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Leningrad NPP and Its Successors

The Russian nuclear industry has one another thing to be proud of as Leningrad NPP Unit 6 is connected to the power grid. According to the IAEA, the facility is classified as operational. The next step in the development of Russia's nuclear power industry is to deliver reference facilities based on VVER-TOI reactors.

On October 23, 2020, Leningrad NPP Unit 6 located in Sosnovy Bor, Leningrad Region, supplied its first electricity to the national power grid. **"Russia has received one more 1,200 MW power unit and strengthened its leading position in the global nuclear power industry,"** Alexander Lokshin, First Deputy Director General for Operations Management at Rosatom said.

At the moment, the unit is operating in a pilot mode as preparations are underway for a stepwise increase in reactor power to 100%. At each step of the process, the facility will undergo dynamic tests, with shutdowns of core equipment simulated at various power levels. Following pilot operation, the power unit will be stopped for inspection of its equipment, and then put into commercial operation. The commissioning is scheduled for 2021.

The power units based on VVER-1200 are now the best in terms of cost efficiency and safety.

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Is it true that VVER-1200 reactor units are no longer built in Russia and only being exported? This is a question that Rosatom experts are often asked outside Russia.

This is not true.

First of all, there will be two more power units with VVER-1200 reactors at Leningrad NPP. They are included in the Generation Capacity Development Strategy 2035 approved by the Russian government. Starting this June, preparations are underway for the new construction projects.

Besides, two power units based on Generation III+ VVER-TOI reactors (VVER-TOI stands for Water-Cooled Water-Moderated Energy Reactor Universal Optimized Digital) are being built at the Kursk nuclear power plant.

VVER-TOI is an upgraded version of the VVER-1200 reactor. Both types of power units are designed to resist earthquakes, operate in the load following mode, withstand outside impacts, and maintain operation in the absence of external power and water sources.

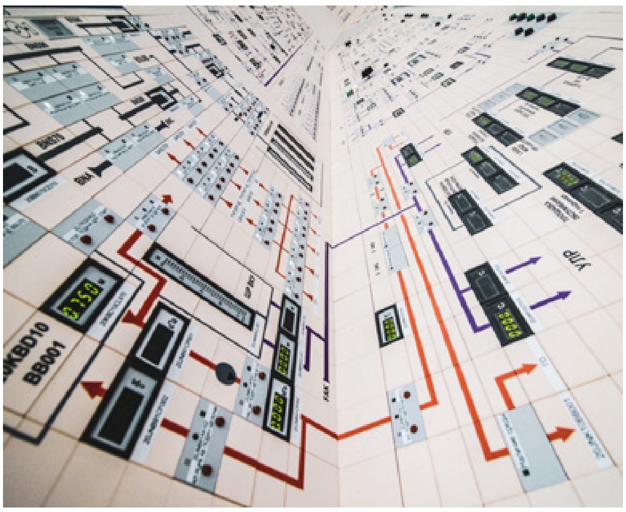
However, a VVER-TOI reactor unit is a little more powerful (each unit will run at 1,225 MW), and its core machinery has a longer service life. These units are expected to take less time to build and require lower construction and operation costs. Besides, they will be capable of using MOX fuel.

The two VVER-TOI power units at Kursk NPP will replace Units 1 and 2 constructed in 1976 and 1979, respectively. The new units will have aggregate power of about 2,510 MW. After commissioning, each of them will generate heat and power for 60 years.

Preparations are underway for another two VVER-TOI units to be built at the Smolensk nuclear power plant. They are also intended to replace the existing capacity.

The reason why VVER-TOI reactors are not exported is very simple — there are no reference facilities yet. Rosatom prefers piloting new technologies in Russia before offering them to customers across the globe.

The Development Strategy also provides for construction of fast BN-1200 reactor at Beloyarsk NPP and a BREST-300 reactor unit in Seversk. Both of them will be crucial for delivery of the closed nuclear fuel cycle program.



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Rosatom's long-term plans specified in the Development Strategy suggest that systematic efforts are made to replace the retiring capacities. It is true that the company is not building many power units in Russia. However, it simply makes no sense to commission many generation capacities as the country's power consumption levels are virtually stagnant. The Russian energy ministry reported that power consumption reached 1,075.2 billion kWh in 2019, thus remaining at the 2018 level.

In these conditions, the top priority is to improve efficiency. According to the energy ministry, nuclear power plants account for 12.3% (30.31 GW) of Russia's rated capacity as at January 1, 2020. At the same time, the share of nuclear power industry in power generation is 19.3% and is expected to grow this year. Compared to other utility scale generators in Russia, nuclear plants demonstrate the highest capacity utilization factor (79.82%), while thermal power plants are the second best with 45.68%.

According to the Development Strategy, the increasing share of nuclear generation will be instrumental in curbing emissions. With this in mind, Rosatom intends to stick to the principles of cost efficiency and environmental friendliness both in and outside Russia.

Vladivostok: Atom Goes Virtual

Rosatom and the Far Eastern Federal University (FEFU) have established the International Research Center for Innovative Nuclear Technology on Russky Island. The center is intended to train experts in nuclear research and application of Rosatom's technologies. It will also be a venue for Rosatom to showcase its technologies and their practical application in research and commercial projects.

Located in the university campus, the new research center is a standalone division of Rosatom's subsidiary Science and Innovation. It is a demonstration hall equipped with projectors, large monitors, computers, VR headsets and joysticks to visualize objects in virtual and augmented reality. The center also has administrative premises, a manager's office, and a server room. The center has a total floor area of about 100 sq m.

The staff is now busy finishing the installation of software products (virtual laboratory classes developed at the National Nuclear Research University), demonstrating

VR capabilities and integrating them into educational programs. The FEFU students majoring in Chemical Technology in Power and Nuclear Engineering have already started taking virtual laboratory classes and mastering new professional skills.

Each lab class follows the same steps: first, students do an experiment, obtain empirical data, and then do calculations. The difference is that students put on VR headsets before they start. This brings them into a virtual laboratory where they see a three-dimensional model of a subcritical fuel assembly (with uranium as fuel and graphite or light water as a moderator), sensors, data readers or recorders, and other necessary equipment. The students can do with the fuel assembly what is required by the task — for example, they can insert an extra neutron source into the assembly and then count the number of neutrons with and without the source. The laboratory also features dedicated software packages for experimental calculations.

It is also planned to equip the research center with the Logos software. FEFU plans to obtain two Logos user licenses. One of them will be an educational license to be used by university students and teachers. The other will be a commercial license intended for research and development projects, including those commissioned by third parties.

In 2021, digital twins are planned to be installed in the research center. Digital twins are virtual replicas of complex facilities, whether industrial or, as in this case, research ones. Among the most likely candidates for digital twins is the Ural Test Facility developed at Rosatom's Institute of Reactor Materials (Zarechnoye, Sverdlovsk Region). The Ural Test Facility will make it possible to carry out virtual tests of materials for resistance to radiation exposure. The facility is less suitable for educational purposes, but will be more helpful in commercial research.

One more function of the research center is to coordinate joint efforts of Rosatom (represented by Science and Innovation) and FEFU in three areas. First, these include Rosatom's research activity in the university, and involvement of FEFU experts into projects delivered by the company. Another area is career development. The parties are considering the possibility of offering students long-term internships in research organizations run by Science and Innovation, with prospects of receiving a master's degree from Rosatom's core universities and returning to the research teams where the students worked as interns.

"The opening of a Rosatom division at FEFU creates new opportunities for groundbreaking projects at the interface of nuclear engineering and digital economy and allows us to jointly train top notch experts. This is an important step that accelerates the development of Russia's Far East and strengthens the country's position as a global leader," FEFU Rector Nikita Anisimov said at the opening ceremony. The

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new R&D center allows for research activities in such areas as small modular reactors, laser technologies, modification of materials, effects of space radiation on material aging, composite materials, hydrogen energy, closed nuclear fuel cycle (Breakthrough Project), etc.

The parties willing to cooperate with the center should contact its Director Anna Bondarenko or Evgeny Papynov, Deputy Director for Research Cooperation, who will provide necessary information on its capabilities and ensure required assistance in organizing research.

The university will promote the center through its representative offices in Asian Pacific countries and contacts in the scientific community.

“FEFU is supposed to become a point of access for showcasing and applying Rosatom’s latest technologies for both educational and research purposes. Researchers and experts both in Russia and abroad already know about our center and are taking interest in its functionality, especially digital twins,” Evgeny Papynov assured.

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From Centrifuges to Batteries and 3D Printers

Rosatom Newsletter continues publishing stories about Russia's nuclear industry celebrating its 75th anniversary this year. Today, you will learn about Urals Electrochemical Plant (UEP), whose main function from the very beginning was uranium enrichment. Nowadays, UEP also manufactures metallic powders, 3D printers, energy storage systems, and automotive catalysts.

UEP is part of Rosatom's nuclear fuel division. The company traces its history back to the birth of Russia's nuclear industry in November 1945 when the Soviet government decided to build an isotope fabrication facility in Sverdlovsk-44 (now Novouralsk), Sverdlovsk Region. The plant was started up in April 1949. On November 11 of the same year, Alexander Churin, the first director of Plant No. 813 (now Urals Electrochemical Plant), signed a quality acceptance certificate for the first 341 grams of uranium hexafluoride. The plant became the country's first facility for commercial separation of uranium isotopes.

Initially, it produced 75% enriched uranium-235 hexafluoride. In 1954, the plant began manufacturing low-enriched uranium for power generation as it was that same year that the world's first nuclear power plant was put in operation Obninsk.

In the first years of its operation, UEP used the gas diffusion technology — uranium-235 was repeatedly sieved through a set of membranes. However, it took much time and, most importantly, energy to create a product with required properties. In 1958, the Scientific and Technical Council of the USSR Ministry of Medium Machine Building took a historic decision to switch from gaseous diffusion to gas centrifugation. After half a year's use of centrifuges, it became evident that they allowed saving a huge amount of electric energy. In 1964, the plant commissioned the world's first commercial cascade of gas centrifuges for separating uranium isotopes.

At present, all enriched uranium producers use the gas centrifugation process developed by the Soviet scientists and engineers.

This cheap technology helped the Soviet Union enter the global market in 1973 and supply enriched uranium to all countries operating nuclear reactors.

How gas centrifuges work

Gaseous uranium hexafluoride is supplied to a rapidly rotating centrifuge. Atomic mass differences make the isotopes travel along different trajectories. The heavier uranium-238 concentrates at the rotor walls, while the lighter uranium-235 at the axle. The waste uranium-238 is removed through special tubes, while the product enriched in uranium-238 goes to the next centrifuge. Since the separation efficiency of a single centrifuge is rather low, tens of thousands of centrifuges are joined into cascades.

In Russia, centrifuges are manufactured at Kovrov Mechanical Plant and Centrotech, both owned by Rosatom's TVEL Fuel Company.

In 1989, the plant ceased the production of weapons-grade uranium. Six years later, it started to process highly enriched uranium into reactor fuel under the HEU-LEU program.

Meanwhile, the centrifugation technology and equipment kept improving. In 1997, UEP commissioned the first ever process unit equipped with seventh-generation gas centrifuges. In 2013, the plant began commercial operation of the industry's first process unit featuring a seven-tier layout and ninth-generation centrifuges.

At present, Rosatom is a global leader in uranium enrichment, holding 36% of the market.

Enrichment is, however, not the only UEP business. The company has established two subsidiaries, Ecoalliance and Centrotech. The former manufactures automotive catalysts, and the latter produces 3D printers, additive manufacturing powders, and energy storage systems (batteries).

The production of catalysts started back in 1994. At Ecoalliance, engineers define the size of catalyst bricks, develop optimal formulas for catalyst slurries, do the coating of the bricks, and insert them into the catalytic converter to test their performance. The company accounts for 30% of Russia's automotive catalyst market.

The battery production at UEP began in 1999. At present, Centrotech manufactures energy storage systems based on lithium-ion batteries for industrial and logistic machinery (forklifts, logistic robots, mining machinery, and airport equipment), electricity consumers using energy storage systems as a reserve power source, and urban electric transport (electric buses and trolleybuses with off-wire capabilities). The company has modernized the in-house logistic transport at UEP and now provides both standard and tailored services to customers outside the Rosatom Group.

Besides, Centrotech is one of Rosatom's development centers for additive manufacturing technology and a leading domestic producer of powders for 3D printing. This May, the company began to manufacture two multi-beam 3D printers designed by Rosatom. Once completed, the devices are expected to be installed at Rosatom's Additive Manufacturing Center in Moscow. Their powder recovery system helps reduce the printing costs by separating two powders by particle size during the printing process and returning the recovered powder back into the printing module. NL

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The Art of Combining Fuels

Responding to the market demand for maximum safety, cost efficiency and eco-friendliness in nuclear, Rosatom is working to develop new types of nuclear fuel, such as accident tolerant and CNFC fuel, and improve fuels for the reactors in operation.

Accident tolerant fuel

Accident tolerant fuel has been a priority area for the nuclear power industry over the past decade. The necessity to create nuclear fuel that would, to the maximum extent possible, help to avoid major accidents was recognized following the investigation into the Fukushima Daiichi accident caused by the shutdown of the cooling system and a steam-zirconium reaction at over 1,200 °C. At the moment, there are two ways to improve the technology, either by reducing the amount of zirconium in a reactor core or by increasing thermal conductivity of fuel by changing its chemical composition.

One should not think that the new fuel alone will prevent accidents. However, it might allow more time for response to rare incidents and accidents, while making the routine reactor operation more cost-efficient and more advantageous in terms of technology.

The engineering efforts are focused on creating both new cladding materials and fuel compositions. Chromium-coated claddings are believed to be the easiest of all possible solutions. Another interesting option, albeit requiring more detailed examination, is the use of silicon carbide composites as fuel claddings. For fuel compositions, researchers consider adding chromium or molybdenum and replacing uranium oxide with uranium silicide or uranium nitride.

Chromium coatings ensure higher corrosion resistance, durability and water permeability, thus, allowing zirconium alloys to remain ductile.

So far, there is no universally preferred coating technique, and many manufacturers are using solutions they find most suitable. For example, Alexei Yakushkin from the Pulsed Processes Department of the Troitsk Institute for Innovation and Fusion Research and Prof. Fyodor Vysikaylo from the Theoretical Physics Department of the Moscow Region State University, write in their article that thin film deposition methods, as well as heavy doping, are effective in terms of technology but very costly. Laser deposition techniques hold more promise, the authors believe. They also note that magnetron sputtering could be useful in coating fuel elements due to high deposition speed and homogeneity of coatings.

The new fuel compositions include doped uranium dioxide (UO2), high-density fuels (e. g. U3Si2) and metallic fuels (e. g. uranium-molybdenum fuel).

Keeping pace with the current trends, Rosatom is developing various combinations of claddings and fuel compositions. Last year, two pilot fuel assemblies were loaded into the MIR research reactor at the Research Institute of Atomic Reactors, with chromium-coated zirconium alloy and chromium-nickel alloy used as cladding materials. Their fuel compositions were based on the conventional uranium dioxide and uranium-molybdenum alloy with an increased density and thermal conductivity. Each fuel assembly consisted of 24 fuel elements with different combinations of materials.

That same year, Rosatom's Bochvar Russian Research Institute of Inorganic Materials created samples of silicon carbide fiber with 10–12% oxygen content. The next step would be to develop a technology to produce zero-oxygen carbide fiber that could be used in nuclear fuel cladding. The bank of samples is already in place, with brazing and sealing technologies being tested. The project will continue in 2021.

The pace of introducing accident tolerant fuel to the market will depend not only on the progress in research and development, but also on the feasibility of using specific accident tolerant fuels in specific nuclear reactors. Experience shows that this may take a few years.

Closed nuclear fuel cycle

Rosatom works systematically to create new types of fuel for the so-called closed nuclear fuel cycle.

The new range of fuels consists of three products — REMIX, MOX and MUPN, each being currently studied and tested.

Closed nuclear fuel cycle (CNFC)

In general terms, the CNFC concept suggests that spent nuclear fuel can be reprocessed and again loaded into the reactor. Some fuel compositions allow using up to 99% of depleted uranium, which lies idle at storage facilities. This helps solving the problem of fresh feedstock for the nuclear industry and cutting down on waste. Another option is to burn highly radioactive elements called minor actinides.

According to the Rosenergoatom (Russian NPP operator, part of Rosatom), 26 MOX fuel assemblies are now used in the BN-800 reactor. Eighteen of them contain pelletized MOX fuel and are the first standard fuel assemblies manufactured at Rosatom's Mining and Chemical Plant and supplied to Rosenergoatom by Rosatom fuel company. They were loaded into the BN-800 reactor at Beloyarsk NPP in late 2019. Another eight fuel assemblies, which contain vibro-packed MOX fuel, have been made at the pilot production line of the Research Institute of Atomic Reactors. The assemblies with pelletized MOX fuel will be irradiated for a year and a half, with the reactor to be refueled thrice during that period. By the time of unloading, these fuel assemblies will have worked for about 465 effective days. **"At the moment, these fuel assemblies are functioning as designed, and have worked for about 310 effective days,"** Rosenergoatom says.

The performance of pelletized MOX fuel has been confirmed by irradiating tens of pilot fuel assemblies in the BN-600 reactor. Almost a quarter of the fuel initially loaded into the BN-800 reactor, which was started up in 2015, consisted of MOX fuel assemblies manufactured at the pilot production lines of the Research Institute of Atomic Reactors and Mayak Production Association. The irradiation of these assemblies confirmed the reliability of pelletized MOX fuel. This allowed BN-800 to run solely on pelletized MOX fuel, which was manufactured at the Mining and Chemical Plant (MCP).

Rosatom has already produced and supplied the first batch of 168 MOX fuel assemblies for refueling the entire reactor core at Beloyarsk NPP. These fuel assemblies will be loaded into the reactor in the first half of 2021.

The transition to MOX fuel is expected to be completed in the second half of 2022. There may be minor shifts in the refueling schedule due to changes in the maintenance timeline.

Just like MOX fuel, REMIX fuel is a mixture of uranium and plutonium oxides but with lower plutonium content (1–3 wt%). Besides, REMIX fuel contains enriched uranium

Plutonium in MOX fuel

The MOX fuel used in Russian fast-neutron reactors is a mixture of plutonium oxides with depleted or natural uranium. The mass fraction of plutonium reaches 15–25 wt% depending on enrichment region and plutonium isotope content. Pelletized MOX fuel assemblies may contain plutonium of various origins:

- Low-level plutonium (extracted by reprocessing spent nuclear fuel from sodium-cooled fast breeder reactors)
- High-level plutonium (extracted by reprocessing spent nuclear fuel from VVER reactors)
- Homogenized plutonium (a mixture of weapons- and fuel-grade plutonium; it is currently out of use as Russia has suspended the agreement on management and disposition of surplus weapons-grade plutonium, known as the Plutonium Management and Disposition Agreement).

The pelletized MOX fuel assemblies now irradiated in BN-800 contain low-level plutonium. In 2021–2022, MOX fuel is planned to use high-level plutonium, which differs from low-level and homogenized plutonium in its isotope content. For instance, it contains more even-A isotopes accumulated during irradiation of nuclear fuel in power reactors (BN, VVER and RBMK).

(ca. 3–4 wt% U-235) instead of depleted one. Unlike MOX fuel, REMIX fuel is loaded into power reactors (VVER or RBMK), not fast breeders. One more difference is that REMIX fuel will be used with TVS-2M fuel assemblies, which house more fuel than previous models and feature longer fuel rods (including those with uranium-gadolinium fuel) and racks, enhanced cell shape, and thinner bottom spacer grids.

Since 2016, three fuel assemblies, each containing six rods with REMIX fuel, have been piloted at Balakovo NPP Unit 3. Each fuel bundle has a total of 312 fuel rods. Their third 18-month irradiation cycle began in 2020. The next step will be the loading of fuel assemblies containing REMIX fuel only.

In August 2020, Rosatom's Investment Committee decided to create a REMIX fuel bundling line at the Mining and Chemical Plant to provide the necessary number of fuel assemblies. The new line will be made by upgrading a pilot fuel fabrication line and adding the equipment for production of fuel elements and assemblies. It will be commissioned by 2021. Once the new production line is tested and the pilot fuel assemblies are unloaded at Balakovo NPP, Rosatom will decide whether to start commercial production of REMIX fuel.

What makes MUPN fuel different from REMIX and MOX fuels is that it is based on nitrides, not oxides (MUPN stands for Mixed Uranium-Plutonium Nitride). The fuel will be used in the BREST-OD-300 reactor as part of the Breakthrough Project. It is also planned to load MUPN fuel into the BN-1200 fast-neutron reactor, which is now at the design stage. The pilot fuel assemblies for the new reactor are now manufactured and tested in the BOR-60 and MIR research

reactors and the BN-600 commercial reactor. More than 20 of them are being irradiated, with fuel burn-up already exceeding 9%. Equipment installation is underway at the fuel fabrication/refabrication unit now built at the Siberian Chemical Plant for the BREST-OD-300 reactor.

When organizing commercial production of REMIX, MOX and MUPN fuels, a crucial problem is proper management of high-level radioactive materials, particularly nuclear fuel that has been irradiated or reused for two or more times.

Enhancements also matter

Rosatom not only develops new fuel for new reactors, but also enhances the existing fuel types for its current customers. In October, the company completed a project set up in 2017 to introduce a modified version of fuel assemblies for VVER-440 reactors at Hungary's Paks NPP. Due to an optimized water-uranium ratio, the new fuel assemblies improve fuel utilization and make reactor operation more cost-efficient.

This July, Rosatom and the Czech energy company ČEZ a. s. signed an agreement to

introduce RK-3+, a new version of nuclear fuel for VVER-440 reactors, at Dukovany NPP. The improvements on the previous version include replacement of ducts with gusseted framework structures, increased distance between fuel rods, and a modified cross-section enrichment profile. These improvements will extend the fuel cycles at Dukovany.

In accordance with the contract between Rosatom and Slovakia's Slovenské elektrárne a. s., a project is underway to develop a new nuclear fuel and a new fuel cycle strategy for the Mochovce and Bohunice nuclear power plants. The new fuel will feature an optimized cross-section enrichment profile (with fuel elements placed depending on the U-235 enrichment level) and fuel pellets made of a different uranium grade. The enhanced fuel is expected to extend the fuel cycle and improve the cost-efficiency of power units. NL

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New Plants, New Staff

Akkuyu NPP is going to be Turkey's first but could not be the last nuclear power plant as construction of two more facilities will be considered next year in accordance with the 2021 Annual Presidential Program. Along with building the Akkuyu NPP, the country is training staff for the national nuclear industry.

The first group of young employees from the radiation safety department of the Akkuyu NPP has completed a training course at the Turkish Energy, Nuclear and Mineral Research Agency (TENMAK) in Ankara. For several days, they studied the basics of radiation protection and dose measurements and were instructed in using measurement devices. The trainees also practiced how to behave in emergency situations. Additionally, they were lectured on the Turkish radiation safety law, procedures for licensing radionuclide sources, and regulations on safe transportation of radioactive materials. All the trainees succeeded in the final exams and were certified to supervise any operations involving the use of radiographic equipment and ionizing radiation sources in Turkey.

"We had a chance to study Turkish laws and regulations on radiation safety. Our instructors were highly experienced people and answered in plain terms any questions we asked during the training course," Okan Yıldız, a dosimetrist, who had been among the trainees, said.

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Not long ago, the young employees of the Akkuyu nuclear power plant arrived in Russia to undergo one month's training as dosimetrists at Rosatom's Technical Academy in Obninsk. After that, Akkuyu Nükleer will send them to Russia's most sophisticated nuclear power plants, Novovoronezh and Leningrad, to do internship and receive hands-on experience in maintaining radiation safety. **"I will be doing internship with my colleagues. Now that we have received Russian university diplomas, I am happy to resume training and acquire new knowledge and skills,"** said Fikri Türkmen from Akkuyu's radiation safety department.

Turkey maintains a rapid pace in building its first nuclear power plant, which will consist of four Russian-designed units with Generation III+ VVER-1200 reactors. Construction of Unit 1 began in 2018. This June, the first concrete was poured for the second unit of the plant. Akkuyu Unit 1 is planned to be commissioned in 2023. The other three units will be put in operation one after another by 2026. The plant will generate 35 billion kilowatt-hours of electricity per annum and meet around 10% of the country's demand for electric power.

At November 10, equipment of major importance for Power Unit 1 — the reactor pressure vessel (RPV) — has been delivered to the Akkuyu NPP site, having covered a distance of 3,000 kilometers. The RPV is large-size equipment, which, at the NPP operation stage, accommodates nuclear fuel, and where a nuclear reaction involving liberation of a high amount of heat takes place under high pressure.

"Construction and installation works at Akkuyu NPP site are progressing at a very good pace. Some key structural components have been mounted in the first power unit — the second tier of the internal containment, the cantilever truss and the supporting truss; the corium collecting and cooling device and the reactor dry shielding have been installed as per design position. The main equipment is delivered to the site according to schedule. The vessel complete with the thrust and support rings has covered a distance of nearly 3,000 kilometers from JSC AEM-Technology branch Atommash in Volgodonsk to the site of Akkuyu nuclear power plant — the first NPP in Turkey. Upon completion of all necessary customs procedures, the reactor pressure vessel will pass the incoming inspection", Sergei Butckikh — First Deputy Chief Executive Officer — Director of the NPP under construction said.

According to the 2021 Presidential Program, Turkey will continue its efforts in growing the share of nuclear in its energy mix. Anadolu Agency reports that the program provides for another two nuclear power projects to be considered next year. Specifically, the plan is to select a construction site and sign an official agreement with the technology vendor for one project, and file an application for the construction license for the other plant.

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From Russia to Bangladesh with Love

Russian nuclear companies continue producing and supplying core equipment for the Rooppur nuclear power plant constructed in Bangladesh. On his visit to one of the companies of Rosatom's mechanical engineering division, the Bangladeshi ambassador praised the scope and quality of the services it provides.

High officials from Bangladesh visited the Petrozavodsk branch of AEM Technologies (part of Rosatom's engineering division Atomenergomash). The delegation was headed by Kamrul Ahsan, Ambassador of Bangladesh to Russia. Other delegates included Subhashish Sardar, Counselor for Nuclear Energy at the Embassy of Bangladesh in Russia and a group of experts from ASE Engineering Company (Rosatom's engineering division) headed by the company's Deputy Director for Local Equipment and Materials Sergei Streltsov and Deputy Director for Equipment Supply Project Sergei Osipenko.

Pavel Marchenko, Director of Petrozavodskmash, told the guests about the company's history, current operations and progress in the production of equipment for the Rooppur nuclear power plant. While taking a tour of the production facility, the visitors learned about nuclear machinery production practices and were shown how nuclear equipment, including that for the Rooppur NPP, was manufactured.

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"The goal of our visit is to view the process of making the equipment for our nuclear power plant. What we see here is sophisticated high-precision machinery in action, so we have no worries about the quality and safety of products manufactured here," Bangladesh Ambassador Kamrul Ahsan said.

"As the general contractor, we appreciate the confidence of our customers from Bangladesh. Customer visits to the manufacturing plants help us demonstrate that all the equipment for the Rooppur NPP is made to high quality standards and right on time," Sergei Osipenko stressed.

Pavel Marchenko noted that fulfilling the order from Bangladesh was both an honor and a great responsibility. **"Today, we have had an opportunity to show our guests not only the process of manufacturing nuclear equipment, but also products for the Rooppur NPP at the final stages of production. Petrozavodskmash is already shipping the first items of this order,"** the plant director said.

The first product shipped was a main circulation pump casing — a safety class 1 product — made at Petrozavodskmash. At a nuclear power plant, the main circulation pump ensures that the coolant flows from the reactor to steam generators. The pump operates under the pressure of about 160 atm and temperature of 300 °C. Each reactor unit needs four spherical casings for the main circulation pumps.

A single spherical casing weighs more than 31 metric tons, measuring 3.5 m in height and over 3 m in width. The finished products are transported by road to the sea port of St. Petersburg to be transshipped and delivered by sea to the port of Mongla, Bangladesh. Upon arrival, they will be loaded onto a riverboat and transported by the Padma River to the pier near the Rooppur construction site.

The production of equipment for Rooppur is also underway at other subsidiaries of Atomenergomash. ZiO-Podolsk has produced and shipped a set of turbine island equipment for Unit 2 of the would-be nuclear power plant. Rooppur will receive the first of three sets of separators and superheaters. They are intended to dry and superheat wet steam coming from the high pressure cylinder of the turbine. Their service life is 50 years.

The company has also shipped two accumulation tanks of the emergency core cooling system (ECCS) and two high-pressure preheaters for Unit 2.

The ECCS tanks are designed to supply a cooling boric acid solution into the reactor core in accidents involving coolant leaks from the primary circuit (loss-of-coolant accidents). High-pressure preheaters belong to the turbine island equipment and are intended for feedwater heating. The total weight of the products shipped approximates 400 tons.

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Atommash, the Volgodonsk-based branch of AEM Technologies, has finished the assembly of steam generators for Rooppur Unit 2.

It took 21 days to mount 11,000 coiled tubes row by row (105 horizontal rows in total) inside each steam generator. The coiled tubing is made from straight tubes, each 10 to 16 meters in length, and placed inside the steam generator, with the tube ends connected to the primary circuit collectors. Afterwards, welders flare and weld the tubing ends.

Steam generators belong to the nuclear island and are safety class 1 products. The next step is to weld the top and bottom plates to the generator vessels. The steam generators will undergo hydraulic tests and a series of quality control procedures, including eddy current tests of the heat exchange tubing.

In mid-October, the reactor vessel and steam generators for Rooppur Unit 1 arrived at the construction site. A special barge carrying the core equipment moored at the newly built river pier. The cargo had been delivered from the port of Mongla under military escort. **"The people will have more confidence in the equipment as it has traveled such a long way, nearly 15,000 kilometers from the famous Russian river Volga to the famous Bangladeshi river Padma,"** Yafes Osman, Minister of Science and Technology of Bangladesh said.

Featuring two Russian-designed VVER-1200 reactors with a total power capacity of 2,400 MW, the Rooppur NPP is constructed 160 km away from Bangladesh's capital Dhaka. The country's first nuclear power plant will be based on the Russian design featuring VVER-1200 reactors. Their service life is 60 years and can be extended by another 20 years. Rooppur Unit 1 is scheduled for commissioning in 2023 followed by the second unit in 2024.

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Egypt as Member of Global Nuclear Club

Egypt's Nuclear Power Plants Authority has joined the World Nuclear Association. This is an essential step for the country in expanding its international nuclear cooperation.

In October 2020, the Nuclear Power Plants Authority (NPPA) of Egypt became a member of the World Nuclear Association. Egypt joined the international organization that shapes the future of nuclear energy.

Amgad Alwakeel, Head of NPPA, said that joining the WNA met Egypt's interests in establishing contacts with international organizations, leveraging their expertise and adopting industry practices. Amgad Alwakeel added that the WNA membership was a reflection of the government's support of the national nuclear program and its commitment to safety and the non-proliferation. The major benefit of the WNA membership is an opportunity to stay in dialog with industry leaders and technology experts from all over the world, make decisions relevant to the global nuclear industry development, exchange ideas and strategic experience, and participate in international forums.

Egypt will be among the leaders in civil nuclear applications in the coming years, Alexander Voronkov, Vice President for Middle East and North Africa at Rosatom, told the Middle East News Agency. He noted that El Dabaa was one of the largest national projects supported by President Abdel Fattah al-Sisi. When delivered, the project will become a driver for the energy industry and power generation in Egypt.

Alexander Voronkov also said that El Dabaa in Egypt employed the most advanced Generation III+ technology meeting international safety standards and IAEA recommendations.

El Dabaa will have a positive effect on the economy of the country and its national power industry, Alexander Voronkov says with confidence, **"Speaking in terms of numbers, according to our calculations, every dollar invested in building a nuclear power plant with Russian technology will generate an average of $2 in revenue for local companies and about $1.50 in taxes and contribute about $4 to the country's GDP."**

The project will improve employment, create new jobs and facilitate nuclear medicine and research. Alexander Voronkov stressed, **"In addition, these projects need highly qualified researchers and engineers. This will stimulate development of education and science and also open up more job opportunities. According to our estimates, one job created during the construction of a nuclear power plant produces more than 10 jobs in related fields."**

Alexander Voronkov explained that Rosatom and Egyptian contractors continued preparations at the construction site for El Dabaa nuclear power plant. He said that Russia and Egypt were cooperating in peaceful uses of nuclear energy and noted that more than 60 students from Egypt studied nuclear engineering, nuclear

physics and other related majors in Russian universities. Voronkov also confirmed that Rosatom would train operators and employees of El Dabaa NPP in accordance with the agreement between the two countries.

Today, Rosatom works in more than 50 countries all over the world. The Russian nuclear corporation is proud of decades-long strategic collaboration with the MENA countries.

"As far back as the 1960s, the first small research reactors in the region with a capacity of up to 5 MW were built using our technologies. It was on the basis of research reactors that the steps of these countries were worked out in the development of a future peaceful atomic program in terms of personnel training, materials science, isotope products for industrial needs, and nuclear medicine. We have trained some of the nuclear specialists from these countries," says Voronkov.

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