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Double Concrete

In late July, first concrete was poured at two nuclear power plants built by Rosatom abroad. On July 20, construction was officially kicked off at El Dabaa Unit 1 in Egypt. A day later, first concrete was poured for the foundation of Akkuyu Unit 4 in Turkey.

Egypt

El Dabaa is the first nuclear power plant in Egypt and the first one to be built in Africa in the 21st century. It is named after a neighboring town lying on the Mediterranean coast in the Matrouh Governorate.

The nuclear power plant will have four 1,200 MW reactor units. All of them will be built to the Russian Generation III+ VVER-1200 design. This design has many references with four reactors of the same type operating in Russia, another one in Belarus, and 11 more under construction. Leningrad NPP in Russia serves as a reference plant for the Egyptian nuclear station.

Alexey Likhachev, Director General of Rosatom, and Mohamed Shaker, Minister of Electricity and Renewable Energy of Egypt, gave a kick-off to the construction of El Dabaa. The construction permit was issued by the local regulator, Egyptian Nuclear and Radiological Regulatory Authority, in late June this year. **“The start of construction works at the first unit of El Dabaa NPP**

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means Egypt has joined the global nuclear club. This will be the largest Russian-Egyptian project since the construction of the Aswan High Dam. Nuclear industry has been a dream of the Egyptian people for more than half a century, so it is an honor for Rosatom to make this dream come true," Alexey Likhachev said at the ceremony.

Amged El-Wakeel, Chairman of the Nuclear Power Plants Authority (NPPA) of Egypt, noted: **"This day would not have come if not for the decision of President of the Arab Republic of Egypt Abdel Fattah al-Sisi to give a green light to the Egyptian nuclear project. All government authorities spare no effort to achieve our common goal as they understand that the Egyptian nuclear program is part of the overarching national development strategy."**

The package of contracts for the construction of El Dabaa was signed in December 2017. They provide that Rosatom will not only build the power plant but also supply nuclear fuel for it throughout the station's service life and assist the Egyptian party in staff training, operation and maintenance of the station for the first ten years after commissioning. Russia will also build a storage facility for spent nuclear fuel and supply dedicated storage casks.

Starting from September 2021, the Russian nuclear corporation has been fulfilling its contract obligations related to staff training. Several hundreds Egyptian students are already doing a training course at the Saint Petersburg branch of Rosatom's Technical Academy. It is planned that about 1,700 employees will complete their studies by December 2028. They will also undergo practical training on a simulator installed at the new power units of the Leningrad nuclear power plant.

Production of equipment for El Dabaa has started in Russia. In June 2022, workers proceeded with the manufacturing of workpieces that will be turned into a reactor pressure vessel. **"We are sure that El Dabaa nuclear power plant will bring new power technologies to Egypt and contribute to the well-being and prosperity of the people of Egypt in the decades to come,"** Amged El-Wakeel said when the production started.

A contribution to prosperity has already been made as Egyptian companies received orders and local employees began to work on the construction site. **"We expect that the local content in the construction project will exceed 25%. During the construction phase, of course, most work will be done by Egyptian companies. In other words, local content in general construction works will be notably above 50%,"** Alexey Likhachev said on the sidelines of the AtomSkills contest in early August this year.

Turkey

In the Turkish town of Büyükeceli, first concrete was poured for the fourth — and last — reactor of the Akkuyu nuclear power plant. The construction permit for Unit 4 was

issued by the Turkish Nuclear Regulatory Authority in October 2021.

The concreting was preceded by extensive preparations, including pit excavation, dewatering, laying of a concrete pad and waterproofing, and installation of rebar and embedments. With the concrete layer to reach 2.6 meters high, the workers will have to lay 17,000 cu m of concrete.

For Rosatom, Akkuyu is a flagship construction site overseas. **"We all see a tremendous amount of work done on the NPP construction site. I can say with certainty that efficient cooperation between the companies of our countries, interest from Turkish businesses, and a smooth supply chain make our project a textbook example of collaboration between Russia and Turkey,"** Alexey Likhachev said. The backlog of orders placed with local Akkuyu suppliers has exceeded USD 3 billion. More than 25,000 people are busy working on the construction site, and about 80% of them are Turkish nationals. According to the Republic of Turkey Social Security Institution (SGK), the Akkuyu NPP is the largest employer in Mersin Province.

After all the four power units of the Akkuyu NPP are brought online, the plant will meet around 10% of the country's demand for electric power. The nuclear power plant will prevent 35 million tons of greenhouse emissions per year, or 2.1 billion tons over its 60-year design life.

Batteries for Belarus

Rosatom develops its battery production business and has entered export markets. With the first export shipment made, Li-ion batteries were supplied to BKM Holding in Belarus. The Russian nuclear corporation continues working to expand its partnerships with Belarusian companies.

Trolleybus as a birthday present

RENERA (part of Rosatom's nuclear fuel division TVEL) is engaged in the production and distribution of energy storage systems. The company produces Li-NMC batteries for electric vehicles. As the name suggests, their cathodes are made of nickel, manganese, cobalt and lithium oxide alloys, making the batteries less prone to temperature changes and increasing their nominal capacity. Thanks to a built-in thermostatic system, RENERA batteries have an extended operating temperature range (–35 °C to +40 °C). Their affordable price is another advantage.

In March 2022, RENERA signed a contract to supply batteries for trolleybuses produced by BKM Holding. It is a Belarusian manufacturer of electric public transport vehicles (electric buses, trolleybuses and trams) and charging infrastructure. Established over 50 years ago, the company runs a research and development program and develops experimental solutions.

RENERA batteries made it possible for BKM Holding to fulfill a contract with the Saint Petersburg (Russia) electric transport operator Gorelectrotrans. The contract was signed a few weeks before the companies agreed on the shipment of batteries and provides for the supply of 97 Olgerd 32100D trolleybuses. The first trolleybus was delivered to Gorelectrotrans on May 27, the birthday of Saint Petersburg.

"Our partnership with RENERA in using their batteries will make operation and maintenance of our vehicles extremely efficient," says BKM Holding CEO Oleg Bytsko.

But why do trolleybuses need batteries if electricity is fed through contact wires? Autonomous mobility is needed to drive roads that have no trolley grid. Thanks to RENERA batteries, trolleybuses can run up to 45 kilometers without external power supply. **"Advanced energy storage systems will help municipal authorities organize new transport routes and make public transport in Saint Petersburg safer and more convenient,"** RENERA CEO Alexander Kamashev explains.

Exploring new opportunities

This July, RENERA made another step in strengthening its ties with Belarus. The company top managers had a meeting with representatives of the Ministry of Industry and the National Academy of Sciences (NAS) of Belarus.

First Deputy Minister of Industry Alexander Ogorodnikov noted that large mechanical engineering companies in Belarus were interested in purchasing Li-ion traction batteries. Moreover, the parties are ready to join their efforts in the development of Russian-Belarusian batteries for electric public transport vehicles and discuss a possibility of organizing local production of energy storage systems in Belarus.

At a meeting with Vladimir Gusakov, Chairman of the NAS Presidium, RENERA CEO Alexander Kamashev expressed interest in the solutions developed by Belarusian researchers in such fields as graphite materials, sodium-ion batteries, battery disposal, heat removal, and electromagnetic radiation protection.

Belarus puts emphasis on the development of electric public transport. Last April, the country adopted the Comprehensive Electric Public Transport Development Program for 2021–2025. The program mentions the fact that the Belarusian EV market is still taking shape, and demand is met with imports. Demand in the domestic market of public EVs is estimated at 2,500 trolleybuses and electric buses in the next few years.

As international experience shows, the most developed segments of the global EV market are urban electric buses (33% of total bus sales) and two-wheel electric scooters and bikes (30% of the market for these vehicle types). It is expected that e-buses will make 67% of the total bus market by 2030 while the share of two-wheel electric vehicles will grow to 47%.

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Rosatom regards energy storage systems as one of its key business segments. With this in mind, the Russian nuclear corporation plans to construct a production facility for Li-ion cells and batteries in the Kaliningrad region. The facility is designed to produce 4 GWh of storage capacity per year, with the possibility of increasing annual output to 14 GWh. The construction is scheduled to begin in 2025.

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RENERA supplied six electric sightseeing cars equipped with Li-ion traction batteries to a theme park in Moscow regoin. The 26 KWh Li-ion battery produced by RENERA enables a maximum travel range of 100 kilometers. The battery can be charged using a standard 220V outlet. The charging process takes 6 to 10 hours. Since electric vehicles produce no emissions and run almost noiselessly, tourists can enjoy the signing of birds and rustling of leaves in the park.

Art of Construction

We talked about Rosatom's division focused on the international promotion of Russian nuclear technologies (Rusatom Overseas, or RAOS) with its President Evgeny Pakermanov. He spoke about Russian nuclear non-power exports, small nuclear reactors RITM-200 and Shelf-M and hydrogen economy.

— Mr. Pakermanov, does RAOS have a distinctive description like other Rosatom divisions? For example, AtomStroyExport is an engineering division, RosEnergoAtom is an electric power division, and so on…

— According to the Rosatom organizational chart, our division is called 'Overseas.' Initially, in 2015, the company was established as a contracting agent for the construction of large nuclear power plants overseas, hence its name. Some time later, we launched another major business line dealing with nuclear science and technology centers (NSTC). In 2017, we signed an agreement to construct such a center in Bolivia. Later, RAOS was tasked with integrating Rosatom's solutions and services in the field of small nuclear power plants and the hydrogen economy. Since the new business lines necessitated changes in the company's structure, we gained control over the State Specialized Design Institute (GSPI), another Rosatom company. GSPI specializes in the

provision of design and construction services for the contracted projects, including the Bolivian NSTC and a pilot small modular reactor construction project in Russia's Yakutia.

Today, our business is diversified across many segments, so our corporate structure looks more like that of a holding company. This is what makes us different: Rosatom's other divisions are usually built around a single core product or business line. But RAOS has found its own way.

— What business lines does RAOS concentrate on at present?

— Over the years, our company has gradually transformed from a contracting agent for large NPPs abroad to a rapidly growing operating company. In addition to contracting, RAOS has acquired engineering design competencies through GSPI and is now delivering a number of large-scale EPC projects in the power, healthcare, transport infrastructure and other sectors. Many of those projects are of priority importance for the Russian federal and regional development programs. At some point we came to an understanding that it was time to change the strategy and structure of RAOS and strike the right balance in assigning responsibilities and human resources.

— Did those processes drive the establishment of the Rusatom Energy Projects (REP)?

— Yes, they did. Since the focus of RAOS activities shifted to new business lines over the last few years, this also affected the engagement of employees. While almost 100% of our staff was initially engaged in contracting, this share decreased to as little as 20% as at the end of the last year. It was only natural to spin off the department that specialized in selling big NPPs. No doubt that they will always remain in the focus of Rosatom's attention as its core business line. We are glad to see that the Rusatom Energy Projects, is making bold steps in promoting Rosatom's nuclear power solutions.

— How did Rusatom Overseas change afterwards?

— Our business underwent massive restructuring which made us realize that the time came to formulate a new corporate mission statement that would reflect the current environment and objectives pursued by RAOS. Truth be told, it was not an easy task because our activities comprise many products and business lines. It was like 'seizing the unseizable" with a single statement, but we succeeded after numerous attempts. Our new mission reads as follows, "By unlocking technology potential, teaming up the best and changing markets, RAOS creates new affordable solutions — from design to delivery — for the world and the future."

— Could you please explain what the company's business is after the restructuring?

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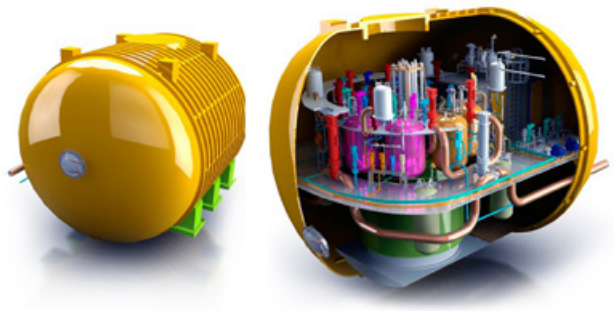
— We continue our pilot projects to build small nuclear power plants in Russia, promote hydrogen economy, and develop RIVER-branded non-power solutions. Nuclear science and technology centers belong here, too. Another major area of focus is the development of strategic partnership with TransMashHolding (TMH). Together with TMH, we intend to enter the market with new products and services in power and transport engineering, logistics, electrical engineering and digital technologies. Earlier this year, RAOS acquired a 25.01% stake in TMH Energy Solutions, a manufacturer of railway propulsion systems. As you see, RAOS has many projects, and all of them are of priority for Russia because they contribute to the environmental agenda and secure our technological leadership in the energy and hi-tech sectors.

— Could you please update us on all the key projects RAOS works on as of August 10, 2022? Please highlight the most significant events.

— Completion of the first facilities at the world's highest-situated nuclear research and technology center is definitely this year's highlight event for us. The center is built in Bolivia at 4,000 meters above the sea level. On August 5, the ceremony was held to put in operation a radiopharmaceuticals production facility and a multi-purpose irradiation facility. IAEA experts admit the two facilities are among the best examples of nuclear technology application in Latin America. The center is unique and is one of the largest projects delivered by Russia in the region. It opens up new export opportunities for Russian nuclear technologies. The Bolivian center for nuclear research and technology will serve as an important reference for Rosatom's advanced solutions, which we promote under the RIVER brand. Another important project is the construction of an onshore small nuclear power plant with a RITM-200N reactor in Yakutia (Russia). The construction site has been selected, and the work is ongoing to design the plant. Two years of engineering surveys are coming to an end — application documents for the site license received a positive opinion from environmental experts, and erection of a construction camp began.

One more project that is important for the development of Russia's Arctic regions — construction of a small nuclear power plant with a Shelf-M reactor — is gradually gaining momentum. We are considering suitable sites at the moment.



Construction of a new nuclear medicine department at the Dmitry Rogachev Center — one of the most critical healthcare projects in Russia — also continues on schedule.

Active work is also going on in hydrogen technology. We have signed more than a dozen agreements and are making preparations to launch four pilot projects. The main focus is on the domestic development of competitive solutions at every stage, from production to delivery.

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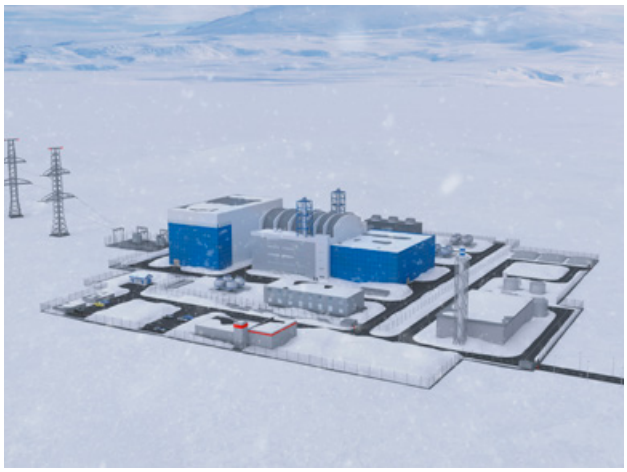
Here are some of the latest updates on our pilot projects. A feasibility study has been prepared for the hydrogen plant planned to be built on the island of Sakhalin (Russia). The plant will use the steam methane reforming process and carbon capture systems to produce hydrogen. The work is underway to prepare preliminary design documents. As for the Sakhalin hydrogen train project, we have developed a concept of the fueling station and selected potential sites for it. We have also signed agreements with major Russian steelmakers and oil refining companies for the use of hydrogen in their production processes.

— What are the company's plans for the rest of this year?

— The goals we have set are ambitious enough. But we will surely do our best to achieve them. As for the small nuclear power plant in Yakutia, we plan to develop a detailed design of a RITM-200N reactor and submit documents for a site license by the year end. In our RIVER business line, we intend to make cooperation agreements with a few countries from our pool of potential customers. Regarding our pilot hydrogen projects, we will begin engineering surveys on the train fueling sites on Sakhalin later this year. We also expect to finish the development of preliminary design documents for the hydrogen plant in the Sakhalin region.

— What is your assessment of the company's performance year to date?



— We safely went through restructuring and set out new areas of focus for the years to come. No project has been put on hold. We have completed construction of the first two facilities at the nuclear research and technology center in Bolivia. RAOS is also advancing with the SMR project in Yakutia and building a new facility at the Dmitry Rogachev National Medical Research Center, while keeping track of promising business lines. I am confident our team will maintain the pace, working towards the goals established for Rusatom Overseas.

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Green Light for Nuclear

The European Union has finally recognized that nuclear meets sustainability criteria. In the context of today's energy crisis and still-relevant climate agenda, nuclear looks no less attractive than 50 years ago, which is proved by figures, including cost estimates.

European recognition

In July 2022, 328 members of the European Parliament opposed the attempt to block the inclusion of gas and nuclear in the EU Taxonomy, a classification system establishing a list of environmentally sustainable economic activities. The members of the European Parliament who voted against the inclusion numbered 278, while another 33 abstained. Before that, the proposal to include nuclear and gas in the Taxonomy had been approved by the European Commission. Since the European Council is not expected to vote against gas and nuclear energy either, they are likely to be included in the Taxonomy on January 1, 2023 as transitional activities contributing to the net-zero goal in Europe.

"The European Parliament's positive vote sends a clear endorsement of nuclear energy to the financial community. It has listened to the science and recognized that sustainable investment in nuclear energy will help the EU reach net-zero by 2050. Now governments, investors, and industry must act urgently and accelerate

the deployment of new nuclear capacity to achieve this goal," Sama Bilbao y León, Director General of the World Nuclear Association, an international organization that represents the global nuclear industry, commented on the voting results.

As for Russia, nuclear energy was included in its national taxonomy of sustainable economic activities as early as March 2021.

The main benefit of having nuclear in the EU Taxonomy is that it secures access to sustainable — or 'green' — finance. Institutional investors will be able to report nuclear projects as sustainable investments, increasing the proportion and amount of finance allocated to the European climate goals (see the endnote).

Sustainable finance will be available mostly to European projects but may also be used in projects outside the EU. **"The EU taxonomy will impact non-EU companies, given the global nature of financial markets and trade flows. For example, a non-EU-investor or financial advisor offering products in Europe is subject to the SFDR, which requires alignment with the EU taxonomy of investment products. In addition, a non-EU company with EU-based investors will likely be required by these investors to provide information about the company's alignment with the EU taxonomy,"** says a comment by France's BNP Paribas, one of the world's largest investment banks.

Nuclear energy benefits climate more than solar and wind

The energy crisis, which broke out in the second half of 2021, sparked a greater interest in nuclear generation as a carbon-free and reliable source of power, almost independent of the weather. As we mentioned in November's newsletter, a similar trend took shape in 1973 in response to the then energy crisis.

The same point is made in the report 'Nuclear Power and Secure Energy Transitions' published by the IEA in July: **"In the decade following the 1973 oil shock, construction started on almost 170 GW of nuclear power plants. These plants still represent 40% of today's nuclear capacity. Nuclear additions in the last decade reached only 56 GW. With policy support and tight cost controls, today's energy crisis could lead to a similar revival for nuclear energy."**

Nuclear energy is an ideal solution to both energy security and environmental issues. **"Nuclear energy, with its 413 gigawatts (GW) of capacity operating in 32 countries, contributes to both goals by avoiding 1.5 gigatons (Gt) of global emissions and 180 billion cubic meters (bcm) of global gas demand a year,"** says the report. Its key message is that both goals can be achieved through nuclear technology.

The authors of the report make policy recommendations for the countries intending to develop nuclear (see the endnote). The

report also says that nuclear projects in advanced economies should cost around USD 5,000 per kilowatt in 2030. If we want nuclear to compete with renewables, the cost should be even lower: **"An even larger role for nuclear power will require greater declines in construction costs. Hydropower, bioenergy and fossil fuel plants equipped with CCUS are the main alternative dispatchable low emissions sources to nuclear. Where there is potential to expand these alternatives and CCUS is commercially available, the construction costs of nuclear power would need to fall to USD 2 000–3 000/kW (in 2020 dollars) to remain competitive."** As estimated in the report, the levelized cost of electricity in a feasible nuclear project should be USD 40–80 per MWh, with the cost of financing, decommissioning and waste disposal factored in. The message is simple: nuclear project owners should first reduce CAPEX to prove that nuclear is worth investing in.

By contrast, the authors of the study titled 'Economic Value of Nuclear Power in Future Energy Systems' from the University of Groningen (the Netherlands) draw totally different conclusions. Although outside the mainstream, their conclusions appear to be quite credible as they are based on real statistics of the Dutch power market.

The researchers compared the economics of renewable energy investments with those of nuclear generation in a market where renewables already have a large share in the energy mix. According to Statistics Netherlands, renewables accounted for 12% of the national power generation in 2021. It can be assumed that this percentage is already perceived to be a 'large share'. For the sake of comparison, nuclear generation had a 3.1% share in 2021, according to PRIS.

The study comprised a nuclear power plant, onshore and offshore wind farms and a solar farm, each having a capacity of 1 GW. Calculations were based on third-party estimates available. According to them, a nuclear power unit can be built for EUR 4,2 million per 1 MW (IEA gives higher estimates) within seven years after licensing, and operate for 60 years. Then, the unit will be decommissioned for 15% of its initial cost.

If compared, the cost and present value of investments in nuclear plants, solar and wind farms (both onshore and offshore) show that subsidies will be needed in every scenario covered and regardless of the generation technology used, but nuclear energy is more cost efficient. **"Based on a number of scenarios regarding the (Dutch) electricity market, we also find that a nuclear power plant needs more subsidy (in euro/MWh) than an onshore wind turbine, but less than a solar PV installation and an offshore wind park. In a scenario with a high share of renewables, however, also onshore wind turbines require more subsidies than a nuclear power plant, which is related to the strong decline in the capture price of renewable power plants. Hence, when there is a large installed capacity of renewables,**

investing in a nuclear power plant is more efficient than further extending the renewable capacity," the authors of the study conclude.

Building new renewables is a threat to renewable generation itself as the capture price of electricity falls, as follows from the analysis, from EUR 50 to EUR 10 per MWh. As a result, renewable generation becomes cost-ineffective and wind farms cease power production. This is the key factor that prevents expansion of renewable capacity. When the share of renewable generation is large, lower capture prices have no dramatic effect on nuclear. The price decreases from EUR 40 to only 35 per MWh because nuclear power plants produce and supply electricity when renewables cannot function.

Model analysis shows that LCOE (levelized cost of electricity) is not flat across generation technologies due to its heavy dependence on the market. In a scenario that assumes a large number of renewable energy sources and only a modest growth in demand, the use of every generation technology shrinks. The reason is simple: when electricity prices become too low, producers with low profit margins are forced to stop generation. But even if renewable generation is subsidized, it is more reasonable not to provide subsidies when the market price falls below margin. If renewable output is large, much of the generation capacity is at standstill and LCOE grows. This conclusion was made regardless of any potential grid limitations that might be imposed on renewable capacity due to overloads in favorable weather conditions. If the grid limitations persist, renewable power output will be much lower.

Climate goals of the European Union

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Transition to circular economy
5. Prevention and pollution control
6. Protection and restoration of biological diversity and ecosystems

If the share of renewable generation increases, the nuclear capacity utilization decreases from 90 to 60%. In relative numbers, the utilization of renewable capacity decreases as well. And this is yet another confirmation that a too large share of renewable generation makes the whole energy system less cost-efficient. Growing demand partially levels off this effect.

The authors of the study also compared emission reduction subsidies per generation technology. In a scenario with a larger share of installed capacity, emission reduction costs measured in euros per ton of CO2 are lower for nuclear than for wind or solar. This is also attributable to lower capture prices for renewable power. **"This implies**

that it is more efficient to install a nuclear power plant than renewable technologies to reduce carbon emissions," the authors sum up.

The researchers conclude that renewables — despite any policy incentives — will not be enough to meet the climate agenda. Growing power demand fueled by electrification and hydrogen production is one of the reasons. This is why there is increasing interest in nuclear as another non-carbon energy source. For instance, the Dutch government recently announced that it would endorse construction of two nuclear power units in the Netherlands.

Given the ongoing freeze in EU-Russia relations, one may wonder how Rosatom could benefit from the EU recognizing nuclear as sustainable, the IEA suggesting measures to develop nuclear generation, and the Netherlands proving that it makes more sense to build nuclear plants when renewables take a large share in the energy mix.

First, the methods used by the Dutch scientists can also be used by any other country, including non-European countries, to calculate the cost of energy security and carbon footprint reduction, understand cost efficiency of nuclear plants and then make deals with Rosatom.

Second, Rosatom maintains leadership in new nuclear construction worldwide — even if the IEA prefers to forget about Russian achievements in nuclear generation — and has extensive nuclear expertise it is ready to share with its partners.

IEA policy recommendations

1. Extend plant lifetimes
2. Make electricity markets value dispatchable low emissions capacity
3. Create financing frameworks to support new reactors
4. Promote efficient and effective safety regulation
5. Implement solutions for nuclear waste disposal
6. Accelerate the development and deployment of small modular reactors
7. Re-evaluate plans according to performance

Third, the political landscape is, by definition, always about "right here, right now." On the contrary, nuclear is, by definition, always about decades, even a century-long cooperation. In its 80 years of existence, the nuclear energy industry has seen wars and peace, global freezes and thaws. Even a regional "Yes to nuclear" is a reason for celebrations. The world is into nuclear once again, and it is amazing. There is no doubt this nuclear revival will raise demand for Rosatom's knowledge, competencies and engineering capabilities one way or another.

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