



Conexão
Nuclear

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Nuclear Summit

A convergence of industry leaders to discuss the role of innovation in the nuclear sector.

SMRs and NuScale

Exploring the challenges, opportunities, and lessons learned from small modular reactors.

Advancements in Nuclear Medicine

A look at how new treatments are transforming the lives of patients with Alzheimer's disease and prostate cancer.

Exclusive Interview with Celso Pansera, President of Finep

In-depth conversation on partnerships, research, investments, sustainability, and the driving force of innovation.

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SUGGESTIONS AND QUESTIONS

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ARTIFICIAL INTELLIGENCE AND OTHER INNOVATIONS IN NUCLEAR



Hello, readers,

It's undeniable: Artificial Intelligence (AI) has permanently entered the stage. And while it excites many, it also raises questions and even skepticism among some. AI is the subject of widespread conversation.

AI has seamlessly woven into our daily routines, through virtual assistants, simulators, chatbots, and more, transforming marketing experiences, social media interactions, corporate functions, and sectors as diverse as medicine and health, law, and education. It's clear that those not yet engaged with AI

will inevitably do so soon.

In the nuclear sector, the potential for AI is immense. Beyond streamlining administrative and management tasks, AI significantly enhances safety by predicting accidents, identifying hazardous material interactions, and preventing leaks. It's instrumental in conducting vital simulations, replacing human roles in high-risk scenarios, offering cost savings, and mitigating environmental harm.

Yet, while innovation captivates our focus, we mustn't neglect our immediate, responsible duties. Notably, Brazil has yet to sign the Convention on Supplementary Compensation for Nuclear Damage (CSC), an international agreement that provides a framework for financial protection in the event of nuclear incidents. The absence of such an agreement leaves us exposed to staggering financial (and human) risks. It's hard to fathom why we haven't joined this global initiative, which would offer nuclear industry stakeholders access to resources crucial for business continuity in a crisis.

Just as we insure our cars, homes, and businesses to protect against material losses that could spell financial ruin, the nuclear industry faces risks of a far greater magnitude. A single incident can jeopardize not only the industry but also tarnish our nation's reputation, deter future investments, and affect academic and professional pursuits.

Let's embrace the advancements that AI and technological innovations provide, but not at the expense of essential groundwork. Nuclear medicine, for instance, continues to leverage research breakthroughs to enhance patient care. In this edition, we highlight innovations aiding the battle against Alzheimer's and prostate cancer.

We also delve into innovation in our exclusive interview with Celso Pansera, president of Finep, discuss the skill sets needed for the nuclear industry's professionals, and extend an invite to Nuclear Summit 2024, among other topics. This issue truly shines a spotlight on innovation!

Happy reading! ■

IAEA DIRECTOR GENERAL LEADS DISCUSSIONS AT THE NUCLEAR SUMMIT

INNOVATION EVENT TO TAKE PLACE ON APRIL 8 AND 9 IN RIO DE JANEIRO



On April 8 and 9, Rio de Janeiro will become the epicenter of the most relevant discussions in the nuclear sector with the holding of the Nuclear Summit, an innovation event promoted by the Brazilian Association for the Development of Nuclear Activities (ABDAN). The Director General of the International Atomic Energy Agency (IAEA), Rafael Grossi, a renowned leader in the international nuclear scene, will be responsible for opening the event by addressing “Global Nuclear Trends.”

Unlike a conventional fair, the Nuclear Summit proposes a unique approach to debate and analyze the main trends in the nuclear field, including a

special focus on communication. ABDAN’s president, Celso Cunha, highlights that the event stands out not only for its innovative format but also for its comprehensive vision on various crucial themes for the sector. “Divided into two rooms of content and innovations, the Nuclear Summit will feature lectures and panels that will address essential issues such as sustainability, the development of nuclear energy in Brazil, the nuclear fuel cycle, safety, logistics, innovation, and advances in nuclear medicine,” he explains.

The Ministry of Mines and Energy will also be present, consolidating the Brazilian government’s

THE NUCLEAR SUMMIT IS AN INDISPENSABLE FORUM TO DRIVE DISCUSSION AND COLLABORATION IN THE NUCLEAR SECTOR.

commitment to the sustainable and safe development of nuclear energy in the country. Representatives from major industry companies will participate actively, including ENBPar, INB, EDF, Holtec, Westinhouse, and Rosatom, ensuring a diverse and comprehensive perspective on the topics under discussion.

As an innovation-focused event, there will be the 2nd edition of Hackapower, the Nuclear Energy Hackathon with the participation of students from all over the country, which will be sponsored by the Ministry of Science, Technology and Innovation (MCTI). Live recordings of the Nuclear Cast, a podcast with opinion-makers and sector authorities, will also take place during the meeting. Another novelty: SEBRAE will present the project of the nuclear production chain, firsthand.

With the support of FAPERJ, the Nuclear Summit has already established itself as a fundamental meeting point for experts, authorities, and companies in the segment. This is not the first edition of the event, which made its debut in 2021, and continues to play a crucial role in promoting discussion and collaboration in the sector.

The lectures and panels of the event will offer a broad and up-to-date vision of global nuclear trends, addressing topics from sustainability to nuclear safety. The Sustainability panel, for example, will discuss the importance of nuclear energy as a key to the climate solution, addressing topics such as the World Energy Transition and Decarbonization of the Energy Matrix, especially relevant to Brazil.

Moreover, the event will explore the nuclear fuel cycle, with insights on the financial market of uranium and global aspects of the cycle, including discussions on the fuel supply of Brazilian nuclear plants. The disruptive technology of nuclear, known as SMR, will be covered in the lecture "SMR: A Disruptive Nuclear Technology," highlighting the potential of SMRs for nuclear energy in Brazil.

In the Nuclear Safety panel, experts will discuss advanced technologies in this field, addressing studies of scenarios and nuclear accidents, emphasizing the importance of analyzing challenges and the relevance of communica-

tion to ensure the safety of all involved.

Celso Cunha emphasizes the importance of the Nuclear Summit as an indispensable forum to boost discussion and collaboration in the nuclear sector, promoting advances and innovations that will shape the future of atomic energy in Brazil and the world.

OPEN REGISTRATION FOR THE NUCLEAR ENERGY HACKATHON

Those interested in registering for the 2nd edition of Hackapower, Hackathon for the development of practical solutions in the areas of energy, sustainability, and medicine in the nuclear sector, have until March 29 to formalize their registration. Undergraduate, master's, and doctoral students from all over the country can participate. The event is organized by ABDAN - Brazilian Association for the Development of Nuclear Activities and will have the support of the Ministry of Science, Technology and Innovation (MCTI).

"Hackapower drives innovation in the nuclear sector by reinforcing collaboration networks between industry, academia, research centers, and regulation," says Patricia Wieland, one of the project directors.

"After the success of Hackapower 2023 as a novel experience, we hope to reach even more university students covering various areas of knowledge in Brazil," reveals Eliene Silva, also a director of the initiative.

SCHEDULE:

- **Until 03/29:** registration
- **April 8 and 9:** launch at the Nuclear Summit
- **04/09 to 11/05:** competition period
- **11/05:** award ceremony at Nuclear Legacy

RIO DE JANEIRO: STAGE FOR NUCLEAR

The city of Rio de Janeiro has been consolidating its position as a center of excellence in the nuclear sector, and the Nuclear Summit emerges as a significant prelude to the World Nuclear University Summer Institute. This international event, which will take place from June 2nd to July 6th over five weeks, plays a crucial role in shaping new leaders in the global nuclear arena.

Standing out as a speaker, Celso Cunha will contribute his expertise to the event. The World Nuclear University Summer Institute, renowned for its significance, brings together highly promising young professionals from the nuclear sector from various parts of the world. The program offers a unique opportunity to explore the latest developments in the nuclear industry, promoting the exchange of knowledge and the building of a global network of future leaders. ■

NEOINDUSTRIALIZATION IN BRAZIL: WHERE ARE WE?

THE TIME IS RIPE TO INVEST IN NUCLEAR MODERNIZATION OPPORTUNITIES

Neoindustrialization refers to the process of restructuring and renewing the industrial foundation of an economy. This term is typically applied to countries that have experienced a phase of deindustrialization, where industrial production has diminished in comparison to other economic sectors like services and technology. It involves adopting new technologies, more efficient production methods, and an approach more focused on innovation. This could include incorporating artificial intelligence, digital technologies, automation, robotics, and other forms of industry modernization.

The aim of neoindustrialization is to revitalize a country's industrial sector, making it more globally competitive, generating high-quality jobs, increasing productivity, and fostering sustainable economic growth. This process is usually supported by government policies and industrial development strategies.

BRAZILIAN SCENARIO

In Brazil, CNI President Ricardo Alban has underscored the significance of new industrialization for the country, suggesting that neoindustrialization might include transitioning to a green economy and adopting Industry 4.0 practices.

It's plausible that Brazil could seek to modernize and revitalize its nuclear industry to make it more efficient, competitive, and aligned with current and future demands. This could involve adopting advanced technologies, improving production processes, investing in research and development, among other actions.

Scholars have already acknowledged the importance of neoindustrialization for Brazil, arguing that the country is at a propitious moment to enhance its industrial base. Advantages include modernizing manufacturing facilities, investing in technology and innovation, and adopting a more strategic approach to industrial development. Brazil has the resources and potential needed to become a protagonist in the new industrial era, but appropriate public policies and a business-friendly environment are crucial to seize this opportunity.

For Leonam Guimarães, ABDAN's technical director, integrating the nuclear industry into the concept of neoindustrialization can be seen from various perspectives, considering technological advancements, the demand for clean and safe energy, and challenges associated with sustainability and economic development. Highlights:

- **Technological Innovation:** Continuous research and development in the nuclear field aim to enhance the efficiency and safety of nuclear power plants. This includes developing more advanced reactors, such as fourth-generation reactors, promising greater safety, reduced waste production, and higher energy efficiency.
- **Sustainability:** While nuclear energy still faces debates over its environmental impacts and safety issues, many argue it can play a significant role in transitioning to a cleaner, low-carbon energy matrix. Neoindustrialization seeks ways to sustainably integrate nuclear energy, considering not just energy generation but also the safe management of nuclear waste and minimizing environmental risks.
- **Energy Efficiency:** Nuclear power plants are renowned for their high capacity for continuous and reliable energy generation. In the context of neoindustrialization, this can be seen as an important asset to ensure a stable electricity supply to support economic and industrial growth, without solely relying on intermittent sources, like solar and wind.
- **High-Tech Employment:** The nuclear industry employs a variety of cutting-edge technologies, from reactor engineering to monitoring and control systems. This not only drives innovation in the nuclear sector but also contributes to developing skills and knowledge in science and engineering-related areas, promoting technological competitiveness and workforce empowerment.
- **Global Challenges and Opportunities:** Neoindustrialization in the nuclear industry faces significant challenges, including safety issues, nuclear proliferation, and waste management. However,



it also offers opportunities for international cooperation, sharing best practices, and developing global standards for safety and sustainability.

In short, both globally and in Brazil, the nuclear industry is integrated into the context of neoindustrialization through ongoing efforts for technological innovation, international cooperation, investments in safety and waste management, and exploring new nuclear energy applications to drive sustainable economic and sustainable development.

AI AND NUCLEAR SAFETY

The neoindustrialization process is also collaborative, with innovations sharing best practices and learning from each other. For instance, an article recently published by MIT Technology Review highlighted the importance of learning from nuclear safety to avert potential catastrophes related to artificial intelligence (AI). It argues that just as nuclear safety developed rigorous protocols to

BOTH GLOBALLY AND IN BRAZIL, THE NUCLEAR INDUSTRY IS INTEGRATED INTO THE CONTEXT OF NEOINDUSTRIALIZATION.

address potential risks, AI also needs a similar approach to ensure its safe and ethical development and deployment.

The main concept is that lessons and practices from nuclear safety, such as emphasis on redundancy, transparency, and international cooperation, can be applied to the AI field to mitigate potential negative outcomes and ensure its safe and beneficial use. ■

FRAMATOME BRAZIL: BRAZILIAN SPECIALISTS TO SUPPORT THE OKILUOTO PLANT IN FINLAND

**COMPETENCE AND TALENTS OF THE NATIONAL NUCLEAR SECTOR
AT THE SERVICE OF THE WORLD**

Framatome, the French leader in the nuclear industry known for its expertise in innovative solutions and services, is gearing up to make history. In March 2024, two Brazilian technicians from Framatome Brazil will have the opportunity to participate in the maintenance shutdown of the Okiluoto plant in Finland. It will mark the first time Brazilian experts have collaborated at this plant, clearly demonstrating the partnership established between Framatome Brazil and other companies involved in the project.

The selected technicians are young and have extensive experience, thanks to their participation in the last shutdown of Angra 1 and teamwork with international experts in Germany. The expectation is that they will bring their skills and knowledge acquired in Brazil to contribute to the successful maintenance of the Okiluoto plant.

In an exclusive interview for *Conexão Nuclear* magazine, Holger Ludwig, Technical Director of Framatome Brazil, expressed his confidence in the Brazilian market and praised the current moment, highlighting the existing support and cooperation. «I believe in the industrial potential of the country and its plants. In fact, we have recently hired Brazilian engineers and technicians to work at Framatome,» he stated.

Ludwig has been in the nuclear market for nearly 30 years, having worked at Siemens KWU, Areva, and Framatome. As a nuclear engineer, he worked on the commissioning of Angra 2 and was the resident engineer of this Plant.

In recent years, Framatome Brazil has focused its efforts on forming a national technical team, hiring technicians and engineers to work on contracts with Eletronuclear. For 2024, the company plans to

continue expanding its presence in the Brazilian market through new hires, intending to increase the number of Brazilian professionals in its technical team.

In this way, Framatome Brazil will strengthen its local knowledge and competence base, benefiting both the Brazilian nuclear market and the international projects in which the company is involved. Moreover, the company recognizes the importance of the political relationship of the Brazilian Association for the Development of Nuclear Activities (ABDAN) with lawmakers, acting as a facilitator and representative of the private sector companies.

With another opportunity to establish itself on the international stage, Framatome Brazil is ready to demonstrate its talent and show the world the potential of Brazilian professionals in the field of nuclear energy. ■

**THIS WILL BE THE FIRST TIME
BRAZILIAN SPECIALISTS
COLLABORATE AT THIS
FINNISH PLANT, CLEARLY
DEMONSTRATING THE
PARTNERSHIP ESTABLISHED
BETWEEN FRAMATOME BRAZIL
AND OTHER COMPANIES.**

NUCLEAR: AN ESSENTIAL ALLY IN DECARBONIZATION

NET ZERO A FOCUS AT EVENTS LIKE COP 28, THE BELGIAN MISSION, AND THE CLEAN ENERGY MINISTERIAL

For a long time, the nuclear sector has played a crucial role in the global energy landscape, and as the world aims for carbon neutrality, it emerges as a key piece in this environmental puzzle. In this edition of *Conexão Nuclear*, we explore the “Net Zero” theme through the insights of Carlos Leipner, a respected member of the Board of the Brazilian Association for the Development of Nuclear Activities (ABDAN).

In an exclusive interview, Leipner shared his perspective on the significant role of the nuclear sector in the quest for carbon neutrality. He highlights the milestone that was COP 28, where the nuclear theme was acknowledged and discussed in an internationally significant forum, and discusses what’s on the horizon, like the Belgian Mission.

“We are at a critical moment in the global energy transition, and nuclear energy emerges as a viable and sustainable solution. COP 28 was a turning point, highlighting the essential role that nuclear plays in reducing carbon emissions,” Leipner states.

Reflecting on the evolution of nuclear energy’s role in climate conferences, Leipner looks back to COP 26 in Scotland, where the nuclear theme began to emerge more prominently, and COP 27 in Egypt, which saw an even greater presence of the sector. He emphasizes the crucial role played by countries like the United Arab Emirates, which recently built four reactors—an inspiring example of how nuclear energy can be successfully implemented.

“Looking at these examples, we realize that nuclear energy is not just a theoretical solution but a tangible reality. These countries demonstrate that, with investment and international cooperation, it’s possible to build a clean and efficient energy matrix,” Leipner emphasizes.

NUCLEAR ENERGY AS A PATH TO “NET ZERO”: 22 COUNTRIES AGREE

During COP28 in Dubai, a group of 22 nations, including the United States, the United Kingdom, and France, joined forces to endorse a bold proposal: to triple the global capacity for nuclear energy production by 2050. The joint statement aims to reduce carbon emissions over the coming decades, in response to growing concerns about climate change. Despite recent dips in investment, nuclear

energy remains the second largest source of clean international energy.

The initiative gained prominence as part of the scenario presented by the Intergovernmental Panel on Climate Change (IPCC) to prevent the global temperature increase from surpassing 1.5°C. French President Emmanuel Macron expressed his support during the event, stating that small modular reactors are “an indispensable solution.”

Supporting this approach, US Climate Envoy John Kerry stated that “achieving the net-zero goal by 2050 is impossible without nuclear energy.” The flexibility and the ability to install near consumption areas are additional advantages of nuclear plants, making them more practical and occupying less space compared to alternatives like hydroelectric plants.

According to a study by the International Energy Agency (IEA), a reduction in nuclear energy supply will make and increase the cost of transitioning to a clean energy matrix. For Wille Magwood, director-general of the Nuclear Energy Agency, tripling nuclear capacity by 2050 is a realistic path to achieving carbon emission goals. Currently, the global installed nuclear capacity is about 375 GW, with projections to reach 631 GW by 2050.

As per data from S&P Global Commodities Insights, in 2022, six new reactors were activated in countries such as China, Finland, Pakistan, South Korea, and the United Arab Emirates. Additionally, eight new projects were initiated in nations like China, Egypt, and Turkey. By 2030, China is expected to surpass the US as the country with the largest nuclear generation capacity, while Germany ends its nuclear operations, closing its last three active reactors.

“The statement highlights the growing acceptance of this sector as a fundamental piece on the journey towards carbon neutrality,” the expert claims. Leipner emphasizes the importance of international forums like COP to promote dialogue and cooperation between governmental, private, and civil sectors. He also mentions the upcoming COP 30 in Brazil as a unique opportunity for the country to showcase its energy matrix, including nuclear contribution.

“ABDAN is committed to leading discussions on the role of nuclear energy in the transition to a carbon-neutral economy. With COP 30 in Brazil, we have a unique oppor-



tunity, and we hope to demonstrate the significant potential that nuclear holds,” he highlights.

Moreover, Leipner underscores the significance of other initiatives, like the Belgian Mission and the Clean Energy Ministerial (CEM), which will gather leaders in Foz do Iguaçu in September to discuss clean energy issues at the ministerial level.

BELGIAN MISSION

In a global effort to boost decarbonization and tackle climate change, ABDAN is embarking on a journey to Belgium to participate in the international treaty aimed at tripling the use of nuclear energy. The joint initiative between the International Atomic Energy Agency (IAEA) and associations from various countries stands out, bringing together world leaders at the Nuclear Energy Summit, scheduled for March 21, 2024.

Co-chairing the event will be Rafael Mariano Grossi, Director-General of the IAEA, and Alexander De Croo, Belgian Prime Minister. This promises to be the highest-level meeting to date, focusing exclusively on the crucial role that nuclear technology plays in combating climate change.

ABDAN President, Celso Cunha, believes the meeting becomes a milestone to promote awareness and international cooperation in the nuclear sector. “Brazil, recognizing the strategic importance of nuclear energy, actively participates in the discussions and seeks to expand its role in this scenario. The expectation is that collaboration

DESPITE THE RECENT DROP IN INVESTMENTS, NUCLEAR ENERGY REMAINS THE SECOND LARGEST SOURCE OF CLEAN INTERNATIONAL ENERGY.

between nations and organizations represents a crucial step towards a more sustainable and carbon emission-free future.”

For Leipner, the event, gathering top leadership from various countries, will reaffirm the commitment to nuclear energy and its growth. Besides discussing what can be done to truly achieve the goal of tripling the nuclear sector,” he explains. He acknowledges it’s a very ambitious act and, in any case, will need support, not only from governmental organizations but from the entire industry, sector, actors, and even civil society, such as non-governmental organizations, associations, and academia. “It’s going to be a very important event for the nuclear sector that will unfold many global actions, and I think, with Brazil participating once again, it reinforces its importance within the global nuclear sector,” he concludes. ■

CELSO PANSERA, PRESIDENT OF FINEP

In this edition of Conexão Nuclear, we bring you an inspiring chat with Celso Pansera, president of FINEP, an entity whose mission is to promote the economic and social development of Brazil through public funding for science, technology, and innovation in companies, universities, technological institutes, and other public or private institutions. Discussing the nuclear sector, our guest talks about partnerships, research, investments, sustainability, and, of course, innovation.

1 – Innovation is essential for advancing the nuclear industry. How is FINEP promoting this in the sector, and what strategies does the entity adopt to establish strategic partnerships that boost the development of nuclear technologies in Brazil?

One of the main projects FINEP supports is in the nuclear sector. The most significant financing, involving the largest resource allocation at the moment, is for the Brazilian Multipurpose Reactor (RMB) project, which will benefit millions of Brazilians. Just in December 2022, FINEP allocated BRL 172 million in non-repayable resources from the National Fund for Scientific and Technological Development (FNDCT) for the engineering project of the Radioisotope Processing and Handling Laboratory of the Reactor. This reactor is intended for the production of radioisotopes and serves both for the production of radiopharmaceuticals and for use in nuclear medicine for diagnostics and treatments. Additionally, the entire nuclear fuel qualification process can be done with the multipurpose reactor. There is also a longstanding project, a Navy nuclear program that FINEP directly supports. There is already, let's say, a tradition of FINEP's interaction with the nuclear sector, supporting initiatives of the Brazilian Nuclear Energy Commission institutes. We expect new projects to emerge, especially in the area of small modular reactors. FINEP will always be ready to support the research infrastructure that will lead to technological development in the sector.



2 – How is FINEP directing investments to boost nuclear research in Brazil? What are the main projects and initiatives underway to strengthen technological development in this sector?

Regarding investments in innovation and strategic partnerships, there is a tradition of supporting innovative initiatives in the nuclear area, especially the Navy's nuclear program, which led us to master the nuclear fuel cycle. As mentioned earlier, various institutes of the Brazilian Nuclear Energy Commission have been FINEP clients over the years, and what they do is precisely to advance the application of nuclear technologies in various areas – agriculture, medicine, industry, among others. These applications are becoming increasingly interesting due to the various innovations that have emerged in the sector. Another area worth mentioning is food. Nuclear techniques are currently widely used worldwide for food preservation and pest control, among other applications.

3 – Amid the growing search for more sustainable energy sources, how is FINEP contributing to making nuclear energy a more viable and sustainable option in the Brazilian energy scenario?

Regarding the sustainability of nuclear energy, it is already quite accepted. It is clean energy in the sense that it effectively does not contribute to greenhouse gas emissions and now there seems to be an international trend of integrating it into the range of energies considered sustainable. And the development, which is internationally accepted as quite promising in this area, is precisely that of small modular reactors. As the name suggests, they have a modular construction, are safer reactors, and can be used to form sets, clusters, providing energy not only for conversion into electrical energy but in multiple applications, such as desalination and industrial use. Mastering the technique of uranium enrichment is another element in this context.

4 – The training of skilled professionals is crucial for the success of the nuclear industry. Is FINEP supporting projects for the training and formation of specialized human resources in the nuclear sector, considering future demands?

Regarding human resource training, some universities in the country, such as the Federal University of Rio de Janeiro, offer undergraduate courses in nuclear engineering, in addition to postgraduate studies at COPPE. We can find very good quality training in the nuclear area in universities like the Federal University of ABC, Federal University of São Carlos, and UNICAMP. And FINEP, obviously, has a tradition of supporting scientific and technological institutions. We must not forget the aforementioned Navy research institutions that operate in the nuclear area, at the Navy's Technological Center in São Paulo. Not to mention the institutes of the Brazilian Nuclear Energy Commission, for example, IPEN, the Energy and Nuclear Research Institute (São Paulo), which have been training professionals in this area for many years, including in partnership with the University of São Paulo. There is also the Center for the Development of Nuclear Technologies, in Belo Horizonte, on the campus of the Federal University of Minas Gerais.

**“
FINEP WILL
ALWAYS BE READY
TO SUPPORT
THE RESEARCH
INFRASTRUCTURE
THAT WILL
LEAD TO
TECHNOLOGICAL
DEVELOPMENT
IN THE NUCLEAR
SECTOR.
”**

5 – Looking to the future, what are FINEP's perspectives for the growth and expansion of the Brazilian nuclear industry?

Looking to the future, nuclear energy should increasingly become part of the Brazilian energy matrix, as it is considered clean energy. In Europe, it is already being considered green energy. And there is this whole movement of diversifying energy matrices, with an increase in nuclear participation. But beyond that, the nuclear area tends to become increasingly important in medicine. And with the support for the Brazilian multipurpose reactor, we will solve a serious problem, which is our dependence on radioisotopes – both for treatment and diagnosis, and for nuclear medicine. We will also have neutron lines for materials research, a significant impact on the entire nuclear sector. In techniques for food preservation, for pest control, it has also been increasingly used. And there is the current challenge of producing small modular reactors, safer, which already meet the requirements arising from the last accident that occurred in Fukushima, which demanded the incorporation of many safety measures. These reactors take this into account. They have a lower cost, can be used in remote areas not only for energy but also – as mentioned – for water desalination, so the future prospects are very good. Society needs to understand that the nuclear sector is extremely beneficial. ■

NUCLEAR BATTERIES: THE PROMISE OF LONG- LASTING ENERGY

EFFICIENCY AND POWER HIGHLIGHTED BY IPEN-CNEN AND BETAVOLT

Recent innovations in nuclear battery technology are driving the promise of long-lasting and reliable energy for extended periods. With studies led by the Institute of Energy and Nuclear Research (IPEN-CNEN) in Brazil and significant advancements by the Chinese startup Betavolt, the prospect of energy devices with exponential autonomy is closer than ever.

THE BRAZILIAN ADVANCEMENT: IPEN-CNEN'S NUCLEAR BATTERY

In Brazil, scientists from IPEN-CNEN have developed the nation's first nuclear battery using the isotope americium-241. This thermoelectric battery, also known as a Radioisotope Thermoelectric Generator (RTG), has the potential to provide power for over 200 years without the need for recharges, making it a promising option for applications in remote or hard-to-reach locations.

At the core of this advancement is americium, a radioactive metal, whose natural decay heat is harnessed to generate electrical energy. Nuclear batteries operate using thermoelectric energy-generating pellets (TEGs), which capture the heat from decaying americium to produce electricity.

Although these batteries currently offer a modest output voltage of 20 millivolts (mV), their true value lies in their

incredible longevity. With a half-life of 432.6 years, americium allows for an estimated durability of up to 200 years for each battery.

This phenomenon results from the temperature difference between the hot side, where the americium source is located, and the cold side of the pellets. The voltage powers a collector circuit, which stores enough energy to periodically supply small charges. However, due to the current model's limited energy generation capacity, a source with higher activity is required just to light a simple LED.

Maria Alice Morato Ribeiro, researcher at IPEN's Nuclear Engineering Center and project coordinator, explains how the entire execution occurs. Inside a nuclear battery, energy arises from a fascinating process. The heat generated by the natural decay of a radioisotope is the engine behind this energy innovation. The thermal energy is then channeled through small thermoelectric energy-generating pellets (TEGs), bringing the electrical potential of the battery to life.

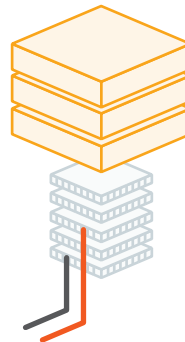
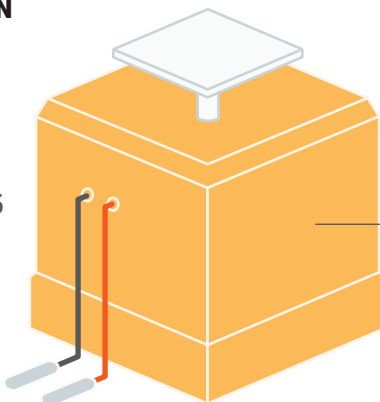
Despite this potential, technical challenges still persist, especially related to the reliability of the thermoelectric pellets, which must operate for an equivalent period. According to Maria Alice, this first battery was developed primarily to validate the concept. The next step is to build an

THE BRAZILIAN NUCLEAR BATTERY



200 years

is the potential to provide energy without the need for recharges.



AMERICIUM-241

A radioactive metal, whose natural decay heat is harnessed in TEGs.

TEGS

Thermoelectric energy-generating tablets. They capture the heat from decomposing americium to produce electricity.

Source: ABDAN

WITH A HALF-LIFE OF 432.6 YEARS, AMERICIUM ALLOWS FOR AN ESTIMATED DURABILITY OF UP TO 200 YEARS FOR THESE BATTERIES.

improved version, with increased power to 100 mW.

It's worth noting that this is a multidisciplinary achievement of INPE-CNEN. The project was developed by the Nuclear Engineering Center (CEENG), and the battery was assembled by researchers from the Center for Radiation Technology (CETER), using Americium-241 pellets stored in the Radioactive Waste Management Service (SEGRR) as fuel.

THE REVOLUTION OF BETAVOLT: MINIATURE NUCLEAR BATTERIES

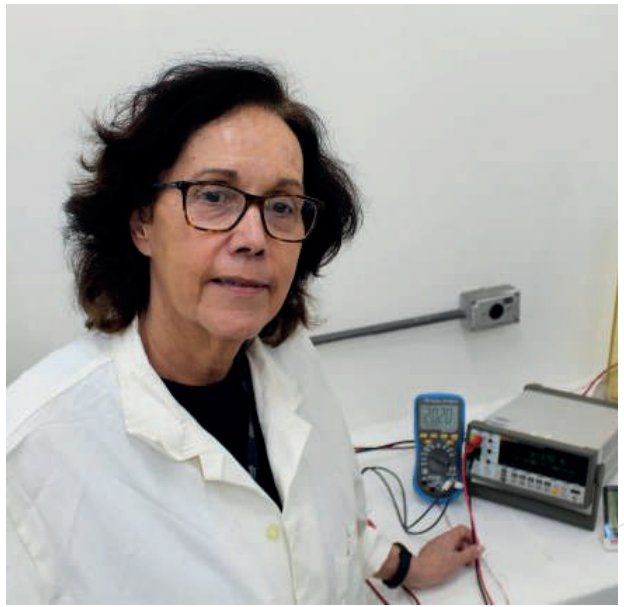
Meanwhile, the Chinese startup Betavolt has reached a milestone by developing a small nuclear battery the size of a coin. This innovation, named BV100, promises a lifespan of 50 years without the need for recharges. With a power of 100 microwatts and compact dimensions of 15 x 15 x 5 cubic millimeters, this battery represents a true revolution in the miniaturization of nuclear energy.

The Beijing-based company is making history. Imagine 63 nuclear isotopes compacted into a module smaller than a coin - it's a real technological feat!

But how is this possible? The functionality of this battery is based on the conversion of energy released during the decay of isotopes into electricity. This process, which dates back to the 20th century, has been refined and optimized by Betavolt, resulting in an efficient and powerful battery.

According to the company, the achievement is not limited to miniaturization but also involves the modularization and efficiency in the production of atomic energy batteries. In other words, Betavolt not only compacted nuclear energy but also made it applicable for various practical uses.

With plans to expand its portfolio, according to Zhang Wei, president and CEO of Betavolt, the company plans to launch a 1-watt battery by 2025.



Researcher Maria Alice Morato Ribeiro, from CEENG, is the coordinator of the project to develop a nuclear battery

This initiative promises to open doors to a variety of innovative applications. Wei envisions a future where, if regulations allow, nuclear batteries could indefinitely power cell phones. Additionally, he suggests transforming short-flight drones into continuous fliers, thanks to the potential of atomic batteries. The company also considers these batteries safe for medical devices inside the human body, such as pacemakers and cochlear implants, without external radiation.

These advancements indicate a significant shift in the landscape of portable energy, with profound implications in various areas, from consumer technology to industrial uses.

THE FUTURE OF NUCLEAR ENERGY IN OUR HANDS

The innovations presented in this article have the potential to transform a variety of sectors, from use in spacecraft to remote surveillance devices. Currently, nuclear batteries are already used in lighthouses on remote islands, satellites, and NASA's rovers, such as Curiosity and Perseverance.

With the continuous development of this technology, nuclear energy is becoming an increasingly viable and long-lasting option to meet the growing demands for energy, offering a reliable and sustainable alternative for the future. ■

NUCLEAR MEDICINE INNOVATIONS: ALLIES IN THE FIGHT AGAINST ALZHEIMER'S AND PROSTATE CANCER

STAY UPDATED ON THE FOREFRONT OF THIS SPECIALTY

Nuclear medicine has stood out in diagnosing and treating various diseases plaguing humanity for years, benefiting patients and healthcare professionals. Some countries are quite advanced in this area and in democratizing access to innovations for a large part of the population.

In Brazil, the scenario is perhaps still slow for those suffering from an ailment, but it does advance with the strength and determination of those dedicated to study and research, ensuring we closely follow everything happening worldwide. The goal is challenging, but the desire to improve the prognosis and quality of life of over 200 million inhabitants motivates and invites partnerships and business generation.

In this article, we will specifically address how nuclear medicine can change the reality of patients with Alzheimer's Disease (AD) and prostate cancer (PCA).

ALZHEIMER'S DISEASE: EARLY DETECTION, EFFICIENT TREATMENT

Alzheimer's Disease (AD) is a growing concern worldwide, affecting millions, mainly the elderly population. According to the World Health Organization, there are currently an estimated 35.6 million people with the disease, expected to double by 2030 and triple by 2050. In Brazil, about 1.2 million people live with AD. It's important to note that the increased life expectancy raises the disease's incidence, socioeconomically impacting the world.

Alzheimer's is a progressive, incurable neurodegenerative disorder manifesting with cognitive function deterioration, as well as neuropsychiatric and behavioral changes, leading to the impairment of daily life activities (DLA). As the brain's affliction by the disease progresses, the patient moves from recent memory loss to non-recognition of close people, as well as the inability to perform self-care,

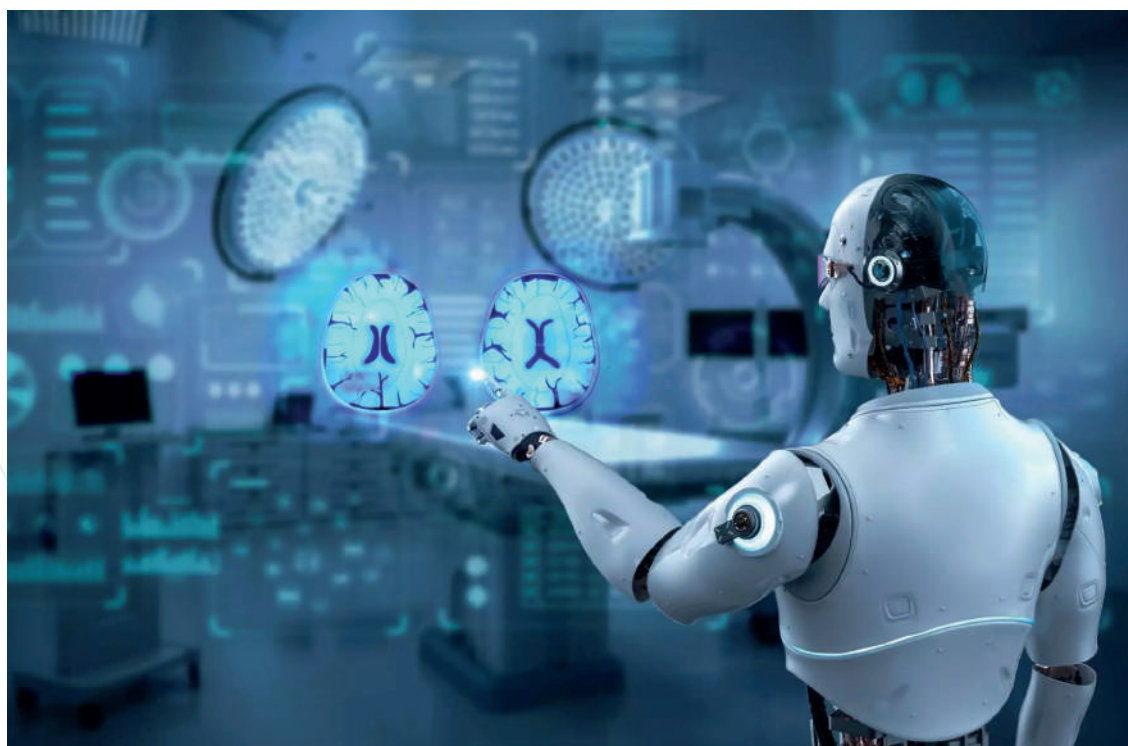
reaching a state of immobility, complete loss of independence, and eventually death, invariably occurring 7 to 10 years after diagnosis.

The diagnosis of AD used to be post-mortem, but advances in Nuclear Medicine have allowed for the early detection of brain proteins associated with the disease during life, through Positron Emission Tomography (PET) with β -amyloid markers.

"This non-invasive exam has the potential to identify the presence of proteins in early stages of the disease, even before clinical symptoms manifest. In Brazil, the amyloid marker with fluorine-18 (18F), such as Florbetaben (FBB), stands out as a promising tool, although its availability is still limited. This innovation not only confirms the AD diagnosis but also opens doors for treatments in earlier phases," explains Flávia Dornelas Kurkowski, nuclear medicine physician at the Brain Institute of Rio Grande do Sul (InsCer).

Nuclear Medicine has other well-established exams in the AD diagnosis, such as Cerebral Perfusion Scintigraphy and 18F-FDG-PET/CT. The former uses the tracer ^{99}Tc -ECD, capable of assessing cerebral perfusion. The latter uses fluorodeoxyglucose (18F-FDG), a glucose analogue that allows observing cerebral metabolism. In AD, both blood flow and cerebral metabolism are affected and can be detected by PET.

Nuclear Medicine exams are extremely relevant tools in Alzheimer's disease, capable of assisting in the diagnosis and, therefore, in clinical management, providing a better quality of life for these patients. The inclusion of PET with β -amyloid marker currently allows the confirmation of AD diagnosis and its identification in early stages, and it will undoubtedly be a fundamental tool in treatment, paving the way for the use of therapies when clinical symptoms are still absent. These are significant advances provided by the medical specialty of Nuclear Medicine.



PROSTATE CANCER: DIAGNOSTIC PRECISION, TREATMENT HOPE

Prostate cancer (PCa) is one of the most significant public health problems worldwide, occupying the second position in male mortality in Brazil - only behind lung cancer - and the sixth position in the world, according to data from the National Cancer Institute (INCA) and the World Health Organization (WHO). It's estimated that for the biennium 2023-2025, about 72,000 new cases will be diagnosed in the country.

Prostate cancer (PCa) is a disease characterized by the abnormal and uncontrolled growth of cells in the prostate, a male sexual gland responsible for part of the seminal fluid production. This abnormal growth can lead to tumor formation, which can spread to other body parts, such as bones, lymph nodes, and other organs. Age is a significant risk factor, with the disease being more common in men over 50, especially after 60 years.

Prostate cancer presents challenges for doctors in diagnosis and treatment. The initial phase is asymptomatic, complicating early detection. The diagnosis of PCa can be made through different exams, such as rectal touch, PSA (Prostate-Specific Antigen) dosage, abdominal and transrectal ultrasonography, biopsy, computed tomography, pelvic magnetic resonance, and nuclear medicine exams. The PSA exam can have false-negative results or lead to unnecessary biopsies. The biopsy is invasive and can have complications.

Treatment resistance and metastases are additional obstacles. Research seeks to improve diagnosis, reduce side effects, and develop new, more effective treatments.

Nuclear Medicine has played a crucial role in this scenario, offering advanced technologies for diagnosis and treatment, as explained by Josino Garcia, general manager of Medical. Especially with the use of PET/CT (Positron Emission Tomography associated with Computed Tomography) technology and, more recently, PET/MR (Positron Emission Tomography associated with Magnetic Resonance). This technology allows the visualization of tumor cells with high precision, enabling a more accurate and early disease diagnosis, in addition to assisting in staging and evaluating treatment response.

Moreover, new radiopharmaceuticals, such as Xofigo (Ra-223) and ¹⁷⁷Lu-PSMA, have been approved for therapeutic use, offering hope for patients with resistant tumors. Despite challenges, such as the industrial-scale production of the radioisotope ²²⁵Ac, research continues to advance, with promising clinical studies underway. Nuclear Medicine is at the forefront of fighting PCa, offering increasingly precise and effective solutions.

"In summary, innovations in Nuclear Medicine are transforming how we diagnose and treat prostate cancer. The development of new radiopharmaceuticals and theranostic techniques is a promising field offering hope for patients," concludes Josino. ■

ESSENTIAL SKILLS FOR TECHNOLOGICAL INNOVATION IN THE NUCLEAR INDUSTRY

PROFESSIONALS NEED TECHNICAL COMPETENCIES AS WELL AS MANAGEMENT, MOTIVATION, AND ENGAGEMENT IN RELEVANT PROJECTS

The nuclear industry plays a crucial role in various areas, from electricity production to applications in medicine and agriculture. However, it faces complex challenges in an environment marked by volatility, uncertainty, complexity, and ambiguity. Innovation is fundamental to its relevance and sustainability, but many barriers hinder its development, such as the long maturation time of projects and the lack of integration between academia and companies.

Scholars categorize our current environment with the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) acronym. Elaborating a bit more: changes are more dynamic, uncertainty about the scenario and future has never been so present, and the analysis for decision-making presents multiple perspectives. In general terms, there's a need to identify priorities, and innovation is a necessary piece being both cause and effect of this process.

According to Dr. Patricia Wieland (Advisor to ABDAN and Amazul and director of the World Nuclear University from 2014 to 2020), there is a need to innovate to remain useful, relevant, economically viable, and in compliance with the sustainable development goals. Innovation doesn't end with the publication of a scientific article in a journal. For her, it's essential to identify innovative ideas and projects that are relevant to the industry and deserve incentives for their operational implementation. Whatever the innovation portfolio and its choices are, the main base is human resources, including employees, managers, and decision-makers.

For Dr. Eliene Silva (Science Specialist on the engineering team at Framatome), innovation is a fundamental part of the nuclear industry given the unique demands of this sector, needing to be present and active. There's much to develop in terms of the sector's production chain in Brazil.

BUILDING SKILLS FOR INNOVATION

Innovation should, therefore, be contemplated throughout the chain, in both the physical and human parts, from projects, ideas, analyses, research, to actual execution and subsequent steps. It's impossible to think about nuclear without considering innovation as an essential element.

And how can we foster an innovative stance? Below we share suggestions from Drs. Patricia and Eliene on the subject:

EFFICIENT MANAGEMENT: Skilled managers are essential to lead dynamic teams, promote continuous learning, and stimulate innovation. They should create an environment conducive to expressing new ideas and developing efficient solutions, avoiding demotivation and stagnation. According to Patricia Wieland, training managers for innovation is a critical and urgent topic: managers must have the ability to lead diverse and dynamic groups and stimulate continuous learning and knowledge sharing in themselves and their collaborators, maintaining a global vision of the goals to be achieved.

The professional emphasizes that managers who help their employees develop their careers also grow and prepare to occupy higher positions, sometimes in different

WHATEVER THE INNOVATION PORTFOLIO AND ITS CHOICES ARE, THE MAIN BASE IS HUMAN RESOURCES, INCLUDING EMPLOYEES, MANAGERS, AND DECISION-MAKERS.

sectors. Although professional advancement can be challenging, those who have already made this journey may be ready to act as “executive coaches.” This will accelerate the learning process, prioritizing the most important issues, presenting the network, providing information, and addressing concerns.

“By developing the specific skills needed to meet the intended increase in electricity generation from nuclear generation, for example, we should target today’s managers and tomorrow’s leaders. We need to think about the legacy we ourselves have inherited and also about what we are leaving for the next generation. What comes to mind here is communication. We need to abandon the expectation that future leaders will do better than what we can do now; we must make every effort to improve the planet we are passing on to the next generation,” she states.

INDIVIDUAL MOTIVATION: Recognition, self-confidence, and a healthy environment are crucial to stimulate the application of technical competencies and the creativity of professionals. Individual motivation drives progress and innovation.

MENTORSHIP PROGRAMS: Can be for any stage of professional life, from young graduates to executives from other segments who join the nuclear area as directors, advisors, and presidents. The mentorship program should focus on continuous evolution and a culture of innovation. Mentors are senior experts in the nuclear field who dedicate part of their time to support and motivate other professionals with their historical knowledge and the trends in the nuclear world.

ENGAGEMENT IN RELEVANT PROJECTS: Participation in technical events, focal workshops, and multidisciplinary collaboration networks promotes knowledge sharing and the resolution of technological challenges. Technological competitions and mentorship programs are also powerful tools to develop skills and drive innovation. As an example, we mention the Brazilian Nuclear Olympics (ONB), organized by ABDAN and inaugurated in 2023, which not only contributes to forming future leaders for Brazil’s nuclear sector but also paves the way for a knowledge exchange network between students and professors from academia and research centers, with nuclear industry experts and regulators, bringing the necessary strategic vision to the specific context of each project.

INTERNSHIP AND EMPLOYMENT OPPORTUNITIES: Internships in the last periods of formation are crucial for the industry to absorb talents. The lack of opportunities in the private sector can lead to the loss of qualified professionals, harming the industry’s development.

ORGANIZATIONAL CULTURE OF INNOVATION: Establishing

WITH AN APPROACH FOCUSED ON HUMAN DEVELOPMENT AND THE PROMOTION OF INNOVATION, WE CAN FACE THE CHALLENGES OF THE NUCLEAR SECTOR AND BUILD A SUSTAINABLE AND PROSPEROUS FUTURE.

units dedicated to innovation and encouraging the emergence of start-ups and start-up accelerators are important measures to promote an innovation culture and ensure the continuity of innovative initiatives.

In summary, the essential competencies for recent graduates in the nuclear industry include not only technical competencies but also management skills, motivation, and engagement in relevant projects. With an approach focused on human development and the promotion of innovation, we can face the challenges of the nuclear sector and build a sustainable and prosperous future. ■



SMRS: CHALLENGES AND OPPORTUNITIES IN TRANSFORMING THE NUCLEAR SECTOR

LEARNING FROM THE CHALLENGES OF THE NUSCALE PROJECT

The nuclear sector is on the brink of a revolution with the rise of Small Modular Reactors (SMRs), an innovation that promises to shape the future of the industry, according to specialists in the field. In this article, we will explore the challenges and opportunities surrounding this technological advancement with insights from Carlos Leipner, a member of the Board of the Brazilian Association for the Development of Nuclear Activities (ABDAN).

“SMRs represent a paradigm shift in nuclear energy generation. Offering greater safety, lower costs, facilitated financing, and better compatibility with smaller national electricity grids, this new generation of reactors aims to reduce project risks, improve social acceptance, and attract private investment. A true potential for a much-anticipated ‘nuclear renaissance,’” says Leipner.

LEARNING FROM PAST MISTAKES

However, to fully understand this evolving scenario, it is essential to analyze recent events that shape the future of SMRs. “The cancellation of the NuScale project in the United States and the advancements of GE’s BWRX-300 in Canada and the US are indicators of the complexities involved,” says Carlos Leipner. He also emphasizes that to ensure success, it is crucial to learn from past mistakes.

The promise of low costs is highlighted as a critical issue. Leipner warns of the danger of overpromising, recalling the early days of nuclear electricity when it was believed to be “too cheap to meter.” The economies of scale that drove the growth of larger nuclear power plants in the past now need to be evaluated under the lens of SMRs, where over 80 projects are under development. The question arises: Is there a substantial enough market to feed factory-line production?

THE CHALLENGE OF REGULATIONS

Efficient time management is another challenge addressed by Leipner. “The lengthy timelines necessary for the im-

plementation of nuclear power plants, often due to prolonged regulations, need to be overcome. The development of ‘risk-informed’ regulations adapted to SMR projects is crucial, and the harmonization of these regulations globally could take inspiration from the model of the United States Federal Aviation Administration,” reveals the expert.

WASTE MANAGEMENT

Leipner also highlights the need for a proactive approach to the management of nuclear waste. “Anticipating issues related to the safe disposal of irradiated fuel and/or high-activity radioactive waste from the initial design phases is essential. This preventive approach can mitigate objections to the expansion of nuclear energy, considering the ‘unresolved waste problem,’” he emphasizes.

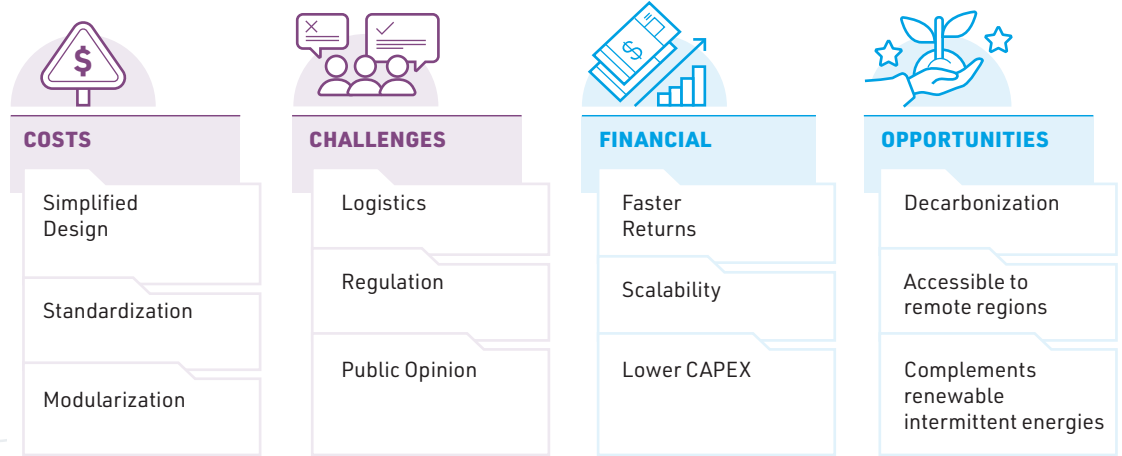
GLOBAL SCENARIO AND CHALLENGES ASSOCIATED WITH PIONEERING PROJECTS

In the global context, nuclear energy is an important option for implementation in a decarbonized global energy system. However, recent news, such as the mentioned discontinuation of NuScale’s Carbon Free Power Project (CFPP), raises concerns. “This cancellation represents a significant setback for the company, but it does not necessarily reflect the broader market prospects for SMRs and advanced reactors in the United States or globally,” comments Leipner.

Pioneering projects like the CFPP face inherent risks and expenses, regardless of the technology. In the case of the CFPP, the project risks extended beyond the technology itself. Launched in 2015, even before NuScale submitted its application for standard design certification to the Nuclear Regulatory Commission (NRC), the project’s timing reflected the company’s need for a client to instill investor confidence.

However, choosing the Utah Associated Municipal Power Systems (UAMPS) as the first client compounded NuS-

ADVANTAGES AND SIMPLIFICATIONS OF SMRS



Source: ABDAN

cale's challenges. UAMPS, a collective of municipal utilities near an available site at Idaho National Labs, had little experience in nuclear technology. The organization could not assume cost risks on behalf of its customers and operated in a market with cheap natural gas and growing wind energy deployment. Consequently, the project was not positioned for commercial success from the beginning, with the number of subscriptions not reaching the levels needed to sustain NuScale's original design of 12 VOYAGR model reactors.

As a result, NuScale downsized the project to an array of six reactors to offset the cost and attempted to compensate for the increased marginal cost by raising the capacity from 50 MWe to 77 MWe per reactor. However, this adjustment proved insufficient for this specific design.

The design complexities of the VOYAGR, though innovative, require significant civil works on-site. Notably, constructing a large pool, in which the reactors would be submerged, incurred a considerable fixed cost, regardless of the number of modules. This lack of modularity made the design more expensive and less adaptable than other SMR alternatives, contributing to its commercial challenges. The VOYAGR design is also a relatively large and complex nuclear power plant, capable of generating up to 924 MWe with 77 MWe modules. Other SMR developers are pursuing more modular and smaller designs, which may be better positioned for competitive energy markets.

ADVANCING IN THE SMR INDUSTRY

"Despite these challenges and the project's failure to progress as initially structured, the CFPP initiative played a crucial role in advancing NuScale's technology and achieved victories with implications for the entire advanced reactor

and SMR industry. Although it was costly and time-consuming, through the process of obtaining the first design certification for an SMR, NuScale also secured limitations on Emergency Planning Zones (EPZ) and reductions in staffing and control room security requirements. The company bore the cost of these achievements for the entire industry," acknowledges the professional.

The licensing process also resulted in many lessons learned for both developers and the NRC, such as design readiness, the need for risk-informed decision-making, reform of the Advisory Committee on Reactor Safeguards (ACRS), and others. Ultimately, it allowed NuScale to ensure projects better positioned for success, such as those with Nuclearelectrica in Romania (an experienced nuclear utility company well-placed to develop SMRs in a market needing Western nuclear technology for energy security and decarbonization) and Standard Power, a data center developer whose financial model requires large-scale, carbon-free, 24/7 energy.

Given this context, the termination of the CFPP should serve as a signal for governments, industry stakeholders, and the nuclear sector at large to reconsider the FOAK deployment strategy for SMRs. The traditional approach of licensing a design and proceeding to construction is too slow and expensive for today's dynamic market.

LEARNED LESSONS

"The CFPP's outlook could have been different, for example, if governments provided reactor sites where companies could deploy prototype/demonstration reactors through a significantly simplified process for testing and operations aimed at regulatory licensing, with government procurement or insurance provided to a developer and proj-



ect owner that would cover costs beyond a certain limit. This approach would have avoided trying to turn a demonstration reactor into a commercial model. Of course, this doesn't mean giving a blank check to a reactor supplier; suppliers should be incentivized with milestone-based payments (e.g., upon completing the full design or achieving successful regulatory milestones)," observes Carlos Leipner.

To transform the trajectory of FOAK SMR deployment, several changes are imperative. This includes treating prototype projects as demonstrations rather than complete commercial ventures, which implies setting realistic expectations, especially for very early-stage projects like the CFPP.

There are more than 50 SMRs around the world today. It's simply unrealistic to believe they will all be successful, or that every project undertaken by a developer (especially before construction begins) will advance. Failures are expected in a free-market society and have been notable in the climate technology sector. This doesn't mean that the United States will abandon ambitious solar, offshore wind, or electric vehicle implementation plans. It simply means that the market will adjust, and among some losses, winners will emerge.

"The same is expected in advanced nuclear energy. It's not enough to set expectations; the right incentives and support for FOAK demonstrations (e.g., insurance against cost overruns) are needed, as well as recognizing that profit-driven utility companies may not be ideal customers for this model. Heavy industries and data centers, artificial intelligence, and public utilities with strategic goals and a strong demand for reliable zero-emission energy may be more suited to take on such technological and implementation risks," he warns.

Governments should also focus on encouraging large order portfolios and fostering partnerships between industries to support the expansion of the nuclear sector, draw-

ing inspiration from successful models like the U.S. Department of Energy's Regional Clean Hydrogen Hubs for the hydrogen market. Redefining nuclear business cases, emphasizing design completion, promoting new, more modular and less complex SMR projects, and simplifying the nuclear regulatory process are all essential steps toward a more successful and sustainable future for advanced nuclear technologies.

While all these steps are necessary to improve the chances of success for nuclear energy, a final note should be made regarding cost comparisons between technologies. Although the projected "levelized cost of electricity" (LCOE) for the VOYAGR increased over time to \$89/MWh, it is now widely understood that LCOE is not the proper assessment of an electricity unit because it does not consider its value to the system. This value needs to account for technological features beyond levelized cost, such as 24/7/365 dispatchability and its impact on the total system (e.g., avoided transmission, reserve contribution, etc.). Decarbonization studies of the electric system continue to overwhelmingly support the conclusion that clean dispatchable resources, like nuclear energy, reduce the total cost of decarbonization. This doesn't suggest that FOAK price points like those of VOYAGR are desirable, but even these elevated costs need to be put in perspective considering the value to the grid.

With this context in mind, while NuScale may be seen as a new casualty of a challenging energy scenario, the lessons learned from the termination of the CFPP highlight the broader challenges within the traditional nuclear ecosystem. This prompts a critical reflection on how innovative designs can thrive within this framework. The CFPP experience, rather than highlighting a flaw in the SMR concept, presents an opportunity to reshape strategies, redefine partnerships, and revitalize the trajectory of advanced nuclear technologies in an evolving energy landscape. ■

BOOK UNVEILS UNTOLD STORIES OF WOMEN IN NUCLEAR

THE FIRST VOLUME WILL BE LAUNCHED BY EDITORA LEADER IN RIO AND SÃO PAULO IN MARCH, WOMEN'S MONTH

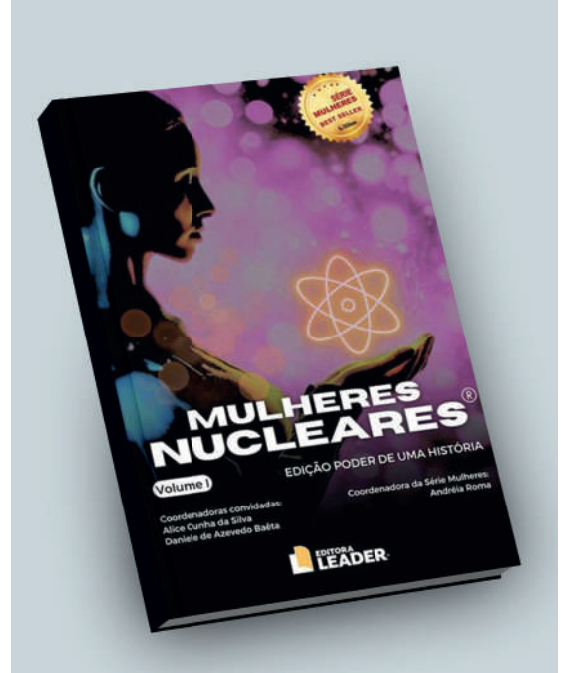
In the most feminine month of the year, the launch of the book “Nuclear Women - Volume 1,” by Editora Leader, will take place. The book signings are set for March 20th in São Paulo at Livraria Cultura Paulista, and on the 22nd in Rio de Janeiro at Livraria Travessa Leblon. The pages of this work narrate the stories of resilience, expertise, and brilliance of women who shape the future of nuclear energy.

According to Andréia Roma, CEO of Editora Leader, the book emerges as a pioneering work, dedicated to highlighting the fundamental role of women in the nuclear field. “Originated from the publishing label Série Mulheres, this project stands out by offering a unique and essential perspective on the intersection of women with the significant nuclear area. Each page of this book is a testimony of Editora Leader’s commitment to extending the reach of female voices, now also encompassing the nuclear area,” she says.

The book was coordinated by guest editors Alice Cunha da Silva and Daniele de Azevedo Baêta, who curated and selected the women featured and spoke exclusively with our reporters. They emphasize that diversity is widely explored in the book. “There are stories of women working on various fronts of the nuclear sector, from newcomers to those with years of experience. In each chapter, a woman tells her professional journey, but also the personal side, the obstacles, and the triumphs, which give visibility to the role that women have been building in this sector,” explains Alice.

Daniela adds that the book will be an inspiration for other women to not feel alone in such a male-dominated sector. “We hope to be giants for others, paving the way. We believe that today’s difficulties will be overcome and will allow the next generations to achieve much more than we have.”

Women, as representatives and leaders in this crucial field, share their stories, learnings, achievements, and valuable advice throughout the book. “This book not only celebrates the present but also serves as an inspiring guide for the women who are shaping the future of this ever-growing area. By bringing to light these authentic narratives, ‘Nuclear Women’ stands out as a significant contribu-



tion, promoting diversity and gender equality. An essential read for anyone seeking inspiration and valuable insights in the fascinating world of nuclear energy from the unique and powerful perspective of women,” states Andréia Roma.

The cover also deserves attention. A mosaic of intertwining colors forms a dynamic background that centers on a woman holding the symbol of the nuclear area in her hands, a design that not only symbolizes the field but also reflects the grandeur, dedication, and commitment of each of the women in this area.

The book is co-written by Adelia Sahyun, Ana Beatriz Julião, Ana Celia Freitas Sobreira, Ana Cristina Lourenço da Silva, Andreia Pontelo, Angélica Kiepper, Beatriz Leme, Bruna Oliveira do Nascimento, Clédola Cássia O. Tello, Cristiana Altino de Almeida, Divanizia N. Souza, Inayá Lima, Juliana Pacheco Duarte, Karla Kwiatkowski Lepetitgaland, Kátia Costa, Mércia Assis, Rejane de S. H. Spiegelberg Planer. ■

KNOWLEDGE MANAGEMENT IS THE FUEL FOR INNOVATION

BOTH ARE FUNDAMENTAL PILLARS FOR THE SUCCESS OF AN INNOVATIVE ORGANIZATION AND ARE MORE INTERCONNECTED THAN THEY SEEM AT FIRST GLANCE.

In a highly competitive world, organizations have begun to view knowledge management as a way to stand out and add value to their products and services. Knowledge management has been applied to optimize processes and invigorate activities, while innovation is sought to achieve success and differentiate from others. But how are innovation and knowledge management interconnected?

According to the OECD's Oslo Manual, innovation should be viewed as a process of implementing a new product, process, or organizational model in business, company, or trade relations. Innovation can be classified as incremental (when improvements to a product are proposed), semi-radical (some changes are implemented in the product, but existing basic standards are maintained), and radical (the product is discontinued in favor of a completely new one). However, to innovate, it is necessary to know how this product or service is made and how it reached the state of the art. Many organizations fail to innovate because actions are implemented without fully mastering the basic concepts to develop them, that is, there is a lack of knowledge (or if it exists, it is dispersed and not correctly mapped).

Knowledge is of great importance to organizations as it underpins innovation, which is currently a key to being competitive. For consultant Valter Pieracciani, knowledge management and innovation are related. During the 5th Journey of Knowledge, organized by AMAZUL in 2023, Pieracciani stated that knowledge management is "the twin sister of innovation, both grow together and depend on each other."

AMAZUL's knowledge management methodolo-

gy was endorsed as a Strategic Defense Product in 2021 and is the result of significant work that began with the pilot project developed in 2017 at the Uranium Hexafluoride Production Pilot Unit (USEXA), located at the Nuclear Industrial Complex of Aramar (CINA), in Iperó (SP). Since then, AMAZUL's knowledge management methodology has been implemented in various Military Organizations (MOs) linked to nuclear activities and also in the private sector, with the INBRA case in 2020.

One of the strengths of AMAZUL's knowledge management methodology is that it incorporates innovation as one of its primary components. It stimulates and improves the generation of ideas, facilitates the exchange of knowledge with other collaborators, provides strategic guidance for projects with specialized knowledge, produces knowledge resources throughout the innovation cycle, and integrates lessons learned over time, among other points. Collaborators are encouraged to share their knowledge with colleagues and help in the development of new products, seeking innovative solutions for current problems, thus contributing to the advancement of strategic programs in which AMAZUL actively participates: the Navy Nuclear Program (PNM), the Submarine Development Program (PROSUB), and the Brazilian Nuclear Program (PNB).

Innovation and knowledge management go hand in hand. We can say that knowledge management itself can be considered an innovation since it introduced new tools for the capture and dissemination of employee knowledge within corporations, making internal processes more efficient and information more accessible to everyone. ■

ROSATOM'S DIGITAL TECHNOLOGIES: TRANSFORMING THE PRESENT AND SHAPING THE FUTURE

Digital transformation is spreading to more and more industry sectors, particularly in the nuclear sector. The key to Rosatom's successful digital expansion is the scientific and technical potential accumulated over nearly 80 years.

Russia's nuclear sector companies have always worked under unprecedented technological challenges, coupled with quality and safety demands at work. Already during the implementation of the Soviet "nuclear project," a huge volume of mathematical calculations was necessary. Later, the question of their automation arose. That's how the necessary IT competencies gradually developed.

DIGITAL TRANSFORMATION PATH

The ROSATOM State Atomic Energy Corporation pays great attention to digitalization, launching software, developing the necessary IT infrastructure, and implementing other innovative solutions in the work of its companies.

We now have an ambitious task ahead of us—to achieve leadership in various technologies in the global digital solutions market by 2030. The State Corporation's revenue from the digital area in 2022 exceeded \$300 million, growing more than sevenfold compared to 2021. At the same time, profit from the implementation of digital projects increased and its portfolio expanded.

The ban on nuclear field testing, which was supported by the Russian Federation, boosted the development of computational modeling and the creation of proprietary software. At the Russian Federal Nuclear Center's All-Russian Scientific Research Institute of Experimental Physics (RFNC-VNIIEF) located in Sarov, Nizhny Novgorod region, mass production of compact supercomputers—both super-powerful and small-class—was organized. They were used to solve problems in high-tech industry sectors at nuclear energy companies, Roscosmos, the Sukhoi Design Bureau, and other large companies. Along with RFNC-VNIIEF, another sector company, the E.I. Zababakhin VNIITF (Sne-

zhinsk, Chelyabinsk Region) managed to achieve leadership positions in creating national supercomputing solutions. Thus, over the last 30 years, IT developments have been created and improved, and today they become the basis for Rosatom's digital solutions and products.

INNOVATING PRODUCTION: ROSATOM'S UNIFIED DIGITAL STRATEGY

A broader and more structured approach to digitalization tasks began after the approval of Rosatom's Unified Digital Strategy in 2018. It foresees the digitalization of internal processes, the development of digital technologies and the launch of digital products in the market, participation in Russia's digitalization, and the development of digital competencies and culture.

One of the main focuses of work on developing the State Corporation's digital portfolio today is to develop and deploy complex digital solutions, with the provision of digital services, and to promote a customer-centric approach to the formation of the digital portfolio, aiming to solve customers' business tasks and meet market trends.

One of the leaders in Rosatom's digital transformation is the Chepetsk Mechanical Factory, which is part of Rosatom's TVEL Fuel Division and specializes in the production of metals and alloys for the nuclear industry. It is the only factory of its kind in Russia and one of the world leaders in the creation of zirconium products and their alloys.

Considering that most of Chepetsk Mechanical Factory's production is destined for high-tech nuclear industry productions, it was decided to implement digital technologies in the plant's processes.

For this, in 2018, the company began implementing a production management system (MES), which allows increasing the speed and accuracy of production planning and provides objective information for timely management decision-making.

The company also implemented a laboratory management system (LIMS), which allows centralized storage and processing of laboratory data, significantly speeding up the flow of information between divisions, automating the acquisition of results, and their transfer to specialists for further processing.

Another applied technology is the equipment maintenance and repair management system (TORO), which makes it possible to plan and execute the maintenance of equipment as necessary, without waiting for breakdowns and emergency shutdowns. This avoids unnecessary equipment downtime and, as a result, increases the intensity of equipment use and staff work.

ATOMMIND: ARTIFICIAL INTELLIGENCE AT ROSATOM

The digital solution AtomMind is the flagship of Chepetsk Mechanical Factory for the quality and state management of its equipment. This predictive analytics tool was implemented taking into account the production scale of this factory, where more than two million parameters need to be collected and analyzed monthly to ensure quality, control technological discipline, and improve production techniques.

AtomMind collects reliable data about processes and the state of equipment in real-time and analyzes the collected data using artificial intelligence algorithms. Based on the results of this analysis, the system provides suggestions for the optimized parameters and ideal operating modes of the equipment, contributing to the reduction of production failures.

AtomMind integrates with all relevant information systems of Chepetsk Mechanical Factory, including ERP (Enterprise Resource Planning), MES (Manufacturing Execution System), LIMS (Laboratory Information Management System), as well as quality control systems and equipment sensors and controllers.

“For the corporation, artificial intelligence is no longer a distant future but a present reality, a concrete tool that allows increasing the efficiency of processes day by day. At Rosatom, it has found application in various areas: there is a large block related to video analysis, equipment monitoring, predictive analysis, and unstructured text analysis. The main project of Rosatom’s Nuclear Fuel Company (TVEL) is the AtomMind production technology platform, created for predictive analysis in any indus-

trial process and for managing the quality of production. A major breakthrough in the development of industrial artificial intelligence for us will be the moment when AtomMind is supplied with classic products: with fuels and equipment. This way, we can improve their design and be even more customer-centered, using the feedback received from equipment in real-time. In addition, we will have the opportunity to influence the quality of the products manufactured through predictive analysis and significantly increase the speed of product launch in the market,” commented TVEL’s Director of Digitalization, Evgueny Garanin.

The AtomMind system stands out for its flexible integration capacity with the existing digital infrastructure of any company, allowing its rapid implementation in different industry segments. This flexibility ensures an efficient adaptation to the specific needs of each organization, optimizing processes, and generating significant results. For example, through the implementation of the AtomMind system at the Chepetsk Mechanical Factory, the company achieved a notable 30% reduction in maintenance costs, in addition to reducing the rate of defective products by 0.5%.

In the case of the Chepetsk Mechanical Factory, the implementation of the MES (Manufacturing Execution System) system together with AtomMind produced exceptional results. The “on-time delivery” rate of the rolling shop was raised from 26% to 100%, while the volume of production in progress in the shop’s flow was reduced by 30%.

PROSPECTS OF NUCLEAR SECTOR DIGITIZATION

Rosatom’s Unified Digital Strategy stands out as a pioneering project in the national scenario, representing the first digital transformation initiative on an entire industry scale in Russia. This ambitious strategic vision aims to drive a tenfold decrease in the State Corporation’s IT costs while ensuring the impeccable quality of digital services and the complete eradication of routine tasks in the sector.

Rosatom is a prominent national market supplier of IT solutions for leading companies in the industrial, energy, and oil and gas sectors, acting as a key player in the strategic development of the Russian economy. Currently, the State Corporation’s portfolio includes over 60 digital products, and this number is expected to continue growing, following global trends and meeting specific market demands. ■



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