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Big Science Steps Forward

Two complex Big Science projects in Russia have come closer to completion. On February 8, power launch of the PIK research reactor finally took place. Two days later, on February 10, the Russian nuclear watchdog Rostechnadzor issued a construction license for a pilot power unit with a fast neutron reactor BREST-OD-300. Both these projects are unique.

PIK

PIK is a Russian acronym for 'a high flux beam research reactor'. The main function of the PIK reactor, as its name suggests, is to generate high flux neutron beams.

Neutron flux is used across many disciplines, including biology, medicine, material science and archeology, as a multi-purpose means of research. The neutron scattering method helps obtain detailed information about micro and nano systems. The use of cold neutrons, i. e. neutrons having low energies, small-angle scattering techniques and reflectometry enables researchers to take a deeper look into the physics of polymers, nano dispersions and other long disordered structures.

The reactor has a long (and difficult) history. Its construction began in the early 1970s, the 'golden era' of Soviet nuclear technology. By 1986, PIK was almost 70% complete, but after the Chernobyl disaster some of the reactor systems had to be modified, followed

by the installation of additional safety systems and construction of new buildings and structures. It was only February 8, 2021, when the reactor was finally launched.

"It is our joint success — success of a broad academic community, success of Rosatom and, of course, Kurchatov Institute. The result achieved was only made possible thanks to our close and effective cooperation," Mikhail Kovalchuk, President of Kurchatov Institute, where PIK is located, said at the launching ceremony.

PIK is an international project: it was developed with assistance from German researchers, and also a part of its equipment was manufactured in Germany. Kurchatov Institute has already signed an agreement with foreign research teams. **"We signed an agreement with our Belarusian colleagues just two days ago… It provides for their participation in staging experiments using PIK,"** Mikhail Kovalchuk said. According to him, researchers from many different countries express their interest in cooperation.

Russia will continue to build and launch research reactors. **"Another project in this field is carried out by the Joint Institute for Nuclear Research in Dubna and the Research Institute of Atomic Reactors in Dimitrovgrad. It is MBIR, a research facility with a multi-purpose fast neutron reactor. With these two reactors, we will actually meet the total global demand for neutron research. This is important in terms of both fundamental science and development of nuclear power, particularly transition to the fourth generation of nuclear reactors,"** Rosatom Director General Alexey Likhachev reassured.

PIK is expected to be fully commissioned in 2022.

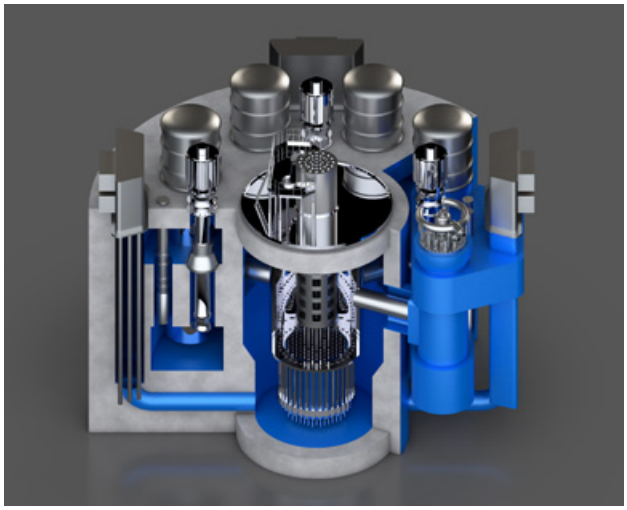
BREST

BREST-OD-300 stands for a 'lead-cooled fast neutron reactor'. Its electrical capacity is 300 MW. The reactor has an integrated arrangement: steam generators are placed inside a multi-layer steel and concrete core barrel.

The use of lead coolant with a relatively high boiling point (around 1,700 °C) and high-density mononitride fuel with a melting temperature of over 2,800 °C, passive residual heat removal, and the possibility of coolant circulation even with pumps off are natural safety systems preventing severe accidents.

With the regulatory license issued, Rosatom is allowed to begin construction of the reactor.

BREST-OD-300 is part of a pilot research center (ODEK), which is currently built in Seversk (Tomsk Region). The center will also have a fuel fabrication and re-fabrication facility and a spent fuel processing facility.



The fabrication/re-fabrication facility is already under construction.

"All the key systems and equipment of the BREST reactor and the fabrication/re-fabrication and spent fuel processing facilities are absolutely unparalleled. The team of the Proryv (Breakthrough) project has to solve non-routine tasks in both construction management and an extensive program of research needed for the technical part of the reactor design," Natalia Nikipelova, President of TVEL (Rosatom fuel company), pointed out.

For eight years now, TVEL and its subsidiary Siberian Chemical Plant (SCP) have taken part in the BREST project. The plant has manufactured over a thousand of pilot fuel assemblies containing mixed uranium plutonium nitride (MUPN) fuel. SCP has tried different designs and structural materials to find an optimal solution for the reactor. The first lot of pilot fuel rods was loaded into the BN-600 reactor of the Beloyarsk NPP in 2014. In 2016, they were taken out and studied thoroughly. The study showed that the rods had maintained its dimensions, with no defects identified in their structural parts. Several more assemblies, each containing 61 fuel rods, were loaded into the reactor in the spring of 2020. Engineering design of fuel rods to be used in commercial operation of the reactor was developed at Bochvar Russian Research Institute of Inorganic Materials (VNIINM).

BREST is scheduled to go critical in 2026. The launch of ODEK will bring the industry forward on its way to closing the nuclear fuel cycle, maximizing the use of energy contained in natural uranium and minimizing radioactive waste.

Xudabao Project Proceeds

Rosatom begins work on building two units at the Xudabao nuclear power plant. According to the general contract, the first concrete will be poured at Unit 3 in October 2021 and Unit 4 in August 2022.

AtomEnergoMash (AEM) will construct Xudabao Units 3 and 4 in the same-name village located on the coast of the Liaoning Province, China. The two units will be built to the Russian VVER-1200 design.

Preparations for the construction began in June 2018 when Russia and China signed a protocol to construct several power units jointly and made a framework agreement to build the Xudabao NPP. As early as March 2019, the parties signed an engineering design contract, which was followed by a general contract for Units 3 and 4 in June of the same year.

According to the contract, Rosatom will design nuclear islands of the both units and

supply key equipment and machinery for them, and also provide design supervision, installation and commissioning services. CNNP Liaoning Nuclear Power Co., Ltd. (CNLNPC) will do installation of the nuclear islands at the both units to the design developed by AtomProekt.

The AES-2006 design has already been tried and tested in Russia — it is used at Leningrad Units 5 and 6 (Leningrad II Units 1 and 2 according to the Power Reactor Information System). However, Xudabao is not an exact replica of Leningrad II and has local specifics arising from the soil type, climate, water supply systems and legal requirements for nuclear, fire and environmental safety.

Operations preceding the first concrete pouring are running ahead of schedule. The foundation pit for the nuclear island buildings was inspected and accepted in early November 2020. Concrete bedding has been laid under the main buildings of the nuclear island for Unit 3. At present, workers are installing lightning protection, waterproofing and reinforcement for the basemat. Installation of reinforcement bars under the reactor building are more than 50% complete.

Earthworks are underway on the site of Unit 4: workers have started digging a pit.

Simultaneously, machines and equipment keep arriving at the site. In early February 2021, the first lot of sealed penetrations was delivered to the site by rail. Sealed penetrations are used to run pipes through walls and slabs of the reactor island without letting water and air in or out.

For reference

AtomStroyExport (ASE) and AtomProekt belong 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. AtomProekt focuses on the design and engineering of thermal and nuclear power plants, technology development, production of machinery and equipment, scientific research, and audit of technical documents related to the use of nuclear energy, nuclear and radiation safety.

Rosatom's fuel company TVEL 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 icebreakers.

AtomEnergoMash (AEM) is Rosatom 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 nuclear, thermal, petroleum, shipbuilding and steel-making industries. Its production facilities are located in Russia, Czech Republic, Hungary and others.

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Also in February, AEM Technologies (part of AEM) began to manufacture a VVER-1200 reactor and steam generators. Workpieces for the RPV shells have passed incoming quality inspection; their machining has begun. It is not a fast process: each 92-ton nozzle shell of the reactor pressure vessel is machined for 15 days. Simultaneously, core shells are prepared for anti-corrosion deposition welding. Steam generator shells are smaller (37 tons) and machined for only six days. After the machining of all 16 shells is finished, the assembly of steam generators will begin.

Although Xudabao has not yet entered a construction phase, TVEL signed a contract with subsidiaries of China National Nuclear Corporation (CNNC) back in November 2019 to supply nuclear fuel for Xudabao Units 3 and 4.

Xudabao is not Rosatom's first project in China. It also takes part in the construction of Units 7 and 8 of the Tianwan nuclear power plant. Four other units built by Rosatom earlier are already in operation. The first two units were commissioned in 2006 and 2007, followed by the third and fourth units in 2017 and 2018, respectively.

Besides, the Research Institute of Atomic Reactors (RIAR, part of Rosatom) made a contract with China's Fangda Carbon New Material Co. to carry out material research. RIAR will conduct in-pile tests and post-irradiation analysis of graphite samples. Test conditions will imitate those that graphite will meet inside a high-temperature gas-cooled (HTGR) pebble-bed reactor HTR-PM600. The test results will be used in a feasibility study for the use of graphite as a structural material of the reactor core.

TVEL will also produce fuel for the first load of the Chinese fast neutron reactor CFR-600 and reloads during the next seven years. Fuel deliveries are scheduled to begin in 2023.

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New Life with Belarusian NPP

Last year Belarus entered the ranks of nuclear power countries. Cooperation between Russia and Belarus has demonstrated that, despite politically motivated protests of a neighboring country, ten years is enough to build a nuclear plant and create a new industry that will benefit the community, environment and national economy.

Step by step

In March 2011, Russia and Belarus signed an agreement to cooperate in the construction of a nuclear power plant. The Belarusian NPP has two units featuring generation III+ VVER-1200 reactors with an electrical capacity of 1,200 MW each. The nuclear plant design is fully compliant with the IAEA recommendations.

The first unit was brought online on November 3, 2020 and has generated 1.5 billion kWh since then (data as at February 26, 2021). The unit is currently in its pilot operation phase. Dynamic tests on the reactor unit, which precede the final commissioning and the start of commercial operation, will begin in the near future. **"Unit 1 will enter commercial operation this spring subject to the completion of the final licensing process and receiving all regulatory permits,"** said Vladimir Gorn, Director of Rosatom Eastern Europe.

Unit 2 has entered a pre-commissioning phase and, according to the schedule, will soon undergo hydrostatic tests and flushing on the primary and secondary loops of the reactor unit. Fuel loading is scheduled for the

third quarter, to be followed by bringing the reactor to power in the fourth quarter.

In March, the loading of dummy fuel assemblies took place at the second unit of the plant. A total of 163 dummy assemblies were loaded into the reactor. Dummies are exact copies of standard fuel assemblies and have the same design and dimensions. They are loaded instead of nuclear fuel containing assemblies in the pre-commissioning phase to run necessary checks on the reactor unit and verify it complies with design specifications and safety requirements.

Safety confirmed

Strong opposition from Lithuania has been dominating the political background of the nuclear construction project. The country considers the plant dangerous, but its position could hardly be described as substantiated. Instead of providing arguments, Lithuania organizes performances like the one in May 2017 when European Commission Vice President for Energy Union Maroš Šefčovič and Lithuanian Minister of Energy Žygimantas Vaičiūnas flew on a hot-air balloon to see the plant under construction implying lack of transparency in the project.

There has never been a need in tricks like that because the Belarus NPP has always been open to international inspections. Nuclear safety experts from the European Nuclear Safety Regulators Group (ENSREG) made a peer review visit to the plant on February 9–10, 2021. They also carried out an off-site technical audit. The team of experts has an extensive expertise in nuclear and is independent in its opinion and conclusions regarding the compliance with safety requirements by both the Belarus NPP operator and Belarus authorities.

Speaking in the European Parliament on February 11, 2021, European Commissioner for Energy Kadri Simson called on all parties to refrain from commenting until the mission presented its report on the plant. But the European lawmakers decided not to wait even for preliminary conclusions and urged to postpone the plant's launch until all the stress test recommendations made by the EU were met.

"It is regrettable to see that some politicians in Europe have become hostages of antinuclear bigotry and have adopted stereotypes in their discourse. It speaks volumes that a European Parliament resolution, which yet again baselessly branded the plant as 'unsafe', was passed before the relevant EU nuclear safety body had completed its on-site evaluation or voiced any conclusions. The verdict appears to have been read and sealed even before the jury was given a chance to convene and deliberate on the matter at hand," Vladimir Gorn concludes.

The fears and concerns of the European parliamentarians did not come true. In early March 2021, ENSREG published its Preliminary Peer Review Report on

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Belarus Stress Test National Action Plan. **"A stress test and the implementation of follow-up actions should not be used to justify or authorize the safe operation of an NPP nor its long-term operation or lifetime extension. Such authorizations have to be in line with the procedures prescribed in national law and under the full responsibility of the national regulatory authorities,"** the authors of the report stressed.

Since the ENSREG peer review was divided into two parts due to the coronavirus pandemic restrictions, the report was also divided into preliminary and final sections. The preliminary section reports on the progress in seven priority issues and related stress tests. It says, **"The preliminary report concludes, based on the information made available and the site visit, that the National Action Plan has addressed all the peer review team's recommendations related to the priority issues and that progress has been made in addressing all recommendations related to the seven priority issues."**

The IAEA monitored the construction closely. In August 2019, a Pre-Operational Safety Review Team (Pre-OSART) mission visited the site. It consisted of 15 experts from Armenia, Belgium, Brazil, the USA and other countries. In late February — early March 2020, an Integrated Nuclear Infrastructure Review (INIR) mission visited the plant. **"We met well-prepared, motivated and competent professionals ready to openly discuss all infrastructure issues. The team saw a clear drive to meet the objectives of the program and deliver benefits to the Belarusian people, such as supporting the country's economic development,"** head of IAEA Expert Team Milko Kovachev said. **"We are grateful to Belarus for the invitation to visit the plant notwithstanding that our missions are voluntary and non-obligatory. Belarus is a showcase country — it invites the IAEA to all inspections,"** Sputnik news agency quoted IAEA Deputy Director General Mikhail Chudakov as commenting on the missions. He pointed out that Belarus Unit 1 surpassed his expectations, **"The unit is very good and reliable. It belongs to Generation 3+, which means that all post-Fukushima requirements are met and measures taken."**

Community transformations

While the Belarus NPP was constructed, the hosting community of Astravets grew considerably. With around 12,000 residents now, the town will be home to twice as many people. In August 2019, Astravets approved a new urban development plan that expects the number of residents to grow to 22,000 by 2025.

Forty-five new residential buildings have been developed in the town. This makes 2,678 apartments with a total floor area of 179,733 square meters. Out of this number, 1,267 apartments were transferred to ASE (Rosatom engineering division, general

contractor of the plant) to accommodate its staff working on the construction site.

Simultaneously, the town was developing its social infrastructure, including two schools for 720 and 520 students, two kindergartens for 190 and 150 children, a library for 10,000 books, a post office, a fitness center with a swimming pool, stores, cafes and restaurants.

In 2019, a new hospital with a capacity for 380 patients was opened in Astravets. Built on recommendations from the IAEA, the hospital is equipped with CT and MRI scanners and an angiographic unit. In 2020, the Astravets Central Clinical Hospital was presented with laboratory equipment for PCR tests, including tests for COVID-19.

In 2014–2020, Rosatom spent around RUB 57 million on charity. In 2021, donations will be given to improve the quality and access to health care, sports events and reforestation of the area around Astravets.

“The local companies that took part in the construction of the first unit gained valuable experience and acquired

competencies in the construction of nuclear power facilities. This experience helps us accelerate some of the construction processes almost twofold while maintaining the quality of work. BelenergoStroy, GrodnoPromstroy, BelelektroMontazhNaladka and PromtekhMontazh demonstrate excellent performance throughout the construction of the Belarus NPP,” Alexei Kononenko, Director for Belarus NPP Construction and Head of ASE Belarus, expresses his satisfaction.

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Winter Generated Demand for Reliability

This winter's power outages in Europe and the USA are living examples of a simple truth: electricity generation should be not just clean, but also reliable.

In January 2021, a surge in power demand and a subsequent split of Europe's grid into two regions brought the continent close to a massive blackout. A month later, generating equipment damaged by the extreme cold caused rotating outages in Texas (USA). Aggressive expansion of renewable generation was the first thing blamed by media and industry experts. Mass media in France, Germany and Sweden called on the power industry not to cause problems for itself.

Europe

A malfunction at a substation in Croatia on January 8, 2021 nearly caused a collapse of the continental Europe synchronous area. It split into two regions, each trying to maintain the grid frequency and power supply separately from the other. Around 200,000 households across Europe and industrial sites in France and Italy were cut off power supply. Power stations in other European countries had to increase power output immediately in order to maintain critical grid parameters.

In France, a subsidiary of Electricité de France (EDF) published a statement asking

retail consumers to save electricity — turn off the light, bring the heating down to 17°C if no one is home, refrain from using washing machines where possible, and switch off routers if no one uses the Internet. The reason behind the statement was an unusually high demand for power amidst lower power output at nuclear power plants. According to EDF, 44 out of 56 reactor units were brought offline in January as maintenance campaigns were postponed due to coronavirus restrictions.

Experts asked by European media pointed out that the pursuit of renewable generation might be a threat to the stability and reliability of power supply. **"It would be bitter if we had many renewable energy sources in the grid. Because if you could not connect and disconnect wind farms at random or if you did not have enough solar energy, the grid would almost surely collapse,"** Peter Zeller, Professor of Electrical Engineering at the University of Applied Sciences Upper Austria, said.

"The problem isn't posed by growing green electricity directly but by shrinking conventional capacity. The upshot is a gap in secure power generation and grid balancing that must be fixed," says Eglantine Kuenle, Chief Modeler at the EWI Institute of Energy Economics at Cologne University.

Sweden also wonders about the consequences arising from the decommissioning of baseload capacity. **"With the retirement of Ringhals 1 and the arrival of what used to be a normal Swedish winter, the country's electricity system is coming away at the seams. The southern regions, which previously housed six more reactors, are now forced to import fossil-based electricity — coal from Poland and Denmark, and Russian gas fired in Germany. What would happen if a real wolf winter came?"** WNA Director General Sama Bilbao y Léon and WNA Public Affairs Manager John C.H. Lindberg write in their article 'Sweden Must Reconsider its Nuclear Policy' published by Dagens Industri.

It is not unlikely that reliability of power supplies in Europe will be put at more risk in the future as Germany, one of the largest power consumers in the region, will continue to phase out nuclear and coal, two main sources of baseload power yet. It becomes increasingly more difficult to replace baseload capacity with renewable energy sources because people protest against building wind farms in their communities. Moreover, it is not just the matter of installed capacity, which is more than enough in Germany. In 2017, installed renewable capacity was 112 GW, while the peak capacity demand was only 80–85 GW. The country will come short of reliable energy sources available at any moment, not only when the weather conditions are favorable.

According to Professor Harald Schwarz of the Brandenburg University of Technology, Germany's energy market development

scenario until 2030 provides for the coal and nuclear generation to decrease from 57.2 GW to 19.1 GW. If this scenario unfolds, the generating capacity available at any time will plunge from 87.2 GW in 2017 to 54.8 GW in 2030, which is less that the peak demand of 80–100 GW expected in 2030. The plans to import power from Poland or France may well fall short if the neighboring countries face increased demand or energy shortage at home.

Media criticize instability of power supplies in Germany increasingly more often. **"The forecast weather conditions mean almost zero solar energy, and the expected high winds may necessitate the shutdown of wind turbines or cause wild feed-in fluctuations. One thing is certain: the grid will be challenged over the coming hours and days. Most likely, the grid will hold up and keep everyone out of the cold and darkness. But the bad news is that in the wintertime the country's power grid has turned into a game of energy roulette and citizens have to rely on "a little luck" every time the weather turns stormy and frigid cold — thanks in large part to disastrous energy policies by the German government,"** German climate and energy blogger Pierre L. Gosselin laments.

USA

The fact that the cold weather and snow were approaching was known no less than two days in advance. On February 9, 2021, CPS Energy, a local provider of electric power and gas, announced that it was preparing for harsh weather conditions and power outages, and the need to respond to customer requests. Just three days later, in February 12, Texas Governor Greg Abbot declared a disaster.

On February 13 and 14, authorities of Texas's capital San Antonio and the Electric Reliability Council of Texas (ERCOT) operating Texas's electrical grid, called on local residents to minimize electric power consumption due to a record high demand for electricity. The reason for the feverish demand was simple: people tried to keep warm, turning electric heaters full on.

In the night of February 15, ERCOT made a decision to start controlled outages. The outages were planned to last a few hours but continued through to February 18. The outages affected two thirds of the state grids. At peaks, the number of blacked-out consumers reached 4.5 million. All that was happening amidst extremely low temperatures and a 3 to 6-inch snow cover, a record high since 1985.

Electrical water pumps made the situation even worse for the Texans: with power out, water supply either stopped or was intermittent. **"As cold weather was approaching, people stocking up on food flooded local stores. No one expected that the things to be prepared for were very much different — long power outages and shortage of water. The stored-up food could neither be warmed nor cooked. People could not even imagine that they would**

need firewood and propane, and many had to urgently decide how to heat up their houses. Since the temperature in Texas almost never goes below zero, houses there are not built to withstand frost or power outages and cool off within a couple of hours when it is -10°C outside," Ekaterina Manor, a postgraduate student at Texas A&M University, shared her impressions. Power supply did not begin to resume until February 18 and returned to normal within the next few days as the temperature was rising. In Texas, discussions are underway about who and how will pay for electricity. Prices soared 16,000% to $9,000 per MW — the maximum allowed in the power market.

What caused the Texas blackout was outage of 46 GW of installed capacity, or about 40% of the state's generating capacity, including coal and gas-fired power stations (61%) and renewable energy sources (39%). According to ERCOT data as at February 15, 8:15 pm, only 800 MW out of 30 GW of installed wind capacity in Texas was online.

Unit 1 of the South Texas Nuclear Generating Station was also disconnected temporarily from the grid. The disconnection was caused by a false trip of the feedwater pump protection relay. In its turn, the relay tripped because there is no turbine hall — the turbines of South Texas 1 are installed in the open, nuclear expert Rod Adams explains in his blog.

It is debated whether the situation in Texas was exacerbated by a small number of grid connections with the neighboring states and whether Texas could receive electricity from them when they also struggled with power demand growth amidst the extremely cold weather. Nevertheless, experts and state authorities share the opinion that the power grid in Texas was not prepared for the cold weather, which happens regularly, although seldom.

Texas faced the same frigid weather ten years ago, and the outcome was not different, with households blacked out and power generating equipment partly damaged. **"Key recommendations from various experts were to require winterizing of power-generating equipment and fuel-delivery infrastructure such as gas pipelines, and to provide for reserve generating capacity that would be needed when demand surged or when some providers went offline. Both moves would impose somewhat higher costs and result in marginally higher electric rates. But they might have averted the much higher costs Texans now face for business disruption, broken pipes, flooding, and spiking electric bills — not to mention human suffering and death,"** Jeffrey Ball from Texasmonthly.com recollects.

Reliability of renewable energy sources are also debated. **"The Texas blackouts prove 'how the Green New Deal would be a deadly deal for the United States of America',"** the Texas governor said. Local media, however, often give a political complexion to those debates, pointing out, for example, that Greg Abbott is a Republican. The governor later

admitted that gas-fired power stations also proved unreliable in low temperatures.

Another topic of the debate is the ability of wind turbines to withstand icing. Renewable energy advocates insist that the problem is not in the design or functionality of wind turbines but in their unfitness or unpreparedness for the operation in cold weather.

Consequences

In Europe, where reaction to the Fukushima Daiichi disaster was more radical than elsewhere, publications began to appear, calling for the development and promotion of nuclear energy as it ensures a reliable supply of electricity and does not produce hazardous emissions. **"We call on the Swedish government to revise its nuclear energy policy and reaffirm what the academic community has been saying for decades: nuclear energy has made Sweden a prosperous country and can give much benefit to every part of our planet,"** WNA representatives said.

Giving a lecture at an event organized by the Swiss Nuclear Forum, Horst-Michael Prasser, Professor of Nuclear Energy Systems at ETH Zurich, said **"nuclear phase-out is riskier than to continue the operation of advanced nuclear stations."** Otherwise, exposure to considerable environmental risks is very likely.

"Switzerland will not be able to replace nuclear entirely with wind and solar. Sooner or later, but the government will have to consider other options as well. Since gas-fired power plants derail the climatic goals and safety of imports is likely to be put under threat, new nuclear stations are becoming a matter of interest," an article about Mr Prasser's lecture reads.

Even if natural disasters last only a few days in several years, their consequences might be felt long thereafter, affecting the everyday life and wellbeing of people and the economy. People begin to realize that reliability of power supply is no less valuable than its environmental safety. Today, thanks to the strictest safety requirements, nuclear power plants are well-protected facilities capable of supplying power in any climatic conditions and harsh environments, whether cold or hot. The examples are plenty: Rosatom-built nuclear power plants operate both in the Far North (Chukotka) and in tropical areas (India, China with another plant is under construction in Bangladesh). NL

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Nuclear Can Help Africa Jumpstart its 4th Industrial Revolution

One-out-of-two people in sub-Saharan Africa do not have access to electricity, while in the next two decades the power demand will increase exponentially. How can nuclear solve many continent problems from energy poverty, low industrialization levels to advances in science, healthcare, and agriculture and what does Rosatom offer its partners from the region? Ryan Collyer, CEO Rosatom Central and Southern Africa, answers the questions.

— Please give a brief outline of the energy picture in central African countries today. What are the main sources of the generation? How dire are the energy shortages?

From the Africa Development Forum's research we know that today 600 million people in sub-Saharan Africa (one-out-of-two people) do not have access to electricity, and any significant change is not forthcoming. Estimations show that only 530 million people (one-out-of-three people) will remain without electricity in 2030. Annual gains in access would need to triple to reach universal access by 2030.

More troubling is the evidence from the World Health Organization survey shows that nearly 600,000 Africans die annually and millions suffer from chronic illnesses caused by air pollution from inefficient and danger-

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ous traditional cooking fuels like wood, charcoal, crop waste, dung, coal and kerosene. It also imposes tremendous direct costs on economies and households and contributes to a wide range of adverse environmental and climate change effects.

Energy shortages exacerbate problems with energy access and its sustainability. These shortages are sometimes so severe that whole areas must be cut off from power for hours every day, translating to colossal setbacks for the economy. The Africa Energy Outlook Report states that around 80% of sub-Saharan African businesses suffered from electricity disruptions, leading to average annual losses of about 8% of sales in 2018.

The reason is an unbalanced energy mix. South Africa, for example, is reliant on coal (69% of total energy supply), but its coal-fired fleet is aging, and new projects will not fully compensate for it. As a result, the country has been plagued for years by so-called 'load sheddings (power cuts) that can cause losses of approximately USD 65 million per day according to some estimates. In 2020 there were about 24 days of these power outages.

In Zambia, the critical source is hydropower (85% of energy mix), subject to the weather's unpredictability. Droughts in recent years have produced electricity shortages estimated at nearly one-third of Zambia's total installed hydroelectric capacity of 2,380 megawatts. In 2019, the Kariba dam's water levels plunged to their lowest level since 1996, falling to 10% of usable storage.

A third example, Rwanda, is plagued by a different problem — limited energy sources. With a small population of 12 million, only 3 million have access to electricity. There are minimal options as to energy sources that are not cash-draining. The country has zero oil and coal reserves, a reserve of methane gas that is still in development and several small-scale projects in renewable energy. In order to achieve 100% electrification by 2030 — a goal set in national strategy Vision 2030 — the country is exploring many options that will can cover all its needs and remain as carbon-free as possible: solar, wind, geothermal, hydro and nuclear.

— What are the energy trends and projections? Is it correct to say that in the coming years, the region will need much more energy than is currently being generated?

As GDP growth and urbanization in Africa escalate, the power demand will increase exponentially. Today the electricity demand in Africa is 700 terawatt-hours (TWh), with the North African economies and South Africa accounting for over 70% of the total. According to the International Energy Agency estimate scenarios, by 2040, the electricity demand will more than double in the Stated Policies Scenario to over 1600 TWh, and may reach 2300 TWh in the Africa Case Scenario.

Currently, renewables show the fastest-growing curve in meeting this demand with the solar potential of 10 TW, the hydro of 350 GW, the wind of 110 GW and the geother-

mal energy sources of 15 GW. Africa also emerges as a significant force in global oil and gas markets with higher demand than that of China and second only to India as the car fleet's size more than doubles. Another forerunner is liquefied petroleum gas (LPG) which is increasingly used for clean cooking. Many countries are also turning to nuclear power to satiate their growing energy needs as it provides a clean and reliable baseline energy source that can fossil-fuel ones.

It is undeniable that Africa needs vast amounts of sustainable energy to transform societies and grow economies, as well as reduce the global carbon footprint. A diverse energy mix is needed that utilizes all available resources, including renewables and nuclear, to ensure climate resilience while still moving towards carbon zero. Generation sources should not be fighting over which source is best for the continent but rather working together to empower the continent and its people through access to affordable and clean energy. In my opinion, the ideal future energy mix for Africa is nuclear, accompanied by renewables — hydro, solar and wind. It is how we can make the world green and at the same time deliver cost-efficient electricity to Africa in a sustainable manner.

— Why is nuclear power the best solution for the region? What are its main advantages?

Nuclear can solve many continent problems, from energy poverty, low industrialization levels to advances in science, healthcare, and agriculture, thus propelling the continent towards African Union's ambitious Agenda 2063 Master plan, which envisions Africa's transformation into the global powerhouse of the future.

Out of all electricity sources, nuclear is one of very few that is currently capable of answering the so-called Energy Trilemma. This trilemma posits that individual countries must balance energy affordability and access, security, and environmental sustainability to thrive and prosper in their respective energy mixes.

Energy is a good that can enable growth; without it, many daily functions are not possible. Electricity allows for industrial development, entrepreneurial activity, and other public goods to be offered, such as health and education. Thus, the government must ensure that the population can access electricity and afford it at large. Energy security allows the country to have an uninterrupted supply of energy, meaning that there should be suitable investment and management of primary energy supply from domestic and external sources. The energy infrastructure should be reliable, and the energy providers can meet current and future demand. Energy sustainability is the indication of its propensity to create damaging pollution. The less a particular source produces greenhouse gas, the better.

The top performers in the Energy Trilemma Index by World Energy Council have a combination of both nuclear and renewable

resources to balance all three dimensions: equity, security and environmental sustainability, thus enabling their prosperity and competitiveness. For example, Switzerland has over 30% nuclear, Sweden roughly 40% nuclear, Finland — 18% and France — over 70% nuclear.

— How does nuclear power affect the country's economy as a whole? What additional benefits does the country gain by developing it?

The example of Egypt clearly shows the impact of nuclear power on the country's economy. More than USD 4 billion (1% of the country's GDP) will be the value added to Egypt's GDP for the construction period Al-Dabaa» nuclear power plant, about USD 570 million will be additional tax revenues to the country's budget for the construction period and 70% of the workers at the construction stage will be the local population of Egypt.

Africa has essentially skipped over the second and third industrial revolutions. The continent is home to 16.3% of humanity but home to less than 1% of the world's billion-dollar companies and only about 4% of global GDP. While Africa certainly cannot afford to miss the 4th industrial revolution, it should also be focusing its attention on beneficiating the vast resources under its soils. Beneficiation and industrialization, however, require vast amounts of reliable, affordable, and clean energy.

The construction of nuclear power plants will provide the much-needed reliable energy to fuel the African Union's ambitious Agenda 2063 Master plan, which envisions Africa's transformation into the future's global powerhouse and power investment into a country and local business. The direct and indirect

economic and socio-economic benefits of NPP construction are immense.

There is a great deal of opportunity for direct localization during the construction phase of an NPP. This includes engineering services and the manufacture of components like pumps, valves, piping, tubing, insulation, reactor pressure vessels, pressurizers, heat exchangers, and moisture separators. Construction will also provide a substantial boost to suppliers of commodities such as concrete and steel.

Such undertaking entails a major boost for local manufacturers and job creation. Not to mention the business opportunities in unrelated industries as a result of the economic spinoffs: necessary infrastructure at the plant site, accommodation for workers, hospitals, schools, agriculture plots as well as the retail sector (due to an influx of workers and higher salaries in the region).

Our experience shows substantial dividends for any country that joins the international nuclear community. We are talking about thousands of new jobs, quantum leaps in R&D, and the creation of entirely new sectors of the economy. According to our estimates, 1 US dollar invested in nuclear power plants under the Rosatom project brings in USD 1.9

to local suppliers, USD 4.3 for the country's GDP, and USD 1.4 to the Treasury in the form of tax revenues.

— In addition to nuclear power, what other radiation technologies could be used in the region's countries?

Nuclear technologies offer many benefits in science, education, healthcare, and agriculture, among others. Nuclear medicine will contribute directly to African people's well-being through early detection and the effective treatment of cancer and other diseases. Nuclear technologies are also used to sterilize medical products, test new pharmaceuticals and medical imaging. The medical imaging with use of nuclear technologies includes Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT), which make it possible to scan human bodies in a much more accurate way to detect any abnormalities and tumors at the very early stage.

Another use is non-destructive testing, for example in pipeline blockages and welds; in measuring the density of material being drilled through; in testing the dynamic characteristics of blast furnaces, in the measurement of combustible volatile matter in coal, and for on-stream analysis of a wide range of minerals and fuels. Mining companies also use radionuclides to locate and quantify mineral deposits, to map geological contours using test wells and mine bores, and to determine the presence of hydrocarbons.

Nuclear technology also assists in food security via Rosatom's food irradiation services that can extend shelf life, reduce spoilage, need for pesticides, additives, toxic chemical treatments, and risk of food-borne diseases. There are already plenty of success stories in many African countries. In Benin, soybean farmers were able to triple their income using the benefits of nuclear irradiation. The implementation of nuclear techniques also made it easier to regulate the amount of nitrogen in the soil, which is necessary for healthy plant growth. Using radiation technologies Tanzania enhanced significantly its crop productivity, for instance, banana yield multiplied through radiation-induced mutation. The technique improved varieties of basic crops such as rice and banana shielded from viruses and insects.

Another example in Tanzania is how its island of Zanzibar became tsetse-free thanks to Sterile Insect Technique (SIT). Since 2014 when the technique was introduced there, studies have shown that the total number of all cattle breeds have increased by roughly 38%. These figures are truly impressive, as most rural households earn more than 20% of their total income from the livestock business. By implementing the same methods Senegal has in four years declared some its regions totally tsetse free. Ethiopia has also chosen this option, which has already helped to bring down the fly population by 90%.

African coastal countries could benefit from our desalination facilities based on both thermal and nuclear power plants.

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— What does Rosatom offer to its partners from the region?

We offer a full range of nuclear solutions, from large-scale PWR reactors to small modular reactors (SMRs) that have a particular appeal to African countries with their easy grid connection, flexibility in terms of placement, multipurpose application, and possible integration with renewables. Moreover, since many of our partners are fairly new to the technology, we provide full support for a customer country's national nuclear energy program at all its stages from a single supplier. Our partner countries include Ethiopia, Ghana, Kenya, Nigeria, Republic of Congo, Rwanda, South Africa, Tanzania, Uganda, and Zambia via various agreements, either framework agreements, memoranda of understanding or intergovernmental agreements. Among most prominent is a contract with Zambia for the construction of a CNST.

As part of our commitment, we also assist our partner countries with training local personnel via a government-sponsored bursary program by the Russian Ministry of Science and Higher Education. Since 2010, hundreds of students from Algeria, Ghana, Egypt, Zambia, Kenya, Nigeria, Tanzania, Uganda, Ethiopia, and South Africa have been receiving nuclear and related education at leading Russian educational institutions.

— What are the activities of the regional center?

Since 2013, the Central and Southern Africa Rosatom Office has been operating from South African economic capital Johannesburg and connecting with 46 African nations. Our main goals are to promote the use of nuclear technologies in the region as well as support the activities of Rosatom divisions in the area; to search for new business opportunities, promote products and services of Russian nuclear enterprises on the global market as well as assist in fostering effective business alliances. One of the Regional Centre's responsibilities is to identify partners and possible suppliers who are capable of providing quality services and products to Rosatom projects, not only in Africa but also in Russia and globally.

We actively involve African youth in our educational and social programs, opening new life horizons for them. We have strong cooperation with universities in all parts of Africa, organizing lectures, distributing educational brochures, participating in career days, and promoting Russian nuclear education online.

We assist in organizing short-term educational projects for schoolchildren and students, called International Smart Holidays. Thanks to them, dozens of children from partner countries, including African, visited Russia and participated in educational, sporting, and artistic activities.

We are encouraging youth to explore nuclear technologies and their benefits on their own. We are now running our 6th annual online video competition for young African adults. It has already inspired hundreds across the continent, and some of these bright minds have now begun their careers in the nuclear industry. NL

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Best Staff for New Plant

In mid-February, Turkish students obtained their degrees in nuclear science and engineering from Russian universities. That was the fourth graduation under the joint Russian-Turkish educational program.

This time, 43 Turkish students graduated from the National Research Nuclear University (MEPhI) with a degree in Design, Operation and Engineering of Nuclear Power Plants. Eighteen of them studied at the Obninsk Institute for Nuclear Power Engineering (a branch of MEPhI), and the rest at the central campus of MEPhI in Moscow. The students pursued three majors: nuclear plant design and maintenance, radiation safety of nuclear plants, and nuclear plant operation and control systems. The graduation ceremony was held online because of the coronavirus pandemic.

Congratulating the graduates, Turkish Ambassador to Russia Mehmet Samsar said that the Akkuyu nuclear power plant was a cornerstone of cooperation between Russia and Turkey. **"Thanks to the top-quality education in nuclear power and engineering, Turkish graduates from the National Research Nuclear University will be able to work at Akkuyu, thus building new bridges of friendship between Turkey and Russia. We are proud of their achievements in education, proud of all our students,"** Mehmet Samsar stressed.

The Turkish graduates shared memories of their education and thanked their teachers

and mentors. **"What I remember best is our internship at Atommash in Volgodonsk. We learned a lot about the core machinery and equipment of nuclear power plants. I saw it with my own eyes how this equipment is manufactured. It was a very useful experience for me,"** Hande Yur Nacar said.

"Courses in our major were very difficult, but we did our best and finally graduated from the university. We are very glad and grateful to our teachers. Thank you very much!" Denizhan Kotan said.

After returning home, the young engineers will receive job offers from Akkuyu Nükleer and soon start working at the construction site of Turkey's first nuclear power plant.

The educational program was initiated by Akkuyu Nükleer in 2011. Tuition of the Turkish students is paid by Russia. Today 107 students from Turkey study at Russian universities. In March 2021, twenty-five more graduates from Bachelor's programs of Turkish universities will be selected to do a Master's course at Peter the Great Saint Petersburg Polytechnic University.

The educational program provides for a total of 600 Turkish students to be trained in Russia, says Sergey Butskikh, First Deputy CEO at Akkuyu Nükleer and director of the under-construction nuclear power plant. Speaking at a media briefing in Mersin on February 24, he placed emphasis on the safety of the plant, **"I have no doubt that our nuclear power plant will be one of the safest in the world. The reactors to be operated at Akkuyu have been installed at five power units. Four of them are in Russia, and one in Belarus. These are the so-called Generation 3+ reactors. Their design life is 60 years and can be extended for 20 more years."**

Sergey Butskikh said the work on the construction site was in full swing and explained that it would become more intensive with every year. **"The work is underway at three units simultaneously, in full accordance with the carefully drafted and approved action plan,"** Sergey Butskikh stressed.

For reference

The National Research Nuclear University (MEPhI) is a leading nuclear research university in Russia and a key supplier of staff for Russian nuclear corporation Rosatom. MEPhI offers its students over 200 programs.

What makes MEPhI different is that it closely integrates education, research and innovation. Senior students, masters and post-graduates take part in research projects on a par with laboratory and department staff. MEPhI is a member of international mega-science collaborations, including ATLAS, ALICE and CMS (CERN), FAIR and XFEL (DESY, Germany), and ITER (France).

AtomEnergoMash (AEM) is Rosatom's mechanical engineering division and a leading Russian manufacturer of generating equipment. The company operates an engineering center staffed with seasoned designers and engineers and two production facilities, AEM Technologies Petrozavodsk (PetrozavodskMash) and AEM Technologies Volgodonsk (AtomMash).

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Russian companies continue to manufacture and ship key machinery and equipment for the nuclear island of the under-construction nuclear power plant. In mid-February, the Petrozavodsk branch of AEM Technologies (part of Rosatom's mechanical engineering division AtomEnergoMash) shipped the first lot of primary coolant pipes for Akkuyu Unit 1.

The set of primary coolant pipes for each unit consists of 20 pipe assemblies made of 34 pipe sections. Each set also includes steel rings to verify the weld schedule and certify welders on the construction site. The total weight of primary coolant pipes for Unit 1 of the Akkuyu NPP exceeds 265 tons.

The pipes are 850 mm in diameter and have a total length of 146 meters. They connect systems and equipment belonging to the plant's

primary loop, such as the reactor, steam generators and primary coolant pumps. When the plant is in operation, coolant circulating in the primary loop has a temperature of up to 330 °C at a pressure of 160 atm. NL

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Rooppur as Symbol of Friendship

Russia cherishes contribution of Bangladeshis to the construction of the country's first nuclear power plant, says Alexander Shevchenko, a top manager of Rosatom's ASE Bangladesh. Russia will also help Bangladesh train staff for the plant. The project is on schedule despite the pandemic — coronavirus is kept in check.

Alexander Shevchenko, Deputy Director of AtomStroyExport (ASE, Rosatom's engineering division) in Bangladesh, said Rosatom appreciated the contribution of Bangladeshis involved in the construction of Rooppur nuclear power plant. **"There are many highly qualified engineers and workers among them,"** he told media.

Shevchenko also reminded that Russia had committed itself to training personnel for the nuclear plant as part of the Rooppur construction project. A special training program was developed jointly with Bangladesh. **"Many employees from Bangladesh do practical training in Russia, including internship at the nuclear power plants in operation. The project also provides for the construction of a training center here, in Rooppur. The center will offer a number of vocational training courses taught by Russian professionals for their Bangladeshi colleagues. They see Bangladeshis as very good, promising and hard-working students capable of solving complex tasks,"** Shevchenko said.

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Speaking about the impact of the coronavirus pandemic on the construction project, the deputy director noted that the situation was under full control and made no great impact on the implementation of the Rooppur project. He explained that all necessary quarantine measures, including mandatory temperature checks at the entrance to the construction site and office buildings, regular disinfection of the premises and mandatory mask wearing, had been taken at the start of the pandemic. These measures are still in force, and so are restrictions on leaving places of residence — the villages of Green City and Bangla Kutir — for Russian employees. In order to prevent the spread of coronavirus at the Rooppur construction site, a response team has been set up to analyze the situation and recommend necessary measures. The team holds meetings three times a week. The response team follows guidelines and instructions of the competent authorities of Bangladesh and Russia. Local management has established procedures for COVID-19 testing and providing medical care when necessary. All newly arriving employees are routinely placed under quarantine.

"I am glad to say that there have been no project-affecting issues caused by the coronavirus thanks to the measures taken and well-organized work of the medical staff from Russia and Bangladesh," Shevchenko said.

He was very positive on the cooperation between the two countries on the Rooppur project. **"I was impressed by the Bangladeshi people and, most importantly, their ability and willingness to work for their home country,"** Alexander Shevchenko noted.

In mid-February, a bilateral delegation spent two days inspecting the progress of the Rooppur construction project. Yafes Osman, Minister of Science and Technology, on behalf of Bangladesh and Alexander Lokshin, First Deputy Director General for operations management at Rosatom and President of ASE engineering company, on behalf of Russia, headed the delegation. It also included representatives of the Ministry of Science and Technology of Bangladesh, Bangladesh Atomic Energy Commission (BAEC), Bangladesh Atomic Energy Regulatory Authority (BAERA) and, on behalf of Russia, ASE Engineering Company, RosEnergoAtom, Russian nuclear regulator RostechNadzor and nuclear industry experts. **"It is very important to keep the project on track while maintaining the highest quality of work,"** Yafes Osman noted.

Also in mid-February, Alexey Deriy was appointed new Vice President of ASE and Director for Rooppur construction project. Previously, he had been in charge of the Kursk NPP construction project in Russia. Introducing Alexey Deriy in his new capacity, Alexander Lokshin pointed out that the experience and competencies he had acquired during the construction of the Kursk nuclear power plant and other nuclear facilities would prove useful in the high-priority construction project in the People's Republic of Bangladesh. Lokshin also thanked Sergey Lastochkin, who had been

in charge of the Rooppur project before, for his work in moving the project forward and a major contribution to the development of the nuclear industry.

Russian expert Nikolai Popov from the Design Engineering Analysis and Optimization Department of AtomEnergoProekt (part of Rosatom) participated in a webinar organized by Rosatom for Bangladesh reporters. Rosatom's expertise in nuclear construction in Russia and abroad enables the Russian nuclear corporation to develop the best solutions for on-site construction and installation operations and deliver nuclear plant projects on time and on budget, he highlighted. Popov explained construction planning, design management and project organization stages and processes needed to complete the construction of a nuclear power plant in a timely and efficient manner.

He reminded that Rosatom's engineering division had designed and built 92 power units, including those under construction, in 14 countries in compliance with the strictest international safety regulations. Its extensive expertise in design and construction of nuclear plants around the world plays a crucial role in meeting the construction schedule for the Rooppur nuclear power plant despite its local geographical and environmental specifics. The Rooppur NPP will have a design life of 60 years.

Construction of Bangladesh's first nuclear power plant is fully on schedule. Leading Russian companies continue to manufacture core machinery and equipment for the nuclear island of the plant. In mid-February, the Volgodonsk-based production facility of AEM Technologies (part of Rosatom's mechanical engineering division AtomEnergoMash) passed another milestone in the production of a reactor pressure vessel (RPV) for Rooppur Unit 2. After radiographic testing, the 320-ton reactor pressure vessel was placed into a gas furnace, and six thermocouples were installed. The PRV was held in the furnace for three days at a temperature ranging from 10 to 650 degrees Celsius. During this period, readings of the thermal detectors were recorded to ensure that the vessel was tempered properly. The heat treatment of the reactor pressure vessel aims to relieve weld stress and obtain the required mechanical properties of the steel. A complete set of the core equipment for Unit 1, including the reactor and four steam generators, was shipped to the customer in 2020.

For reference

AtomStroyExport (ASE) is Rosatom 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 nuclear, thermal, petroleum, shipbuilding and steel-making industries. Its production facilities are located in Russia, Czech Republic, Hungary and others.

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Nuclear Science is Fascinating!

Egypt hosted the first Science Festival organized by Rosatom in association with the Russian Center for Science and Culture. Egyptian students spent a week listening to lectures, taking part in seminars and playing scientific games.

The festival was held in two Egyptian cities, Cairo and Alexandria. The opening ceremony took place at the Russian Center for Science and Culture in Cairo. School and university students and their parents were greeted by Egor Zadeba, one of the guest experts and an assistant professor at the National Research Nuclear University (MEPhI), who told the audience about the educational process in Russian universities and ways of obtaining a degree in nuclear science and engineering in Russia. They were particularly interested when listening to the first Egyptian students graduated from Russia's Tomsk Polytechnic University with degrees in nuclear science. The students shared their experience of studying in Russia, reflected on why they had chosen to specialize in nuclear, and answered questions from the audience.

Aleksey Tevanyan, who is in charge of Rossotrudnichestvo (Russian agency responsible for administering civilian foreign aid and cultural exchange) representative office in Egypt and a director of the Russian Center for Science and Culture in Cairo, said, **"I am sure the Science Festival will be one of the brightest events of the year-long civil coop-**

eration between Russia and Egypt. Not only will it provide Egypt's younger generation with a chance to learn about Russia's advances in science, but also give them information about Russian academic programs for foreign students."

The goal behind organizing the Science Festival Week was to introduce school and university students to the fundamentals and applications of nuclear science, and the role of nuclear technology in a nation's development, as well as to inspire them to consider nuclear engineering as a future profession. **"It is impossible to imagine modern science without achievements of the nuclear industry and new technologies it has produced. In addition to scientific research, nuclear technologies are used in many areas from industry to agriculture and medicine. We are convinced that the El Dabaa NPP project implemented by Rosatom in Egypt will enable the country to step into a new stage of its technological and scientific development, and use the full potential of [available] civil nuclear technologies for the prosperity and sustainable development of Egypt,"** said Alexander Voronkov, Regional Vice President and Director of Rosatom Middle East and North Africa.

During the festival, Russian and Egyptian nuclear researchers and industry experts visited schools in Cairo and Alexandria to make presentations about peaceful uses of nuclear technology. Students learned more about nuclear technology and how it helps overcome challenges faced by humanity, benefit people's lives and achieve the UN Sustainable Development Goals of affordable energy, quality education, economic growth and innovations.

"We are proud of the collaboration between our country and Russia. Our science teach-

ers and students were excited to discuss the new topics presented to them during the Science Festival. We will now be able to integrate the information we learned into our curricula to create an even more well-rounded academic program," said Nashwa Eladl, High School Coordinator at the Princeton International School.

In Cairo, the festival participants visited the Museum of Egyptian Antiquities where they were told about radiocarbon dating, radiation sterilization and data science — these methods are used for the precise dating and preserving of ancient artifacts. In Alexandria, the students visited the Antiquities Museum in the Bibliotheca Alexandrina (Library of Alexandria) to learn how nuclear science helps preserve ancient books and manuscripts.

At the opening and closing ceremonies held in Cairo and Alexandria respectively, the audience watched a documentary on the threats and challenges humanity faces worldwide and the role of science and nuclear technologies in overcoming them. Rosatom also presented another unique documentary called Atoms for Humanity. The project is a series of short and simple stories on how nuclear technology transforms people's lives

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and changes their cities and communities for the better. This documentary showed the breadth of possibilities for using nuclear technology to achieve the UN Sustainable Development Goals, including clean and affordable energy, quality education, economic growth, innovations, and social responsibility.

An accompanying photo exhibition presented peaceful uses of nuclear technology across the world, from clean energy generation at nuclear power plants to nuclear medicine and nuclear-powered icebreakers on the Northern Sea Route in the Arctic.

"It was a very interesting event that offered much information on how to apply to study in Russia, especially at universities offering degrees in nuclear. I hope we will have more events like these in the future," Dina Muhammad, a senior at the Women for Science faculty of Ain Shams University, shared her impressions.

"Such events give us an opportunity to tell the younger generation what nuclear power is, how nuclear power plants work, and what benefits nuclear power and nuclear technologies bring. Knowledge they gain removes phobias and allows us to better understand each other and build trusting relationships", concluded Grigory Sosnin, Vice President of Rosatom's engineering division ASE and El Dabaa Project Director.

El Dabaa NPP is Egypt's major national project. The power plant will have four units with VVER-1200 reactors considered to be the most advanced in the world.

El Dabaa is a long-term project, so its economic effects will materialize gradually, Prof. Ali Al-Idrisi, an expert in economics, said in an interview to Egypt's weekly Akhbar el-Yom. **"The plant's service life is 60 years; as soon as it is brought online, the country will begin benefiting from this source of energy in addition to other sources. The technology used at El Dabaa guarantees the stability of power supplies,"** the expert explained. NL

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