operating the electricity system;
- International collaboration for innovation in renewable energy.

The **Offshore Microgrid** project has the potential to save millions of *Reais* and considerably reduce carbon emissions.

Laboratories

Accreditations

Inmetro's General Accreditation Coordination (Cgcre) has increased the types of accredited tests carried out by Cepel:

- **Continuity** of the high voltage and current calibration service, this being the national benchmark for voltage impulse measurement systems.
- **Inclusion** of the Photovoltaic Modules area, in accordance with Ordinance nº 140/2022.
- **The Smart Grids Laboratory** (LabSG) has received accreditation to perform more than 20 types of tests, including:
  - Photovoltaic inverters;
  - Battery charge and discharge controllers.

Testing on **electrical equipment**

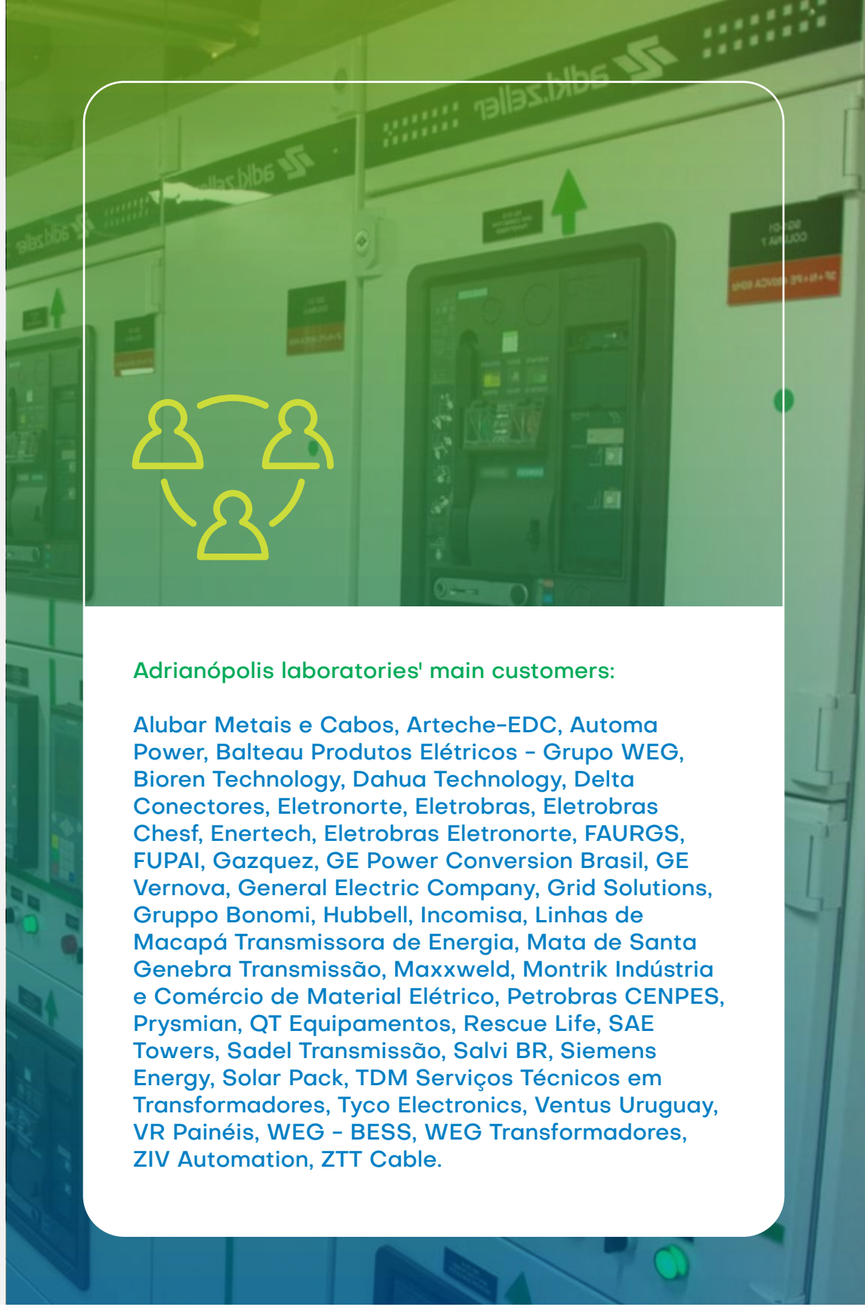
The Adrianópolis Unit stands out as a unique research center in Brazil, with the largest laboratory complex for electrical testing in Latin America and one of the largest in the world, making it a national and international benchmark. Its strategic infrastructure is fundamental to the modernization of the electricity sector, conducting performance evaluations of electrical equipment used in power plants, substations, transmission lines, distribution systems, and facilities operated by large consumers in the Brazilian electricity system.

> Our Adrianópolis Unit boasts the largest electrical testing laboratory complex in Latin America

In **2024**

We have tested transmission equipment for the Eletrobras energy sector (current transformers, insulators, fittings, connectors, OPGW cables, disconnect switches, etc.) for voltage classes up to 800 kV.

- Evaluation of lightning rods taken out of operation for the feasibility of using them as spare parts;
- Evaluation of OPGW cables for foreign customers;
- Endurance tests on 550 kV polymeric insulators, the only laboratory capable of carrying out these tests in the country;
- Atmospheric impulse and frequency response tests on reactors for Eletronorte;
- Power tests on industrial and distribution equipment with up to 85 kA short-circuit and permanent current tests with three-phase 5kA, the only laboratory in Latin America capable of achieving these values.



Adrianópolis laboratories' main customers:

Alubar Metais e Cabos, Arteche-EDC, Automa Power, Balteau Produtos Elétricos - Grupo WEG, Bioren Technology, Dahua Technology, Delta Conectores, Eletronorte, Eletrobras, Eletrobras Chesf, Enertech, Eletrobras Eletronorte, FAURGS, FUPAI, Gazquez, GE Power Conversion Brasil, GE Vernova, General Electric Company, Grid Solutions, Gruppo Bonomi, Hubbell, Incomisa, Linhas de Macapá Transmissora de Energia, Mata de Santa Genebra Transmissão, Maxxweld, Montrik Indústria e Comércio de Material Elétrico, Petrobras CENPES, Prysmian, QT Equipamentos, Rescue Life, SAE Towers, Sadel Transmissão, Salvi BR, Siemens Energy, Solar Pack, TDM Serviços Técnicos em Transformadores, Tyco Electronics, Ventus Uruguay, VR Painéis, WEG - BESS, WEG Transformadores, ZIV Automation, ZTT Cable.

Materials and mechatronics **analyses**

Cepel's teams worked on several fronts:

- Agile technologies for the predictive maintenance of lubricating oil in large machines, with a focus on mitigating the formation of lacquer.
- A contract with one of Brazil's leading oil and gas companies to inspect and classify anomalies in metal components embedded in concrete at the Angra I Power Plant, as part of the LTO (Long-Term Operation) program, with a view to extending the plant's useful life for another 20 years.
- Evaluation of the integrity of boilers and pipes for thermoelectric generation based on monitoring and mathematical modeling for Petrobras.
- Modeling the corrosive process of galvanized steel in substations
- Self-repairing anti-corrosive paints based on intelligent micro-capsules
- Lubrication diagnosis in critical equipment at 6 Petrobras TPPs
- Tackling golden mussel infestations in hydroelectric plants
- Mitigating the impact of corrosion in hydroelectric plants and transmission lines
- Boiler integrity analyses at thermal power plants
- Seismic qualification tests on equipment and structures
- New layout for the signaling ball installation robot

Technological services provided for Eletrobras (35 service calls), including:

- Field inspections (power stations, substations, and transmission lines)
- Specifications and methodologies for evaluating the performance of impact protection barriers for guyed towers in the Eletrobras transmission system
- Technical specification and technical monitoring of the penstocks repainting service at the Simplício HPP
- Protection of Transmission Assets and Substations in the Joinvile (SC) region
- Laboratory tests for compliance with technical standards
- Physico-chemical analysis and diagnosis of insulating oil
- Failure analysis of equipment and structures

Highlights:

- Inspection of helical pile foundations
- Water quality analysis of Eletrobras hydroelectric power plant lakes
- Physico-chemical aging analysis of the lubricating oil used in the turbines of the Santa Cruz Thermal Power Plant (TPP)
- Monitoring transformer insulating materials
- Evaluation of corrosion protection technologies
- Mechanical and non-destructive testing of polymeric insulators
- Analysis of corrosive processes and component failures
- Specification of anti-corrosion paint
- Evaluation of floats for photovoltaic plants
- Improvement of a robot for changing a signaling ball
- Fundamentals of Anti-corrosive Paint Inspection (FIPA) training, in-company and at Cepel
- Evaluation of impact protection barriers for the prevention of collisions of agricultural machinery on transmission support lines
- Installation of a vibration monitoring system developed by Cepel in auxiliary engines at the Tucuruí Hydroelectric Power Station

Main clients of the materials and mechatronics laboratories:

Argo Energia, Caddel Construtora, Celeo, Chromax, Diamante Energia, Endress Hauser, Eletronuclear, Eletrobras, Evoltz, GE Celma, Itaipu, Mata Grande Transmissora, Maxxweld Conectores, Oliveira Energia, Petrobras, Quantum, SAE Towers, Serena, Siemens Energy, and WEG Tintas.

Espaço NZEB **inauguration**

In 2024, the *Espaço NZEB* (Near Zero Energy Building) was inaugurated at the Fundão Unit, the first building in Brazil to apply the concept of net energy consumption for its near-zero operation.

This modern building serves as a living laboratory for the application and demonstration of new efficiency and renewable energy generation technologies for end users.

The *Espaço NZEB* is the first building in Brazil to apply the concept of **zero net energy consumption** to its operations.

Characteristics of the laboratory:

- Bioclimatic architecture (optimized use of natural light, ventilation, and water collection);
- Use of a local renewable energy source with photovoltaic panels;
- A battery energy storage system (BESS);
- Low-energy lighting and air-conditioning with intelligent control;
- Demonstration of the impact of household appliances on energy consumption.

Recognition:

- National Energy Conservation Label (ENCE) – Class A, with top marks for Envelopment, Lighting and Air-Conditioning.

Bonus for water rationalization and photovoltaic generation

- *Procel Edifica* seal, issued by ENBPar.

FIND OUT MORE
Learn more about
Espaço NZEB

Technical **publications**

Patents

	PATENTS GRANTED
PI-0002430-9	Electricity meter and housing for an electricity meter
PI-0801469-8	Monitoring system for transformers used in an indirect electricity metering system in an electricity metering installation, and a method for monitoring and diagnosing transformers in an indirect electricity metering installation
PI-0705108-5	System and method for evaluating capacitive bushings
PI-0800367-0	Device for establishing electrical contact in high-voltage circuits
PI-0905866-4	Robot for inspecting conductor cables
PI-9902611-2	Process for identifying fraudulent consumers in an electricity distribution network in a given region, and the system and process for determining the existence of hidden conductors that allow the bypassing of an electricity meter

	PATENTS FILED
BR102014021142-0	Methodology for calculating the useful life of thermal power plants
BR102019013232-9	Modular device, system and method for monitoring high-intensity magnetic fields near consumption meters
BR102023017102-8	Electric field protection device and its method for installation and attachment

	INDUSTRIAL DESIGNS GRANTED
DI-6704136-1	Configuration applied to electrical conductor line spacers

FIND OUT MORE
Click here to access the content in the standards supplement

Academic articles, **theses, and dissertations**

Our researchers and postgraduate scholarship students have published 36 articles focusing on the research and work carried out at Cepel in prestigious international journals.

The scientific output of our technical staff over the years, and especially in 2024, is indicative of Cepel's importance and commitment to dialogue with the academic community, and our role in applied research, which solves real needs in the market and in society.

See the appendix on page 58 for a full list of Cepel publications in 2024.

A number of these papers have also been presented at congresses and symposiums, including:

WebSummit

At one of the most popular international meetings concerning innovation, Cepel presented its **Net Zero Game**, an educational game focused on actions designed to combat climate change; and the **Green Hydrogen Calculator, which simulates the cost of producing H2V in different scenarios**. There were also talks and mentoring from our experts.

International Workshop on Advancing Energy Efficiency in the Public Lighting Sector in Brazil

Hosted by Cepel, this workshop was hosted by the Collaborative Labeling and Appliance Standards Program (CLASP), in partnership with Inmetro. The event brought together manufacturers, importers, laboratories, certification bodies, the government, and consumers to discuss regulations and improvements for the street lighting market.

CIGRE-Brazil and CIGRE International

Cepel maintains an active and strategic presence in CIGRE-Brazil and CIGRE International, organizations recognized globally for the fundamental role they play in the technical development of the electricity sector. We are collective members of CIGRE-Brazil and have a representative on its Board of Directors, reinforcing our commitment to technological evolution and the exchange of knowledge in the sector.

Currently, 30 Cepel researchers are individual members of CIGRE, reflecting our institutional engagement with the organization's Study Committees (SCs). Some of these members hold coordinating positions in the SCs, expanding our contribution to developing guidelines and good practices for the sector.

Among the outstanding activities in 2024, it is worth highlighting Cepel's participation in the **Cigre Biennial Session in Paris**, with special mention going to researcher Flávio Rodrigo Miranda Alves, Secretary of Study Committee C2, who was recognized with the **Technical Council Award**, one of the organization's most prestigious awards.

We are also involved in other important technical events, such as the Meeting for the Development of the Operating Environment (EDAO), in which we participate in the organizing and technical committees. Throughout the year, Cepel researchers were present at webinars, workshops, and national and international working groups, actively contributing to the preparation of technical brochures that guide the sector on current and strategic issues.

30

Cepel researchers are individual members of CIGRE

Cultural transformation

Organizational **efficiency**

In anticipation of the transformations in the energy sector and in order to respond with increasing agility to the demands of its customers, Cepel has been undergoing a process of restructuring to offer more agile and focused support to our clients. Areas were created or redesigned in order to optimize processes, expand commercial capacity, and improve the customer experience. In addition to this, the process includes the hiring and training of staff in specific skills to boost the Center's entrepreneurial potential.

The guidelines for this restructuring, which is still underway, are:

1. Simplification of processes, in support of the strategy;
2. More autonomy for the different areas;
3. Culture of data and indicators;
4. Customer-oriented decision-making;
5. Agility as an operating principle in all sectors.

Energy transition, **renewable sources, and sustainability**

The energy transition is a global movement aimed at responding to an urgent need in society: safe, affordable and sustainable energy. However, this path presents challenges that demand a vision of Research and Development that is combined with innovation and based on sustainable development.

Even though Brazil has a mostly renewable electricity grid (88.2% in 2024), according to the EPE, the transition scenario demands an increase in the development of renewable sources, combined with more efficient and sustainable forms of energy generation, which is a critical factor in achieving long-term environmental goals, such as reducing greenhouse gas emissions, and targets agreed at national and international level.

And although it is beneficial, the energy transition also brings with it numerous challenges. In this sense, it is necessary for this transition to take place in fairly, reconciling job creation, income, social inclusion, the fight against inequalities, and improved quality of life.

In this new context, new risks and opportunities present themselves to companies in the electricity and other sectors, such as data centers, for example, which will demand scientific knowledge and R&D projects that promote innovation and sustainable development.

Several of Cepel's research projects are moving in this direction, in order to ensure that electricity generation takes place with the least negative socio-environmental impact, while also maximizing the positive impacts.

The research projects developed by Cepel's Energy Transition and Sustainability area aim to respond to the new context and bring benefits in terms of alignment with market needs, given that environmental, social and governance (ESG) criteria are increasingly used to evaluate companies and help investors avoid those that may represent a greater financial risk due to their practices, and seek out those that offer greater profitability and value creation.

The issue is therefore a priority for Cepel, which is working to contribute as follows:

- **Accelerate** the electrification of the economy;
- **Expand** the use of clean energies;
- **Reduce** greenhouse gas emissions;
- **Increase** the competitiveness of the industry;
- **Generate** positive impacts on the environment and people's lives.

Here are some of our main developments and projects over the last year on various fronts.

Cepel's vision of the future is fully **aligned with the demands of the ESG agenda**. One of the paths involves developing energy transition and decarbonization projects, among others

Green hydrogen

This green fuel should become a central part of the global energy matrix, complementing the use of renewable electricity and allowing an expansion of clean sources with a better balance between supply and demand.

Cepel develops tools for the technical and economic analysis of integrated production chains for green hydrogen and its derivatives:

- Ammonia (LCOA);
- E-methanol (LCOM);
- SAF – Sustainable Aviation Fuel (LCOK).

These tools were applied to strategic projects funded by ANEEL in 2024, with a focus on assessing the environmental and economic impacts of renewable hydrogen in different sectors.

FIND OUT MORE
on page 54.

Cepel is also taking part in the project to develop two hydrogen production plants:

One with **PEM electrolysis** of **10 MW**

Another with **alkaline electrolysis** of **1 MW**

Floating photovoltaic **modules**

This solution could be the key to more sustainable energy generation, as it harnesses energy from the sun and from the surface of bodies of water used by hydroelectric power plant, creating an efficient solution for energy production while minimizing negative impacts.

In 2024, Cepel participated in pilot projects on **reservoirs at the Sobradinho and Itumbiara hydroelectric power plants, involving:**

Installation of photovoltaic modules on the surface of bodies of water.

Generation of solar energy using existing areas, without the need for deforestation.

Gain in efficiency: generation of 4% to 14.5% more energy than land-based systems, due to the lower temperature of the panels.

Cepel also works to qualify suppliers, analyzing:

- Floats
- Inverters
- Photovoltaic modules
- Cables

Wind energy

The focus of the actions here is on optimizing, monitoring, and evaluating the performance of wind farms

Principal initiatives:

CALC-P90e:

- A web platform for calculating annual energy production with a 90% probability of overshoot (P90);
- Reduces subjectivity and allows uncertainties to be traced;
- Complies with IEC 61400-12-1.

Wind SOMA:

- A version of the SOMA system for wind farms (find out more about SOMA on page 57);
- Provides production and wind-speed data per wind turbine;
- Access via computer, tablet or cell phone, with agile decision-making.

Wind O&M Project:

- Complete diagnosis of wind farm operations;
- This project integrates data from AMA, SCADA, work orders and event logs;
- It uses high-performance computing with statistical and AI models;
- Available on the web platform, with no need for additional hardware.

MATRIX model

The MATRIZ model, developed by Cepel, supports forecasting studies on the Brazilian energy grid. It:

- Is flexible and incorporates new technologies;
- Expresses flows of energy and materials;
- Is part of the electricity, green hydrogen, and ammonia chains, among others;
- Calculates greenhouse gas emissions and water consumption from extraction to final consumption.

FIND OUT MORE
on page 57.

Socio-environmental vulnerability and climate change

In 2024, Cepel developed an innovative solution for prioritizing areas for adaptation actions aimed at reducing socio-environmental vulnerability to climate change in the vicinity of electricity sector projects. The georeferenced web portal systematizes a methodology to guide climate adaptation strategies, making it possible to identify the most vulnerable publics and ecosystems, analyzing the pressures caused by their sensitive situations and their capacity to adapt. This data is synthesized into a vulnerability index, made up of three components: Indigenous vulnerability, ecosystem vulnerability, and present and future climate vulnerability.

The portal also organizes large volumes of data in a visual and accessible way, offering an integrated view of territorial, social and environmental dynamics. This represents a significant advance in the accuracy and integration of information, allowing for more sustainable and socially responsible planning.

Cepel has developed a tool to help increase the resilience of vulnerable communities and regions

With the possibility of visualizing different river basins in a single environment, the tool helps define the adjustments needed to increase the resilience of vulnerable populations and areas. At the same time, it reduces the climate, social, reputational, and legal risks associated with the projects.

This solution is scalable, technically feasible, and won 2nd place in the Sustainability subcategory of the Solution Creator category at the 2024 Eletrobras Innovation Awards.

Carbon footprint and **water footprint**

In 2024, Cepel finalized the development of its methodologies for calculating the carbon footprint and water footprint:

- Simple cycle and combined cycle thermal power plants;
- Hydroelectric power plants;
- Transmission lines;
- Wind farms;
- Solar photovoltaic power plants.

The results will be used to plan the expansion of companies in the sector. The development of projects using the Life Cycle Assessment (LCA) method is in line with the current trends towards greater control over socio-environmental impacts throughout the production chain, pursuing the continuous process of improvement, and incorporating a mindset of efficiency and circularity into their activities. By integrating renewable energies into all stages of the life cycle of projects, from strategy to operation, companies in the electricity sector can achieve greater sustainability, economic efficiency, and competitiveness in the market.

Corporate Sustainability Management System (IGS)

In 2024, the IGS Reporting System was officially certified as a software partner of the Global Reporting Initiative (GRI), the leading global organization for sustainability indicator standards. IGS Reporting provides companies with the means to powerfully and reliably measure, manage, and report their performance, in line with the highest international standards. The IGS continues to undergo constant updates in relation to international standards to enable companies to keep up with the trends and changes in this market, whether it be updates to the GRI, CDP, ISE/B3, DJSI, Sasb (Sustainability Accounting Standards Board) etc.

Human **rights**

In 2024, Cepel began developing a methodology to improve the human rights due diligence tools used by Eletrobras with its suppliers. The main focus is to advise on a fair energy transition process, monitoring the negative impacts and risks involved in the company's projects, with special focus on:

- **Reduction** of risks associated with fines;
- **Mitigation** of risks related to the topic;
- **Better** relationships with stakeholders.

As an offshoot of this project, we began designing a web system for collecting, storing and consulting information related to human rights management in Eletrobras' own enterprises. This tool should soon be organizing information and providing outputs aligned with Eletrobras' framework for human rights, allowing for a dynamic flow of information between the different stakeholders.

A year **of evolution**

The progress made in 2024 reflects Cepel's ability to continuously evolve. With the energy transition moving forward, we know that, despite our long history of contributions to the development and technological autonomy of the Brazilian electricity sector, there is no room for complacency. That's why we are looking to the future with ambition and enthusiasm, to deliver even more value to Brazilian society.

We have started designing a system for **managing human rights** in Eletrobras' own enterprises.

Financial results

In line with its strategic planning, in 2024 Cepel moved forward with actions designed to strengthen its financial sustainability. The main initiatives include cooperation with associates, expanding the provision of technological services, diversifying customers, and raising funds for R&D projects.

With the new organizational structure of Eletrobras, Cepel is now directed by the Vice-Presidency of Technology and Innovation, which guides its strategies towards sustainability.

	DEC/24 (IN BRL)
NET OPERATING REVENUE	248,795,437
OPERATING EXPENSES	(259,408,885)
NET FINANCIAL RESULT	13,691,329
OTHER INCOME/EXPENSES	432,429
NET RESULT	**3,510,310**

The 2024 financial year ended with a **surplus of BRL 3.5M**.

FIND OUT MORE
See the annexes for more details

In the field of expense management, the following stand out:

Consensual dismissal program, which has made adjustments to the workforce, reducing costs and maintaining essential functions.

Reduction of the area occupied by the Fundão Island headquarters, reducing rental costs and providing space for UFRJ, which owns the site, to carry out other projects.

Termination of outsourcing contracts, with functions being brought in-house, maintaining only strategic cases.

Reorganization of laboratories, with the integration of areas, optimization of teams, and prioritization of investments focused on the energy transition.

These measures have enabled Cepel to balance income and expenditure, ensuring the continuity of its research, development, and technological innovation activities.

4

BUILDING THE FUTURE

· New lines of research

Our vision is very well defined: we want to lead the way in providing innovative and competitive solutions to enable the energy transition. Technological leadership, built through digital solutions, high-quality services, and research that meets the demands of a constantly evolving sector.

What we can do

- **Energy storage** (including batteries and pumped storage);
- High performance computing capacity for artificial intelligence
- **Application of intelligent sensors**, using the Internet of Things (IoT) for asset management;
- **Weather forecasts** of extreme weather conditions;
- **Hardware and software** technologies designed to expand energy transmission capacity (including the offshore and subsea powergrid);
- **Security** of people, and physical and digital assets, including cybersecurity;
- **Industrial electrification** and green hydrogen with its derivatives.

We are committed to leading the sustainable energy transition by offering competitive innovations.

Over the following few pages, we outline some of the lines of research that our technical staff are working on, as well as the cultural and structural changes that we have begun to promote over the last year in order to bring our work even more into line with the needs of the market and society in general.

New lines of research

The energy transition demands a more reliable, affordable and sustainable energy supply. As such, the way in which we generate and use energy is changing all over the world. Cepel, in its role as an agent of innovation, has the ambition to lead this movement in Brazil and become a global benchmark on the subject. To this end, we have become increasingly dedicated to mastering new technologies and developing state-of-the-art solutions to help our customers and partners definitively embrace this new energy era.

On our **innovation horizon,** the main themes are:

Solutions for **energy storage**

Cepel participates in Battery Energy Storage System (BESS) projects, with a focus on developing models to simulate scenarios and support decision-making in investment planning.

We develop solutions that help our clients make decisions

Technological security, through:

- Research into access and connection to networks;
- Use of in-house control and supervision software;
- Analysis of the accelerated aging of batteries;
- Intelligent monitoring of these assets.

Laboratory tests are carried out at the Adrianópolis Unit, focusing on:

- The development of large storage systems for specific applications in the electricity system (find out more on page 57);
- Applications in different types of installations, from generation and transmission to behind-the-meter applications (in the user's home).

Investigation of economically viable solutions that:

- Reduce storage costs;
- Increase the reliability of the power grid;
- Increase revenue by combining ancillary services;
- These tests are carried out together with Eletrobras, strengthening Cepel's strategic position as the PDI arm in this area.

High performance computing capacity **for artificial intelligence**

A technology that has grown exponentially in recent years, artificial intelligence requires much greater computing capacity and structures than the world is used to. Thanks to its mostly clean energy matrix, Brazil is at the center of global interest in installing sustainable data centers.

To become a leading service provider in this area, Cepel is investing in:

- **Study centers** to understand the challenges relating to the infrastructure, and the energy, connectivity, and cooling needs;
- **Being a cloud provider** for high-performance AI;
- **Offering AI** as a service;
- **R&D development** with innovative AI applications in high-performance computing (HPC);
- **Tests and trials** on modules to increase the capacity of data centers and check the energy efficiency, safety, and electrical performance of the equipment;
- **Partnerships with companies** that support the development of solutions and foster collaboration to absorb new technologies and deliver results to the market.

Cybersecurity

With the advance of digitalization, cybersecurity risks in the electricity sector are also increasing. To meet this challenge, Cepel is acting proactively through its Smart Grids and Digital Substations Laboratory, which is home to:

- **A digital environment** that simulates digital substations or parts of them;
- **The integration of** Information Technology (IT) and Operational Technology (OT) network connections to emulate cyber attacks;
- **The development** and testing of efficient defenses against threats to the ratification of digital components (hardware and software);
- **Studies** on the safe virtualization of substation operations, and, in some cases, the entire operation of the installation.

As a means of advancing our work on cybersecurity, in 2024 we began working with the National Institute of Telecommunications (Inatel) and Eletrobras.

Green **hydrogen**

The use of green hydrogen (H2V), considered one of the most promising solutions for producing clean energy in the future, is still a challenge due to the high cost of this technology. As well as customizing SAGE for H2V, to enable the application of this fuel, Cepel participates in initiatives such as:

Projects under development

- Participation in ANEEL R&D projects related to H2V (find out more on page 40);
- Support for the Eletrobras plant for Technical-Economic Analyses;
- Development of LCOM (for e-methanol) and LCOK (for sustainable aviation fuel) economic analysis tools;
- Application of models for economic and financial analysis of new H2V production projects, including integration with renewable energy generators.

Strategic partnerships

- Collaboration with Eletrobras in the development of hydrogen projects;
- Formation of a team exclusively dedicated to the subject within the Center.

Technological excellence and strategic partnerships **for a sustainable electricity sector**

Throughout this report, we have shown that innovation combined with Research and Development and a focus on market needs are the pillars that underpin our commitment to the energy transition of both our customers and the country as a whole. The initiatives presented, from predictive maintenance systems to the development of energy storage technologies, show that we are prepared to face the challenges of a sector in transformation. This journey is not just technological – it is also strategic, as it connects science, the private and public sectors, and society in search of a safer, more efficient, and sustainable electricity system.

We want to expand our capabilities and strengthen partnerships that will allow us to accelerate the development of increasingly innovative solutions We believe that the path to an even cleaner and more resilient energy matrix lies in continually investing in knowledge, stimulating creativity, and cultivating collaboration with our partners and customers. With this vision, we are reaffirming our role as a benchmark in the development of technologies that will shape the future of energy in Brazil and the world.

We want to expand our capabilities and strengthen partnerships that will allow us to accelerate the development of increasingly innovative solutions

ANNEXES

- An overview of solutions
- Scientific articles
- List of tests

An overview of **solutions**

Cheias
The *Cheias* (Floods) system carries out studies to prevent and control flooding in reservoirs in order to preserve the structure of dams against overflows.

Confint
The *Confiabilidade de Subsistemas Hidrotérmicos Interligados* (Interconnected Hydrothermal Subsystem Reliability) program enables assessment of the reliability of large interconnected systems with a high level of reliance on hydroelectric power. The analysis takes into account losses of power due to reductions in the volume of water in the reservoirs and simulates random events that could affect the ability to meet energy demands.

Decomp and Dessem
Two types of software used for economic planning by agents in the electricity sector in Brazil, based on water availability. Both work on the basis of data generated by Newave. Decomp is used to plan the operation of hydrothermal systems in the short term, with a timeframe of two months, while Dessem operates with very short term scenarios of up to one week.

DIANE
The *Sistema de Diagnóstico Preditivo de Ativos de Energia* (Energy Asset Predictive Diagnosis System) analyzes substation and power plant equipment, recommending where predictive maintenance actions should be prioritized.

GAMMA
A system designed to optimize the operation and maintenance of equipment and installations in the electricity sector. Aligned with ISO 55001 standards.

MATRIX
Model developed for application in long-term energy planning studies, such as national or state energy plans and corporate plans, considering energy expansion scenarios and associated emissions. It also makes it possible to frame the need to reinforce the technologies that make up the Brazilian energy system in an integrated way, from reserves or imports to the demand for useful energy.

MELP
A model developed to help plan the expansion of electricity and natural gas generation, making it possible to define an expansion schedule, considering investment projects individually.

NEWAVE
An energy model used to plan medium and long-term energy use in systems that combine hydroelectric, thermoelectric, and wind sources. In 2024, the Hybrid Newave was launched, a model that allows for the individualized representation of power plants.

PREVENT
A system that forecasts daily, weekly, and monthly flows in hydrothermal systems. It is officially used by the ONS in the programming of short-term energy operations and by the CCEE in activities related to energy trading.

LIGA PROJECT
An asset health management system that integrates three levels of analysis and monitoring, offering a comprehensive analysis of the condition of the company's assets. This comprehensive view is made possible by the use of various types of software developed by Cepel, such as **SOMA (*Sistema Orientado ao Monitoramento de Ativos* / Asset Monitoring-Oriented System), DIANE, CONWEIB and IMA-DP (*Sistema de Monitoramento de Descargas Parciais* / Partial Discharge Monitoring System).**

SINAPE
The *Sistema de Gerenciamento e Análise Automática de Oscilografias* (System for the Management and Automatic Analysis of Oscillographs / **SINAPE.Net**) uses sophisticated algorithms to automatically analyze electrical disturbances based on digital oscillographs. Other forms of software form part of the solution, such as the oscillography COLLECTOR, which allows data to be retrieved from digital oscillography devices and manages the data collection network, and the SINAPE desktop program (for viewing and analyzing oscillographs).

SOMA
Our Asset Monitoring-Oriented System acquires, processes, and sends data from various assets (generators, transformers, circuit breakers, and protection systems, among others) to a server. The information includes data on vibration, temperature, partial discharges, and more. It is also capable of applying Industry 4.0 technologies, such as artificial intelligence, the Internet of Things, and Digital Twins.

FIND OUT MORE
Find out more about other Cepel solutions at www.cepel.br

Scientific **articles**

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Financial statements

The main and permanent objective of Cepel, a non-profit civil association under private law, is the preservation of its potential and capability in research, development, innovation, qualification and training in the area of electrical systems and related matters, as established in its Bylaws.

Eletrobras and its main subsidiaries Chesf, CGT Eletrosul, and Eletronorte, are its founding members. Special members include Petrobras, Eletronuclear, Itaipu-Binacional, EPE, CEEE, Celesc, Cemig, ISA CTEEP, Roraima Energia, CCEE, and Norte Energia.

Cepel has a tradition of playing an aggregating role in technological innovation, developing innovative solutions that are of interest to the national electricity sector. In this context, the Center has been impacted by the changes that have taken place in the sector in recent years, with important internal repercussions.

In fact, there are trends or changes in the external environment that have the potential to influence Cepel's activities in the short, medium and long-term, as is already the case with other research and technology institutions in Brazil and around the world. Examples of these changes are: (i) new business models in the electricity sector; (ii) regulatory changes; (iii) new technologies, systems; and operations; and (iv) adapting and optimizing the workforce. These are all factors that justify Cepel re-evaluating its strategic positioning, sources of funding, and applications.

It is therefore imperative that Cepel, in line with global trends of change in the energy sector, should evaluate organizational and operational changes with a view to the Center's financial sustainability.

Cepel plays an aggregating role in technological innovation, developing solutions that are of interest to the national electricity sector

In relation to Cepel's inflow of funds, the most important factor in recent years, with extensive repercussions, has been the capitalization of Eletrobras, in accordance with Law nº. 14,182/2021, as it determines an annual reduction of 1/6 (one sixth), and correction by the IPCA, with the conclusion date of Eletrobras' capitalization process taken as the reference date.

However, in line with the Center's strategic planning, Cepel's Board of Directors is looking for ways to improve the institution's financial sustainability, whether through negotiations with associates, an increase in income through the provision of technological services, expansion of the portfolio of users of the technological solutions developed, or the raising of funds for Research and Development (R&D) projects.

Furthermore, with the installation of Eletrobras' new organizational structure, following its capitalization, Cepel is linked to the Vice-Presidency for Innovation, which has been guiding the Center's actions in order to support its strategies, with actions focused on financial sustainability.

The year 2024 was also notable for important actions aimed at reducing and making better use of the PMSO. As for the workforce, in 2024, Cepel implemented the consensual dismissal program, which allowed for adjustments to be made to the staff in light of the new sector context, involving the replacement of workstations considered necessary to maintain operations, but at a lower cost. At the end of the year, personnel accounted for 63% of operating expenses, including POS costs.

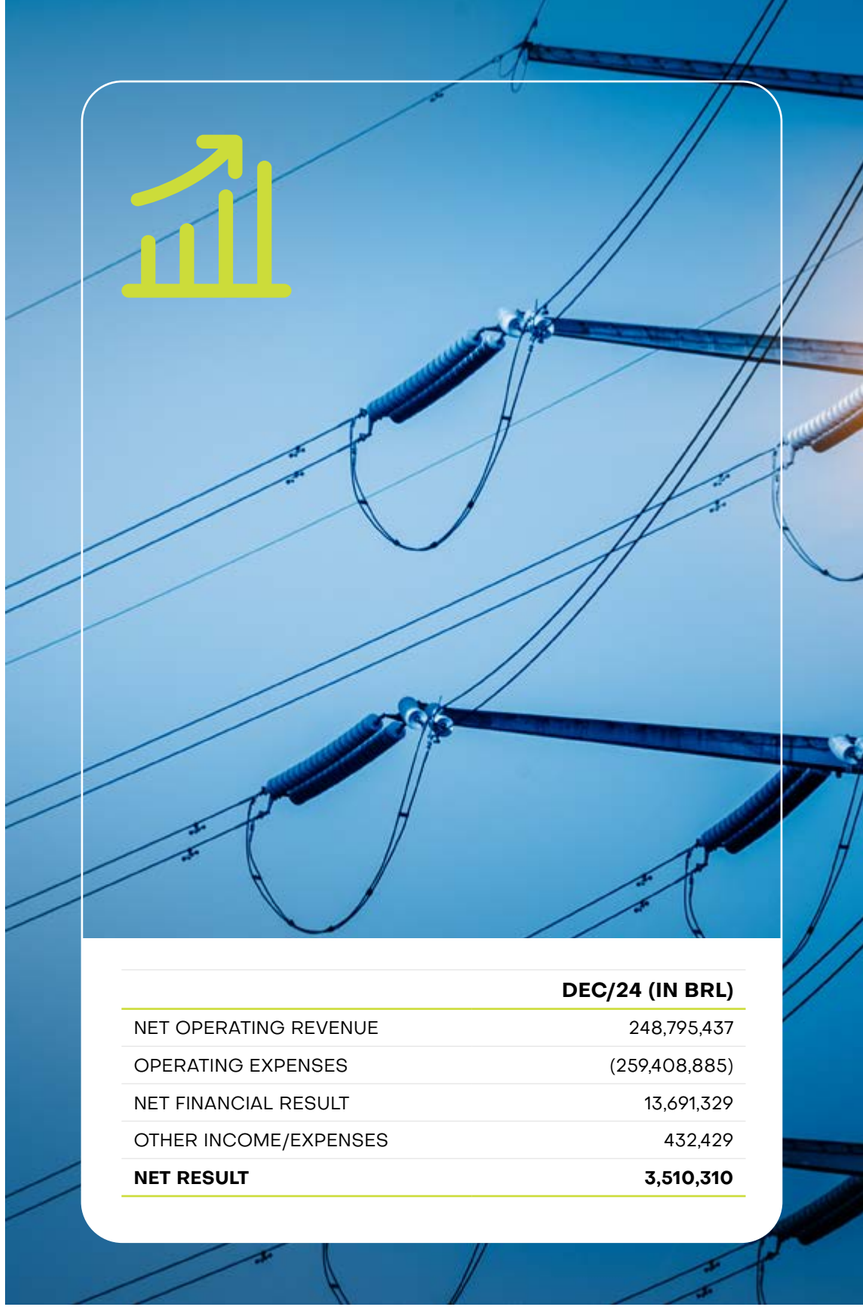
With regard to the other MSO items, a number of other actions have been implemented, including:

- **A reduction of the area occupied by the headquarters** on Fundão Island to reduce leasing costs.
- **A significant reduction in the number of outsourced staff**, ending service contracts involving labor in activities that can be performed by company employees, with only strategically justified exceptions remaining.
- **Actions in Cepel's laboratory areas**, with expected impacts on cost reduction and increased efficiency, including those that promote greater integration between laboratories, making it possible to unify areas and reduce teams, and the operational interruption of laboratory areas related to energy efficiency, since the Center's work in this area, which has continued, does not require its own laboratory infrastructure, thus prioritizing new infrastructures that contribute to the energy transition.

Following all the initiatives implemented during the year, Cepel showed a balance between the application and origin of resources, a factor which is essential to guaranteeing the institution's financial sustainability, allowing it to continue carrying out its research, development, and technological innovation activities.

BRL 248M +
was the net operating revenue for the year

In 2024, the result was a **surplus of BRL 3.5M**.



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NET RESULT	**3,510,310**

List of **tests**

Materials and Mechatronic Testing

CHEMISTRY
Various analyses of interfacial tension of insulating mineral oil and water
Analysis of electrical insulating liquids – determination of dielectric strength
Gas analysis of transformers in service
Viscosimetric degree of polymerization in insulating papers
Kinematic and dynamic viscosity
Oxidation stability
Determination of corrosive sulfur
Determination of water content
Determination of flash points and combustion in an open vessel
Determination of the pour point
Determination of the dielectric loss factor and relative permissiveness
Determination of specific mass and relative density using a digital densimeter
Determination of the acidity and basicity number
Determination of the compatibility of materials used in electrical equipment
Determination of particle content
Determination of the acid number – potentiometric titration method
Color determination – astm colorimeter method
Determination of 2-furfural and its derivatives
Determination of oxidation stability – rpvot
Determination of the passivator content in insulating mineral oil
Determination of the electrical stiffness at industrial frequency – cap electrode
Determination of elements by inductively coupled plasma atomic emission spectrometry (icp-oes)
Foam test on lubricating oils (equivalent to ABNT NBR 14235)

CHEMISTRY
Foam test on lubricating oils (equivalent to ABNT NBR 14359)
Deposit potential test on lubricating oils (mpc – membrane patch colorimetry)
Analysis of used lubricating oils by infrared spectroscopy (ft-ir)
Determination of the total base number (tbn) in used lubricating oils – potentiometric titration method
Determination of the total base number (tbn) in used lubricating oils – potentiometric titration method
Atomic absorption (aas) – determination of metallic elements (matrix: water)
Ion chromatography – determination of anions/cations (matrix: water)
DSC (differential scanning calorimetry) thermal analysis – thermal transitions, stability, specific heat
TGA (thermogravimetric analysis) thermal analysis – loss of mass vs. temperature, thermal stability
Measuring conductivity and pH in solutions
Determining the density of liquids and solids
Thermal diffusivity (lfa/flash or equivalent) – thermal diffusivity of materials
Determination of hardness (shore a or d / xor a or d) in polymers/rubbers
Controlled thermal aging tests
Hydrophobicity tests – determination of wetting / contact angle
Particle size distribution and degree of purity (laser diffraction / purity / attenuation bar)
Determination of water content
Determination of water content
Carbon and sulfur analysis (leco) – carbon and sulfur content in solid samples
Determination of copper content by electrolysis
Determination of settleable particles
Water absorption tests – determining the absorption capacity of materials

METALLOGRAPHY
Preparation of metallographic samples
Scanning Electron Microscope (SEM) analysis – Morphological and micro-structural characterization
EDS (Energy Dispersive Spectroscopy) analysis – Elemental determination coupled with SEM
X-ray (XRD) diffraction – Identification of compounds and crystalline phases
Hardness tests on solid materials
Determination of metal alloys
Creep tests, including on reduced specimens extracted from the field (small Punch)
Thermo-mechanical fatigue tests
Charpy impact tests
Field inspections
Failure analysis by non-destructive testing (NDT)
Structural integrity assessment of equipment/structural components
Estimating the remaining life of equipment/structural components

MECHANICS/MECHATRONICS
Monitoring and measuring mechanical vibrations in equipment/structures to detect malfunctions
Monitoring and measuring mechanical deformation in equipment/structures using extensimetry
Vibration tests on equipment/structures (structures up to 1,200 kg and 2 m high)
Analysis of mechanical stress in equipment/structures with complex geometry, using finite elements
Development of mechatronic sensors for monitoring power transmission, and generation structures and equipment
Evaluating the efficiency of shock absorbers in conductor cables
Computational methodologies for fault diagnosis, and application to conductor cables and wind turbines

CORROSION
Preparation of metal surfaces using hand tools, mechanical tools and dry abrasive blasting
Application of liquid paint coatings using air gun, roller and brush
Physico-chemical analysis of liquid paints
Pickling and mass-loss tests
Physical tests on coatings (adhesion, impact resistance, abrasion resistance)
Steam permeability tests
Accelerated corrosion tests:
Exposure to salt spray
Exposure to sulfur dioxide
Exposure to UVA and UVB radiation
Exposure to condensation
Immersion conditions in aqueous and industrial liquids and in soil
Exposure to natural weathering (also conducted at an accelerated rate)
Electrochemical tests: potential over time, anodic and cathodic polarization, cyclic voltammetry, electrochemical noise, and cathodic protection, among others
Inspection of corrosive processes in the field
Characterization of atmospheric corrosiveness

Electrical equipment testing

HIGH POWER
High Current - High Power Tests
Short-circuit serviceability in power transformers, voltage regulators, reactors, disconnect switches, conductor and OPGW cables, cable accessories, armored busbars, panels, cubicles, current transformers, circuit breakers, etc.
Effectiveness of the protection circuit in panels, cubicles, and shielded busbars
Coordination types 1 and 2 ("Q" type currents, "R" type currents, time x current characteristics of relays and circuit breakers, dielectric properties, contactor checks) in panels
Internal arches in panels and cubicles
Lightning strikes on conductor cables and OPGW
Temperature rises in reactors, disconnect switches, conductor and OPGW cables, cable accessories, armored busbars, panels, current transformers, circuit breakers, etc.
Opening and closing of disconnect switches under bus-transfer conditions.
Voltage measurements with open secondary circuits in current transformers
Interruption capacities in disconnect switches and fuse switches, circuit breakers, etc.
Establishment and interruption of electrostatically and electromagnetically induced currents in transmission line earth switches
Fault currents in lightning rods and verification of actuation time in automatic lightning rod disconnectors

HIGH VOLTAGE
AT/EAT/UAT tests
Potential gradient tests with alternating voltage or direct voltage
Radio interference and corona tests on various types and quantities of conductors, connectors and strings (anchor, type "I" and type "V" suspension) for classes up to 1,300 kV
Tests of withstand voltage or determination to atmospheric impulse and shunting and tests of combined voltages, dry and under rain, for classes from 3.6 kV up to 800 kV under rain and 1100 kV dry
Tests to verify the bearable voltage at industrial frequencies, in the dry and in the rain (in different voltage classes up to 800 kV in the rain and 1100 kV in the dry).
Tests to measure capacitance, delta tangent.
Tests to evaluate partial discharges in class equipment up to 800 kV
Multiple impulse tests cut at the front and tail in different voltage classes
Accredited and non-accredited calibration of high voltage AC, DC and impulse measurement systems at Cepel or the customer
Periodic electrical tests on trucks with insulated air baskets for classes up to 800 kV
Radio interference and impulse tests on reactors and transformers
Leakage current measurement tests on insulating cords
Testing to check insulators' resistance to artificial pollution
Tests to verify supportability in low and medium voltage cubicles and panels
Drawing up procedures for live line maintenance up to 1300 kV
Perforation tests on insulator strings
Accelerated aging testing on insulators
HVDC supportability tests for classes up to 800 kV
Radio interference and corona tests on various types and quantities of conductors, connectors and strings (anchor, type "I" and type "V" suspension) for classes up to 800 kV

SMART GRIDS AND DIGITAL SUBSTATIONS
Distributed Energy Resources Tests
Conformity Tests on Photovoltaic Inverters: evaluation of efficiency, dynamic response, and compliance with national and international standards
Characterization of Power Converters: analysis of the electrical and thermal performance of PCS (Power Conversion Systems)
Energy Controller Tests: validation of the operation of DER controllers under different load and generation conditions (Hardware in the Loop)
Essays on Control and Management Strategies: testing control algorithms to optimize the operation of DERs (using the 'Hardware-in-the Loop' method)
Performance tests for short duration voltage sags (LVRT) in centralized converters
Energy Storage Systems (BESS) – IEC 62933-3-1
Performance Characterization: evaluation of battery capacity, efficiency, and degradation
Cycling tests: simulation of different loading and unloading regimes to evaluate service life
Dynamic Response Analysis: evaluation of the BESS response time for dynamic events in the electrical system using the Hardware-in-the Loop test bench
Safety and Security Tests: verification of safe operation against overload, short circuit and thermal faults
Integration with Smart Grids: interoperability tests with energy control and management systems
IEC 61850 Digital Substation Protection and Automation
IEC 61850 Protection Relay Tests: performance evaluation of IEDs and relays under different operating conditions – Hardware-in-the Loop
Validation of Communication-Based Protection Systems: testing of protection schemes using GOOSE and Sampled Values
Fault Simulation in the Electrical System: Tests on the response of protection devices to short circuits and contingencies

SMART GRIDS AND DIGITAL SUBSTATIONS
Power Quality Measurement
Field measurements with energy analyzers to assess different power quality disturbances:
Undervoltage and overvoltage
Harmonic distortions
Flickers
Sags
Swells
Transients
Unbalance
Frequency deviation
Simulation, Validation, and Modeling of Electric Power Systems
Hardware-in-the Loop (HIL) trials: integration of real devices with real-time simulations for control and protection validation
Simulation of Smart Distribution Networks: assessment of the impact of DERs (Distributed Energy Resources) and control strategies
Interoperability Tests: validation of communication and integration of different technologies in smart grids.
Cybersecurity for Critical Infrastructures
Pentest: assessing the vulnerability of devices and systems to cyber attacks
IEC 62351 Protection Relay Tests: validation of protection mechanisms for IEC 61850 protocols.
Network Traffic Analysis and Monitoring: monitoring and identifying suspicious patterns in automation networks

GRI STANDARDS **SUPPLEMENT**

Standards supplement

This Standards Supplement provides information regarding Cepel for the period from January 1 to December 31, 2024. Organization of the content is based on the standards of the Global Reporting Initiative (GRI) version 2021, an internationally recognized methodology that establishes guidelines for sustainability reporting, through disclosure of the performance and actions of organizations in the environmental, social and economic spheres.

The contents and guidelines reported in this document have been defined according to Cepel's materiality topics (find out more on page 73).

GRI 2: General disclosures 2021

GRI 2-1 - Organizational details

The Electric Power Research Center (CEPEL) is a non-profit, civil association, the founding members of which are companies belonging to the Eletrobras group: Eletronorte, CGT Eletrosul, Chesf and Eletrobras itself. Its headquarters are located at Avenida Horácio Macedo, 354, Cidade Universitária, Ilha do Fundão, zip-code 21941-911, Rio de Janeiro/RJ, Brazil.

Cepel also has a unit located in Adrianópolis, at Avenida Olinda, 5,800, Nova Iguaçu/RJ, Brazil, which houses laboratories that perform tests and activities involving ultra-high, extra-high, and high voltage, high power (high current), and equipment certification, among others.

GRI 2-2 - Entities included in the organization's sustainability reporting

Cepel does not control or participate in any organization.

GRI 2-3 - Reporting period, frequency and contact point

This report covers the period from January 1 to December 31, 2024, and is published annually, following the same reporting frequency as the financial report.

For questions and additional information, please contact the Communication and Events department by the e-mail: comunicacao@cepel.br.

GRI 2-6 - Activities, value chain and other business relationships

Cepel performs research, development, and innovation activities in the areas of laboratories and experimental research, asset management, renewable energy and sustainability, system automation, energy optimization, and electricity network analysis, serving entities operating in the national electricity system and some foreign ones.

Its supply chain includes national and international companies that provide laboratory equipment, laboratory supplies of ferrous and non-ferrous materials, fuels, and specialty gases. In the downstream flow, Cepel provides specialized services for companies in the electricity sector and manufacturers of electrical equipment.

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GRI 2-7 - Employees

EMPLOYEES BY TYPE OF CONTRACT AND GENDER GRI 2-7

	2023	2024
	PERMANENT EMPLOYEES	**PERMANENT EMPLOYEES**
MEN	190	131
WOMEN	70	65
TOTAL	**260**	**196**

EMPLOYEES BY GENDER AND REGION GRI 2-7

	2023			2024		
	MEN	**WOMEN**	**TOTAL**	**MEN**	**WOMEN**	**TOTAL**
SOUTHEAST	190	70	260	131	65	196

EMPLOYEES BY TYPE OF EMPLOYMENT AND GENDER GRI 2-7

	2023[1]			2024		
	PART-TIME	**FULL-TIME**	**TOTAL**	**PART-TIME**	**FULL-TIME**	**TOTAL**
MEN	0	190	190	0	131	131
WOMEN	1	69	70	1	64	65
TOTAL	**1**	**259**	**260**	**1**	**195**	**196**

[1] In the previous year (2023), Cepel's general director was included, although this position was not considered part of the company's workforce.

GRI 2-8 - Workers who are not employees

Cepel currently has 318 non-employee workers. This group includes 275 people with outsourcing relationships in activities such as surveillance, cleaning, maintenance, technological support, administrative support, and others, as well as 43 trainees. In 2023, there were 295 outsourced workers, but trainees were not included.

GRI 2-9 - Governance structure and composition

Cepel's governance is structured around a General Assembly, an Advisory Board, a Board of Directors, and an Oversight Board. The General Assembly is the highest governing body, composed of representatives of Cepel's Founding Members: Eletrobras, Chesf, Eletronorte, and CGT Eletrosul. No committees were set up during the period in question.

The Advisory Board has up to 19 members, seven of whom are appointed by Eletrobras, the general director of Cepel, three appointed by members Chesf, CGT Eletrosul, and Eletronorte, and up to eight members appointed by special members, divided into three classes. The term of office for members is two years, with up to three consecutive reappointments permitted.

The Board of Directors is made up of a General Director, a Director of Corporate Management, a Director of Laboratories and Technological Services, and a Director of Technology. All of them are chosen by the General Assembly based on an appointment by Eletrobras, with a two-year term and the possibility of reappointment. The Board of Directors is responsible for managing Cepel, implementing the decisions of the Advisory Board, and submitting budgets, reports, and accounts to the General Assembly.

The Fiscal Council is composed of three members, one appointed by Eletrobras, one by the members of Chesf, CGT Eletrosul and Eletronorte, and one by the special members. The chairperson and their deputy are chosen from among the board members nominated by the founding members. The term of office is for two years, with up to three consecutive reappointments permitted.

The General Assembly is composed of external and independent executive members appointed by the founding members. Here follows some information on the members:

- **Juliano de Carvalho Dantas** represents Eletrobras. Sworn in on March 10, 2024, he is also executive vice-president of Innovation, R&D, Digital and IT at Eletrobras. He previously worked at Petrobras in various managerial positions, including acting as head of Cenpes and the Statutory Board of Digital Transformation, Technology and Innovation until 2022.
- **João Henrique de Araújo Franklin Neto** represents Chesf. He took office on April 10, 2024, and is also the CEO of Chesf, vice-president of ABRAGE, a member of the Board of Directors of ONS, and Chesf's representative on various Boards of Directors of Special Purpose Entities (SPE) in the energy sector.

- **Antônio Augusto Bechara Pardauil** represents Eletronorte. Sworn in on September 14, 2021, he is CEO of Eletronorte. Between 1995 and 2002, he was a member of the Board of Directors of Companhia de Eletricidade do Amapá (CEA). He worked towards obtaining Eletronorte's certification in the National Quality Award, winning the Summa cum Laude from the FNQ.
- **Cleicio Poleto Martins** represents CGT-Eletrosul. He took office on April 10, 2024, and is also CEO of CGT Eletrosul. Formerly, he was CEO of Celesc, where he was a member of the Board of Directors, and a member of the Board of Directors of EDP Transmissão Aliança SC. He is certified by the Brazilian Institute of Corporate Governance (IBGC).

All the members of the General Assembly are male and do not belong to under-represented social groups. Although there is no specific term for the representatives of the founding members, in practice they follow the mandate of the Board of Directors, that is, two years, with the possibility of three reappointments.

GRI 2-10 - Nomination and selection of the highest governance body

The General Assembly is Cepel's highest governance body, composed of members appointed by the Founding Members. The appointment and selection of these members takes place by means of formal nomination by the Members, sent to Cepel's General Directorate (DG).

Eletrobras is responsible for appointing and selecting the members of the General Assembly, encouraging a diversity of profiles in its composition. The goal is to promote complementary experiences and enrich professional qualifications and specializations for safer and more efficient decision-making. In the search for diversity, criteria such as gender, age, ethnicity and culture are all taken into account.

The members of the governance bodies must have an unblemished reputation, knowledge compatible with the position, and suitable academic training, in addition to at least one of the following professional experiences: 10 years working in the area of activity of the company or a related company; four years in a senior management position, on the Board of Directors or Audit Committee, or in a senior management position at a company of similar size; four years as a professor or researcher at senior level in company's area of activity; or four years as a liberal professional linked to the company's area of activity.

GRI 2-11 - Chair of the highest governance body

The chair of the highest governance body does not hold an executive position in the organization itself.

GRI 2-12 - Role of the highest governance body in overseeing the management of impacts

The General Assembly is the body responsible for decision-making, consultation, and institutional supervision, while also providing a platform for statements from the founding members. With powers to decide on all business relating to the Institution's corporate purpose, its mission is to protect the interests expressed in Cepel's Bylaws, promote its objectives, protect and enhance its assets, establish strategic guidelines, ensure sustainable development, and safeguard the interests of the Members and other stakeholders. However, in the year under review, the General Assembly did not play a specific role in overseeing the organization's due diligence to identify and manage the organization's impacts on the economy, the environment, and people.

The due diligence activities were rigorously performed at other levels of the organization.

GRI 2-13 - Delegation of responsibility for managing impacts

In 2024, no senior executives were specifically appointed to manage the organization's impacts on the economy, the environment, and people. However, employees in managerial positions and functions at Cepel may occasionally assume specific responsibilities in this area. In 2023, the Center's Jurisdiction Policy was approved, establishing guidelines, responsibilities, and limits for the approval of tangible and intangible values with internal impact. This document also defines decision-making levels for financial and non-monetary impacts, such as changes to the Bylaws and hiring limits.

To ensure efficient and integrated management, the Board of Directors holds weekly meetings. During these meetings, employees have the opportunity to report on impacts on the economy, the environment and people. When a situation requires evaluation by a higher authority, the Board of Directors submits the matter to the General Assembly, the Advisory Board, or the Fiscal Council. There is no fixed periodicity for these reports, as they are developed as new demands arise and according to management analysis.

GRI 2-14 - Role of the highest governance body in sustainability reporting

The General Assembly is not the governance body responsible for reviewing and approving the information reported, since this is task is assigned to Cepel's Board of Directors, another of the institution's governance bodies.

The approval process for the information reported takes place as follows: the final version of the Annual Report is presented to all of Cepel's directors during a meeting of the Board of Directors, and approval is formally recorded in the governance system used by the Center.

GRI 2-15 - Conflicts of interest

Cepel has institutionalized its Compliance Program based on the guidelines and directives of its founding member and main funding associate, Eletrobras. The program complies with good governance and administration practices and respects the specific nature of the Center's legal status. It involves creating mechanisms to detect and correct misconduct and illegal acts, while also establishing preventive measures to stop such misconduct from occurring, involving five aspects:

- Development of a business management environment focused on compliance;
- Periodic risk assessment;
- Structuring and implementing of policies and procedures;
- Internal promotion of communication and training activities;
- Continuous monitoring of the program.

The program also includes remediation measures and penalties. Several of Cepel's formal documents now include corporate integrity criteria, ensuring that the Compliance Program is effectively inserted into those of the Center's activities that are most exposed to the risk of fraud and corruption. All these documents are made available on Cepel's homepage and intranet for access by external individuals and employees.

To monitor possible conflicts of interest, Cepel's Board of Directors has also approved the Conflicts of Interest and Nepotism Regulations, and provided employees with the Due Diligence and Declaration of Links questionnaire, which was monitored via the system throughout 2024. No conflicts of interest were identified during the period, but, should they occur, the stakeholders will be duly informed.

GRI 2-16 - Communication of crucial concerns

Cepel has reporting channels to allow employees and stakeholders to report concerns about unethical or illegal behavior or behavior that violates our policies, such as conflicts of interest, fraud, harassment, and security issues. The main channels available are:

- Cepel Ombudsman: an internal channel for compliments, complaints, requests for action, and suggestions.
- Eletrobras' Reporting Channel: an external and independent channel designed to receive reports of ethical irregularities and illegal acts, which offers anonymity and protection against retaliation. Cepel, with the support of Eletrobras, takes the appropriate measures to investigate and resolve complaints in line with the governance of the Eletrobras System, ensuring that issues are dealt with in accordance with internal policies and legislation. When a complaint is considered critical, the Board of Directors takes it to Cepel's General Assembly, the institution's highest governance body.

In 2024, there were no complaints or concerns considered critical enough to be referred to the General Assembly. The complaints received through the Ombudsman and the Eletrobras Reporting Channel mainly concerned occupational safety, conflicts of interest in research projects, and possible infractions in the use of resources. The issues were dealt with by the Board of Directors, which took the necessary corrective steps. The effectiveness of the handling of protests reflects the suitability of the internal mechanisms and the resolutions achieved by the competent bodies, without the need to escalate matters to the level of the General Assembly.

GRI 2-17 - Collective knowledge of the highest governance body

In the year under review, there was no training or measures adopted for the members of the General Assembly to advance their collective knowledge of sustainable development.

GRI 2-19 - Remuneration policies

The remuneration policy for the members of the Board of Directors was defined jointly with Eletrobras and the consultancy firm Korn Ferry. The directors, who are Cepel employees, are remunerated at the same level as Eletrobras' executive managers, including variable remuneration, which is aligned with Eletrobras' demands and needs, and is deployed in accordance with its Goals and ESG Policy.

Cepel's other governance bodies are not remunerated. There is no definite policy on signing bonuses, incentive payments on hiring, or a clawback clause. Contract rescissions follow CLT legislation and executives are treated in the same way as other employees.

The retirement benefit also follows the model practiced for all employees, with new hires being directed to the ELOS pension fund.

GRI 2-20 - Process to determine remuneration

Cepel's remuneration policy was created by the Consultoria Korn Ferry consulting firm, in conjunction with Eletrobras, which supervised and approved it together with the Center's directors and the Human Resources Department.

GRI 2-21 - Annual total compensation ratio

The ratio between the annual total remuneration of the highest paid individual in the organization and the average annual total remuneration of all employees (excluding the highest paid) was 3.16 in 2023 and 3.5 in 2024. The ratio between the percentage increase in the annual total compensation of the highest paid individual in the organization and the average percentage increase in the annual total compensation of all the employees (excluding the highest paid) was 1 in both 2023 and 2024.

GRI 2-23 - Policy commitments

Cepel takes an integrated approach to corporate governance and social responsibility. Its governance is based on integrity, impartiality and transparent communication, with a Compliance Program structured around five pillars: business management focused on compliance; periodic risk assessment; well-defined policies and procedures; effective internal communication; and continuous monitoring. This program is formalized through documents such as the Code of Ethical Conduct and Integrity and various specific policies, including Anti-Corruption, and Management of Conflicts of Interest. All contracts include clauses requiring commitment to this program, with appropriate due diligence in the selection of suppliers. The Internal Audit works to disseminate this culture, dealing with topics such as document management, LGPD, and combating fraud.

The commitment to ethics extends to the social sphere and, in 2024, Cepel signed the Term of Commitment to the Gender and Race Pro-Equity Program, hired 46% women, and undertook actions such as Inclusive Language Training and a Conversation Circle on violence against women. At the same time, the organization has promoted well-being campaigns, such as White January for mental health; Green April, focused on safety at work; and environmental initiatives such as participation in World Recycling Day. Social responsibility also took the form of a collection of donations for victims of the floods in Rio Grande do Sul; the Red June Campaign for blood donation; Volunteer Day, with educational activities; and the Artistic Expression Workshop to promote emotional health.

GRI 2-24 - Embedding policy commitments

The Center's values, principles and standards of behavior are described in Cepel's Code of Ethical Conduct and Integrity – the institution's main guiding document, which is periodically updated (the latest version was in the final stages of approval in the first quarter of 2025). This code is part of the Compliance Program, which also includes the Anti-Corruption Policy, the Consequences Policy, and the Management of Conflicts of Interest Policy. While the policies establish general guidelines, the standards and procedures are operationally applicable to all employees and are available on the intranet and disseminated by email. Each recipient must implement its commitments as directed in the "application" section of each document.

In commercial relations, suppliers are subjected to a due diligence process and must sign the Statement of Awareness of the Integrity Program, declaring that they have read the Code of Conduct and the Supplier Integrity Booklet. This obligation is reinforced by specific clauses in all the contracts, which require a commitment to the established principles and standards.

As for training, the annual Integrity and Ethics course, promoted in partnership with Unise, is compulsory for all employees. This training is a requirement for career development and recognition processes, including meritocracy, management appointments, and the composition of the Board of Directors.

GRI 2-25 - Processes to remediate negative impacts

Although our commitments do not provide for automatic redress, should any negative impact occur, the situation will be analyzed individually to define the best course of action.

Cepel has specialized systems for receiving complaints, including reports of fraud, corruption, ethical irregularities, and violations of the Code of Ethical Conduct and Integrity or the Integrity (Compliance) Program. The complaints made regarding Eletrobras companies and Cepel are made through a centralized Reporting Channel. Based on an external and independent platform, the channel guarantees anonymity and follows strict procedures for receipt, forwarding, and follow-up, operating 24 hours a day, seven days a week, via the telephone number 0800 721 9885, or link: https://relatoconfidencial.com.br/eletrobras/.

Secrecy, confidentiality and institutional protection are guaranteed both for those individuals fining a report in good faith and for the members of the committees responsible for processing reports of ethical, disciplinary, and fraud and corruption infractions, with mechanisms in place to prevent retaliation.

GRI 2-26 - Mechanisms for seeking advice and raising concerns

As part of its governance practices, Cepel makes several formal documents available on its website and internal network to guide both employees and external individuals on corporate integrity issues.

In order to receive feedback – such as compliments, claims, requests for action, and suggestions – the individual should contact the Cepel Ombudsman, whose role is to support the Eletrobras Ombudsman in preventing and mediating conflicts, and is an important channel of communication between the internal/external public and Cepel. This type of feedback should preferably be registered through a link made available on Cepel's homepage and intranet or by telephone: 0800 721 3275

GRI 2-27 - Compliance with laws and regulations

During the reporting period, there were no significant incidents or fines related to non-compliance with laws and regulations. Cepel considers any situation of non-compliance of which it has received formal notification to be significant.

GRI 2-28 - Membership associations

Cepel actively participates in various industry associations, other associations, and national and international advocacy organizations. Its main activities include its presence on the Strategic Advisory Committee of the Itaipu Technology Park Foundation, on the Eletrobras Technology Policy Commission (CPT), and on the Commission of Users of the IEN Multiuser Parallel Computing Cluster. It is also a member of the Privacy Subcommittee and the Eletrobras Companies Operational Technology Committee.

It is also a member of the ABNT (Brazilian Association of Technical Standards), the ABENDI (Brazilian Association for Non-Destructive Testing and Inspection), and the ABIPTI (Brazilian Association of Technological Research and Innovation Institutions). Its work in academia and innovation includes participation in the UFRJ/CEPEL Agreement Management Commission (CGA) and on the Board of Directors of the COPPE/UFRJ Business Incubator.

In the engineering and energy sector, Cepel is linked to the ABM (Brazilian Association of Metallurgy, Materials and Mining), the SLT (Short Circuit Testing Liaison) and CIGRE-Brasil (Brazilian National Committee for Electricity Production and Transmission). It is also a member of CIER - BRACIER, where it serves as Executive Secretary, and sits on the Advisory Board of FGV Energia.

In terms of governance, Cepel sits on the Supervisory Board of Memória da Eletricidade and ABIPTI, the Board of Directors of Memória da Eletricidade and the Associação Eletros Saúde, as well as the Advisory Board of the Fundação Eletros Previdência.

GRI 2-29 - Approach to stakeholder engagement

In the Business area, the engagement of stakeholders is a critical factor in the success of projects, technological services and technical interactions, enabling the delivery of value that contributes to positive results and customer satisfaction. This engagement takes place mainly through Communication initiatives and the Business and Innovation Department (DNI), with different objectives depending on the nature of each relationship.

For the internal public, the aim is to provide information on management decisions, engage employees and collaborators in actions of qualification and awareness, and communicate new processes. Involving members, administrators, board members, the press and civil society, the focus is on publicizing Cepel's projects and achievements, justifying investments and disseminating its contributions to the electricity sector and society in general, as well as garnering institutional support.

The other stakeholders are institutions with which Cepel maintains commercial relations or projects, whether as a contractor, contracting party, or partner. For this reason, the engagement initiatives aim to raise awareness of the Center's action fronts, products and services, as well as its potential to execute or cooperate in projects, mainly R&D+I.

To strengthen this engagement, Cepel uses a variety of channels tailored to each key audience. The digital channels include: its institutional website, intranet, profiles on social networks (LinkedIn, Instagram, Twitter and Facebook), a YouTube channel, e-mail (sending to lists and individual communications), and a corporate communication app (MS Teams). There are also direct contact initiatives, taking the form of technical visits to customers and associates, which are becoming more and more frequent in order to understand the needs of stakeholders and ensure effective service, as well as alignment with the stakeholders' expectations.

GRI 2-30 - Collective bargaining agreements

100% of the workforce is covered by collective bargaining agreements.

Material topics

GRI 3: Material topics 2021

GRI 3-1 - Process to determine material topics

Following in the tradition of previous editions, Cepel's senior management, on the recommendation of its Sustainability Committee, decided to prepare the 2024 Annual Sustainability Report based on the 2021 version of the Global Reporting Initiative (GRI) standards. The process was guided by a specialized external consultancy firm, from conception of the content through to production of the final document, including definition of the material topics and collection of the indicators. With technical guidance, the specific reporting period, the main groups of stakeholders to be consulted, and the priority topics were established, taking into account their relevance to stakeholders and the availability of information for balanced and accurate reporting.

The double materiality methodology adopted by the consultancy firm identified the impacts of Cepel's activities through consultations and interviews with senior management, and internal and external experts with knowledge of the business and the sector. Each topic was assessed from three perspectives: impact materiality (expert analysis), financial materiality (assessment by executives and market analysts), and relevance to stakeholders (consultation with the various relationship groups, weighted according to their degree of interaction with Cepel). The topics were prioritized by combining the scores obtained in these three dimensions. Cepel's management complied with all of the consultancy firm's recommendations, with only one additional topic being included following a strategic decision, due to its importance in the relationship with Eletrobras, the institution's main associate and maintainer.

The mapping identified the most relevant stakeholders for consultation, according to the criteria of frequency, dependence and influence: founding and special members who make up the Advisory Board; top management (directors, assistant directors, and department heads); customers and project funders; sector entities and associations; employees; and suppliers and service providers.

GRI 3-2 - List of material topics

- Production of studies, research and technological solutions;
- Innovation and technology;
- Attracting, developing and retaining employees;
- Energy transition in the sector;
- Privacy and data security;
- Quality of technological services and consultancy;
- Health, well-being and safety.

GRI 3-3 - Management of material topics - PRODUCTION OF STUDIES, RESEARCH AND SOLUTIONS

The purpose of research management at Cepel is to drive innovation in the energy sector, ensuring that advances are sustainable, economically viable, and socially responsible. Technological development seeks to meet the sector's needs with solutions that increase efficiency and reduce environmental impacts.

On the other hand, the implementation of advanced technologies, such as LIGA and ATMOS, poses initial financial challenges, requiring adaptation and integration with existing systems, as well as the need for specialized training, generating additional short term costs. In addition, the consumption of resources in computer simulations and the development of energy models requires intensive use of energy and data processing.

To manage its impacts, Cepel is modernizing its infrastructure with a focus on energy efficiency, expanding training for technical teams and strengthening waste management through predictive systems. Internal audits ensure compliance, while collaborations with research institutions and industry extend the reach of innovations.

The initiatives are monitored through systematic records of publications and bibliometric analysis, with key indicators including articles in high-impact journals and participation in international congresses. The positive trend in these indicators reflects the importance of research, the lessons of which are incorporated into institutional policies.

The Center maintains a constant dialogue with stakeholders through public consultations, workshops and seminars, disseminating results through reports, bulletins, and scientific events. Strategic planning identifies the priorities of the energy sector and guides innovation management, with constant revision of the research agenda to align it with technological and regulatory changes in the market.

GRI 203-1 - Infrastructure investments and services supported

The investments made were voluntary and earmarked for Cepel's infrastructure, including maintenance, upkeep, and the company's other internal needs.

GRI 3-3 - Management of material topics - INNOVATION AND TECHNOLOGY

Cepel develops technological solutions that boost the operational efficiency of the Brazilian electricity sector, generating positive economic, environmental, and social impacts. The social impacts of Cepel's innovations include greater operational safety, a reduction in climate risks, and support for the energy transition through the introduction of renewable sources. The Center also develops climate and social vulnerability analyses, supporting strategies to mitigate impacts on indigenous communities and sensitive ecosystems.

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In the environmental area, Cepel promotes technologies that minimize dependence on fossil fuels. The AME Project improves the management of hydrothermal dispatch to avoid unnecessary activation of thermal power plants and reduce carbon emissions, while optimizing the use of water resources. In addition to this, the ATMOS Project improves weather forecasting for the electricity sector and allows for more efficient operational adjustments in the face of extreme weather events, thus contributing to the resilience of the energy supply. Tools such as EMISFERA and methodologies for calculating the carbon and water footprints reinforce the integration of sustainability into the sector's strategic planning.

Despite the benefits, certain challenges need to be managed: technological modernization can impact companies with obsolete infrastructures, requiring adaptation and retraining; growing digitalization increases energy consumption and the demand for data processing; and there is a risk of widening inequalities if the adoption of these technologies is not accessible to all regions. The lessons learned are incorporated by revising procedures and making operational adjustments, so that solutions evolve in line with best practices in the sector.

To monitor the effectiveness of its initiatives, Cepel has implemented the System of Indicators for Sustainability Management (IGS), which tracks ESG metrics and the performance of the technologies implemented. The Center sets targets for reducing emissions, increasing energy efficiency and expanding the adoption of renewable energies, carrying out periodic analyses of the impact of projects and constantly investing in the technical training of its team, in order to ensure continuous improvement and preparation for emerging challenges.

GRI 3-3 - Management of material topics - ATTRACTION, DEVELOPMENT AND RETENTION OF EMPLOYEES

Personnel management at the Center is based on ethical principles that guarantee respect for human dignity, moral and physical integrity, and combating all forms of discrimination. It is also conducted with transparency and strategic alignment, encouraging career planning and creating conditions for negotiations between the expectations of the organization and its employees.

Without effective talent attraction strategies, Cepel can face high turnover rates, high recruitment and training costs, and a drop in productivity. The absence of development opportunities can result in dissatisfaction and lower levels of employee engagement, as well as a workforce with outdated knowledge. Talent retention problems impact the continuity of knowledge and increase operating costs. Non-compliance with human rights in management processes can lead to legal and reputational repercussions.

To mitigate negative impacts, Cepel implements fair and transparent recruitment practices, uses virtual interviews to reduce environmental impacts (having adopted the Gupy platform to completely digitize its processes since 2023), promotes continuous training, and adopts fair remuneration policies and competitive benefits. When problems such as discriminatory practices or high turnover are identified, the Center reviews its internal policies and implements additional training programs. Furthermore, the activities of Cepel also mitigate negative impacts along the energy supply chain by providing innovative solutions for the Brazilian electricity sector. Keeping employees engaged with this objective and up-to-date on technological innovations is part of the ongoing work of developing people.

The effectiveness of the measures implemented is mainly measured by the turnover rate. In 2023, the recruitment regulations were revised to bring them into line with best market practices, with procedural adjustments being applied the following year. All changes are communicated internally and discussed at Board meetings, ensuring engagement of the stakeholders.

GRI 202-1 - Ratios of standard entry level wage by gender compared to local minimum wage

In 2023, the lowest salary recorded was BRL 2,660.71 for a male employee and BRL 4,665.20 for a female employee. Currently, these amounts are BRL 3,034.78 for men and BRL 4,081 for women. Considering the national minimum wage set by the government of BRL 1,412.00, the ratio of the lowest wage to the minimum is 2.5 for men and 2.9 for women.

GRI 202-2 - Proportion of senior management hired from the local community

Cepel's top management is made up of four members, three of whom are professionals hired from the local community, meaning 75% of the executive board.

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GRI 401-1 - New employee hires and employee turnover

NEW EMPLOYEE HIRES AND EMPLOYEE TURNOVER GRI 401-1

	2023				2024			
GENDER	**TOTAL EMPLOYEES**	**HIRES**	**TERMINATIONS**	**EMPLOYEE TURNOVER RATE**	**TOTAL EMPLOYEES**	**HIRES**	**TERMINATIONS**	**EMPLOYEE TURNOVER RATE**
MEN	190	17	12	6.32	131	13	72	54.96
WOMEN	70	14	5	7.14	65	20	24	36.92
TOTAL	**260**	**31**	**17**	**6.53**	**196**	**33**	**96**	**48.98**

NEW EMPLOYEE HIRES AND EMPLOYEE TURNOVER GRI 401-1

	2023				2024			
REGION	**TOTAL EMPLOYEES**	**HIRES**	**TERMINATIONS**	**EMPLOYEE TURNOVER RATE**	**TOTAL EMPLOYEES**	**HIRES**	**TERMINATIONS**	**EMPLOYEE TURNOVER RATE**
SOUTHEAST	260	31	17	6.53	196	33	96	48.98

In 2024, we included a specific consensual redundancy plan in our collective agreement. We also had a number of dismissals without cause and some dismissals by agreement. This explains the significant reduction in the total number of employees.

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GRI 401-2 - Benefits provided to full-time employees that are not provided to temporary or part-time employees

The benefits granted to full-time and part-time employees are:

- Transport vouchers;
- Funeral allowance;
- Parental leave;
- Medical and dental assistance;
- Life insurance;
- Retirement fund;
- Food and meal allowances;
- Psycho-pedagogical assistance;
- Childcare and education;
- Gym memberships;
- Vacation bonus;
- Bonuses due to length of service;
- Pharmacy allowance;
- Leave for workers who are victims of domestic violence;
- Additions to sickness benefit;
- Accompanying leave;
- Leave for the death of a stepmother or stepfather;
- Language course.

GRI 401-3 - Parental leave

PARENTAL LEAVE GRI 401-3

	2023	2024
FEMALE EMPLOYEES WHO TOOK MATERNITY LEAVE IN THE REPORTING YEAR	1	1
PERMANENT EMPLOYEES WHO TOOK PATERNITY LEAVE IN THE REPORTING YEAR	2	5
FEMALE EMPLOYEES WHO RETURNED TO WORK AFTER MATERNITY LEAVE IN THE REPORTING YEAR	1	2
PERMANENT EMPLOYEES WHO RETURNED TO WORK AFTER PATERNITY LEAVE IN THE REPORTING YEAR	2	5
PERMANENT FEMALE EMPLOYEES WHO RETURNED TO WORK AFTER THE END OF MATERNITY LEAVE AND WERE STILL EMPLOYED 12 MONTHS AFTER THEIR RETURN	4	1
PERMANENT MALE EMPLOYEES WHO RETURNED TO WORK AFTER THE END OF PATERNITY LEAVE AND WERE STILL EMPLOYED 12 MONTHS AFTER THEIR RETURN	5	2
RETURN TO WORK RATE - WOMEN	0	100
RETURN TO WORK RATE - MEN	100	100
RETENTION RATE - WOMEN	100	100
RETENTION RATE - MEN	100	100
TOTAL NUMBER OF EMPLOYEES ENTITLED TO MATERNITY LEAVE	**70**	**65**
TOTAL NUMBER OF EMPLOYEES ENTITLED TO PATERNITY LEAVE	**190**	**131**

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GRI 404-1 - Average hours of training per year per employee

AVERAGE NUMBER OF TRAINING HOURS, BY EMPLOYEE GRI 404-1

	2023	2024
TOTAL HOURS TRAINED - MEN	9,927	5192
TOTAL HOURS TRAINED - WOMEN	3,490	1634
TOTAL NUMBER OF HOURS TRAINED	13,417	6826
AVERAGE HOURS OF TRAINING - MANAGEMENT POSITIONS - MEN	90.27	59.71
AVERAGE HOURS OF TRAINING - MANAGEMENT POSITIONS - WOMEN	179.88	24.38
AVERAGE HOURS OF TRAINING - MANAGEMENT POSITIONS	128	40.87
AVERAGE HOURS OF TRAINING - WITH HIGHER EDUCATION - MEN	57.35	32.05
AVERAGE HOURS OF TRAINING - WITH HIGHER EDUCATION - WOMEN	34.48	19.7
AVERAGE HOURS OF TRAINING - WITH HIGHER EDUCATION	51.08	27.64
AVERAGE HOURS OF TRAINING - WITHOUT HIGHER EDUCATION - MEN	15.6	68
AVERAGE HOURS OF TRAINING - WITHOUT HIGHER EDUCATION - WOMEN	11.81	158
AVERAGE HOURS OF TRAINING - WITHOUT HIGHER EDUCATION	14.63	73.29
AVERAGE HOURS OF TRAINING PER MALE EMPLOYEE	52.25	39.63
AVERAGE HOURS OF TRAINING PER FEMALE EMPLOYEE	49.86	25.14
AVERAGE HOURS OF TRAINING PER EMPLOYEE - TOTAL	51.6	34.83

GRI 404-2 - Programs for upgrading employee skills and transition assistance programs

Although Cepel does not yet have specific structured programs designed to develop employees' skills, it is constantly investing in training its staff through the provision of internal and external training in various areas of knowledge. One example of this is the partnership with the Alura platform to offer a variety of courses, as well as the availability of Eletrobras' *Aprenda Mais* platform, with online courses on general skills, leadership, and sustainability.

GRI 404-3 - Percentage of employees receiving regular performance and career development reviews

Cepel did not carry out a performance evaluation in 2024.

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GRI 405-1 - Diversity of governance bodies and employees

EMPLOYEE CATEGORY AND GENDER (%) GRI 405-1

	2023			2024		
	MEN	WOMEN	TOTAL	MEN	WOMEN	TOTAL
GOVERNING BODIES	0.77	0.77	1.54	1.02	0.51	1.53
MANAGEMENT	3.84	3.46	7.3	4.59	4.59	9.18
SENIOR LEVEL	50.38	16.54	66.92	47.96	25.51	73.46
MIDDLE MANAGEMENT	18.07	6.16	24.23	14.28	3.06	17.34

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EMPLOYEE CATEGORY AND GENDER (%) GRI 405-1

	2023			2024		
	BLACK, ASIAN-BRAZILIAN, BROWN AND INDIGENOUS PEOPLE	DISABLED PERSONS	TOTAL	BLACK, ASIAN-BRAZILIAN, BROWN AND INDIGENOUS PEOPLE	DISABLED PERSONS	TOTAL
GOVERNING BODIES	0.38	0	0.38	0.51	0	0.51
MANAGEMENT	0	0	0	2.04	0	2.04
SENIOR LEVEL	13.08	0.77	13.85	20.92	1.02	21.94
MIDDLE MANAGEMENT	12.69	0.77	13.46	10.2	0	10.2

PERCENTAGE OF UNDERREPRESENTED GROUPS AND GENDER GRI 405-1

	2023			2024		
	MEN	WOMEN	TOTAL	MEN	WOMEN	TOTAL
BLACK, ASIAN-BRAZILIAN, BROWN AND INDIGENOUS PEOPLE	20.38	6.92	27.3	23.47	10.2	33.67
DISABLED PERSONS	1.15	0.38	1.53	1.02	0	1.02

GRI 2-4 - Adjustment to 2023 data, no change, only updated percentage reporting.

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GRI 405-2 - Ratio of basic salary and remuneration of women to men

RATIO OF BASIC SALARY AND REMUNERATION OF WOMEN TO MEN GRI 405-2

	2023	2024
RATIO OF FEMALE TO MALE BASIC SALARY - MANAGEMENT LEVEL	0.88	0.87
RATIO OF FEMALE TO MALE BASE SALARY - SENIOR LEVEL	0.88	0.92
RATIO OF FEMALE TO MALE BASE SALARY - MIDDLE MANAGEMENT	0.87	1
RATIO OF FEMALE TO MALE PAY - MANAGEMENT LEVEL	0.79	0.87
RATIO BETWEEN FEMALE AND MALE PAY - SENIOR LEVEL	0.8	0.62
RATIO OF FEMALE TO MALE EARNINGS - MIDDLE MANAGEMENT	0.75	1

GRI 3-3 - Management of material topics - ENERGY TRANSITION OF THE SECTOR

The challenges of the energy transition remained intense in 2024, requiring a vision of R&D integrated with innovation and sustainable development, taking into account economic and social development and environmental preservation. This process has required the expansion of renewable sources combined with more efficient and sustainable forms of energy generation, which are fundamental to achieving long-term environmental goals, such as reducing greenhouse gas emissions and complying with national and international commitments. The recent enactment of Law nº. 15.042 of 2024, which establishes the Brazilian Emissions Trading System (SBCE) and regulates the carbon market in Brazil, is expected to bring about gradual changes, directly affecting all agents subject to greenhouse gas emissions quotas. In the electricity sector, this regulation will have an enormous impact even for a country in which the electricity generation matrix is predominantly renewable, requiring companies to position themselves strategically in the face of this new reality. Although Brazil already has more renewable generation than the global average, there is vast potential to exploit hydro, solar and wind resources in a more efficient and stable way. However, the energy transition also presents challenges that can have negative impacts on human life and the environment, making it essential that it takes place equitably, reconciling the generation of jobs and income, social inclusion, the fight against inequalities, and improved quality of life. In this new context, new risks and opportunities present themselves to companies in the electricity and other sectors, such as data centers, for example, which will demand scientific knowledge and R&D projects that promote innovation and sustainable development. Many of Cepel's research projects are aligned with these challenges.

Cepel's Department of Energy Transition and Sustainability (DTS) develops research projects that seek to respond to this new scenario, providing benefits in line with market needs. The growing use of environmental, social and governance (ESG) criteria to evaluate companies has been a determining factor for investors, who seek to avoid organizations posing financial risks due to their practices and prioritize those that offer greater profitability and value creation. Cepel assesses the impact of its research projects using Value Delivery spreadsheets, which identify the expected and achieved benefits, both in terms of deliverables and positive impact for Eletrobras (NPV), in addition to other intangible impacts. Projects are also monitored using indicators that assess the percentage of completion in relation to the forecast, as well as compliance with the deadlines set for delivering the agreed products, using the SIPPED system for monitoring R&D projects.

Since its creation, Cepel has conducted R&D projects and provided technological services with the aim of developing methodologies and solutions that guarantee the generation of electricity with the least negative socio-environmental impact, while maximizing positive impacts. Among the highlights of 2024 are floating photovoltaic plants, which combine solar energy and the advantages offered by lake surfaces used by hydroelectric power plants. Cepel is leading the studies in this technology, conducting simulations, tests, and analyses to assess its technical and economic viability, and developing methodologies to identify the best locations and float suppliers. Another innovation involves reversible hydroelectric plants (RHP), considered one of the most promising energy storage technologies. These use surplus energy to pump water from a lower reservoir to an upper one, releasing it for generation when demand increases. In 2024, Cepel completed a detailed study on the restrictions to implementing this technology in Brazil, developing methodologies, making computer models compatible, and contributing to public policies aimed at implementing it in the electricity sector.

In wind farm management and optimization, Cepel has finalized the web version of the Wind O&M tool, which, together with Wind SOMA, makes up the portfolio of wind farm management systems, now using artificial intelligence to optimize operations. Brazil already ranks 6th in the worldwide ranking for onshore wind energy, and the new Law nº. 15.097 opens the way for the exploration of offshore wind energy. With regard to green hydrogen, Cepel, the RDI arm of Eletrobras, is leading an innovative initiative with the launch of SAGE H2, a SAGE operation for monitoring electrolysis hydrogen plants. SAGE H2 was implemented in the hydrogen plant at the Itumbiara HPP, marking a milestone in the development of this technology in Brazil, where there are still no commercial green hydrogen plants in operation. Another innovative tool launched in 2024 was the green hydrogen derivatives leveled cost calculator, which allows calculation of the production costs of green ammonia, e-methanol, and e-SAF (Sustainable Aviation Fuel). Law nº. 14.993/2024, known as the Fuel of the Future Law, should further boost this demand and drive the decarbonization of the transport sector.

Cepel has also made progress in creating corporate sustainability management systems. In 2024, the IGS Reporting System was officially certified as a partner software of the Global Reporting Initiative (GRI), the global benchmark for sustainability indicator standards. This certification enables companies to reliably measure, manage, and report their performance in line with the highest international standards. Another important initiative was the inauguration of *Casa NZeb* (Near Zero Energy Building), a sustainable building that will serve as a pilot and model for energy efficiency and renewable generation technologies for the construction industry. The objective of Cepel's management is aligned with Eletrobras' Strategic Planning and with its mission of "Caring for the Planet by delivering the energy we believe in", in addition to the themes prioritized in the Innovation Power House, defined by Eletrobras' Innovation Vice-Presidency.

GRI 302-1 - Energy consumption within the organization

Total energy consumption (direct and indirect) at Cepel was 21,326 GJ in 2023 and 20,630.72 GJ in 2024. Purchased electricity from renewable sources made up the bulk of this consumption, with 20,907 GJ in 2023 and 20,322.24 GJ in 2024. As for fuels, 837.37 L of gasoline was consumed in land vehicles and 950 L from other administrative sources, as well as 1,268.17 L of diesel oil in land vehicles and 5,165.8 L from other administrative sources. Another 80 kg of LPG was consumed for administrative purposes.

In summary, fuel consumption from non-renewable sources (gasoline, diesel oil and LPG) reached 266.4 GJ, while renewable sources (ethanol and biodiesel) contributed 42.8 GJ in the reporting period.

GRI 302-2 - Energy consumption within the organization

Energy consumed outside the organization, involving upstream transport and distribution, totaled 3,181.3 GJ. Consumption relating to employee transport was 108.78 GJ, equivalent to 3,180.8 liters of diesel oil. In addition, corporate travel required 599 GJ of consumed energy.

GRI 302-3 - Energy intensity

The energy intensity rate was 18.4, expressed in GJ/million BRL and calculated using the ratio between: Cepel's energy consumption in 2024 (consolidating scopes 1, 2 and 3 - registered on the Emisfera platform), which was 4,578 GJ, and net operating revenue (NOR) in the same year, which totaled BRL 248.8 million (the institution's financial data).

GRI 302-4 - Reduction of energy consumption

In 2024, there was a reduction of 171 GJ in the consumption of non-renewable sources (gasoline, diesel oil, and LPG), with no reduction in the use of renewable fuels (ethanol and biodiesel, present in the gasoline and diesel oil of vehicles in the company's own or outsourced fleet). The reduction in energy consumption amounted to 45.13 GJ, bringing the total consumption down by 295 GJ. As a result, Cepel achieved a significant reduction in non-renewable fuel consumption compared to 2023.

GRI 302-5 - Reductions in energy requirements

The Center has no estimate of the reduction in energy requirements for products or services.

GRI 305-1 - Direct (Scope 1) GHG emissions

Taking 2024 as the base year, the emissions inventory shows that gross direct GHG emissions (Scope 1) fell from 345.4 tCO_2eq in 2023 to 143.6 tCO_2eq in 2024 (see standard 305-5). The survey considered the following gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Quantification followed the GHG Protocol guidelines and the calculation methodologies established by the IPCC (Intergovernmental Panel on Climate Change).

GRI 305-2 - Indirect (Scope 2) GHG emissions

Cepel has contracts for the purchase of electricity from renewable sources in the Free Contracting Environment, serving the Fundão and Adrianópolis units. Thus, the energy consumed in the two units is considered neutral in terms of GHG emissions. The calculation included the following gases: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); sulfur hexafluoride (SF_6); hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Emisfera adopts the GHG Protocol guidelines and IPCC calculation methodologies.

GRI 305-3 - Direct (Scope 3) GHG emissions

In 2023, the gross indirect GHG emissions (Scope 3) totaled 352.1 tCO_2eq, while in 2024 this figure was 319 tCO_2eq. The gases considered in the calculation were: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), with 2024 as the base year.

GRI 305-4 - GHG emissions intensity

For Scope 1, the intensity was 0.00000125 tCO_2/BRL in 2023 and 0.58 tCO_2/BRL in 2024. Scope 2, on the other hand, remained at 0 tCO_2/BRL in both 2023 and 2024. These calculations are based on the ratio between emissions (tCO_2) and net operating revenue (NOR), which in 2024 reached BRL 248.8 million.

The neutrality of Scope 2 is due to the fact that both Cepel units (Fundão and Adrianópolis) use renewable energy purchasing contracts in the Free Energy Market (ACL). According to the GHG Protocol methodology, this practice allows indirect emissions from the institution's electricity consumption to be considered zero.

GRI 305-5 - GHG emissions intensity

The total volume of GHG emissions was 183 tCO_2eq in 2023 and 233 tCO_2eq in 2024, considering the gases CO_2, CH_4, N_2O and SF_6 in the calculation.

Looking at the total (scopes 1, 2 and 3), there was a reduction in emissions at Cepel, from 697 tCO_2e in 2023 to 464 tCO2e in 2024. However, there is no evidence to attribute this decrease to specific initiatives aimed at reducing emissions. The most likely explanation is that the restructuring process, which has significantly reduced the workforce, has contributed to this decrease.

GRI 3-3 - Management of material topics - DATA PRIVACY AND SECURITY

Cepel is not involved in negative impacts related to data privacy, as it does not practice the excessive collection of information from customers, suppliers, employees or partners. The institution adopts strict security measures to protect its systems and environments, actively monitoring access to data and avoiding any relationship with unreliable technology suppliers.

The commitment to privacy is reflected in a transparent and accessible policy, based on minimizing the collection of information, adopting appropriate security measures, responsibility and accountability, respect for the rights of individuals, and frequent monitoring and audits to ensure compliance with regulations.

To prevent or mitigate negative impacts, Cepel conducts privacy and security risk assessments, adopts encryption to protect information, maintains policies for the continuous updating of software, and offers regular training to raise awareness of information security.

In the event of incidents, the institution has structured procedures for responding to violations, including appropriate notifications and redress measures for the individuals affected. In order to maximize positive impacts, the organization undertakes continuous improvements through the PDCA cycle, reinforces transparency and communication with users, encourages responsible innovation, and is constantly seeking recognized certifications, such as the ISO 27001.

The effectiveness of the measures adopted is monitored in the form of regular audits, continual analysis of logs, and the identification of vulnerabilities using specific tools. The main goal is to increase the maturity of information security according to the NIST framework, thereby increasing security coverage for assets and infrastructure according to market standards. Although there are no historical data security indicators due to the lack of prior exploration of the subject, the evolution of maturity and established controls indicates significant progress. The lessons learned from the audits are incorporated into internal policies and procedures, with the revision of regulations and the implementation of processes that guarantee the dissemination of these guidelines to all employees, with a digital signature of compliance.

Governance of data security at Cepel is supported by the senior management, a designated officer, and the direct involvement of the IT department in the formulation of policies, regulations, and risk assessments – always in compliance with the Brazilian General Data Protection Law (LGPD).

418-1 - Substantiated complaints concerning breaches of customer privacy and losses of customer data

There were no records of proven complaints regarding breaches of customer privacy, whether in the form of third-party complaints, notifications from regulatory agencies, or incidents related to data leaks, thefts, or losses.

GRI 3-3 - Management of material topics - QUALITY OF TECHNOLOGICAL AND CONSULTING SERVICES

Since it was founded, Cepel has kept pace with regulatory developments and the sector's requirements, making a significant contribution through research, the development of methodologies, procedures, computer models, equipment, tests, experimental research, technical expertise, and technological services. Its activities cover areas such as Energy Optimization, Analysis of Electrical Networks, Automation, Supervision and Control of Systems, Asset Management, Energy Transition, the Environment, and Sustainability, as well as Laboratories and Experimental Research.

The positive impact of these actions is perceived by agents in the sector, suppliers, consultants, and society, with the application of technologies and solutions that increase the operational safety, reliability, and efficiency of the Brazilian electricity system (SEB). Potential negative impacts of services include additional costs for industry players due to rework and lower-than-expected efficiency, loss of credibility in the procedures applied, and negative consequences for manufacturers and regulatory agents. From an environmental point of view, inadequate waste management and the application of insufficient technologies can have unforeseen and costly impacts on society. Furthermore, lapses in the safety of activities can result in risks to people.

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Cepel's commitment to quality, ethics, and transparency is reinforced by an internationally recognized quality management system based on the ABNT NBR ISO/IEC 17025:17 standard, which contributes to minimizing the negative impacts of the Center's technological services. This includes internal and external audits, satisfaction surveys, and monitoring of performance indicators, as well as the immediate handling of incidents. Periodic reports from the Ombudsman, and the Compliance and LGPD departments are presented to the Board of Directors for monitoring and correction of any shortcomings – which includes high-voltage, high-power and calibration testing, and chemical and materials analyses, among others. In 2024, registration was limited to low-impact occurrences, with the handling, monitored by customers, keeping the negative effects under control.

GRI 3-3 - Management of material topics - HEALTH, WELL-BEING, AND SAFETY

Cepel manages its Occupational Health, Well-being and Safety Policy through programs such as PCMSO, PGR, SIPAT, health campaigns, and cultural initiatives. The aim of risk management, an integral part of the Compliance Program, is to establish guidelines for identifying, assessing, treating, and monitoring the risks inherent in the Center's activities, ensuring compliance with best market practices. The Occupational Health, Workplace Safety, and Social Service areas execute the actions, with funds from the Annual Acquisition Plan (PAA).

In 2024, the Center undertook a number of initiatives including flu vaccinations and artistic-expression workshops, encouraging blood donations and awareness campaigns on traffic, breast and prostate cancer, breastfeeding, violence against women, and mental health. Events such as the *Festa Junina*, 'Merry Christmas' and get-togethers have strengthened internal engagement. The organization also promoted cultural activities and signed agreements aimed at developing physical activity. The Center encourages a balance between professional and personal life while respecting the right to turn off digital devices and relax.

Safety at work receives priority treatment with mandatory training and awareness campaigns such as SIPAT. When incidents occur, the Incident Investigation and Analysis Committee assesses and deals with the situation in order to adopt the necessary corrective measures. To check the effectiveness of the measures, Cepel uses indicators such as frequency and severity rates, absenteeism, and compliance with occupational programs. The Center monitors progress by reducing absences and meeting contractual deadlines. The knowledge gained from forums, consultancy firms, and training is integrated into the organization's policies and operating procedures.

GRI 403-1 - Occupational health and safety management system

Cepel has established an Occupational Health and Safety Management System to ensure compliance with legal requirements and improve safety in the workplace. One of the main measures adopted was the implementation of the work order required by NR-1, an essential document that informs employees of the activities to be performed, the risks involved, and the necessary safety measures. Structuring of the risk management was also based on the ISO 45001 standard, adopting a preventive approach based on proactive indicators.

To operationalize this system, the Occupational Safety department established a routine involving field and area inspections, with clear goals and objectives. The field inspections are aimed at employees working at the Fundão and Adrianópolis units, while the area inspections cover the sites and equipment within these facilities. At the same time, a complete Occupational Health and Safety Policy has been established to ensure that all levels of the organization are committed to the safety and well-being of workers.

As part of the specific training actions, firefighting training was given to the supply management department, strengthening emergency response capacity. Flowcharts have also been created for the processes of contracting non-routine services to ensure that all security procedures are strictly followed.

This entire prevention and control system complies with a range of legal regulations, including NR-01, NR-04, NR-06, NR-07, NR-09, NR-10, NR-11, NR-12, NR-17, NR-18, NR-20, NR-23, NR-26, NR-33, and NR-35, as well as Cepel Procedure 4570.01. The integrated platform covers all employees – both in-house and third parties – in the Hazard and Risk Analysis, Incident (Occurrence) Reporting, Safe Practices Index (IPS), and Behavioral Observation (OBS) modules. However, certain modules, such as anamnesis, submission of health documents, and TF and TG targets, are only applicable to the internal workforce, since third-party management is conducted by contract managers.

GRI 403-2 - Hazard identification, risk assessment, and incident investigation

Cepel has adopted a structured approach to identifying work-related hazards, assessing routine and non-routine risks and applying a hierarchy of controls to eliminate or minimize them. This strategy is made up of several complementary tools: the constantly updated Risk Management Program; Preliminary Risk Analyses carried out before each activity; Safety Dialogues that reinforce awareness; regular area and field inspections at the Fundão and Adrianópolis units; and mandatory Service Orders before any work begins. The control hierarchy follows the NIOSH model, prioritizing: first, complete elimination of the risk; when this is unfeasible, replacement with safer alternatives; then engineering controls to isolate the risk factors; then administrative controls to modify procedures; and, as the last barrier, the use of personal protective equipment (PPE).

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So that workers can report occupational risks and hazardous situations, Cepel has a system that forms an integral part of the Occupational Risk Management Program. Reports can be made via either a QR Code, which directs the informant to an electronic form (Forms), or a physical form available at the units. There is also a dedicated telephone line and the company's intranet, which allow unsafe conditions to be reported immediately. Employees are protected against reprisals for exercising this right, as established in NR-01, item 1.4.3.3, ensuring the possibility of refusing to work in unsafe conditions without suffering unjustified consequences. This protection is widely publicized during the onboarding process and training.

When workers think that a situation could cause injury or health problems, a procedure is outlined in the Escape and Emergency Plan, which is available on the company's internal network, providing guidance on how to safely leave the workplace. To reinforce this practice, a simulation is scheduled for 2025 that will involve all the employees.

Work-related incidents are investigated through a detailed process, which begins with gathering information at the site where the incident has occurred. Interviews are conducted with the victim and any witnesses, where applicable, and a photographic record is made of the area. An extraordinary meeting of the Incident Investigation Review Committee is called, the composition of which depends on the seriousness and maturity of the event. Based on this analysis, actions are defined to manage the risk of the incident and implement change management to prevent recurrences.

GRI 403-3 - Occupational health services

Cepel's Occupational Health team is responsible for designing and implementing preventive and corrective actions focused on employee well-being, with these being periodically evaluated for continuous improvement. These actions include the Occupational Health Medical Control Program (PCMSO), general and specific medical examinations, periodic training, and orientation talks.

The medical team analyzes the results of the tests, performed in a certified clinic, to ensure quality control and provide guidance to employees. These examinations are offered free of charge on an annual basis to employees whose activities involve identified risks, taking place on a specific work day.

GRI 403-4 - Worker participation, consultation, and communication on occupational health and safety

100% of Cepel's workforce is represented on formal health and safety committees. The Internal Committees for the Prevention of Accidents and Harassment (CIPAs) operate at both the Fundão unit in Rio de Janeiro and the Adrianópolis unit in Nova Iguaçu, with the members, drawn from the units' employees, elected and appointed annually, in accordance with Regulatory Standard nº. 5 (NR-5) of the Ministry of Labor and Employment's Ordinance nº. 3,214/78. The CIPA at the Fundão unit is made up of ten members, five of whom are elected by the employees and five appointed by the company, while the CIPA at the Adrianópolis unit has one representative appointed by Cepel. These committees work together with the company's management through CIPA meetings, participation in governance forums, and organization of the Internal Week for the Prevention of Work-Related Injuries (SIPAT).

In addition to the CIPAs, there are regular meetings with the health and safety team, the Occupational Health and Safety project leader and representatives of Cepel's technical staff to discuss occupational health and safety issues in various departments of the company. At these meetings, some of the proposals analyzed emerge as feedback from employees, ensuring a safer working environment aligned with the team's needs.

The company's national collective bargaining agreement addresses two health and safety topics, representing a total of 3.33% of the clauses contained in the agreement.

GRI 403-5 - Worker training on occupational health and safety

Occupational health and safety training, aimed at the specific occupational risks, activities and dangerous situations, is based on the profile of risk factors defined in Cepel's Risk Management Program (PGR), in accordance with the applicable Regulatory Norms, especially NR-01, NR-04, NR-06, NR-07, NR-09, NR-10, NR-11, NR-12, NR-17, NR-18, NR-20, NR-23, NR-26, NR-33 and NR-35.

GRI 403-6 - Occupational health services

Every year, Cepel hires a company to carry out check-ups on all its employees, including a series of clinical, laboratory, and imaging tests, allowing the early diagnosis of diseases or predisposing conditions. Employees with chronic illnesses are monitored by Cepel's Occupational Health department, based on the results of these check-ups.

The medical center has three health professionals: an occupational doctor and two nurses, who care for the physical and psychological health of collaborators, whether they are part of the company or not, providing first aid whenever needed. Cases requiring more intensive care are referred to hospitals covered by the company's health plan.

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The health plan offered to employees and their dependents has an extensiveaccreditation network, online service, and ICU transportation. Employees can also count on reimbursement for medicines. Every year, there is a free of charge flu vaccination campaign, offered both at the company and at vaccination clinics, which is also extended to employees' dependents.

Cepel has implemented two prevention initiatives related to health and well-being: the *Cepel Saudável* (Healthy Cepel) Program and the Gender and Race Committee. Both act preventively in the areas of "Health and Well-being", "Volunteering and Human Rights" and "Diversity". These programs systematize actions aimed at promoting the physical and mental health of employees, encouraging self-care, self-knowledge, the adoption of healthy habits, and a good environment at work, through organizational practices that improve health and safety in the workplace.

Promoting healthy attitudes extends beyond the corporate environment. Employees are encouraged to practice physical activity through the fitness and mental health program offered by Wellhub (formerly Gympass). This partnership gives employees access to a general wellness app that takes an holistic approach, including activities for tobacco control, sleep improvement, mindfulness, meditation, diet and meal plans, and self-care. The evaluation and monitoring of access to Wellhub is performed by means of a recorded daily *check-in* when the employee arrives at the establishment registered with their plan.

GRI 403-7 - Prevention and mitigation of occupational health and safety impacts directly linked by business relationships

Cepel's occupational health and safety management focuses on safe practices, behavioral observations, incident investigation and analysis, defibrillator training, and hazard and risk management. The institution invests in training that meets Regulatory Standards, especially NR-01, NR-04, NR-06, NR-07, NR-09, NR-10, NR-11, NR-12, NR-17, NR-18, NR-20, NR-23, NR-26, NR-33 and NR-35. Together with the contract inspection area, it has also been implementing measures to guarantee greater security for service providers, suppliers and partners.

GRI 403-8 - Workers covered by an occupational health and safety management system

Cepel has an occupational health and safety management system, based on legal requirements, which covers 100% of its employees. This same system also covers 85.5% of other workers – who are not employees but whose work and/or workplace is controlled by the institution – which corresponds to 275 people.

GRI 403-9 - Work-related injuries

WORK-RELATED INJURIES GRI 403-9

	2023	2024
NUMBER OF EMPLOYEES	260	196
BASE OF NUMBER OF HOURS WORKED	1,000,000	1,000,000
NUMBER OF FATALITIES RESULTING FROM ACCIDENTS AT WORK	0	0
NUMBER OF ACCIDENTS AT WORK WITH SERIOUS CONSEQUENCES (EXCEPT FATALITIES)	3	0
NUMBER OF WORK-RELATED INJURIES REQUIRING COMMUNICATION	0	0
RATE OF HIGH CONSEQUENCE, WORK-RELATED ACCIDENTS	11.67	0
RATE OF RECORDABLE WORK-RELATED INJURIES	0	0

GRI 403-10 - Work-related ill health

Cepel does not present risks of high incidence or high potential for specific illnesses caused or aggravated by working conditions or practices. Furthermore, we can confirm that there were no fatalities or occupational diseases needing reporting, thus explaining the absence of these records.

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NON-MATERIAL TOPIC - Waste management

GRI 306-1 - Waste generation and significant waste-related impacts

Cepel works on applied research into electrical systems and equipment, developing technological solutions for the generation, transmission, distribution and trading of electricity. The activities generate different types of solid waste, originating from laboratory research and testing, production of parts and materials, maintenance of equipment and structures, conservation of green areas, occupational health services, and administrative activities. Among the hazardous waste generated are leftover chemical products, solvents, paints, mineral oil, and contaminated packaging. Non-hazardous waste includes rubble, wood, paper scraps, plastics, electronic scrap, metals, cardboard boxes, and pruning and sweeping waste.

The negative impacts associated with the waste generated are related to soil and groundwater contamination, greenhouse gas emissions, the proliferation of pests and vectors, and a reduction in the useful life of landfills. These impacts can be exacerbated by improper disposal. To minimize the impacts, Cepel has adopted a strict management approach, following its internal procedure, Solid Waste Management Plan (PGRS), and the National Solid Waste Policy (PNRS). The waste collected is separated and temporarily stored in appropriate locations, with one specific disposal area for hazardous waste and another for recyclables, serviced containers, and safety mechanisms such as containment pallets and emergency response kits .

At the disposal stage, Cepel hires licensed companies to ensure that the waste is treated correctly, according to its classification under NBR 10004, either through autoclaving, incineration, co-processing, re-refining, decontamination or final disposal in class I landfills. Recyclable materials are preferably sent to collectors' cooperatives, thus generating jobs and income. Non-recycled waste goes to licensed recyclers, helping to reduce the volume of waste going to landfills and boosting the circular economy. Organic waste from the green areas is composted to improve soil fertility, while tailings are sent to licensed class II landfills.

The EcoCepel Project stands out as an initiative that increases selective waste collection and reduces the volume of waste sent to landfills. It promotes the collection of recyclable and hazardous materials from employees' homes, such as light bulbs, vegetable oil, batteries, expired medicines, X-rays and electronics, in order to ensure their recycling or proper treatment.

The raw materials that generate waste at Cepel include of oils, paints, materials and electrical equipment sent by customers for studies and laboratory tests, which, after testing, become waste treated in accordance with the legislation. As for the outputs, since Cepel does not produce material goods, the impacts are linked to waste management, especially transportation and final disposal.

The impacts are also noticeable in the value chain, both upstream and downstream. The upstream impacts result from the receipt and processing of materials, while the downstream ones are related to emissions from transport vehicles and waste disposal machinery. Other potential risks include leaks and cargo tipping over during transportation, which could compromise the environment and society. To mitigate these impacts, Cepel maintains strict control over all stages of waste management, reaffirming its commitment to sustainability and environmental responsibility.

GRI 306-2 - Management of significant waste-related impacts

Among the measures adopted by the organization to avoid the generation of waste is the encouragement of the non-generation of single-use waste, such as the use of disposable cups, which have been replaced by eco-cups. Internal reuse of waste such as *pallets*, wires, pipes, and cardboard boxes is continually encouraged. In order to reduce paper consumption, Cepel has implemented a series of actions, such as adopting signatures with digital certificates, changing procedures to reduce the need for printing, storing documents in the form of Electronic Document Management, sending documentation to clients only in digital form, and strictly controlling printing, with limits per user.

Cepel manages its waste, monitoring the entire process of internal collection, separation, temporary storage, and external collection. The latter is performed by licensed third-party companies, which send the waste for environmentally appropriate disposal. In order to verify that the third party is disposing of the waste correctly, the environmental licenses of both the transport company and the final receiver are requested, as well as IBAMA's Federal Technical Register and other legal documents relevant to the transport of each type of waste. Furthermore, the deadlines for issuing Receipt Reports and Final Destination Certificates are monitored on the MTR INEA system platform, which complements the Waste Transport Manifest. When possible, a visit is made tothe units of new suppliers, in order to get to know the site, understand new treatment technologies, and check that the company has adopted safe and appropriate processes.

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Waste monitoring begins with separation and weighing at the time of collection from the generating areas, and internal transportation to temporary storage facilities. The weight data is entered into spreadsheets with the date, type and generating sector. Once the volume or weight is sufficient to enable collection for final disposal, the transport company is called and the Waste Transport Manifest is scheduled and issued via the MTR INEA System platform. Following external transportation, the Receipt Reports and Final Disposal Certificates are issued by the platform, thereby proving that the waste has been received by the consignee and that the waste has been treated and disposed of correctly. Following these steps, the data is entered into the corporate sustainability indicator system spreadsheets (IGS system).

GRI 306-3 - Waste generated

WASTE GENERATED GRI 306-3

	2023			2024		
	ADRIANÓPOLIS UNIT	FUNDÃO UNIT	TOTAL	ADRIANÓPOLIS UNIT	FUNDÃO UNIT	TOTAL
CLASS I	7,236.44	1,836.28	9,072.72	5,252.15	2,861.46	8,113.61
CLASS IIA	28,952.60	46,673.40	75,626.00	35,488.52	66,580.10	102,068.62
CLASS IIB	64,136.38	72,929	137,065.38	130,753.87	2,897,931.40	3,028,685.27
TOTAL	**100,325.42**	**121,438.68**	**221764.1**	**171,494.54**	**2,967,372.96**	**3,138,867.50**

All the waste generated by the organization is closely monitored. That forwarded to third parties, stored internally, or sent for processes such as composting, are accounted for in internal control spreadsheets. Every quarter, this data is transferred to the corporate sustainability indicators system (IGS), where it is evaluated and stored, allowing for future consultation and analysis.

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GRI 306-4 - Waste diverted from disposal

WASTE DIVERTED FROM DISPOSAL GRI 306-4

	2023	2024
	ADRIANÓPOLIS UNIT	ADRIANÓPOLIS UNIT
OIL FOR RE-REFINING	1.9	1.379
RECYCLABLE WASTE FOR RECYCLING	36.2048	83.3594
RUBBLE, WOOD, AND LIGHT BULBS FOR RECYCLING AND REUSE	17.365	12
HAZARDOUS WASTE FOR CO-PROCESSING AND PROCESSING	5.992	0.531
HAZARDOUS WASTE FOR INCINERATION	0.0513	2.3781
PRUNING AND SWEEPING WASTE FOR INTERNAL COMPOSTING	21.1	26.5
TOTAL	**82.61383**	**126.148**

WASTE DIVERTED FROM DISPOSAL GRI 306-4

	2023	2024
	FUNDÃO UNIT	FUNDÃO UNIT
OIL FOR RE-REFINING	0.623	0.7
RECYCLABLE WASTE FOR RECYCLING	7.0914	28.5045
RUBBLE AND WOOD FOR RECYCLING	73	2,878
LIGHT BULBS FOR DECONTAMINATION	0.1711	0.37718
HAZARDOUS WASTE FOR INCINERATION	1.0421	1.6079
HAZARDOUS WASTE FOR INCINERATION	0.0894	0
PRUNING AND SWEEPING WASTE FOR INTERNAL COMPOSTING	27.8944	27.5472
TOTAL	**109.9114**	**2,936.7367**

HAZARDOUS WASTE DIVERTED FROM DISPOSAL GRI 306-4

	2023	2024	2023	2024
	ADRIANÓPOLIS UNIT		FUNDÃO UNIT	
OIL FOR RE-REFINING	1.9	1.3795	0.623	0.7043
HAZARDOUS WASTE FOR CO-PROCESSING AND PROCESSING	5.99273	0.531	1.0421	1.608
LIGHT BULBS FOR DECONTAMINATION AND RECYCLING	0.075	0	0.1711	0.3771
HAZARDOUS WASTE FOR INCINERATION	0.0513	2.3781	0.0894	0
TOTAL	**8.01903**	**4.2886**	**1.9256**	**2.6894**

NON-HAZARDOUS WASTE DIVERTED FROM DISPOSAL GRI 306-4

	2023	2024	2023	2024
	ADRIANÓPOLIS UNIT		FUNDÃO UNIT	
MATERIALS FOR RECYCLING BY COOPERATIVES AND RECYCLING COMPANIES	36.2048	83.3594	7.0914	28.5045
RUBBLE AND WOOD FOR RECYCLING AND REUSE BY SPECIALIZED COMPANIES	17.29	12	73	2878.46
PRUNING AND SWEEPING WASTE FOR INTERNAL COMPOSTING	21.1	26.5	27.8944	27.5472
TOTAL	**74.5948**	**121.8594**	**107.9858**	**2934.5117**

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GRI 306-5 – Waste directed to final disposal

HAZARDOUS WASTE DESTINED FOR DISPOSAL GRI 306-5

	2023	2024	2023	2024
		ADRIANÓPOLIS UNIT		FUNDÃO UNIT
CLASS I LANDFILL	0.31071	0.43797	0.31071	0.757
AUTOCLAVE		0.0079	-	0.0162
TOTAL	**0.31071**	**0.44587**	**0.31071**	**0.7732**

NON-HAZARDOUS WASTE DESTINED FOR DISPOSAL GRI 306-5

	2023	2024	2023	2024
		ADRIANÓPOLIS UNIT		FUNDÃO UNIT
COMMON WASTE - CLASS IIA (SANITARY LANDFILL)	7.33764	8.26495	14.1591	13.8281
CLASS IIB (SANITARY LANDFILL)	19.54	34.89166	10.4655	10.95
TOTAL	**26.87764**	**43.1566**	**24.6246**	**24.7781**

All hazardous and non-hazardous waste designated for disposal was sent outside the organization.

GRI CONTENT **INDEX**

GRI **content index**

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