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Education for Nuclear

Obninsk Tech, an international research and educational center for nuclear and related technology, was established at the birthplace of the world's first nuclear power plant. It was in the focus of attention at Obninsk NEW, an international youth nuclear forum held in late September with Rosatom's help.

About the center

The idea of establishing an educational center was approved by Russian President Vladimir Putin at a meeting with the Rosatom Director General Alexey Likhachev. **"I am confident the center will be a leading cluster and a point of attraction for the talented youth from all over the world. It will train high-class professionals for different industries and state-owned companies. The center will contribute to Russia's technological sovereignty in nuclear research and development,"** Russian Prime Minister Mikhail

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Mishustin said in his welcoming speech to the forum participants.

The center is expected to open by 2030. It will offer training programs in closing of the nuclear fuel cycle, Generation IV nuclear technology, and nuclear medicine. Further plans include the opening of training centers for industrial design and engineering, prototyping, additive technologies, and other fields of study. The research program will be drawn up in association with partner countries.

Classes will be held at Rosatom's Technical Academy and the Obninsk branch of the National Nuclear Research University MEPhI. This year, the Obninsk branch of MEPhI celebrated its 70th anniversary. About 500 foreign students study there despite geopolitical tensions. Each of the universities offering nuclear engineering programs will make its contribution to Obninsk Tech.

The infrastructure for Obninsk Tech is in place, but key facilities — a campus, laboratories, exhibition spaces, etc.— are yet need to be built.

Rosatom Director General Alexey Likhachev has high hopes for the center: **"With Obninsk Tech established, Russia will take at least 20% of the global market for nuclear and related education by 2030. The center will foster talents who are active, think globally and strategically, and are knowledgeable not only in natural sciences but in humanities as well,"** Alexey Likhachev said.

International attention

Speaking at the Strong Education as the Foundation for the World Sustainable Development plenary session, IAEA Deputy Director General Mikhail Chudakov supported the Obninsk Tech project. About 2.3 million people are employed in the global nuclear industry, he said. If the nuclear power industry grows as the IAEA expects, four million professionals will be needed by 2050. **"We hope that Obninsk will train at least a million nuclear workers by that time. We will support your every endeavor,"** he assured.

"Nuclear is an integral part of the future clean energy mix and a symbol of decarbonization. Education is a key component of the strong foundation that underlies the understanding of how nuclear technology is important," said Sama Bilbao y León, President of the World Nuclear Association.

Heads of nuclear agencies from Bolivia, Turkey, Vietnam and Brazil expressed interest in the center.

Radiating purity

As the forum was underway, a multi-purpose irradiation center was put in operation at the Karpov Research Institute of Physics and Chemistry (NIFHI), which is also based in Obninsk. It will specialize in radiation sterilization of medical products. Previously, NIFHI irradiated food products, polymer materials, and cables. **"Domestic companies have significantly increased the output of medical products after the foreign suppliers withdrew. Rosatom has noticed the market demand for cold sterilization and expanded the chain of its irradiation centers,"** Alexey Likhachev commented.

This is the seventh multi-purpose irradiation center in Russia. The eighth one is expected to be commissioned late this year in Kazan. **"We plan to have 70% of the Russian mar-**

ket. We also go global as we are building irradiation centers in Bolivia, Bangladesh and Uzbekistan and negotiating with three more foreign partners," said Igor Obrubov, Head of Rosatom's Healthcare Technologies division.

Facts & figures

>600 students and young researchers from 70 countries visited the forum

>50 events in 4 days

2 plenary and 8 topical sessions

Fresh Glance at Radiopharma

Izotop (part of Rosatom's Healthcare Technology division) took part in the 36th Annual Congress of the European Association of Nuclear Medicine (EANM 2023). The company presented medical isotopes produced by the Russian nuclear corporation, one of the global market leaders.

About the congress

Held in Vienna on September 9–13, the EANM Congress was attended by over 7,000 nuclear medicine experts from more than a hundred countries. The key topics covered were advances in radiation diagnostics and therapy. In particular, the congress discussed the development of particle acceleration and cyclotron technology and the use of alpha-emitting radioactive nuclides (ɑemitters) in nuclear medicine. These are the radionuclides preferred as radiopharmaceuticals at present.

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Canada, Japan and some European countries put a premium on astatine-211 as an alpha emitter. This is an element that is virtually uncommon in natural conditions — it was synthesized even before it was discovered. Most market participants, however, still consider actinium-225 to be the most effective alpha emitter and therefore show keen interest in it. Currently, over 50 medical institutions around the world, including a number of clinics in Russia, are conducting research on actinium-225. The only one in Russia, Rosatom is also a Top 3 global producer of actinium-225. Since this isotope is produced in extremely small amounts, only a few hundred patients per year can receive treatment with actinium-225 worldwide.

Lutetium-177 is the most widely used beta emitter. It is highly effective in diagnostics and targeted therapy of a number of cancers, such as inoperable metastatic prostate cancer. Coincidentally, while the congress was running, the Russian regulator Rostechnadzor granted the Leningrad NPP (part of Rosatom) a permit to produce lutetium-177 at two of its units at once, Units 3 and 4. The pilot batches of the radionuclide will be produced by the end of this year.

The congress also discussed the development of fundamentally new techniques, such as neutron capture, photon capture and others.

Rosatom's contribution

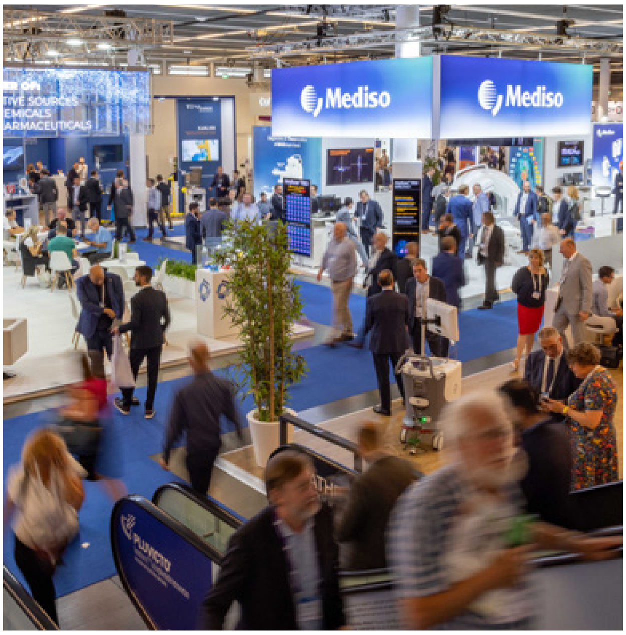
Izotop's booth at the congress featured information about Russian isotope products. It was also a venue for business meetings with existing partners and potential customers.

"The congress confirmed the high level of Rosatom's competencies in isotope technology. We made agreements with our long-term partners to continue and expand cooperation. What is more, our delegation made new contracts for the supply of key isotope products," Anton Shargin, Deputy CEO for Commercial Affairs at Izotop, commented on the results of the congress.

Earlier this year, Izotop made the first shipments of isotope products to Italy and gallium generators to Kazakhstan and India. Gallium-68 is used in diagnostics of a wide range of cancers by PET scanning. Each year, over 100,000 diagnostic procedures are carried out with this radionuclide worldwide.

Izotop also won an international contract with Belarus to fully meet its needs for technetium-99m generators, and the first deliveries have already been made.

In late September, Rosatom signed a memorandum of understanding with the Algerian Commission of Atomic Energy (COMENA). The parties will cooperate in carrying out medical projects and developing nuclear medicine.



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Isotope mainstay

Rosatom operates two out of the world's four largest production facilities for stable isotopes and at least 30% of the reactor fleet involved in the commercial production of radioisotopes. In addition, the Russian nuclear corporation is building Europe's largest radiopharmaceuticals factory. In 2025, when the factory is commissioned, its 21 process lines are expected to produce more than 25 different radiopharmaceuticals. The construction works on the factory site started in January and are going ahead of schedule. The cast-in-place concrete frame of the building is almost ready.

The first section of the factory will manufacture technetium-99m generators for the production of diagnostic drugs for over 20 diseases, iodine-131-based drugs for the treatment of the thyroid gland and neuroblastoma in children, samarium-153 to reduce pain syndrome and suppress metastasis to bone tissues in various cancers, and radium-223 for the treatment of bone metastases in patients with castration-resistant prostate cancer. The factory will also produce new radiopharmaceuticals based on carrier-added and non-carrier-added lutetium-177, actinium-225, thorium-227 and other isotopes for the treatment of inoperable metastatic forms of cancer.

Rosatom is also involved in the development of innovative radiopharmaceuticals. For example, a drug based on radium-223 developed jointly by the Research Institute of Atomic Reactors (part of Rosatom) and the Federal Research and Clinical Center for Medical Radiology and Oncology has proved safe and effective during clinical trials in the treatment of bone metastases of prostate cancer. The drug is not inferior in quality to foreign counterparts but its price is lower. **"If you take a look at the production chain of any radiopharmaceutical, you will see that Rosatom is present at its every link,"** Izotop CEO Maxim Kushnarev noted earlier in an interview to the Novy Atomny Ekspert (New Nuclear Expert) magazine.

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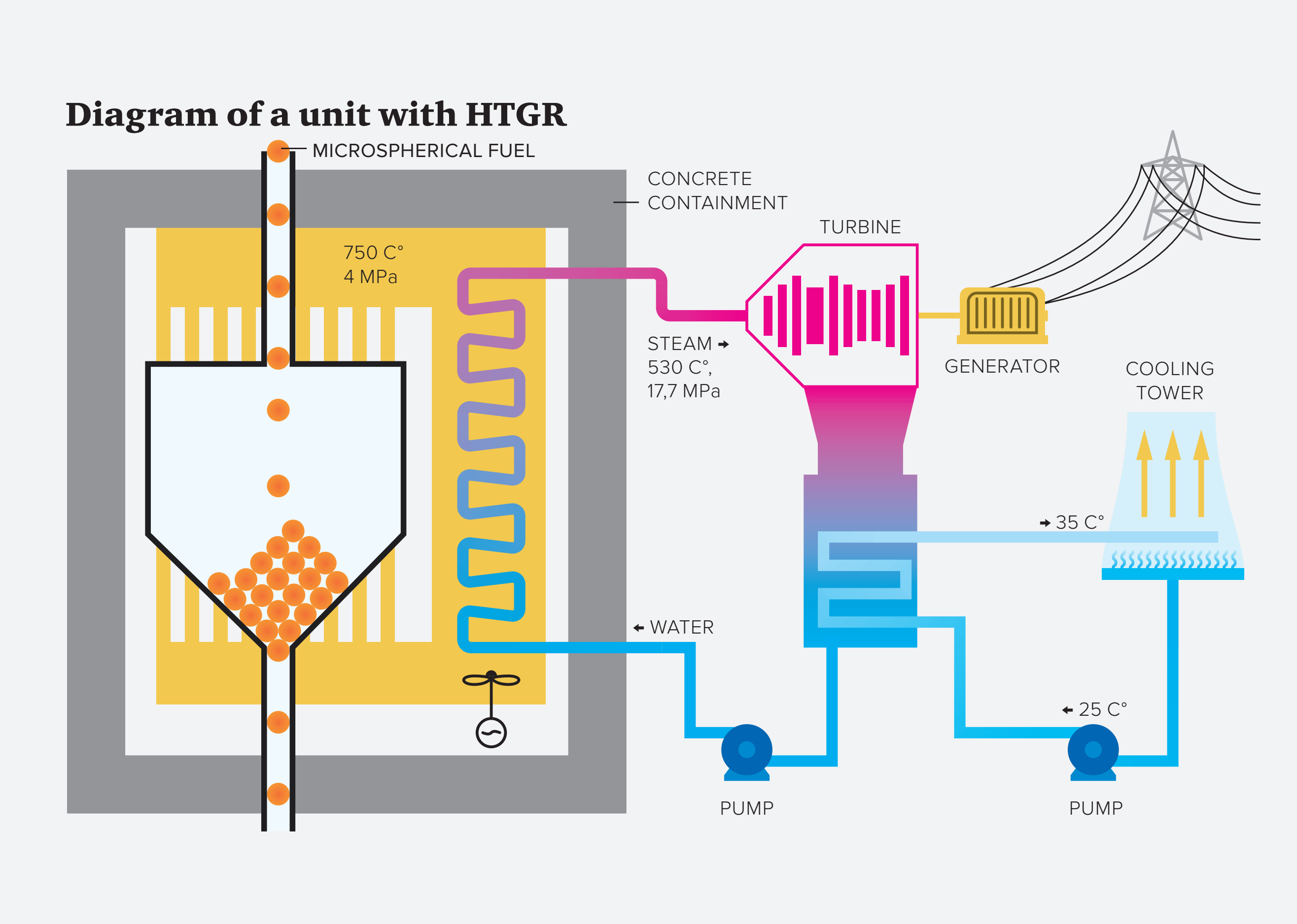

High-Temperature Gas-Cooled Reactor

Rosatom is developing a project for an engineering nuclear power station with a high-temperature gas-cooled reactor (HTGR) and a hydrogen plant. The project is a new round in the development of both gas-cooled reactors and hydrogen technology.

Background

The engineering nuclear power station (ENPS) under development has several predecessors. The first one was a Soviet-designed experimental reactor ABTU-15 and a pilot plant ABTU-ts-50 with a VGR-50 reactor. It was designed for power generation and radiation-induced modification of materials (polyethylene, wood, and others). In the 1970s, a pilot high-temperature gas-cooled reactor VG-400 was developed to generate electricity and high heat energy. This was followed by the development of modular HTGRs, such as the VGM-200 pebble-bed reactor and MVGR-GT power unit with a closed-cycle gas turbine. That was the time when Soviet engineers developed the conceptual design of a VTGR-10 small power reactor and principles of combining nuclear and hydrogen technologies, which implied the use of hydrogen produced with nuclear power as a source of energy for industry, transport and households.

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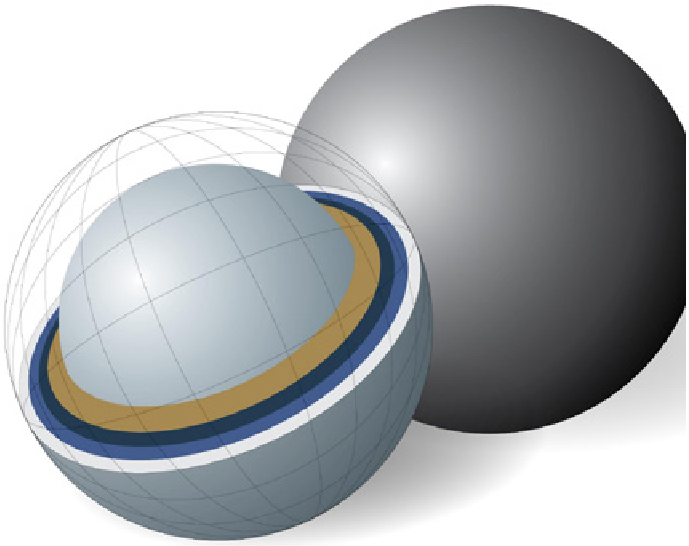
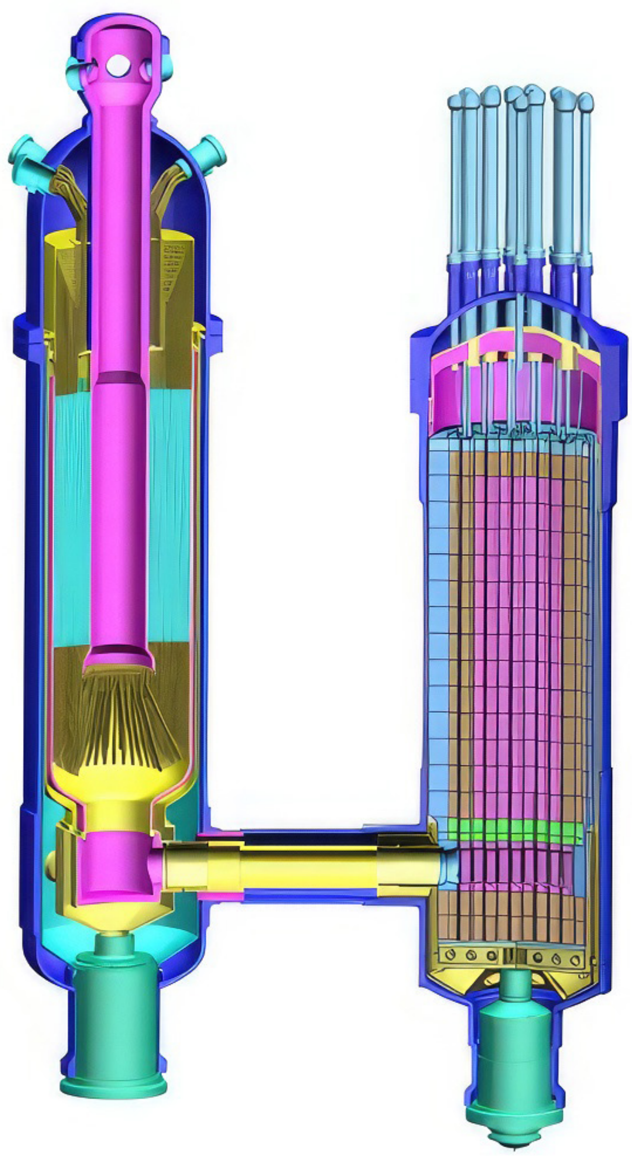
In the 1980s, the Soviet government adopted a national hydrogen economy program that provided for the development of HTGRs for energy-intensive applications and processes. For example, the VG-400 reactor design was modified for the production of ammonia fertilizers. It was planned to build five plants with HTGRs but the plans were disrupted by the fall of the Soviet Union.



However, the idea to build a high-temperature gas-cooled reactor persisted to evolve into the development of a 600 MW reactor with a direct gas turbine cycle, which was underway through 1998–2012.



General Atomics (US), Framatome (France) and Fuji Electric (Japan) participated in the development. The project revived cooperation between Russian companies and complemented their competencies.

Current status

Today, development of an advanced ENPS with a high-temperature helium-cooled reactor and a hydrogen plant is in the front end engineering design phase, with a site for the ENPS being selected. The principal difference of the current ENPS design from the previous ones is that the hydrogen production plant is made an integral part of the nuclear station. Hence, the final product of the station will be not heat but hydrogen, which can be stored, transported and sold to customers.

Engineers had to make several tough choices. For example, they decided not to use any foreign technology in the ENPS and opt for Russian technology only. For this reason, a carbon-free steam methane reforming (SMR) process was chosen instead of electrolysis as a preferred hydrogen production method.

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The SMR process has long been mastered in Russia, and the country also has plenty of both methane and water for it. Another choice to be made was whether to use an intermediate circuit for transferring heat to the hydrogen plant. It was decided for safety reasons to physically separate the hydrogen-producing and reactor circuits with an intermediate helium circuit. One of the next questions to be answered is therefore how far apart the reactor and hydrogen-producing circuits will be placed so that no accident at the hydrogen plant can damage the reactor.

ENPS parameters

It is assumed that the high-temperature gas-cooled reactor will have a thermal capacity of 200 MW. The hydrogen plant will be capable of producing 110,000 tonnes of hydrogen per year. Since the ENPS will have four HTGRs and, accordingly, four hydrogen plants, the station's total capacity will be 800 MW of thermal energy and 440,000 tonnes of hydrogen per year.

The temperature of helium will be 330 °C at the reactor inlet and 850 °C at the outlet. Fuel elements are being designed to meet inherent safety requirements: the reactor must be capable of shutting down without triggering shutdown systems, and residual heat removal from the shut-down reactor needs no external energy source or staff involvement. Another requirement is to make the reactor more powerful given the existing reactor vessel fabrication capabilities. As a result, the developers chose to use block-type fuel assemblies as fuel.

Prospects

The ENPS project is expected to be brought to the investment stage in 2024 as the technical design of the reactor unit, declaration of intent and other documents will be prepared by that time. The design and licensing stages of the ENPS project are scheduled to be completed in 2028, followed by construction of the first unit, which is expected to be completed in 2032. The remaining units are planned to be built in 2035.

Context

The engineering nuclear power station is one of the investment projects carried out by RosEnergoAtom (part of Rosatom) under the umbrella of developing nuclear and hydrogen technologies for massive hydrogen production and consumption applications. Apart from the ENPS, RosEnergoAtom develops electrolytic methods of hydrogen production with electricity from nuclear power plants. A pilot modular electrolysis plant with a 50 Nm^3/h anion exchange membrane is ready for trials. In 2025, the Kola Nuclear Power Plant plans to commission a 200 Nm^3/h testing facility for hydrogen production by electrolysis.

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Uranium Prices Climb Higher

As uranium is becoming increasingly scarce, supplies will not grow in the short term. In September, natural uranium prices increased sharply reacting to that very revelation. Let us take a look at what this may bring about.

Yesterday

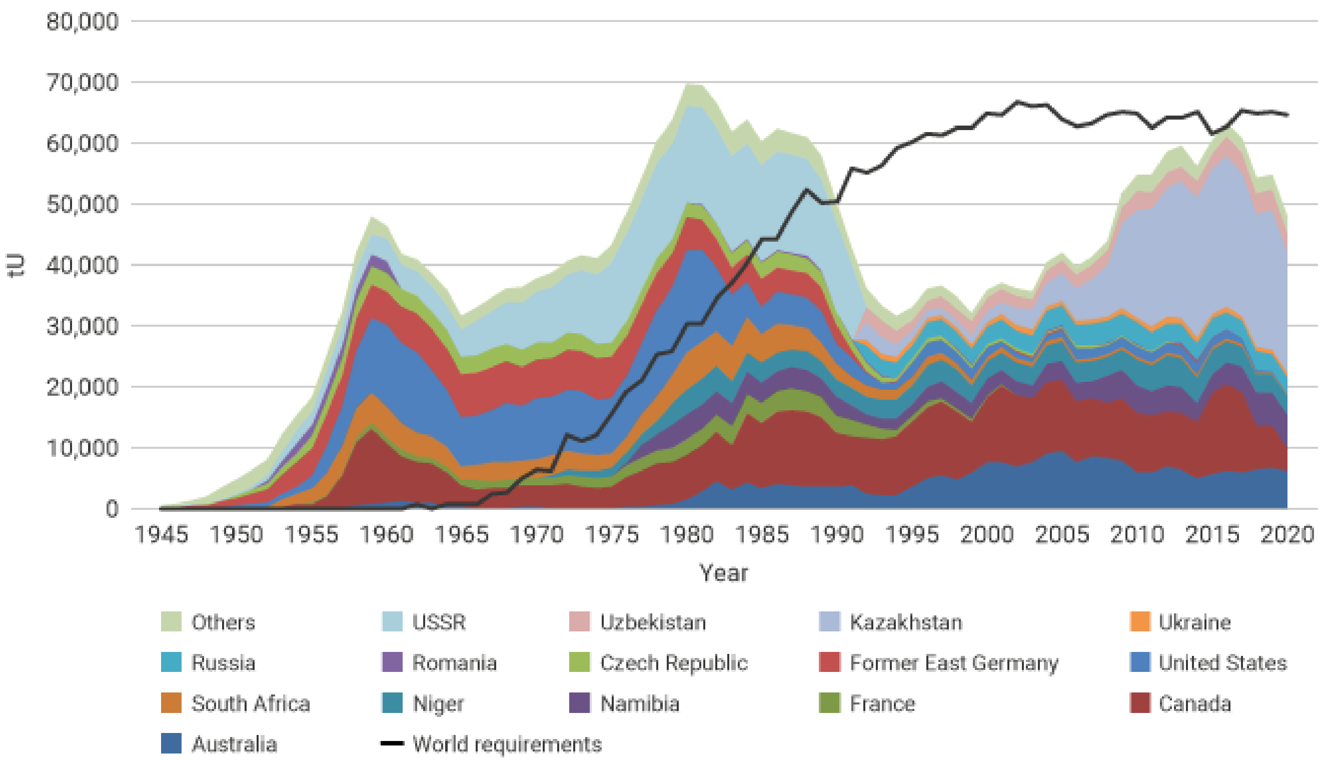
The uranium produced worldwide has been insufficient to meet the global reactor requirements for over 30 years. The primary cause of the decrease in production was the collapse of the Soviet Union, which used to be the world's largest uranium producer since around 1965. In the 2010s, production and consumption converged. According to the WNA (see Fig. 1), supplies from natural sources met 85% to 98% of uranium needs in 2013–2018, with the highest percentage reached in 2015. That year, as the prices of industrial metals were falling, the uranium price, although low, remained relatively stable, hovering around the range of about USD 34–37 per pound of U_3O_8 (USD 36.6/lb on the annual average). Apparently, on the back of shrinking demand after the Fukushima accident, the producers in Kazakhstan and Canada sought to maintain revenues by increasing supply. Then the tactics changed, and some producers cut production. The uranium output fell most drastically in Canada, from 13,100 tonnes in 2017 to 7,000 tonnes in 2018. In Kazakhstan, production fell from about 24,700 tonnes of uranium in 2016 to below 19,500 tonnes in 2020.

To be fair, the production was affected not just by the market factors, but also by the obligations to the government (production cuts in Kazakhstan were determined by the provisions of subsoil use contracts), mine depletion (COMINAK deposits in Niger and the Ranger Mine in Australia), willingness or necessity to increase output (Husab in Namibia and Four Mile in Australia), and others.

In 2021, uranium production and prices started to rise again amidst the post-COVID global recovery and, especially, growing prices for key commodities. In September 2021, the price passed the USD 40/lb mark and has never fallen below since. Global production also increased with a slight lag (47,730 tonnes in 2020, 47,800 tonnes in 2021 and 49,360 tonnes in 2022). March 2022 saw a surge in uranium prices on the back of concerns over sanctions against Russia although it quickly became clear that the situation was difficult but workable. Canada's Cameco reported logistics problems in the same year as the national rules prevented it from exporting uranium from Russian ports. The company started exporting uranium from Kazakhstan, where it co-owns and operates the Inkai mine, via the Trans-Caspian International Transport Route. However, delays were lengthy: the uranium that was supposed to arrive in Canada in the first half of 2022 did not reach the country until December.

Fig. 1. WORLD URANIUM PRODUCTION AND REACTOR REQUIREMENTS, tonnes U

Data: World Nuclear Association



For about a year — from April 2022 to April 2023 — uranium prices were quite stable, fluctuating in the range of USD 47–53/lb. Reporting its operating results for 1H 2023, Kazakhstan's Kazatomprom noted the spot market had been fairly quiet for most of April but the market activity picked up in the last week of the month, with the spot price rising to USD 53.8/lb U_3O_8. In May, expectations of increased demand from the financial sector drove the price up to USD 54.50/lb. In June, sustained demand made the spot price climb further up to USD 57.5/lb mid-month, but it then retreated to USD 56/lb by the end of the month. **"According to third-party sources, the spot market saw a significant decrease in activity year over year in the first half of 2023,"** the operating report says. In the second quarter of 2023, the plans were voiced and decisions made to refuse the supply of Russian nuclear fuel products, which worsened the market separation. In April, five countries agreed to join their efforts for reducing dependence on Russian nuclear fuel, and the US Congress was drafting bipartisan bills to ban imports of Russian uranium and introduce a domestic nuclear fuel program. Urenco approved investments to increase enrichment capacity at its US-based facility. The combination of the relatively low market activity and the reference made in Kazatomprom's report to the expectations of increased demand suggest that fear was one of the most essential factors driving the price increase in the second quarter.

This fear and the desire to be on the safe side by protecting supplies from the surprises of spot trading caused changes in the market structure. While about 12,500 tonnes of uranium was sold in the spot market and around 27,500 tonnes in the long-term market in the first half of 2022, the sales in the same period of 2023 were as little as 7,000 tonnes of uranium in the spot market and as much as 41,600 tonnes in the long-term market. Thus, the share of spot sales decreased from 31.25% to 14.4%, while the total market size increased by 8,600 tonnes or 21.5%.

Today

The uranium prices stabilized in July, but the coup d'état that occurred in Niger late that month raised fears about the possible interruption of supplies. And they did interrupt because Benin, through whose port yellow cake from the landlocked Niger is shipped, closed the border. The border closure had another consequence, namely the inability to continue uranium production due to lack of necessary chemicals. **"Given the ongoing closure of Niger's main supply corridor and diminishing stocks of chemical products, SOMAÏR, the only mining company currently with mining operations in progress, has implemented a gradual reorganization of work by bringing forward its maintenance activities,"** the French Orano, a co-owner and operator of the mine, said on September 13.

The impact of the developments in Niger on the market in August was not significant as the spot price of uranium grew from USD 56.1/lb to only USD 58.5/lb in less than a month. In early September, though, it sharply rose to above USD 60/lb and continued to climb to over USD 70/lb at the time of this writing. So, what happened?

On September 3, Cameco issued a production and market update, saying that production would drop from the previously projected 18 million to 16.3 million pounds of U_3O_8 at the Cigar Lake mine, and from 15 million to 14 million pounds at the McArthur River mine and associated Key Lake uranium mill. In total, production will drop from about 12,700 tonnes to 11,650 tonnes. **"As mining activities continued in the west pod during the third quarter, equipment reliability issues emerged which further affected performance. The mine is scheduled to enter its planned annual maintenance shutdown that will run through most of September,"** the company commented.

Even more disturbing was the comment on the McArthur River mine: **"There is continued uncertainty regarding planned production in 2023 at Key Lake due to the length of time the facility was in care and maintenance, the operational changes that were implemented, availability of personnel with the necessary skills and experience, and the impact of supply chain challenges on the availability of materials and reagents. These factors have combined to impact production at Key Lake, leading to the reduced forecast."**

Ironically, it is not a Russian company burdened with commodity, monetary and logistics sanctions, but one of the world's leading uranium miners, a Canada-based uranium supplier to European nuclear power plants (long-term contracts have recently been signed with Ukraine and Bulgaria), that is facing equipment issues and shortages of qualified personnel, chemicals and materials. And such a great company cannot straighten things out and de-mothball its flagship projects! What then can be said about other companies and mothballed facilities?

This begs the question why recognizing the problem of re-energizing uranium mines is so important.

A spokesperson for Euratom made two key points in a comment to Reuters on the situation in Niger. The first one was on the short-term situation: **"If imports from Niger are being cut, there are no immediate risks to the security of nuclear power production in the short term."** The other touched upon the long-term prospects: **"Medium and long-term, there are enough deposits on the world market."**

Cameco's press release disproved the second statement. It turned out it would not be possible to quickly set up production of U_3O_8 at the existing mines, at least in the medium term, and there are no available reserves. This is how the situation looks like, statistically and emotionally for one, and the data and emotions are the primary factors that drive the behavior of financial investors. It should be noted that Cameco has not produced more uranium than it has sold for the last 15 years at least. The minimum gap was in 2015, with 32.4 million pounds sold and 28.4 million pounds produced. The largest gap was registered in 2020 (5 and 30.7 million pounds, respectively).

In such a situation, the most reliable solution is to enter into a long-term contract with someone who surely has uranium and faces no supply problems. That this idea is reasonable was confirmed very soon. At the very end of September, Kazatomprom announced the convening of an extraordinary shareholders' meeting. One of the items on the agenda was the approval of a major transaction. The Kazakhstan company agreed to sell U_3O_8 to China's State Nuclear Uranium Resource Development Company Limited (SNURDC). The transaction has to be approved by the shareholders because **"together with the deals previously made with SNURDC, the value of this transaction is fifty percent or more of the total book value of the Company's assets."** The first deal between Kazatomprom and SNURDC was concluded in November 2021. According to the consolidated financial statements for 1H 2023, the total assets of the company make almost KZT 2.43 trillion. Given the forecast exchange rate of KZT 470 per USD adopted by the company for 2023, its assets amount to over USD 5.16 billion. For a rough understanding of the deal's size, we can take whatever price seems most likely to readers. We took USD 50/lb for our estimate. As a result, the supplies will be slightly less than 20,000 tonnes of uranium, which is almost 94% of the last year's production in Kazakhstan (nearly 21,230 tonnes of uranium).

And, of course, uranium can be bought from Rosatom. The Russian nuclear corporation

mines uranium in Russia (the country ranks fourth worldwide in terms of reserves) and develops uranium projects in other countries. Its production is quite stable, and there are plans to increase it both in Russia and abroad. Rosatom does not disclose information on its transactions due to the geopolitical situation, but indirect data shows that demand remains high.

Tomorrow

The financial sector is most interested in whether the price of uranium will rise. Western business media say it will because governments look favorably on nuclear power. However, the authors of A Critical Disconnect: Relying on Nuclear Energy in Decarbonization Models While Excluding It from Climate Finance Taxonomies from the Center on Global Energy Policy (CGEP) at Columbia University's School of International and Public Affairs (we wrote about this report in our previous issue) note that institutional investors either explicitly exclude nuclear power from their policies or fail to clarify the issue. Governments are the main investors in nuclear, but the USA has no money but a huge

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debt, as seen from the latest budget debate, and Europe's economy is either stagnant or in recession.

So, accidents at nuclear power plants and the state of economy are the two most important factors affecting the uranium market and price. We do not discuss the former, but the latter is completely uncertain for now. In March, the World Bank released a report entitled Falling Long-Term Growth Prospects: Trends, Expectations, and Policies, in which experts promised the world's economy would slow down to its lowest in 30 years: **"Nearly all the economic forces that powered progress and prosperity over the last three decades are fading. As a result, between 2022 and 2030 average global potential GDP growth is expected to decline by roughly a third from the rate that prevailed in the first decade of this century — to 2.2% a year." "A lost decade could be in the making for the global economy,"** says Indermit Gill, the World Bank's Chief Economist and Senior Vice President for Development Economics.

The IMF said this July that the world economy was recovering from the crises and global growth would be 3% this and next years. But a report released in early October this year notes that the fragmentation of the global economy could decrease the world GDP by from 0.2% to 12%. Such a high dispersion of figures is a lack of consensus in estimates, the IMF admits.

It is therefore easier to make a bet on what the uranium price will be by the end of the year. Checking on the New Year's Eve whether your bet has won is at least interesting.

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