Conexão Nuclear

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A necessary route

Nuclear is key to enabling large-scale clean hydrogen production

The role of SMRs in Brazil

Interview with president of EPE Thiago Barral

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ENVISAGING THE BRAZILIAN ELECTRICITY MATRIX OF THE FUTURE

To envisage the electricity matrix in evolution is a challenge, even more so when we remember that God is indeed Brazilian. We have all the resources for that. We have wind, sun, oil, we have the 6th largest uranium reserve in the world...

Starting from those facts, the challenges begin: to plan and fulfill the plan.

With so much diversity of energy sources and the challenges of competitiveness, seeking resilience to severe events and making generation and transmission flexible were some of the lessons learned from last year's water crisis. Despite the search for flexibility, the complex sectorial governance makes it difficult to implement many measures, as already warned by the Brazilian planning itself.

And the future is full of uncertainties. Today, we have technologies already consolidated. The next wave comes with hydrogen, nuclear (especially with the SMRs – Small Modular Reactor) and flexible devices, and, later on, technological breakthroughs such as nuclear and ultra-deep geothermal fusion.

To envisage the future of the matrix, it is important to balance four axes: efficiency, reliability, flexibility and resilience. And it is already clear to anyone who thinks about the country's energy sector that resilience comes from diversification, which requires the integration of technologies in Brazil.

COP26 made it very clear that, without nuclear thermal generation, it is not possible to decarbonize the world energy matrix. During the COP26 period, several countries launched their nuclear generation programs. China launched a program to build 150 nuclear reactors in 15 years; France, 14 reactors; England, serial construction of SMR; the US has significant investments in its production chain, etc.

The question is: "Are we going to benefit from the fact that we are among the three countries that have uranium and master the fuel cycle? Are we going to use that and the technological conditions we have to move forward with our nuclear program as a STATE program or will we continue as a country that basically exports commodities?"

Today we have the second most expensive electricity tariff in the world, second only to Germany, which is now directly affected by the ongoing war and paying the price for its decision to deactivate its nuclear power plants.

The price of gas has skyrocketed and it will not return to previous levels. We see it in the daily lives of Brazilians. My question: Wouldn't it be better for us to sell the gas we have from the pre-salt to Europe and focus on the total decarbonization project of our matrix?

Another important topic to consider when we talk about the future is the fact that the Brazilian people have heavily subsidized solar and wind sources in recent decades, causing the prices of this energy to fall sharply, even though those sources have not managed to generate a strong local supply chain so far. I bring this topic to discussion, as I see in the select circles of influencers of the energy sector conversations about producing hydrogen from renewable sources. Scary if we think that cheap and subsidized energy will be another export commodity while the price of energy for Brazilians will remain very high.

With those considerations in mind, I state my dream of having a zero-carbon electricity matrix and with a tariff closer to the needs of the Brazilian people. ▪

ESG – NEW IDEOLOGY OF MODERN BUSINESS

Modern society want more from businesses: not only is financial success important, but also the positive impact of the company on society and the planet. This approach affects the work of large corporations, encouraging them to change their business model and pay special attention to socially responsible projects. Today, the principles of sustainable development, or ESG (Enviromental, Social and Governance), are the only proper approach to doing business, without which no organization can thrive.

A company that intends to comply with the principles of sustainable development must take into account environmental and social criteria in its activities, as well as comply with accepted corporate governance standards. Greenhouse gas emissions that affect climate change, waste recycling, consumption of natural resources and education to change actions towards the environment are among the environmental criteria. The social criteria include aspects of personnel policy, interaction with suppliers, customers and partners, in addition to corporate social responsibility – the company's impact on society and contribution to develop the region in which it operates. In turn, management criteria determine the effectiveness of the company's management: giving equal attention to the interests of the business, guaranteeing the transparency of activities and sustainable development factors in corporate decision-making.

ESG PRINCIPLES IN ROSATOM'S ACTIVITIES

In its activities, ROSATOM focuses mainly on the local population's needs, as the success of the company depends directly on the well-being of people – and that principle has always been part of the DNA of the State Corporation. In general, we can say that all Rosatom products significantly contribute to improving the quality of life in Russia and abroad, in countries where the State Corporation operates, and when creating a product, first we think if it can improve people's quality of life. That is confirmed, for instance, by the fact that international rating agency V.E (part of Moody's ESG Solutions Group) has awarded Rosatom an "advanced" level of assessment of activities in the field of sustainable development.

As an example of the implementation of ESG principles, one can mention the development of regions located close to the construction site of the Center for Research and Development of Nuclear Technology (CIDTN, its initials in Spanish) in Bolivia, Rosatom's key project in Latin America today. The center is being built in the city of El Alto, the highest and second most populous city in Bolivia. It is home to around one million people, most of whom are representatives of indigenous Aymara people.

THE SAFETY FACTOR WHEN IMPLEMENTING NUCLEAR PROJECTS

When it comes to nuclear facilities, first of all, local populations have questions about how safe the project is to people and the environment. Given that indigenous people revere nature, that aspect is often decisive for a project to be approved. That was the case for CIDTN in Bolivia, where about half of the population represents one or another local native folk, mainly Quechua and Aymara, and treats their territory as a living being, mother earth, Pacha Mama[1].

For CIDTN project, its safety is confirmed as Rosatom has many years of successful experience in building such projects: more than 120 nuclear research reactors were built with the support of the State Corporation, 22 science and nuclear technology centers based on research reactors were built abroad – in the Czech Republic, Hungary, Egypt, Poland, Kazakhstan, Uzbekistan, Vietnam and other countries. Currently, Rosatom operates approximately 20% of all research reactors in the world.

Regarding the project location, there is a worldwide practice of building facilities for the use of research reactors close to or even in the cities themselves. A good example is the Triga research reactor, located a 20-minute drive from central Vienna, Austria. There are similar examples of locating re-

1 https://olma.org.br/2019/08/01/pachamama-a-mae-terra-da-cultura-andina/

search reactors close to cities in Latin America - in São Paulo, Lima and other cities.

Furthermore, it is important to have in mind that nuclear projects are under the control of the international community, and only proven solutions are used in their implementation. In particular, the research reactor in Bolivia is being built in compliance with the standards of the International Atomic Energy Agency (IAEA) and the Bolivian nuclear regulator. At the same time, nuclear technologies are absolutely safe for the population and the environment.

CONTRIBUTION OF ROSATOM'S PROJECT IN BOLIVIA TO DEVELOP THE REGION

The ESG agenda covers not only the environment, but also social aspects. In this context, it can be said that Rosatom's projects significantly contribute to develop regions where the State Corporation operates.

The launch of the CIDTN project has become an incentive for the development of both the area in which it is being built – District 8 – and the entire city of El Alto. In particular, thanks to Avenida Arica (Arica Avenue), built close to the future center, infrastructure and communications development work began and new public transport routes emerged. As a result, more and more people started moving to this area of El Alto, as it is now considered a prestigious place. Those centers contribute to the development of scientific collaboration, attract scientists from around the world and help solve global problems.

"The center has already brought us many benefits. When the project was just beginning, I understood that its implementation, first of all, would help in the development of the basic communications system. Indeed, soon there were sewage service, water supply and the quality of life in Copacabana, Parcopata and other places increased thanks to this project", says Adolfo Colque Pati, one of the community leaders of the El Alto Indigenous Association. "I think many local leaders made the right decision in their time by agreeing to implement the project. If it weren't for CIDTN, these areas would probably still live without basic amenities," he adds.

"We have everything in Bolivia: natural resources, ancient languages, thousands of years of history and culture, but we lack scientific progress, knowledge and highly qualified experts. We need scientists, innovators, because only knowledge can bring progress to our country. Therefore, when representatives from local authorities talked about the project, all of us El Alto residents liked it. And we immediately said that the Nuclear Research and Technology Center should be built in our District 8, and soon we immediately voted in favor. This project is very important and it will benefit several industries. Thanks to radiation technology, we will be able to start sterilizing and exporting our agricultural products. In addition, oncological diseases are very common in the country, and the center will allow them to be detected earlier and treat patients more effectively," District 8 community leader Alfonso Ramos Cututu says.

Regarding the benefits of CIDTN for the health system, it is worth noting that its construction is part of the national strategy to develop nuclear medicine in Bolivia. In addition to the Russian project, three nuclear medicine and

radiotherapy centers are also under construction in El Alto, La Paz and Santa Cruz. One of them is being built alongside the Russian CIDTN project. Radiopharmaceuticals produced at CIDTN can supply to those centers. Together, they must meet Bolivia's need for modern instruments to treat cancer and other diseases, which will allow local residents to have access to nuclear medicine services without traveling abroad and save the lives of thousands of people for whom it was previously impossible due to lack of financial resources.

In addition, the project will generate new jobs in the city. At the moment, Bolivian companies are actively involved in the construction of the center: now more than 450 Bolivian citizens are working on the site. Once the center is commissioned, the contract will create around 500 highly skilled jobs for residents of El Alto and La Paz.

ROSATOM'S EDUCATIONAL AND HUMANITARIAN PROJECTS IN BOLIVIA

The need for new professionals in a high-tech field such as the nuclear industry contributes to raising the level of education in the region. In particular, the contract for the implementation of the project also provides for work to attract talented students to study at Russian universities in nuclear specialties. Currently, 32 students from Bolivia are studying in Russia in specialized fields for the nuclear industry with scholarships provided by Rosatom, which has already provided scholarships to 124 students between 2015 and 2021. Several graduates from Russian universities are already working in their field at the Bolivian Nuclear Energy Agency (ABEN, its initials in Spanish).

After the project is commissioned, experts on nuclear physics and related specialties from Bolivia and other countries will also be trained at CIDTN, and subsequently pass on their knowledge to future generations. Thus, the center will stimulate scientific collaboration and technological development throughout the region.

Furthermore, as part of its work in the field of social responsibility, Rosatom, together with ABEN, is implementing several humanitarian projects. In particular, the partners sponsor the local rural Copacabana I school and are helping to equip it to make learning easier and more efficient: in March 2022, Rosatom State Corporation purchased educational literature for the opening of the first library in that educational institution. Also, in May, Rosatom and ABEN launched the first children's book on nuclear technology in Spanish for the Bolivian people.

The goal of such projects is to increase the level of education of the local population in general and awareness in the field of nuclear technology in particular. In the long run, work in this area increases interest for the nuclear industry and helps attract new experts to the sector.

From the example of the application of ESG principles in the implementation of Rosatom's project in Bolivia, we can see how corporate social responsibility is stimulating the development of the regions where the corporation is carrying out business activities. ROSATOM State Corporation always takes into account in its activities the social welfare factor of the local population, and now we are already seeing with satisfaction the results of those activities in the construction area of the CIDTN in El Alto. ▪

THE IMPASSE OF THE BRAZILIAN MULTIPURPOSE REACTOR

PROJECT COORDINATOR RESIGNS IN PROTEST AGAINST GOVERNMENT SLOW MOVES

The Brazilian Multipurpose Reactor (RMB, in Portuguese) project was created in 2008 surrounded by many promises and expectations. The undertaking would be the bridge that would lead Brazil to self-sufficiency in the production of radioisotopes used in the treatment and diagnosis of cancer. Today, despite its own production, the country is still needs to import those products to meet its domestic demand. In addition, the reactor could be used for other purposes, such as testing nuclear materials and fuels for power reactors. According to the original schedule, construction works should have been completed in 2014. However, the RMB still finds itself surrounded by questions, without great positive prospects, in a difficult situation with even more challenges: RMB technical coordinator José Augusto Perrotta decided to end his participation in the project, as a protest against the delay in the government's decision-making to carry out the project.

Indeed, since the RMB was conceived, much progress has been made in terms of concept, with the production of 16,000 engineering documents and even obtaining environmental licensing for it. The big dilemma, however, lies in the lack of resources to build the reactor. In 2018, a symbolic ceremony in Iperó (São Paulo), where the RMB is planned to be built, laid the cornerstone for the project. At that time, it was at least a glimmer of hope that, at last, construction works could be started. Unfortunately, not a single drop of concrete has been poured since.

Currently expected to cost US$ 500 million, there is no prospect of funding for the project, given that it did not receive resources in 2022. For next year, prospects are not encouraging either. That is what Perrotta, who decided to leave the position of technical coordinator of the RMB at the beginning of June, says, facing so much dismay as the project fails to move forward: "My request for retirement is a personal decision, like a protest", he says. "I am about to turn 69 years old, almost 44 years dedicated to the nuclear area, working as technical coordinator of the RMB since its creation in 2008. I would still have a lot to contribute to the Brazilian Nuclear Program and the implementation of the RMB", he pities.

After working more than a decade for the RMB, Perrotta talks about the reasons that prevented such an important project for the country to take off, with a mix of sadness and frustration given the stagnation: "Perhaps our most serious mistake was having a lot of will and commitment to the area of nuclear technology, promoting its importance to society. We fought so that nuclear would be recognized as a strategic area of Brazil, which made us reach the current technical stage of the project", he jokes, as getting it off his chest. "But to correct that, I retired, giving the opportunity for the higher managers to do everything that has to be done," he adds.

RESOURCES, POLITICAL WILL AND STRATEGIC VISION: WHAT HAS THE RMB BEEN MISSING SO FAR?

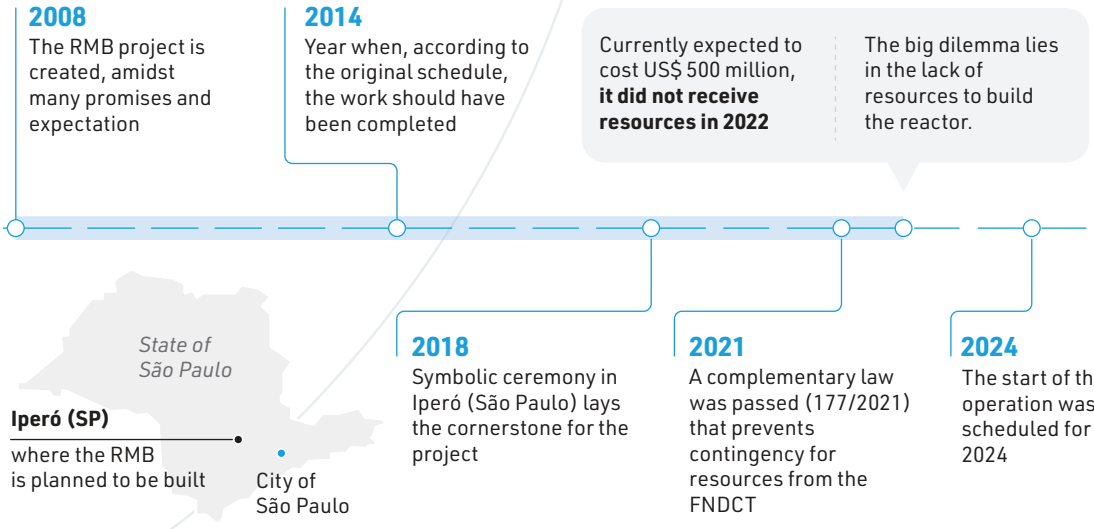
According to Perrotta, the detailed project of the reactor has already been completed, as well as the basic project of the entire infrastructure to be built in Iperó, on a plot of 2 million square meters. In addition to the reactor building itself, the RMB will have other buildings in its surroundings, with an infrastructure of associated laboratories for research. The production of documents for the project consumed around 2 million man-hours of work. According to the engineer, for all that to get off the drawing board, three actions must be put into practice. The first step, as mentioned before, is precisely funding by the federal government.

"The National Fund for Scientific and Technological Development (FNDCT in Portuguese) funded the RMB basic and detailed projects, in addition to the nuclear fuel cycle development project. Until around 2013, the fund had many resources, which were distributed almost in their entirety, without contingency. However, from 2014 onwards, a decrease in the distribution of the fund began to occur", he says.

Today, the situation is different. In March last year, a complementary law was passed (177/2021) that prevents contingency for resources from the FNDCT. The former technical coordinator of the RMB believes that one of the reasons that prevented the development of the project was

BRAZILIAN MULTIPURPOSE REACTOR (RMB) TIMELINE

RMB still finds itself surrounded by questions, without great prospects



Source: ABDAN, 2022

the lack of a vertical allocation of resources. "Big projects cannot be funded with small amounts. We are talking about US$500 million for the RMB. But that amount is nothing for the FNDCT, which has between R$ 5 billion and R$ 6 billion per year, without contingency", he says.

Perrotta acknowledges that the horizontal distribution of resources is interesting for the Brazilian scientific community as a whole, but believes that it is equally important to make a vertical distribution for large projects, such as the RMB.

The second topic missing to so far to enable the undertaking would be political will to guarantee the necessary financial resources. Perrotta emphasizes that the amount of investments for the reactor in 2022 will be zero, while the prospects for 2023 are also not good. "It takes political action to say that the RMB vertical is important. Strategic projects should be looked at equally strategically. So, the effort is to get the resources of the FNDCT", he observes.

Finally, Perrotta believes that the Ministry of Science, Technology and Innovation (MCTI, in Portuguese), the department responsible for the project, lacks long-term vision. He draws a comparison between the RMB and the Nuclear and Energy Research Institute (IPEN, in Portuguese), which began its history in 1957 with the IEA-R1 research reactor. "That was the first reactor in the Southern Hemisphere and around it a great research center sprang up. With RMB, it will be no different. The Brazilian Multipurpose Reactor is intended to be a continuation of what IPEN is, with an infrastructure of another level, attracting knowledge and large research projects", he projects.

Thinking about the future, Perrotta also points out another discussion that he considers essential to ensure the financial health of the multipurpose reactor. In the current management model of IPEN, which is still responsible for supplying most of the radioisotopes used in Brazil, there is a dependence on federal funds. The money raised from selling those products does not go to the institute, but goes into the federal coffers.

"How can we serve society with that type of constraint? The RMB proposes a model change. The capital from selling radioisotopes is enough to maintain and operate that facility and for investing in research and development," he declares. "It is no use having just the money, but we also need human resources and an adequate management model. We have made all the necessary propositions, but no solution came from higher managers," he finishes. ▪

NUCLEAR POWER IN THE PRESIDENTIAL RACE

PROPOSITIONS PRESENTED BY ABDAN TO PRESIDENTIAL CANDIDATES CAN UNLOCK MORE THAN R$ 25 BILLION IN INVESTMENTS BY 2026

Almost in the blink of an eye, this is the second half of the year and it ignites expectation for the next presidential elections, in October. The race for the presidency is getting more attention by the day in the country and, from now on, Brazilian society begins to analyze ways to overcome current economic challenges. As people reflect on them, it would not be an exaggeration to say that one topic, in particular, must certainly stand out: energy. This is an issue that has been very present in the daily lives of Brazilians since last year, due to the water crisis that increased electricity tariffs. Therefore, it is safe to say that voters will pay special attention to the energy issue when comparing election platforms of those running for president. With the presidential race gaining momentum, several sectors - including energy - began to suggest propositions for the candidates' election platforms. The nuclear industry is obviously part of this movement. With the Brazilian economy still trying to find the way to growth, large nuclear projects can unlock more than R$ 25 billion in investments between 2023 and 2026. The data is part of a special document produced by the Brazilian Association for the Development of Nuclear Activities (ABDAN, its initials in Portuguese), which brings together the propositions of the segment for presidential candidates. In the document, there are also other encouraging projections on job creation, reduction of energy costs, technological development and well-being of the population and the environment.

President of ABDAN Celso Cunha explains that the association aims to sensitize presidential candidates to suggestions and projects of the Brazilian nuclear sector in areas such as electricity generation, medicine, food irradiation, among others. In the document, there are more than 20 actions and it points out the positive impacts on economy from each of them. One of the highlights of the document refers to the Angra dos Reis nuclear power plants. Currently, Eletronuclear, the operator of the plants, is about to resume work on Angra 3. In parallel, the company is also working to extend the lifespan of Angra 1 and Angra 2 plants.

ABDAN states that elaborating and carrying out those projects would leave a legacy of positive impacts. Looking to the horizon between 2023 and 2026, investments in Angra 3 will total 20 billion, with an expected nationalization rate of 70%. In addition, the life extension of Angra 1 and the modernization of Angra 2 will, together, require over R$ 5 billion. The three projects would also help create more than 9,000 direct and indirect jobs.

Considering the medium term, between 2027 and 2030, the association points outs two other important projects: the life extension of Angra 2 and the completion of the fourth Brazilian nuclear power plant, which was indicated by the federal government in Brazil's 2031 Ten-Year Energy Plan (PDE, its initials in Portuguese). Investments in these projects will reach US$ 7 billion, with a socio-economic impact of 9,000 direct and indirect jobs.

In the long run, from 2030 to 2050, the construction of possible new plants will attract impressive figures. As it is known, Brazil's 2050 National Energy Plan (PNE, its initials in Portuguese) indicates the construction of 8 GW of nuclear generation in the country by the middle of the decade. Taking into account that each 1 GW plant would need US$ 7 billion, investments could total US$ 56 billion.

"Completing Angra 3 and carrying out PNE 2050, with 8 GW of new nuclear power plants, are key. In addition to large investments, we are talking about a steady generation source for the country, which will guarantee the stability of the Brazilian electric system. The nuclear source has no volatility, which means it does not depend on climatic factors such as sun, rain or wind. It is not subject to environmental inclement weather", Cunha says.

The president of ABDAN also mentions other benefits that Brazil could achieve by building new plants. One of them would be the technological advance in control systems and optimization of assembly processes and construction works of plants. In addition, the serial construction of nuclear plants could help reduce the cost of electricity generated by these plants. In this case, according to ABDAN's calculations, the price of electricity can be reduced by up to 80% compared with the generation of thermal plants using natural gas.

Finally, the new plants that are being planned until 2050 would be essential for Brazil to fulfill its pledges at COP26, since the nuclear source does not emit greenhouse gases. To get those projects off the drawing board, ABDAN

argues that the regulatory framework should have flexibility to allow private companies to work in partnership with the public sector. "Countries are beginning to acknowledge that the nuclear source is necessary to decarbonize the world energy matrix. COP26 made it very clear that without nuclear power there will be no decarbonization", the association's leader declares.

A SLEEPING GIANT IN NUCLEAR FUEL PRODUCTION

Another area highlighted in ABDAN's set of propositions was the segment of uranium mining and beneficiation. Cunha emphasizes that Brazil currently has the ninth largest reserve of that ore in the world. And the expectation for the future is that the country will be able to climb new positions on the list. "Serviço Geológico do Brasil (public company for geological survey) is working on mapping uranium potential in our territory. We have the ninth largest uranium reserve in the world, but we have only investigated a third of the national territory. By investigating the potential of other areas, we will be able to have the second largest reserve on the planet", he projects.

ABDAN suggests to presidential candidates that they consider in their election platforms the expansion of Brazil's production capacity in the main stages of the so-called nuclear fuel cycle. The stage that starts this cycle is precisely the mining and production of uranium concentrate (U_3O_8). According to Celso Cunha, the country has a huge potential still dormant in this niche of activity, with the capacity to meet all its domestic demand for U_3O_8 and even start exporting this product. "The beneficiation of uranium will also enable Brazil to seek its self-sufficiency in critical raw material for the production of fertilizers," Cunha adds.

The second stage of the fuel cycle is the conversion of uranium concentrate to gaseous state - called uranium hexafluoride (UF_6). Currently, this part of the fuel production process is not carried out at industrial scale in Brazil, only abroad. According to calculations from the association, Brazil could sell US$ 22 million per year of uranium concentrate between 2023 and 2026. The Brazilian nuclear industry, in turn, argues that the country should invest more in this niche to reduce national dependence on other nations. Also in this case, Brazil can go from importer to exporter. ABDAN estimates that between 2027 and 2031, the sale of reactor services and engineering services for fuel element project should reach US$ 1.5 million per year, if the country expands its conversion capacity.

The third stage of the nuclear fuel cycle is uranium enrichment. Currently, the country enriches an amount of uranium that can supply 65% of the demand for annual replenishment at Angra 1. Brazil has already announced plans to expand its industrial park, in order to meet all the demand of Angra 1, 2 and 3 plants. That added capacity could reduce external vulnerability and, at the same time, sustain the expansion of Brazilian nuclear generation indicated in PNE 2050. ABDAN's projections for 2026 onwards show that the export of enriched uranium by Brazil could reach US$ 2 million/year.

"COMPLETING ANGRA 3 AND CARRYING OUT PNE 2050, WITH 8 GW OF NEW NUCLEAR POWER PLANTS, ARE KEY. IN ADDITION TO LARGE INVESTMENTS, WE ARE TALKING ABOUT A STEADY GENERATION SOURCE FOR THE COUNTRY, WHICH WILL GUARANTEE THE STABILITY OF THE BRAZILIAN ELECTRIC SYSTEM."
CELSO CUNHA,
RESIDENT OF ABDAN

The improvements suggested by ABDAN for mining, conversion and enrichment stages demand changes in legislation, to allow new investments and participation of private companies. Those stages are currently also under the federal government monopoly, which is carried out by state-owned Indústrias Nucleares do Brasil (INB). The association also suggests that investments should be made to strengthen the partnership between INB and the Navy Technological Center in São Paulo (CTMSP, its initials in Portuguese). As the market is aware of, ultracentrifuges used for uranium enrichment were developed by CTMSP, in partnership with the Nuclear and Energy Research Institute (IPEN, its initials in Portuguese), and are operated by INB, in Resende (RJ). "Brazil can play an important role as a fuel supplier, not only for large plants, but mainly for small modular reactors (SMRs), which are projects that will make a technological disruption in the energy production sector", the president of ABDAN projects.

MAIN PROPOSITIONS PRESENTED TO PRESIDENTIAL CANDIDATES BY ABDAN

Actions target development of the production chain and expansion of research and development projects

PROPOSITION 1

Extension of lifespan for Angra 1, modernization of Angra 2, completion of construction works of Angra 3 plant

OUTCOME

Investments of
R$ 27 billion
BETWEEN 2023 AND 2026

With nationalization rate of 70% expected to Angra 3

PROPOSITION 2

New 1 GW plant in the Southeast, indicated in Brazil's 2031 Ten-Year Energy Expansion Plan

OUTCOME

Investments of
US$ 7 billion
BETWEEN 2027 AND 2030

PROPOSITION 3

Carry out constructions works of plants provided for in Brazil's PNE 2050, which indicated 8 GW of new plants by 2050

OUTCOME

Investments of up to
US$ 56 billion

Taking into account that each 1 GW plant would require US$ 7 billion in resources

PROPOSITION 4

Increase capacity to enrich uranium in Brazil

OUTCOME

2023-2026:
Exports of uranium concentrate should reach
US$ 22 million/year

2026 ONWARDS:
Exports of enriched uranium should reach
US$ 2 million/year

PROPOSITION 5

Secure federal funds for 2024, in order to enable the project and start of works on the RMB in 2023

OUTCOME

FROM 2029 ONWARDS:
Export to Latin America, Asia and Africa

FROM 2030 ONWARDS:
Imports of primary radioisotopes with **domestic production at lower cost and greater self-sufficiency** of these strategic inputs.

PROPOSITION 6

Increase investments to purchase irradiation equipment by companies, cooperatives and sectorial associations

OUTCOME

30% **in loss reduction**
in Brazilian agribusiness

More than 60 markets with which Brazil already does business can immediately receive products that undergo this technology.

Source: ABDAN, 2022

NUCLEAR TECHNOLOGY FOR HEALTH AND FOOD

In addition to electricity generation, nuclear technology has many other applications that can guarantee the well-being of Brazilian society. In medicine, for instance, radioactive sources are tools for diagnosis and treatment of cancer. In the country, according to data from the sector, there are around 2 million nuclear medicine procedures per year. For the future, the expectation is that access to those services will grow even more. In April, the National Congress enacted Constitutional Amendment 118/2022, which allows the production, sale and use of all types of radioisotopes by the private sector. In the market, the understanding is that this change in legislation will allow a greater number of treatments in nuclear medicine services throughout the country.

In the document of propositions for the presidential candidates, ABDAN states that the next step now is to make the proper regulation and implementation of the flexibilization of the government monopoly on the production of radiopharmaceuticals. However, the association also believes that the public sector should not be left out of this equation: in an ideal scenario, the private sector should focus on the manufacture of radiopharmaceuticals, while the public sector should concentrate efforts on the preparation of radioisotopes.

To that end, the suggestion for presidential candidates is that Brazil should secure federal funds for 2024, in order to enable the project and start of works on the Brazilian Multipurpose Reactor (RMB, its initials in Portuguese) in 2023. The RMB is an undertaking that aims to guarantee the country's self-sufficiency in the production of radioisotopes – elements that emit radiation and are used in to diagnose and treat many diseases. The project was presented in 2008 and should have been completed in 2014. However, due to lack of financial resources, the work did not even start.

With the RMB, Brazil would stop importing primary radioisotopes from 2030 onwards and would start producing those substances in the country, at a lower cost. As a result, medical services would have access to a sustainable supply of radioisotopes for diagnosis and therapy. In addition, it would be possible to export surplus production to countries in Latin America, Asia and Africa from 2029 onwards.

"Brazil needs to complete the RMB in order not to be dependent on the importation of molybdenum (one of the main radioisotopes used in nuclear medicine). We need to produce it here in Brazil and, with that, reduce exchange risk and logistical problems. Now, in this moment of global crisis, especially due to the conflict between Ukraine and Russia, we are subject to not having the necessary products to treat our patients", Celso Cunha warns.

In addition to ensuring the health of millions of Brazilians, the nuclear source can play another crucial social role. The use of the food irradiation technique could expand national agricultural production. To that end, it is necessary to increase investments for the acquisition of irradiation equipment by companies, cooperatives and sectorial associations.

ABDAN suggests the creation of a financing policy and organizational support for the acquisition of such equipment. Additionally, another proposition is to carry out social communication actions and awareness campaigns on the importance and benefits of irradiation applied to many production sectors.

One of the main benefits achieved by increasing the use of this technique would be the reduction of food losses by about 30%. In addition, Brazilian agribusiness would have access to new consumer markets abroad, since some countries only import certain foods that have undergone irradiation process. According to data from the Ministry of Agriculture, more than 60 markets with which Brazil already does business can immediately receive products that undergo this technology.

"Brazil is now recognized worldwide for its great food production capacity. However, we still waste more than 30% of everything we produce, whether due to logistical problems or losses caused by ripening or contamination. The irradiation technique is a very safe process adopted by several nations. In fact, many countries only agree to buy certain products as long as they have been irradiated. So, it is essential that Brazil invests in this area to open new markets", the president of the association finishes.

The document produced by ABDAN also has propositions for other areas of the nuclear industry, to the development of the production chain, creation of a definitive place for radioactive waste, expansion of research and development projects and to get the country ready for the production of the SMRs. "Brazil will be able to follow the trajectory of SMR technology and eventually develop skills for a modality of energy generation with less risk and more flexibility of operation and distribution in a country of continental dimensions", Cunha finishes. ▪

THE ROLE OF SMRS IN BRAZIL

INTERVIEW WITH PRESIDENT OF EPE THIAGO BARRAL

Small modular reactors (SMRs) have attracted the attention of several countries because of the benefits offered by this technology. In Brazil, the topic is already on the radar of Empresa de Pesquisa Energética (EPE), a state-owned company that produces studies that help the country's energy planning. In an interview with Conexão Nuclear, the president of EPE, Thiago Barral, points out how the SMRs can contribute to the expansion of nuclear power in Brazil and emphasizes the importance of such source for the country.

1 – How are SMRs being discussed within EPE?

The creation of the 2050 National Energy Plan (PNE 2050, its initials in Portuguese) indicated the importance of having nuclear power as a very relevant option in the energy transition, in addition to renewable sources, efficiency gains and forms of carbon removal. This finding is valid both for the world and for Brazil. Given the move of many countries to invest in nuclear energy, this strategic directive of energy planning in Brazil is right. PNE 2050 is also assertive about the challenges to be overcome. Small modular reactors (SMRs) are part of this context as a concept that has the potential to contribute to reducing costs and increasing the competitiveness of the nuclear source, as well as providing greater flexibility and versatility to generation projects.

At EPE, in line with our strategic planning and with the guidelines of PNE 2050, we have structured a set of actions to support Brazil in decisions regarding the participation of nuclear power in our matrix, especially "post-Angra 3" investments, including the understanding of the role of the SMRs in this new phase of development.

We have assigned professionals to dedicate more time to nuclear energy and we have promoted training opportunities, mainly in technical events in Brazil and abroad. In parallel, we have increased the number of meetings with companies operating in the nuclear sector. International cooperation was also increased: we have a cooperation agreement with the International Atomic Energy Agency (IAEA) for studies on SMR, as well as we have a work front on SMR within the scope of the United States-Brazil Energy Forum (USBEF).

Finally, EPE is co-leader, in partnership with ABDAN (Brazilian Association for the Development of Nuclear Activities), of the SMR Forum, which brings together several companies and institutions interested in the topic.

2 – In your opinion, what would be the main application of SMR in the Brazilian matrix?

The SMRs, in fact, cover a very comprehensive set of reactors, as well as different levels of maturity. There are many concepts under development around the world, which brings greater versatility and flexibility to nuclear generation projects. Those characteristics mean that SMRs have several potential applications, and may present greater or lesser competitiveness depending on the needs of energy systems.

I believe that the most important thing is that the SMRs are a strategy to seek cost reduction, through modularization and innovative constructive strategies. The smaller scale of reactors can also be useful to facilitate the financing of nuclear generation projects, reducing the risks of project overruns.

I also consider it worth mentioning that nuclear power, being sufficiently competitive, is an option to increase the climate resilience of electric systems based on renewable sources, helping to diversify generation sources, as well as contributing to energy security, reducing dependence on fossil fuels.

> “MORE FLEXIBLE NUCLEAR POWER PLANTS WILL HAVE IMPLICATIONS FOR BALANCING THE ELECTRIC SYSTEM. THIS WAY, NUCLEAR GENERATION CAN PLAY A VERY INTERESTING ROLE IN COMPLEMENTING RENEWABLES”

3 – Wind and solar sources are variable and need to be complemented by dispatchable plants. Could SMRs play this role, as this technology is expected to offer flexibility?

Future electric systems will demand greater and greater flexibility, but we still need to better understand the degree of flexibility that smaller, modular reactors can offer in nuclear generation. More flexible nuclear power plants, whether on a seasonal scale or on an intraday scale, will have implications for balancing the electric system. Being more flexible, nuclear generation can certainly play a very interesting role in complementing renewables. Otherwise, combining renewables and nuclear will require more storage or demand response.

4 – The Constitution determines that defining a location for nuclear power plants is done through federal law. Is that a barrier for SMRs?

Initially, that is a challenge to be addressed in future nuclear generation projects, regardless of whether they adopt the SMR concept or not. In any case, SMRs may contribute to greater flexibility in site studies for new projects, influencing the process of engaging the stakeholders and approval of future project locations.

5 – EPE and the International Atomic Energy Agency (IAEA) have agreed to cooperate on SMR studies. What are the results of that work so far?

The cooperation between EPE and the IAEA seeks to not only bring gains to the process of including SMRs in the modeling and studies being carried out in Brazil, but also to contribute to the Brazilian experience in energy planning, so that the products available in the future by the IAEA may be more generally applicable to its member countries. The activities developed within the scope of cooperation have been important to guarantee the conceptual robustness of the methodology that has been developed by EPE, as well as to ensure that this methodology is compatible with what has been produced internationally.

This concern with conceptual robustness is relevant since nuclear energy is a complex topic, not only in terms of technology, but also several other important aspects for energy planning. Cooperation with the IAEA should be seen as a longer-term work, given that the agreement runs until December 2024.

6 – How has EPE been working with the Permanent Forum on SMR, launched together with ABDAN?

The Permanent Forum on SMR seeks to fill in some knowledge gaps that could hamper the process of including SMR in modeling and studies carried out in Brazil. A large part of those gaps to be filled is related to particularities of the Brazilian nuclear sector and to technological characteristics related to the potential benefits of SMRs.

It should be noted that much of this information is not public knowledge, being under the control of few institutions, also due to the current stage of progress of SMRs. In this type of situation, the Permanent Forum on SMR is very important, as it allows EPE to present the identified knowledge gaps. The adequate treatment of those gaps will provide the conditions for a more effective roadmap to be built for SMRs in Brazil.

7 – Is there something that Brazil needs to do to make sure it has that type of technology in the future?

Now, we are diagnosing and building that agenda. This way, the Forum on SMR, co-led by ABDAN and EPE, and other cooperation initiatives, will be essential to give a better answer to this question.

In addition to increasing technological maturity and competitiveness, there are certainly necessary advances in the representation of SMRs in planning studies and modeling, and it will also likely be important to assess the need for improvements in legislation and regulation. ▪

STABILITY IN ENERGY TRANSITION

BRAZIL AND OTHER COUNTRIES INCREASE INTEREST IN NUCLEAR TO DECARBONIZE THEIR MATRICES

Energy transition is the response given by governments and companies around the world when facing climate change issues. Given the fact that emissions from polluting sources - such as coal and oil - are the cause of global warming, countries began to allocate significant investments to expanding the use of clean energy, such as wind and solar power. But this transformation movement will not be limited to these two generation technologies. In a recent trend, seen in different nations, nuclear power started to receive more attention in discussions about that transition. For Giovani Machado, director at state-owned research company Empresa de Pesquisa Energética (EPE), atomic generation will play an important role in the energy transition and in the decarbonization of global economies - and that will be no different in Brazil. As head of Economic-Energy and Environmental Studies for EPE, Machado states that even though Brazil already has a low-carbon electricity matrix with a high share of renewables, nuclear power should be used more from now on, both to contribute for the reduction of carbon emissions, as well as to further improve the stability of electricity supply in the country.

"In addition to helping decarbonization, nuclear power will contribute to energy security, system reliability, technological spillovers to other sectors, market coupling and the climate resilience of electric systems", he explains. Machado also emphasizes that the water scarcity experienced in Brazil in 2021, which reduced the volume of hydroelectric reservoirs to worrying levels, made evident the importance that thermonuclear generation can have in energy security and system reliability. "In particular, the greater participation of nuclear power in the electricity matrix may allow a change in the operating role of hydroelectric power plants with reservoirs, resuming their role of providing flexibility to the Brazilian electric system with greater participation of variable and seasonal renewables. Without nuclear power, this role will have to be played by fossil thermal plants and/or probably more complex energy storage systems", he analyzes.

Given this situation, Brazilian energy planning already is moving towards reserving more space for nuclear in the expansion of power generation in the country. As the market is already aware of, Brazil's 2050 National Energy Plan (PNE, its initials in Portuguese) and 2031 Ten-Year Energy Plan (PDE, its initials in Portuguese) highlight and have assessments on the effects and importance of nuclear power for the Brazilian matrix. The PDE 2031 even indicates the construction of a new 1 GW thermonuclear plant, in southeastern Brazil, by the end of the decade. For the future, EPE also develops new works regarding the source.

"EPE is also seeking to strengthen its expertise in [nuclear] site selection studies, which should be done in 2023 with EPRI [Electric Power Research Institute]," he says. The energy planning company also started to participate in the International Atomic Energy Agency (IAEA) Technical Working Group on Nuclear Power in Low-Carbon Energy Systems, with the goal of obtaining international exchange of knowledge and additional expertise gains on the subject.

To attract attention to nuclear once again is not a move seen only in Brazil. Last year, during COP26, the source also gained special attention during debates on energy transition. Those discussions must be expanded even further now, given the recent geopolitical disturbances in Europe. "Before the conflict between Russia and Ukraine, several countries had already pointed out that they would have nuclear power among the alternatives for electricity generation in the energy transition. The USA, Canada, United Kingdom, France and Brazil itself had already announced that nuclear power would play a relevant role in energy transition. That became more evident at COP26, in Glasgow", Machado says. According to EPE director, the military confrontation in Europe has further highlighted the weight of nuclear generation in the decarbonization of economies and energy security.

Brazil and other countries that master nuclear technology for electricity generation are also attentive to new technological developments in the sector. In this context, the so-called small modular reactors (SMRs) stand out the most. For Machado, this new type of technology brings great expectations for expanding the role of nuclear power in the energy transition and in a decarbonized economy, including the complementarity with renewables. "Thus, it is possible to have sites in the future with some SMRs being added or progressively removed from the load due to the variability of renewables, as well as integrated into the pro-

duction of low-carbon hydrogen. All that would increase the flexibility of the system as a whole. Anyway, many operating and business models can be evaluated and adopted", he believes.

Finally, EPE director emphasizes that competitiveness and the reduction of construction time are key aspects that need to be worked on so that nuclear power actively participates in this movement of energy transition in Brazil and in the world. The resumption of expansion, the consolidation of safety and licensing requirements for reactors and the standardization of construction methods are also essential to gain scale and knowledge. "In particular, the size, modularization, standardization and simplicity of SMRs concepts seek precisely to increase competitiveness and reduce the construction time of new nuclear plants", he adds.

In addition, Machado believes that it will be necessary to engage stakeholders and communication with society to make nuclear energy projects viable, including site studies. "In Brazil, in particular, there is a need to complement institutional, legal and regulatory improvements, as well as define the business model for private companies' participation in the Brazilian nuclear industry. Several important actions have been taken in recent years by the Brazilian government, especially in 2021 and 2022, to allow the resumption of the nuclear industry", he finishes. ▪

"IN ADDITION TO HELPING DECARBONIZATION, NUCLEAR POWER WILL CONTRIBUTE TO ENERGY SECURITY, SYSTEM RELIABILITY, TECHNOLOGICAL SPILLOVERS TO OTHER SECTORS, MARKET COUPLING AND THE CLIMATE RESILIENCE OF ELECTRIC SYSTEMS"
GIOVANI MACHADO,
EPE DIRECTOR OF STUDIES

TECHNOLOGY THAT BOOSTS

CONSTRUCTION OF ONBOARD NUCLEAR PLANTS WILL BRING TECHNOLOGY INNOVATION TO MANY AREAS OF BRAZILIAN SOCIETY

Among so many generous treasures, that nature has reserved for Brazil, one of the most beautiful and precious is certainly its coastline of almost 7,400 km. Beyond the coast, Brazil's exclusive economic zone (EEZ), our Blue Amazon, is home to dense marine biodiversity, in addition to our prolific pre-salt oil and gas reserves. Transforming all those riches into benefits for society is not the only challenge for Brazil. The country has also concentrated efforts to ensure its sovereignty in this vast maritime territory. To that end, one of the main initiatives is the Navy Submarine Development Program (PROSUB in Portuguese), which provides for the construction of four conventional submarines and the long-awaited nuclear-powered submarine. Considered a milestone in the history of the Brazilian Naval Force, the nuclear submarine Álvaro Alberto (SN-BR) will raise the level of coastal defense in the country. At the same time, the compass that guides the Navy to design a vessel also points to a series of other subsequent benefits from the construction of the SN-BR's onboard nuclear plant. That is what the director of the Naval Agency for Nuclear Safety and Quality (AgNSNQ in Portuguese), Rear Admiral Humberto Moraes Ruivo, says. According to him, the future nuclear plant of the submarine could be the starting point for the development of technologies with several applications, from the generation of energy in remote areas to the production of what has been pointed out as the fuel of the future - hydrogen.

Rear Admiral Ruivo has been leading the AgNSNQ since the beginning of work at the agency, in 2018. The agency was created to the regulation and inspection of the safety of naval assets with nuclear

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propulsion. The body also oversees the quality assurance of naval defense products and systems. The director of the agency emphasizes that the Brazilian Naval Force's initiatives for the development of onboard nuclear plants originated with the Navy's Nuclear Program (PNM in Portuguese). "The technological innovation resulting from that effort [by the PNM] established the basis for the use of nuclear technologies at sea, creating capacity in the country for sectors linked to the production of nuclear fuel, the construction of nuclear plants for naval propulsion and other types of nuclear reactors. Many of the technologies, materials, systems and equipment developed also have applications to civilians, contributing to generation of jobs and income, in addition to the well-being of our society," he says.

For Ruivo, nuclear plants onboard floating structures that can be moved to remote regions by sea or navigable rivers already are a reality. In the Brazilian case, specifically, the reactor being conceived for the SN-BR will leave a trail of technological knowledge, allowing the development of a technology that is currently a big trend in the world energy industry: small modular reactors (SMRs). "The onboard nuclear plant being developed for the Brazilian nuclear submarine could be the starting point for the development of SMRs, which have applications in energy generation and cogeneration in remote areas, applicable to supply small communities, desalination, production of hydrogen, district heating and refrigeration", he observes.

The journey to get the SN-BR off the drawing board and achieve all these technological developments has already begun. For AgNSNQ, the mission will be to lead the entire process of regulation and nuclear licensing of the submarine Álvaro Alberto, the first onboard nuclear plant in Brazil. Here, it is worth making an addendum for better understanding. Military undertakings and activities are exempt from environmental licensing, but not from nuclear licensing. Even so, all legislation about the risk of contamination of people and the environment is being applied to projects under development by the Navy. As for possible non-military nuclear plants, the environmental licensing process recommended in Brazilian regulations will be fulfilled.

Rear Admiral Ruivo explains that, given that the task of licensing a nuclear-powered vessel is something new, a process for granting partial licenses was established, in order to adapt design and construction activities to those of licensing. According to him, that allows organizations involved in the design and construction and AgNSNQ to work more effectively.

"In November 2021, the first partial construction license for the first conventionally armed, nuclear-powered submarine was issued. Currently, the application process for the second partial construction license is in progress. With these two licenses, the organization responsible for obtaining the conventionally armed, nuclear-powered submarine (Nuclear-powered Submarine General Coordination – COGESN in Portuguese, applicant for the license) intends to fulfill requirements for the beginning of the construction of the resistant hull of the submarine", he says.

In parallel, AgNSNQ also works to develop, review and propose standards for naval assets with onboard nuclear plants. According to the director of the agency, a general framework has been established, based on the normative framework of the International Atomic Energy Agency (IAEA). Among the areas covered by the regulatory framework are radiation protection and safety of radioactive sources, safety analysis, decommissioning and management of radioactive waste, preparation and response to naval nuclear and radiological emergencies, naval nuclear propulsion plant, immersion safety, operational safety and maintenance. "Based on that framework, 24 standards have been developed so far. The process of creating standards is continuous and permanent, in order to support the licensing process that has already begun to obtain, by construction in the country, the first conventionally armed, nuclear-powered submarine", he explains.

As usual in all branches of the world nuclear industry, safety is crucial in the development and operation of atomic generation plants on vessels. Rear Admiral Ruivo says that AgNSNQ will also be monitoring a possible response to a naval nuclear and radiological emergency, through the Emergency Response Monitoring Center (CARE in Portuguese). "To operate the Center, with all its functionalities, a computerized and georeferenced system has been developed by the Navy's Research Institute, called SisCARE, which allows the monitoring, in real time, of ENRN (Naval Nuclear and Radiological Emergency). ENRN training is being programmed and conducted with the goal of making all those involved in such emergencies familiar with their jobs and procedures provided for in the standards created by AgNSNQ", the director finishes. ▪

A NECESSARY ROUTE

NUCLEAR IS KEY TO ENABLING LARGE-SCALE CLEAN HYDROGEN PRODUCTION, BUT STILL LACKS INCENTIVE POLICIES

Climate change imposes a sense of urgency on decision-making for the decarbonization of the planet, and the energy industry will play a leading role in this race against time to stop global warming. Given the challenge - not a trivial one - of reducing the current dependence on fossil fuels, a solution increasingly attracts the attention of governments, scientific institutions and companies: hydrogen (H_2). Touted as the "fuel of the future", its energy potential has attracted attention and encouraged investments in several countries, and several ways to obtain hydrogen are being researched - some of them even presuppose the use of fossil sources, such as natural gas. But the technological routes that stand out the most are those that do not generate emissions, using sources such as wind, solar and nuclear. Wood Mackenzie data show that the demand for H_2 is expected to grow sixfold by 2050, compared with 2020 levels. For Brazil to join that international effort in favor of hydrogen, companies such as Eletronuclear are seeking partnerships and exchange with other institutions on the subject. That is what the company's Research, Development and Innovation (RD&I) coordinator Karla Lepetitgaland says. She sees great potential in the production of hydrogen from the use of nuclear energy, but recognizes that there are still regulatory and incentive challenges to make this route viable. In parallel, the expert also says that Eletronuclear has just taken new steps within a project that aims to demonstrate the feasibility of developing a plant for beneficiation of H_2 at the Angra dos Reis (Rio de Janeiro) station.

Karla states that current market estimates indicate that hydrogen will be responsible for 8% of the reduction in world carbon emissions by 2050, assuming that 60% of this energy vector will be produced from clean sources, such as renewables and nuclear. Low-emission hydrogen generated from the use of electricity from wind and solar plants is a route that has been prioritized by countries in general. However, despite being a promising choice, it will face challenges.

"Wind and solar generation are variable, which means they do not produce power all the time. So, how can we guarantee that the electricity used to produce hydrogen will be entirely renewable, given the variability of those sources?", Karla asks. The expert points out that hydrogen is not a source of energy itself, but an energy vector. "H_2 production demands to be fed by a source. However, today there is not an amount of renewable energy left in the world to be used in the generation of hydrogen", she explains.

Given the low availability of energy surplus, specific projects of clean hydrogen from the nuclear source would be an alternative. "Hydroelectric power is being used in its entirety, renewables are variable and thermoelectric plants generate emissions. So, we know that the route that does not emit carbon and that can provide power in a steady way for a hydrogen plant would be the nuclear one", Karla points out. In that context, she also explains that small modular reactors (SMRs) could be used to power an H_2 production plant, for example. "With SMRs, hydrogen generation would be independent of the electricity circulating in the grid. Modular reactors would allow uninterrupted, distributed production without greenhouse gas emissions," she believes.

For Eletronuclear RD&I coordinator, Brazil now needs to take a step towards encouraging and stimulating research involving the technological route of low-emission hydrogen from nuclear. "The country needs to keep up with what is happening around the world in terms of investment in R&D in the areas of hydrogen generation and SMR. There is a lack of these resources. So, I believe that the way forward involves investing in public policies to encourage research and development in the nuclear sector, in general, and in hydrogen generation", she observes.

In parallel, Karla also states that there are other policies related to H_2 that need to be developed, regardless of the chosen technological route. In 2021, state-owned research company Empresa de Pesquisa Energética (EPE) published a document called "Bases for the Consolidation of the Brazilian Hydrogen Strategy". The expert emphasizes that this work highlights the need to strengthen the technological bases, train people, create standards in terms of security and develop markets in which the energy vec-

HYDROGEN WILL BE RESPONSIBLE FOR 8% OF THE REDUCTION IN WORLD CARBON EMISSIONS BY 2050, ASSUMING THAT 60% OF THIS ENERGY VECTOR WILL BE PRODUCED FROM CLEAN SOURCES, SUCH AS RENEWABLES AND NUCLEAR

tor can be applied. "There already are some R&D projects being carried out in the country that, even with low production volumes, have difficulty to market hydrogen. So it is not enough to know that there is a demand. You must have a way to market that hydrogen," she points out.

A COMMUNITY AROUND NUCLEAR HYDROGEN

The Angra plants have a system for the production of sodium hypochlorite, a substance used to prevent the proliferation of biofouling in the piping and equipment of the plants. The by-product of this process is hydrogen and one possibility being analyzed by Eletronuclear is, in the future, to implement a beneficiation plant to raise the degree of purity of that hydrogen from the current 95% to 99.99% - step that would open up a range of possible uses of this gas. To get that project off the drawing board, in April, the company started, in partnership with Furnas and the Itaipu Technological Park, a complete study to assess the technical feasibility, security and possible applications of that hydrogen.

"Eletronuclear does not only intend to carry out this study, but our idea is to bring together a community around the topic of nuclear hydrogen", says the company's RD&I coordinator. "Since the beginning, we have sought partnerships with institutions that have experience with hydrogen in its various facets. In addition to those partnerships, Eletronuclear is establishing memoranda of understanding with many international and national institutions, the scope of which also includes hydrogen," she adds.

In early June, Itaipu and Furnas teams visited the H2 generation systems in Angra dos Reis, together with the Eletronuclear project team. "We will assess all the necessary parameters and the final result should be published by December. In the meantime, several reports will be produced to point out the economic feasibility, environmental benefits, implementation costs and possible scenarios for the application of that hydrogen", she finished. ▪

REACTORS OF THE FUTURE

CHINA STARTS TESTING REACTOR MODEL WITH POTENTIAL TO REVOLUTIONIZE NUCLEAR POWER GENERATION

The world's nuclear industry is paying attention to China for obvious reasons. The Asian giant has a bold goal of building 150 reactors over the next 15 years – a robust plan by Beijing to reduce its reliance on heavily polluting sources such as coal. But it is not just the size of the fleet of new Chinese nuclear plants that attracts researchers and members of the global nuclear industry. Recently, the country has announced the start of testing for a specific type of technology that has long been of interest to nuclear energy experts: the molten salt reactor. The technical concept of this type of equipment is already well known in the sector, which tried to make some projects viable from the 1950s onwards, but was not successful at the time. However, those past efforts were not in vain. That is what physicist and professor of the nuclear engineering program at the Federal University of Rio de Janeiro (UFRJ) Aquilino Senra says. With recent progress, Chinese researchers are hoping to achieve good results in this new round of experiments with that type of reactor. If the tests are successful, a large window of new possibilities for the application of nuclear energy will be opened – and Brazil may, at some point, benefit from this technological race.

According to Senra, the molten salt reactor has numerous advantages when compared with the types of reactors operating worldwide. "To keep it simple, I will mention just a few benefits that I consider to be the most relevant ones: high thermal efficiency; low production of waste, due to the possibility of removing fission products during the reactor operation; and continuous nuclear fuel replenishment, without the need to shut down the reactor", he explains. The professor also mentions that molten salt reactors eliminate the need to produce fuel elements, unlike current reactors. "That will make the nuclear fuel cycle simpler and less expensive," he adds.

In general terms, one of the main characteristics of the molten salt reactor is the fuel used to generate energy. Instead of the traditional uranium, the equipment uses thorium, a material found in abundance in nature. Also, the way these units are cooled is different, with the use of salts that work as refrigerants.

The UFRJ professor believes that molten salt reactors should be used mainly to generate and store energy. But the list of applications does not end there. As it has the capacity to generate heat at high temperatures, the technology can be used in the future for the production of hydrogen, through thermolysis process (a reaction that occurs when a chemical substance is heated and decomposes into at least two other substances). "The molten salt reactor can also be used for nuclear propulsion due to the reduced size and weight of this type of reactor, resulting from the low operating pressure, as well as operational safety and construction costs," Senra adds.

The expert explains that, as in all innovative technology, the challenges for molten salt reactors

are significant and they will still have to be proven as viable, according to the level of maturity of the technology. “Those are still projects with little development compared with most advanced nuclear reactor projects,” he emphasizes.

One of the main risks is the corrosion of reactor components. According to Senra, molten salts require strict management to reduce that possibility. The professor explains that that is particularly complex for projects with molten salt circulating in the reactor’s cooling system. “In circulating molten salt projects, radionuclides dissolved in the fuel make contact with pumps, heat exchangers and valves, which will require remote maintenance at a higher cost,” he adds. Another concern is that tritium appears during the reactor operation, bringing possible risks to the plant operators. Tritium is a radioactive isotope of hydrogen and can permeate to secondary systems, exposing workers to radiation.

Although those intrinsic challenges exist, there is a lot of interest from the nuclear energy sector in experiments that will be carried out in China. The country’s molten salt reactor is located in Gansu province. As it is an experimental pilot plant, its capacity is very small, only 2 MWt. “There are still important tests to be carried out before proving that the technology can be commercialized in the future. There are challenges inherent to this new technology and the Chinese pilot plant will serve to verify the adequacy of the project”, Senra comments. The UFRJ professor believes that once the operation of this prototype is approved, the first commercial version of China’s 100 MWt molten salt reactor will be able to start operating after 2030.

ONE OF THE MAIN CHARACTERISTICS OF THE MOLTEN SALT REACTOR IS THE FUEL USED TO GENERATE ENERGY. INSTEAD OF THE TRADITIONAL URANIUM, THE EQUIPMENT USES THORIUM, A MATERIAL FOUND IN ABUNDANCE IN NATURE

But it’s not just the Chinese who are in this technological race. Other countries such as Canada, France, the United States, Japan, Russia and the United Kingdom are also developing molten salt reactor projects. Once this technology proves to be efficient, the expectation is that those nations will also build that type of reactor for electricity generation and other possible applications.

Brazil, in turn, should not be left out of this new technological frontier in nuclear generation. For Senra, the Brazilian role in this context of molten salt reactors is promising, since the country has large reserves of thorium. In the physicist’s opinion, in addition to exporting the ore, Brazil could even design and build a molten salt nuclear reactor, by the time the country has an energy matrix with a greater share of the nuclear source. “What cannot happen for Brazil is to be limited to being a mere exporter of thorium to the international market. In any case, there is still a long way to go for the introduction of that new technology in the country”, he finishes. ▪

EXPANDING RESERVES

CONGRESS DISCUSSES BILL THAT WOULD ALLOW MINING OF URANIUM AND OTHER RESOURCES IN INDIGENOUS LANDS

Brazil surely is a world key figure when it comes to mineral resources. As geological research progresses in our territory, those natural resources are expected to reach new and greater volume levels in the future. When we consider a particular ore, uranium, the country currently has the ninth largest reserve of this resource on the planet and, according to market estimates, could rank second. To that end, public company for geological survey Serviço Geológico do Brasil (SGB-CPRM, its initials in Portuguese) has recently created a new front for research and mapping of the Brazilian uranium potential. Expanding this geological knowledge in the country will meet the future needs of the Brazilian Nuclear Program, which will demand more and more uranium to supply reactors of new plants and other radioactive enterprises. However, part of the country's mineral potential cannot yet be investigated for legal reasons, as some of those uranium reserves may be located within indigenous lands. According to Constitution, mining in these locations must be regulated by law and needs authorization from the National Congress. More than 30 years have passed since the promulgation of the Constitution, and some attempts were made to regulate the subject, but all without success. Now, the federal government is making a new move in this direction, proposing a bill to solve the legal issues that still prevent mining from taking place within those areas.

Bill 191/2020 was presented by the government in February 2020 and is currently in the House of Representatives, still awaiting the creation of a temporary commission to discuss such proposition. To sum up, the bill sets specific conditions for carrying out research and mining of minerals and hydrocarbons in indigenous lands. In addition, the bill also paves the way for the use of water resources to generate electricity in these locations.

The Assistant Secretary of the Secretariat of Geology, Mining and Mineral Transformation of Brazil's Ministry of Mines and Energy (MME) Lilia Sant'Agostino says that it is still not possible to as-

"WHAT WE CAN SAY IS THAT THERE ARE URANIUM POTENTIALS ASSOCIATED WITH REGIONS WHERE THERE IS A HIGH DENSITY OF INDIGENOUS LANDS. AND THEN, SURELY, THERE COULD BE A POSITIVE IMPACT ON OUR RESERVES"

LILIIA SANT'AGOSTINO, ASSISTANT SECRETARY OF THE SECRETARIAT OF GEOLOGY, MINING AND MINERAL TRANSFORMATION OF BRAZIL'S MINISTRY OF MINES AND ENERGY (MME)

sess what would be the impact on Brazilian uranium reserves when mineral research in indigenous lands gets the green light. Especially because there is a limitation to the knowledge of that potential, since the SGB-CPRM still does not have access to those locations to carry out studies that allow a better approach to those mineral resources. "What we can say is that there are uranium potentials associated with regions where there is a high density of indigenous lands. And then, surely, there could be a positive impact on our reserves," she suggests.

The representative of the Ministry of Mines and Energy says that the lack of regulation on mining and electricity generation from water sources in indigenous territory causes damage to Brazil, such as legal uncertainty, risks to life and health, in addition to non-payment of financial compensation and taxes. Therefore, she believes that bill 191/2020 presents the necessary legal bases that can make those activities possible in indigenous lands.

"This bill contemplates several precepts of the Constitution. The regulation establishes that prior studies will be carried out to really assess the mineral and hydroelectric potential of a particular indigenous reserve. The project also provides for hearings with the population living on these lands and sets the procedures for possible authorization by the National Congress, provided for by the Constitution, for undertakings in the areas of mining and hydroelectric energy generation", she says. Lilia emphasizes that the bill also proposes remuneration in indigenous communities where those economic activities are carried out. "These precepts are within the Constitution and were brought into the bill," she adds.

The MME Secretary also points out that the bill has some additional points, such as the payment of compensation to native communities affected by the restriction of usufruct over their lands. Another topic addressed in the bill proposes the creation of a trustee council to allow the indigenous themselves to share financial resources among legitimate representatives of the communities. Lilia also says that the creation of these councils will allow the local population to choose the best way to use those amounts paid as compensation and royalties. Finally, the bill opens up the possibility for indigenous people to economically exploit their lands, in activities such as agriculture, farming, extractivism and tourism.

"The idea is that that population gets the chance to progress in terms of civilization and to develop all aspects. Many of those communities live in isolation, in conditions of underdevelopment", Lilia explains. In total, according to the most recent data from Brazil's National Indian Foundation (Funai), there are 727 indigenous lands in different phases of the demarcation process in Brazil. Of this total, around 480 areas have already been fully ratified.

Lilia gives examples of other countries, noting that in developed countries there is a peaceful and conciliatory coexistence between economic activities and local communities - and, in most cases, this relationship becomes profitable for native people. That is the case for Canada, as the MME Secretary points out. According to her, private companies of the mining industry in that country are the biggest employers for the Canadian indigenous population. "There are about 500 contracts between indigenous people and mining companies, which make up a Natural Resources Canada database. These agreements are specific and reflect the interests of indigenous people and the constraints of mining activity," she adds.

Meanwhile, on the other side of the globe, in Australia, 60% of the mines are close to indigenous communities, according to Lilia. "Australia's mining industry is the one that employs the most natives. In 2020, more than 6,500 Aboriginal people worked in this sector. It is a very expressive number. In addition, there are commercial partnerships, in which indigenous people themselves participate in the mining activity. It is a form of conciliatory action, which provides conditions for indigenous people to better integrate into the modern world", she finishes. ▪

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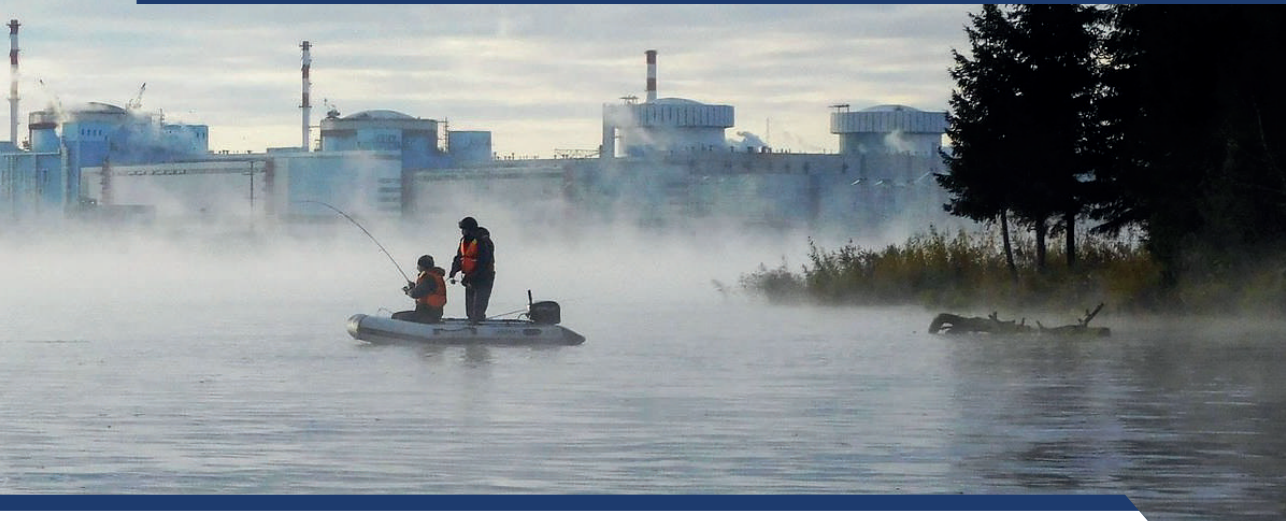

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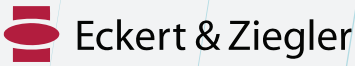
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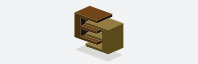
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