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Russian Atoms in 57 Countries

In late February, Rosatom Director General Alexey Likhachev spoke in the State Duma (the lower house of the Russian Parliament) about the current state of affairs at Rosatom, the goals set for the future, and the projects under consideration.

New power units in Russia

At present, Russia has 36 reactor units in operation, including the world's only floating nuclear power plant. The share of nuclear generation averages 20% across Russia and exceeds 40% in some Russian regions. Rosatom is also engaged in the development of wind generation capacity, with 9 wind farms already built. Rosatom's nuclear and wind power plants prevent the emission of about 110 million tonnes of CO₂ per year.



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By 2045, the share of nuclear power in Russia's energy mix will increase to 25%. The Russian nuclear corporation will have to build 42 large, medium and small modular reactors with an aggregate capacity of 33.5 GW to reach this goal. **"We plan to deploy new capacity in the Urals and then move further into Siberia and the Far East, where we expect electricity consumption to grow fastest. Nuclear stations will be built in seven new regions,"** Alexey Likhachev said. For instance, discussions are underway to construct nuclear power plants in the south of the Zabaykalsky Krai and in the Tyn-da Municipal District of the Amur Region.

Next generation

Alexey Likhachev highlighted in his speech the efforts made to develop next-generation nuclear power technologies: **"We are the world's only country to work on the Generation IV nuclear technology. This is the technology that makes beyond-design nuclear accidents physically impossible due to the specific design of the reactor core."**

It should be recalled that Rosatom is building a pilot power production facility in Seversk,

Tomsk Region. Its first unit, which is designed for the fabrication and refabrication of mixed uranium-plutonium nitride fuel, will be operational later this year. A lead-cooled fast neutron reactor will be brought online in 2027.

Alexey Likhachev emphasized that the new technology would remedy two shortcomings that are challenging the present-day nuclear power sector. First, fuel reserves become unlimited by involving the stockpiled uranium-238 isotope into the fuel production cycle. Second, closing the nuclear fuel cycle solves the world's most demanding problem of spent fuel accumulation. This would meet the so-called radiation equivalence principle, with as much radioactivity disposed of to the environment as was 'taken away' when mining natural uranium.

In the next decade, Rosatom will be using the new technology to build large-scale nuclear power plants and power generation facilities in Russia. The technology will also be offered to international partners. **"We are at least 10 years ahead of the competition in this field, according to our estimates. But since they are on our heels, we need to move forward faster in our innovative projects,"** Rosatom Director General said in conclusion.

Rosatom abroad

The advantages of Russian technology make Rosatom a top nuclear vendor in international markets. Rosatom is a leading supplier of nuclear fuel products and services and is building 22 nuclear power units in seven countries, with 8 units completed abroad over the last eight years. Rosatom's portfolio of international contracts includes 33 power reactors in 11 countries.



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The Belarusian and Russian energy ministries are working on the proposal of Belarusian President Alexander Lukashenko to build new nuclear capacity. **“There is an option to build a third reactor unit at Ostrovets (Belarus’ first nuclear power plant is located there — editor’s note), and there is an option to build a two-reactor nuclear power plant in the south of Belarus. We are ready for both options,”** Alexey Likhachev told the Members of Parliament.

The work is also underway to explore the possibility of building a new nuclear power plant in Turkey. **“As announced publicly by President Recep Tayyip Erdogan, a political decision has been made to allocate another site to us. Most likely, it will be a site at Sinop. We are now looking into the details,”** Rosatom Director General said.

New high-tech products, both nuclear and non-nuclear, make an essential part of international cooperation. They include offshore and onshore modifications of small and medium-scale nuclear power plants, nuclear science and technology centers, medical equipment, and multi-purpose irradiation centers. Rosatom supplies over 70% of the isotopes produced worldwide to more than 50 countries.

“I can’t wait to tell you about the latest invention of our medics, Hepatoren, an unparalleled rhenium-labeled drug capable of stopping the growth of liver tumors even in the most elderly patients,” Alexey Likhachev said.

Last year, Rosatom earned a record USD 16.4 billion in revenue from its international operations, including over USD 12 billion from friendly countries. **“What is our international leadership based on? First, it is the best technology that is tested and proven in Russia on a mandatory basis. Second, it is our comprehensive offer that extends beyond nuclear power plants. We create the entire industry from scratch, contributing to research activities, regulatory framework, local production, and end-to-end staff training. Relying on the principles of respect and equality, we make our partner countries technologically independent. This being said, we continue to compete for our share in the markets of unfriendly countries as well,”** Alexey Likhachev concluded.

All in all, Rosatom is present in 57 countries around the world by building nuclear facilities there, supplying its products or otherwise.



Nuclear Technology for Healthy Living

In February, Rosatom took part in the Future Technologies Forum to present its latest developments in medicine, including 3D-printed organ samples, radiopharmaceuticals, and quantum algorithms for medical applications. Members of the BRICS Working Group on Nuclear Medicine shared their experience, discussed challenges, and proposed solutions.

Exhibits from the future

Held in Moscow for the second time, this year's Future Technologies Forum was dedicated to medical solutions. The first forum held last year dealt with quantum technology. Rosatom, however, extended quantum technology into medicine. The visitors to the Russian nuclear corporation's booth had an opportunity to learn about a quantum algorithm capable of detecting early signs of

pneumonia on X-ray images, and see pre-production samples of laser units and electronic modules for quantum computing, which are being tested in the laboratories of the Russian Quantum Center.

Custom-made and standardized implants printed with 3D MRI or CT images were another product developed and presented by Rosatom. The implants are covered with an osteotropic antibacterial material, so they fuse with the bone much better. These solutions reduce implant production time from 60 to 7 days and help patients recover 2–3 times faster.

The world's leading supplier of radioisotope products, Rosatom also demonstrated mock-ups of its radiopharmaceutical products, iodine-125 microspheres, ophthalmic applicators containing ruthenium-106 and strontium-90 (Rosatom is the only manufacturer of these products worldwide), and a compact rhenium-188 generator GREN-1. The nuclear corporation is currently building Europe's largest radiopharmaceuticals factory in Obninsk (Kaluga Region) to expand its production and cover the entire range of radiopharmaceuticals used in global medical practice.

The most interesting exhibit was, perhaps, a mock-up of a bioprinter that uses magnetic and acoustic fields to grow tubular tissues (such as vessels), and a bioreactor in which vessels 'learn' to function properly. The device uses the patient's cells to bioprint small-diameter blood vessels. Such vessels then grow together with the body, which is of critical importance in pediatric transplantology. Rosatom researchers have grown a 2 cm long vessel and plan to obtain samples up to 10 cm long by the end of the year. As the next step, they will attempt to grow complex systems and organs.



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“Rosatom Group companies are conducting research in additive technology, radiopharmaceuticals and quantum computing for the needs of the healthcare sector. These efforts are aimed at significantly expanding doctors’ ability to help patients. Our research is designed to bring healthcare to a completely new level and achieve a totally different quality of life for people,” Rosatom Director General Alexey Likhachev said.

Joining efforts

The Future Technologies Forum hosted a meeting of the BRICS Working Group on Nuclear Medicine. The meeting was opened by Kirill Komarov, First Deputy Director General for Corporate Development and International Business at Rosatom. He noted that interest in nuclear medicine was growing on the back of the rising number of cancer patients and cancer-related deaths. With radionuclide imaging equipment improving and more effective radiopharmaceuticals for diagnostics and therapy developed, the capabilities of nuclear medicine are becoming increasingly wider. In addition to oncology, radionuclide imaging is used in cardiology, neurology and other areas of medicine.

BRICS is expanding and strengthening ties between its member countries. There are nine of them now as Brazil, Russia, India, China and South Africa have been joined by the UAE, Iran, Egypt and Ethiopia, with more countries looking forward to joining the organization.

Representatives of the BRICS countries spoke about the situation in nuclear medicine. In Egypt, for example, most nuclear medicine facilities are located in Cairo and Alexandria. The country with a population of 110 million



has at least 85 SPECT machines and 80 PET and CT scanners. Egypt produces technetium-99m, fluorine-18 and iodine-131, and imports gallium-68, yttrium-90 and lutetium-177.

The 120-million Ethiopia possesses 12 SPECT machines and 4 PET/CT scanners located at six institutions. The country is planning to build its own isotope production capacity, for which purpose Ethiopia has developed the design of a cyclotron and conducted a pre-feasibility study for a research reactor. The country has only 35 people working in nuclear medicine, one of whom has already retired. Unfortunately, training programs for nuclear medicine specialists are very poor, so the staffing issue is one of the most critical in the country.

Iran has been practicing nuclear medicine since 1960. Currently, there are 220 nuclear medicine centers in the country. Iran produces 66 different radiopharmaceuticals, with over 40 of them produced on a daily or weekly basis. Drugs based on lutetium-177, microspheres and applicators containing yttrium-90, and other radiopharmaceuticals



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are undergoing clinical trials. Iran plans to produce radionuclide-containing substances in accordance with GMP standards, launch a 70 MeV cyclotron and a 10 MW high-flux reactor, and produce molybdenum-99 using targets irradiated in the Tehran Research Reactor.

South Africa produces and uses a dozen isotopes for medical purposes, and also helps neighboring Ghana. In 2023, the country opened a radionuclide therapy center. The plans for the future include developing therapeutic services, opening new therapy centers, and training staff, including through increased cooperation and improved supply.

India already uses carbon, fluorine, nitrogen and technetium isotopes and considers terbium isotopes to be promising for theranostics (diagnostics and therapy with one radioactive substance). India plans to develop theranostics and targeted alpha therapy for chemoresistant tumors, early diagnosis of

Alzheimer's disease with radionuclide imaging, personnel training, and isotope production technology.

Almost every member of the working group spoke about the need for cooperation in staff training, expanding the range of radiopharmaceuticals, and accelerating delivery of isotopes and radionuclide products. The discussion of these challenges will continue at the 1st BRICS Expert Forum on Nuclear Medicine to be held in Saint Petersburg on June 20–21.

“Russia and other countries that are now part of the BRICS economic space have great potential in nuclear medicine. We are confident that cooperation between the partner countries will consolidate efforts to more effectively put nuclear medicine solutions into medical practice,” Kirill Komarov said in conclusion. 

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Light Steps of Composite Materials

Production of composites is one of Rosatom's most interesting new businesses. These materials are used, among other things, in advanced vehicles, clean energy generation, cost-effective construction solutions, and high-performance sports.

Back in the 1970s, the USSR belonged to the top three producers and consumers of composite materials in the world. They were, and still are, used to manufacture gas centrifuges for uranium enrichment. Since 2016, Rosatom has been making consistent efforts to set up an end-to-end composites production chain — the only one in Russia, CIS countries and Eastern Europe — that spans from crude oil processing to finished products like ship hulls, car bodies, fuel gas cylinders, construction materials, and sports equipment. Rosatom Group companies also produce PAN precursors, a variety of carbon fibers, fabrics, tapes, and prepreps.



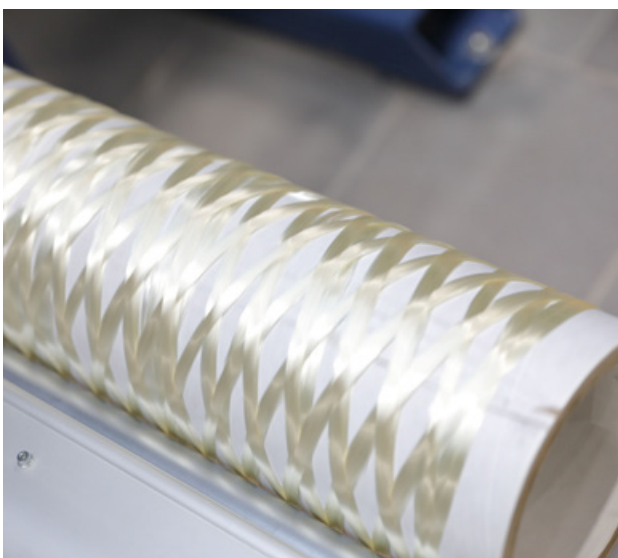
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The Russian composites market is still small in absolute terms, making as little as about 1% of the world market, but it is growing at the global rate of around 5–6% per year. On the upside, the Russian market of carbon composites, in which Rosatom is a leader, showed a 3.5-fold growth over the past six years alone.

It will continue to rise, particularly on the back of demand from the aircraft industry, which uses composites for the production of aircraft parts. Demand from the shipbuilding sector is also expected to increase. In September 2022, Rosatom signed an agreement to construct a shipyard in the Far East. The shipyard is assumed to build fully composite small-sized fishing, passenger and cargo ships.

Rosatom also intends to manufacture proprietary designed blades for wind turbines. They will be made of 90% glass fiber, with the remaining 10% being carbon fiber stiffeners. The first set of blades will be ready by the end of this year. The plan is to supply the blades to both national and international markets as the work is underway to develop several wind power projects overseas.



Rosatom holds a leading position in the Russian market of composite gas cylinders for buses, trucks, gas transportation and storage systems, and mobile refueling stations. Export orders are also in the pipeline. For example, the first shipment of 1,500 gas cylinders was delivered to the Minsk Automobile Plant (MAZ) last year. The next stage is to finalize the design of hydrogen cylinders; their prototypes have been made and are being tested. Aiming at the production of hydrogen and equipment for hydrogen economy, the Russian nuclear corporation is developing a line of small and large capacity tanks for different applications, from cars and trucks to gas carriers. Rosatom is also developing composite body parts for Russian electric vehicles.

Composite materials are becoming increasingly popular with the construction and infrastructure sectors both in Russia and other countries. Rosatom has upscaled its product offering for these sectors over the past 3–4 years.

Rosatom subsidiaries produce and supply composite sheet piles and chutes for coastal reinforcement structures and external reinforcement systems for the upgrade and capital repair of buildings and structures, make engineering plans of one-piece composite pedestrian bridges, and build coastal sites for commercial and household needs. External reinforcement systems allow structures like bridges to be repaired without suspending their operation. This might be critical for the cities divided by a river — such locations are in plenty all over the world. Composite sheet piling is used to isolate hazardous facilities. Sinking sheet piles into the ground prevents mercury, petroleum products and other pollutants from getting into groundwaters.

Consumption of composite materials in sports is also growing. Professional hockey sticks



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were Rosatom's first composite product for the sports sector, which was only the beginning. Not long ago, a novelty product — professional SUP boards — hit the market. Leading Russian athletes rated it high.

Prospects

Rosatom puts much effort into pushing its composite materials business forward across multiple dimensions, and the first of them is expansion of the product range for the sectors discussed above. Second, the company is building new production capacity. Third, it is engaged in the development of proprietary equipment for the composite materials sector. The fourth is the production of chemical agents for composite binders. The fifth is the development of new technology and solutions, and the sixth is recycling.

Thus, Rosatom intends to install carbon and glass fiber production lines, partly using

Global Composites Market 2023

Size: USD 100 billion

Glass fiber production:
12 million tonnes

Carbon fiber production:
120 thousand tonnes

Russian-made equipment, and to increase the production of high modulus carbon fiber. Last year, Rosatom obtained the first samples of such fiber with a strength of 7 GPa. This ground-breaking product is a result of advanced research, with only two Japanese companies producing fiber of the same strength in the world so far. This fiber makes it possible to build even more light-weight structures, which is critical, for example, for space flights as placing each kilogram of payload into orbit costs a lot of money.

The recycling business is also going forward. Rosatom has installed the first line for chopping fabric leftovers. The chopped fabric is used as feedstock for stamping operations. This is the first step on the way towards composite waste recycling. Rosatom will continue working to make its composite materials more eco-friendly.

Rosatom also intends to build partnerships with international and local consumers to enter new markets with its high-tech composite products. [NL](#)

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Coming Up Short Without Rosatom

The main trend gaining momentum in the nuclear fuel market is the intention to increase output on the back of political fragmentation of the global economic landscape. This trend is manifested both in natural uranium mining and uranium enrichment. However, the intended increase in uranium output is halting and dragging due to shortages. Against this background, Rosatom is increasing uranium production and taking a strong position in supplying nuclear fuel products.

Uranium market

One of the trends of the last six months is that uranium spot prices began to respond to the news about possible supply disruptions. In the past, even in the pandemic, mines could open and close but the market took almost no interest in it. Even the July 2023 embargo on Niger, the seventh-largest uranium supplier according to the WNA, did not shake up the market. The first reaction to the news about mining problems became apparent last autumn when Cameco said it was lowering its expectations about annual output. At that time, the price, which was below USD 60/lb per pound, passed the USD 70/lb mark and continued to rise.



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The market shook for the second time this January when Kazatomprom, the world's largest uranium producer, announced a shortage of sulfuric acid. The price then soared straight from USD 92/lb to USD 106/lb and has not fallen below USD 100/lb since then.

It should be remembered that sulfuric acid is the key chemical agent for the in-situ leaching method — it is injected into the soil to dissolve uranium, and the resulting solution is then brought to the surface and processed into a uranium concentrate. **“Given the strong growth in domestic consumption of, and demand for, sulfuric acid for fertilizer production over the past few years, the domestic market is facing a shortage of sulfuric acid. Regional markets are also experiencing shortages due to the growing demand from agriculture and a combination of factors, such as supply chain disruptions and geopolitical uncertainties,”** the company commented in its annual report for 2023.

The company planned to reach 90% of its production target set out in the mineral licensing contracts for 2024, but the report says that **“the uranium production at most mining operations will be 20% below the target.”** According to Kazatomprom estimates, the company's 100% output (that is, total production in Kazakhstan) will be 21,000 to 22,500 tonnes in absolute terms (vs. 21,110 tonnes in 2023), while its pro rata participation interest will be 10,900 to 11,900 tonnes (10,600–11,200 tonnes in 2023).

Kazatomprom and Cameco are among the world's largest uranium producers, but they are not the only ones facing production problems. For example, production remains low and unstable at the mining operations in the United States.

According to the EIA, uranium production at all US mines tumbled from 27,000 pounds in Q3 2023 to 12,650 pounds in Q4 2023. The largest decline in production was recorded at the Smith Ranch-Highland Operation (from 10,830 to 2,980 lbs) and the Lost Creek Project (from 15,760 to 6,520 lbs). Meanwhile, enCore Energy announced the start of uranium production at its Rosita Project in South Texas, and Energy Fuels began to produce uranium at its Arizona and Utah operations. However, data from these mines were not included into the EIA report for Q4 2023, so we can assume that the output is, at best, too insignificant yet to make it into the statistics.

France's Orano resumed uranium concentrate production at its Arlit mine in Niger in February 2024. It should be recalled the operations were suspended there in September 2024 due to a shortage of consumables after the borders were closed by the neighboring countries, primarily Benin, through which supplies flowed to Niger. In late December 2023, transit through Benin resumed after its main port, Cotonou, had seen its revenues plummet. Orano noted that the recovery of operations was very slow.





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France has also resumed the production and use of nuclear fuel made from regenerated uranium after a 10-year break. This resumption solves two issues: it reduces the amount of regenerated uranium in stock (and, consequently, its storage costs) and minimizes the amount of natural uranium required to make new portions of fuel, which might be an indication of uranium shortage and the desire to overcome it.

One can say, therefore, it is far from easy to increase the output in response to surging demand, triggered by the desire of natural uranium buyers to secure physical deliveries and reduce the impact of spot prices on the final contract price. There is also a shortage of personnel who had to be laid off during the 'lean years', when uranium mining companies had to cut back and, in some cases, shut down production. It is not easy to find new qualified employees. There is a shortage of chemicals and components. These problems, of course, are gradually being solved but the process is slow. As practice shows, it takes at least a quarter of a year to resolve difficulties.

In Russia, all the difficulties are resolved routinely due to the absence of demand fluctuations. The year 2023 was successful for Rosatom in uranium mining as the company exceeded its target by 3%. There is no shortage of sulfuric acid at Khiagda and Dalur, two in-situ leaching uranium operations of Rosatom's mining division.

The key goals for the current year are to continue the construction of Mine No. 6 scheduled for commissioning in 2025, which is the key asset of the Priargunsky Industrial Mining and Chemical Union (PIMCU, part of Rosatom), to begin development of the Namaruskoye deposit (Khiagda), and to obtain exploration and production licenses



for the Tetrakhskiye (Khiagda) and Shirondukuyskiye (PIMCU) deposits. Another goal is to prepare engineering design documents and cost estimates for the launch of operations at the Elkon gold and uranium deposit. The Elkon uranium ore district is regarded to be the world's largest in terms of reserves, but it has not been considered for mining before due to low prices and demand, poor infrastructure and remote location. Economic and political circumstances have changed, though, to reconsider development plans.

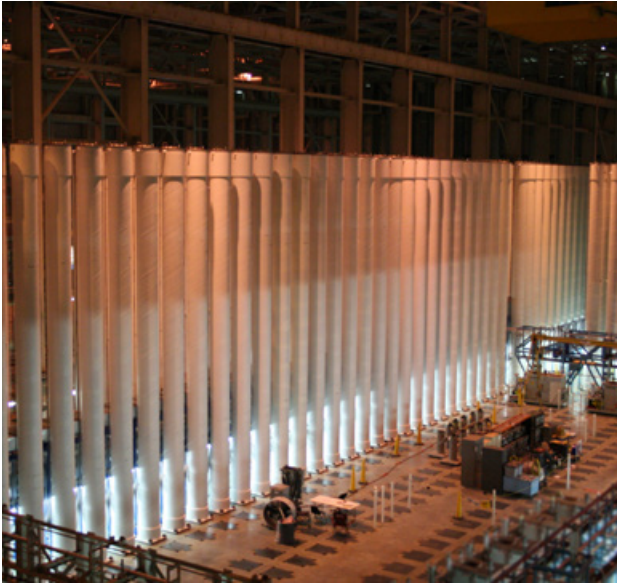
Fuel market

In the nuclear fuel segment, some governments continue to take actions, attempting to complicate Russia's access to international markets and expand their own limited capacity. The United States is the most active in these efforts.

In late December 2023, the U. S. House of Representatives passed a bill banning Russian imports of enriched uranium products from 2028. If the bill is enacted, it will come into



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force in 90 days and remain in effect until the end of 2040. However, the bill has a loophole: if there are no other sources of uranium than Russia, the U. S. Department of Energy may, in consultation with the Secretary of State and the Secretary of the Treasury, issue an import permit.

A little earlier, also in December 2023, the National Defense Authorization Act came into effect to provide for USD 886 billion in defense spending. It also requires the National Nuclear Security Administration to submit a plan for building uranium enrichment capacity in the country.

The United States is focusing much of its attention on building local capacity for the production of high-assay low-enriched uranium (HALEU, uranium enriched to 5–20% of the U-235 isotope). This January, the U. S. Department of Energy issued a request for proposals for HALEU enrichment services.

In late December, the U. S. Nuclear Regulatory Commission (NRC) amended terms of the operating license for the plant in Wilmington

operated by Global Nuclear Fuel — Americas (GNF-A). The amendment authorizes the plant to produce uranium enriched up to 8% (the previous enrichment limit was 5%). The NRC also issued GNF-A a certificate of compliance allowing the company to ship nuclear fuel containing uranium enriched up to 8% in its RAJ-II transportation packages.

It is not that simple, though, to obtain higher enriched fuel in practice. The shortage of 5B cylinders has been a stumbling block to HALEU production by Centrus (formerly ill-fated USEC). The company signed a contract with the U. S. Department of Energy for the production of 900 kilograms of HALEU in the form of uranium hexafluoride in Phase 2 (through November 2024). Under the contract, the Department is responsible for providing the HALEU storage cylinders to collect the output of the cascade. They have provided a few cylinders for Centrus to get started with production and they have ordered more, but the Department has experienced supply chain delays. **“The centrifuges will continue to operate, but the quantity of HALEU we are able to withdraw from the cascade in Phase 2 is limited by the number of cylinders the Department can provide and will be less than 900 kilograms,”** Centrus CEO Amir Vexler said in a conference call on the company’s performance in Q4 2023.

The United Kingdom also intends to establish its own HALEU production. The government plans to invest GBP 300 million in launching HALEU capacity.

It should be remembered, though, that Rosatom is so far the only commercial supplier of HALEU. Moreover, the facts show that it is extremely difficult to do without Russian-made nuclear fuel components at different production stages.



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The American Honeywell has applied for an export license to supply 8,500 tonnes of natural uranium to Russia for enrichment until 2028. Urenco Nederland B.V. has obtained a transportation permit for enriched uranium hexafluoride supplied to the company until February 2027. Finally, the operators of Europe-based nuclear power plants with VVER-440 reactors are in no hurry to give up Russian fuel, although they are working to diversify supplies.

IAEA Director General Rafael Grossi also spoke about the high importance of Russian supplies for the global nuclear fuel market in an interview with Reuters: **“Many companies in the West depend on Russian supplies —**

enriched uranium or fuel... The consensus is sanctioning Rosatom would not be realistic and it’s impractical. It would put the nuclear industry at a standstill in many countries.”

According to him, reducing dependence on Russia’s nuclear sector would cost Europe billions. He saw no immediate shift away. The larger issue was infrastructure and incentives, and projections of rising uranium demand globally. **“Frankly, I see an increased presence of Russian uranium enrichment capabilities in the world rather than a decrease,”** the IAEA chief concluded. ¹⁰

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