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Rosatom to Enter Li-Ion Tech Market

TVEL (part of Rosatom) is expanding its presence in two segments of the lithium-ion market. In March, Angarsk Electrolysis Chemical Plant piloted a lithium hydroxide unit, while RENERA closed the deal to buy a 49% stake in Enertech International, a South Korean manufacturer of electrodes, Li-ion cells and energy storage systems.

Feedstock for batteries

Angarsk Electrolysis Chemical Plant (AECP, TVEL's subsidiary) launched a pilot unit to manufacture battery-grade lithium hydroxide, which is a key component of chemical power sources or, in simpler terms, lithium-ion cells and batteries.

During the pilot operation phase, the unit will be tested in different modes to confirm process parameters and obtain product samples. Based on the results obtained, AECP will develop larger-scale production solutions for a manufacturing facility that will be launched in 2024.

The new production process will generate zero waste and consume less energy, thus contributing to the UN Sustainable Development Goal Responsible Consumption and Production. By contrast, the conventional technology, which provides for lithium feedstock to be treated with calcium hydroxide, yields nearly one metric ton of waste (calcium carbonate) per ton of product,

For reference

Rosatom's TVEL Fuel Company consolidates nuclear fuel producers, uranium conversion and enrichment companies, gas centrifuge manufacturers, and research and development organizations. TVEL supplies nuclear fuel for 75 power reactors in 15 countries, research reactors in nine countries, and Russian nuclear-powered ships.

with some portion of lithium also going to waste. AECP uses an improved technology that needs lithium and water only.

The product will be mostly exported with sales to begin later this year. Cell manufacturers will be key buyers of lithium hydroxide. **"Lithium hydroxide produced at AECP will strengthen TVEL's position in the global lithium market, which is expected to demonstrate a double-digit growth in the coming decade,"** says Mikhail Metelkin, Director of TVEL's Special Chemistry business unit.

Cells for the future

TVEL already assembles energy storage systems at its production facility TsentroTech in Novouralsk. Components for these systems – Li-ion cells – are imported. The deal between RENERA (TVEL's subsidiary and an integrator for energy storage technologies) and Enertech aims to build a plant and set up production of Li-ion cells in Russia by 2024. Its initial capacity will be 0.6 GWh per annum and is planned to reach 2 GWh per annum by 2030.

Battery cells are different in their form. Most often, they are cylindrical just like ordinary AA batteries or, much more seldom, prismatic and enclosed in a rigid plastic or aluminum casing. Another form is a pouch cell, which is a thin flat prism enclosed in a soft aluminum casing. The casing contains electrolyte, cathode and anode sheets, and a separator between them. In order to make a large storage system, cells are connected together in series or in parallel to form modules. The modules are then placed in a casing and connected to controllers and temperature sensors. The process ends with installation of battery management software (BMS) – now an energy storage system is ready for operation.

It takes years to develop a production technology and begin mass production of lithium-ion battery cells, TVEL explains. Since the market grows very fast, buying a company that already possesses the required technology is a more lucrative option.

RENERA plans to sell battery cells and cell modules, as well as complete energy storage systems. The company sees its task in ensuring that the last two products account for most of

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The amount of electric energy accumulated and then released by an energy storage system is measured in Watt-hours (Wh) and derived units. The system's storage capacity is measured in ampere-hours (Ah) – this is the strength of the charging current that a battery can absorb or release at a given voltage over a certain period of time. Capacity is converted to electric energy with the following formula: $E = U \cdot Q$, where E is energy (Wh), U is voltage (V), and Q is electricity charge (Ah).

new orders in its portfolio. The products will be sold both domestically, including inside Rosatom, and internationally.

Enertech with its established customer base will help RENERA enter external markets. **"Joining efforts with a technology partner is a strategic step for the development of Rosatom's business in the energy storage segment. This will increase our production capacity, considerably improve our competencies and technologies in Li-ion batteries, and open access to international markets,"** Natalia Nikipelova assured.

Energy storage systems have two primary applications, green vehicles (electric cars and buses) and the energy industry. In energy applications, storage systems are used as backup sources of energy, in demand management systems, data centers, renewable-energy power stations, power distribution grids, etc.

"Having acquired a share in Enertech, we will establish an end-to-end supply chain – from Li-ion cells to complete energy storage systems – in Russia and enter global markets with world-class products. I am sure that the plant will become a development driver for the domestic production of electric vehicles," says RENERA CEO Emin Askerov.

The global energy storage market is very promising and expected to grow at the fastest pace. According to Bloomberg, installed capacity for the production of energy storage systems amounted to 540 GWh in 2020. The forecast for 2025 is 2 TWh. In 2020, demand was estimated at 126 GWh (Bloomberg data). It might reach 682.7 GWh by 2025 and 2 TWh by 2030.

Akkuyu NPP: Good News Only

March was a month of good news for the Akkuyu project. The Russian bank Sovcombank provided two sustainability-linked loans to finance construction of the Akkuyu plant. It was the first time ever a nuclear plant had obtained sustainable finance directly. On March 10, first concrete was poured at Unit 3.

Sovcombank provided two loans, USD 200 million and USD 100 million, to AKKUYU NUCLEAR to finance and/or refinance construction and installation costs and costs of equipment for the nuclear power plant. The two loans will be disbursed simultaneously for a period of seven years. The loans are sustainability-linked, which means the actual interest rate will depend on whether the borrower (AKKUYU NUCLEAR) will meet its sustainable development commitments.

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AKKUYU NUCLEAR has committed itself to complying with the emission and discharge limits and monitoring the condition of aquatic and terrestrial plants and animals. The company will provide the bank with annual sustainability reports. If AKKUYU NUCLEAR meets its sustainability commitments in full, the interest rate is reduced by the agreed percentage until the next audit.

"We can say with confidence that sustainable finance is economically feasible and advantageous," Ilia Rebrov, Deputy Director General for Economics and Finance at Rosatom, commented on the event.

"We work together with our Turkish partners to make Akkuyu a landmark nuclear project in sustainable development," said Anton Dedusenko, Deputy Chairman of the Board and Managing Director for Sustainable Development and Shareholder Relations at AKKUYU NUCLEAR.

The first concrete pouring at Akkuyu Unit 3 began with the go-ahead given by the presidents of Russia and Turkey. Rosatom's Director General Alexey Likhachev noted that the Akkuyu NPP was an unprecedented project. **"First, Akkuyu is the world's largest nuclear project with four VVER-based large-capacity power units, with three of them constructed at a time. Second, it is the world's only nuclear facility built to the BOO (Build - Own - Operate) model. And third, Akkuyu is the world's only nuclear construction project managed by a woman, Anastasia Zoteeva,"** he explained.

Fatih Dönmez, Minister of Energy and Natural Resources of Turkey, reminded the audience of how important the nuclear power plant was for the country. He said, **"The plant will cover 10% of Turkey's energy needs. It is also a major contribution to environmental protection. The nuclear station is a reliable source of green energy. It is a driver of industrial and economic growth and employment in the region."**

On November 13, 2020, AKKUYU NUCLEAR obtained a construction license for Unit 3 from the Turkish Nuclear Regulatory Authority (NDK). Since then, the site has been prepared for concreting – the construction pit excavated and dewatered, concrete pad and waterproofing laid, rebar and embedments installed. The basemat will

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The Akkuyu Nuclear Power Plant is constructed on Turkey's southern coast in the Mersin Province. The plant will have four power units with VVER-1200 reactors and a total capacity of 4,800 MW. The project is governed by the Russian-Turkish Agreement on Cooperation in Akkuyu NPP Construction and Operation. AKKUYU NUCLEAR was established in Ankara in December 2010.

require laying nearly 17,000 cubic meters of ready-mix concrete. The foundation slab was protected against precipitation with a temporary cover. The concrete laying process is supervised by representatives of four organizations – the concrete batching plant, AKKUYU NUCLEAR, Russian-Turkish company Titan 2 IC Içtaş Inşaat (the main contractor for the Akkuyu NPP construction), and French company Assystem acting as an independent auditor.

Construction work or preparations are now underway at all four units of the plant. At Unit 1, workers have installed a core catcher and a dry containment shell and continue to concrete internal containment walls and external walls of the containment building. Sections for Tier 3 of the internal containment are pre-assembled and prepared for installation. Ahead is installation of the reactor pressure vessel.

At Unit 2, concreting of the annular floor has been completed, the core catcher has been installed in its permanent position. Workers have installed Tier 1 of the containment and are erecting ring walls of the reactor building. The next milestone to be reached in 2021 is to install an RPV structural support in place.

Application documents for a construction license for Unit 4 were submitted to NDK in May 2020 for consideration. The site of Unit 4 is being prepared for groundwork and pit excavation.

The first unit of Akkuyu is scheduled for commissioning in 2023.

One more credit

In April, Akkuyu Nuclear received another stable loan. A subsidiary of Rosatom and bank Otkritie signed an agreement on the provision of a non-revolving credit line for a period of 7 years with a limit of USD 500 million.

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Japan in Fukushima's Shadow

Ten years after the accident at the Fukushima Daiichi nuclear power plant in Japan, nuclear energy remains divisive. However, in the same 10 years it has become clear that meeting the decarbonization goals and facilitating economic growth is impossible without nuclear. Rosatom helps Japan mitigate the accident consequences and develop hydrogen economy.

Who needs nuclear in Japan

According to the IAEA Power Reactor Information System, there were 33 power units listed as operating as at March 2021. In reality, there were only nine units operating at five nuclear power plants: Ōi and Takahama (Kansai Electric Power Company), Genkai and Sendai (Kyūshū Electric Power Company), and Ikata (Shikoku Electric Power Company). Before the Fukushima disaster, Japan had 54 units generating about 30% of electricity. In 2019 – the most recent data available – nuclear accounted for only 7.5% of electricity produced in the country. According to Nippon.com, the units that have obtained permits to resume operation use the pressurized water reactor (PWR) technology. The units that use the boiling water reactor (BWR) technology, including the reactors at Fukushima Daiichi have not been re-launched yet.

The Japanese show mixed feelings about nuclear energy. In a recent NHK's Broadcasting Culture Research Institute survey of 4,800 respondents, 50% believed that the number of nuclear power plants in Japan should be reduced. Another 17%

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was sure that nuclear energy should be abolished, while 29% said the status quo should be maintained. Only 3% thought that the number of reactors should be increased.

Most respondents (85%) were anxious about the possibility of a nuclear accident that might affect the surrounding communities. Only 14% of them answered they were 'not really' or 'not at all' anxious. Eighty-two percent of respondents believed that the decommissioning of the Fukushima Daiichi nuclear power plant was 'not going well' or 'somewhat not going well'.

Interestingly, 75% of respondents said that the overall picture of the nuclear accident was 'not very clear' or 'not clear at all' to them.

Japan has made a commitment to reduce emissions by 26% by 2030 and achieve a net zero target by 2050. It will not be possible to meet the goals without restarting 27 to 30 reactors, Bloomberg quotes Masakazu Toyoda, CEO and Chairman of the Institute of Energy Economics of Japan (IEEJ).

Japan's nuclear community shares the sentiment. **"In order to achieve carbon neutrality and improve energy self-sufficiency, Japan will have to restart the remaining idle nuclear reactors as soon as possible and endeavor to replace older plants and build additional new ones,"** Takashi Imai, Chairman of the Board at the Japan Atomic Industrial Forum, said in his New Year address.

Eiji Hashimoto, Chairman of the Japan Iron and Steel Federation, also called on the government in his New Year address to restart nuclear power plants in support of Japanese steelmakers, according to world-nuclear-news.org.

Japan's Business Federation Keidanren, the country's largest business community, also supports nuclear. **"Furthermore, since it will be difficult to achieve 2050CN [carbon neutrality by 2050] without nuclear power, it is necessary to engage in serious discourse on the use of nuclear power in order to win the people's understanding,"** reads the federation's statement on future energy transformations in the country.

The current government reaffirmed its commitment to increase the share of nuclear to 20–22% by 2030, but new builds and connections remain low.

In late 2020, the government presented its Green Growth Strategy in Line with Carbon Neutrality in 2050. The strategy provides that renewable energy sources will make 50% to 60% of the energy mix by 2050, including hydrogen and ammonia (10%) and thermal and nuclear generation (30–40%). At present, the strategy is being amended. **"It is quite likely the amendments will be compiled into a new strategy. Unless other figures are published, we might see**

the share of nuclear generation in Japan to make 20–22% of the energy mix," Sergei Dyomin, Director at Rosatom Japan, suggested.

Rosatom offers safety

Today, the cooperation between Japan and Rosatom is focused on bringing Fukushima Daiichi to a safe state.

Rosatom engineers have developed a compact neutron detector. It will be used to identify and remove damaged fuel assemblies and internal structures from the containment.

In January 2018, a consortium of Rosatom Group companies won a contract to study age-related changes in the corium. The study was completed in 2019 and followed by another one. In the second study, which is already at its final stage, researchers have made an integrated forecast of age-related changes in the corium during removal, transportation and storage.

Another consortium is about to finish a project to study properties and develop a system to collect dust formed by fragmentation of the lava-like fuel-containing material in the damaged units of the Fukushima Daiichi nuclear power plant.

In addition, TENEX and TEPCO are discussing the possibility of removing radioactive zeolites used to clean up water that cooled the damaged reactors.

Hydrogen economy is another area of cooperation. Rusatom and the Agency for Natural Resources and Energy of Japan's Ministry of Economy, Trade and Industry are conducting a feasibility study for pilot supplies of hydrogen from Russia to Japan.

Debate over waste

Nuclear waste disposal is an example of mixed feelings the Japanese have about nuclear energy.

In early March, Junichiro Koizumi, who was the country's prime minister in 2001–2006, and Naoto Kan, who held the same post in 2010–2011 when the accident happened, held a joint press conference. "It should be noted that they belong to different political factions but they both supported nuclear energy when they were prime ministers. But now, the two oppose nuclear saying that Japan has no place to bury radioactive waste due to seismic risks," noted Sergei Dyomin, Director of Rosatom Japan.

The Japanese government is known to hold private talks on nuclear waste disposal abroad. A few years ago, local media published information about talks with Mongolia. About a month ago, the rumor had it similar talks were held with Canada. Presumably, Japan sees the nuclear waste disposal abroad to be the best option for itself.

In Japan, debates continue whether to build radioactive waste repositories near two villages, Suttsu and Kamoenai, on the island of Hokkaido. On the one hand, geological surveys alone will contribute up to 2 billion yens to the local budget. Subsequent field surveys will bring up to 7 billion yens more. As a comparison, Suttsu collected as little as 244.2 million yens in local taxes in 2019. On the other hand, radiophobia of local residents cannot be ignored.

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The latest area of cooperation discussed by the countries is the Northern Sea Route. It is planned to organize a seminar for Japanese businesses where representatives of the Russian nuclear corporation will be speaking about the advantages of delivering cargo via the Arctic sea artery. The seminar will be held in a combined – online and offline – format to connect Moscow and Tokyo via a video link.

"Rosatom has much to offer in the back end of the nuclear fuel cycle, including decommissioning and post-accident recovery at Fukushima. What is more, hydrogen economy projects and the Northern Sea Route might also give a new impetus to the cooperation in nuclear," Sergei Dyomin concludes.

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Safety in Post-Fukushima Era

Ten years that passed after the Fukushima disaster have reshaped the nuclear energy industry to make it safer, more reliable and technologically advanced. Changes in the industry were multifaceted, ranging from IAEA recommendations to Rosatom's practices.

Glance into the past

On March 11, 2011, a severe earthquake hit Japan and triggered a massive tsunami. The giant wave devastated the eastern coast of Japan leading to many deaths. The tsunami also caused a major nuclear accident at the Fukushima Daiichi nuclear power plant operated by Tokyo Electric Power Company (TEPCO).

The earthquake destroyed power transmission lines leading to the plant; water flooded the basements that housed emergency generators and DC batteries. Water also damaged switchgear of the emergency generators installed on the ground floor. This in turn led to a blackout of Unit 1 and a failure of the reactor core cooling systems, causing nuclear fuel meltdown and, as a result of the zirconium-steam reaction, hydrogen explosions at the first and third units, and then also at the fourth unit, which was in refueling at that time. The explosion at Unit 4 was brought about by hydrogen getting through the ventilation system from Unit 3.

Two employees of the plant drowned after the tsunami hit the turbine island of Unit 4. The nuclear accident itself killed no one. **"The post-accident analysis confirmed**

that radiation released during the accident had no direct impact on human health. However, health and well-being of over 150,000 people living in the neighboring communities were affected in a greater or lesser degree, including some early deaths, due to evacuation on the back of tsunami and radiation, absence of medical care and medicines, stress-related problems, and for other reasons," experts from the Nuclear Energy Agency conclude in their 2021 report entitled 'Fukushima Daiichi Nuclear Power Plant Accident, Ten Years On: Progress, Lessons and Challenges.'

The consequences of the accident were dramatic for the global nuclear industry. The governments of Germany, Belgium and Switzerland voted to phase out nuclear. Growing mistrust of nuclear power added up to economic difficulties caused by the 2008 global financial crisis and made it almost impossible to obtain finance for new construction projects.

With a view of improving reliability and emergencies preparedness of nuclear stations and building up trust to them, the IAEA, national regulators and nuclear industry players have amended construction, operation and decommissioning guidelines and recommendations to account for the lesson learned from Fukushima.

Amendments to IAEA documents

The International Atomic Energy Agency publishes the so-called IAEA Safety Standards for protecting people and the environment. They contain specific safety requirements that, according to the IAEA Statute, are obligatory for the IAEA and apply to its activities.

"The requirements specified in the IAEA Safety Standards become obligatory if regulatory bodies of the IAEA member states undertake a commitment to meet the IAEA Safety Standards or amend national standards accordingly. The IAEA Safety Standards can also guide organizations engaged in design, construction and operation of nuclear facilities in their activities. This pertains to post-Fukushima requirements as well," explains Andrei Kuchumov, First Deputy CEO for Technology Policy at AtomEnergoProekt.

After the Fukushima disaster, the IAEA developed the IAEA Action Plan on Nuclear Safety. Approved by the IAEA Board of Governors and endorsed by the IAEA General Conference in September 2011, the plan set out an action program to strengthen global nuclear safety by capitalizing on the lessons learned from the Fukushima disaster.

In particular, the plan required to 'review and strengthen the IAEA Safety Standards and improve their implementation.' As required by this paragraph, the Commission on Safety Standards and the IAEA Secretariat had to review, and revise as necessary using the existing process in a more efficient manner, the relevant IAEA Safety Standards in a prioritized sequence. The member states

had to utilize the IAEA Safety Standards as broadly and effectively as possible.

The IAEA started revising its general safety requirements (GSR) published as part of the IAEA Safety Standards in 2011. **"The agency revised requirements related to legal and regulatory framework, emergency preparedness and response, and nuclear safety. They also focused on engineering and technical aspects, such as site selection and evaluation, evaluation of natural hazards and their combined effects, management of severe accidents, station blackouts, loss of ultimate heat sink, accumulation of explosive gases, nuclear fuel behavior, and safe storage of spent nuclear fuel,"** Andrei Kuchumov says.

In October 2012, the IAEA made a decision to revise and amend five of its publications (see Changes in IAEA Documents below for details). The new versions were built on additional materials, conclusions made by international experts of the IAEA, and reports made at the 2nd Extraordinary Meeting of Contracting Parties to the Convention on Nuclear Safety in August 2012. A number of national and local reports were also taken into account.

In the first half of 2013, key bodies of the IAEA, including its Secretariat and four committees on nuclear, radiation, transport and waste safety standards, considered draft amendments. The amendments were reviewed by the IAEA member states and, subject to their comments, were approved in November 2014.

Fukushima lessons in Europe

National and regional regulators were amending their standards alongside the IAEA.

Changes in IAEA documents

1. **«Governmental, Legal and Regulatory Framework for Safety (IAEA General Safety Requirements No. GSR Part 1, 2010). The changes pertain to the following areas:**

- Independence of the regulatory body
- Responsibility for safety
- Emergency preparedness and response
- International commitments and international cooperation
- Relations between the regulatory body and officially authorized parties
- Revision and assessment of safety-related information
- Communications and consultations with stakeholders

2. **Safety Assessment for Facilities and Activities (GSR Part 4, 2009). The changes in GSR Part 2 pertain to the following key areas:**

- Safety margins sufficient to withstand external events
- Safety margins sufficient to avoid cliff edge effects
- Safety assessment of several facilities or activities on a single site
- Safety assessment of jointly used nuclear installations
- Human factor in accidents

In 2013, for example, the Western European Nuclear Regulators Association (WENRA) published a report on safety of new NPP designs. The report set out three requirements for independence of the defense-in-depth (DiD) levels as a key to achieving safety goals.

"There shall be independence, to the extent reasonably practicable, between different levels of DiD so that failure of one level of DiD does not impair the defense in depth

Changes in IAEA documents

3. **«Safety of Nuclear Power Plants: Design (SSR-2/1, 2012). The changes in SSR-2/1 pertain to the following key areas:**

- Prevention of severe accidents through design basis improvements
- Prevention of unwanted radiological impact of severe accidents on people and the environment
- Mitigation of severe accident consequences to avoid or minimize radioactive contamination beyond the site borders

4. **Safety of Nuclear Power Plants: Commissioning and Operation (SSR-2/2, 2011). The changes in SSR-2/2 pertain to the following key areas:**

- Regular reviews of safety and best operating practices
- Emergency preparedness
- Accident management
- Fire safety

5. **Site Evaluation for Nuclear Installations (NS-R-3, 2003). The changes in NS-R-3 pertain to the following key areas:**

- Potential combination of events
- Determination of design-basis hazards and related uncertainties for a nuclear installation
- Several installations on a single site
- Hazard monitoring and regular review of site-specific hazards

ensured by the other levels involved in the protection against or mitigation of the event.

The adequacy of the achieved independence shall be justified by an appropriate combination of deterministic and probabilistic safety analysis and engineering judgment. For each postulated initiating event (starting with DiD level 2), the necessary SSCs should be identified and it shall be shown in the safety analysis that the SSCs credited in one level of DiD are adequately independent of SSCs credited in the other levels of DiD.

Appropriate attention shall be paid to the design of I&C, the reactor auxiliary and support systems (e. g. electrical power supply, cooling systems) and other potential cross cutting systems. The design of these systems shall be such as not to unduly compromise the independence of the SSCs they actuate, support or interact with," the report says.

One of the measures adopted in response to the reactor core meltdown at Fukushima provides for the mitigation of meltdown and radiation effects. In this respect, the safety goal for new reactors is to **"reduce potential radioactive releases to the environment from accidents with core melt, also in the long term, by following the qualitative criteria below:**

• Accidents with core melt which would lead to early or large releases have to be practically eliminated;

• For accidents with core melt that have not been practically eliminated, design provisions have to be taken so that only limited protective measures in area and time are needed for the public (no permanent relocation, no need for emergency evacuation outside the immediate vicinity of the plant, limited sheltering, no long term restrictions in food consumption) and that sufficient time is available to implement these measures."

Improvements in Russia

In Russia, the lessons learned from Fukushima were incorporated into the General Safety Requirements for Nuclear Power Plants, a document published by the Russian nuclear watchdog Rostechnadzor.

In particular, the document requires that **"the NPP design should provide for special technical capabilities to manage beyond-design-basis accidents."** They should ensure safety of the plant in case of a failure of operating and safety systems, which remove heat from the reactor and fuel storage to the ultimate heat sink, and a failure of power supply systems, including emergency supply. This is what happened at Fukushima. The document sets out specifically that the nuclear station design should provide for measures to protect technical devices from external impact, as well as impact caused by accidents, including beyond-design-basis accidents. An example is mobile technical devices stored in a safe place.

In addition, organizational measures should be in place to manage beyond-design-basis accidents. The document also provides for measures to decrease exposure of the plant staff, population and environment to radiation.

Another requirement is that the design should have technical capabilities to monitor the condition of reactors and the plant in accidents, including severe accidents, as well as post-accident monitoring capabilities. These capabilities should be sufficient for accident management.

The document published by Rostechnadzor also says that overlapping operation and safety functions should not affect safety or

reliability of a nuclear power plant. Safety systems of each reactor unit at a multi-unit nuclear power plant should be independent from one another.

After the Fukushima disaster, all the nuclear plants in operation, under design or under construction in Russia passed stress tests to identify their weaknesses in extreme external impact situations, with test parameters exceeding design parameters.

In an effort to increase tolerance to Fukushima-type faults (loss of ultimate heat sink and station blackout), stress tests were conducted at nuclear power plants with VVER-440 and VVER-1000 reactors. Based on the test results, their designs were upgraded to include additional equipment enabling beyond-design-basis accident management. This equipment includes air-cooled diesel generators supplying power to accident monitoring and management systems, motorized pumps to supply water to the reactor, and cooling ponds.

Novovoronezh NPP Unit 6 was the first Generation III+ unit put in operation in Russia (2016) and internationally. It features a VVER-1200 reactor and is equipped with the most advanced active and passive safety systems. For example, the reactor

containment is capable of withstanding an 8 magnitude earthquake, flood, a hurricane with the wind speed of up to 56 m/s and an airplane crash. A hydrogen removal system with passive autocatalytic recombiners prevents accumulation of explosive hydrogen. A sprinkler system decreases pressure inside the containment, while a passive heat removal system decreases temperature in the reactor in case of depressurization of the primary circuit. Finally, it has a core catcher which would hold corium and debris inside.

At present, VVER-1200 reactors are Rosatom's flagship design. Russia operates four reactors of this type, two at Novovoronezh and two at Leningrad NPPs. In Belarus, one reactor of the same design is already online; the work is going on to prepare the second reactor for launch. Three units at Akkuyu (Turkey) and two units at Rooppur (Bangladesh) are under construction; documents are being prepared for Paks, Hanhikivi, Tianwan, Xudabao and El Dabaa.

For Reference

AtomEnergoProekt's main activity is engineering surveys, engineering and technical design, project management for the construction of thermal and nuclear power plants, construction control and architectural supervision, technical consultancy in these areas.

"Analysis of the stress tests results for Generation III+ reactors (Novovoronezh II and Kursk II) shows that the available safety systems and beyond-design-basis accident management tools ensure the nuclear power plant will remain safe in the same events that occurred at Fukushima," Andrei Kuchumov assures. Nevertheless, extremely low probability scenarios were considered to ensure a higher level of safety. **"These scenarios provide for large-break loss-of-coolant accidents in addition to the failures observed at Fukushima. Additional management tools for such accidents include air-cooled diesel generators, an alternative intermediate circuit, a cooling tower or a motorized pump, depending on a specific power plant design,"** Andrei Kuchumov explains.

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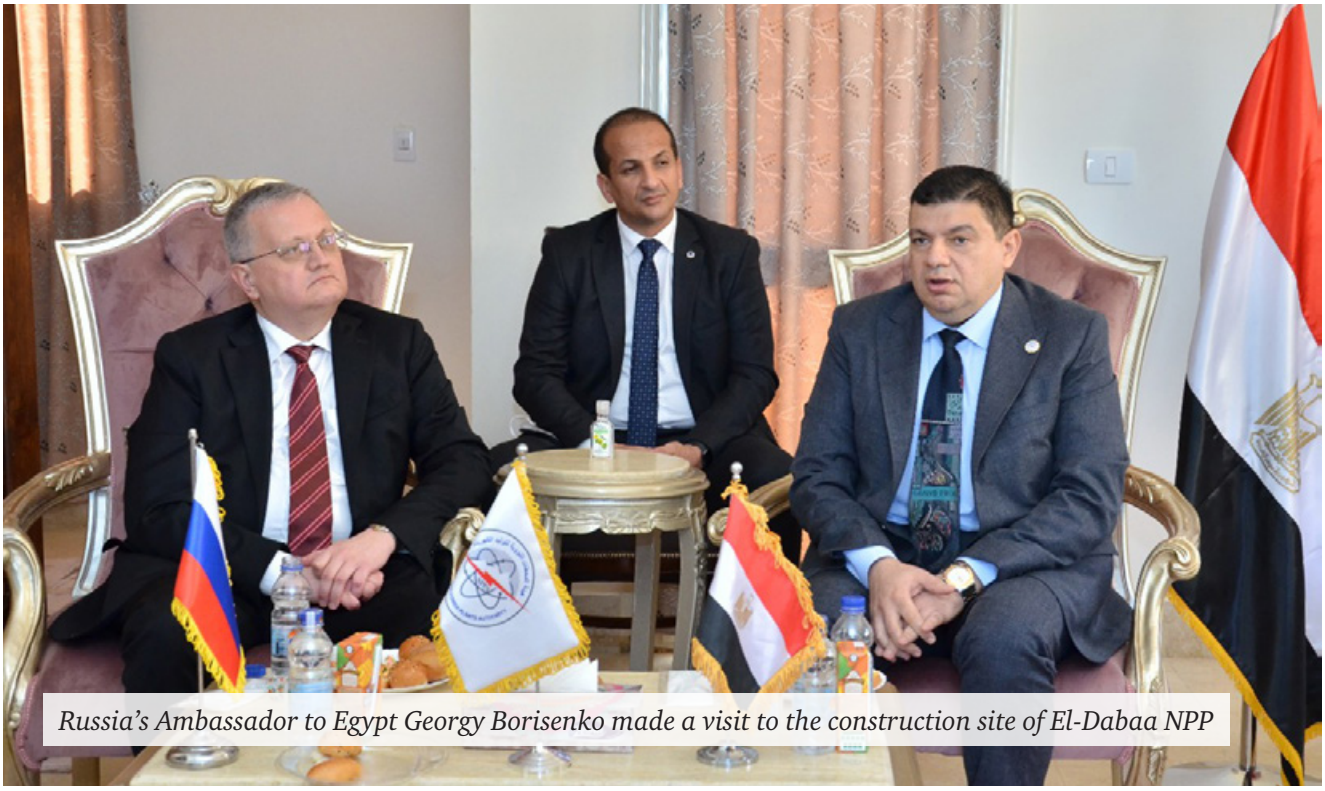

Russia's Ambassador to Egypt Georgy Borisenko made a visit to the construction site of El-Dabaa NPP

Energy for Decades Ahead

El Dabaa is the largest Moscow–Cairo project and one of the most ambitious initiatives undertaken in Egypt today as stated by high-ranking Russian and Egyptian officials during their visit to the construction site.

In March, Russia's Ambassador to Egypt Georgy Borisenko made a visit to the construction site of El-Dabaa NPP together with the Chairman of the Board of Directors of Egypt's Nuclear Power Plants Authority (NPPA) Dr. Amged El-Wakeel and supervisors of the El-Dabaa NPP construction project from Rosatom and NPPA.

The delegation inspected the construction site of future power units and stopped by a meteorological tower and an information stand, where they were updated on the state of the project's implementation and on upcoming construction plans. Afterwards, the delegation surveyed the nuclear power plant's seaport site, which is currently under construction and will be used to transport heavy equipment to the station. There, they attended an award ceremony for Russia's Ambassador to Egypt.

"The El-Dabaa NPP project is the largest joint project between Moscow and Cairo. It not only reinforces our traditional relations, but also brings them to a new level. This project is comparable to that of the Aswan Dam Hydroelectric Project, which was done by our countries during the Soviet period. I am confident that the El-Dabaa NPP project will too be a successful demonstration of the highest professionalism of Russian and Egyptian specialists and will make a significant

contribution to Egypt's social and economic development, providing the country with clean and affordable energy for decades to come," Georgy Borisenko said.

Dr. Amged El-Wakeel called the construction of El-Dabaa NPP one of the most ambitious projects currently being implemented in Egypt. **"In light of the station's importance for the country's future economic development and for its energy sovereignty, it was crucial for us to choose a reliable partner with a proven track record, and we are glad to have found such a partner in Russia, our long-time ally and friend. We are convinced that advanced Russian technologies, coupled with the Egyptian sense of diligence, will be the key to the success of this grandiose project,"** Dr. Amged El-Wakeel stressed.

The visit ended with a tour of the NPP's residential area. As part of this tour, the delegation saw a temporary gym, a standard residential apartment, school and kindergarten buildings, and a local sports complex.

Cooperation between Russia and Egypt goes far beyond the El-Dabaa construction project. For example, Russian and Egyptian engineers have long been working together on research reactors. In March, the Novosibirsk Chemical Concentrates Plant (NCCP, a subsidiary of TVEL) and the Egyptian Atomic Energy Authority (EAEA) signed contract documents to ship another batch of components for low-enriched nuclear fuel to Egypt in 2021.

Shipments are made under a long-term framework contract concluded by NCCP and EAEA in 2020 and providing for the supply of nuclear fuel components for Egypt's second experimental training research reactor (ETRR-2). The components to be supplied include low-enriched uranium and parts made of aluminum alloys and aluminum powder. The first shipments under the contract were delivered in 2020. The Russian party met its obligations in full despite the restrictions caused by the coronavirus pandemic.

"Our Egyptian customer is fully satisfied with the performance of the contract. In 2020, some of the products were delivered ahead of schedule at the customer's request," noted Alexei Zhiganin, NCCP CEO.

The Argentinian-designed ETRR-2 installed in Egypt's Nuclear Research Center in Inshas is used to carry out research in particle physics and material science and fabricate radioisotopes.

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Rosatom's fuel company TVEL is one of the world's largest nuclear fuel manufacturers. It is the sole supplier of nuclear fuel to all Russian nuclear power plants, marine and research reactors. TVEL also supplies fuel to nuclear plants in 15 countries, thus fueling every sixth power reactor in the world.

TVEL is a holding company for a group of businesses specializing in R&D, production of gas centrifuge machines, uranium enrichment, and fabrication of nuclear fuel.

Construction at Full Throttle

Rosatom set about manufacturing a reactor pressure vessel for Akkuyu Unit 3. The management of Rosatom's power engineering division says production of equipment for Turkey's first nuclear power plant is a priority in its order pipeline. Construction of Akkuyu is supervised by independent auditors.

In mid-March, the Volgodonsk-based production facility of AEM Technologies (an AEM subsidiary) began to manufacture a reactor pressure vessel for the third unit of the Akkuyu nuclear power plant.

Workpieces for the RPV passed incoming quality inspection, including measurements with a 3D scanner. Nozzle shells and a flange are now being machined to prepare them for anti-corrosion cladding. Nozzles for the emergency core cooling system are also in the process of production. These operations will be followed by inspection, cladding and welding of the nozzles.

For reference

AtomEnergoMash (AEM) is Rosatom's power engineering division and one of Russia's largest power machinery producers providing comprehensive solutions in design, manufacture and supply of machinery and equipment for the nuclear, thermal, petroleum, shipbuilding and steel-making industries. Its production facilities are located in Russia, Czech Republic, Hungary and others.

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"Equipment for Turkey's first nuclear power plant Akkuyu is a priority in our order pipeline. Every production step is closely monitored by Turkey's Nuclear Regulatory Authority. We have a long and effective track record of international cooperation and are open to dialog on the most complex technological and organizational matters. Equipment for the first unit has been already manufactured and delivered to the construction site," Igor Kotov, CEO of AEM Technologies, pointed out.

The same plant started to manufacture accumulation tanks for the passive core impoundment system to be installed at Akkuyu Unit 1. It belongs to Stage 2 passive safety systems of a nuclear power plant. The system consists of eight tanks with a capacity of 120 cubic meters each. When the nuclear plant is in operation, the tanks contain an aqueous boric acid solution warmed up to 60°C. When pressure in the primary loop decreases below a pre-set level, the solution is injected automatically into the reactor core and cools it down.

OKB Gidropress, another AEM subsidiary, shipped more than 2,000 expanded graphite gaskets for the first unit of the plant in mid-March. The gaskets are designed to seal off joints of the reactor equipment. They will be used in the reactor vessel head.

Construction of the first nuclear power plant in Turkey is supervised by independent auditors, such as the Turkish Nuclear Regulatory Authority (NDK) and French company Assystem. As Kerem Sadiklar, Assystem Country Managing Director for Turkey and Uzbekistan, said in an interview to the Turkish daily Sabah, the VVER-1200 technology used at Akkuyu and four other units already operating in the world was very reliable thanks to multi-level safety systems, a combination of active and passive systems, and their independence from one another.

"Reliability and safety of a complex nuclear facility depend on the quality of equipment, construction and installation. Safe technology, appropriate construction, effective quality control and independent audit will jointly contribute to ensuring safety of the Akkuyu nuclear power plant," Kerem Sadiklar said.

Construction is not the only thing Rosatom does in the region– the Russian nuclear corporation also carries out educational and social projects. On the International Women's Day, AKKUYU NUKLEAR organized a meeting of women working in leading media in Mersin province and women involved in Turkey's first nuclear power plant construction project. Amid the COVID-19 pandemic restrictions, the meeting was held in compliance with epidemiological safety and social distancing rules. During the meeting, employees of AKKUYU NUKLEAR and the representative of the Ministry of Energy and Natural Resources of Turkey spoke about their experiences in the nuclear industry and shared inspiring success stories.

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Natalia Konovalova, Head of AKKUYU NUKLEAR CEO Administration, who has over 20 years of experience in the industry, talked about the role of women in the nuclear power industry: **“In my opinion, women contribute as much as men to the development of the industry. The fact that our CEO is a woman is a vivid example of this. This is her energy and commitment that drive the construction of our unique facility, Akkuyu NPP, the first nuclear power plant in the Republic of Turkey.”**

Emine Tellioğlu, a graduate of National Research Nuclear University MEPhI and participant of the target training program for operating personnel at Akkuyu NPP, said: **“I am very proud to be part of this project, especially because I am a female engineer. I think it’s time to dispel a myth that women have difficulties in mastering technical trades. The common objective of our team, whether you are a woman or a man, is to work hard and contribute to the development of the project. Gender doesn’t matter. The Akkuyu NPP project provides a high level of employment for people living in the region and stimulates development in many spheres: we can build roads, open schools, hospitals and restaurants.”**

As part of the discussion, the speakers talked with journalists and answered their questions. The session ended with taking photos and giving flowers to all women present in the hall on the occasion of International Women’s Day.

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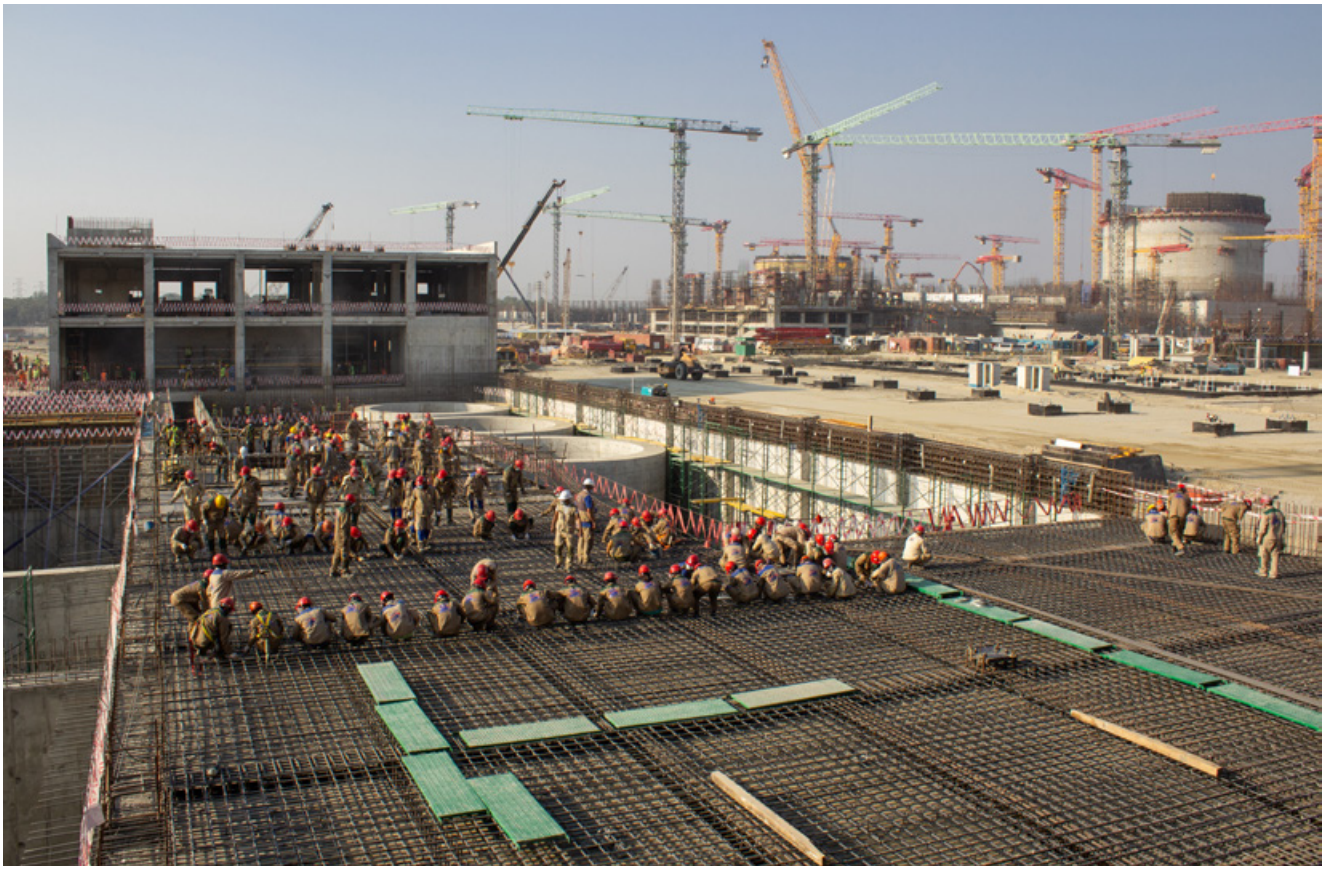

Project Not Affected by Pandemic

Vaccinations started at the nuclear plant construction site in Bangladesh. Over the last few months, there have only been isolated cases of coronavirus among almost 20,000 on-site workers, doctors reported. Deliveries of core equipment for the plant are fully on track.

Rosatom's engineering division has started vaccination of employees against coronavirus infection at overseas construction sites. The first to receive a batch of Sputnik V medication were the employees at the Rooppur NPP construction site. In total, vaccine for 1,000 personnel was delivered.

"ASE takes health support of its employees very seriously as it is an integral part of our safety culture. Considering the importance of the Rooppur NPP construction project, we have become the first international project where Rosatom arranged for the vaccination of employees against COVID-19. This is not just a proof of a socially conscious approach, but also the key to success in implementation of tasks set for the project," said Alexey Deriy, ASE Vice President - Director for Rooppur NPP Construction Project.

Kirill Orlov, medical adviser of the ASE branch in Bangladesh, noted that not a single case of coronavirus infection has been registered among the nearly 3,000 Russian,

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AtomStroyExport (ASE) belongs to Rosatom's engineering division, which is a global leader constructing the most nuclear power plants abroad and having the world's largest portfolio of nuclear construction contracts. The division is active in Europe, Middle East, North Africa, and Asia Pacific. ASE's core activities are project management in the construction of thermal and nuclear power plants, construction and design supervision, and related consultancy services.

Belarusian and Ukrainian project employees. Among almost 16,000 Bangladeshi project workers cases of the disease are very rare – in single digits.

"We have managed to prevent the spread of coronavirus infection thanks to the timely adopted strict sanitary and organizational measures, which in many ways continue to operate today. Moreover, the pandemic forced to reorganize and improve the work of the entire medical service of the project," says Kirill Orlov.

For example, a system has been created in which no person could enter the site without a test or with a positive test result. At the same time, test results are accepted only if there is a QR code on the document, that is, it is possible to check the result in the database of the Directorate General of Health Services (DGHS) of Bangladesh.

Project employees are being tested systematically. Typically, employees are tested every two weeks, but there is a category of employees who are tested weekly.

In addition, Kirill Orlov explained that the project staff have round-the-clock access to medical assistance. There is a central first-aid post with several doctors in the Green City village. There is a diagnostic room with modern equipment, which allows one to perform a number of checkups. **"Bangladeshi employees also make frequent visits to health posts at the NPP site and in the Green City. They are provided with first aid, and, if necessary, a referral to specialized specialists is issued,"** added Kirill Orlov.

Construction on the site is running at pace. In March, two girders for the polar crane were installed at Unit 1. The girders are core steel structures of the crane that will later handle heavy pieces of equipment inside the containment.

"The heavy-weight structures were installed in a well-arranged effort of the subcontractors. Roin World prepared an access way to lift the girders with a crane. Within the shortest time possible, Trest RosSEM installed containment segments to hold rails at Level +38.500 m, while EnergoSpetsMontazh completed the task by laying the girders onto the railway," explains Yuri Koshelev, Deputy CEO for Rooppur Project Management at ASE and Chief Engineer of the project.

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Russian companies continue manufacturing core equipment and machinery for the nuclear power plant in strict compliance with the time schedule.

In late March, Atommash (part of AEM) successfully completed hydraulic tests of the nuclear reactor pressure vessel for the second power unit of the Rooppur NPP. The hydraulic tests were carried out in a three-level underground caisson test bench. To install the reactor pressure vessel in the design position, a supporting ring was first installed in the test bench, and then a VVER-1200 reactor pressure vessel was placed on it. The equipment was moved using an overhead crane with a lifting capacity of 600 tons. The reactor pressure vessel with height of 11 meters was lowered into the caisson with high precision and closed with a process cover. Then workers installed 54 one and a half meter studs and tightened them using a special wrench.

The hydraulic tests of the reactor pressure vessel for Rooppur NPP Unit 2 confirmed the tightness of the base metal and the weld joints of the reactor pressure vessel.

Earlier in March, Atommash completed threading for the main joint studs on the reactor pressure vessel for the second power unit of the Rooppur NPP.

The boring of threaded holes is required to seal and secure the main vessel joint to the upper unit cover, which is one of the defining factors for the safe operation of complex equipment. In 10 days, specialists formed a high-precision metric thread with a diameter of 170 mm on 54 holes.

In March, ZIO-Podolsk (part of AEM) manufactured and shipped equipment for the second power unit of Rooppur NPP. The last set of large-sized products - the fourth MSR SPP-1200 and the second high-pressure heater HPH-K-5 - was shipped to Bangladesh.

The total weight of shipped products amounted to 350 tons. The equipment has a 50-year operating life. The specialists of the Department of Nuclear Engineering Equipment ZIO-Podolsk JSC developed design documentation and provide design support for manufacturing.

Also in March, a set of twelve high-pressure gate valves for turbine island of units 1&2 of Rooppur NPP was manufactured.

The valves with flow area from 80 to 125 mm are made of stainless steel with enhanced corrosion resistance and are intended for operation under heavy load — pressure up to 11 MPa and temperature up to 300 °C. The main function of these pipeline valves is to shutoff the operating medium flow tightly in order to ensure reliable operation of drainage and oil supply systems of nuclear station turbine plant.

The gate valves passed the entire set of factory tests including pneumatic, hydraulic and leak tests. Customer's representatives conducted an acceptance inspection of the equipment.

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