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Ural On Duty, Yakutia Catches Up

On November 22, the third Project 22220 icebreaker Ural hoisted the flag while Yakutia, the fourth icebreaker of the same design, was put afloat. The new ships expedite year-round navigation on the Northern Sea Route, which is to begin by the end of 2024.

Ural hoists the flag

"I sincerely thank our shipbuilders, nuclear specialists, designers, workers and engineers — everyone involved in the construction of these high-tech and, without overstating it, unparalleled vessels — for their hard work, professionalism and readiness to grow personally and achieve the most ambitious goals," Russian President Vladimir Putin said during the flag raising ceremony via a video link.

The Ural icebreaker hoisted the flag and officially joined the Russian nuclear-powered fleet. In December, Ural will head for the Ob-Yenisey region where she will escort ships carrying construction materials for the Vostok Oil project. **"This is Rosneft's major investment project in the Arctic that will**

stimulate an increase in cargo traffic on the Northern Sea Route from 30 million tons in 2024 to 100 million tons in 2030," Rosatom Director General Alexey Likhachev said.

Ural is the third Project 22220 icebreaker. Such vessels can change their draft, which enables them to navigate in river estuaries and shallow seas. Convoys escorted by two other icebreakers of the same design, Arktika and Sibir, to and from the Arctic Gate terminal and in the Yenisey Gulf demonstrated their ability to operate in shallow waters.

Ural was laid down at the Baltic Shipyard in 2016 and put afloat in 2019. Sea trials of the icebreaker took place on October 14–31, 2022 in the Gulf of Finland. The crew tested the icebreaker's speed performance, maneuverability, and operation of communication, automation, navigation, electric propulsion, steam turbine, shaft line, anchoring and steering systems and equipment.

On November 23, Ural left Saint Petersburg for her home port of Murmansk. Her work on the Northern Sea Route (NSR) will begin in early December.

Also on November 22, the Baltic Shipyard in Saint Petersburg put afloat the fourth Project 22220 icebreaker, Yakutia, laid down in May 2020. With RITM-200 reactors and almost all other pieces of core equipment already installed, the ship will be fitted out afloat. Yakutia is planned to be commissioned in December 2024.

The icebreaker will escort ships carrying hydrocarbons from the Yamal and Gydan Peninsulas and Kara Sea offshore deposits to the Asian-Pacific markets.

More icebreakers to follow

Another two nuclear-powered icebreakers — Project 22220 Chukotka and Project 10510 Rossiya — are under construction. Speaking at the ceremony, Russia's Minister of Industry and Trade Denis Manturov said that Rosatom would make contracts for the construction of the fifth and sixth Project 22220 icebreakers by the year-end. The NSR Development Program 2035 provides for the allocation of RUB 56.61 billion and RUB 61.34 billion for this purpose, respectively. Construction of four diesel-electric icebreakers (assumed to be built in 2023–2030) will require another

RUB 220 billion. According to the program, this money will come from non-government sources.

The upgraded nuclear fleet will ensure year-round navigation along the entire NSR by the end of 2024 and cargo traffic of 150 million tons by 2030. **"By developing this crucial transport corridor, Russia will unlock its export potential and set up cost-efficient transportation routes, including to Southeast Asia. We are open to partnerships with those who want to work with Russia,"** the Russian president said.

Atomexpo Is Back

Held on November 21–22 after a three-year break, Atomexpo International Forum brought together over 3,000 people from 65 countries. Meetings, negotiations, off-the-record discussions and 47 agreements signed at the forum exemplify that international ties with the Russian nuclear sector grow stronger.

Nuclear as a common theme

"Today's assembly is an assembly of the global nuclear family that has responded as one to external challenges and threats. The nuclear industry has produced no empty rhetoric but taken real action against climate change, remaining a stronghold of common sense. We manage to maintain a technological unity and continue partnerships in research and development," Rosatom Director General Alexey Likhachev set the pace for the forum in his opening speech.

Other plenary session speakers included Hungarian Minister of Foreign Affairs and

Trade Péter Szijjártó, Belarus Minister of Energy Viktor Karankevich, Minister of Science and Technology of Bangladesh Yafes Osman, Turkish Deputy Minister of Energy and Natural Resources Alparslan Bayraktar, and CEO of Brazil's ENBPar Ney Zanella dos Santos. Hungary, Belarus, Turkey and Bangladesh are the countries where Rosatom is either building or preparing to build new reactors. Brazil is a sales market for medical and commercial isotopes fabricated by the Russian nuclear corporation. Besides, ENBPar and Rosatom signed a memorandum of understanding to build, operate and decommission Russian-designed large-capacity nuclear power plants in Brazil.

Topics on the forum agenda

The agenda of the forum covered those emerging business areas of the Russian nuclear corporation that can meet present-day pressing needs. Construction of small modular reactors (SMRs) was one of them. As became apparent at Atomexpo, increasingly more governments and businesses are interested in SMR benefits. **"We would like to have Rosatom as our partner for SMRs and wind power plants. They can benefit our national economy,"** said Thaung Han, Myanmar's Minister for Electric Power and Energy. Myanmar and Rosatom signed a memorandum of understanding on the sidelines of the forum to jointly conduct a pre-feasibility study for the construction of a small modular reactor in the country.

Kyrgyzstan is another country considering the possibility of building an SMR. The Ministry of Energy and Rosatom signed a document defining the scope of work to be covered by a pre-feasibility study for the construction of an SMR in Kyrgyzstan. The nation needs a small nuclear power plant to mitigate climate and weather factors affecting hydro generation, a primary source of electric power in the country. Electricity generation by hydro power plants decreases on the back of lower precipitation levels, and Kyrgyzstan is forced to import electric power to compensate for shortages. As for businesses, their interest in SMRs is driven by flat electricity prices over decades to come. This is essential for building investment models and negotiating terms of commercial construction loans with banks. This point was stressed by Georgiy Fotin, CEO of Baimskaya Management Company, when speaking at the SMR plenary session. A subsidiary of Kazakhstan's KAZ Minerals, Baimskaya builds a mining and processing facility at one of the world's largest copper deposits, Peschanka, in the Chukotka Peninsula (Northeast Russia).

The second principal topic discussed at the forum was management and disposition of spent nuclear fuel. This topic is a major concern for many emerging nuclear countries that do not want to face the problem of hazardous waste accumulation. As a solution to this problem, Rosatom offers a new

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high-tech service, Balanced Nuclear Fuel Cycle (BNFC). Spent nuclear fuel will be transported back to Russia for breaking up and reprocessing. Fissile materials will be recycled to fabricate different kinds of new fuel, while highly toxic minor actinides will be burnt up in fast neutron reactors and, while irradiated, transmutate into less active and less toxic elements. Highly active short-lived isotopes will be stored until their radioactivity decreases and sent back to the customer to be buried in near-surface repositories, which do not require much investment or engineering effort. According to experts, BNFC is the best available option today to manage spent nuclear fuel from commercial light-water reactors.

The possibility of obtaining 'green' finance for nuclear construction projects was also discussed at Atomexpo 2022. **"Russia took a chance and became the first country in the world to issue green bonds for the nuclear industry. Other countries followed. On July 14, nuclear officially became green in the EU. The world needs bright ideas in the thick of challenges it faces. Nuclear is one of them, isn't it?"** First Vice President of Gazprombank Denis Shulakov asked a rhetorical question.

Much attention was paid to digitalization in the nuclear industry. Rosatom presented its digital products and solutions at the forum. For instance, the nuclear corporation announced that its Logos software package for engineering analysis and mathematical modeling would be available in international markets starting 2023.

Dozens of documents were signed at Atomexpo to establish multiple cooperation frameworks and formats between governments, organizations and businesses from Mexico, Uzbekistan, Kyrgyzstan, Myanmar, China, Zimbabwe, Burundi, Belarus and other countries. NL

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Rosatom Turns 15

This year, the Russian nuclear corporation celebrates its 15th anniversary. Obviously, key Russian nuclear companies existed long before. In 15 years, Rosatom has turned into an integrated holding group, with its operations divided into business units. Our readers had a chance to learn more about Rosatom's divisions during the year.

On December 1, 2007, a decree establishing Rosatom State Atomic Energy Corporation was signed. It comprised production facilities, research institutes and other sectoral organizations. Much has been done since then: a vertically integrated corporation possessing end-to-end competencies in nuclear energy, from uranium mining to operation of nuclear power plants, was set up. Power generation has increased considerably; new reactors have been built in Russia and abroad. **"The corporation places a priority on implementing large-scale programs in research, nuclear medicine, environmental protection, ship and aircraft building, and digital technology. Much is done for economic development of the Arctic territories and the Northern Sea Route. And, of course, the nuclear sector makes a truly unparalleled contribution to maintaining nuclear parity and defense capabilities of our country,"** the Russian president said in his anniversary address.

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"At that time, 15 years ago, the first thing we had to do was to integrate huge expertise and immense potential gained by the founders of the first atomic project into a newly established government corporation. The second thing was to augment what they had created. We started with new businesses and then proceeded with import substitution and major projects to make our country technologically independent," Director General of Rosatom Alexey Likhachev described the company's progress in an interview to Russia 24 TV channel.

New businesses are based on the long-existing sectoral competencies. Composite materials were initially used in gas centrifuge rotors and then found their way into civil, aircraft and even sports engineering.

Nuclear icebreakers were initially placed under management, and then a program was launched to build a series of powerful icebreakers. Three of them are already on duty on the Northern Sea Route. Rosatom now administrates navigation on this shortest route from Europe to Asia, escorts ships carrying cargo for Arctic projects and delivering goods to consumers, and provides cabotage services between western, northern and eastern Russian ports. A new area of focus is floating nuclear power plants with RITM-200 reactors.

Fuel cells were developed for space programs — now they are used in hydrogen electrolyzers. Both electrolyzers and hydrogen are considered to be promising segments of the energy market. Available expertise in energy storage facilities is now applied to produce lithium-ion batteries. In Kaliningrad, Rosatom is building a gigafactory that will have a capacity sufficient to equip 50,000 electric vehicles per year.

Another example is mathematical modeling and supercomputers. Rosatom has developed proprietary software and powerful hardware for in-house applications. Now these systems are of interest to third-party consumers. For example, Logos Software can model heat, fluid and gas transfers, strength of materials and so on, both in artificial (mechanical engineering) and natural (hydrogeology) environments.

Some areas of focus are relatively young, and wind generation is one of them. With its domestic production facilities and local production of key components, Rosatom is today a key player of the Russian renewable energy market and a member of international alliances. Six wind farms built by Rosatom operate in three Russian regions, and more are under construction.

Finally, Rosatom positions itself as a corporation of knowledge — it engages in fundamental and applied research, collaborates with colleges and universities, and takes part in international projects. The most vivid example is ITER, which cannot be completed without Russia. Russia is where the idea of tokamak was conceived and where ITER superconductors and gyrotrons

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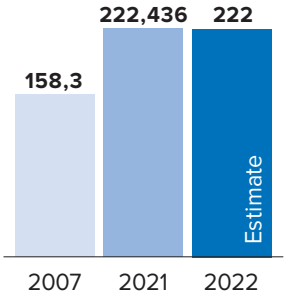
FIRST 15: HIGHLIGHTS

40%
INCREASE IN POWER GENERATION AT RUSSIAN NPPS, billion kWh



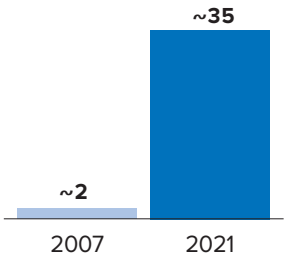
11
NUCLEAR POWER UNITS BUILT IN RUSSIA

6
POWER UNITS BUILT ABROAD

Including

- FOUR GENERATION III+ UNITS
- BN-800 FAST NEUTRON REACTOR
- DUAL-REACTOR FLOATING NUCLEAR POWER PLANT

17,5-fold
INCREASE IN CARGO TRAFFIC ON THE NORTHERN SEA ROUTE, mmt



are produced. Just recently, unparalleled ultra-powerful magnets were shipped to the ITER site. **"This international project brings together our partners from the People's Republic of China, as well as from the United States. For the moment, ITER remains politically neutral. Universal values do exist, and I hope that, among others, our Western neighbors realize that accumulation of knowledge on our planet cannot be put at risk of current political ambitions or personal sympathies and antipathies of certain European and American politicians,"** Alexey Likhachev shared his hopes in the anniversary interview. NL

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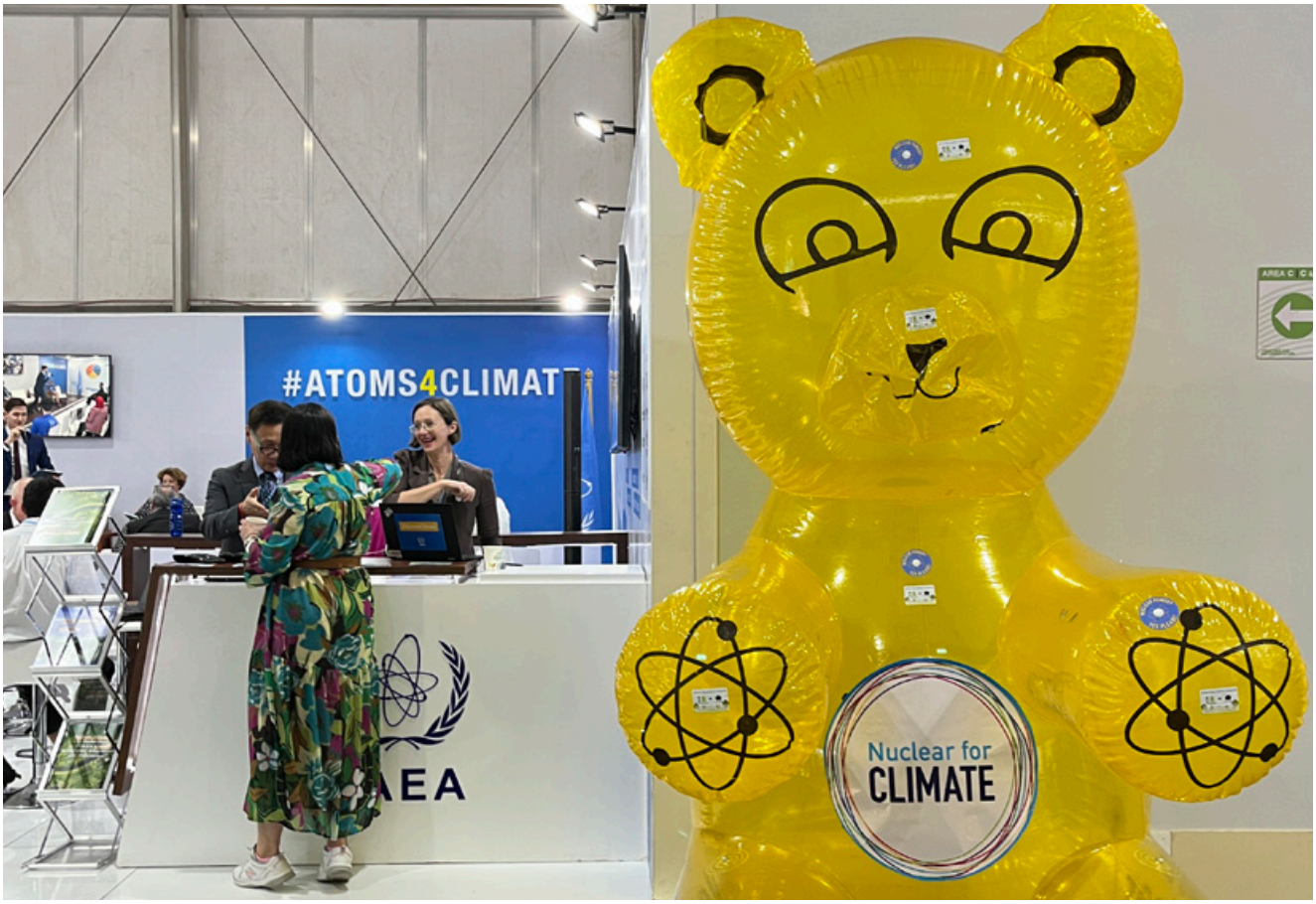


Nuclear Means Stable

The year 2022 has once again demonstrated the significance of nuclear for the global energy mix. And while the focus was initially on the non-carbon nature of nuclear energy, over time it shifted on the property important for every consumer's wallet — price stability.

Recognizing contribution to net zero

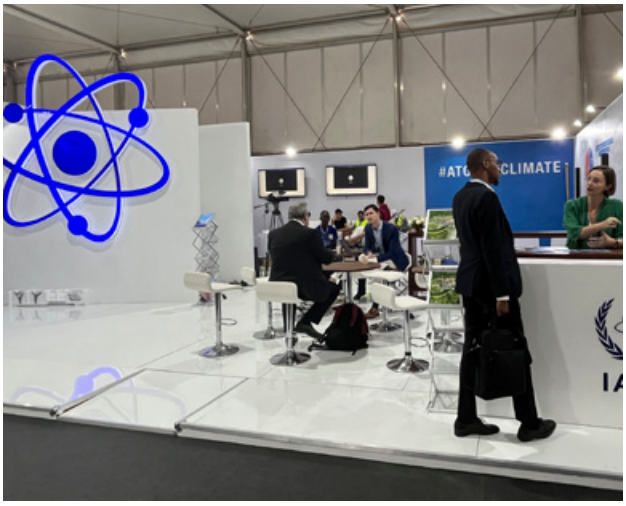
There was much talk last year about how important nuclear energy is for achieving the net zero goal, but relevant evidence of its importance materialized no earlier than this year.

The most relevant of them is likely to be the inclusion of nuclear in the EU taxonomy of sustainable activities. Sustainability criteria for nuclear energy projects were published early this year. That was followed by rigorous research conducted by the UNECE and the Joint Research Center (the two organizations confirmed that nuclear stations are safe and have the least impact on the climate), heated debate, and pro and con letters by high-ranking politicians. Only after that, the criteria were approved by the competent EU authorities. The European Taxonomy now includes such activities as construction of nuclear power plants for which the construction permit has been issued by 2045, modification of existing nuclear installations for the purposes of extension authorized by 2040, and innovative technology (Generation IV reactors). The criteria for recognizing

nuclear projects sustainable will apply from January 1, 2023.

It was not Europe, though, that pioneered the recognition of nuclear energy contribution to a carbon-free future — China and Russia had included nuclear in their national taxonomies before. Moreover, Rosatom already obtained several 'green' loans for the construction of Akkuyu NPP in 2021. Anyways, other countries often follow Europe's example and adopt preferential programs, taking cue from the European Union. In November, for example, the Canadian government included small modular reactors (SMRs) into the list of technologies to which investment tax credits may apply.

We can assume that the inclusion of nuclear energy projects into the EU Taxonomy made COP 27 organizers approve a 'nuclear' pavilion. **"As far as I know, both the World Nuclear Association and the IAEA had repeatedly filed applications for such a pavilion, but the organizers never approved it. This year, the application was finally approved, and I consider this to be our outstanding achievement and a signal that the global climate change conference organizers have changed their attitude towards nuclear and its role in decarbonization of the economy,"** Polina Lion, Chief Sustainability Officer at Rosatom, said.



The pavilion does not only symbolize appreciation of nuclear energy by the organizers but rather an opportunity for the visitors to learn more about nuclear technology capabilities and get rid of prejudice. This process has accelerated all over the globe.

Energy crisis

The growing appreciation of nuclear energy has been driven primarily by the energy crisis that affected everyone's — and preeminently consumers in Europe — bills. The crisis broke out in the second half of 2021 when energy prices and, most notably, the price of gas started to grow. This trend intensified greatly in 2022 on the back of anti-Russian sanctions. The price of natural gas skyrocketed from about USD 200 per 1,000 cu m last January up to USD 3,000 in 2022. As of early December 2022, the price stood at around USD 1,500 per 1,000 cu m. Electricity soon followed energy: in Europe, the average price of electric power soared from about EUR 50/MWh before the crisis up to EUR 1,000/MWh in 2022. According to the Eurostat, non-household electricity prices in the first half of 2022 ranged from EUR 80/MWh in Finland to EUR 300/MWh in Greece. As at December 1, 2022, the price of electricity at the Power Exchange Central Europe platform was EUR 367.61/MWh.

Electric power makes up a significant portion of business costs and household expenses, so it is only natural that the public, businesses and governments raise the issue of price

stability increasingly more often. **"Nuclear power plants are the only 24/7 source of clean energy, while the cost of electricity they generate does not depend on weather or commodity market fluctuations. In the production of fossil electricity, the price of fuel accounts for 60% to 80% of total costs, so any increase in prices immediately translates into the price of electricity. In nuclear generation, the share of fuel is less than 5% of electricity costs, so no one will even notice an increase in nuclear fuel prices,"** Deputy CEO for Corporate Development and International Business at Rosatom Kirill Komarov said when speaking at Atomexpo 2022.

"When we were deciding what power supply option to choose, we were considering coal, LNG and other sources but opted for nuclear. The possibility of building a financial model and showing it to banks is a crucial factor for us as investors," Georgiy Fotin, CEO of Baimskaya Management Company, echoed Kirill Komarov. Baimskaya operates Baimsky GOK, a large mining and processing site at the gold and copper deposit Peschanka in the Chukotka Peninsula (Northeast Russia). It will be supplied with electric power from an upgraded floating nuclear power plant designed by Rosatom.

Making long-term contracts is a common practice for Rosatom. For example, the Russian nuclear corporation and Egypt's El Dabaa NPP have signed a fuel supply contract for 60 years, the entire service life of the plant.

Another aspect of stability is a full range of technologies, from plant design to decommissioning and from uranium mining to spent fuel management. Kirill Komarov assured the audience at the press conference that Rosatom could offer all those technologies and make them fully functional.

"Nuclear power plants are the most balanced, most predictable and clean source of power generation. We have four operating power reactors in the country, preventing 100 million tons of CO2 emissions per year. After the new reactors at Paks NPP are brought online, this figure will grow. Besides, it is nuclear that helps us maintain a guaranteed level of electricity prices in the country. The more nuclear you have in your energy mix, the safer you feel in the current energy crisis," Hungarian Minister of Foreign Affairs and Trade Péter Szijjártó summarized key advantages of nuclear generation when speaking at Atomexpo 2022.

New money

Director General of WNA Sama Bilbao-y-Leon believes that the efforts invested in nuclear energy are insufficient. IAEA Deputy Director General Mikhail Chudakov put this insufficiency into figures: the next 30 years

will require USD 3 trillion in investments, or six times more than invested in the previous 30 years (USD 0.5 trillion). The number of reactors going online every year should grow 3 to 4 times (to compare, six reactors were commissioned last year).

Whatever the prospects, the first money starts to flow in. In addition to the investments accounted for in the WNA report (see our Words Without Deeds article in the Newsletter's October issue), we would like to mention some further investment declarations.

In November 2022, Dutch media reported that EUR 5 billion was allocated to initiate the work on two large power reactors, which are assumed to be built near the operating Borssele Nuclear Power Station. The new reactors are expected to be put in operation no later than 2035.

The Canada Infrastructure Bank (CIB) has finalized an agreement with Ontario Power Generation (OPG) and committed USD 970 million towards Canada's first small modular reactor (SMR). CIB invests in the first phase of the project that includes design engineering, site preparation, procurement of long-lead equipment, etc.

At COP 27, the Export–Import Bank of the United States (EXIM) issued two letters of interest in financing pre-project engineering services for Units 3 and 4 of the Cernavoda Nuclear Power Plant in Romania. **"Based on the preliminary information submitted, EXIM would be able to consider financing up to USD 50,000,000.00 of the US export contract for pre-project engineering services as part of engineering multiplier program (EMP) and up to USD 3 billion of the US export contract for engineering**

and project management services for Units 3 and 4 Cernavoda NPP Completion Contract," says a statement by the Romanian nuclear operator Nuclearelectrica. It should be noted that EXIM finances only goods and services originating from its home country. "Up to USD 3 billion" for engineering and project management services means, in fact, the choice of the US technology. But, first of all, there will be two units, and USD 3 billion is not enough to build them. Second, two units of Romania's only Cernavoda NPP were built to the Canadian design. With that in mind, me might assume it would be more reasonable for Romania to build the new reactors to the same heavy water technology — just because of the experience gained in operating such reactors. What is more, the last US reactor built to this technology was shut down in 1963.

Besides, the US Trade and Development Agency has awarded a grant of USD 14 million to RoPower Nuclear SA, the project company recently established by Nuclearelectrica and Nova Power & Gas. The grant will be used for the front-end engineering and design (FEED) study to advance the development project of Romania's first SMR nuclear power plant.

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As for Rosatom, as per usual, it embodied nuclear energy development in concrete. This year, Rosatom began construction works at Tianwan Unit 8, Xudabao Unit 4, and two units at Egypt's El Dabaa NPP.

The latest news from nuclear construction sites comes from Brazil where construction of Angra 3 has resumed. The priority task is to finish concreting of the internal containment dome. A tender for the completion of construction works will be announced soon. On December 2, Iran started construction of its Karoon nuclear power plant with a 300 MW pressurized water reactor. This will be Iran's first SMR (all reactors with a capacity of up to 300 MW inclusive are considered to be small).

Small modular trend

Growing demand for SMRs is another trend that has gained momentum this year. Small modular reactors are attractive for countries with low generation output, island states, and remote regions. Owners of large projects, which can be connected to the grid, also take interest in installing an SMR to ensure the stability of pricing.

Russia is a leader in the SMR technology: Akademik Lomonosov floating nuclear power plant has been in operation for two years; floating power units to supply power to Baimsky GOK are currently under construction; an onshore SMR project is under development in Yakutia. In addition, China launched a high-temperature gas-cooled reactor in 2021. According to Rusatom

Overseas CEO Evgeny Pakermanov, Rosatom holds talks on SMR construction with a number of African countries. **"A small modular reactor can always find its place in the energy mix of any country,"** Kirill Komarov said with confidence at Atomexpo.

To sum it up, this year has demonstrated that nuclear has become almost synonymous with stability. What does it mean? It means, for one thing, new long-term contracts for the supply of nuclear fuel and its components to mitigate volatility risks — this year has already produced a number of examples. We can also assume that the next year will bring in more decision to begin construction and truly allocated (not just declared) investments in nuclear energy. This can be nothing but positive because, as the history of renewable energy technology shows, investments stimulate development and commercialization of technology. As a result, construction costs decrease, and attractive offers appear in the market.

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