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Africa Learns Russian Atoms

In late July, Saint Petersburg hosted the second Russia–Africa Economic and Humanitarian Forum. Rosatom, a general partner of the Forum, signed five agreements with African partners on the recognition and deployment of nuclear technology and professional education in this field.

The African continent suffers from energy shortages. Although one in five people on Earth lives in Africa, the continent accounted for less than one trillion kWh out of the 30 trillion kWh generated on our planet last year. With the African population growing, Africans will make up a third of the world's total population by 2050. If the power production does not increase, there will be no growth in industry or information technology, the quality of life will deteriorate, and this is fraught with rising migration and social upheavals.

African governments are considering nuclear as a reliable source of power generation. **"We would like to consider the possibility of using nuclear energy to meet our needs. Only about 70% of our country's population has access to electricity and we**

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hope to increase that proportion. We need stability and reliability. Since nuclear power seems to be an effective solution, we have embarked on this path," Rwanda Atomic Energy Board CEO Fidel Ndahayo said at the Nuclear Technologies for the Development of African Region plenary session.

Burundian President Evariste Ndayishimiye decided to see for himself how nuclear technology works and visited the Leningrad NPP during the forum. Alexander Belyaev, Chief Engineer at Leningrad II, took him and members of the Burundian Government to a tour of the power units with VVER-1200 reactors. They were shown a control room and a turbine island, and informed about the unparalleled safety systems of the plant. **"Only one fifth of our country has access to electricity. We are working hard to build hydro power plants, but we were amazed to hear that each nuclear reactor has a power capacity equal to dozens of our hydro plants,"** Ibrahim Uwizeye, Minister of Hydraulics, Energy and Mines of Burundi, said after the tour.

On the next day, July 27, Rosatom and Burundi signed two documents. The first was a memorandum on training staff for the nuclear power industry. It provides for the cooperation between specialized educational institutions, organization of short-term educational programs, training and reskilling of teachers, and development of educational and scientific literature. The second document is an agreement on cooperation in peaceful use of nuclear power. The parties will work together on the creation and development of Burundi's nuclear infrastructure, regulatory framework for nuclear and radiation safety, fundamental and applied research, production and application of radioisotopes in industry, medicine and agriculture. Rosatom and Burundi also agreed to cooperate in using nuclear medicine and training the staff for this radiation technology application.

Another cooperation agreement to the same effect was signed between Rosatom and the Government of Zimbabwe. Also on July 27, Rosatom and Ethiopia signed a roadmap to develop cooperation in peaceful uses of nuclear energy. In 2023–2025, the parties will work out the possibilities of building a large or small nuclear power plant and a nuclear science and technology center in the country. The roadmap sets out plans to establish dedicated work groups, hold technical tours and seminars, and develop nuclear infrastructure in Ethiopia.

Rusatom Infrastructure Solutions (a part of Rosatom) signed a memorandum of understanding with the Moroccan company Water And Energy Solutions. The parties will work jointly on water treatment, desalination and purification projects. **"The Russian Federation keeps its word and shows willingness to extend a helping hand and share its know-how with our countries. The fact that Rosatom has decided to work in the Kingdom of Morocco is a great**

proof that we are able and willing to grow together, helping each other and the people by supplying them with clean water at an affordable price," said Mohammed Amine Cherkaoui, Chairman of the Board at Water And Energy Solutions.

Nuclear technology improves economic and social conditions, facilitates knowledge sharing and provides career prospects for qualified professionals. This was stressed by Amged El-Wakeel, Chairman of the Board of Directors of the Egyptian Nuclear Power Plants Authority: **"The nuclear project, which is part of a broader industrialization program, is already making a positive impact on Egypt, expanding the existing opportunities for local industries and creating new options for highly skilled professionals."** Participation in a dedicated nuclear school in El Dabaa presents one such opportunity.

As our readers know, Rosatom is building a nuclear power plant with four VVER-1200 reactors in Egypt's town of El Dabaa, which will become the second nuclear station on the continent. The first one was South Africa's Koeberg whose reactors were brought online in 1984 and 1985. By the way, Rosatom's fuel division TVEL and the Nuclear Energy Corporation of South Africa (NECSA) signed a memorandum of understanding in early August. The parties will cooperate in the production of nuclear fuel and its components. Generally speaking, Rosatom is present in two dozen African countries, either through uranium exploration and mining activities, nuclear medicine programs or construction of nuclear research and technology centers.

Along with African leaders and government representatives, there were African students who had a chance to learn more about the capabilities of Russian nuclear technology. **"I am very glad to see that you are interested in nuclear physics because our country has accumulated unrivaled experience in this area. In a few years, we expect to set up a large international center in Obninsk. It will be a point of attraction for the people from different countries willing to study and upgrade their skills,"** said Russia's Deputy Minister of Science and Higher Education Konstantin Mogilevsky at the Russia-Africa: Nuclear Education as a Potential for Successful Development of the Region youth forum.

Women in STEM, a session held at the forum, aimed at promoting scientific and technical professions among girls and supporting them in their career choices. Due to prejudice, women worldwide do not always pursue their profession even if they have received an excellent technical education.

Various opportunities to get an insight into the Russian nuclear industry aimed at building trust between Russia, particularly Rosatom, and African countries. **"International cooperation in the nuclear field has always been high on the agenda of the first persons, heads of state and government. However, cooperation can only be successful if there is much trust between the countries. The power of nuclear energy is too great to consider it in terms of business only,"** Rosatom Director General Alexey Likhachev pointed out when speaking at the forum.

Training Replica

In mid-July, a full-scale simulator was delivered to the Akkuyu NPP construction site. An exact replica of the control room of Turkey's first nuclear power plant, it is designed for operating personnel training, licensing and upskilling. The development of training simulators for the nuclear power plants is a critical competency possessed by some of the Rosatom companies.

The full-scale simulator for Akkuyu is a digital twin of the plant's instrumentation and control systems. Its hardware and software components are made to simulate the control room design — all the instruments, keys and control panels are identical to those of the control room in terms of arrangement, size, shape and color. This is essential for the staff to develop and reinforce the correct reactions. The information on the simulator displays and indicator lamps is also similar to that in the real control room. **"With simulation training, personnel practice their behavior in different situations and under the conditions closest to reality before the nuclear power plant is commissioned,"** Akkuyu Nuclear CEO Anastasia Zoteeva commented on the delivery.

Manufactured at the Russian Research Institute for Nuclear Power Plant Operation (VNIIAES, a part of Rosatom), the simulator uses a complex mathematical model that imitates every operating mode of the nuclear plant in real time.

Earlier, in June, an analytical simulator was delivered to the Akkuyu NPP. **"The analytical simulator is based on the same real-time model of a power unit as the full-scale simulator. This model was created at VNIIAES and does not use any foreign modeling codes. It is a fully Russian-designed system that meets all Russian and international requirements,"** says Viktor Chernakov, Head of the NPP Operation Modeling Support Department at VNIIAES. Its main difference from the full-scale simulator is that the control panels are not physical but are displayed graphically on touch-screen monitors.

The would-be operators of the Akkuyu NPP have been using the full-scale and analytical simulators since last year to improve their professional skills. They were first trained at VNIIAES and the Leningrad NPP. Seven groups of engineers completed a course for control room operators taught at VNIIAES. Among them were Russian and Turkish graduates of Russian universities with degrees in Nuclear Power Engineering. After the training was completed, the simulators originally installed at VNIIAES were disassembled and sent to Akkuyu. They will be re-assembled there and put into operation

when the building of the training center is ready. After the reassembly, they will undergo a series of pre-commissioning tests to receive an operation permit.

VNIIAES produces full-scale and analytical simulators for nuclear power plants with RBMK, VVER-440, VVER-1000 and VVER-1200 reactors, that is, any Russian-designed nuclear plants except for small stations (Bilibino and Akademik Lomonosov).

VNIIAES also develops digital twins of nuclear power plants. Released in March 2022, the Virtual NPP software package simulates the operation of more than 300 nuclear power plant systems by calculating over 3.5 million variables. Since February 2021, VNIIAES has been working on the development of a digital twin for small nuclear power plants with RITM-200 and Shelf modular reactors. Tests on the new system and its release are scheduled for 2024.

VNIIAES is not the only Rosatom company engaged in the production of simulators for nuclear power plants. Another is the JET Engineering and Technical Center (JET ETC), which joined the Rosatom in 2020. JET ETC has supplied almost every simulator installed at the Russian-designed nuclear plants constructed abroad (two simulators in China, and one in each of India, Belarus and Bangladesh). Another simulator, intended for China's Tianwan Units 7 and 8, was shipped this May. Although the shipment was scheduled for 2024, it was delivered well in advance to allow more time for personnel

training. A simulator for Xudabao Units 3 and 4 is being prepared for shipment in early 2024, again ahead of schedule.

JET ETC is also working to upgrade a full-scale simulator at Paks I in Hungary, as well as producing simulators for Egypt's El Dabaa and Russia's Kursk II.

Another aspect of the company's activities involves creating simulators and digital twins for other types of power plants. This April, for instance, the company signed an agreement with Belenergo and BelenergoRemNaladka at the TIBO 2023 forum in Minsk (Belarus) to deploy full-scale simulators and digital twins at power generation facilities operated by the Ministry of Energy of Belarus. The partnership also provides for the training and upskilling of power plant workers, as well as the introduction of best practices in power equipment operation.

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Going Onshore

RITM-200N will be Russia's first small modular reactor (SMR) to be built onshore. Designed at OKBM Afrikantov, it differs from its predecessor, the RITM-200 marine reactor. This article takes a deeper look into the differences.

Background

Russia's first onshore SMR will soon be built in the Republic of Sakha (Yakutia). A cooperation agreement to this effect was signed between Rosatom and Yakutia's Government in 2018. As set out in the document, OKBM Afrikantov and the State Specialized Design Institute (GSPI), both part of Rosatom, conducted a series of feasibility studies for a nuclear power plant with support from local authorities and organizations.

In February 2020, a pilot project was launched to build a small nuclear power plant with a RITM-200N reactor in Ust-Yansk, Yakutia. The project provides for the pilot plant to have a single reactor with an electric power capacity of 55 MW.

In 2022, OKBM Afrikantov produced a detailed engineering design for the

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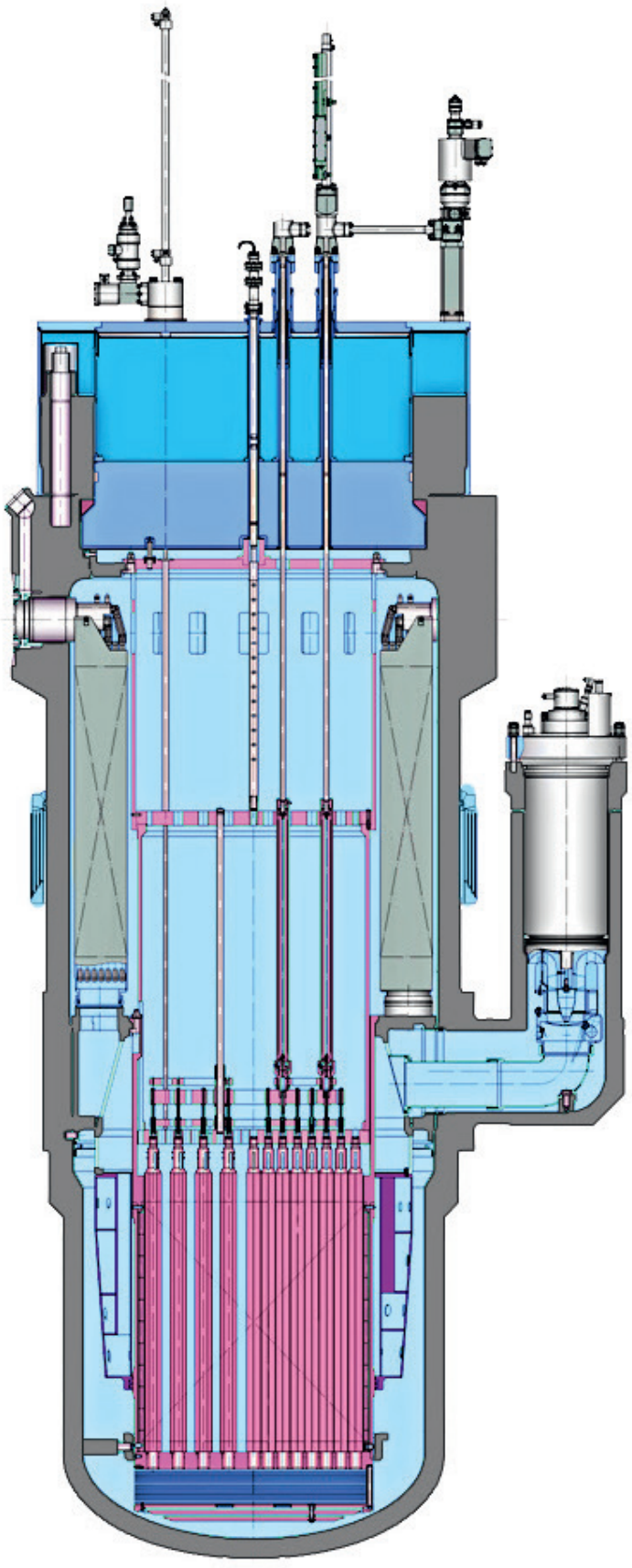
RITM-200N reactor and its core. In April 2023, RosEnergoAtom obtained a site license from the Russian regulator Rostechnadzor.

At present, OKBM Afrikantov and GSPI are performing probabilistic safety analyses to prepare a safety report, which will be submitted to Rostechnadzor to obtain a construction license. OKBM Afrikantov has also set about developing detailed design documents for the reactor equipment, as well as commissioning and operating documents.

The work is concurrently underway to improve the existing regulatory framework, develop standardization documents for small modular reactors, and prepare the construction site.

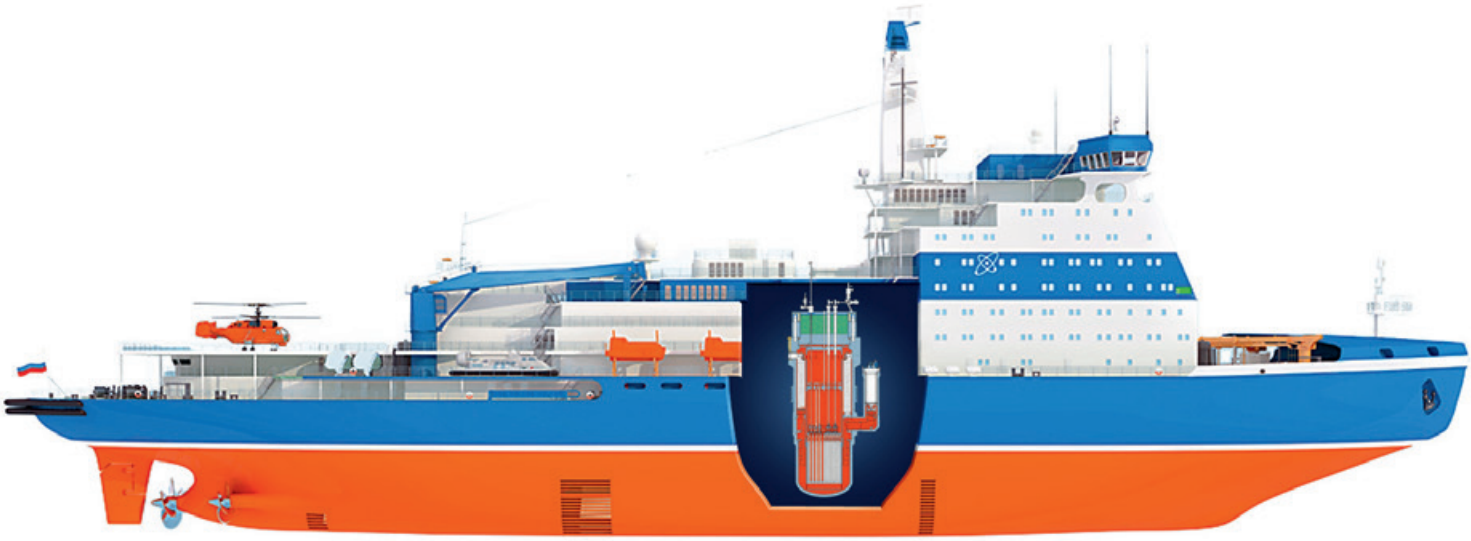


Onshore modification

The prototype of the onshore SMR is RITM-200, a universal marine reactor that is installed on nuclear-powered icebreakers. With all the necessary design-basis and experimental validations in place, the reactor has been produced on a commercial scale, featuring the SMR-critical properties, such as compact size, excellent load-following capabilities, and minimal liquid radioactive waste. Another essential feature is the integral layout of the reactor unit.

As far as possible, RITM-200N replicates the design and layout solutions used in RITM-200 and RITM-200S, which are to be installed on upgraded floating power units.

In RITM-200N, all the safety systems are designed to be redundant. That implies that the critical safety functions performed by



active systems are all duplicated by passive safety systems.

Since the SMR will be built onshore and operated in the Arctic environment, special technical solutions have been incorporated in the RITM-200N design, with necessary research and experimental studies conducted. Certain solutions aim to extend the service life of non-replaceable reactor equipment from 40 to 60 years. Improvements are also being made to passive safety systems to ensure the reactor remains safe for at least 72 hours even if it is completely de-energized or loses coolant (as happened at Fukushima). Another set of solutions provides protection against external impacts, encompassing both natural like earthquakes and man-made incidents such as a 20-ton airplane crash.

Signaling devices will be installed in the reactor to monitor loss-of-coolant accidents in the primary circuit. The data they will provide will make emergency responses more timely and accurate. To monitor the reactor vessel condition during operation, the so-called 'witness samples' will be used. These are sacrificial test pieces made of the same steel as the reactor vessel is — they can be safely removed and, unlike the reactor, subjected to destructive testing.

The onshore RITM-200 has a higher steam capacity (305 t/h compared to 248 t/h) and a higher power capacity (190 MW compared to 175 MW) than its marine version.

Fuel

The core of RITM-200N reactors will contain 199 fuel assemblies with 1650 mm-fuel rods, 45 cm longer than those used in the marine reactors are. Instead of an intermetallic fuel, the onshore reactor will use uranium oxide ceramic as fuel, with uranium enriched to less than 20%. These features almost double the energy potential of the fuel (8 TWh for an onshore reactor compared to 4.5 TWh for a marine reactor). Being used in the KLT-40S reactor of the Akademik Lomonosov floating nuclear power plant, the ceramic fuel has proved functional. Fuel claddings will be made of corrosion-resistant alloy and, together with fuel rods, intended for

operation in a load-following mode. The design life of the fuel for onshore reactors is the same 10 years as for the marine fuel.

Plans

The first concrete for the SMR foundation is planned to be poured in 2024. An operating license is expected to be obtained by 2027, followed by the commissioning of the plant in 2028. It is assumed that the key consumers of electricity from the Yakutian SMR will be mining and processing facilities at the large Kyuchus gold mine, rare-earth metal and tin deposits, and the nearby towns of Ust-Kuyga, Deputatsky, Kazachye and Severny.

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Technology Chains That Store Energy

In July, the International Energy Agency (IEA) released its Critical Minerals Market Review 2023 report summarizing the major market trends for the minerals essential for a range of clean energy generation and storage technologies and electric vehicles. A key player in the Russian clean energy market, Rosatom is following those trends, taking measures to ensure sustainable supplies and developing technology chains that span from exploration and mining to end products, such as energy storage systems, electric vehicles and wind turbines.

Global outlook

From 2017 to 2022, the energy sector drove a three-fold growth in demand for lithium, a 70% jump in demand for cobalt, and a 40% rise in demand for nickel, according to the IEA report. In 2022, for example, sales of electric vehicles grew 60% over 2021, reaching 10 million cars. This year, a further 30% growth to 13 million cars is expected. Although wind capacity additions declined to 75 GW in 2022, down 20% year-on-year, they are estimated to grow 70% this year to over 120 GW.

The rising demand stimulated prices and production growth, so the market for the minerals crucial to the new energy sectors (solar, wind, storage, and electric vehicles) doubled in five years, reaching

USD 320 billion in 2022. In terms of individual minerals, the market for lithium grew 6.7 times, rare earth elements 2.5 times, nickel 3.1 times, and cobalt 1.9 times.

Lithium production rose from about 45,000 tons in 2017 to about 130,000 tons in 2022, with the share of clean energy sectors increasing from 30% to 56%. Nickel output climbed from about 2.1 million tons to about 3 million tons, with the clean energy share rising from 6% to 16% of this amount. Cobalt production rose from 100,000 tons to 170,000 tons, while the share of clean energy sectors went up from 14% to 40%.

While prices for many minerals have declined in 2023, some remain above their average level in the second half of the 2010s. This is most true for lithium, with its price approaching USD 70,000 per ton of lithium carbonate late last year, while the average 2016–2020 price was below USD 20,000 per ton. Its price in the second quarter of 2023 was stuck in the range of USD 40,000 to USD 50,000 per ton.

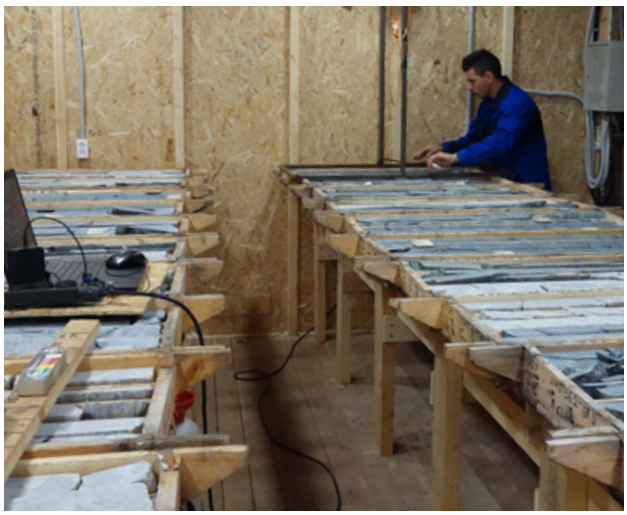
Challenged by instability, governments and companies are focusing their efforts on making supplies as reliable as possible.

"There is growing recognition that policy interventions are needed to ensure adequate and sustainable mineral supplies," the report notes. In the past few years, over 100 policies and regulations were enacted worldwide to facilitate investments in the production and supplies of minerals for the new power generation and storage technologies, and to introduce certain export and import restrictions.

Investment in these minerals was up 20% in 2021 compared to 2020 and up 30% in 2022 vs. 2021. **"Our detailed analysis of the investment levels of 20 large mining companies with a significant presence in developing energy transition minerals shows a strong rise in capital expenditure on critical minerals, spurred by the robust momentum behind clean energy deployment,"** the report says. Year-on-year exploration spending also rose by 20% with lithium accounting for most of this growth. The leaders in the segment were Australia and Canada, while Brazil and African countries also posted an increase in exploration spending.

Russia

Over the past few years, Russia has sharply intensified its efforts towards developing the electric vehicle segment and securing reliable supplies of minerals crucial to the new power generation and storage technologies. In 2020, the Russian government approved the New Materials and Substances Technology Roadmap that, among other things, focused on the supply of rare earth elements (REEs). The roadmap was updated in 2022. In 2021, the Government also adopted the Electric Mobility Development Program 2030.



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Rosatom is responsible for the delivery of REE goals under the New Materials and Substances Technology Roadmap. The Russian nuclear corporation is also a key player in the Russian market of energy storage systems for both power and EV applications, and in the wind energy market. Rosatom is working consistently to develop its competencies necessary to build vertical production and technology chains in these markets.

Russia is largely self-sufficient in many of the minerals required for the new power generation and storage technologies. In particular, the Russia-based Nornickel, a key global nickel miner, also produces cobalt, copper and platinum group metals, all of which are essential for the clean energy segment. Another Russian company, RUSAL, is a major player in the global aluminum market. Several Russian companies produce copper. The country is also rich in phosphates, which are extensively mined for fertilizer applications and can also be used in lithium iron phosphate batteries for electric vehicles.

So far, Russia does not have a domestic lithium production but the issue is being addressed. This February, Polar Lithium, a joint venture between Nornickel and Rosatom, obtained a mining license for the Kolmozerskoye lithium deposit. Production is planned to begin in 2029. Reserve estimates are expected to be finalized by the end of 2024. According to preliminary estimates, the deposit will yield 1.96 million tons of ore per year, which is equivalent to 45,000 tons of lithium carbonate and hydroxide. This will be enough to meet Russia's needs, with more left for export.

Rosatom is also establishing foreign partnerships in the lithium segment. In the last issue of Newsletter, we wrote that Rosatom's subsidiary Uranium One Group and Bolivian state-run company Yacimientos de Litio Bolivianos signed a USD 600 million framework agreement to build a 25,000-ton lithium carbonate production facility in the Salar de Pastos Grandes.

Rosatom is also broadening its presence in the REE segment. This May, the Russian state-run corporation acquired Lovozersky GOK, Russia's sole producer of loparite concentrate, a source material for the production of titanium and compounds, tantalum, niobium and light REEs. The loparite concentrate produced by Lovozersky GOK is processed at the Solikamsk Magnesium Plant. According to the presidential decree, its shares will also be transferred to Rosatom.

Along with securing mineral supplies, Rosatom is expanding the range of components produced. For example, Rosatom's fuel division TVEL intends to set up large-scale production of permanent rare-earth magnets in Glazov (Udmurtia). This is an important component of electric motors and generators for wind turbines. The company is expected to manufacture over 1,000 tons of neodymium-iron-boron

magnets by 2028. It is possible to increase production up to 3,000 tons after 2030. **"We plan to enter new segments of the rare-earth magnet market to cover the developing sectors of the Russian economy, from automotive and aerospace industries to electronic applications and high-capacity generators,"** Andrey Andrianov, CEO of Rusatom MetalTech (part of TVEL), said when signing the agreement with the Udmurtia Government.

Rosatom is a leader in the construction of new wind generation capacity in Russia. So far, its wind power division NovaWind has added 940 MW of new wind capacity with a total of around 1.7 GW of new capacity to be commissioned by 2027. NovaWind manufactures parts and components for wind turbines and, in addition to magnets, plans to initiate production of turbine blades.

Rosatom is also working to establish production of storage batteries. In Kaliningrad, TVEL's subsidiary RENERA will soon proceed with building a gigafactory to manufacture battery cells with an annual capacity of 4 GWh. The project, which received official approval in June will see RENERA starting construction in the coming months with on-site preparations already completed. The gigafactory is expected to be commissioned in 2025, to be followed by similar factories in the future.

Currently, RENERA operates a battery assembly site in Moscow and supplies energy storage systems for public transport applications, such as extended-range trolleybuses operating in Saint Petersburg.

RENERA will also supply batteries for the Russian-made electric car Atom. In addition to storage batteries, Rosatom engineers are developing a relatively inexpensive and reliable motor for this vehicle. From the very beginning, the engineers provided for the modifiability to create a wide range of motors for other EV models. Atom is expected to have a travel range of 500 kilometers and will be adapted to the cold Russian climate.

Given that electric mobility requires a well-developed charging infrastructure, Rosatom is also focusing on charging stations. Its electric power division RosEnergoAtom intends to deploy a chain of electric charging stations that will first cover cities with over a million inhabitants and major highways, such as those linking Moscow and Saint Petersburg. **"Russia plans to put at least 9,400 charging stations in operation by 2024, including almost 3,000 fast charging stations that fully charge a car in 20 minutes. The delivery of Rosatom's plans will make the company a market leader and contribute to the development of domestic electric mobility infrastructure,"** says Dmitry Baranov, a leading expert at Finam Management.

According to him, the Russian electric mobility segment is developing steadily as electric cars are growing in numbers, the

emergence of new brands, rising consumer interest, and the expansion of EV charging and servicing infrastructure. The optimistic scenario prepared by the Russian Ministry of Industry and Trade predicts electric vehicles will account for 15% of the market by 2030.

Finally, Rosatom plans to engage in the battery recycling business. For this purpose, the Russian state-run corporation has initiated a project to build a battery recycling plant. Currently, engineering design work are underway and site survey results are reviewed by the regulator.

The brief overview above demonstrates Rosatom's involvement in many segments of the new power generation and storage technology, and the intention to build a vertical technology chain in the EV segment. By acquiring expertise and technology, Rosatom ensures Russia's technological sovereignty but also lays a solid foundation for hi-tech exports.

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