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BRICS Backs Up Nuclear

Nuclear technology was one of the topics at the BRICS Summit held in Kazan this October. The heads of Russia, Turkey, Iran and Egypt discussed the construction of nuclear power plants, while Rosatom Director General Alexey Likhachev commented on the nuclear projects in India and Egypt. Rosatom also took part in the industry-specific events held before the summit.

Construction works continue

The Russian and Turkish Presidents, Vladimir Putin and Recep Tayyip Erdogan, discussed the progress of the Akkuyu NPP project. “The construction of Turkey’s first nuclear power plant at Akkuyu is our joint flagship project. Building works are going on round the clock, simultaneously at each of the four power units,” Vladimir Putin said.

At a meeting with Iranian President Masoud Pezeshkian, Vladimir Putin named cooperation around the Bushehr NPP among the priorities of the two countries.

Another large-scale project, El Dabaa nuclear power plant in Egypt, was the subject of discussion between the Russian and Egyptian presidents. “We highly appreciate the rapid evolution of our bilateral relations since we signed a strategic partnership agreement in 2018, particularly in terms of implementing major projects,” said Egyptian leader Abdel Fattah Al-Sisi.

Rosatom chief Alexey Likhachev pointed out in an interview with Rossiya 1 TV channel that the Western sanctions had not had any substantial impact on the delivery of the El Dabaa project. “The will of the Egyptian leadership and, I believe, the Egyptian people to implement this project is as high as we are enthusiastic about this epochal task, so we are finding solutions,” Alexey Likhachev commented on the construction progress. He also outlined the prospects for the Kudankulam NPP in India: “Two units are already in commercial operation, while another two units are in the final construction phase. We expect them to be commissioned in 2025–2026.”

Context

The BRICS Summit hosted a high-level discussion of the climate agenda, investments, e-commerce, food security, and other strategic partnership issues. Vladimir Putin called for intensifying cooperation in technology, education, efficient resource management, trade, logistics, finance and insurance, and for multiplying capital investments, and suggested creating a new BRICS investment platform to support national economies.

Nuclear platform

A week before the summit, the heads of major nuclear companies and organizations of the BRICS member states discussed a new nuclear platform initiative that might have a far-reaching effect on the global nuclear industry. Alexey Likhachev gave an insight into the new association: “Virtually every BRICS member is working on nuclear energy projects. Many member states are technology drivers in today’s international nuclear market. That is why we propose to join efforts under the BRICS Nuclear Platform, a voluntary alliance of companies, professional nuclear communities and NGOs supporting the development and deployment of nuclear technologies,” Alexey Likhachev said.

The primary goal of the platform is to introduce and promote best practices and advanced approaches in the energy and non-energy applications of civil nuclear technology in the BRICS and BRICS+ markets, and to develop mechanisms and models that would stimulate nuclear projects.

According to the IAEA, there are 440 power reactors with a total capacity of about 395 GW operating in the world, and another 63 units with a total capacity of 66.1 GW are under construction. As estimated by Russian experts, the BRICS countries will account for at least half of the world’s power production and consumption by 2050. Nuclear will make up a sizable portion of the energy mix of the BRICS countries as they will account for at least two thirds of nuclear capacity additions by 2030.

Mr. Orpet Peixoto, Deputy Chairman of the Supervisory Board of the Brazilian Association for the Development of Nuclear Activities

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(ABDAN), expressed confidence that the new platform would benefit every member of the association. He cited Brazil as an example. "We are one of the few countries that have all the components of the nuclear fuel cycle. But we need support, we need funding, and we know that we can get it through cooperation with the BRICS countries. The new platform opens up great opportunities for us," Orpet Peixoto said.

Other areas of focus

Rosatom is an active contributor to many of the BRICS events. In October, Rosatom representatives took part in the BRICS Scientific and Educational Congress on Ecology and Climate Change. Professional training was among the topics discussed at the Congress.

In September, Alexey Likhachev spoke at the 4th BRICS Youth Energy Summit to give a lecture on Russia's contribution to the energy sector of the BRICS countries. "The overarching challenge we have to overcome on our path to energy transition is to introduce more carbon-free power sources into the global energy mix. And nuclear power will definitely play a key role there," he said.

At a meeting between communications ministers at the BRICS Digital Forum held in Russia's Innopolis, the Russian party presented the University of Future Technologies, an international research and educational center for the development of quantum and biomedical technologies and new materials. Rosatom is one of the founders of the university.

In June, Russia's nuclear fleet operator Atomflot hosted representatives of the BRICS Ocean and Polar Science and Technology Working Group at its base in Murmansk. They visited GlavSevmorput, Rosatom's Marine Operations Headquarters, to learn about the technology used in nuclear icebreakers and discussed an environmental monitoring and research program for the Northern Sea Route and Arctic territories.

A forum on nuclear medicine was held in the same month, followed by setting up a ministerial working group on nuclear medicine in October. The group is tasked with improving cooperation in the production of radiopharmaceuticals and diagnostics. Rosatom was among the organizers of the event.

Russia-China Partnership

Rosatom is actively involved in the construction of new nuclear units in China, but cooperation between Russian and Chinese nuclear engineers is not limited to this field alone. For instance, Chinese specialists have recently studied the Russian experience in nuclear decommissioning and radioactive waste management.

Operating personnel of Tianwan Units 7 and 8 started a simulator-based training course. The simulator is an accurate imitation of the main and backup control rooms of Unit 7, which is equipped with a Russian-designed VVER-1200 reactor.

The simulator was developed at the JET Engineering and Technical Center (part of Rosatom) and subsequently manufactured at a factory of China Techenergy Corp (CTEC). After the software was loaded onto the equipment and tested, the simulator was delivered to the nuclear station's training center, assembled, test-run and put into operation.

The system was commissioned six months ahead of the contract deadline due to the concurrent development of the two components, a mathematical model simulating all power unit operation modes and software for the instrumentation and control (I&C) systems.

The Tianwan operators will now be trained in the closest-to-real conditions. They will use the simulator to practice the actions to be taken during normal operation of the plant, responses to accidents, and interaction between shift employees. The simulator also serves to check the correctness of instructions, to conduct certifications, etc. The training course is taught by instructors from China's Jiangsu Nuclear Power Corporation (JNPC), an operator of the Tianwan NPP.

Steam generators

On October 15, three steam generators were shipped from Volgodonsk, Russia to Xudabao Unit 4 in China. Weighing a total of 1,000 tonnes, the steam generators will travel by river, sea and road to reach their point of destination. This is the second shipment of critical equipment for this power unit. The first one, which comprised a VVER-1200 reactor pressure vessel and the first steam generator, was shipped in mid-August this year. There will be more to come as Rosatom's mechanical engineering companies in Petrozavodsk and Saint Petersburg are manufacturing a pressurizer, primary coolant pipes, and a primary coolant pump for the Xudabao Nuclear Power Plant. The process is fully on schedule, so the equipment will be shipped to the construction site in accordance with the contract terms.

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"The companies of Rosatom's mechanical engineering division are working at pace to manufacture equipment for the nuclear power plants the nuclear corporation is building abroad. Hardly a month goes by without our production sites in Volgodonsk, Saint Petersburg and Petrozavodsk shipping nuclear and turbine island components for the nuclear stations under construction. Regular shipments are owed to the well-coordinated work of nuclear engineers and once again confirm the outstanding quality of Russian nuclear technologies," said Igor Kotov, head of the mechanical engineering division.

As our readers know, four power units with VVER-1200 reactors are under construction in China, two at each of the Tianwan and Xudabao nuclear power plants. The service life of Russian-designed nuclear power units is 60 years and can be extended up to 80 years.

Graphite waste

In late October, representatives of the CNNC Environmental Protection Company (CEPC) arrived in Seversk, Russia to visit the Experimental Decommissioning Center for Uranium-Graphite Reactors (EDC UGR, part of Rosatom). The purpose of the visit was to study the experience of decommissioning graphite-moderated reactors and managing radioactive graphite waste. The Chinese environmentalists saw the results of applying one of the decommissioning methods, the so-called 'in-situ disposal', and learned how Rosatom conducts comprehensive engineering and radiation surveys of the graphite pile. Russian experts demonstrated approaches and techniques for dismantling the graphite pile and the results of radiation studies on irradiated graphite, for which special software programs and analytical tools were used.

Also during the visit, the parties shared their experience in the design, construction and procurement of radioactive waste treatment systems and discussed further cooperation.

"We maintain a broad dialog with our Chinese partners across many areas of the nuclear fuel back-end management. Cooperation between our countries in this field sets long-term trends for the global nuclear power industry and promotes the adoption of best practices and solutions," said Eduard Nikitin, Director for Nuclear Decommissioning and Radioactive Waste Management at TVEL.

"We have extensive experience in studying mechanical, radioactive and thermodynamic properties of irradiated graphite, planning safe management of graphite waste, and developing solutions for dismantling graphite piles. We are open to cooperation and are confident that our solutions will be in demand in the international market," said Sergey Markov, CEO at EDC UGR.

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Nuclear medicine

Nuclear medicine is a key non-energy application of nuclear technology and an important business dimension for Rosatom. This business comprises production of medical isotopes and radiopharmaceuticals, development of medical devices, and construction of nuclear medicine centers.

Nuclear medicine is not a totally new business for Rosatom. The USSR held global leadership in using nuclear technology in medicine, producing about 140 radioactive isotopes and 40 radiopharmaceuticals for domestic needs and for export. The country operated 650 radionuclide diagnostic laboratories that conducted over 1.5 million studies annually, and 20 radionuclide therapy departments with a total of 2,000 beds.

At present, Rosatom maintains its leading position in the radioisotope segment, being among the Top 5 global suppliers and producing the widest range of radionuclides. Demand for Rosatom's radioisotope products is steadily growing: in 2023 alone, annual isotope exports increased by 15%. Around 2.5 million diagnostic and therapeutic procedures are performed worldwide using Rosatom's isotopes, which are supplied to more than 170 companies in 50 countries.

However, Rosatom does not restrict itself to the production of isotopes and enters new segments of the nuclear medicine market.

Radiopharmaceuticals

Rosatom is building Europe's largest radiopharmaceuticals factory in Obninsk, Russia. The decision to set up the factory was taken after the Russian nuclear corporation had analyzed the market in consultation with the medical community and identified the most demanded products and undersupplied segments. Its product range and capacity were planned with regard for Rosatom's capabilities, product specifics, competition and consumer environment. The factory will produce dozens of substances for diagnostics and therapy of oncological, cardiovascular and neurodegenerative diseases in compliance with GMP standards.

Production will start with the most in-demand substances, including technetium-99m generators for diagnosing more than 20 diseases and iodine-131-based radiopharmaceuticals for treating thyroid cancer and neuroblastoma in children. Samarium-153-based drugs reduce pain and inhibit bone metastases. Radiopharmaceuticals containing radium-223 are used for the treatment of bone metastases in patients with castration-resistant prostate cancer.

The factory will also produce innovative radiopharmaceuticals based on carrier-added and non-carrier-added lutetium-177, actinium-225, thorium-227 and other isotopes intended for the treatment of inoperable metastatic forms of malignant neoplasms.

By now, shell and core works, including glazing, facade cladding and thermal envelope, have been completed at the factory site. Work is currently underway to finish the interior and pave the adjacent territory, bringing the equipment installation phase much closer.

Medical equipment

Rosatom develops and supplies high-tech equipment for nuclear medicine. For instance, the company is working on the project to develop a superconducting magnetic resonance imaging (MRI) scanner. It also manufactures multi-channel dosimeters for clinical applications and has been supplying hospitals with Brachyum gamma therapy systems since 2022.

Brachyum is a device for contact radiation therapy of oncologies. It is when a gamma radiation source is delivered close to the tumor or introduced into the affected tissue with a minimal exposure for healthy tissues. The device is equipped with an advanced dosimetry unit and a 3D radiation mapping system enabling accurate, real-time therapy progress and exposure monitoring. Brachyum applicators are compatible with various diagnostic imaging systems.

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Rosatom is expected to launch mass production of superconducting MRI scanners in 2027. They will produce a 1.5T-strong magnetic field, which is enough for detailed and clear visualization of internal organs.

Rosatom is studying the possibility of entering the markets of the CIS, BRICS, Middle East, Southeast Asia, Latin America and Africa with its medical equipment products.

NRTC

Rosatom is eager to share its expertise in nuclear medicine with partners. For example, the nuclear corporation is building a nuclear research and technology center (NRTC) in Bolivia. One of its components, a cyclotron, was put in operation in 2023 and has been used for the production of radioisotopes and radiopharmaceuticals. Its product range includes radiopharmaceuticals containing fluorine-18 (for diagnosing oncological and cardiological diseases), carbon-11 (for detecting brain tumors), iodine-123 (for diagnosing thyroid pathologies) and technetium-99m (used in a variety of diagnostic applications).

The key component of the NRTC, a research reactor, will be capable of generating isotopes for medical purposes. In late October this year, the initial batch of nuclear fuel for the reactor passed factory acceptance tests at TVEL (Rosatom's nuclear fuel division). Its shipment is scheduled for 2025. The Nuclear Research and Technology Center is expected to be fully operational in the same year.

Rosatom is currently working on the project to build a similar NRTC in Vietnam. In September this year, Rosatom Director General Alexey Likhachev and Vietnamese Minister

of Science and Technology Huynh Thanh Dat discussed a construction program for the NRTC. The time schedule was set forth in the inter-agency memorandum signed during the visit of Russian President Vladimir Putin to Vietnam in June 2024.

Sharing experience

Rosatom is a regular participant of international events dedicated to nuclear medicine. In July, Rosatom co-organized the first high-level BRICS International Forum on Nuclear Medicine for representatives of the BRICS member states to discuss the opportunities and needs of their countries, propose development ideas, and exchange views. In October, Rosatom experts took part in the European Association of Nuclear Medicine (EANM) Congress 2024 in Hamburg. They presented Russian isotope products and nuclear medicine solutions and spoke about the corporation's capabilities in this field.

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Thermonuclear Progress

Fusion energy draws much attention from the Russian nuclear community. The national thermonuclear program is advancing, and so is the full-fledged cooperation within the ITER project.

Domestic plans

The immediate goals of the Russian thermonuclear program are to achieve design parameters for a T-15MD tokamak at the Kurchatov Institute and develop a 'reactor technology' tokamak at the Troitsk Institute of Innovative and Thermonuclear Research (TRINITI).

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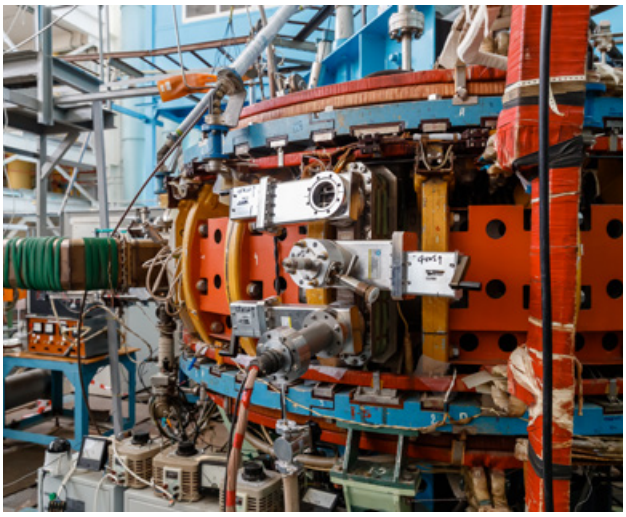
T-15MD is an operational tokamak, which was test-launched in May 2021. In March 2023, it generated high-temperature plasma for the first time. Then, during two series of experiments, researchers developed algorithms for producing plasma discharges and managed to create a magnetic field with a magnitude of 1 Tesla and maintain it for 30 seconds. In December 2023, researchers produced a discharge with a plasma current of 260 kA and duration of over two seconds. The temperature of plasma electrons reached nearly 40 million degrees, which is twice the temperature at the center of the Sun.

To improve the performance of T-15MD, it is planned to equip it with auxiliary plasma heating, current maintenance and diagnostic systems, install a divertor, and clad the chamber with graphite.

The reactor technology tokamak (RTT) is being developed as a full-scale experimental prototype of a fusion reactor or a neutron source. It is designed to study plasma behavior in quasi-stationary modes, study and improve auxiliary plasma heating and fuel delivery methods, and much more. The RTT will be built in Troitsk, Russia.



Development of its concept design and diagnostic equipment began in 2021. Expected to be completed by the end of 2024, this phase will be followed by detailed engineering, which will begin in 2025. In addition to the tokamak itself, engineers will have to develop many peripheral systems for diagnostics, plasma heating and current generation. The plan is to test-launch the reactor in 2035 and generate the first plasma in 2036.

Russia pays great attention to thermonuclear technology. The government-sponsored Thermonuclear Energy Technologies federal program will be implemented in 2025–2030 as part of the national umbrella-like New Nuclear and Energy Technologies project. The federal program provides for research into controlled thermonuclear fusion and development of innovative plasma technologies, and will involve efforts from Rosatom Group companies, the Kurchatov Institute, the Russian Academy of Sciences, and the Russian Ministry of Science and Higher Education. The program also provides for building (upgrading and retrofitting) a number of test stands and installations for the development and improvement of basic thermonuclear and plasma solutions.

Another R&D area will comprise studies on the interaction between plasma and plasma-facing components using test instrumentation, digital control equipment and data collection systems at an experimental tokamak facility. Finally, the federal program provides for the development of regulatory acts governing the use of thermonuclear and hybrid systems, including for licensing purposes.

The projects that are being developed in Russia by Rosatom, the Kurchatov Institute and other organizations contribute to the development of fusion technology worldwide. “Fusion is one of the most open fields of research

these days. I think it will continue to remain so, at least until the technology begins to be commercialized," Director of Rosatom's ITER Center Anatoly Krasilnikov said in an interview with the Novy Atomny Ekspert (New Nuclear Expert) magazine.

ITER and international cooperation

Rosatom is a key contributor to the ITER project. It should be recalled that the international thermonuclear project was initiated by the Soviet Union back in the 1980s. It was first agreed between the leaders of the USSR and the US, Mikhail Gorbachev and Ronald Reagan, and then Euratom and Japan joined the project. These four partners developed the engineering design of the thermonuclear reactor. This was when China, India and South Korea joined the ITER.

The overarching goal of the project is to build an experimental thermonuclear reactor with high-temperature deuterium-tritium plasma. The reactor must be able to ignite and, more importantly, sustain it for 500 to 1,000 seconds. "It's like with a bicycle: if you maintain balance for two or three seconds, it doesn't mean you can ride it. We need to maintain plasma for a long enough time," Anatoly Krasilnikov explained to the Novy Atomny Ekspert.

Russia has been supplying fusion equipment for several years as part of its ITER contribution. Superconductors and the PF1 magnetic coil have been delivered in full. The shipments of switchgear equipment are continuing, with about 30 to 40 trucks sent to the construction site every year. Eighteen upper ducts of the vacuum vessel have been manufactured and are being prepared for shipment. They are needed for the installation of diagnostic systems, heating equipment and pumping devices. Russia is also responsible for supplying eight out of 24 gyrotrons (these devices are used for auxiliary plasma heating and current generation). The Institute of Applied Physics of the Russian Academy of Sciences has manufactured them, with four already delivered to the site. Their installation will begin by the end of the year. The ninth gyrotron will be manufactured in 2025 as a spare part. However, their number may grow since the ITER Organization decided to increase the capacity of the electron cyclotron resonance heating (ECRH) system.

The plans for the next few years include the delivery of port plugs. These are complex structures that host plasma diagnostics, test blanket modules, elements of the ion and electron cyclotron heating systems, and other hardware.

Russia is manufacturing four test stands for testing port plugs. In late August this year, a steel frame weighing over 20 tonnes for the first of these test stands was shipped to the ITER site in Cadarache, France. Other equipment for these stands will be shipped to France by the end of the year.

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Another task entrusted to Russia is the production of the first wall facing plasma. It should have high mechanical strength, vacuum density, thermal and electrical conductivity, high heat resistance, and also resistance to thermal cyclic loads and radiation exposure.

The wall was first planned to be made of beryllium, but its toxicity and obvious difficulties with obtaining necessary permits made it clear that it would be faster to try another material. Tungsten was chosen for being non-toxic and having a much higher melting point. However, there is a risk that tungsten particles will get into plasma, decreasing its temperature, so much more energy will be needed for heating. Russian researchers suggested shielding tungsten with a boron carbide coating as in the design of Russian tokamaks. The proposal was accepted, and the R&D works began.

In October, Pietro Barabaschi, Director General of the ITER Organization, came to Russia to discuss the prospects, difficulties and solutions to the problems of the ITER project. He visited laboratories of Moscow's ITER Project Center (part of Rosatom), Efremov Research Institute of Electrophysical Equipment, and the Ioffe Institute of Physics and Technology, and had a meeting with the inspirer and initiator of the ITER project and Honorary President of the Kurchatov Institute Evgeny Velikhov and Rosatom Director General Alexey Likhachev.

When visiting the ITER Center in Moscow, Pietro Barabaschi was shown how artificial single crystal diamonds are grown and how diagnostic systems for the fusion reactor are developed. At the meeting with Alexey Likhachev, he discussed issues related to the implementation of the ITER project. "We have some difficulties with the supply of equipment from Russia, but this is not so important compared to other problems of the project," Pietro Barabaschi said at the press conference.

Prospects of the project were in the spotlight of the discussion. "This visit is very important for us. The International Thermonuclear Experimental Reactor project is now at the crossroads as its members are discussing a new 'baseline'. The timing and costs of the project may change dramatically. Russian companies need complete information from the immediate head of the project," Anatoly Krasilnikov said.

The parties were satisfied with the results of the meeting. "I am genuinely happy with the visit of my colleague Pietro Barabaschi to Russia. We had an open and trusting conversation in an atmosphere of mutual understanding and common focus on success," Alexey Likhachev said.

"ITER is a remarkable example of international cooperation, where science unites nations in pursuit of a common goal," Pietro Barabaschi said. "The input made by Russia,

as well as by any other ITER member, is of utmost importance as it shows a shared commitment to the development of fusion energy that will exist for the benefit of all mankind. This input spans every aspect of the project, from critical components to key technological innovations. As we move forward, it is the global spirit of collaboration that remains the cornerstone of success, ensuring progress of one of the most ambitious scientific projects of our time."

Development of academic and personal ties, advancements in technology and research, production of sophisticated equipment, current and forward-looking financial and legal support — all these things testify to Russia's commitment to facilitating thermonuclear technology and putting it into practice.

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ITER stands for the International Thermonuclear Experimental Reactor. It is also the Latin for 'the way' or 'the path'.

Maximum Safety

The latest important events at the El Dabaa NPP construction site are centered around molten core catchers, also known as melt traps. The installation of this device has been recently completed at El Dabaa Unit 3, while components of the core catcher for Unit 4 were delivered to the site in early November.

The ship carrying core catcher components left the Russian port of Novorossiysk in October. Their total weight exceeded 700 tonnes, with the catcher body alone weighing 155 tonnes. The cargo was delivered to Egypt ahead of schedule.

"We installed core catchers at Units 1 and 2 in 2023, and another one at Unit 3 in 2024. If we manage to do the same at Unit 4 this year, this will prove our process is resilient, with two such devices installed each year.

The construction of VVER-1200 reactor units is a well-established process that has become routine for Rosatom. We have transitioned from one-off projects to a commercial, workflow approach to construction," said Alexey Kononenko, Vice President of ASE and Director of El Dabaa Construction Project.

Installation of the core catcher at Unit 4 is scheduled to begin by the end of the year.

"As soon as the melt trap is installed at Unit 4, each of the power units at El Dabaa NPP will be equipped with this safety device. This will mean that another important milestone has been passed on the way to the Egyptian dream of a nuclear power plant thanks to God's grace and joint efforts of the Egyptian and Russian teams," said Amged El-Wakeel, Chairman of the Board of the Egyptian Nuclear Power Plants Authority (NPPA).

The core catcher is a pioneering safety device designed by Russian nuclear engineers. This cone-shaped vessel made of high temperature resistant steel is installed at the bottom of the concrete pit, right under the reactor, and filled with the so-called 'sacrificial material'. In case of a core meltdown, the core catcher reliably retains corium fragments and keeps them inside the reactor containment. However, the probability of such accidents is extremely low and, according to expert estimates, stands at one in a million.

Core catchers are included in the design of every nuclear power plant with VVER-1200 reactors. Foreign reactor designs, even those belonging to Generation III+, do not have such safety devices.

Installation of the core catcher at El Dabaa Unit 3 started in early October. These works were carried out by a 10-strong team using a heavy Zoomlion ZCC 32000 crane with a lifting capacity of 2,000 tonnes.

"The installation of the core catcher at Unit 3 started on time, but this would not have been possible without all-round cooperation between the Egyptian customer and the general contractor. I would like to express my deep gratitude to everyone who made efforts to achieve this milestone of our joint project," Alexey Kononenko said.

Both in Egypt and Turkey

Another project similar to El Dabaa in scale is the Akkuyu Nuclear Power Plant being built by Rosatom in Turkey. All of its four VVER-1200 reactor units are simultaneously under construction.

Full-scale pre-commissioning operations are underway at Akkuyu Unit 1. Its systems and equipment are being gradually made ready for operation and checked thoroughly for compliance with the design parameters. In early November, workers finished concreting

the outer containment dome on the reactor building of the first power unit. The outer containment shell is an essential safety element of each reactor. Its reinforced concrete structure will safely protect the reactor from external impacts.

In October, the second low-pressure rotor was assembled and placed into the turbine stator in the turbine building of Unit 1. The turbine will soon be ready for the jacking gear installation and a subsequent series of pre-commissioning tests.

Construction and installation works at the other units are continuing as scheduled. Earlier this autumn, two emergency core cooling system (ECCS) tanks were installed in their design position at Akkuyu Unit 2. The ECCS tanks contain an emergency stock of aqueous boric acid solution. Being a neutron absorber, it is used for flooding the reactor core, thus ensuring safety in an emergency situation.

In early autumn, workers concreted a foundation slab for the turbine of Unit 3. It is designed to withstand and evenly distribute heavy loads caused by the turbine in operation. NL

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Powerful, Safe, and Efficient

Full-scale pre-commissioning operations are underway at Akkuyu Unit 1. Its systems and equipment are being gradually made ready for operation and checked thoroughly for compliance with the design parameters. Works at the other units are continuing as scheduled.

In early November, workers finished concreting the outer containment dome on the reactor building of the first power unit. This operation was divided into four stages and took 104 days. The outer containment shell is an essential safety element of the reactor unit. Its reinforced concrete structure will safely protect the reactor from external impacts.

In late October, workers finished installing a rotor into the turbine stator in the turbine building of Unit 1. The rotor is a large-size

piece of equipment weighing 245 tonnes, so the installation required using the main overhead crane of the turbine building.

"Thanks to the concerted efforts of our workers and engineers, we have successfully carried out the complex and critical operation of inserting the rotor into the stator, mounting it onto the bearings and setting it up. The rotor installation will allow all auxiliary systems to be connected to the stator. This will also allow workers to proceed with aligning the turbine and generator shafts," said Sergey Butskikh, CEO at Akkuyu Nuclear.

With the rotor put in place, the turbine assembly process moves into the final stage. First, the shafts of the turbine and generator rotors are connected into one line and aligned precisely. The turbine unit is then ready for the jacking gear installation and a subsequent series of pre-commissioning tests.

Also in late October, a low-pressure heater (LPH) was delivered to the Akkuyu NPP construction site. This device improves efficiency of the reactor heat utilization by heating the main condensate to, and maintaining, the required temperature. Before being delivered to Turkey, the LPH made a long journey, having traveled from the manufacturing site in Podolsk near Moscow to the port of Saint Petersburg and then across three seas and one ocean to Akkuyu.

The Akkuyu project is in the focus of attention of the Turkish leadership. In late October, a delegation of deputies from the Grand National Assembly of Turkey (TBMM) visited the construction site of the nuclear power plant. The members of Turkish Parliament were taken to the site's highest point offering a panoramic view on the power units under construction. Then they inspected a storage area for large-size equipment, such as components of turbines and reactors for Akkuyu Units 2–4. The visit was followed by a meeting at which the delegates were given a detailed briefing on the progress of the construction project.

"The Akkuyu NPP is one of the largest and most ambitious projects, perhaps, even worldwide. It will make a substantial contribution to the sustainability of the national energy system since energy is a key factor in the development of any country. I am looking forward to all four power units of the Akkuyu NPP with a total capacity of 4,800 MW soon being commissioned and becoming the key to the stability of Turkey's energy sector," Yusuf Ziya Yılmaz, who headed the TBMM delegation, commented on the visit.

Beyond construction

Since construction of the Akkuyu NPP started, Rosatom has launched a great number of educational and social initiatives in the host communities. One of the most outstanding is the Sails of Spirit initiative that includes a sailing regatta, an environmental action, and other

events. Three yachts took part in this year's regatta. As usual, Akkuyu Nuclear employees were on their crews, which consisted of people with and without disabilities. The winner was a team representing the Kurs Sailing Club from Mersin and comprising handicapped people from this Turkish city. While the yachts were competing, master classes were held on shore. The event ended with an evening concert.

"Rosatom is an active organizer and supporter of the initiatives aimed at the development of human potential. For five years in a row, Akkuyu Nuclear employees have been gladly participating in the activities of the Sails of Spirit mission. This unparalleled initiative gives people an opportunity to get support, overcome themselves and the circumstances, and develop new abilities," Sergey Butskikh said.

Another traditional event, an angling tournament, was held in early November near the village of Yeşilovacik and close to the Akkuyu NPP site.

Sixteen amateur fishermen representing districts of the Mersin province took part in the tournament. They competed in two categories, a team competition for the largest catch and an individual competition for the largest fish. In total, the contestants caught about 42 kilograms of fish. After weighing the catch and determining the winners, a dosimetry expert from Akkuyu Nuclear measured radiation from the fish caught. The measurements showed that the radiation did not exceed natural background levels.

"The test results once again confirmed that the fish caught near the Akkuyu NPP site may be consumed. This means that the nuclear power plant is safe for the marine ecosystems," said Abdullah Aslaner, head of the Silifke district administration.

"Our experts have been monitoring environmental parameters in the 30-kilometer zone around the Akkuyu NPP site for several years. We regularly take samples of air, soil, plants, and also fish," Sergey Butskikh pointed out.

Not in Turkey alone

Another construction project similar to Akkuyu in scale is Egypt's first nuclear power plant, El Dabaa. Rosatom is simultaneously building all of its four VVER-1200 reactor units. In early November, a molten core catcher for El Dabaa Unit 4 arrived at the construction site. In early October and fully on schedule, workers proceeded with the installation of a core catcher at Unit 3. The installation was assisted with a heavy Zoomlion ZCC 32000 crane having a lifting capacity of 2,000 tonnes.

In September, erection of an inner containment shell started at the reactor building of Unit 2. The inner containment shell consists of six tiers, the first of which includes 12 pre-assembled structural sections. These sections were manufactured right at the El Dabaa construction yard. NL

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With Word and Deed

Rosatom has strong, long-standing ties with its Latin American partners. The Russian nuclear corporation supplies products to local customers, provides assistance in professional staff training, takes part in various thematic events, and is building an unparalleled center for nuclear research and technology in Bolivia.

Rosatom fosters young nuclear talents in Latin America. In late October of the anniversary year of the world's first nuclear power plant, Rio de Janeiro hosted the Latin American Youth Nuclear Forum sponsored by Brazil's Eletronuclear, Rosatom, the IAEA, and other organizations. Fifty young students and professionals from Brazil, Argentina, Colombia, Bolivia and El Salvador gathered at the site of the Brazilian National Nuclear Energy Commission (CNEN) to discuss the role of nuclear energy in the development of the region. They talked about the potential of nuclear science and technology in overcom-

ing the challenges faced by their countries. The young people presented their vision of how energy transition could be staged in Latin America and emphasized that nuclear was a clean and sustainable energy source that would contribute to strengthening energy sovereignty and addressing climate change in the region. The forum participants agreed to promote nuclear technologies at every major global summit, including G20, COP30 and BRICS+.

Rosatom also took part in the Congress of the Mexican Nuclear Society (SNM) held in late October. This year's congress is held in conjunction with a meeting of Women in Nuclear Global, an organization bringing together women employed in the nuclear industry from all over the world. Rosatom is supporting numerous initiatives aimed at maintaining gender balance in the industry. Over 3,000 female professionals are members of the Women in Nuclear community. Rosatom's international collaboration in the field of gender balance covers more than 20 countries around the world, including countries in the Middle East, Central and Southeast Asia, and Africa.

All the best for Bolivia

Rosatom subsidiaries continue to supply key systems and components for the national Nuclear Research and Technology Center (NRTC) under construction in Bolivia's El Alto. At the heart of the NRTC will be a research reactor, BRR-1. Once operational, it will produce radioisotopes for scientific research. They will be used in the neutron activation analysis to study the chemical composition of materials in a variety of applications. 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 technology.

The reactor pressure vessel was delivered from Russia and put in place in 2023. Late this October, Rosatom's Novosibirsk Chemical Concentrates Plant manufactured nuclear fuel for the initial batch to be loaded into this reactor. The fuel is designed to remain operational during an earthquake with the maximum 8.7-point intensity on the MSK-64 scale. The first set of fuel assemblies is scheduled to be delivered to the country in 2025.

Construction of the first two facilities making up the NRTC was finished in 2023 when a cyclotron and a multipurpose irradiation center were put in operation. The cyclotron produces a wide range of isotopes, which are supplied to Bolivian medical clinics for cancer diagnostics. The irradiation center serves for the treatment of agricultural and food products to ensure their safety and longer shelf life. It can also be used to sterilize a variety of medical items.

Along with building the NRTC, Rosatom is helping Bolivia train professional staff to operate this innovative facility. This autumn, the Tomsk Polytechnic University (TPU, Russia) began training young specialists who will take up positions as operating personnel of the research reactor.

"We are moving decisively forward on the path to achieving our country's technological sovereignty. A group of 18 Bolivian scholarship recipients are traveling to Russia to take a training course in the operation of nuclear research reactors. Their dedication and talent open before us a door to the future

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that will help develop and innovate Bolivia," President Luis Arce wrote in his Telegram channel.

The training course consists of three modules. The theoretical and practical modules will be taught in Russia for eight months, with the TPU research reactor to be used for training practical skills. The final third module is scheduled to be taught in Bolivia for the students to learn how to operate the BRR-1 research reactor.

The Tomsk Polytechnic University has already trained Bolivian specialists, who are now employed at the NRTC and operate the multipurpose irradiation center and the pre-clinical radiopharmaceutical cyclotron facility. The Nuclear Research and Technology Center is therefore staffed with a highly qualified professional team.

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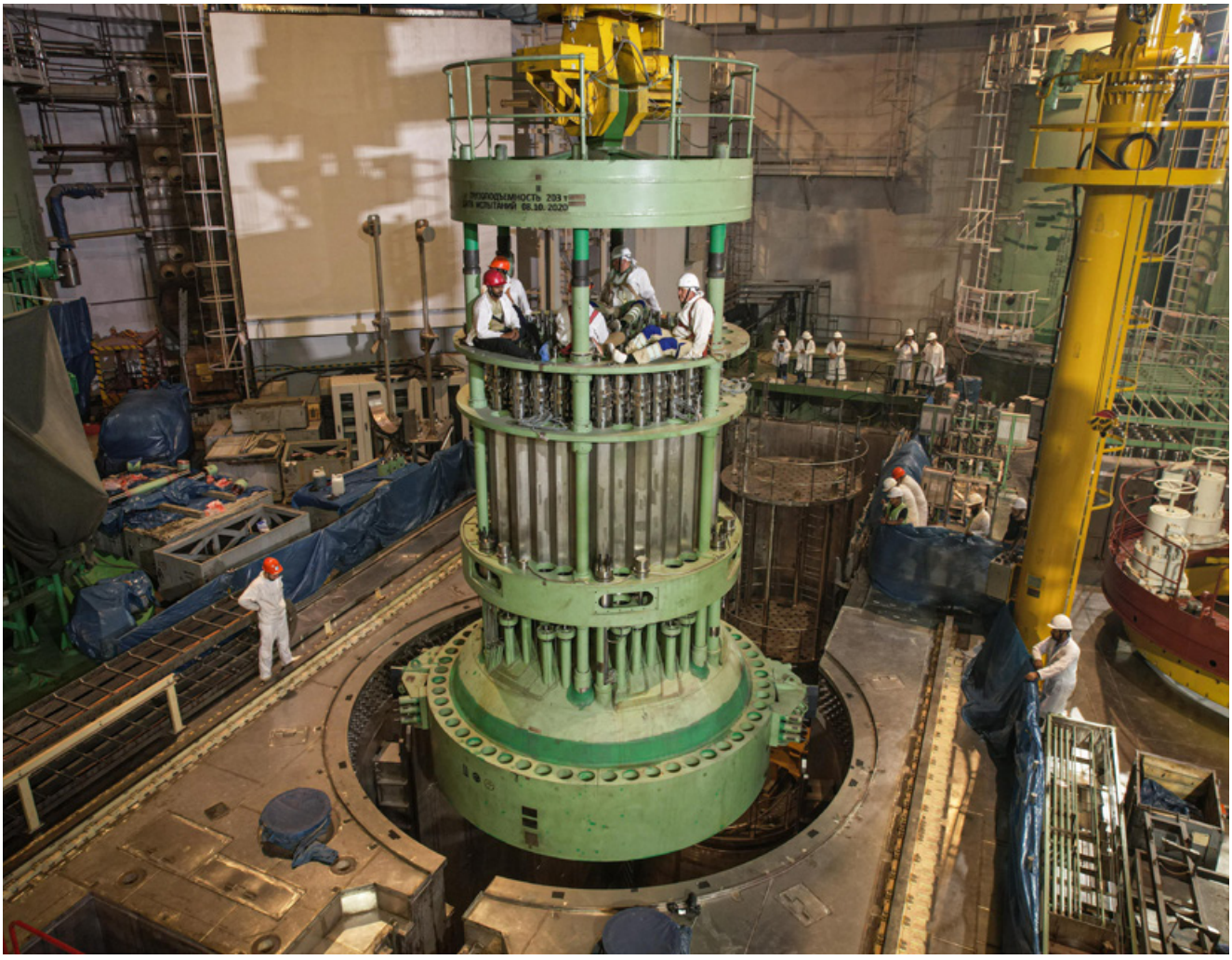

Unit 1 on Homestretch

Workers finished assembling the reactor at Rooppur Unit 1. This marks the beginning of another milestone for the project as the power unit is now being prepared for tests.

The workers installed reactor internals, a core barrel and a core baffle, loaded dummy fuel assemblies, and mounted a protective tube unit, an RPV head, and sensors needed for pre-commissioning checks.

"Completing the assembly process and preparing the reactor for key tests is an important step in ensuring the smooth and efficient operation of the power unit. Since we are responsible for making the nuclear power plant safe and reliable, we carefully control every single stage of work, keep building up our competencies, and use time-proven methods and processes that have been repeatedly tested at our construction sites. This will ultimately contribute to a sustainable and prosperous future of the energy industry in Bangladesh," said Alexey Deriy, Vice President for Bangladesh Projects at AtomStroyExport. The next step will comprise hydraulic tests to check the leak tightness of the reactor unit equipment.

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In early November, an auxiliary boiler was put in operation at the Rooppur site to supply process steam for in-house needs. Proper functioning of this boiler is critical for ensuring safe and uninterrupted operation of the nuclear power plant. The steam produced by the boiler is used during the construction phase to carry out the most important pre-commissioning works, such as hot functional tests on the reactor unit and trial vacuum buildup in the turbine condenser. During the operation phase, the boiler is needed for conducting preventive maintenance and supplying hot water to on-site facilities, and also ensures safe operation of the power unit in case of an emergency reactor shutdown.

Bringing the reactor of Unit 1 to criticality is just around the corner. Meanwhile, Rosatom is helping Bangladesh to train employees for the country's first nuclear power plant. In October, Bangladeshi specialists from the Rooppur NPP Nuclear Safety and Reliability Department completed an internship course with Rosatom's research and development institute located in Troitsk, Russia. The nuclear industry workers spent three weeks learning the specifics of VVER reactor fuel operation and practicing the use of advanced calculation tools in solving professional tasks. They studied, among other things, the RTOP-SA computer code, which is used to simulate behavior of depressurized fuel rods and release of fission products into the primary coolant circuit in VVER reactors.

With the knowledge and skills acquired, the Bangladeshi specialists will better understand the interrelation of physical processes determining the behavior of nuclear fuel in emergency situations.

"Our trainees can earn the maximum amount of knowledge in this field as the training program comprises both theoretical modules consisting of lectures and review of technical documents, and practical modules that include various tasks to control the tightness of fuel cladding during the reactor operation," said Kirill Ilyin, General Director of Rosatom's research institute in Troitsk.

Having completed the training course, the Bangladeshi team passed an exam and received certificates qualifying them to use the RTOP-SA computer code.

Muhammad Sharaf Uddin, Head of the Fuel Cladding Spectrometry and Monitoring Laboratory at the Rooppur NPP, noted that the training courses organized by Rosatom for Rooppur personnel were a great opportunity for them to improve qualifications. "The course curriculum included practical and theoretical components. Every lecture, assignment, training material or guideline was clear, concise and workable to the maximum extent possible. Having necessary competencies and a deep knowledge in their professional field, Rosatom instructors were always ready to answer questions and give detailed explanations. What's more, the weekend tours organized by the host party were fantastic. Our Russian colleagues put a lot of effort into making our internship as effective and memorable as possible!" Muhammad Sharaf Uddin said.

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Reliable Partners

Rosatom is actively enhancing its cooperation with Central African countries. In the last couple of months alone, Russian nuclear engineers have spoken at major events in various countries of the region.

In early November, the South African city of Cape Town hosted the African Energy Week 2024 (AEW 2024), one of the most representative forums of the global energy industry. The event, this year themed as Invest in African Energies, is a traditional meeting place for African leaders and global energy industry players. The Russian delegation comprised representatives of energy and financial companies, including Rosatom.

Rosatom's subsidiary TVEL and South African AllWeld Nuclear and Industrial met on the sidelines of the forum to sign a memorandum of cooperation on nuclear decommissioning and radioactive waste management.

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The document provides for joint research, technological and commercial programs in the field of decommissioning nuclear power plants and other facilities. The parties agreed to develop infrastructure for radioactive waste management, including treatment, storage and disposal.

Rosatom also sponsored one of the forum's panel discussions, entitled 'From Vision to Action: Navigating a Just Energy Transition for Africa Through Green Innovation'. It focused on the balance between energy security, social and economic development, and global decarbonization goals. Experts discussed strategies for diversifying Africa's energy mix, including through the integration of nuclear generation and solar-based energy storage systems, and gave consideration to the existing infrastructure vulnerabilities.

Visitors to Rosatom's booth at AEW 2024 had an opportunity to take part in 360-degree virtual tours of the Novovoronezh nuclear power plant and the world's first floating nuclear station. The tours were provided by detailed commentary on the project features and key equipment.

In late October, Rosatom experts took part in the business program of the 2nd Nuclear Science and Technology Conference in Namibia. Representatives from government, business and industry of different countries discussed the development of the nuclear industry in the African region. The delegates noted the importance of efficient uranium mining for the continent's economic development. Tom Alweendo, Minister of Mines and Energy of Namibia, said that the mining sector's contribution to the Namibian GDP had increased from 11.9% in 2022 to 14.4% in 2023, while purchases from local suppliers exceeded NAD 21 billion.

Representatives of Headspring Investments (Rosatom's subsidiary running the Wings uranium exploration project in Namibia) spoke about the in-situ leaching (ISL) process. "The process we use is one of the cleanest and safest mining methods available worldwide. This approach reflects our commitment to both providing energy solutions and conserving Namibia's unique environment for future generations," said Kirill Egorov-Kirillov, Managing Director of Headspring Investments.

Ryan Collier, CEO at Rosatom Central and Southern Africa, noted that nuclear could lay a solid foundation for a sustainable energy infrastructure in African countries. "Rosatom has developed a wide range of technologies to achieve this goal, including small and large-scale nuclear generation solutions, which can be a reliable source of electric power. For instance, small modular reactors are fast to build and easily scalable, thus being an ideal solution for hard-to-reach regions or regions with a relatively low electricity consumption. We are delighted that Namibia is exploring the possibilities of nuclear power. This decision could make the

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country a major energy player on the African continent," Ryan Collier commented.

In mid-October, Russian nuclear specialists visited Uganda to take part in the International Youth Festival 2024, which brought together over 10,000 people at two venues. One of the sessions was dedicated to nuclear power. Its participants discussed how nuclear technology and solutions could contribute to the sustainable development of the continent. A special part of the program was a scientific stand-up, during which young researchers presented their findings.

"We at Rosatom are deeply committed to engaging with young people. We continuously offer a wide range of educational programs for international students and young professionals, providing them with knowledge across various scientific fields. We support the aspirations of talented young people as their success is important to us. Our goal is to help them learn, grow and make meaningful contributions to society," Ryan Collier said.

In early October, Nikolai Spassky, Deputy Director General for International Relations of Rosatom, met with Yakuba Zabre Guba, Minister of Energy, Mines and Quarries of Burkina Faso. The parties aligned their views on the current and prospective agenda of bilateral cooperation, having discussed the development of nuclear infrastructure, public acceptance of nuclear power, nuclear and related training programs for Burkina Faso students, and potential joint projects in the renewable energy sector.

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