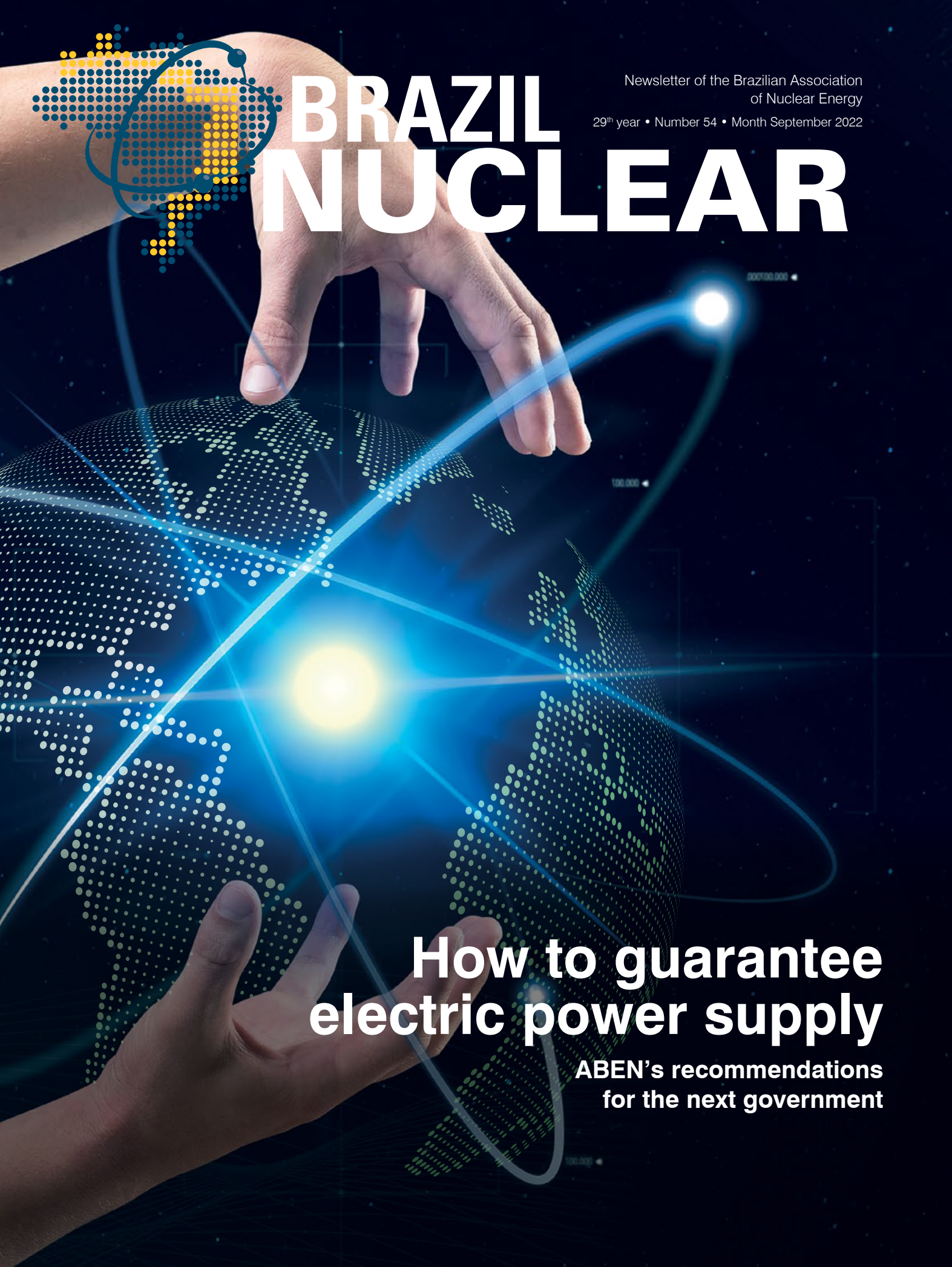


BRAZIL NUCLEAR

Newsletter of the Brazilian Association of Nuclear Energy
29th year • Number 54 • Month September 2022

How to guarantee electric power supply

ABEN's recommendations for the next government

Table of Contents

President of Aben
Carlos Henrique C. Mariz

Editorial Board
Alexandre Gromman – Aben
Cláudio Almeida – Aben
Edson Kuramoto – Aben
Francisco Rondinelli – Cnen
Márcia Flores – Aben

Editor
Vera Dantas

Contributor
Bernardo Barata

Editorial Production
Inventhar Comunicação

Artwork
IG+ Comunicação Integrada

Brazil Nuclear is produced by the Brazilian Association for Nuclear Energy – Aben
Rua Candelária, 65 • 14º andar • Centro Rio de Janeiro • RJ • CEP: 20091-906
Tel: (55 21) 2266 0480 • 2588 7000 • Ramal 4721
aben@aben.com.br • www.aben.com.br

Energy, one of the main challenges for the next government

The huge and persistent rise in energy prices (mainly natural gas) due to the conflict in Ukraine, and the soaring prices of agricultural commodities, which are also affected by climate change, are having a profound impact on the world economy. In Europe, countries are discussing measures to reduce electricity consumption in order to avoid power cuts and to help families pay their energy bills. Industry sectors and agricultural producers are demanding urgent measures to limit price increases. An example of how citizens' lives are being affected comes from Italy where, in mid-August, an ice cream seller posted his electricity bill on his social networks: the amount, over 5,000 euro, represents a 489% increase compared to the same period in 2021 - which he already considered too high. In China, droughts and heat waves resulted in the suspension or reduction of the electricity supply to factories.

In Brazil, climate variations are already affecting agribusiness, while the drought of 2021 brought the threat of rationing and provoked a large increase in electricity prices. In this context, the country started the process to choose new governors that will take place in October. The new Brazilian government, that takes office in 2023, faces the huge challenge of guaranteeing energy that is indispensable for the resumption of economic growth and social development, at competitive prices - Brazil has some of the highest electricity prices in the world. In order to overcome this challenge, Brazil needs to prioritise electric power supply, a strategic issue for most countries, and invest in expanding supply. Nuclear energy is a key element in this sense, since it guarantees a large volume of supply at competitive prices. Besides, it contributes to the reduction of greenhouse gases, which cause global warming, and plays a role in reducing the high incidence of cardiorespiratory diseases which result from the pollution that is inherent in energy produced from fossil fuels. For all these reasons, it is essential to increase the participation of nuclear energy in the electrical matrix.

This edition of Brazil Nuclear presents the Brazilian Association for Nuclear Energy's (Aben) proposals for the development of the nuclear sector, to the presidential candidates.

We consider as fundamental, the completion of the Angra 3 power station by 2028, the year in which it is scheduled to start operating. With 67.3% of the construction work completed, at an investment of approximately US$ 1.6 billion, the project will require US$ 3.013 billion of resources for its conclusion.

We also consider of great importance the definition of a programme to expand the nuclear base, in accordance with the PDE 2032 guidelines, which foresee the inclusion of at least 1,000 MW of nuclear energy within 10 years, and of the PNE 2050, which foresees the installation of about 10,000 MW within the next 30 years. Within the horizon of the ten-year programme, provisions related to the design, licensing, financing and construction of the new plant, and of the power stations that will follow, are required. Regarding the PNE 2050, it is necessary to define time frames that serve as reference and guidance for companies not only for the supply of goods, services and financing, but also for the operation, maintenance and training of personnel, besides legal, institutional and administrative arrangements.

One necessary measure is to coordinate actions so as to secure the approval of Congress for a constitutional amendment that releases private investment in the construction and operation of nuclear power stations. With a well-defined programme and the participation of the private sector, it will be possible to build nuclear power stations in less time and at a lower cost.

The National Nuclear Safety Authority (ANSN in Portuguese) must have the capacity to carry out, within the required timescales and depth, the licensing of the nuclear power stations defined in the programme.

We also consider it fundamental for the expansion of the sector, that the government defines and carries out the complementary studies of the new nuclear sites.

An important request made by the nuclear sector to the next government is the consolidation of the Brazilian Nuclear Programme (PNB in Portuguese), with the establishment of objectives, goals, deadlines and the designation of resources to be invested in it. One of the main projects of the PNB is the construction of the Brazilian Multipurpose Reactor (RMB in Portuguese). In order for it to come to fruition, it is necessary to guarantee, without interruption, a contribution of an estimated at R$ 2.5 billion in resources, to be spent over the expected five-year period of its implementation.

It is also necessary to invest so that Brazil becomes self-sufficient in the production of nuclear fuel.

Finally, we consider that human resources are an indispensable factor for the execution and success of nuclear policy. With this in mind, Aben calls for the recruitment of new researchers at the National Nuclear Energy Commission (Cnen in Portuguese), so as to replace the losses of recent years.

These and other measures aimed at guaranteeing the country's self-sufficiency in energy we present to the presidential candidates and are detailed in the following pages.

Enjoy your read!

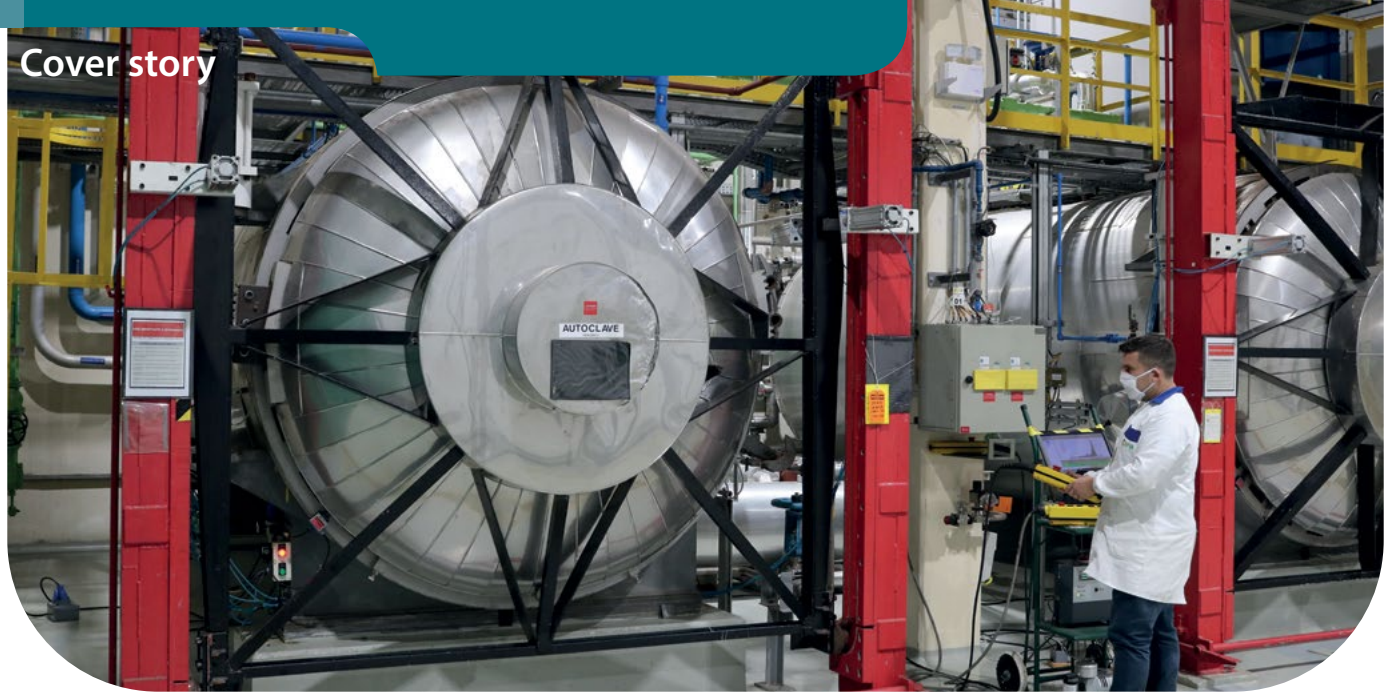


Photo: Comunicação INB

Nuclear energy

Guaranteeing electric power supply plus the economic and environmental sustainability of the electricity system

Vera Dantas

The threat to cut off natural gas supplies from Russia, rising fuel costs and the increased use of coal to generate electricity, as a result of the Ukraine conflict, and high summer temperatures in the Northern Hemisphere as a result of global warming place electric power supply at the centre of global attention. At the same time, they reinforce concerns about commitments to control greenhouse gas emissions.

At this time of energy crisis and intensifying climate-related problems, nuclear energy assumes strategic importance. The International Energy Agency (IEA) warned in a recent report that the world needs to double its nuclear energy generation capacity by 2050 to meet the goals of the Paris agreement for the reduction in emissions of polluting gases. Another indicator of the recognition of the importance of nuclear power for clean generation is its classification as a "green" investment by the European Parliament, in a decision made last July. The classification (taxonomy) is intended to help mobilise private funds for projects based on this energy source.

Nuclear energy is the only strategic and economically viable alternative for guaranteeing the security of supply together with stable electricity prices. Germany, Europe's largest economy and heavily dependent on Russian natural gas, stepped backed from abandoning nuclear energy, postponing until 2024 the closure of its last three operational power stations which had initially been scheduled for the end of this year. France, on the other hand, which has about 70% of its electricity generated by nuclear power stations, announced that it will build six new power stations by 2050 and will study the construction of eight more, in addition to extending the useful life of the power stations in operation. Additionally, as part of its strategy to expand nuclear energy, the country will fully nationalise the power company EDF, in which it already has an 84% share. After 30 years without investing in nuclear energy, the United Kingdom now has nearly 8,000 people working on the construction of Hinkley Point C. This new power station will have two reactors with capacity to supply 3260 MW of electricity for 60 year and the UK also has plans to implement new power stations. While the Netherlands and Belgium are looking at extending the useful life of their existing power stations, Poland and Romania have signed agreements with US companies to build power stations based on small modular reactors (SMRs). In July, Egypt started construction work on its first power station using Russian technology.

In Asia, China has approved the construction of six new reactors as part of its project to reach 70 GWe of nuclear capacity by the end of 2025, according to the 14th Five-Year Plan (2021-2025). China has 54 reactors in operation, with a capacity to generate 52.1 MWe, and is building 21 more, with a capacity of 21.7 MWe[1].

In Japan, which has 33 reactors, ten have been licensed to return to operation under post-Fukushima safety rules. Another seven power stations have also been licensed by the country's nuclear regulator to resume operations, but have not yet been connected to the grid. Finally, in the United States, the leader

[1] China Nuclear Power, World Nuclear Association. Available at https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

in terms of the number of power stations in operation, the government has just approved a billion-dollar package of measures for the environment, health and electric power supply. The proposal will inject US$ 437 billion into climate actions and programmes aimed at increasing the country's energy efficiency.

Human Development

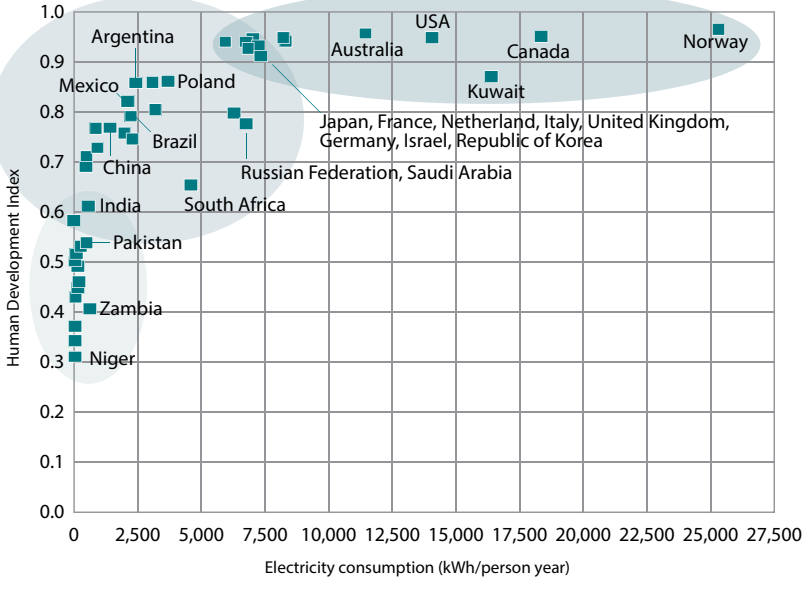
Electricity is essential for the economic and social development of a society. The relevance of this basic input is demonstrated, among other indicators, by the relationship between electricity consumption per capita and the Human Development Index (HDI).

Occupying the 84th position in energy consumption and the 75th position in the HDI ranking, Brazil has a low per capita consumption of electricity, around 2,500 kWh/inhabitant/year, half the per capita consumption of Portugal and a third of that of Spain, for example. It is far from the per capita consumption of Canada (13,854 kWh/inhabitant/year), the United States (11,730 kWh/inhabitant/year), Germany (6,693 kWh/inhabitant/year), and France (6,644 kWh/inhabitant/year), and below even other South American countries, such as Chile (4,026 kWh/inhabitant/year).

According to the relationship between electricity consumption per capita and HDI, Brazil needs to more than double its electricity consumption per capita, that is, generate twice as much electricity as it does today to reach a level of economic and social development that raises the quality of life of our society.

On analysing the relationship between electricity consumption and Gross Domestic Product (GDP), the engineer Drausio Atalla, who was the superintendent responsible for the operation of the Angra 1 and Angra 2 power stations, pointed out that a 10% increase in electricity consumption in a country represents a 10% increase in GDP. According to Atalla, Brazil needs 170 thousand MWe of electricity from sources with a high-capacity factor (over 80%), located close to the centres of consumption, which would represent a total investment of around US$ 600 billion. This investment could add US$ 4 trillion to Brazil's GDP which would mean an increase per capita of US$ 7,500 per year. Despite the enormous amounts, these resources should be considered a strategic investment and not expenditure. "Investing US$ 600 billion over a period of 10 to 15 years means an annual investment of US$ 40 billion to US$ 60 billion, or 2% to 3% of our GDP. No investment in infrastructure could bring such a result, for such a low cost and in such a short period of time. The Americans, the Chinese, the Japanese, the Germans, the British, the French and all the other rich countries did exactly that", argues the analyst[2].

HDI X Electricity Consumption



Brazil | Consumption: 84th position | IDH: 75th position

Nuclear sector in full Expansion

- 440 power stations in operation
- 55 power stations under construction
- 95 power stations at approval stage
- 340 power stations at the planning stage

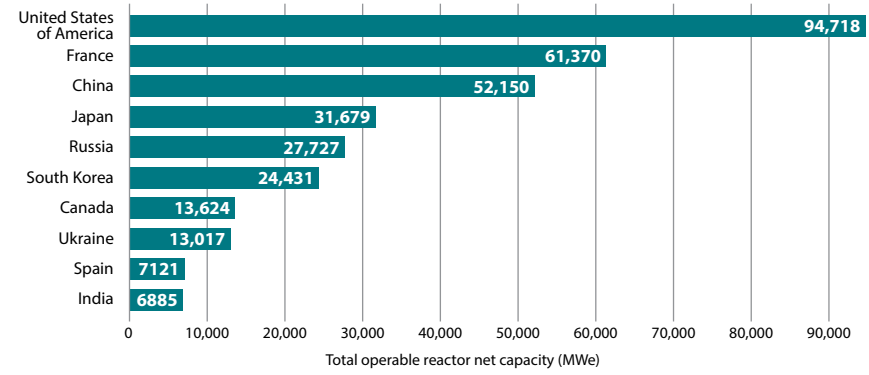
Source: World Nuclear Performance Report - World Nuclear Association

Threat to supply

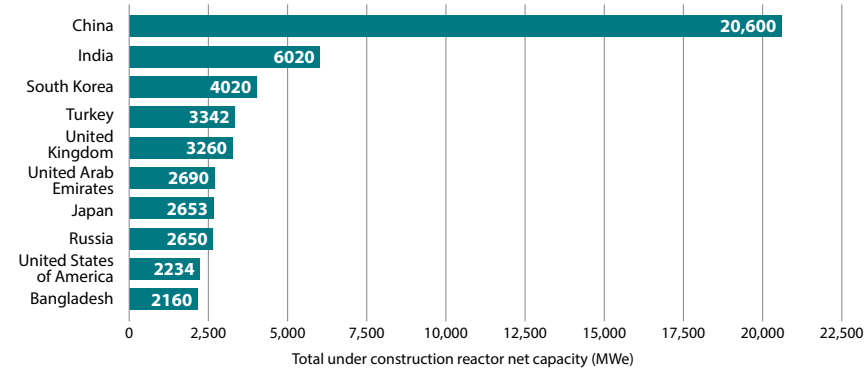
Even without the problems arising from geopolitical instability - such as the one that affected the supply of Russian natural gas to European countries - Brazil faces threats to its electric power supply. With 65% of its electricity matrix based on hydropower generation, the energy supply is directly linked to rainfall. Since 2011, rainfall rates have been low, compromising the storage capacity of reservoirs. Last year, for example, this strongly affected the level of reservoirs in the Southeast and Midwest regions, a subsystem responsible for about 70% of the capacity of Brazilian hydroelectric power stations, which reached levels close to those seen in 2001, when there was energy rationing. As a result, the country started importing electricity from Uruguay and Argentina and anticipated, by a few months, turning on diesel-powered thermoelectric power stations, originally built to run only as an emergency during the official dry season (April to October).

[2] Aben – 27/06/2022.

Top 10 Countries Installed Capacity



Top 10 Countries Under Construction



Environmental legislation limited the use of the country's hydropower potential, which, since the 1990s, led to the construction of hydroelectric power stations with small reservoirs, almost run-of-the-river. The result has been a loss of water storage capacity to be able to cope with the periods without rain.

Water scarcity has had a big impact on electricity prices. The amount paid by consumers between September and December 2021 was four times that of the last four months of 2019, the year before the Covid pandemic, and 16 times that of the same period in 2020[3]. The increase could have been even higher, were it not for the contribution of the energy produced by the Angra 1 and Angra 2 power stations for the National Integrated System (SIN in Portuguese). The amounts that these power stations received were recently readjusted by 39,86%, going from R$ 249,64 per MWh in 2021 to R$ 349,15 per MWh in 2022. Even so, they are far below the contract prices awarded at the last capacity market auction - which trades energy sources that bring security to the system, such as thermoelectric power stations -, at around R$ 600.00 per MWh.

Whether due to their economic merits or for reasons of network security, the Angra 1 and Angra 2 power stations are the preferred sources for dispatchable generation. From the viewpoint of the National System Operator (ONS in Portuguese), their low variable unit costs, as well as their high rates of available generation and reliability, make them one of the main resources for meeting the load of the Southeast/Central-West subsystem and of the SIN (*see Angra power stations are vital for balancing the NIS*).

Although they correspond to only 1.7% of the country's installed capacity, with 2 GW installed, Angra 1 and Angra 2 nuclear power stations are responsible for almost 3% of the electricity generated. With the entry into operation of Angra 3, scheduled for 2028, the Almirante Álvaro Alberto Nuclear Power Station will increase to 3.5 GW.

[3] https://www.poder360.com.br/energia/escassez-hidrica-quadruplicou-custo-com-bandeiras-tarifarias/

Bottlenecks

The existence of public policy, which gives continuity even with changes in government, is an indispensable condition for a country to successfully develop any strategic project. This is the case in the nuclear area, as nuclear projects are long-term, going beyond the period of one or two presidential terms.

The discontinuity of objectives, one of the main vulnerabilities of the Brazilian nuclear sector, is responsible for the enormous delay and increased costs of projects such as the construction of nuclear power stations. Lots of interruptions have multiplied fourfold the time it took to build Angra 2 – initially scheduled to last six years, the work lasted 20 years -, during which time the operator was forced to pay interest on the financing. Also, behind schedule, Angra 3 is not expected to be operational until 2028, 30 years later than planned (see PNB: *71 years of sparse actions and no continuity*).

The absence of public policy negatively impacts other strategic projects in the nuclear area, such as the development of a nuclear-powered submarine for the Brazilian Navy, the delivery deadlines for which have been extended many times due to the unreliability of resources. Even more critical is the Brazilian Multipurpose Reactor (RMB) which will extend the benefits of nuclear medicine to a large part of the Brazilian population. The programme's deadlines are constantly modified depending upon the financial contributions received. In 2017, for example, of the budget of R$ 1,959,887 dedicated to actions related to site ownership, conservation and environmental licensing, just R$ 826,000 was actually received. There are still no funds allocated to the project for 2022. The perspective is that, from 2023, resources of the order of R$ 300 million/year will be allocated to the project.

Although it has one of the world's largest uranium reserves as well as nu-

The discontinuity of objectives is responsible for the delay and increased costs of nuclear power stations

clear fuel cycle technology, Brazil currently imports most of the inputs required to manufacture the fuel used in the Angra 1 and 2 power stations. The fuel cycle activities are a state monopoly and Brazil Nuclear Industries (INB) is responsible for the entire uranium production chain (research, mining, enrichment, industrial production and trade of nuclear ores and derivatives).

Until very recently, INB was dependent on public funding to carry out its activities. Provisional Measure 1.133/2022, dated 12th August 2022, reduced this dependence, giving the company more flexibility to enter into partnerships with the private sector in the areas of research, mining and the trading of nuclear ores, their concentrates and derivatives, and nuclear materials. The Provisional Measure also transferred INB to ENBPar, which brings together the Itaipú and Eletronuclear power generators, which will allow the company to manage the resources resulting from the sale of its products and services.

Another important bottleneck in the nuclear sector is in the area of research. The number of research staff at the National Nuclear Energy Commission (Cnen) was reduced by 70% due to retirement and professionals leaving to work in other areas. As a result, much research was discontinued and some laboratories were closed. The resources available for the area of research today are one third of those available in 2010.

Angra power stations are vital for Balancing the NIS

The production from the Angra 1 and Angra 2 nuclear power stations is vital for balancing the National Integrated System (SIN). Thermonuclear generation is made directly available to the Southeast/ Central West subsystem, which has the highest load of the SIN, and contributes towards avoiding congestion at the interconnections between subsystems and, in scenarios with low availability of hydropower generation in the South and Southeast regions, to meet the maximum load period of the SIN. The absence of the dispatchable generation of these plants increases the risk of rationing to control the frequency of the SIN. The information is contained in a document sent by the National System Operator (ONS) to the Ministry of Mines and Energy, on 6 January, 2021.

The failure of generation at Angra 1 and Angra 2 would require the ONS to adopt measures to avoid the risk of instability for the SIN. These measures would involve: the restriction on the exchange of energy from the South region to the Southeast region; the restriction on the flow of energy from power stations in the North region, especially in the case of energy generated from the Belo Monte and Tucuruí hydroelectric plants; and potentially the need to turn on thermoelectric power stations in the state of Rio de Janeiro. This additional dispatch would have a strong economic impact, and could result in costs of up to R$ 5 million per day.

The document cites simulations carried out in January 2021 showing that the unavailability of Angra 1 and Angra 2 power stations would increase, in average terms, about R$ 1.7 billion in total operating costs over a five-year period (January 2021 to December 2025), which is equivalent to a percentage increase of about 7.3%. And points out that for the most critical hydrological scenarios, this cost increase may be of the order of R$ 60 billion, equivalent to a percentage increase of about 21%.

[1] ONS Letter 0004/DGL/2021. Available at https://www.eletronuclear.gov.br/Imprensa-e-Midias/

The world suffers the effects **of global warming**

In recent months, the world has been experiencing an unprecedented heat wave. Extremely high temperatures and prolonged drought have caused damages in countries in Europe, Asia and the USA.

In Europe, drought has affected freight transport, energy production, drinking water supplies, animal food products and crops. The heat and drought have caused forest fires in countries such as France, Spain and Croatia. More than 2,000 people have been killed across Spain and Portugal as a result of the heat waves.

In Germany, the Rhine River, the country's most important river for freight transport, has reached such low levels that boats have been forced to cancel transportation or reduce their carrying capacity by up to 75 per cent. The crisis on the Rhine could seriously affect the landlocked countries of Central and Eastern Europe, which depend on the river for transporting fuel. As freight transport has also been suspended for several weeks on the Elbe River, economists estimate that the impacts on the shipping corridor could knock half a percentage point off economic growth in Germany.

France is facing its worst drought ever. Due to a ban on irrigation for farmers, corn production will be the worst in a decade - a situation made worse by the impact of the war on corn imports from Ukraine. Other crops including wheat, peaches, strawberries and apricots are also being affected.

The 90% drop in the flow of the River Po has hit corn and risotto rice production in Italy. The risotto rice harvest could fall by 60%. In total, one third of farms in Italy are now producing food at a loss.

In Switzerland, where the level of Lake Constance is at its lowest level for this time of year for more than 130 years, cheese production is being disrupted due to dry pastures and reduced water supplies for livestock. Switzerland is also facing a shortage of petroleum products due to the difficulty of transporting them up the Rhine River.

In the UK, heat waves exceeded the 40°C mark for the first time ever. Drought, the war in Ukraine and Brexit have caused the price of some foodstuffs to rise by up to 20%.

Food prices have also risen by 20% in Slovakia. Around 99% of the country is under drought conditions, with almost 60% in "extreme" drought conditions. Many places are struggling to provide enough drinking water and there is a possibility that tens of thousands of cows will have to be killed due to a lack of food for them during the winter.

Nuclear power reduces emissions of greenhouse gases

Nuclear energy contributes directly to the reduction and control of emissions of greenhouse gases. Replacing 20% of coal generation with 250 GW of nuclear generation would reduce about 15% of emissions from the electricity sector per year, estimates the report Nuclear Energy for a Net Zero World, from the International Atomic Energy Agency.

As a secure source of low-carbon electricity and heat, it is well suited to replace coal and other fossil fuels, while providing heat and hydrogen to decarbonise non-energy sectors such as the production of steel, cement and chemicals, as well as shipping and air transport - which together account for around 60% of global energy-related emissions.

Industry affected in China

Dry rivers, scorching heat and energy rationing in regions of China are paralysing factories and threatening agricultural production. Local governments have ordered local factories to shut down or temporarily reduce their operations to save energy. The cuts although limited so far, are affecting several global manufacturers such as Apple, Toyota and Volkswagen.

Sources: ClimaInfo and newspaper Valor Econômico

Aben's proposals for developing the nuclear sector

Electric power supply is a strategic issue for most countries. The new government, which will take office in Brazil in January 2023, faces the huge challenge of guaranteeing the supply of energy that is indispensable for the resumption of economic growth and social development. As our contribution to the success in meeting this challenge, the Brazilian Association for Nuclear Energy (Aben) presents its proposals for the development of the nuclear sector to the presidential candidates.

Based on the guidelines of the National Energy Plan 2050, which envisages the installation of around 10,000 MWe of nuclear energy in the next 30 years, and taking into consideration that, in order to build quickly and at a lower cost, it is necessary to indicate a series of power stations. Aben proposes the creation of a nuclear expansion programme, that achieves the PNE 2050 goal and with time frames that serve as reference and orientation for companies, not only for the supply of goods, services and financing, but also for the operation, maintenance and training of personnel, as well as taking into account legal, institutional and administrative provisions. Within the horizon of the ten-year programme, several measures must be adopted aiming, not only at the start date for operating new nuclear plants, but, above all, the identification of project arrangements, licensing, financing and construction provisions. Especially in the PDE 2032, the inclusion of at least 1,000 MW, post Angra 3.

Coordinate actions in relation to the approval, by the National Congress, of the Proposed Constitutional Amendment (PEC) that allows for private investment in the construction and operation of nuclear power stations.

Define the nuclear sites and carry out the necessary studies so as to facilitate the execution of the defined national nuclear energy programme.

Provide the National Authority on Nuclear Safety - ANSN with the capacity to carry out, at the speed and depth required, the nuclear licensing of the whole series of nuclear power plants defined in the programme.

Consolidate the Brazilian Nuclear Programme (PNB), by establishing objectives, goals, implementation timescales and the assignment of the resources to be invested.

Guarantee continued funding for the construction of the Brazilian Multipurpose Reactor, with project cost estimated at R$ 2.5 billion, over a five-year timescale.

Accelerate construction of the Angra 3 power station. Already, 67.26% of the construction work is completed, with an investment of about US$ 1.6 billion, the project will require resources of US$ 3.013 billion to be completed.

Invest in completion of the uranium enrichment unit and the construction of the conversion unit so that Brazil becomes self-sufficient in the production of nuclear fuel.

Build a national repository for low and medium level waste.

Contract new researchers at the Cnen's institutes to make up for the reduction in the number of researchers over recent years.

Restore funding for research and laboratories at Cnen's institutes.

Photo: Comunicação Ipen

No talent, no knowledge

Frederico Genezini
Sérgio Filgueiras

A new government always brings the opportunity to change course and try new strategies. After all, continue doing more of the same is to guarantee that nothing will change. Nuclear technology, although little appreciated in Brazil, has an enormous potential to contribute to improving people's lives hence developments within nuclear technology have a wide-ranging relevance for our society.

The application of nuclear technology is strongly linked to the ownership of knowledge and to research, whether to develop new products or services, or to transfer existing ones from outside, including those in electricity generation. For any country, this means maintaining a competent body of researchers and specialists able to transform knowledge into well-being and socioeconomic growth. For this reason, the need to replace staff at the Institutes of the National Nuclear Energy Commission (Cnen) is urgent and fundamental to preserve the knowledge that has been assembled over generations. Several projects have been discontinued due to a lack of staff; without people there is no research. Investment in infrastructure and equipment for institutions operating in the sector should receive attention with the aim of developing cutting-edge projects and achieving excellence in training human resources.

Promoting projects with enormous social impact, especially the production of radioactive substances for use in nuclear medicine, really must receive special attention of the new Government. Among them, the Brazilian Multipurpose Reactor (RMB) stands out as a project capable of leveraging the growth of radiopharmaceutical production in Brazil. The recently approved participation of the private sector in the market will not solve the instability in the supply of radiopharmaceuticals, given that the main input - the radioisotope - will continue to be mostly imported. It is important to remember that dependence on imports was the basis for the recent supply crises: in 2009, due to the closure of a reactor in Canada; in 2020, due to restrictions imposed by the pandemic; and the current one, as a result of the conflict between Ukraine and Russia.

There is, nationally, the need to expand the population's access to nuclear medicine, through public services, which will only be possible with the reduction in price of radiopharmaceuticals, which will occur naturally once national production replaces imports. Besides the sovereignty in the production of radiopharmaceuticals, the construction of the new reactor will have an impact on the wider area of nuclear applications, as well as in the development of new technologies and materials for other industry sectors.

Another demand that directly impacts people's lives is food irradiation. A technique that is widely used throughout the world, but not yet used on a large scale in Brazil, irradiation allows the improvement of food by sterilising it, eliminating microorganisms and pests without altering its nutritional properties, appearance, taste or smell. There is also a delay in the ripening process, which increases the shelf life of highly perishable foods, such as fruit. This increases the supply of food by reducing wastage, and can be used as a tool in the fight against hunger and as a facilitator of food exports. Brazil's longstanding legislation that regulates this type of procedure follows the international standards published by the International Atomic Energy Agency (IAEA). In a country of continental dimensions, in

order for this technology to impact the lives of Brazilians, large irradiation units will need to be strategically installed throughout the country, close to the food producing hubs.

Among other applications, small irradiation units can also be used to promote pest control, such as fruit flies, as well as controlling endemic diseases transmitted by mosquitoes such as the *Aedes aegypti*. This is proven technology, which has been in use in other countries for over 60 years and can lead to savings of tens of billions of reais and the saving of thousands of lives every year. Brazil already has a sterile fly factory; it needs many others.

It is clear, therefore, that the resumption of investments and the reconstitution of staffing levels at Science and Technology institutions in general – and, in particular, in the area of nuclear applications - can contribute to boost the most diverse areas of society and our economy: health and education, with improvements in social welfare; industry and agribusiness, by increasing competitiveness and productivity.

This is a strategy for the next four years, so that retirements and the brain drain abroad do not dismantle irrecoverably the great knowledge base installed in Brazil today.

Frederico A. Genezini is a physicist (USP), with a master's degree and a PhD in Nuclear Technology (USP). He is a researcher at the National Nuclear Energy Commission and works at the Institute for Energy and Nuclear Research - IPEN/CNEN-SP.

Sérgio A. C. Filgueiras has a master's degree in Nuclear Sciences and Techniques (UFMG) and a PhD in Engineering (USP). He is a technologist at the National Nuclear Energy Commission and works at the Centre for the Development of Nuclear Technology (CDTN)

Just like the tilapia skin used to treat burns (photo on the opposite page), biological tissues used in transplants are irradiated to kill bacteria and viruses and avoid rejection by the organism.

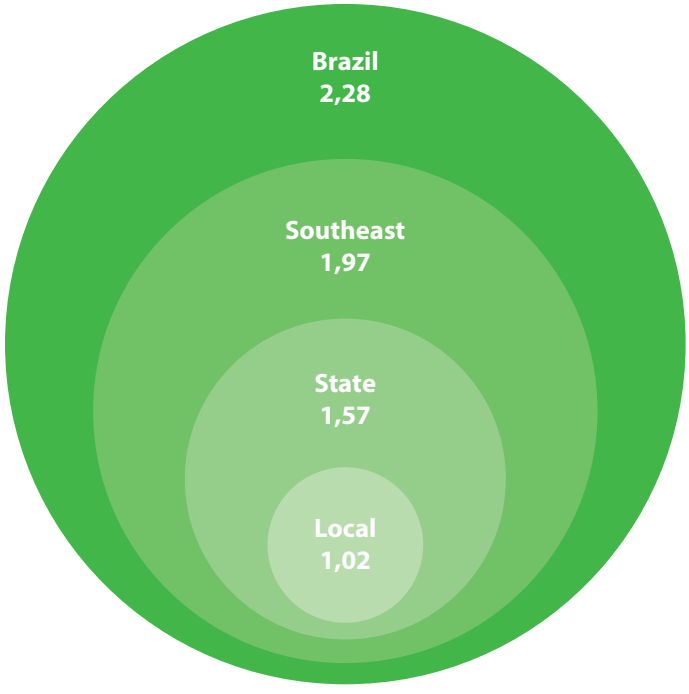
The return on investment **in the nuclear sector for society**

Vera Dantas

Besides offering safety and stable prices to the electrical matrix, nuclear energy provides other important benefits to society, in return for the investment made. Nuclear energy projects are strategic and involve several areas of knowledge and contribute to the technological and productive development of other industrial sectors. The applications of the technologies contribute to the areas of health, agriculture, industry, the environment and the preservation of historical and cultural assets, among others.

The installation of nuclear power stations has a major impact on the economy, as shown in a study carried out by Eletronuclear which evaluates the socio-economic impacts of the investment programme associated with the installation of Angra 3 at the local, state, regional and national levels[1]. The first corresponds to the four local authority areas surrounding the plant (Angra dos Reis, Mangaratiba, Parati and Rio Claro). The second refers to the state of Rio de Janeiro and the regional scope corresponds to the Southeast Region. According to the study, as the geographical scope considered increases, the multiplier effect increases. Thus, if each R$ 1 invested generates R$ 1.57 in the State of Rio de Janeiro, this amount reaches R$ 2.28 in Brazil, distributing employment, income and tax revenue throughout the entire country (*see figure GDP Multiplier*).

GDP Multiplier

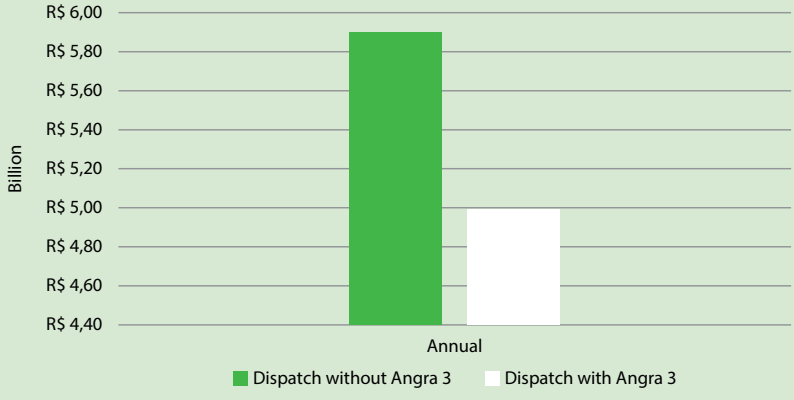


[1] Economic-financial Evaluation of the Installation and Operation of Nuclear Power Stations and their Socio-economic Impacts. Eletronuclear, Rio de Janeiro, 2015.

The study found that jobs generated in the installation and operation of a highly complex project such as a nuclear power station tend to be of high quality, which generates economies of location and agglomeration. This is a transformative process, which tends to produce local centres (relative to their surroundings), while intensifying relations with the main regional centres (such as the state capital).

When Angra 3 starts operating it will bring an annual economy of R$ 900 million in the cost of thermoelectric plants connected to the National Integrated System (SIN), as shown in the following chart.

Dispatchable cost with thermal power stations: Impact of Angra 3



Benefit to the system: R$ 900 million (annually)

Source: Eletronuclear

Nuclear fuel

Brazil has one of the world's largest uranium reserves and it dominates nuclear fuel cycle technology. In terms of uranium mineral resources, Brazil has 244,788 tons of U_3O_8, of which 99,064 tons are in the Lagoa Real Uraniferous Province, Caetité in the state of Bahia; 79,624 tons in Santa Quitéria in the state of Ceará, and 66,100 tons in other locations, as shown in the table below.

Uranium Mineral Resources in Brazil

DEPOSITS	TONS U_3O_8 (URANIUM CONCENTRATE)		
	MEASURED AND INDICATED	INFERRED	TOTAL
Caetité	66.672	32.792	99.064
Santa Quitéria	75.010	4.614	79.624
Outros	39.500	26.600	66.100
TOTAL	**181.182**	**64.006**	**244.788**

Mineralisation Potential: Pitinga (State of Amazonas) 150,000 tons U_3O_8
Cristalino River (State of Pará) 150,000 tons U_3O_8

Source: Brazil Nuclear Industries (INB)

Brazil Nuclear Industries plans, in the long term, to open mines in Caetité and in the Itataia deposit, located in Santa Quitéria. In Caetité, the project envisages the expansion of the Uranium Concentration Unit (URA) and of mining activities at the Unit, increasing its capacity to 800 tons of uranium concentrate/year, which will be sufficient to meet the demands of Angra 1 and 2 and the future Angra 3. It is planned to open 13 new mines in the Lagoa Real Uraniferous Province over a 20-year period. In order to open these new mines, it is necessary to transform these mineral resources into reserves, meeting a series of feasibility requirements that are technical, economic, financial, environmental and social.

The 13 new deposits are at different stages of study. The six major deposits have recently had their mineral resources re-evaluated. As a result of this re-evaluation, four of these deposits require new drilling (a drilling contract process has already been initiated for two deposits) and two have reached the stage of converting resources into reserves.

At the licensing phase, the Santa Quitéria Project will be implemented in the municipality of Santa Quitéria, located in the north-central region of the state of Ceará, where phosphate and uranium are found in association with colophanite ore. This project is led by the Santa Quitéria Consortium, formed by INB and the private sector company Fosfatados do Norte-Nordeste S/A, owner of the Galvani brand. The planned production is 2,300 tons/year of uranium concentrate for electricity generation (enough to supply 3.1 times the demand of the Angra dos Reis power stations, including Angra 3), as well as 1,050,000 tons/year of high-grade phosphate fertilizers for agriculture and 220,000 tons/year of dicalcium phosphate for animal feed.

INB currently produces, at its Nuclear Fuel Factory - FCN, in Resende (state of Rio de Janeiro), the fuel that supplies the Almirante Álvaro Alberto Nuclear Power Station, in Angra dos Reis.

Angra 1 and Angra 2 each use different fuels that use distinct technologies that originate in different countries, both of which are fully dominated by the company. Angra 1 (Westinghouse technology) uses a total of 121 elements and Angra 2 (Siemens technology), 193. Every year, one third of the elements in each plant are changed in the refuelling process. Annually, INB refuels once, on average, each of the power stations.

This year, Angra 2 was refuelled for the 18th time while Angra 1 received its 27th refuelling. The production of powder and pellets for the 19th Angra 2 refuelling started in August, and is due to be transported in July 2023.

When Angra 3 power station becomes operational, INB will increase by more than 50% fuel production, which will provide an economy of scale in the various stages of the nuclear fuel cycle, offering improved financial sustainability for the company.

Brazil dominates the entire nuclear fuel cycle, although some of the services are performed outside of Brazil. A portion of the uranium concentrate, for example, is imported. INB is planning for its mines to produce enough fuel to meet national demand by 2028, which is when Angra 3 is scheduled to start operating.

The conversion stage is also contracted out abroad, which is more viable from a commercial point of view, since it is the least expensive option. However, from a strategic point of view, Brazil's aim is for the whole process to take place within Brazil.

In relation to the capacity for isotopic enrichment of uranium, the costliest and technologically demanding process within the entire cycle, INB will be able to meet 70% of Angra 1's needs with the inauguration of the 10th cascade by the end of 2022, when the first stage of implementation will be concluded. Implementation of the second stage, which is in the detailed design phase, will significantly expand enriched uranium production, giving the company the capacity to supply Angra 1, 2 and 3.

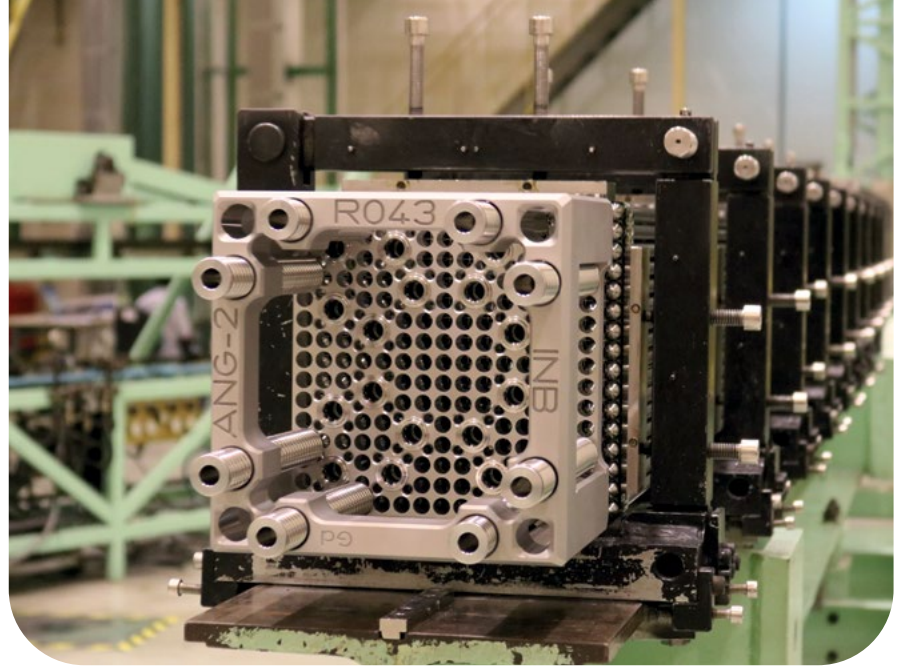


Photo: Comunicação INB

With the enactment of Provisional Measure 1.133/2022, INB will be able to enter into partnerships with private sector companies in its activities throughout the uranium production chain, i.e., in the development of research, mining and the trading of nuclear ores, their concentrates and derivatives, and nuclear materials.

The transfer of INB to ENBPar, also contemplated by MP 1.133/2022, will allow the company to become independent from the Treasury's resources and will begin to manage its own financial resources with greater efficiency and predictability. As it will no longer form part of the Federal Government's fiscal budget this will result in a significant improvement in the planning and execution of INB's supply and raw material chain, which will increase the company's overall productivity, mainly because it is guaranteed that the company will continue to produce the fuel to refuel the nuclear power stations. In addition, there will be a significant improvement in the company's results and profit, increasing INB's ability to invest using its own resources.

Nuclear medicine

The RMB is an undertaking of the Ministry of Science, Technology and Innovation (MCTI in Portuguese) that will ensure national autonomy in the production of radioisotopes for applications in industry, agriculture, environment and, especially, in health. Among the other aims of the project are the testing and qualification of materials and fuels for power reactors and scientific and technological studies using neutron beams on materials.

With the production of radioisotopes for medical use, Brazil will become self-sufficient in nuclear medicine. To meet the annual demand of 2 million procedures in nuclear medicine, Brazil currently spends about US$ 15 million on imports of molybdenum-99 (^{99}Mo) - whose radioactive decay produces the radioisotope technetium-99 (^{99m}Tc), used in more than 80% of the nuclear medicine procedures in the world, especially in scintigraphy exams - and another US$ 3 million on imports of other radioisotopes that are processed and sent to more than 400 Brazilian hospitals and clinics.

In the future, the RMB may have high-powered laser laboratories, a laboratory for studying nuclear fusion technology, as well as high-energy particle accelerators for radioisotope production and research.

SBPC calls for completion of **the Multipurpose Reactor (RMB)**

The Brazilian Society for the Advancement of Science - SBPC published a motion in support of the RMB, aimed at presidential candidates, members of congress and the presidents of scientific associations and societies. The motion was unanimously approved in an ordinary general meeting held on the 28th July. See below, the text of the document.

Technological independence and National Sovereignty in the area of radiopharmaceuticals and the completion of the RMB

The General Meeting of Partners gathered at the University of Brasilia - UnB, in Brasilia/DF, requests investment in the Brazilian Multipurpose Reactor (RMB) for the domestic production of radiopharmaceuticals.

The application of the RMB within society, deploying radiopharmaceuticals both for diagnosis and for therapeutic use in nuclear medicine, provides about *2 million procedures per year* in Brazil. The radioisotopes, which enable the production of radiopharmaceuticals, are mostly produced in dedicated research nuclear reactors. However, the research reactors in Brazil do not have the capacity for large-scale production, which requires the importation of radioisotopes, leading to Brazil being heavily dependent on foreign suppliers. In 2009, the global crisis in the supply of the radioisotope molybdenum-99 - used in the production of technetium-99m generators, which are used in more than 80% of diagnoses - showed Brazil's vulnerability in being able to carry out more than five thousand procedures/day. This crisis is repeats itself every time there is a worldwide shortage of this material.

About three quarters of the use is in private clinics and hospitals and only one quarter is associated with the Unified Health System (SUS in Portuguese). But this proportion is inverted in relation to national healthcare, i.e., three quarters are associated with the SUS and one quarter with the private system. Therefore, nuclear medicine "per capita" applied tin the SUS is almost ten times less than in private healthcare. It is necessary to expand access to nuclear medicine and minimize this asymmetry in society.

The RMB Project will provide the country with a multipurpose nuclear research reactor and the entire infrastructure of laboratories and facilities to meet the needs of the growing production of radioisotopes for medical applications, in addition to promoting technological innovation and contributing to the training of specialised human resources. The RMB laboratories will be a national resource, available to the scientific community throughout the whole country. It will also be a national laboratory that will complement the Brazilian Synchrotron Light Laboratory in relation to the use of neutron beams.

It is true to say that the RMB is a pivotal project that will generate spin-offs for the nuclear sector and is of fundamental importance for enabling public policies and strategic objectives of the country's Science, Technology & Innovation.

The RMB project has a total estimated cost of US$ 500 million for implementation over at least 5 years. Since 2008, the RMB has already spent approximately R$ 280 million from the National Fund for Scientific and Technological Development (FNDCT in Portuguese) through Finep , when established by PACT /MCT. These resources were allocated up to 2014. From 2015 to the present, only R$15 million have been allocated, which is insufficient to implement the reactor.

In relation to the RMB, it is really important that political parties, members of congress and opinion formers:

1. Get to know the project proposal;
2. Understand its strategic importance for developing the country's nuclear technology;
3. Understand its enormous social relevance for the Brazilian population by enabling the sustainability supply of radioisotopes for nuclear medicine;
4. Understand the need to establish public policy to ensure implementation of the RMB over a five-year period;
5. Understand the need to establish a unique management model that is able to facilitate its implementation and operation.

It is important that political parties, members of congress and opinion formers act within the ongoing legislative processes and in informing the candidates for the Presidency of the Republic to position themselves in relation to the RMB so as to:

1. Guarantee the strategic nature of its implementation for Brazil;
2. Ensure the continuity of the financial resources for the implementation of the RMB;
3. Ensure the allocation of human resources for its implementation and operation;
4. Guarantee the establishment of an appropriate management model to facilitate its implementation and operation.

PNB: 71 years with few actions and no continuity

Nuclear activities in the country have been marked by a lack of continuity, with delays in finishing projects and the consequent increase in costs. This vulnerability is largely due to the absence of a state programme for the nuclear sector that is independent of changes in government. There has been no shortage of initiatives to implement it, as shown in the survey carried out by the publication "The Brazilian Nuclear Programme: An Oral History", published by the Getúlio Vargas Foundation and organised by Carlo Patti. In the sequence of events during the period 1934-2010, pioneering actions are recorded, such as that of Admiral Álvaro Alberto de Motta e Silva, the Brazilian representative at the United Nations Atomic Energy Commission, in 1947, when he sent a document with 10 points for the creation of a Brazilian nuclear programme.

In January 1951, the National Research Centre (CNPq in Portuguese) was created, with Álvaro Alberto as president. Responsible for the formulation and coordination of science and technology policies in the country, the agency was charged with creating a nuclear programme. In November 1953, President Getúlio Vargas approved the purchase from the German Federal Republic of three ultracentrifuges for the isotopic separation of uranium. The export of the ultracentrifuges, however, was not authorised by the United States Atomic Energy Commission (USAEC), since the territory of the GFR was controlled at the time by the allied powers - the equipment would only arrive in 1957.

In 1955, important activities occurred in the nuclear field, starting with Brazil's participation in the negotiations for the creation of the International Atomic Energy Agency (IAEA) and the signing of agreements with the USA, such as the Cooperation for the Civil Uses of Nuclear Energy and the Joint Cooperation Programme for the Recognition of Uranium Resources in Brazil. A contract was also signed for the acquisition of the IEA-R1 Nuclear Research Reactor by the CNPq's Atomic Energy Commission. However, the year was marked by the exoneration of Álvaro Alberto from the presidency of CNPq.

In January 1956, the Atomic Energy Institute (IEA, later Ipen) was created. In August, the then President Juscelino Kubitschek approved the Governmental Guidelines for the National Nuclear Energy Policy and, two months later, the National Nuclear Energy Commission (Cnen) was created.

The nuclear sector experienced a great expansion in the following decades. In October 1967, during the period of the military regime, the National Security Council took the initiative to establish a national nuclear energy policy. The 1st National Development Programme (PND in Portuguese) from 1972 to 1974 established goals for the National Nuclear Energy Programme (PNEN in Portuguese). In June 1975, the Brazil-Germany Nuclear Agreement was signed. In 1976, the Programme for the training of personnel for the Nuclear Sector (Pronuclear) was created.

In March 1979, the controversial autonomous/parallel nuclear programme started, which ended up being the target of Congressional Committee hearings in 1990. In 1979, the laser isotopic separation programme was also started, through an agree-

> In 2005, an inter-ministerial group elaborated a new programme with investment proposals in different areas, which totalled, in current values, R$ 125 billion over 10 years

ment with Ipen, the Aerospace Technical Centre (CTA in Portuguese), and Unicamp. In the following year, Ipen signed an agreement with the Navy to develop nuclear propulsion technology for submarines.

In February 1985, President-elect Tancredo Neves received a document from the National Security Council on the autonomous/parallel nuclear programme. In July 1987, a meeting of the Brazilian Society for the Advancement of Science (SBPC) called for shutting down the parallel nuclear programme due to suspicions of the production being diverted towards nuclear weapons.

In 1988, the year the Constitution was promulgated, changes were also made to the nuclear sector. In August, the Aramar Naval Technical Centre was inaugurated, in Iperó (SP), and the reformulation of the nuclear programme was announced, with the strengthening of Eletrobras. The Council for Nuclear Policy was also created to advise the President on nuclear policy.

In March 1990, a working group was created under the coordination of the Secretary for Strategic Affairs (SAE in Portuguese) of the President's Chief of Staff Office to study the necessary measures regarding nuclear policy. But, contradictorily, four years later, the Minister for the Navy, Ivan Serpa, lowered the priority of the nuclear programme from 1 to 18.

In December 1997, Eletronuclear was created from the merger of the nuclear area of Furnas with Nuclen.

In 2005, an inter-ministerial group coordinated by the Ministry of Science and Technology (MCT in Portuguese) elaborated a new programme that promised to establish a plan for the nuclear sector by 2022, the limit of the Federal Government's energy planning. The group consisted of six other ministries: Mines and Energy, Defence, Foreign Relations, Planning and the President's Chief of Staff Office. The institutions that manage the nuclear sector also took part: the National Nuclear Energy Commission (Cnen), Eletronuclear, Brazil Nuclear Industries (INB), Nuclep and the Naval Technical Centre in São Paulo (CTMSP). Among the recommendations forwarded to the Presidency was the creation of a Permanent Management Monitoring Group (GPA), with the function of monitoring the implementation of the plan's actions and evaluating actions that would be taken as of 2009.

In current values, the proposals totalled investments of R$ 125 billion over 10 years, with the following targets:

- Immediate resumption of work on Angra 3, which ended up happening in 2007, and construction of four more nuclear power plants;
- Construction of the new reactor for radioisotope production;
- Implementation of a repository for waste;
- Complete the first phase of implementation of the uranium enrichment plant in Resende and expand it to meet 50% of the demand of Angra 1, 2 and 3;
- Creation of a fund to support research and development in the nuclear area.

In 2006, the first of the ten cascades that CTMSP ordered from INB was inaugurated. Furthermore, the Constitutional Amendment 49/2006 was created, which removed the state's monopoly over the production, marketing and use of short half-life radioisotopes for medical, agricultural and industrial uses.

In 2007, the government released R$ 1.04 billion for uranium enrichment and the National Energy Policy Council (CNPE in Portuguese) authorised the resumption of construction of Angra 3, which took place in 2010.

The proposal put forward by the inter-ministerial group in 2005 resulted in the creation of the Development Committee of the Brazilian Nuclear Programme (CDPNB in Portuguese), linked to the President's Chief of Staff Office, on 2th July 2008. In 2016, responsibility for the coordination of the committee was transferred to the Office of Institutional Security (GSI in Portuguese) of the Presidency of the Republic.

On 5th December 2018, Decree 9.600 was issued, which "Consolidates the Guidelines on Brazilian Nuclear Policy". Decree 9.828, of 10th June 2019, restructured the CDPNB, establishing as its responsibility: the formulation of public policies regarding the nuclear sector and proposing improvements to the Brazilian Nuclear Programme; and the supervision of the planning and execution of joint actions of agencies and entities regarding the development of the Brazilian Nuclear Programme.

Brazilian Nuclear Programme Frame of Reference

Article 1 of Decree 9.600 states that Brazilian Nuclear Policy "aims to guide the planning, actions and nuclear and radioactive activities in the country, in compliance with national sovereignty, with a view to development, protection of human health and the environment."

According to Decree No. 9.600, Brazilian Nuclear Policy is a legal framework for the Brazilian Nuclear Program and allows for the restructuring of the governance of the Brazilian nuclear sector. Among its guidelines, the following stand out: the search for national technological autonomy; international cooperation for the peaceful use of nuclear technology; the incentive to add value in the production, especially for export and the incentive achieve the economic sustainability of the projects in the nuclear sector.

Among the objectives of the Brazilian Nuclear Policy are: preserve control over nuclear technology; meet the decisions of the energy sector, by way of nuclear power generation; expand the medical use of nuclear technology; update and maintain the structure of the nuclear sector, bearing in mind the areas of operation of its agencies, in order to ensure integration, effectiveness and efficiency, in addition to avoiding overlap and accumulation of conflicting attributions; foster research, development and innovation in nuclear technology; foster and encourage the national production of nuclear ores and their by-products; guarantee autonomy in the production of nuclear fuel on an industrial scale; encourage continual training and the establishment of human resources in the sector and guarantee the safe management of radioactive waste.

CDPNB

The mission of the CDPNB is to advise the President of the Republic on the establishment of guidelines and goals for the development of the PNB and to supervise its implementation. The Committee is coordinated by the GSI and made up of 10 other ministries: The President's Chief of Staff Office; Defence; Foreign Affairs; Economy; Agriculture, Livestock and Food Supply; Education; Health; Mines and Energy; Science, Technology, Innovations and Communications; Environment.

The detailing of the Brazilian Nuclear Program was carried out by work groups, formed by specialists and headed by the ministry with most involvement within the specific area under analysis. Thus, the Ministry of Mines and Energy led the working group in charge of studying increasing flexibility within the uranium mining monopoly. The Ministry of Health was in charge of the work group studying ways of increasing flexibility within the production of radioisotopes for medicine. The technical groups' proposals are analysed by the ministers or their representatives in the CDPNB's plenary meetings which are held annually. Once ratified, the measures begin to be implemented.

Technical groups of the CDPNB - Concluded

NO. COORD.	PURPOSE	FINAL PRODUCT / STATUS
GT-1 GSI/PR	Draw up the proposal for the Brazilian Nuclear Policy (PNB)	Publication of the Brazilian Nuclear Policy in Decree No. 9.600 5th December 2018. The purpose of this policy is to guide the planning, the nuclear and radioactive actions and activities within the country, in compliance with national sovereignty, with a view to development, protection of human health and the environment.
GT-2 MME	Analyse the desirability of relaxing the state monopoly on the research and exploitation of nuclear ores	Increasing flexibility within the research and mining monopoly was considered desirable, provided it is implemented in stages and under specific conditions that preserve the national interest, requiring adaptation of the legal framework. Detailing this process of increasing flexibility was the main objective of a new technical group.
GT-3 MCTI	Analyse the desirability of relaxing the state monopoly on the production of radiopharmaceuticals	Enactment of Constitutional Amendment (EC) No. 118/2022, by the National Congress, which gives new wording to item XXIII, art. 21 of the Federal Constitution /1988, and increases the flexibility within the Federal Government's monopoly on the production of radioisotopes for medical research and use.
GT-4 MS	Prepare the proposal for the National Nuclear Medicine Strategy	Development of the proposed National Strategy for the Expansion of Nuclear Medicine, aimed at promoting increased access nationwide by the Brazilian population to nuclear medicine services for diagnosis and treatment of diseases. The document is in progress and under analysis within the Ministry of Health.

NO. COORD.	PURPOSE	FINAL PRODUCT / STATUS
GT-5 MCTI	Present the actions to separate with CNEN the regulatory functions from those of promotion and development	Approval of Law No. 14.222, of 15th October 15 2021, which created the National Authority of Nuclear Security (ANSN), a federal regulatory body with its own assets, administrative, technical and financial autonomy, split-off from the National Nuclear Energy Commission (CNEN). ANSN's institutional mission is to monitor, regulate and inspect the nuclear safety and radiological protection of nuclear activities and facilities, nuclear materials and sources of radiation within the national boundaries, under the terms set out in Brazilian Nuclear Policy and the federal government's guidelines.
GT-6 MME	Stimulate research and the mining of ores, aimed at the Brazilian nuclear sector	Publication of Provisional Measure no. 1.133, dated 12th August 2022, which provides for Brazilian Nuclear Industries plc and for research, mining and the sale of nuclear ores, their concentrates and derivatives, and nuclear materials. The text of the PM, initially drafted within the scope of GT-6, aims to boost nuclear ore extraction activity in Brazil, so as to encourage and attract private investments and to provide greater legal security to these activities, with the strengthening of regulation, nuclear safety, protection of the environment and of the population, as well as to contribute to the social and economic development of the country.
GT-7 MAPA	Boost the application of nuclear technology in agriculture and livestock rearing	Preparation of a business plan by an independent consultant hired by MAPA, aimed at the installation and sustainable operation in Brazil, in order to promote the use of this technology in agricultural products.
GT-8 MCTI	Establish guidelines and goals for the development of the National Repository for Low and Medium Level Radioactive Waste (RBMN)	Governmental coordination to bring about the Nuclear and Environmental Technology Centre (CENTENA in Portuguese), which will house the National Repository of Low and Medium Level Radioactive Waste.
GT-9 MEC	Boost the training of human resources for the Brazilian nuclear sector	The development of a network structure for capacity building the nuclear sector including universities, research institutes and operators.
GT-10 GSI/PR	Stimulate the regulatory environment for the development of the Brazilian nuclear sector	Mapping of existing regulatory impediments within the activities of the nuclear sector, with a view to establishing guidelines to bring about the revitalization of this area. Integration and implementation of updates and improvements to the regulatory and legal framework of activities of agencies and entities related to the nuclear sector.
GT-11 MME	Promote the strengthening and integration of social communication activities, focused on the development of the Brazilian nuclear sector.	Drafting and approval of the social communication plan for the Brazilian nuclear sector, establishing guidelines and actions to implement synergic and integrated social communication among agencies and companies within the Brazilian nuclear sector.

PR = President's Chief of Staff Office | GSI = Office of Institutional Security | MME = Ministry of Mines and Energy | MAPA = Ministry of Agriculture, Livestock and Food Supply | MEC = Ministry of Education | MS = Ministry of Health | MCTI = Ministry of Science, Technology and Innovation

Source: CDPNB/GSI

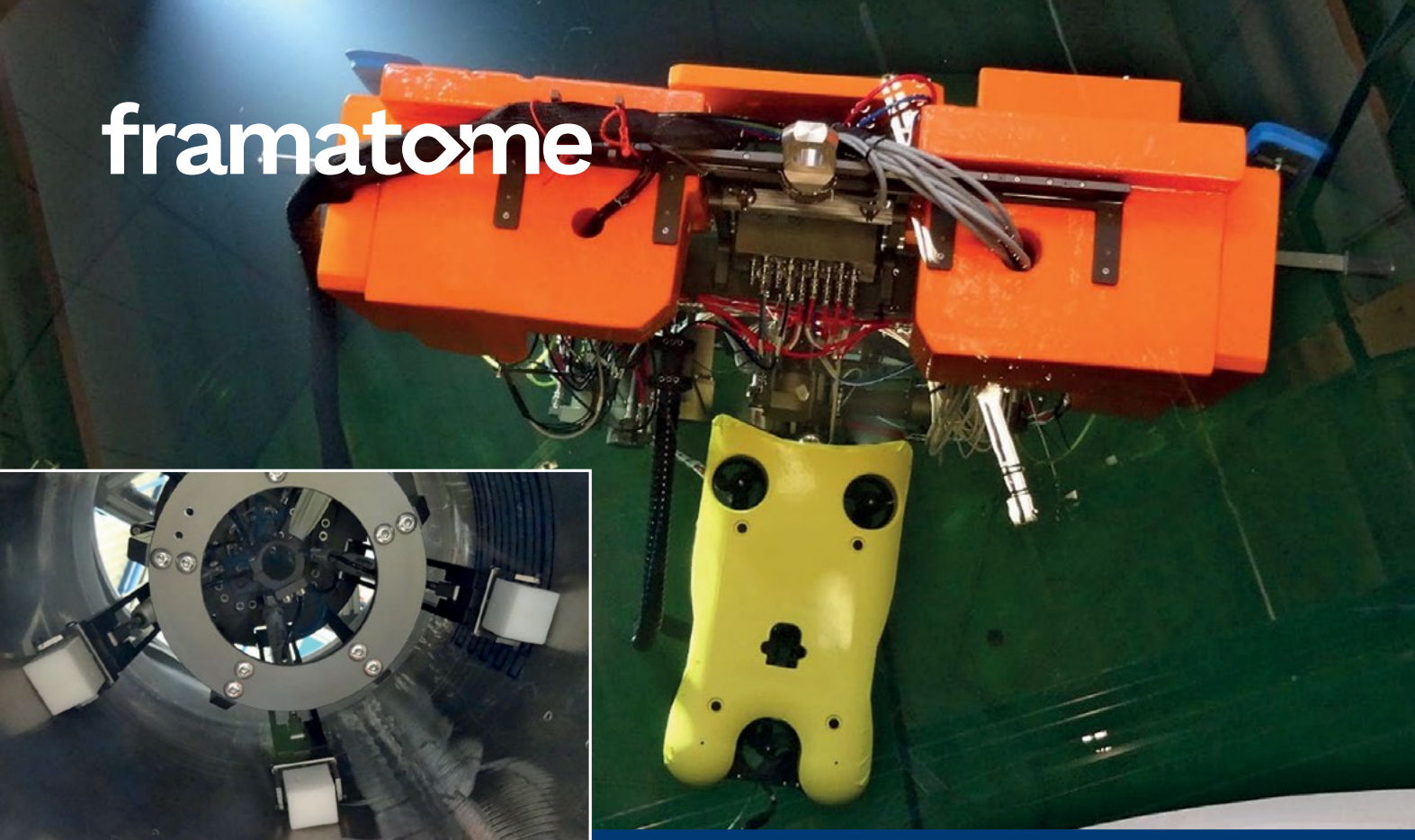
Working through Science, Technology and Nuclear Power to develop Brazil.

ABEN

ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR

www.aben.com.br

framatome



Reactor Pressure Vessel Nozzles NDE at Nuclear Power Plants with reliable, precise and portable underwater manipulator

Framatome is a major international leader in the nuclear energy market recognized for its innovative solutions and value-added technologies for designing, building, maintaining, and advancing the global nuclear fleet. The company designs, manufactures, and installs components, and fuel and instrumentation and control systems for nuclear power plants and offers a full range of reactor services.

With 15,000 employees worldwide, every day Framatome's expertise helps its customers improve the safety and performance of their nuclear plants and achieve their economic and societal goals.

The examination of nozzle and RPV welds is usually on the critical path during a power plant's outage. Tight and multi-tasking outage schedule requires from RPV in-service inspection (ISI) team application of a lightweight and portable system which can be set up, maneuvred and removed quickly to enable shortest possible vessel occupation.

For more information about Framatome's inspection solutions, visit us at:

To discover more, visit us at
www.framatome.com/solutions-portfolio

Your performance
is **our** everyday **commitment**

www.framatome.com