CONTENTS

Back to contents

ROSATOM NEWS

Paks II Enters Key Stage

Reactor at 4,000 Meters Above Sea

TRENDS

Money for Atoms

REACTOR TECHNOLOGIES

The Return of Elena

Paks II Enters Key Stage

On August 18, Rosatom's subsidiary and the general contractor for Paks II NPP, AtomStroyExport, and the project owner Paks II Nuclear Power Plant Ltd signed a series of documents required to continue the construction of two Generation III+ power units with VVER-1200 reactors. On August 21, AtomStroyExport commenced with the construction works of the principal project phase.

The preparatory phase of the project ended with signing an addendum to the EPC contract and delivering a notice from the project owner to the general contractor that the project was moving towards the principal construction phase. Before that, on August 16, technical amendments to the intergovernmental project finance agreement came into force. According to Hungarian Minister of Foreign Affairs and Trade Péter Szijjártó, all the payments are being made and the project is not subject to any sanctions. Rosatom and the Hungarian project owner maintain contacts with Western companies. **"I would like to stress there will be no European sanctions against the nuclear industry in the future, all the more so as it would be**

against our national interests. So, of course, we will keep at bay any such attempts," the minister said with confidence. According to Peter Szijjártó, the amendments will move the project forward more quickly and easily.

As the project transitions to the key construction phase, orders can be placed for the main pieces of power-generating equipment. AtomStroyExport has instructed manufacturers to start production of the necessary equipment for which the contracts have already been concluded.

Preparations are now underway on the site to pour the first concrete for the foundation. The Hungarian company Duna Aszfalt Kft has started excavations on the site of Unit 6. The pit will first be excavated to a depth of 5 meters over an area comparable to four football fields. The same-depth pit has already been excavated for Unit 5.

Another local company, Bauer Magyarország Kft, is proceeding with the installation of a 1-meter-wide, 30-meter-deep impervious blanket. It is being built around the clock, with over 500 meters out of 2,500 meters already completed. The blanket will protect the site from groundwater infiltration during the construction and subsequent operation of the units. Simultaneously, Bauer Magyarország Kft is preparing to start soil stabilization works. Once the blanket is ready and the soil is stabilized, the pit for the two units will be sunk to a depth of 30 meters, with around 1 million cubic meters of soil to be removed. Preparations for the first concrete pouring at Unit 5 will begin next year.

As work at Paks II is gaining momentum, increasingly more employees, machinery and equipment are engaged in on-site operations. Many international companies are involved in the project. One of them is General Electric, which will, together with Alstom, manufacture power generation equipment. Instrumentation and control (I&C) systems will be supplied by a consortium of Siemens and Framatome.

Commenting on the Paks II transition to the new construction phase, Peter Szijjártó noted that the reliability of power supply was one of the most critical issues of the time and the countries able to produce most of the energy they consume would be strong and safe in the future. **"More and more people are realizing that the issue of power supply is a material issue,"** the minister said. He added that, given Hungary's geographical and environmental conditions, a nuclear power plant would be capable of producing large amounts of electricity in a reliable, eco-friendly and cost-efficient way. **"That is why the Paks II project is a long-term guarantee that Hungary will have a reliable source of power and that the nation will have enough affordable electricity,"** the minister emphasized.

> The Paks II Nuclear Power Plant is built in accordance with a Russia-Hungary intergovernmental agreement dated January 14, 2014 and three basic contracts. The construction license for two VVER-1200 reactor units to be built at Paks II was obtained in August 2022. The power units of this design will be built in the European Union for the first time ever. The fact of obtaining the construction license proves that the plant meets the Hungarian and European safety standards. The service life of the reactor units is guaranteed to be 60 years. Hungary's only nuclear power plant Paks operates four VVER-440 reactors. They generate over 50% of the country's cheapest electricity at HUF 12 (RUB 3) per kilowatt hour.

Reactor at 4,000 Meters Above Sea

A pressure vessel for the nuclear research reactor was delivered to Bolivia from Russia. It is a key component of the fourth department of the Nuclear Research and Technology Center (NRTC) that Rosatom is building in Bolivia.

The reactor was developed at the Research Institute of Atomic Reactors (RIAR, a part of Rosatom). This is a water-cooled water-moderated pool-type research reactor with an electric capacity of 200 kW and a service life of 50 years. Apart from RIAR, experts from OKBM Afrikantov and the State Specialized Design Institute, both also part of Rosatom, worked on the reactor design.

In late April, the reactor was pre-assembled for trial fit. During the trial fit process, all the key components of the reactor were test-assembled, with the reflector, dummy fuel rods, control and protection systems and experimental channels installed to preemptively identify and eliminate any problems should they exist.

When launched, the reactor will fabricate radioactive isotopes for research purposes. They are used in neutron activation analysis to study the chemical composition of materials for a variety of applications, ranging from geology and environmental studies to art and forensics.

With this method, researchers analyze the composition of rocks, ores, concentrates and biological samples and develop programs for efficient use of natural resources and continuous monitoring of the environment. The reactor will also be used to train students specializing in nuclear.

"Installations of this kind are capable of producing radioisotopes that can be used to improve our water management practices. Another example is the application of neutron activation analysis in the mining industry. This technique will help find minerals that are of strategic importance to the country and identify areas that are promising for exploration and development," says Erlan Vasquez, a nuclear engineer from the Bolivian Nuclear Energy Agency (ABEN).

It is planned that the third and fourth NRTC departments will be put in operation in 2025. Currently, construction and installation works are underway on the site, while the buildings of the radiobiology and radioecology laboratory are being equipped.

The first two departments — a pre-clinical cyclotron facility and a multi-purpose irradiation center — have already been completed. The irradiation center has been in pilot operation since August 2022 and is about

ROSATOM NEWS

Back to contents

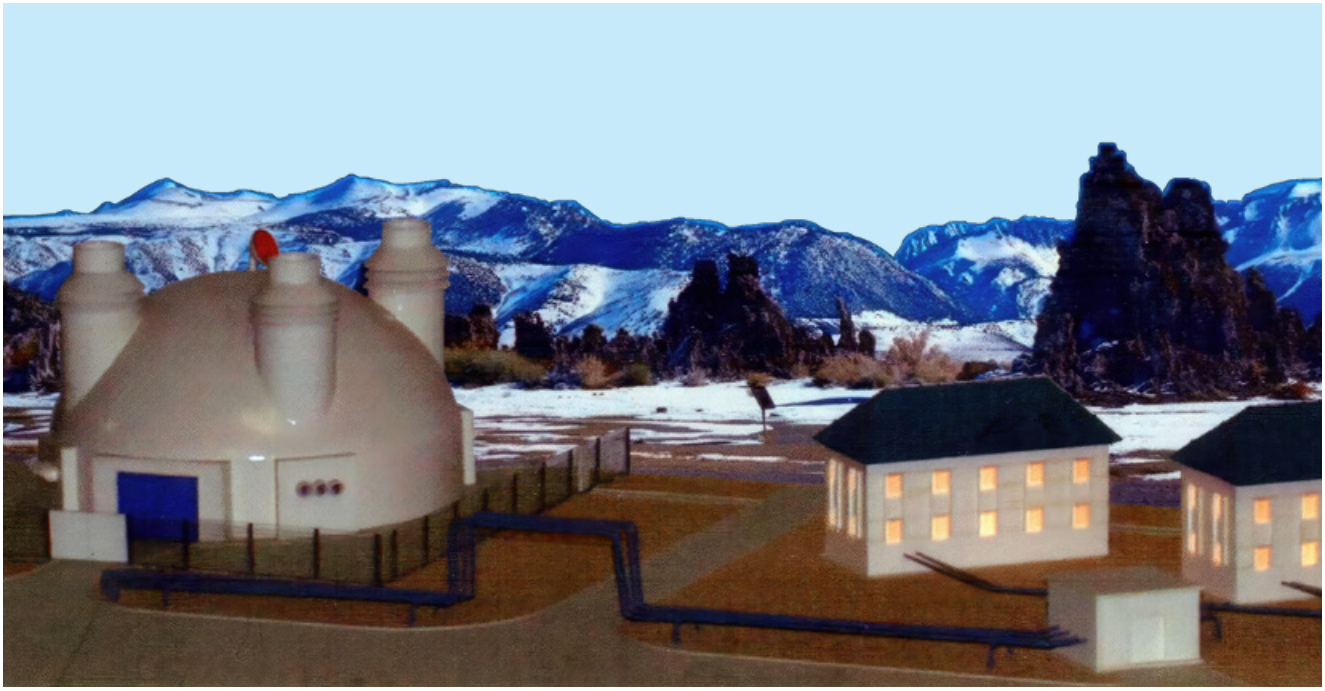
to enter the commercial operation phase. It will be capable of irradiating up to 70 tons of agricultural produce daily to make foodstuff safer and increase its shelf life, and will also be used to sterilize medical items.

In March 2023, Bolivian President Luis Arce Catacora kicked off the production of fluorodeoxyglucose (FDG) at the cyclotron facility. This is the most widely used radiopharmaceutical substance to diagnose lung cancer, colorectal carcinoma, malignant melanoma, Hodgkin's lymphoma, esophageal carcinoma, head and neck cancers, breast cancer, and thyroid carcinoma. FDG is also used in clinical practice to treat central nervous system disorders, as well as cardiovascular, infectious and inflammatory diseases. The cyclotron facility is capable of fabricating a wide range of radiopharmaceuticals on a commercial scale.

The Nuclear Research and Technology Center is being built in Bolivia's El Alto under a contract signed in 2017 between ABEN and the State Specialized Design Institute. This will be the world's highest nuclear facility sitting 4,000 meters above the sea level. The work on the project began in 2018 but was suspended in 2019 due to the pandemic and a political crisis in Bolivia. On-site works resumed in 2021. The construction of the NRTC contributes to the improvement of local infrastructure as a new road connecting over 40 neighboring towns was built and public utilities repaired. The contract provides for about 500 highly qualified jobs for local residents to be created.

Russia has solid expertise in the construction of research reactors. The one in Bolivia is the 23rd research reactor built by Rosatom abroad. Rosatom operates 53 out of 223 research reactors in the world. NL

To the beginning of the section



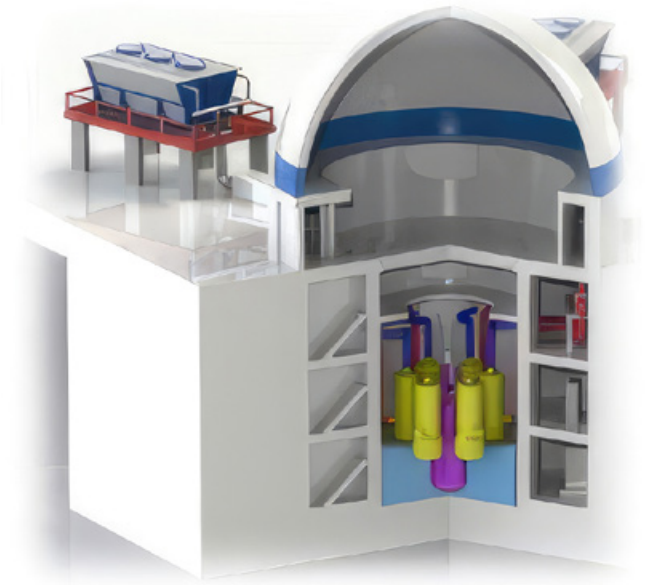
The Return of Elena

Elena-AM is a pilot nuclear thermoelectric plant under development at the Kurchatov Institute on commission from Rosatom. The design of the reactor and critical equipment will be ready by the end of 2024.

Elena in the Pacific

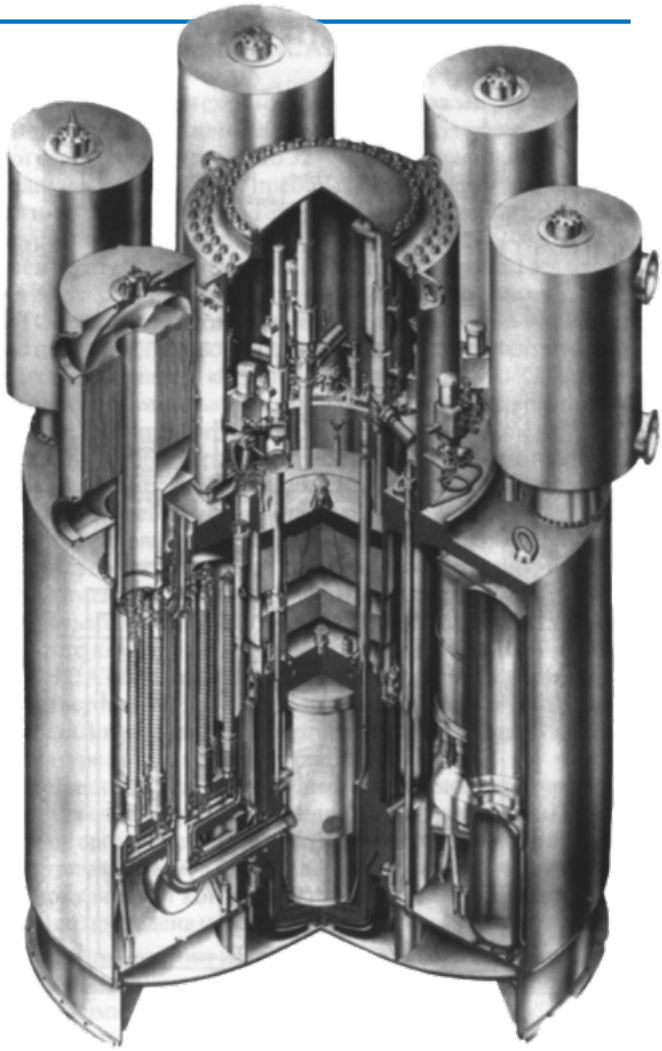
It was the 1960s when the Soviet engineers conceived the idea of making a self-contained nuclear power plant capable of operating for up to 10 years without maintenance. Its detailed design was finalized in 1975, followed by the commissioning of a unit called Gamma in 1982. It used a water-cooled water-moderated self-controlled reactor as a source of thermal energy and relied on natural circulation in the primary and secondary circuits for heat removal. Thermal energy was converted to electricity using a thermoelectric principle.

In a thermoelectric generator, heat is directly converted into electricity: temperature differences between two conductors create voltage differences. Gamma's thermoelectric modules were of the Field-tube type (a pipe placed inside another); semiconductor batteries were made of low-temperature ternary alloys. Gamma could generate 220 kW of thermal power and 6.6 kW of electricity. The



entire unit was placed in a water pool for heat removal and biological protection. Natural coolant circulation and thermoelectric conversion were both revolutionary ideas and innovative solutions for that time.

In 1989, the Far Eastern Division of the USSR Academy of Sciences proposed to develop a pilot thermoelectric cogeneration plant to supply heat and power to a research station operated by the Pacific Oceanological Institute near Elena Bay on Popov Island. The plant was named Elena after the bay. Front-end engineering design was completed by early 1990. Elena was capable of generating 880 kW of electricity and 3 MW of heat. Key structural and technical solutions were taken over from Gamma. However, the project was never put into practice due to a lack of finance and poor economic conditions in the country.



Elena's revival

The new plant developed by Kurchatov Institute on commission from Rosatom is called Elena-AM. The acronym 'AM' stands for 'automated and upgraded'. It is designed to serve as a source of heat in remote and hard-to-access regions that have no heat networks and are too distant and costly to supply with conventional fossil fuels.

Elena-AM has a designed thermal capacity of 7 MW and a natural circulation of coolant (water) in its two circuits. The service life of the equipment under development will be 40 years. The 120 cm high reactor core will consist of 241 assemblies with fuel enriched to no more than 19.5%. Its water-cooled water-moderated reactor will be self-controlled across the full spectrum of electrical and thermal loads due to a negative temperature reactivity effect (the higher the temperature, the lower is the reactivity) and a burnable absorber.

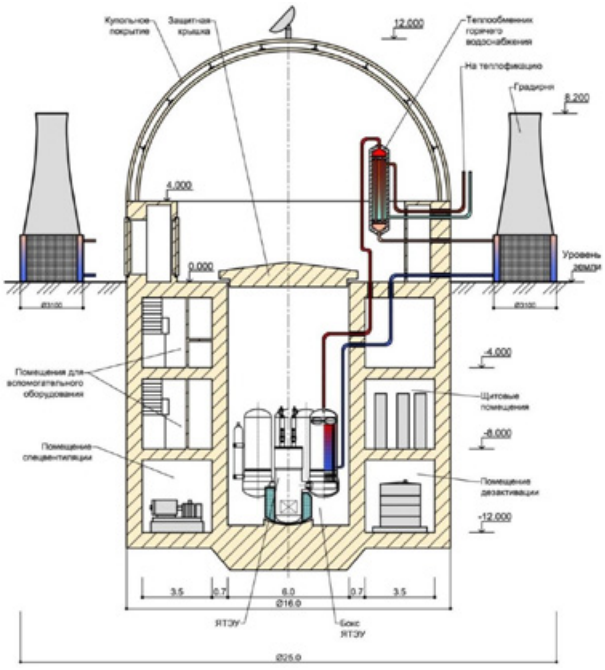
The thermoelectric generator of the plant will have a minimum power generation capacity of 200 kW. The plant will operate in a load following mode with daily output variations from 20% to 100% of its nominal capacity. The electricity produced is expected to be sufficient for plant needs and nearby consumers.

Another important feature of the plant is its maintenance-free design. Elena-AM will be equipped with fully automated I&C and auxiliary systems.

A steel pool filled with water will serve as a supporting structure for the plant's core

equipment. The pool will also perform a biological protection function by absorbing ionizing radiation. Due to its small capacity, the plant stores little heat: the temperature differences between fuel and water do not exceed 50 °C. With no pumps or valves, the plant will be more reliable as there is no part that can go down. Elena-AM will be able to operate during and after earthquakes of an 8-point intensity on the MSK-64 scale and remain safe after a 9-point intensity earthquake. Besides, it will be capable of withstanding a crash of a 20-ton airplane moving at 215 m/s. Beyond-design-basis estimates for a 200-ton airplane crashing at no more than 100 m/s will also be made.

The plant will operate 350 days a year and then be shut down for two weeks for diagnostics and maintenance. Maintenance and repairs are planned to be done annually by a dedicated mobile team during the two-week break.



For now, Elena-AM is in the development phase. Its specifications will be refined as the development activities move forward. NL

To the beginning of the section

Money for Atoms

The Center on Global Energy Policy (CGEP) at Columbia University's School of International and Public Affairs published a study titled "A Critical Disconnect: Relying on Nuclear Energy in Decarbonization Models While Excluding It from Climate Finance Taxonomies". The study's central idea is that institutional investors drag their heels on investing in nuclear energy although its crucial role in decarbonization is widely recognized.

The study begins with a few facts showing the global recognition of nuclear's positive effect on the reduction of emissions. This July, the European Union added nuclear energy to the green activities listed in its Taxonomy, which serves as a guidepost for the investors and companies in identifying which activities are sustainable and which are not.

Then, Ontario Power Generation, a Canadian utility company, issued green bonds that included nuclear energy in its use of proceeds. The bonds were oversubscribed sixfold.

The authors of the study also mentioned the words of Fatih Birol, Executive Director of the International Energy Agency, saying at the Sharm el-Sheikh Conference of Parties in November 2022 that nuclear power was making a comeback.

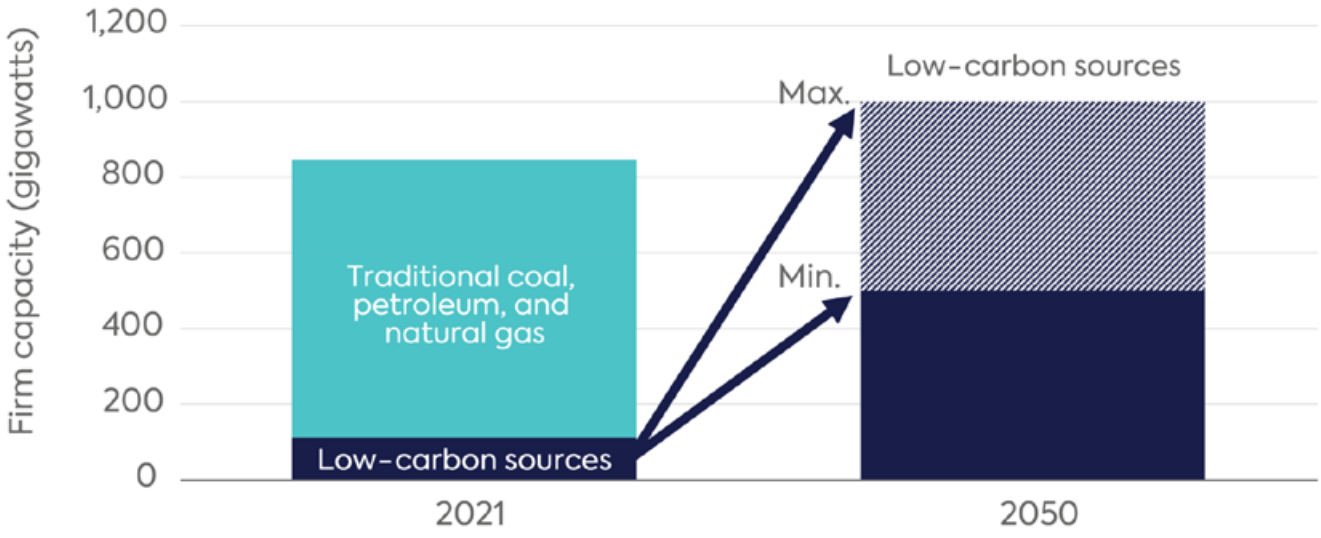
However, having reviewed green and sustainable bond frameworks of 30 global systemically important banks, the authors have come

to the conclusion that none explicitly includes nuclear energy in their sustainable finance taxonomies or they are ambiguous on whether it is included. **"Despite nuclear energy's potentially critical role in supporting deep decarbonization of the global economy, it is more commonly excluded from climate finance taxonomies, or the taxonomies are ambiguous on the issue. Thus, whether nuclear energy is considered green and sustainable or not varies widely across regions and institutions,"** the study says. Out of the 30 global systemically important banks, 57% have explicitly excluded nuclear energy from their green or sustainable financing taxonomies, and 40% are silent on its inclusion or exclusion. The former group includes JP Morgan, Citi, HSBC, BNP Paribas, Bank of China, China Construction Bank, Deutsche Bank, Goldman Sachs, and others. Those that are not explicit on the matter are Bank of America, Barclays, Mitsubishi UFJ, Agricultural Bank of China, Crédit Agricole, ING Bank, Morgan Stanley, Royal Bank of Canada, etc.

The researchers failed to find any pattern in the strategies of investment banks depending on the country's region.

Germany and, paradoxically, France have excluded nuclear power from the permissible uses of proceeds from recent sovereign green

US firm capacity (2021) and estimated minimum and maximum low-carbon firm capacity needed for decarbonization in 2050



Note: In the Princeton study, hydro and storage are not considered "firm," and so are not included in either column. In 2050, combustion turbine and combined cycle gas turbine plants may run on a blend of hydrogen and methane, or in some cases be 100 percent powered by synthetic gas.

Source: US Energy Information Administration, "Electricity explained: Electricity generation, capacity, and sales in the United States," accessed June 22, 2023, https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php; for 2050 capacities, see: Eric Larson et al., "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Final Report Summary,"

bond issues, although the EU Taxonomy includes nuclear power. It is true, however, that the projects to be considered green according to the EU Taxonomy have to meet many conditions. For example, a new plant has to obtain a construction permit before 2045 and be located in a country that has plans to dispose of its radioactive waste by 2050. Life extension projects for the existing nuclear power plants can only be launched before 2040. On the other hand, Électricité de France has included nuclear power in its own green bond framework despite the fact that nuclear power is not considered 'green' at the national level in France and proceeds from sovereign bonds cannot be allocated to finance nuclear energy development.

The green finance framework of the UK Government also explicitly excludes nuclear power as of 2021, according to the study. And this is despite the fact that the UK national energy strategy provides for eight reactor units to be built by 2030. The reason is that many 'sustainable' investors recognize the criteria for excluding nuclear power.

In Asia, Indonesia and India (also surprisingly!) have excluded nuclear energy from their taxonomies. By contrast, China included nuclear in the list of industries the country's regulators consider sustainable back in 2021. South Korea included nuclear energy in its K-Taxonomy in September 2022.

The deep pockets such as development banks, including the World Bank, exclude nuclear from their taxonomies. In addition, the UN Principles for Responsible Investment (PRI) signed by over 5,300 investment and asset managers representing more than USD 121 trillion in assets, are critical of the inclusion of nuclear energy in the EU Taxonomy. The International Capital Markets Association (ICMA), which defines the widely used green bond principles, did not include nuclear in its list of eligible green projects either.

The authors of the study estimate the sustainable investing assets under management reached USD 35 trillion at the end of 2021 and are expected to grow to USD 50 trillion by 2025. **"Due to the tremendous growth and continued momentum projected for sustainable investment, nuclear energy would likely benefit from being able to access this pool of capital,"** the researchers believe. To improve the investors' stance on nuclear pow-

A conceptual rendering of the BWRX-300 SMR plant by GE Hitachi Nuclear Energy.

er, they suggest the groups developing climate taxonomies talk with utility companies about their role in decarbonizing the planet.

This proposal is encouraging but it runs into the fact that utilities are investors in some energy projects. An example is NuScale Power constructing an SMR. And its investors appear to have grown increasingly disillusioned over the past year as NuScale's stock fell by nearly two thirds from USD 15.32 on August 24, 2022 to USD 5.97 on August 31, 2023.

Where to get the money?

The nuclear power industry is growing despite concerns from financial institutions. The key sources of finance appear to be public. The largest nuclear countries — Russia, China, France, and the United States — are investing in the development of their nuclear programs but the amount of funding varies. China, for example, announced back in 2021 that it would build 150 reactors in 15 years. According to preliminary estimates, this will require about USD 440 billion. The US plans are far more modest, with USD 6 billion to be invested in the next five years. Out of this amount, USD 1.1 billion has been provided to the Diablo Canyon Power Plant to finance its life extension program. France has earmarked even less money for the nuclear technology: around EUR 1.2 billion is allocated under the France 2030 national investment plan to support the development of innovative nuclear reactors and emergence of 'new players' in the market.

As for Russia, Rosatom has been investing over RUB 1 trillion annually, equivalent to around USD 14.6 billion at the Bank of Russia's average exchange rate for 2022 (RUB 68.48 per USD), for the second consecutive year. Of course, this money is not used to only finance the construction of nuclear power plants — it is also spent on the nuclear industry and nuclear community in general.

The International Bank for Nuclear Infrastructure (IBNI) could potentially become a financial source for the global nuclear industry. The bank was initially supposed to bring together 50 countries interested in developing nuclear energy. **"It is envisaged that IBNI will be established in early 2023, with Member States (a coalition of no fewer than 50 sovereign governments) initially contributing shareholder capital of USD 50 billion (50% or USD 25 billion of which will**

be paid-in and 50% or USD 25 billion will represent callable capital)," says the IBNI Initial Report and Action Plan. According to the document, the shareholder capital could grow from its initial level to USD 300 billion over the next 30 years in the best case scenario, and the bank could become a catalyst for investments worth USD 26 trillion. The IBNI Implementation Organization, which was to be established in early 2022, was planned to be a vehicle for the bank's initiatives.

However, after the world went through dramatic political changes, the idea of setting up IBNI first halted and then transformed drastically. The bank now has a club-like format. **"We see the initial group that is going to lead the effort to stand up the bank as comprised of potentially seven countries: the United States, Canada, Great Britain, France, Japan, [South] Korea, and the UAE,"** IBNI board member Elina Teplinsky said in an interview to Energy Intelligence. The sources and amount of shareholder capital have also changed, with USD 5 billion to be invested by the participating countries. As IBNI's Strategic Advisory Group Chairman Daniel Dean said, the bank hopes to acquire another USD 25 billion from private investors. A joint declaration in support of the bank is expected to be signed at COP-28, which will be held in the UAE this December.

The problem with IBNI seems to be that the sources of public investments are not very clear. As can be seen from the figures above, the potential IBNI Member States have little money even for their national nuclear projects, while the United States national debt has reached USD 32 trillion. Thus, there is an obvious question: in which countries will IBNI finance projects? In the Member States? But if, as the study shows, large institutional investors drag their heels on investing in nuclear energy directly, why would they be interested in the idea of investing through a bank? If they invest in third countries, other problems will arise. In particular, the problem of distributing roles in technological partnerships will come to a head in certain projects. The conflict between the American Westinghouse and the South Korean KEPCO proves that this will be a painful issue for the potential founders of IBNI. Westinghouse does not consider the South Korean APR-1400 project to be license-free and seeks a ban on agreements to build such reactors in Poland, the Czech Republic, and Saudi Arabia.

Private or, more precisely, individual investments could essentially become a source of funding for the construction of a nuclear power plant (albeit, only of small capacity). A worldwide example of this is Bill Gates, who is developing an SMR project with a sodium-cooled fast reactor. As practice shows, though, it is not an easy task to build a viable nuclear power plant. It became known in August the company would not be able to apply to the regulator (NRC) for a construction license this month. The application deadline was pushed back to March 2024. In addition, production cost of the reactor could double from initial estimates. This is common for pilot projects but hardly pleasant for an investor.

The reality is that only governments are so far ready to finance the development of nuclear technology. Russia is one of the world's largest investors in nuclear energy. Rosatom offers its partners both the tried and proven solutions and develops and tests new ones. Read more on this matter in our Reactor Technologies section. NL

To the beginning of the section