Conexão Nuclear

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Passing the torch

State-owned ENBPar is born with the challenge of leading construction works on future nuclear plants in the country

Synergies between sources

Collaborative model between nuclear and renewables can help Brazil achieve decarbonization goals

Agriculture + Nuclear Plan

Government will launch measures to boost investments in food irradiation in the country

Nuclear, the sector of opportunities

Interview with Mines and Energy Minister Bento Albuquerque

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Contents

THE BUTTERFLY EFFECT

The Butterfly Effect is a 2004 film that deals with the chaos theory, which states that a small action in one part of the world can generate a big event in another part. It is an idea about the unpredictability of events.

Although it is not like in the movie, not long ago there was a case of the butterfly effect, in which events in Kazakhstan affected the entire world nuclear energy production chain. And that happened at a time when many countries are announcing new investments in nuclear power plants, mainly boosted by COP26, which brought to light the importance of strongly considering the use of thermonuclear generation as a way of reducing greenhouse gases emissions.

In the current scenario, there are 52 reactors under construction in 19 countries, which will add 54 gigawatts of installed capacity, and the list is expected to grow a lot in the coming years.

French President Emmanuel Macron has announced the construction of six new nuclear reactors and the possibility of adding eight more to achieve carbon neutrality by 2050.

United States President Joe Biden has called it a "decisive decade" for tackling climate change, and has announced that they will cut carbon emissions by 50-52% below 2005 levels by 2030, which will require nuclear power plants to play an important role.

China has announced the construction of 150 reactors in 15 years; Canada has a program to build small modular reactors (SMRs); England, through Rolls Royce, invests in the development of SMR with a design that allows construction in factories; Europe has approved the green taxonomy for financing new nuclear power plants.

Several factors boost the growth of this form of energy in the world. However, the butterfly effect is always around.

New variables have emerged in the existing scenario that may boost or hinder the construction of new nuclear power plants.

Europe has already embargoed the construction of the new gas pipeline coming from Russia, which puts Nord Stream 2 on the brink of bankruptcy, and that changes the energy scenario of Europe and the world.

Germany, which has the highest electric power tariff in the world, has already announced action to reassess the plan for decommissioning nuclear power plants.

All that leads us to ask: how the "butterfly effect" of those variables will affect the Brazilian Nuclear Program, especially considering the major current issues of the national electric power sector?

Water crisis, high costs of gas-fired thermal plants, a hydroelectric park in which around 40% of the plants are over 40 years old, the need to increase the security level of the electrical system aggravated by the variability brought about by the increase in solar and wind generation, which have intermittent characteristics, among other factors.

The Brazilian Nuclear Program is going through a defining moment. Angra 1 and Angra 2 are in the process of life extension, Angra 3 is resuming the completion works, the dry fuel storage units are in the process of transferring spent fuel, Brazil's National Energy Plan (PNE 2050) stipulates 8-10 GW of new plants, Brazil's Ten-Year Energy Expansion Plan (PDE 2031) stipulates a new 1 GW plant, the study of new sites has already been announced by Brazil's Mines and Energy Ministry, the Caetité Mine, in Bahia, has resumed operation, the Santa Quitéria Mine, in Ceará, is in the process of legalization, and much more.

There were a lot of struggles to get to this point and now there is a new delicate moment, but we need to keep the Brazilian sector united and focused to make sure we continue moving forward. That is a long-term construction and we still have a long way to go. ▪

ROSATOM'S ACTIVITIES IN EDUCATION

One of today's key trends is sustainable development. This concept, which at first seems very broad, boils down to the need to promote economic and social changes, thanks to which all available resources harmoniously complement each other and work to improve people's quality of life.

The nuclear industry is based on high technology and has several fields, including energy, agriculture, nuclear medicine and others, so it fully meets the requirements of sustainable development.

In this context, we can speak not only of the production of clean, safe and cheap electricity and the use of nuclear technologies for the needs of medicine, industry and agriculture, but also of the infinite possibilities for scientific development that the nuclear industry brings. To deliver that potential, it is necessary not to stop at what has been achieved, constantly expanding knowledge and developing existing skills.

ROSATOM – THE KNOWLEDGE CORPORATION

As one of the largest and most experienced players in the nuclear sector, Russian State Atomic Energy Corporation ROSATOM understands how important it is not only to work for business interests, but also to pay attention to the development of science and the training of new specialists. That is why, in Russia, Rosatom is known as the knowledge corporation.

"Implementation of educational projects and personnel training, in Russia and in other regions around the world where Rosatom is working, including the promotion of Russian education abroad in nuclear and engineering fields, are important areas of our company's activities", says Valery Karezin, director of educational development projects and international cooperation at State Atomic Energy Corporation ROSATOM.

"To achieve those goals, the state corporation develops an educational infrastructure to train personnel for partner countries, supports these countries in creating national education systems for the nuclear field based on already proven Russian programs, and trains foreign students in nuclear specialties at Russian universities", Karezin adds.

It should be noted that this approach allows the state corporation to contribute to achieving the sustainable development goals set by the UN General Assembly in 2015. Especially goals 4. "Ensure inclusive and equitable education and promote lifelong learning opportunities"; 8. "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" and 17. "Strengthen the means of implementation and revitalize the global partnership for sustainable development".

ROSATOM SCHOLARSHIPS FOR FOREIGN STUDENTS

Scholarships offered by the Russian Ministry of Education to State Corporation ROSATOM allow foreign students to study at the National Nuclear Research University Moscow Engineering Physics Institute (MEPhI) as well as at other ROSATOM partner universities, including National Research Tomsk Polytechnic University (TPU), Saint Petersburg State University, Dmitry Mendeleev University of Chemical Technology, National Research University Moscow Energy Institute (MPEI), Far Eastern Federal University (FEFU), Ural Federal University (UrFU), Moscow Institute of Physics and Technology (MIPT), National Research University, "Moscow State University of Civil Engineering" (MGSU) and Bauman Moscow State Technical University (MGTU), Alekseev Novosibirsk State Technical University (NSTU), National University of Science and Technology (MISiS).

"Rosatom scholarships cover the cost of education at the company's partner universities and training at resource centers of Russian nuclear industry companies," says Valery Karezin.

These scholarships are designated not only for students from countries with which the state corporation already has specific projects under way, but also for new partners with whom cooperation is only in the initial phase. In particular, for the academic year 2022/2023, students from Argentina, Bolivia, Brazil, Chile, Dominican Republic, Costa Rica, Nicaragua, Paraguay and Cuba had the opportunity to travel to Russia. In particular, there are five quotas for undergraduate and graduate students in Brazil.

In turn, in 2021, around 2,200 foreign students from 65 countries studied at Russian universities, including students from Armenia, Vietnam, Rwanda, Bolivia, Brazil, Paraguay, Cuba, Uzbekistan, Turkey, Bangladesh, Jordan, Egypt, Algeria, Nigeria, Kenya, Kazakhstan, Congo, Ethiopia, Hungary, Serbia, Bulgaria, South Africa, Ghana and others. As part of the educational program, all foreign students undergo training based on resource centers created by Rosatom's industrial companies.

Today, more than seventy students from Latin American countries are getting degrees in the nuclear field and other related specialties at Rosatom's partner universities with the state corporation scholarships. In addition, the company is actively developing joint educational programs of Rosatom's partner universities, such as MEPhI, TPU, Saint Petersburg State University and Lomonosov Moscow State University, with universities from partner countries including Egypt, Bolivia, Brazil, Ghana, Armenia, Kazakhstan, Rwanda, Germany, Japan and Bangladesh. As part of the development of cooperation with MEPhI, in 2021, more than ten educational programs were implemented together with Rosatom's partner universities, including Egypt, Kazakhstan, Rwanda, Brazil, Bolivia, Armenia, Bangladesh and Serbia.

In April 2019, MEPhI signed a memorandum of cooperation with Brazil's Nuclear and Energy Research Institute (IPEN) and the University of São Paulo (USP). In 2020, an annex to the memorandum on the implementation of the joint master's program "Nuclear technologies" was signed and a similar program was launched as distance learning. As part of this initiative, MEPhI professors offered lecture courses to Brazilian students in English.

Furthermore, in 2018, MEPhI developed and launched joint bachelor's degree programs with Bolivian national universities, allowing part of the educational process to occur abroad (educational modules abroad offered by MEPhI). As part of this cooperation model, MEPhI signed agreements on the implementation of joint bachelor's degree programs (licentiate) with the Bolivian universities of San Andrés (UMSA), on November 10, 2018 ("Nuclear technologies"), and San Simon (UMSS), on October 25, 2018.

Additionally, within the framework of national staff training programs for partner countries, Rosatom, together with its key partner universities and the Rosatom Technical Academy, also conducts short-term advanced staff training courses, called "Train-the Trainers". These courses are designed both for university professors, to create other joint educational programs in the future, and for nuclear infrastructure representatives from partner countries.

In conclusion, we would like to emphasize once again that the nuclear sector, more than ever, needs new ideas from young experts, who should be trained by current experienced representatives of the nuclear industry. ▪

NEW TECHNOLOGY FRONTIER

ADVANCED CONSTRUCTION TECHNIQUES BRING INNOVATIONS AND COST REDUCTION TO NUCLEAR FIELD

As the world moves towards energy transition, many countries are trying to decarbonize their energy matrices. The equation for reducing emissions generated due to energy production will necessarily present an essential variant to that end: the nuclear source. Nations that have already publicly declared their intention to expand this type of generation, such as France, China, the United States and even Brazil, also carefully follow the latest advances and innovations in the sector, including small modular reactors (SMRs). Industry experts say that countries that cross this new technology frontier will be able to meet the growing energy demand with lower emissions. However, to benefit from competitive advantages provided by SMRs, such as cost reductions and faster deliveries, companies and even governments must be ready to deal with new and advanced models of manufacturing and construction.

Advanced reactors, especially SMRs and microreactors, will allow significant improvements in their construction thanks to simplified designs, reduced number of components, advanced materials, smaller size and a smarter model to develop projects. New advanced nuclear power plants are designed to be mechanically simpler than conventional power plants.

ADVANCED REACTORS, ESPECIALLY SMRS AND MICROREACTORS, WILL ALLOW SIGNIFICANT IMPROVEMENTS IN THEIR CONSTRUCTION THANKS TO SIMPLIFIED DESIGNS, REDUCED NUMBER OF COMPONENTS, ADVANCED MATERIALS, SMALLER SIZE AND A SMARTER MODEL TO DEVELOP PROJECTS.

"Standardization is embedded in the design philosophy of advanced companies in the nuclear sector and offers clear opportunities for cost reduction. They include more passive safety systems, more opportunities to use natural circulation and have fewer pumps, valves and other components of current nuclear power plants", explains Carlos Leipner, the vice president of the Board of Trustees of the Brazilian Association for the Development of Nuclear Activities (ABDAN). According to him, the simplest projects will reduce the costs of indirect services, such as on-site and off-site engineering design activities and construction supervision.

Another novelty that will come with advanced reactors will be the concept of modularity, transferring most of the construction and assembly of the plant - if not all - to a model similar to that of a shipyard, known in the market as the "shipyard model". According to Leipner, this concept allows for a highly automated production system for the manufacturing, assembly and installation of nuclear power plant systems and components. "These simplified designs minimize labor costs and enable fast, high-quality modular construction techniques to be applied. Standardization also creates an enabling environment for efficient and effective regulatory oversight, resulting in simplified approvals and reduced regulatory costs over time", he explains.

The vice president of ABDAN's board states that these advanced nuclear projects, after being manufactured and assembled in a shipyard model, will be transported as completed facilities to their final operating destination to be installed and commissioned. Once manufactured and assembled, the plant can be used to produce not only electric power, but also clean hydrogen - which can be stored or transported for industrial or transportation use, or converted into ammonia for other applications, such as maritime transport or even agricultural use.

Leipner also points out another important transformative trend in advanced construction of new nuclear power plants – the digitalization of products and services. For

him, these digital technologies will give new possibilities, from better collaboration to more data-driven decision making. These innovations will change the way companies approach operations, design and construction, and engage with partners. Smart buildings and infrastructure, such as auxiliary buildings for nuclear power plants and supporting structures, that integrate the Internet of Things (IoT) will increase data availability and enable more efficient operations, as well as new business models, such as collaborative, performance-based hiring.

"Companies can increase efficiency and integrate the design phase with the rest of the value chain by using building information modeling (BIM) to create a complete three-dimensional model at the beginning of the project, instead of finishing the project while construction is already underway", he says. He also says that will drastically change the risks and the sequence of decision making in construction projects compared with traditional engineering, procurement and construction (EPC) models. "Automated parametric design and object libraries will transform engineering. The use of digital tools can significantly improve on-site collaboration", he expects.

Lastly, the ABDAN advisor points out that other aspects of manufacturing in the nuclear sector are evolving due to transformative innovation, especially in nuclear fuel manufacturing processes. The expert emphasizes that reactor and nuclear fuel designers, such as Westinghouse and Framatome, created additive manufacturing techniques in the manufacturing process of some nuclear fuel components, some of which are already in operation in reactors in the United States. "In 2017, Siemens replaced the 108mm metal impeller in a fire protection pump at the Krško plant in Slovenia with a 3D printed replica. 3D printing of nuclear fuel components will continue to have a positive impact on the delivery of advanced fuel products," he says.

In light of this progress, the market expectation is that advanced manufacturing techniques will contribute to the deployment of advanced nuclear projects and provide opportunities for the nuclear supply chain in general. This new territory through which the source begins to travel should transform advanced nuclear energy into a more competitive and higher performing solution. "These new techniques and models will result in cost reduction, reduction of risk and uncertainty, greater sharing of responsibilities, among other benefits that reduce the cost of capital and attract more investments for the nuclear sector", Leipner finishes. ▪

PASSING THE TORCH

STATE-OWNED ENBPAR IS BORN WITH THE CHALLENGE OF LEADING CONSTRUCTION WORKS ON FUTURE NUCLEAR PLANTS IN THE COUNTRY

The finish line is already looming on the horizon for all those involved in the completion of the Angra 3 nuclear power plant works. The obstacles to resuming the construction of the enterprise are practically all behind us. We are close to finish that marathon is very close and the responsibility of overcoming the final stretch of this journey will be in the hands of a newcomer to the Brazilian electricity sector. Only three months old, Empresa Brasileira de Participações em Energia Nuclear e Binacional (ENBPar) was created to take over most of the shares of Eletronuclear (operator of the Angra dos Reis Nuclear Power Station) after Eletrobras' privatization. That is because Brazilian legislation determines that nuclear generation is an activity exclusive to the Federal Government. Today, the new company is in the warm-up phase, getting ready for when the torch is passed. It will be up to ENBPar not only to work to complete Angra 3 works, but also to play a crucial role in the construction of the fourth Brazilian nuclear power plant, recently announced in the 2031 Ten-Year Energy Plan (PDE). "ENBPar will play a leading role in these two projects", director-president of the state-owned company Ney Zanella says. With an initial budget of R$ 4 billion, the new company will take more than 50% of Eletronuclear's shares - whose shareholding control is currently fully in the hands of Eletrobras.

"Eletronuclear's shares will be shared with Eletrobras, which will continue as a partner because it has already invested a lot in Angra 3. ENBPar will hold most of the shares, more than 50%, so that we can have the power to control nominative shares. We are going to build this final part of the Angra 3 project together. The plant will be completed through financing, possibly international. In this case, we will be the shareholders responsible for managing this financing, helping Eletronuclear in completing the electro-assembly of Angra 3. We have to inaugurate the plant between the end of 2026 and the beginning of 2027", Zanella explains.

Today, the works on the plant have 67% of physical progress. In February, Eletronuclear signed a contract with a consortium formed by Ferreira Guedes, Matricial and ADtranz to begin work on the so-called "Plan for Acceleration of the Plant's Critical Path". The idea is to advance part of the project (civil works and part of the electromechanical assembly) even before hiring the company that will handle works as a whole.

The director-president of ENBPar's says that efforts are

Empresa Brasileira de Participações em Energia Nuclear e Binacional S.A. becomes active

Photo: Rafael Atuchi/MME

now focused on the completion of Angra 3. However, considering the long-term scenario, the company already knows that it will play a key role to build future new plants in the country, once that the 2050 National Energy Plan (PNE) stipulates an expansion of 8-10 GW in the country's nuclear generation park over the next 30 years. The executive also stress that, even after privatization, Eletrobras will continue to be partners with Eletronuclear. In that case, new controllers who will take control of the company will eventually be able to participate in the projects of these new nuclear power plants - which will be developed through the state-owned Eletronuclear. "But that is still an expectation for the future, because it is an issue that will need to be discussed with the new future shareholders of Eletrobras. Now, it is time to work on Angra 3", he emphasizes.

"ENBPAR WAS BORN AT A GOOD TIME TO CONTRIBUTE TO BRAZIL IN EXPANDING A VERY DIVERSIFIED AND CLEAN ENERGY MATRIX"
NEY ZANELLA,
PRESIDENT OF ENBPAR

Before embracing all future responsibilities that it will have from now on, ENBPar now looks at its internal structure, outlining how it will work and the size of its staff. Currently, the company has ten employees. This small initial group is working on the initial structuring of the company, building pillars such as governance, strategic planning, ombudsman, audit and sustainability. ENBPar is also getting the necessary accreditations at Brazil's Electricity Regulatory Agency (Aneel) and at the Chamber of Electric Energy Commercialization (CCEE).

In addition to its role at Eletronuclear and the Angra do Reis Nuclear Power Station, the new state-owned company will be managing the Brazilian side of the binational Itaipu hydroelectric plant, located on the Paraná River. ENBPar will also be responsible for leading some government initiatives, such as the National Electric Energy Conservation Program (PROCEL) and Mais Luz para a Amazônia (a program for access to electric power in Amazon remote regions). The company will also be responsible for managing contracts for the commercialization of energy produced by enterprises contracted under the Alternative Electricity Sources Incentive Program (PROINFA).

"As for the case of Itaipu, we are going to acquire the entirety of Eletrobras' shares in Itaipu Binacional. As soon as the company is privatized, we will be responsible for the commercialization of the plant's electricity. Eletrobras will work with us in this initial period, so that we have the appropriate structure for that", Zanella explains. "As for government programs, Eletrobras will have a period of one year to transfer all those initiatives to ENBPar", he adds. The future technical staff of the newly created state-owned company will undergo training courses offered by Eletrobras itself, in preparation for taking on all those functions.

With that to-do list in mind, Zanella reports that the company is now working on deciding the final size of its workforce. "We are going to take to the Board of Directors the proposition for organizational structure and a functions plan, which will define the initial staff of ENBPar, in order to face its numerous responsibilities", he explains. The director-president preferred not to provide figures, but stressed that the idea is to organize a very lean company. "We believe that the company should be in full swing as soon as the one-year period given to Eletrobrás to transfer all activities of its public policy programs, which are many, ends," he adds.

In addition to concentrating efforts on the governance of Eletronuclear and Itaipu, the company must also seek capital to make new investments, always considering the Brazilian strategy of expanding the share of clean energy in its energy matrix. "This will be our flagship. Our main focus is to contribute to the government's policy of expanding a clean energy matrix. ENBPar will work hard to expand nuclear generation. That means that Brazil will be more structured for new and future water crises. We are watching the world turning its eyes to this kind of clean, zero-emissions generation. ENBPar was born at a good time to contribute to Brazil in expanding a very diversified and clean energy matrix", he concludes. ▪

NUCLEAR, THE SECTOR OF OPPORTUNITIES

INTERVIEW WITH MINES AND ENERGY MINISTER BENTO ALBUQUERQUE

Brazil sees the nuclear source as part of the solution to energy challenges that the country will face in coming years. That is what Mines and Energy Minister Bento Albuquerque says in a special interview to Conexão Nuclear. Leading the ministry since 2019, Albuquerque led important measures that will help unlock new investments for the segment. Looking to the future, the minister points out some initiatives that are being discussed by the government, such as choosing new sites and the flexibilization of uranium mining. In addition, Albuquerque also talks about the resumption of Angra 3 and the possibility of building small reactors in the country. Lastly, the minister details ongoing efforts to attract investment and emphasizes the importance of private sector participation in the future of the national nuclear industry.

1 - One of the main legacies so far in your administration at the Ministry was indicating 8-10 GW of new nuclear generation in Brazil's 2050 National Energy Plan (PNE). What will be the best way for the country to achieve that number?

The world is experiencing an energy transition process with the decarbonization of energy matrices of many countries, in which energy sources with high levels of greenhouse gas (GHG) emissions are being replaced by sources with low (or even zero) emissions of these gases.

In Brazil, we should be proud for having 50% of our matrix coming from renewable sources, but we will not stop there. Our goal is to increase the share of clean energy sources in our energy matrix.

To that end, we still have many challenges to overcome. We depend heavily on hydroelectric sources, which are more susceptible to the impacts of climate change. The worst drought in more than 90 years faced by the country in 2021, which increased the cost of electric power, exemplifies that.

In that international and national scenario, we already know that nuclear power is part of the solution. The thermonuclear source offers many advantages that make it a sustainable option to compose the basic, firm and constant energy sources to guarantee the energy security that our country needs, especially at this time of resumption of growth, after the negative effect of COVID-19 on economy.

We cannot forget that nuclear power will be important for the decentralization of energy, allowing the installation of reactors close to consumer centers, reducing costs and losses due to long-distance energy transportation.

Knowing all of that, the ministry is working to provide legal certainty and create investment opportunities that make thermonuclear generation more economically competitive. That involves easing the monopoly to build and operate those plants.

In addition, Brazil is privileged. We have an abundance of nuclear ore and we are at an advanced stage of making partnerships for nuclear ore mining viable. We also master all the technology needed to produce fuel. Thus, we are in a position to develop, together, both thermonuclear generation and the previous stages of the nuclear fuel cycle. It will be a win-win relationship that will benefit the entire production chain.

2 - The government took a decision, unprecedented until then, to put a new nuclear power plant in the 2031 Ten-Year Energy Plan. What will be the government's next steps to deliver that plant in time?

Defining the location will be the first step to be carried out to make the next plant after Angra 3 feasible. These studies are important to subsidize and lead to the most efficient choice. We will also take this issue to be widely discussed by public agencies in the nuclear sector, by representatives of academia and society.

Our goal is to work on a joint construction, addressing the multiple aspects that are involved in the feasibility of a new nuclear power plant. In addition, the assessment of what will be the reactor model will also be part of that discussion, given the technology progress that the world and Brazil have achieved in this field.

3 - An important aspect to get this new plant off the drawing board is defining the financing model. When should debates on this aspect begin inside the ministry or Brazil's National Council for Energy Policy (CNPE)?

The construction of new plants involves multiple aspects. We deal with one of them, which is defining the location. Furthermore, we understand that it is necessary to create an attractive legal and economic environment for private investment.

Therefore, this matter will be analyzed by a high-level technical group, with the goal of creating propositions to loosen construction and operation of reactors for thermonuclear power production.

It is also worth mentioning that, when talking about nuclear reactors, we are not always talking about reactors of the size of those in Angra. Nuclear technology is one of the technologies that has advanced the most over the last few decades. This way, reactors of the near future will be compact models, with little recharging frequency and quite flexible in terms of installation location. These characteristics are fantastic for a country with continental dimensions like Brazil, which needs to guarantee full access to electric power for its population.

This type of reactor may play an essential role in guaranteeing energy security for supplying isolated systems, avoiding complications in the supply. Our goal is to bring electric power to all corners of Brazil. Access to electric power means access to health services, education, work, leisure, in short, it means quality of life and an increase in the Human Development Index (HDI) of a community. Our work is to improve the quality of life of the Brazilian population.

4 - To build new plants, it is necessary to select new sites. What has the Mines and Energy Ministry been doing to carry out studies of suitable locations for these plants?

Defining new nuclear sites encompasses many variables. One of them is choosing the place where the project will be implemented. That choice involves carrying out studies that assess geological, hydrological and hydrogeological, climatic, demographic aspects, as well as matters about energy demand, among many others. It is a detailed work to list the most favorable places.

To that end, the ministry is working to begin studying, alongside other actions that are also in progress, with the goal of creating attractive conditions for the participation of the private sector in building and operating those reactors for electric power generation.

5 - It is crucial for Brazil to discuss the construction of new plants, but it is equally important to complete the Angra 3 plant. Can you tell us what the next steps will be for resuming the project?

The studies for implementing the model for resuming construction works at Angra 3 are being carried out by the Brazilian Development Bank (BNDES), which will indicate the updated cost of the project and define the energy price, to be submitted to the National Council for Energy Policy (CNPE), for a new contract.

It will be up to the CNPE to authorize the new granting act and commercialization contract for the plant. To that end, the Mines and Energy Ministry has been monitoring BNDES' work, through an Interministerial Committee, which have the Institutional Security Office of the Presidency of the Republic (GSI/PR) and the Ministry of Economy (ME) in its composition.

It is also worth mentioning the importance of Act 14.120/2021, which is a legal milestone for the nuclear sector, as it contains the necessary guidelines for the resumption of Angra 3 works.

Therefore, we can say that we are in the final phase of the resumption of Angra 3.

6 - Regarding the desire to expand the Brazilian nuclear generation capacity, how do you see the participation of the private sector in the construction of new plants?

Private sector participation in the construction and operation of new plants is essential. Knowing that, the ministry is working to create a legal environment and economic attractiveness to attract those investors.

Creating those propositions is our next step towards loosening the construction and operation of reactors for thermonuclear power generation.

7 - Leading the ministry, you had to face the worst water crisis of the century in our country. In your opinion, what will be the role of nuclear power as Brazil may face new periods of scarcity of rain in the future?

Nuclear power is part of the solution to ensure stability in power supply, especially in times of climate instability.

In 2021, we had the worst drought in more than 90 years. Unfortunately, if confirmed, higher temperatures forecast will bring new challenges for Brazil and the world. These water crises will be constant and it will be up to us to create solutions to guarantee the supply of firm energy to the population, as we know the impacts of lack of power supply in citizens' lives.

Thus, due to its characteristics, the expansion of nuclear generation will bring greater reliability to the Brazilian electric matrix.

And plans to expand thermonuclear power generation are under development around the world. Even in Europe, France is working to have nuclear energy labeled as a green source. This will facilitate access to investment for low-carbon energy generation.

Here in Brazil, we are keeping an eye on those opportunities, from attracting investments, access to credit lines for generation sources with low emission of greenhouse gases, to benefiting from hydrogen generated by reactors.

8 - Could you tell us about what the government has been doing so far to boost national uranium production, already considering the future increase in demand for nuclear fuel in the country?

We are thinking about the development of the Brazilian nuclear sector in an integrated way. Here at the Mines and Energy Ministry, the focus is on areas of our field, notably mining and thermonuclear generation.

But the sector has several other areas and activities. We can mention, for instance, the work developed by the Institutional Security Office of the Presidency of the Republic (GSI/PR) in the coordination of the Development Committee of the Brazilian Nuclear Program (CDPNB). This committee has been working to promote projects and meet demands of many areas of our nuclear sector.

The uses of nuclear technology are in our daily lives. Whether it is a scintigraphy for the diagnosis or treatment of diseases, such as cancer, or in the irradiation of food to prevent proliferation of fungi and increase the shelf life, among many other uses.

All those applications require uranium. We have the Brazilian Multipurpose Irradiator project, which will supply the radiopharmaceuticals necessary for medical uses. We have irradiator projects for food and many hospital products, for instance.

To that end, a proposition to loosen uranium mining will soon be sent. Today, that activity is developed only by Indústrias Nucleares do Brasil (INB) company. However, our goal is, still in the monopoly scenario, to create conditions for private sector participation. And we are not just talking about uranium mining itself. That includes the use of waste that contain economic quantities of nuclear ore.

In short, we have many opportunities for partnerships with the private sector and we also have domestic and foreign demand for this nuclear ore production.

Lastly, I would like to point out that at the Mining Week event, held in February this year, state-owned Geological Survey of Brazil (CPRM) presented the first product produced under the Uranium project in Brazil. This is the resumption of geological research on a national scale, with the first map of mineral potential produced since the late 1970s.

This data will be available soon and will be used for the development of new uranium mining projects and investment attraction.

9 - Another important achievement of your administration at the Mines and Energy Ministry is the National Hydrogen Plan (PNH). How does the ministry see the possibility of using our nuclear potential for large-scale production of clean hydrogen?

Brazil has the potential to become a major producer and exporter of green hydrogen in the future. For that, we are investing in research and development programs, especially with the distribution of resources from programs of research, development and innovation (RDI) groups of Brazil's Electricity Regulatory Agency (Aneel) and the National Agency of Petroleum, Natural Gas and Biofuels (ANP). We already have some projects planned, including the purification of hydrogen generated in the Angra plant reactors. This shows the versatility of nuclear energy, which can provide, as a by-product, more clean energy.

10 - How has the government been working to balance intermittent sources with firm generation? And, in this context, could you talk about the importance of the nuclear source to guarantee the country's energy security?

In 2021, Brazil updated its Nationally Determined Contribution (NDC) target, pledging to reduce emissions by 37% in 2025 and by 50% in 2030, based on 2005 emissions. That is the result of our efforts to promote renewable source projects, such as wind and solar.

Compared with other countries, in terms of carbon emissions, to produce 1 MWH, the Brazilian electricity sector emits about 1/3 of the value emitted by the European Union, 1/4 of what is emitted by the North American electricity sector and 1/7 of what is emitted in the Chinese electricity sector. In 2020, renewable sources accounted for 85% of the electric power supply.

Even so, mainly due to the water crisis that we faced last year, we understand that, in order to sustain the network regardless of the climate situation, basic energies are essential. They are the ones that will guarantee our security in the supply of electric power, which shows the reliability of our energy matrix.

And, in this context, nuclear power is important to diversify the Brazilian energy matrix, mainly as a basic energy source, since it is not affected by climate fluctuations. And, in addition, thermonuclear generation will also be essential to avoid increasing greenhouse gas emissions, especially in times of water crisis, when it is necessary to activate other energy sources that emit these gases.

11 - The nuclear sector has gone through an intense reorganization over the last three years. The highlights here, without a doubt, are the creation of Brazil's National Nuclear Security Authority (ANSN) and the Empresa Brasileira de Participações em Energia a Binacional (ENBPar) company. What were the major challenges in this process to restructure the sector?

The separation of regulatory, promotion and stimulation powers from the National Nuclear Energy Commission (CNEN), which culminated in the creation of the National Nuclear Safety Authority (ANSN), was a breakthrough achieved by the country.

It was the result of the current administration's work to deal with a demand pleaded for more than 30 years by society and meet the highest international requirements that advocate the segregation of inspection of the execution and use of nuclear energy.

It is also worth noting that the creation of the ANSN represents a new legal milestone of the nuclear sector in terms of regulation, standardization, licensing, control and inspection of nuclear activities in Brazil and shows the Brazilian government's commitment to strengthening public institutions and meeting the commitments made with the International Atomic Energy Agency (IAEA).

12 - Could you say something to Brazilian and international companies of the nuclear sector that operate in the country?

The Brazilian nuclear sector is transversal, growing and offers several opportunities. The Federal Government understands the importance of private sector participation in this industry and it is working to create the necessary conditions to attract that investment.

In addition, we have made significant progress towards the governance of the nuclear sector, especially in the regulatory and normative fields. We are also working to reduce bureaucracy, reduce regulatory obstacles and correct overlaps of roles between regulatory bodies.

Thus, I can tell people that nuclear technology will be used to generate jobs, income, produce electric power, diagnose and treat diseases and make Brazilian people's lives better. The nuclear sector will be the sector of opportunities. ▪

TIME TO MAKE A FINAL DECISION

GOVERNMENT CONSIDERS BIDDING IN NUCLEAR SECTOR AND MARKET EVALUATES SCENARIOS

At the beginning of the millennium, Brazil launched a mechanism within its electricity sector that forever transformed the way in which consumers purchased electricity – energy auction. Almost two decades since the first event, in 2004, this tool is already well established as a means of bringing predictability to investors and, at the same time, guaranteeing more affordable prices to consumers. Considering bidding processes carried out so far in our country and the types of projects registered in them, it is possible to see the plurality of Brazilian energy resources. From solar and wind, through natural gas, coal, fuel oil and reaching sugarcane bagasse – all of them are sources that have already been acquired by the government through those auctions. Now, a new name could be on that list in the coming years. Mines and Energy Minister Bento Albuquerque said during his participation in the United Nations Climate Change Conference (COP-26), in Glasgow, that Brazil could start to contract new nuclear power plants from processes aimed at this type of generation. According to him, these bidding processes could take place between 2023 and 2025. There are reasons for that decision. The desire to reduce greenhouse gas emissions and the need to guarantee reliability in the electricity system make it a natural choice. Since the minister's speech, members of the sector and industry experts have been discussing the best way to enable the inclusion of nuclear in future bidding processes.

For Adriano Pires, director of the Brazilian Infrastructure Center (CBIE), introducing the nuclear source into energy bidding processes is part of the effort that the government must make to make our electricity system less climate dependent. As it is known, Brazil experienced a dramatic water crisis in 2021, forcing the country to take emergency measures to avoid a traumatic energy rationing. "What we need is to make the Brazilian electricity matrix more reliable. We can do this by slightly increasing the share of dispatchable sources, which are the thermal ones – both nuclear power plants and those powered by natural gas", the expert says.

The Brazilian electricity sector has been facing a dilemma over the last few years. On the one hand, the country stopped building new hydroelectric plants. Meanwhile, the installed capacity of intermittent wind and solar sources grows year after year - together they rank second among the largest providers of electric power in the country. The most recent figures from the government itself help to better understand this scenario. According to the last Monthly Energy Bulletin of the Mines and Energy Ministry, hydropower went from 65.2% of share in the domestic supply of electricity in 2020 to 56% in 2021. In the same period, wind and solar have jumped from 10.5 % to 13.1%. Given that scenario, Pires warns. "Renewable energies are undisciplined, because they only generate when nature allows it. I have always advocated that we should increase the share of nuclear thermal plants in the Brazilian electricity matrix, as it is a reliable source", he says. "Nuclear is a source that could enter capacity auctions, with energy contracts. A characteristic of this source is that it generates at the base of the system. And operating at the base, the nuclear can work as a virtual battery, allowing the expansion of renewable energies and, at the same time, providing reliability to the system", Pires assesses.

In the United States, for instance, auctions for acquiring capacity are already a reality. In February last year, the Independent System Operator of the New England region - which encompasses the states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont - conducted an auction that resulted in the acquisition of 34,621 megawatts (MW) for the period between 2024 and 2025. Of that number, a portion of 3,326 MW corresponds to nuclear capacity. Also in the United States, in June 2021, the PJM Interconnection auction resulted in the addition of 4,460 MW of atomic capacity for the period between 2022 and 2023. PMJ coordinates energy sales in 13 states and the District of Columbia.

In Brazil, if the idea announced by the Mines and Energy minister was taken off the drawing board, this would be the first time that the nuclear would participate in auctions. Although the government does not yet have a design in hand of what this event would look like, the market is already starting to sketch some ideal scenarios, always focusing on attracting private investors. The founding partner of Volt Robotics, Donato da Silva Filho, says that, initially,

REASONS FOR NUCLEAR SOURCE IN ENERGY AUCTIONS

Brazil may start acquiring new nuclear power plants from events for this type of generation. Auctions can take place between 2023 and 2025.

Diversification of the national energy matrix

The current Brazilian matrix is extremely climate dependent. Although the share of hydropower has declined, the share of wind and solar combined has increased. Therefore, the climate dependence dilemma remains.

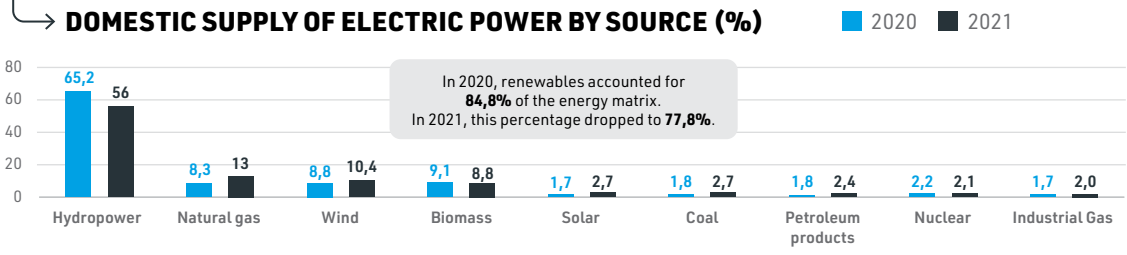
Reduction of greenhouse gases emission

Nuclear power emits only a few grams of CO^2 per kWh of electricity produced. An average value of 12g CO^2/kWh was estimated for nuclear power, similar to wind and lower for all types of solar energy.

Guarantee of constant power supply

The availability factor is one of the great advantages of nuclear. While a nuclear plant generates power for approximately 11 months, wind generates power for only 5 and solar for 3 months.

DOMESTIC SUPPLY OF ELECTRIC POWER BY SOURCE (%)



Sources: World Nuclear and Brazil's Mines and Energy Ministry

the source will need a specific type of contract.

"Nuclear works at the base, always generating power. I think that this auction, if it is going to exist, has to be built as something different from what we have today. Currently, demand from distributors is much lower, due to economic stagnation, the growth of distributed generation and the expansion of the free market. In this scenario, it would be difficult to make an auction of nuclear viable to serve the regulated market. There is little demand and a lot of competition with other sources," he explains. Thus, the executive argues that to make the idea viable, the event should be made for acquiring by all consumers (and not just regulated).

Silva Filho also says that creating an auction for acquiring nuclear would help to develop the industry, strengthening the supply chain. In this way, the selling price of energy could fall over time and, in the future, nuclear could be able to compete with other sources. In this context, he highlights the key role that would be played by small modular reactors (SMRs).

"The SMR issue is a way for the nuclear source to be able to reduce the price of its megawatt-hour (MWh), making it competitive. It is possible to imagine the installation of several of these modules at strategic points in the system where there is electricity need. I think that this technology evolution is super important for the source to be competitive. Furthermore, as nuclear is clean in terms of emissions, it tends to gain a lot of space due to climate goals", he says.

The expert stress that the systemic need for power indicated for Brazil between 2023 and 2027 is 5-7 GW, according to information from the Energy Research Office (EPE), and based on that, he stipulates hypothetical scenarios: "assuming that nuclear would need to have up to 10 reactors to gain scale and competitiveness, it would need to occupy up to 3 GW of that systemic need", he assesses.

The intention to create specific auctions for nuclear also opens up a new horizon of possibilities for financing these ventures, even giving a chance to attracting private investors. This measure would be essential in helping to get the government's goal of achieving an expansion of 8-10 GW generated from new nuclear power plants off the drawing board. The decision to make these events viable is at hand. It is time to make a final decision for the country's energy security. ▪

SYNERGIES BETWEEN SOURCES

COLLABORATIVE MODEL BETWEEN NUCLEAR AND RENEWABLES CAN HELP BRAZIL ACHIEVE DECARBONIZATION GOALS

Brazil's electricity system is going through moments of big changes and transformations. With a genuinely renewable matrix, Brazil has impressive numbers when it comes to generating electricity using clean sources, with low emissions of polluting gases. According to federal energy research company EPE, renewable sources account for more than 80% of total electric power generation in the country. However, the Brazilian system has experienced over the last few years a scenario of hydrothermal transition, in which the expansion of hydroelectric generation is almost stagnant, while the thermal source grows. In parallel, the so-called intermittent energies - wind and solar - have also conquered an increasing share in the national matrix. All this background represents a challenge for the country, which will have to accurately balance that new configuration occurring in the system. At the same time, that scenario is also an opportunity for Brazil to become an example to the world by developing an environment of cooperation between intermittent and basic sources, according to president of Eletronuclear Leonam Guimarães. In the executive's opinion, nuclear could be an ideal partner for renewable energies through a collaborative model between sources, helping the country to achieve its decarbonization goals.

Guimarães says that the need to cut greenhouse gas emissions is increasing, as global warming in-

tensifies, which has caused an increasing number of extreme weather events. Therefore, there are internal and external pressures for low-carbon technologies to be prioritized. Until now, in addition to investments in solar and wind power, Brazil has chosen to activate thermoelectric plants powered by fossil fuels as sources of firm generation - a decision that does not help the country's climate ambitions. But in addition to the environmental issue, engaging thermal plants also has economic consequences.

"There are several issues at stake. Firstly, it is necessary to replace the generation of the most expensive thermoelectric plants, which have been used due to the water crisis that the country has been going through. They are costly both from an economic and environmental point of view", Guimarães states. "At the same time, Brazil needs to expand its electrical system in order to ensure reliable and safe supply. With the increasing participation of renewable variables, it becomes necessary to invest in basic energy", he adds.

Another firm generation option available in Brazil is hydropower. However, the president of Eletronuclear stresses that the country chose to abandon the construction of hydroelectric plants with large reservoirs in favor of run-of-river plants. Meanwhile, the country's water potential is on the way to depletion in the coming decades, and the remaining projects would be restricted to the Amazon region - which present enormous challenges in terms of environmental licensing.

The overall scenario, then, does not seem to work: it is necessary to reduce emissions caused by polluting thermal plants, but the hydroelectric alternative proves to be more difficult to implement. Given this situation, Guimarães believes that the nuclear source is the missing ingredient for the recipe. "Nuclear energy generates firm power, which operates at the base of the system, in a clean and safe way. It is the most adequate generation source to ensure the expansion of the Brazilian electricity matrix in the coming decades", he states.

Given the moment of transition to a hydrothermal matrix experienced by Brazil over the last 20 years, investment in nuclear power will allow the country to increase its installed thermal energy capacity and, at the same time, in combination with variable renewable sources, will help to keep our electrical matrix clean. The idea is that the nuclear source meets the ideal conditions to face the challenges of decarbonization in a collaborative way, working together with variable renewables and other forms of low carbon generation. "A systemic complementarity could be achieved through the use of nuclear power with innovative technologies in areas such as cogeneration, heat and hydrogen production, demand management or the interconnection of ultra-large electric grids", the president of Eletronuclear stipulates.

By building more nuclear power plants, the national electrical system will have more reliability and security of supply to the interconnected system. To that end, Guimarães finds that the 2050 National Energy Plan (PNE), which indicates the construction of up to 10 GW of nuclear generation in the next 30 years, is on the right track. "Brazil cannot give up a source that generates basic energy with a high degree of reliability and low carbon emissions. Furthermore, this is a reality that the rest of the world is being forced to acknowledge," he observes.

GOALS FOR CARBON EMISSIONS AND THE POTENTIAL OF SMRS

Still in terms of the relationship between power generation and decarbonization, the Eletronuclear executive argues that, instead of creating public policies that set goals for the participation of variable renewable energies, increasing costs with grid infrastructure, a better way would be to set carbon generation goals first, so that the country could later identify which electrical system would provide the best cost-benefit ratio. "As the reduction of greenhouse gas emissions is an absolute priority, it makes more sense, from the point of view of electricity sector planning, to have the goals set first", he proposes.

Another topic that the president of the state-owned company discusses is that nuclear power plants can be built in places close to load centers, that is, where power is most needed. That would avoid the construction of long transmission lines to other regions of the country. However, Brazil is not just made of large urban centers. Considering the countryside, Guimarães envisions that small modular reactors (SMRs) can be used in conjunction with renewable energy sources to provide electric power to isolated communities, which today depend on diesel or fuel oil thermoelectric plants.

"SMRs can be used individually or together. In addition, they can be built faster and easier compared with larger nuclear power plants. The power generated by these nuclear reactors would be cheaper and cleaner than fossil fuel-powered alternatives," he concludes. ▪

EYES ON THE FUTURE

TECHNOLOGY DEVELOPMENT IN SECTOR BRINGS CHALLENGES AND OPPORTUNITIES FOR NUCLEAR FUEL PRODUCTION

The world's nuclear energy industry is gearing up to reach new heights in the coming years. Researchers and companies from different countries are designing the next generation of reactors, with technologies that promise to establish a new paradigm in the industry as a whole, both for advantages provided and for subsequent technological challenges from developments. Around the world, experts and executives are practically unanimous in stating that advanced nuclear technologies bring features that are striking, such as modularity and lower capital expenditure. However, those new paths will also require efforts from the nuclear segment supply chain as a whole. To generate power in advanced reactors, several types of nuclear fuels are being studied by the industry. In the midst of this transformation movement, Brazil, which has plans to build up to 10 GW in new power plants by 2050, cannot be oblivious to those developments. Depending on what the country chooses in terms of advanced reactor technologies for its future plants, it will need to prepare its supply chain for this new moment in fuel production.

For the manager of the Nuclear Fuel Center at the Nuclear and Energy Research Institute (IPEN), Elita Fontenele de Carvalho, the world's technology prospects regarding nuclear power will be dominated by the consolidation of new generation III+ reactors, whose first units went into operation in the last two years. The expert also mentions that the development and deployment of the first small modular reactors (SMR) are currently in the process of starting licensing in some countries. The generation IV reactors are still in conception and will need a few decades to be consolidated.

Considering Brazil, Elita observes that the 2050 National Energy Plan (PNE) points out that, after 2030, new projects may be based on PWR (pressurized water reactor), SMRs and generation IV technologies. However, the IPEN manager believes that the most promising technologies for the country in the coming years should be based on generation III+ with parallel construction planning of side-by-side plants, with space for 18 and 24 months, reducing construction costs and sharing the entire construction site infrastructure and workforce. "This was evident in the UAE's construction program, where currently four units are in operation and two are under construction. That model could be used in Brazil, looking for a site with a number of plants to obtain the 10 GWe established in the PNE 2050", she envisions.

The type of technology that will be chosen by Brazil may directly affect the nuclear fuel production chain. Currently, the fuel used in most plants has uranium enriched up to 5%, in technical terms known as LEU (low-enriched uranium). Meanwhile, many advanced reactors and SMRs, as they are designed to operate for long periods without refueling, will require uranium enrichment between 5% and 20% - also known as HALEU (high-assay low-enriched uranium).

Elita says that to ensure a secure supply of HALEU, the current nuclear fuel cycle infrastructure, aimed at commercial nuclear reactors that use uranium LEU at up to 6% concentration, will need to be further developed and more robust. "In addition to all stages of the fuel cycle, we must add an associated transport system, depending on the location of facilities", she adds. "The absence of HALEU production capacity for these applications could delay or even completely prevent these new developments", she points out.

While acknowledging that it is difficult to make accurate predictions about future demand for HALEU, the IPEN expert says that the nuclear industry estimates that it may need around 600 tonnes of this type of fuel by 2030 to deploy new reactors on the market. Even in the face of the challenge of this new technology frontier, the expert says that Brazil already has experience in HALEU production and that this knowledge makes it possible for national production to be an alternative to ensure future availability of this fuel in the country.

Engineer José Augusto Perrotta, technical coordinator of the Brazilian Multipurpose Reactor (RMB) thinks the same. He also believes that Brazil has a unique situation in the development and technology of HALEU, mainly due to the performance of IPEN and other Brazilian institutions in the nuclear chain.

THE DIFFERENT GROUPS OF NUCLEAR REACTORS

Over the last three decades, new concepts and technologies have emerged, resulting in three major groups.

REACTOR GROUP	GENERATION III/III+ REACTORS (EVOLUTIONARY)	SMALL MODULAR REACTORS	GENERATION IV REACTORS (INNOVATIVE REACTORS)
ELECTRIC POWER	**1.000 to 1.600 MWe**	**1 to 300 MWe**	**100 to 600 MWe**
CURRENT STATUS AND CHARACTERISTICS	• There are currently a few options of Generation III reactors developed and operating • It has higher passive technology security functions • It does not require an operator or electronic feedback to safely shut down the plant	• Today there are a few SMRs under construction or in operation • More than 70 SMR and Generation IV projects are under development worldwide • Many possibilities of technologies involved • Reduced cost for power supply in hard-to-reach places • Several of these projects have advanced large-scale manufacturing concept	• Broadly speaking, in little more than a decade we will have reactors of this type working • Waste from these reactors remains radioactive for centuries insteadof millennia • Higher energy performance with the same amount of nuclear fuel • Technologies can be applied for other purposes, such as production of hydrogen, ammonia, desalination, industrial purposes, etc.

Images: 1) AP1000 Model in Sanmen, China (Sanmen Nuclear Power Co Ltd)
2) NuScale Power Module illustration (NuScale Power) - 3) Model of the first Generation IV nuclear unit in China, in Shandong (Weibo)
Sources: ABDAN, OSS Foundation and World Nuclear Association

Perrotta recalls, for instance, that the institute developed the technique for converting UF6 (uranium hexafluoride) to UF4 (uranium tetrafluoride) and producing metallic uranium by magnesiothermic process. With that technology, it was possible to better develop the obtaining of uranium alloys and the technique of powder metallurgy and manufacture of plate-type fuels, using HALEU.

"It can be said then that Brazil has the knowledge, technology and infrastructure to produce HALEU, by bringing together the individual capabilities of Indústrias Nucleares do Brasil (INB), the Brazilian Navy Technological Center in São Paulo (CTMSP) and IPEN", the engineer assesses. "It is also able to produce fuels that use HALEU, especially for research reactors, and for some types of SMR, on a small scale", he adds.

Looking to the future, Perrotta also points out that the RMB project will play a key role in the endogenous development of nuclear fuels and materials for use in reactors. He estimates that the multipurpose reactor will create the capacity to test and qualify nuclear fuels for nuclear propulsion, Brazilian nuclear reactors and research reactors.

Perrotta also reminds us that between 2014 and 2019, IPEN and CTMSP developed a cooperative project that stipulated, among other things, building a 20% uranium isotopic enrichment cascade at the CTMSP Isotopic Enrichment Laboratory, in Aramar (São Paulo). That cascade was inaugurated in 2016 and enriched uranium to 19.75% by weight for the manufacture of RMB-type fuel elements. "One aspect that makes this project, developed by the RMB, important for the country is the fact that everything was carried out with national technology at IPEN, CTMSP and inputs from Indústrias Nucleares do Brasil (INB), which positions the country as a participant in a select group that has the knowledge and technology to produce HALEU-type fuels, design and operate research reactors", he concludes. ▪

AGRICULTURE + NUCLEAR PLAN

GOVERNMENT WILL LAUNCH MEASURES TO BOOST INVESTMENTS IN FOOD IRRADIATION IN THE COUNTRY

Brazil is a little closer to achieving a technique that could reduce food waste and losses, bringing more colors and flavors to the tables of Brazilians and also people from other countries. A Working Group (WG) established by Brazil's Ministry of Agriculture, Livestock and Food Supply (MAPA) has been working for a few months on studies on actions to support the country's strategies for the use of nuclear technology in farming and cattle raising. The food irradiation technique could be a decisive tool to help achieving waste reduction goals, in addition to paving the way for Brazilian agricultural products in international markets. So far, the WG has already made progress in updating the technologies available in Brazil and how they can be immediately implemented in farming and cattle raising activities, both in the treatment of food and in the promotion of innovations for production. The next step to be taken by the group is to present, in the second half of the year, a business plan prepared and adapted to the national farming and cattle raising sector, to provide the investment scenario for the application of irradiation in agricultural activities.

"The business plan is the initiative that the government considered to be the most interesting one, because it will basically show a detailed survey of all strategies that should surround an investment in the field of irradiation", explains Luis Eduardo Rangel, director of programs of the Executive Secretariat of MAPA. The plan should indicate documents and protocols that need to be made at regulatory agencies and licensing bodies, in addition to presenting a logistics map of the country, highlighting food production sites and transport hubs for outflow. "The idea is that the investor who wants to put resources into this project feels comfortable to be able to make an investment in a safer way and confident that the government will be involved", Rangel adds. The expectation is that the business plan will be ready at the beginning of the second semester.

Speaking of figures, the director of the ministry says that, after launching the business plan, investments for the installation of food irradiators in Brazil should be around US$ 20 million. Another interesting fact concerns the goals of reducing food losses. The Food and Agriculture Organization of the United Nations (FAO/UN) states that 30% of all food produced worldwide is lost or wasted each year. To change this scenario, the irradiation technique can be used to fight post-harvest pathogens and the natural degradation of certain fruits. "The global goal is to reduce those losses and waste by 50% by 2030", Rangel points out.

The world already acknowledges the food irradiation technique as safe and adequate for health and quality requirements. More than 60 markets for which Brazil already has trade can immediately receive products submitted to this technology. "Upon commercial viability in Brazil [of food irradiation], we will open negotiations to add this technique to sanitary and phytosanitary requirements and thus expand our access to important markets, such as the Asian ones", he expects.

Rangel also says that a major challenge for implementing such projects in Brazil is to demystify the technique as unsafe or expensive. He stresses that several areas of medicine or engineering already benefit from irradiation technology, making people safer. "The space journey that started in the 1960s already had food irradiation and today, we need to give the benefits of this technology to society", he adds. As it happened with transgenic food, communication with the public will also be another key factor in getting irradiated food ventures off the drawing board in Brazil.

"Wide promotion of the benefits for reducing losses, increasing the life span of food and especially the safety that this technology adds to farming and cattle raising products are strategies that will be part of the policy of expanding the use of the technology", Rangel explains. "Communication strategies involve specific advertising for each of the different technology consumers. But the essence is transparency and broad clarification of its benefits and the safety of its application," he adds.

DIVERSIFICATION OF TECHNOLOGIES

Before the studies carried out by the MAPA Working Group, the technological option that seemed to be the most evident was the gamma irradiator. However, during the surveys carried out by the ministry, technicians realized that other technologies, such as electron beam and X-ray technologies, could also be seen as opportunities. These different models have techniques mastered by Brazilian engineers. In addition, the diversification of equipment increases the possibility of attracting new investments.

One of the major challenges for the gamma irradiator is the availability of cobalt-60 source supply, especially for new facilities. In parallel, there are also safety concerns, which result in complex challenges in international transport and replacement of decayed sources in the irradiator. "All those factors lead to a significant increase in the cost of the gamma irradiator and the uncertainty in the use of radioactive sources", points out Patricia Wieland, member of the Board of Trustees of the Brazilian Association for the Development of Nuclear Activities (ABDAN).

Electron accelerators and X-ray, in turn, emerge as alternatives that fully meet the treatment of food with ionizing radiation, demanding lower costs and reducing licensing time compared with equipment with a gamma source. Today, according to the ABDAN advisor, there are more electron accelerators in operation than large-scale gamma irradiators. "I understand that the main challenge for expanding the technique in Brazil is the lack of clarification from producers and distributors, who could avoid losses in production and distribution when installing the irradiator", explains Patrícia, who also provides technical consultancy for MAPA.

Patricia also explains that there are small irradiators with electron beams that can be attached to food processing lines. According to the expert, that solution would be ideal for disinfecting grains and condiments, such as black pepper, which is subject to infestation by the Salmonella bacteria. ▪

DIVERSITY IN FOCUS

WESTINGHOUSE PRESENTS ACTIONS TO INCREASE REPRESENTATION OF WOMEN AND MINORITIES IN LEADERSHIP POSITIONS BY 2025

When American graphic artist J. Howard Miller finished painting the iconic "We Can Do It!" poster in 1942, he could hardly have imagined that his work would live on for generations. History tells that Miller was hired by American Westinghouse Electric Company to create an advertisement that would have, in short, two purposes. The first one would be to raise the morale of its workers during challenging times, when the United States was still in a war against the terrors of fascism in Europe. The second objective was to motivate women to work in factories, helping the country with the war effort. Years later, during the 1980s, that image had its meaning expanded, when feminist movements used it in the fight for gender equality. With that historical context in mind and considering the current demands of society for greater plurality and equity in the workplace, Westinghouse has recently created a board focused on developing a diversity and inclusion strategy. The first person chosen to hold the position was Evonne Bennett Brown, a professional with more than 20 years of leadership in strategic human resource management.

Leading the board for about a year and a half, the executive discusses what Westinghouse has achieved. In 2020, the company set objective and measurable diversity and inclusion goals, which are continuously monitored. In addition, the company develops a set of programs and resources for continuous improvement of that issue. "Westinghouse Electric Company's commitment to diversity, equity and inclusion has been in our values for a long time and is supported by compelling data that shows that diversity in the workforce generates great results for our customers," Evonne says. "It has been an honor to lead Westinghouse on this journey of cultural evolution. The leadership team and employees have been very supportive and engaged in this work," she adds.

In this first year of Westinghouse's diversity and inclusion strategy, the company has already achieved some important results. The director says the organization has made some progress in putting women in leadership positions. In parallel to this, the company significantly improved the recruitment of underrepresented minorities as well as women in its summer internship program. Evonne also mentions that workplace strategies have been created, such as employee reference groups, which help employees learn, celebrate and promote diversity and inclusion in the workplace. "While we are proud of our progress so far, we know that the work to create a diverse, equitable and inclusive organization will never be fully completed," she says.

The executive explains that Westinghouse's strategy is focused on achieving three specific results. Each business unit and function is responsible for promoting actions in line with these results. The implementation of the company's diversity, equity and inclusion strategy is based on our ability to: create a globally diverse workforce; create inclusive leaders, teams and culture; and connecting customers, communities and suppliers.

"Westinghouse has formal strategies and goals to improve representation of women and minorities in leadership positions by 2025 and in our workforce at large by 2030," Evonne reveals. The compa-

"TOGETHER, WE HAVE THE POWER TO MAKE POSITIVE AND SUSTAINABLE CHANGE TOWARDS A COLLECTIVE WORLD WHERE DIVERSITY, EQUITY, INCLUSION AND RESPECT FOR ALL IS THE RULE"

EVONNE BENNETT BROWN, WESTINGHOUSE, DIRECTOR OF DIVERSITY AND INCLUSION

ny has also publicly committed to bringing gender parity into its environment and, as part of that effort, has joined the Equal by 30 coalition. The initiative brings together public and private sector organizations that want to work towards equal pay, leadership and opportunities for women in the clean energy sector by 2030.

The industry, in general, has taken steps to motivate women to enter STEM (science, technology, engineering and mathematics) careers. According to the United Nations, the female workforce is still a minority within these sectors worldwide. The latest numbers help to understand this disparity. In Unesco's calculations, only 30% of the world's scientists are women. Meanwhile, of the total number of students enrolled in STEM programs, only 35% are women. The UN also states that women are less likely to become senior scientists, in addition to receiving fewer research resources compared to men.

For Westinghouse director of diversity and inclusion, changing this scenario will require a joint effort by society. Furthermore, she suggests that girls' interest in science, technology and engineering should be cultivated and nurtured at an early age. "Increasing women representation in STEM careers must start at a very early age. Organizations like Westinghouse must commit to supporting schools and community initiatives that encourage young girls' interest in science and math," she affirms. The executive also points out that a good part of Westinghouse's charitable funds are dedicated to support STEM education for girls and youth of social minorities.

But in addition to promoting the inclusion of women in science and technology careers, Evonne also sees an opportunity to include other social groups in these professional segments. Regarding specifically the nuclear sector, the director says that this industry has room for all types of professionals, regardless of color, creed or gender. "As a black woman and an ally of the LGBTQ community, I can say that a career in the nuclear field is for everyone," she affirms. Lastly, she states that Westinghouse is committed to supporting a culture in which everyone can feel like they belong, contributing to the success of the organization without giving up being who they really are. "I look forward to continuing the dialogue within the business community to accelerate our impact. Together, we have the power to make positive and sustainable change towards a collective world where diversity, equity, inclusion and respect for all is the rule," she finishes. ▪

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