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Atomic EEF

Committed to developing its business in the Russian Far East, Rosatom was one of the most active participants in the Eastern Economic Forum 2022. Rosatom companies signed a number of agreements, strengthened existing partnerships and mapped new cooperation pathways at the forum. These efforts aim to expand business opportunities for Rosatom and, more generally, secure the Russian presence in the global energy markets.

Northern Sea Route

Operation of the longest Russian sea lane, the Northern Sea Route, rests on three pillars: cargo, vessels, and traffic safety.

NSR is used to deliver cargoes to major Arctic mining sites producing gas and oil and, since recently, copper and gold. It is also used to transport fossil fuels and minerals (except copper until Baimsky GOK mine is put into operation) to consumers. Since early this year, eastbound routes have grown in importance for Russia.

Also earlier this year, the authority to issue sailing permits for the Northern Sea Route was delegated from the NSR Administration (a department with the Russian Ministry of Transport) to a newly established Northern Sea Route Chief Directorate (NSR CD, part of Rosatom). The Russian Merchant Shipping Code was amended to empower the NSR CD to issue, suspend and revoke sailing permits. This might be necessary if it turns out that ice is forming or weather is worsening in the area for which a vessel is heading. Information

about ice and weather conditions is collected and processed at the Maritime Operations Headquarters, another department of the NSR CD. Rosatom's goal is to make the NSR CD a one-stop shop for customers traveling on the route. In order to facilitate the exchange of information and documents and provision of services, Rosatom is working to create an integrated digital service platform that will collect, process and share essential information for the operation of NSR. This will include ice and weather conditions, upcoming voyages, escorting icebreakers, ship convoys, and others.

The Eastern Economic Forum hosted the first meeting of the NSR Navigation Council that brings together NSR stakeholders. **"Economic feasibility, comfort, and safety of traffic on the NSR are invariable values that can be fostered together only,"** Director General of Rosatom Alexey Likhachev explained the Council's goal.

Chairman of the Board of Directors at Sovcomflot Sergey Frank, who was elected head of the Council, stressed that the primary task for the coming years was to make navigation on the NSR year-round and safe. **"The beginning of year-round LNG shipments eastwards will once and for all turn the NSR into an international transport corridor,"** Deputy Chairman of the Management Board at NOVATEK Evgeniy Ambrosov reaffirmed.

New icebreakers are needed to ensure year-round, regular navigation on the NSR. Rosatom is working to achieve this goal as the third Project 22220 icebreaker, Ural, is about to join Russian nuclear fleet operator Atomflot and another two, Yakutia and Chukotka, are being constructed. The first Project 10510 (Leader) icebreaker, Rossiya, is also under construction. At present, Atomflot operates six nuclear-powered icebreakers.

Around 80 more ice-class vessels will have to be built by 2035 to ensure proper operation of the NSR. Since the existing Russian shipyards are fully booked, more shipbuilding sites are needed. Rosatom and United Shipbuilding Corporation are considering available options to improve the situation, including construction of a shipyard on the island of Kotlin in the Gulf of Finland to build large-capacity vessels.

New energy

Rosatom companies signed five agreements focusing on the development of hydrogen economy at the Eastern Economic Forum. Rusatom Overseas, which is part of the Russian nuclear corporation, made a partnership with China Energy Engineering Corporation (CEEC). The Chinese corporation has a long track record of developing energy solutions, including hydrogen projects. It became known this August that CEEC proceeded with the construction of one of the world's largest green hydrogen factories in Lanzhou, Gansu Province, worth USD 2 billion.

Shipyard made of composites

The government of Sakhalin and Umatex (Rosatom's subsidiary dealing with advanced materials and technology) signed an agreement at EEF 2022 to construct a shipyard of composite materials at the existing port infrastructure in Korsakov. The shipyard will build smaller ships, primarily fishing vessels.

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The Sakhalin hydrogen project is expected to be launched in 2025 to produce 30,000 tons of hydrogen per annum. Its capacity will grow to 100,000 tons per annum by 2030. Hydrogen will be liquefied and transported from Sakhalin to China in tanks. **"CEEC is interested in the full-on participation in our project as a developer, technology vendor and consumer. Taking into account recent changes in the partnership structure, it is essential for us to define a new configuration of the project,"** President of Rusatom Overseas Evgeny Pakermanov explained in an interview for the Strana Rosatom newspaper. He did not rule out that hydrogen would be supplied to Japan, South Korea, and Vietnam.

Other documents signed at EEF

- Rusatom Overseas and the Khrunichev State Research and Production Space Center signed a cooperation agreement that provides, among other things, for the supply of rocket fuel hydrogen to the Vostochny Cosmodrome.
- Rusatom Overseas and the Moscow Institute of Physics and Technology agreed to join efforts in the development and deployment of equipment and engineering solutions in the field of hydrogen technology.
- Rusatom Overseas, GAZ Group and Russia Moscow Compressed Natural Gas partnered to study the prospects of hydrogen transport projects in Russia.
- Rusatom Overseas and VEB Infrastructure signed an agreement on cooperation in hydrogen projects.
- Rosatom, the Ministry of Science and Technology and the Ministry of Electric Power of Myanmar signed an agreement on cooperation in peaceful uses of nuclear power for 2022–2023. The agreement provides for the possibility of constructing an SMR in Myanmar, staff training and building positive public attitudes to nuclear energy.
- The Ministry for the Development of the Russian Far East, Ministry of Natural Resources and Environment, Government of Sakha (Yakutia), and Rosatom agreed to develop a regional mining cluster powered by an SMR. The cluster will comprise Kyuchus, Deputatskoye and Tiretyakh deposits, infrastructure, utilities, public amenities, and power transmission lines.
- Rusatom Additive Technologies and the Far Eastern Federal University (FEFU) signed an agreement to establish the first shared access additive center at FEFU.

Fishing With Nuclear Touch

In early September, Rosatom organized the second international fishing tournament in the Gulf of Finland near the Leningrad nuclear power plant. Anglers from nine Rosatom's partner countries came to Russia to try their hand at fishing near nuclear power plants.

Fishing in water reservoirs near nuclear power plants and angling tournaments there is a commonplace for the employees of Russian nuclear companies. **"Rosatom has been organizing fishing tournaments at nuclear station reservoirs for over 10 years,"** says President of Rusatom International Network Vadim Titov. Those who work in the nuclear industry do not need to be convinced that fish is safe but, unfortunately, the people clueless about nuclear technology spread baseless rumors. The tournament was organized to dispel those myths. Its organizers, Rusatom International Network and RosEnergoAtom (Rosatom NPP operator), contacted angling associations in different countries to invite both professional anglers, who earn their living by fishing, and amateurs.

First held in 2019, the tournament in Sosnovy Bor was attended by anglers from Hungary, Egypt, India, Bangladesh and Turkey. The organizers planned to make it annual, but the pandemic came into play and the tournament was postponed until this year. The second tournament was reinforced with teams from South Africa, Uzbekistan, Kazakhstan and Armenia. Russia was represented by employees of the Leningrad NPP and Titan-2 (part of Rosatom). Thirteen teams of two anglers each competed in the tournament.

Every contender had their own reasons for taking part in it. For example, Laszlo Kern studied veterinary medicine in Voronezh, visits Russia often and has been into fishing since childhood. **"I heard about the Leningrad NPP tournament from my cousin who took part in it three years ago. It would be interesting to fish in the Gulf of Finland, on a vast territory. We have only a river and small lakes in Hungary — there are no great spaces like here,"** he said before the tournament.

Egyptian team leader Abdel Naser Abdel Latif takes part in Rosatom's tournament for the second time. **"I have come with a team this time. I wanted to show my teammates the town that is home to a nuclear power plant similar to El Dabaa and how people live there. We are glad to visit the Leningrad NPP — this is an excellent experience for us. The plant is totally safe, and we are sure that El Dabaa will be no less safe."**

Vladimir Tegai, a member of the Uzbekistan team, has a professional interest in the

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Leningrad NPP. **“A nuclear power plant is a tremendous facility in terms of technological complexity. I have seen how the LNPP works and what its safety systems are. It was very insightful for me as a manager of an industrial automation company.”** At present, Rosatom and Uzbekistan authorities are discussing the possibility of building the country’s first nuclear power plant with VVER-1200 reactors. These power reactors operating at the LNPP have proved to be safe and reliable and exemplify advanced Russian technologies that Rosatom exports to other countries.

The tournament was organized in a format adopted by the Pro Anglers League — spin fishing from the boat. The moon played some havoc: by the time the tournament began the tide had been ebbing for ten days and the water level in the gulf decreased by a meter and a half. The anglers had to sail further away from the shore as fish had followed its food going deeper. Each team of two was accompanied by a Russian referee who helped them and watched that the rules were observed. The referees sailed the boats and helped those who had not done spin fishing before.

The contenders caught 203 fish with a total weight of 7 kg. The largest fish was a 500-gram pike caught by a contender from India. He received the Biggest Catch award. The fish caught was not only weighed but also tested for radioactivity. **“All the fish caught were analyzed for radiation. We made sure that the level of radioactivity was within permissible limits,”** says Levent Atalay from the Turkish fishing team. The fish was then released back into water.

“We attach great importance to events like this one because they give us a chance to show that nuclear is a source of clean energy and that nuclear technology and nature complement each other. We are glad to see that our guests from nine countries could see for themselves that clean fish lives in close proximity to the nuclear power plant that has been in operation for almost half a century,” Vadim Titov said.

The team from India won the tournament with a total catch of 1,462 grams. One of the winners, Santosh Jaiswara, is a YouTube blogger making videos about fishing in India, Bangladesh and Sri Lanka. He also filmed a video about fishing in the Gulf of Finland. The team from Egypt came second. The joint Russian-Egyptian team won the third prize.

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Engineering Edge

Rosatom is ranked first worldwide in terms of power reactors currently constructed abroad and the backlog of orders for nuclear power plants. Nuclear engineering and construction are the domain of Rosatom's engineering division. Let us give it a closer look.

Engineering competencies of the division are localized in AtomEnergoProekt, a multi-faceted organization that comprises engineering centers in Moscow, Nizhny Novgorod and Saint Petersburg, research institutes and other business units in Russia and abroad. The engineering division also includes AtomStroyExport (offices in Moscow and Nizhny Novgorod, and international subdivisions) and construction subsidiaries.

The division receives around 80% of its revenue from overseas projects. The companies affiliated with the engineering division provide EPC, EP and EPCM services (for details see the Definitions section below). In Russia and other countries around the globe, they design and build nuclear power plants with VVER-1000 and VVER-1200 reactors, take part in the development of fast neutron power reactors, and are engaged in the Proryv (Breakthrough) Project. The division also develops Multi-D branded software products for the management and operation of complex engineering facilities.

Engineers and researchers of the division have developed the design of a nuclear power plant with VVER-1200 reactors, Rosatom's flagship product in the large NPP segment. Its safety is enhanced with passive systems that remove decay heat from the steam generators

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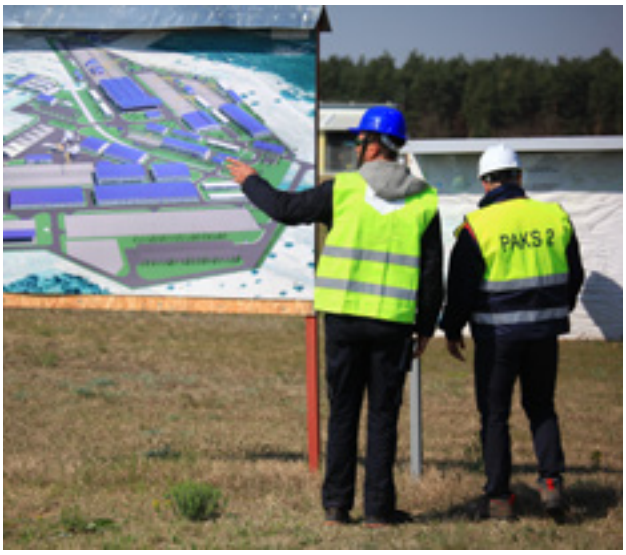

and containment shell and can maintain stability and integrity of a nuclear reactor for an almost unlimited period of time.

Four reactors of this type are under construction in China, at Tianwan and Xudabao nuclear power plants. According to the contracts, Russian companies develop the design of nuclear islands, supply core equipment, and provide design supervision, installation and commissioning services. The Tianwan nuclear power plant has four Russian-designed VVER-1000 reactor units in operation.

In India, two VVER-1000 reactors built to the Russian design operate at the Kudankulam nuclear power plant. Another four reactors are currently under construction. First concrete was poured for Units 3 and 4 in June and October 2017 and Units 5 and 6 in June and December 2021, respectively. To date, a reactor pressure vessel has been installed and nuclear island equipment assembled at Kudankulam Unit 3. Meanwhile, preparations are underway for the installation of a reactor pressure vessel at Unit 4. Installation of oversized equipment at Units 5 and 6 will begin in 2023.

In Bangladesh, Rosatom is building the country's first nuclear power plant Rooppur, which will feature VVER-1200 reactors. Construction of the first unit was officially kicked off in November 2017, followed by the second unit in July 2018. At present, large-size equipment is assembled and installed at both units. In October 2021, a reactor pressure vessel was installed at Unit 1.

In Egypt, the companies affiliated with Rosatom's engineering division began construction of El Dabaa NPP. This July, first concrete was poured for the basemat of Unit 1. Production of equipment for the plant started, too, running in parallel with the training of Egyptian staff. In August, a reputable vendor — Korea Hydro and Nuclear Power (KHNP, South Korea) — joined the project and signed a contract with AtomStroyExport for the construction of turbine islands. The official start of construction works at El Dabaa Unit 2 is scheduled for November. There will be a total of four reactors, and each of them will have a service life of sixty years.

Progress at Paks II (Hungary) is no less substantial. In late August, the national regulator issued a permit to build two units with VVER-1200 reactors. The construction license confirms that the new reactors meet Hungarian and European safety standards. In particular, Paks II will feature advanced active and passive safety systems, a double reinforced concrete shell, and a core catcher. First concrete is expected to be poured next October or November.

In Belarus, the work is underway to commission the second unit of the country's first nuclear power plant. The first VVER-1200 reactor is already online: it was connected to the national grid in November

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2020 and put into commercial operation in June 2021.

AtomEnergoProekt also prepares technical documents for the Akkuyu nuclear power plant in Turkey. In July 2022, first concrete was poured for Akkuyu Unit 4, so all the four reactors of the plant are in the construction phase. A core catcher, a reactor pressure vessel, steam generators, and main circulation pumps have already been installed at Unit 1, and welding of the primary coolant pipeline finished. At Unit 2, a core catcher and an RPV were emplaced, while foundations of the turbine and nuclear islands were concreted and a core catcher installed at Unit 3.

In Russia, Rosatom's engineering division builds two innovative VVER-TOI reactor units at Kursk II, and develops technical documents for Leningrad Units 7 and 8 with VVER-1200 reactors and a BN-1200 fast neutron reactor to be built at the Beloyarsk nuclear power plant.

The new reactors planned to be constructed at Kursk II will replace four operating RBMK-1000 reactors scheduled for shutdown. At the first unit of Kursk II, a containment dome has been installed to date and welding operations started on the primary coolant pipes. Installation of the cylindrical part of the containment shell has been completed at Unit 2.

Logging operations have started on the site of Leningrad Units 7 and 8 ahead of schedule. The new units are expected to be brought online in 2030 and 2032, respectively. They will replace Units 3 and 4 with RBMK-1000 reactors, which are to be decommissioned by then. NL

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Definitions

EPC is a contract that provides for engineering (research, design and GR), procurement (selection and purchase of materials and equipment) and construction (installation, assembly and commissioning) services.

EPCM is a construction contract under which the contractor acts as the customer's agent in selecting subcontractors and suppliers and negotiating terms and conditions of services. The contractor supervises the construction process but does not carry out construction works.

EP is a contract that provides for engineering and equipment procurement services.

Words Without Deeds

The World Nuclear Association published its World Nuclear Performance Report 2022, in which it reviews changes and developments in the global nuclear industry in 2021. The most interesting thing in the report is not statistics but rather conclusions made by WNA Director General Sama Bilbao-y-Leon. She blames the global community for its insufficient efforts to increase the share of nuclear in the global energy mix.

Nuclear statistics

Nuclear reactors produced 2,653 TWh of electricity in 2021. The figure is high — power generation has been higher only twice in the history of nuclear energy, in 2019 (2,657 TWh) and 2006 (2,660 TWh). After a sharp decline in 2012 on the back of Japan shutting down its power reactors after the Fukushima disaster, the subsequent nine years showed an unequivocal upward trend.

However, the growth in nuclear generation was not even across geographies. Electricity output rose at nuclear power plants in Russia, Asia, Africa, South America and Eastern Europe. The situation in Central

and Western Europe was different, though: **"Generation also increased in West and Central Europe, but in this region the overall trend remains downward. Generation declined for the second year running in North America as more reactors in the USA were closed."**

What is Proryv

Proryv (Russian for breakthrough) is Rosatom's project that provides for the establishment of an integrated nuclear power facility that will consist of a nuclear station and a nuclear fuel reprocessing and refabrication unit. Proryv aims at ultimate removal of all radioactive wastes from the fuel production and disposal cycle. The integrated facility will contribute to a number of goals:

1. Eliminating nuclear plant accidents that require evacuation, no less resettlement of local residents;
2. Making nuclear competitive with combined-cycle power plants, wind and solar based on LCOE;
3. Closing the nuclear fuel cycle to maximize the use of energy contained in natural uranium;
4. Learning to turn nuclear waste into a substance equivalent to naturally occurring radioactive materials;
5. Strengthening non-proliferation through technology improvements, including abandonment of uranium enrichment for nuclear power generation, production of weapons-grade plutonium in the blanket and separation of plutonium during spent fuel reprocessing, as well as less need to transport nuclear materials.

In terms of generation capacity, the situation is also ambivalent. On the one hand, total installed capacity of operating nuclear power plants (including those shut down but not decommissioned) increased to 370 GWe in 2021, up 1 GW year-on-year to a record high in the history of nuclear generation. On the other hand, the number of power reactors decreased by five to 436 in the same period. According to the report, around 70% of them are pressurized water reactors (PWR).

Nuclear capacity utilization in 2021 stood at an average of 82.4% globally (80.3% in 2020), having remained flat at around 80% since 2000. It might differ from region to region, but in each of them the capacity factor remains at about the same level as in the previous five years. **"There is no age-related decline in nuclear reactor performance. The mean capacity factor for reactors over the last five years shows no significant overall variation with age. Improvements in average global capacity factors have been achieved in reactors of all ages, not just new reactors of more advanced designs,"** the report says.

In 2021, six new reactors went online. Most of the nuclear power plants worldwide are now 30 to 39 years old although the share of young (less than 10 years old) reactors began to grow after a setback in the second half of the 2000s. In 2019, some of the operating nuclear power plants passed 50 years' milestone for the first time ever.

In 2021, first concrete was poured for eight large power reactors, and construction of two SMRs started. One of them is a Russian-designed 300 MW lead-cooled fast neutron reactor BREST-OD-300. That was the only first concrete poured for a fast neutron reactor last year. BREST belongs to the Proryv Project (for details see What is Proryv below).

In 2021, ten reactors were shut down for good. **"The three German reactors and the one Taiwanese reactor were closed as a result of a political decision to phase out nuclear generation,"** the report notes.

Atom discussed, coal used

In the closing remarks to the report, Sama Bilbao-y-Leon commented on some key events of 2021 and, more importantly, outlined all major trends of the first half of 2022.

She stressed, among other things, that nuclear energy prevented emissions and thus contributed to sustainable future: **"Every additional megawatt-hour of nuclear generation helps in the fight against climate change and every reactor helps provide secure and reliable electricity."**

The trend of paramount importance is a growing recognition of the nuclear's role in decarbonization. **"On the floor of the conference hall nuclear delegates, including a fantastic delegation of Nuclear4Climate representatives, sensed that nuclear energy was being embraced as a vital part of climate change action to a much greater extent than only a few years ago. While I was in Glasgow it seemed that a day didn't go by without a major announcement from one of our member companies, or another government committing to nuclear energy as part of their climate change mitigation strategy,"** Sama Bilbao-y-Leon recalls.

The second trend is disruption of supply chains: **"The fragility of the fossil fuel supply chain has been made plain. Fossil gas prices have sky-rocketed, and with them so have electricity prices. Worse may be yet to come, as electricity and heating demand is expected to rise later in the year as the Northern Hemisphere moves into winter."** It should be noted the prices surged on the back of immense sanction pressure on Russia and a ban on Russian energy imports to Europe. With more bans coming, supplies become even less reliable.

This is what sets off the recognition of atom's growing role in achieving the net-zero goal — the nations are concerned about the most affordable fuel rather than construction of new power reactors. **"The harsh reality is that, despite this enhanced commitment to nuclear and other low-carbon technologies, the growth in energy demand seen as the global economy began to recover from the COVID-19 pandemic was primarily met through an increase in the use of fossil fuels,"** the WNA Director General laments. She noted that national governments faced the challenge of securing energy supply for their countries right there

First and fast

Russia is a global leader in fast reactor technology. Apart from the Proryv Project with its lead-cooled fast neutron reactor BREST-OD-300, Rosatom is building an unparalleled multi-purpose fast neutron research reactor MBIR. Russia is the only country operating two sodium-cooled fast neutron reactors — BN-600 and BN-800 — at the Beloyarsk nuclear power plant. In September, BN-800 was fully loaded with mixed oxide (MOX) fuel. A more powerful sodium-cooled BN-1200 reactor (1,200 MWe) is currently under development.

and then, despite geopolitical headwinds. Coal-fired power plants are brought back to life in Germany, Austria, Netherlands and the UK, while construction of new coal capacity in India and China stepped up pace **"We have actually seen a rebound for fossil fuels. And long-term plans for a more secure low-carbon future are having to wait in line behind short-term shifts to any energy form available, clean or dirty."**

By contrast, nuclear power plants that contribute to carbon-free generation and can produce clean energy are shut down for political and economic reasons. Sama Bilbao-y-Leon cites as an example the US Palisades Nuclear Generating Station that has obtained an operating license untill 2031 and could have worked for some more years. Another example is Germany whose nuclear power plants are little more than 30 years old, but all of them were closed solely for political reasons. **"At a time when every kWh of clean secure energy is precious, and extending the operating lives of existing nuclear plants should be incentivized, misguided political dogma is making things worse,"** the head of the WNA claims.

In 2021, many countries announced their plans for new reactors. However, as Sama Bilbao-y-Leon points out, **"we need to lay down human, physical, commercial and institutional infrastructures that will allow the global nuclear sector to truly scale up fast to meet the urgent and massive decarbonization needs."**

Investments in new projects showcase how different countries are actually prepared to increase nuclear generation. The WNA report contains data on investments in national nuclear programs in six countries.

For instance, the USA allocated USD 6 billion for its Civil Nuclear Credit Program under the Investment and Jobs Act. In addition, in April 2022 the Japan Bank for International Cooperation provided USD 110 million in financing for the US-based NuScale Power developing SMRs.

The Swedish Energy Agency disclosed plans to allocate SEK 99 million (USD 10.6 million) for a joint venture between Uniper Sweden and LeadCold. The money will be used to finance the construction of a demonstration LeadCold SEALER (Swedish Advanced Lead Reactor) lead-cooled small modular reactor. It is expected to be built at the Oskarshamn plant.

In May 2022, the government of Belgium announced that the Belgian Nuclear Research Center (SCK-CEN) would receive EUR 100 million to finance research into small modular reactor technology.

In December 2021, the Dutch government included nuclear in its national climate and energy strategy and announced plans to build two new reactors. About EUR 5 billion will be allocated for a new nuclear power plant until 2030.

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France unveiled plans to build six European Pressurized Reactors (EPR) and considers the construction of another eight EPRs and also a number of SMRs as part of the Energy Futures 2050 study. Exact investments have not been defined yet. Earlier, President of France Emmanuel Macron talked about 'some tens of billions of euros.'

Finally, in March 2021 Akkuyu Nuclear (part of Rosatom) obtained two loans from Sovcombank for USD 100 mln and USD 200 mln to finance construction of the same-name nuclear power plant. In addition to the two loans mentioned in the report, Akkuyu Nuclear signed a USD 500 mln non-revolving loan agreement with Bank Otkrytie in April of the same year. As our readers know, Rosatom is building Turkey's first nuclear power plant consisting of four VVER-1200 reactors, all of which are under construction now.

> Around USD 3 trillion needs to be invested in nuclear energy in the next 30 years to achieve global climate goals, IAEA Deputy Director General Mikhail Chudakov said at the Russian Energy Week.

Curiously enough, a reverse example can also be found internationally, with money not given to but withdrawn from nuclear power plants. **"In October 2021 it was announced that profits from the Kozloduy nuclear plant would be redirected to provide subsidies of EUR 56 per MWh to industrial customers. The measure was taken to protect industry from power prices driven by gas and coal,"** the report says.

Can the current state of affairs in the nuclear industry be called satisfactory? Sama Bilbao-y-Leon believes the existing pace of development is too slow. **"The pace of new nuclear construction must increase. In 2021 first concrete was poured for ten new reactors. Although that is better than in recent years, we still need to see twenty, thirty or more new reactor construction starts per year soon, to ensure that nuclear energy plays the role it should in delivering a secure and sustainable net-zero future."**

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