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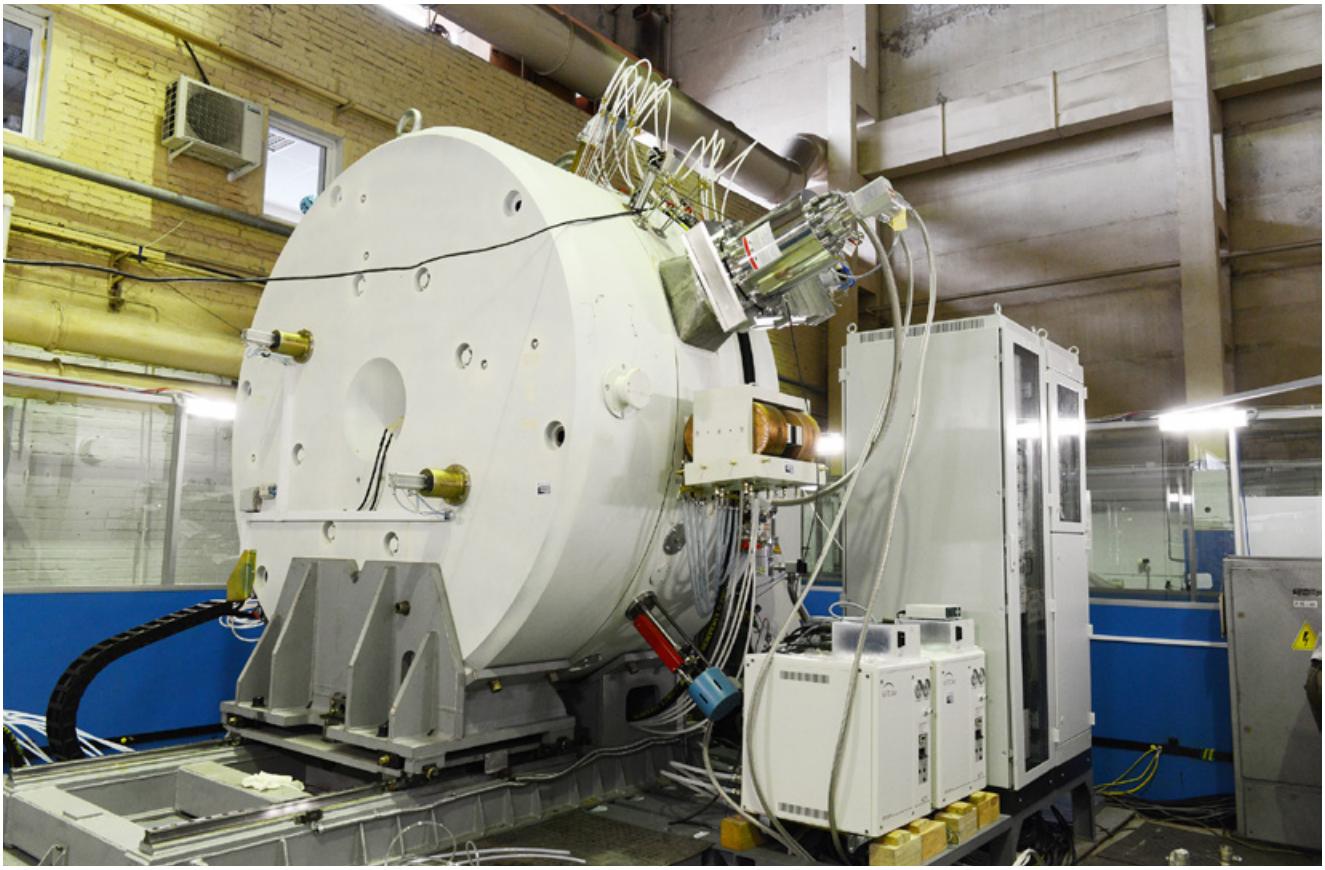

Royal Cyclotron

In July, Rosatom's Efremov Research Institute shipped 120 tonnes of equipment for a cyclotron radiochemistry facility in Thailand. It will be used to fabricate medical isotopes and conduct research.

The equipment supplied by Efremov Research Institute (see the information below) is needed to construct a Model CC-30/15 cyclotron. The cyclotron is a central component of the radiochemical facility built by Rusatom Healthcare (Rosatom's medical project integrator) and Kinetics Corporation Lt. in Nakhon Nayok Province.

Before the shipment, the equipment passed acceptance tests with experts of Efremov Institute confirming its operability. The capacity of the equipment turned out to be higher than designed, with three times higher beam current stability and two times higher beam intensity.

The compact multi-purpose isochronous cyclotron CC-30/15 will be used to accelerate negatively charged ions of hydrogen and deuterium and will have an ability to control the final energy of accelerated particles within the range of up to 30 and 15 MeV, respectively. Similar cyclotrons are produced in Belgium and Canada. However, they are horizontal and need a 10x10 m site. The Russian cyclotron is positioned vertically and only take up 6x7 m space. It is distinguished by an external injection system that increases the beam intensity considerably, maintains high vacuum and reduces radiation exposure during operation.

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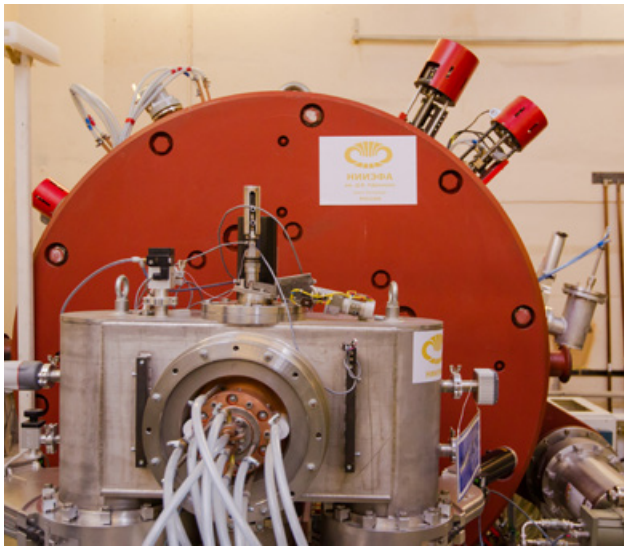
The radiochemical laboratory, which is part of the cyclotron facility, can synthesize radiopharmaceuticals for accurate diagnostics and treatment of a wide range of diseases, particularly cancer and cardiovascular conditions. The cyclotron facility can also serve as a research and development platform for new medical radionuclides.

It gives scientists an opportunity to study property changes in materials (in particular, semiconductors) under the influence of proton, deuteron and neutron beams, radiation corrosion of materials, radiation stability of radioelectronics and the structure of neutron-excessive nuclei, as well as to perform neutron activation analysis.

"Extracted proton beams are used in the radiation material science for proton doping. Apart from that, the facility allows for X-ray spectroscopy of historical artifacts to trace their origin. Today, fakes are often claimed to be antiquities and priced much higher than they really cost," Yuri Gavrish, Director of the R&D Center for Linear Accelerators and Cyclotrons at Efremov Research Institute, explained.

He added that the cyclotron project was very important for the institute. "We make ourselves known in Southeast Asia. It is a very promising market: if a country has a new technology, its neighbor wants to have the same. Much interest to radiochemical facilities is paid in Malaysia and the Philippines," the scientist noted.

Rosatom has also trained the operation, maintenance and production personnel for the under-construction facility. The staff was instructed by scientists and researchers from the National Nuclear Research University



(MEPhI), Efremov Research Institute, Rusatom Healthcare, radiopharmaceutical manufacturer BIONT (Slovakia), and Granov Russian Research Center for Radiology and Surgical Technologies. They studied theoretical aspects of accelerators and the production technology for radiopharmaceuticals based on Cu-64, Zr-89, Tl-201 and Ga-67 isotopes.

"We formed a highly qualified team consisting of young and experienced researchers to develop a design for the new cyclotron facility. They proposed a number of innovative technological, engineering and scientific solutions. It is a great step forward in the development of cyclotron technology. We have entered the ranks of leading global manufacturers of particle accelerators," Yuri Gavrish said.

The contract for the construction of a cyclotron radiochemical facility for Thailand Institute of Nuclear Technology was signed in September 2017. The facility was meant to use technology solutions developed by Rosatom and its group companies. This is the second CC30/15 cyclotron designed and produced at Efremov Research Institute. The

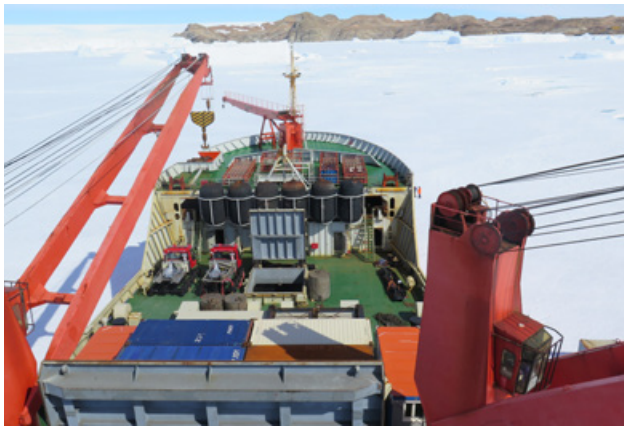
first one was manufactured in 2009 for the University of Jyväskylä (Finland).

Since then, it has been upgraded. For the new cyclotron, scientists of Efremov Institute have developed automatic targets that make it possible to fabricate radioisotopes, transfer them for reprocessing, and simultaneously monitor the radiation level in the premises. The control system has also been upgraded.

The cyclotron equipment is expected to arrive in Thailand this September.

What is Efremov Research Institute?

Efremov Scientific Research Institute of Electrophysical Apparatus is a leading engineering and production center in Russia. It develops electrophysical installations and facilities for research in plasma physics, nuclear physics, particle physics, healthcare, radiation and energy technology, and introscopy.



Russia and Norway Join Efforts to Clean Up Arctic

Improving nuclear and radiation safety in Northwest Russia was a key topic at the 23rd meeting of the Joint Norwegian-Russian Commission on Environmental Protection. Representatives of Rosatom reported on the Arctic cleanup initiatives.

Norway helps Russia to dispose of its nuclear legacy by financing cleanup projects in the Arctic regions of Northwest Russia. **"For Norway, cooperation with Russia in the field of nuclear and radiation safety is a priority. We have achieved a lot in 25 years,"** Audun Halvorsen, State Secretary to the Norwegian Ministry of Foreign Affairs, admitted in his speech at the meeting opening.

Anatoly Grigoriev, the international remediation project manager from Rosatom's Center of International Projects and Programs for Radioactive Waste, Spent Nuclear Fuel and Nuclear Decommissioning, supported Mr. Halvorsen's views.

Grigoriev said that almost all spent fuel has been already removed from the decommissioned nuclear submarines.

Radioactivity of the Lepse service ship went down from 540,000 Ci to 20,000 Ci in 2020 after the removal of damaged fuel assemblies began in the autumn of 2019. The assemblies were kept on board Lepse for many years while she was berthed and decommissioned gradually at an Atomflot naval base after an accident in 1984.

Special facilities have been built at the submarine bases in the Sayda, Andreev and Gremikha Bays to handle radioactive waste and spent nuclear fuel, and rehabilitate nearby territories.

Sayda is a new repository intended for the long-term storage of reactor compartments and service ship parts in special casks. At present, there are 121 casks with submarine reactor components and six casks containing service ship parts. With a total storage capacity of 178 casks, the repository is expected to handle 820 cubic meters of solid nuclear waste in 2020. Besides, Sayda-based facilities are used as a decontamination site for steel, which is then sold as clean scrap.

The aggregate radioactivity of waste kept at the Andreev Bay shrank by one third. After the removal of 7,500 fuel assemblies for disposal, radioactivity fell by about 1 million Ci as compared to 2017. In 2019, more assemblies were removed, with their total radioactivity amounting to 400,000 Ci. Another challenge — extraction of six damaged fuel assemblies from the fuel pool — was accomplished: they were placed into casks and are ready for the transportation to the storage site outside the Murmansk Region.

Almost 900 spent fuel assemblies and 744 cubic meters of radioactive waste were removed from the Gremikha Bay, which used to be a storage site for 11 liquid metal cooled reactors from nuclear submarines. Seven cores were completely disassembled, while another four still remain on the site. It takes one year to dispose of a single reactor core because of high radiation exposure, making it impossible to speed up the process. The work is expected to be completed in 2023.

"We are proud that, together with Norway, we have removed 251 out of 1,000 RITEGs from the Russian coastal territories. No nuclear hazards [RITEGs] are left on the coasts of the Murmansk, Arkhangelsk, Leningrad and Kaliningrad Regions — all nuclear facilities have been replaced with safe sources of power," Anatoly Grigoriev said.

The goals for a period until 2027 are to remove nuclear fuel from the facilities in the Arctic regions of Northwest Russia, complete the disposal of nuclear submarines, nuclear icebreakers and service ships, and proceed with active rehabilitation of the territories. **"Taking into account our positive experience, we are likely to succeed in**

solving these tasks," Anatoly Grigoriev said at the end of his speech.

Another important task to be solved by both countries is the elimination of sunken vessels and other items. All relevant preparations have been completed by now.

A feasibility study for the safe handling of submerged nuclear items was finished in 2020. For four years that have passed since the signing of a contract between the European Commission and Italy's Sogin, an international team of experts has created a database of sunken vessels and other nuclear items, rated them by degree of hazard, estimated the cost of disposal and prepared a time schedule for the project.

In 2019, the document was discussed at several international conferences. The conclusion is that such hazardous nuclear items should not be left for the next generations and need to be removed and brought to a safe condition. Total radioactivity of nuclear submarines sunken in the Barents and Kara Seas is 1 million Ci. According to Russia's preliminary estimates, they can be removed within 12 years.

As stated by Oleg Kryukov, Rosatom's Director for Public Policy on Radioactive

Waste, Spent Nuclear Fuel and Nuclear Decommissioning, lifting these objects from the sea bottom is an extremely difficult task never undertaken anywhere in the world before. Rosatom is considering different cooperation options, technologies and ways of building a suitable vessel. **"Safety and environmental impact will always be a top priority. The most important thing is to have zero accidents during such activities,"** Oleg Kryukov stressed.

Recapping the work of the Commission, Oleg Kryukov concluded that he was fully satisfied with its results and deep understanding between Russia and Norway striving for a common goal of improving environment in Northwest Russia. NL

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Mining Future Belongs to VNIPIpromtechnologii

Next year VNIPIpromtechnologii will celebrate its 70th anniversary. Its name is roughly translated from Russian as the Leading Engineering and Research Institute of Industrial Technology. It used to engineer uranium mining and production facilities. At present, the institute develops engineering designs for Russian and foreign mining plants.

VNIPIpromtechnologii was established on 17 April 1951. Back then it was called State Construction and Design Institute No. 14. Its primary task was to design uranium ore mining and production facilities and other nuclear-linked mining plants.

Uranium deposits in the Soviet Union were discovered in the late 1940s in the Fergana Valley (present-day Tajikistan), near Kryvyi Rih (Ukraine), in Kyrgyzstan, Northwest Russia (particularly Chukotka), and Zabaykalsky Krai. The country needed to mine and process uranium ore and needed new facilities for this purpose.

Mining

The first production facilities designed by State Construction and Design Institute No. 14 were a mining plant and a hydro metallurgical plant at the Zhovti Vody deposit (Ukraine).

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The plants began mining uranium ore and producing uranium as soon as 1959. In what is now Uzbekistan, State Construction and Design Institute No. 14 designed production facilities for the Severnoye Mining Department at the Uchquduq deposit. In January 1959, the institute issued terms of reference for the development of the Uchquduq deposit. They provided for 11 open pits and 14 mine fields to combine open-surface and underground mining methods. The institute also designed a solvent-in-pulp uranium extraction process for the Lermontov Hydro Metallurgical Plant (Stavropol Krai). The institute also acted as a general designer for the Priargunsky Mining and Chemical Plant (now Priargunsky Industrial Mining and Chemical Union, part of Rosatom) at the Streltsovskoye deposit. In the 1960s, the institute was the first in the Soviet Union to develop an in-situ leaching process, which proved to be the most environmentally friendly and cost efficient. Over the years, VNIPIpromtechnologii designed nearly 70 mining plants and facilities.

Along with mining plants, it has designed auxiliary infrastructure, including mechanical repair shops, vehicle repair facilities, thermal power plants, boiler plants, internal and external utility systems, communication lines, automated storage facilities, and even towns and villages.

As the years went by, the institute extended the scope of its activities to go beyond nuclear-related minerals (uranium, beryllium, lithium, etc.). It started developing designs for gold and polymetallic ore mining and processing plants. One of them is Navoi Mining and Metallurgy Plant that produces gold from ores coming from the world's largest gold deposits, including Muruntau, Pokrovskoye, Mnogovershinnoye, Udokan and Nezhdaninskoye.

At present, VNIPIpromtechnologii continues providing expert supervision services for domestic and foreign plants it has designed. For example, the institute designs upgrades and retrofits for the Navoi Mining and Metallurgy Plant (Uzbekistan). In 2018, Uzbekistan's State Commission for Natural Reserves approved Muruntau reserve estimates prepared by the Navoi Mining and Metallurgy Plant on the basis of surveys conducted by VNIPIpromtechnologii. The institute developed a cost-efficient solution for the plant to develop small gold deposits located within 50 km around the Central Mining Administration. The development of these small deposits will enable the Navoi Plant to maintain a stable output of gold until 2120. The institute also designed a conveyor line intended to carry overburden to dumping grounds and a steep inclined conveyor with a carrying capacity of almost 10 million tonnes of ore per annum. In 2019, VNIPIpromtechnologii prepared a gold mining schedule for the Muruntau and Myutenbai deposits for a period until 2030. The technical solutions offered by the institute enables processing lower-grade ores. That same year, the institute developed a mining operations plan for the Muruntau deposit. In June 2020, VNIPIpromtechnologii offered optimal solutions for ore and rock flows and location of transportation conveyors.

Site rehabilitation

After the Comprehensive Nuclear-Test-Ban Treaty was signed, the institute turned to designing nuclear waste storage sites and developing solutions to deal with hazardous industrial waste. At present, VNIPIpromtechnologii continues working in this area. One of the recent examples is a land rehabilitation project in Karelia. The institute launched a site survey in May 2020 and plans to finish it in September. Its expected result is a zero possibility of radioactive contamination.

VNIPIpromtechnologii has developed rehabilitation programs for uranium tailing dumps located in the villages of Kadji Say and Min-Kush (Kyrgyzstan) and near the city of Taboshar (Tajikistan) as part of the Uranium Mining Site Rehabilitation Program for EAEU States Affected by Uranium Production. In North Ossetia, the institute helped the local company Pobedit to decommission its thoriated tungsten production facility. Its engineers develop individual waste management and safety solutions for each production facility.

New focus areas

Since 2010, VNIPIpromtechnologii has been part of Rosatom's mining division ARMZ Uranium Holding and acted as an engineering center for mining applications. VNIPIpromtechnologii offers comprehensive engineering solutions ranging from conceptual design to equipment supply and installation.

The first comprehensive solution offered was a yellowcake dehydration method developed for Dalur, a Russian uranium manufacturer

owned by Rosatom. The end-to-end services provided by the institute covered R&D, engineering, equipment procurement, customs clearance and installation. The new uranium pulp dehydration line at Dalur was put into operation in September 2015.

Another activity area of the institute is the development of recovery technologies for uranium and other minerals. In 2018, VNIPIpromtechnologii designed a facility for sorption recovery of rhenium from sulfuric acid solutions at a copper smelting plant operated by Kazakhmys. In 2019, the institute signed an agreement to design a carbon-in-leach (CIL) facility and provide consulting services for Clean TeQ Sunrise (Australia). The CIL facility designed by the institute will produce nickel, cobalt and scandium and will be a key element of the company's production process.

VNIPIpromtechnologii keeps developing its competencies in industrial engineering and stay focused on winning more orders from mining companies from all over the globe. NL

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Environmentalists Stand Up for Nuclear

Public organizations and activists from different countries join the ranks of the nuclear energy advocates. Certain anti-nuclear activists even become pro-nuclear activists.

The most vivid example here is, perhaps, Zion Lights, a former press secretary of the international environmental and anti-nuclear organization Extinction Rebellion. This summer, quite unexpectedly, she joined a pro-nuclear movement Environmental Progress and became the head of its UK office.

"For many years I was skeptical of nuclear power. Surrounded by anti-nuclear activists, I had allowed fear of radiation, nuclear waste and weapons of mass destruction to creep into my subconscious. When a friend sent me a scientific paper on the actual impacts, including the (very small number of) total deaths from radiation at Chernobyl and Fukushima, I realized I had been duped into anti-science sentiment all this time," Zion Lights admits.

What makes her decision remarkable is that she simply took the trouble to check information about nuclear power. **"Scientific research has found that nuclear power is still safer than fossil fuels, once air pollution, accidents (from energy extraction) and greenhouse gas emissions are taken into account."** In order to support her position, Zion Lights refers to a study

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Zion Lights

showing that the total number of deaths in nuclear is 2.5 times lower than in brown coal-based power generation.

She also admits that renewables, which are almost always understood as wind and solar, cannot fully meet the UK's power needs.

And finally, she has discovered that nuclear wastes are relatively small in amount and, if safely stored and properly monitored, do not kill anyone.

"To my surprise, when I shared the data with my anti-nuclear friends, they argued against the science. Alas, we parted ways," Zion Lights says.

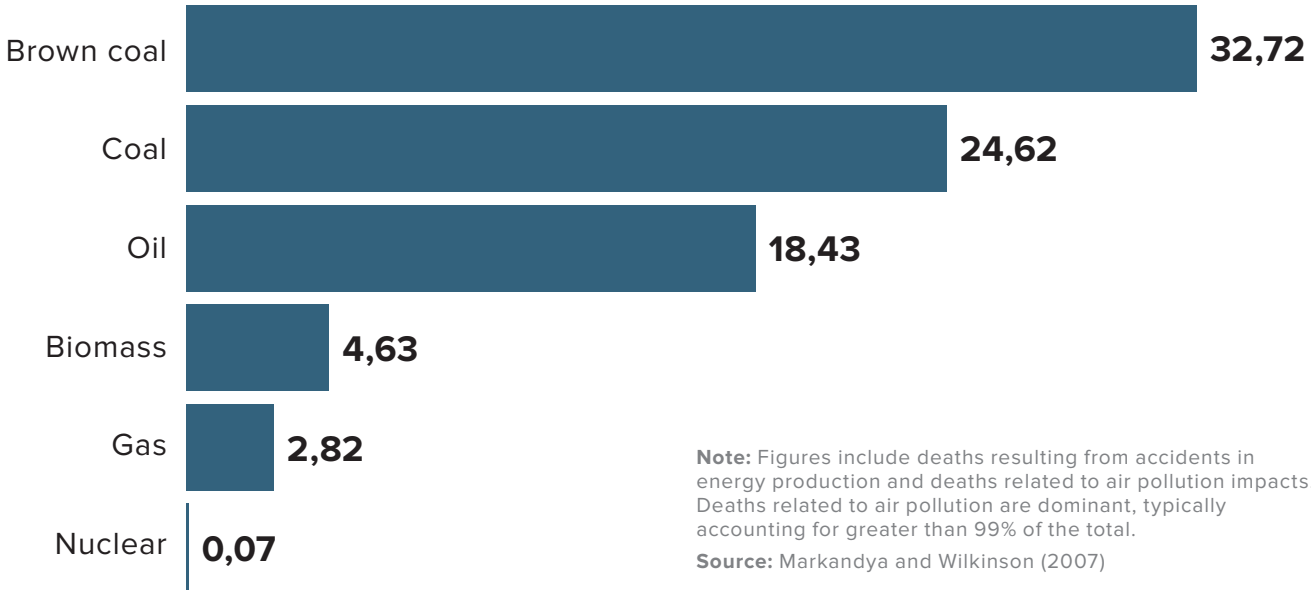
She has admitted that nuclear plays a key role in keeping the air clean and reducing CO2 emissions, **"I invite my fellow environmentalists to speak out in favor of nuclear power. It is — according to the experts — an essential part of our desperately vital attempts to tackle global warming. Here in Britain, and around the world, we do need nuclear."**

It was Michael Shellenberger who inspired Zion Lights. Back in June 2016, he said in his TED Talk that closing nuclear power plants within the next 15 years might lead to a clean energy crisis, rather than energy revolution.

According to the IAEA's Power Reactor Information System (PRIS), the number of

DEATH RATES FROM ENERGY PRODUCTION PER TWH

Death rates from air pollution and accidents related to energy production measured in deaths per terawatt hours (TWh)



Note: Figures include deaths resulting from accidents in energy production and deaths related to air pollution impacts. Deaths related to air pollution are dominant, typically accounting for greater than 99% of the total.

Source: Markandya and Wilkinson (2007)

operating reactors went down globally from 447 in 2016 to 443 in 2019. This is a net result that takes account of all commissioned and decommissioned reactors. Of course, it should be kept in mind that newly commissioned reactors are more powerful than the shutdown ones, so the total installed nuclear capacity in late 2019 remained higher than in 2016 (392.1 GW vs. 390.49 GW, respectively). Tensions between major nuclear players, such as the US and China, is another thing hindering the overall nuclear development. **"Back in September 2019, China's future floating SMRs were called by Washington a mean of powering Chinese imperialism in East Asia. Since then, the US has been imposing more and more restrictions (the last one in June 2020) to complicate international cooperation with China in small-scale nuclear generation,"** says the nuclear news portal Atominfo.ru.

According to Michael Shellenberger, three main nuclear fears exist in the public mind. These are concerns about safety of nuclear plants, nuclear weapons, and nuclear waste.

Irrationality of the first fear is evidenced by the chart showing death rates from energy production. Comparing nuclear generation with coal-fired power plants and wind or solar farms leads to the situation when nuclear as cleaner energy receives the most unexpected supporters. **"We are mothers who used to be skeptical about nuclear energy, but now believe it is essential to protect our children from pollution, our landscapes from sprawl, and future generations from global warming,"** says the home page of Mothers for Nuclear.

Peaceful uses of nuclear power may be a way of eliminating nuclear weapons forever. The most outstanding example in recent history is the HEU-LEU Agreement between Russia and the US to convert highly enriched uranium (HEU) to low enriched uranium (LEU). According to the agreement, nearly 500 tonnes of weapons-grade HEU containing at least 90% U-235 were converted into almost 14,500 tonnes of LEU containing 3.2–4.95% U-235. This amount of uranium was enough to meet almost a half of the US annual needs. Russian-made uranium was used to generate about 7 million GWh of electric energy or 10% of electricity generation in the USA.

Nuclear waste is not always correctly termed as waste. This was seen by environmentalists, who protested against imports of depleted uranium hexafluoride (DUHF) from Germany to Russia.

Bellona, a Norway-based environmental NGO, and Rosatom prepared and presented a report on DUHF and its management.

"The facts are that DUHF is a useful material for the nuclear and other industries. As shown in the DUHF process flow chart, the only waste produced is depleted U3O8 (triuranium octoxide), which is planned to be used as fuel feedstock for fast neutron reactors in the

future," says the report. **"No doubt, it is a resource, not waste,"** stresses Alexander Nikitin, the head of Bellona's office in Russia.

The authors of the study conclude that DUHF cannot be classified as radioactive waste under the Russian law and, for this reason, is allowed to be imported to Russia.

It should be also noted that DUHF radioactivity is significantly lower than that of natural uranium and even some construction materials. Specific activity of natural uranium is 17 kBq/g, while activity of depleted uranium hexafluoride imported in Russia is as low as 2.7 kBq/g.

According to the authors of the report, the probability of an anticipated accident (a heavy aircraft crashing into the DUHF storage facility or into a freight train carrying DUHF) is estimated to be 10^{-8} per annum. For reference, the risk of dying in a traffic accident in Russia was 10^{-3} per annum (2019 data). **"These examples let us compare the risks and see that the fears spread by panic-mongers are not based on facts,"** the report reads.

The report prepared in cooperation with the Bellona Foundation, which could not be suspected of any impartiality towards Rosatom, proves that knowledge and awareness can make environmentalists take sides with the nuclear community. During the presentation, representatives of public organizations admitted that protests against imports of DUHF to Russia were caused by a lack of information on its uses in the nuclear industry.

Raising public awareness of how nuclear technologies work is one of Rosatom's major goals.

In March, Rosatom organized a visit of Heather Hoff, a co-founder of Mothers for Nuclear, who later made a report at the Nuclear Power Plants Expo and Summit (NPPES2020) in Turkey on why she supported nuclear.

In April and May, Rusatom International Network held online sessions titled "Have You Noticed How the Planet Has Changed?" for undergraduates and high school students in Armenia and Belarus. Members of international and public organizations, including the UN, told the young audience about global warming and how nuclear

UK Scientists Defend Clean Atom

UK scientists, engineers and public supporters signed an open letter to Prime Minister Boris Johnson, Secretary of State for Business, Energy and Industrial Strategy Alok Sharma and Chancellor of the Exchequer Rishi Sunak. The letter advocates nuclear power as a way to prevent climate change.

"Fortunately, nuclear energy is extremely compact and works year-round, and thus provides a superb way to eliminate carbon emissions while protecting the environment. Nuclear also provides abundant jobs both in construction and long-term operation, and thus has become an important part of the government's green recovery proposals," the letter reads. It is noteworthy that the document was signed by qualified professionals.

Supporters of nuclear in the UK plan to take another step forward and have staged Stand Up for Nuclear, an event aimed not only **"to show that we do exist"**, but also **"to help unpick the many myths around nuclear power"**.

contributed to improving global environment and keeping the air clean.

In July, Rosatom had a live stream on its YouTube educational channel 'Look Around', explaining how nuclear medicine helps looking into the brain of a living human. Anna Khoruzhaya, a radiologist and researcher at the Moscow Center for Diagnostics and Telemedicine and a deputy chief editor of Neuronovosti.ru, explained how nuclear technology (CT, MRI and PET) help examine the brain and timely detect diseases. NL

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In France, a group of pro-nuclear activists protested against the shutdown of the Fessenheim Nuclear Power Plant. The protesters addressed Greenpeace known for its impressive campaigns for reactor shutdowns. They claimed that nuclear should be supported as a carbon-free power generation industry.

The campaign seems to have revealed a verbal paradox, of which almost everyone is still unaware. The term "renewable" does not always mean "clean" when it is about burning wood and charcoal. Nuclear will be considered "renewable" only when the two-component nuclear power generation is fully in place. The protest against Greenpeace showed that even the term "green" is not always a synonym of "clean" if the greens call for a shutdown of clean energy sources.