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Fighting Coronavirus

Rosatom is fighting the spread of the new coronavirus infection by leveraging every available resource, including engineering capabilities, financial aid and volunteering.

Throughout months of the coronavirus outbreak the world has witnessed new helpful partnerships between nuclear and medicine. The virus-related challenges provided an opportunity for nuclear engineers to demonstrate that they were true professionals capable of finding simple solutions to complex problems given time-sensitive conditions. Some of Rosatom's production facilities were converted to manufacture high-tech medical products. The nuclear corporation also arranged for the testing of people living in nuclear host communities and sanitary treatment of the industrial premises, including with the help of machinery produced by Rosatom's subsidiaries.

Making new products

The municipal hospital in Zheleznogorsk (Krasnoyarsk Krai), a host city for Rosatom's nuclear waste management subsidiary Mining and Chemical Plant, asked the nuclear corporation to install an oxygen supply system in the isolation ward. It took just three weeks to engineer an oxygen station and piping, procure materials and install the system. Now all 67 isolation rooms are supplied with oxygen for mechanical ventilation. In addition, mechanical engineers of the plant produced a new modification of Bobrov's apparatus to moisturize oxygen supplied. Further developments are underway.

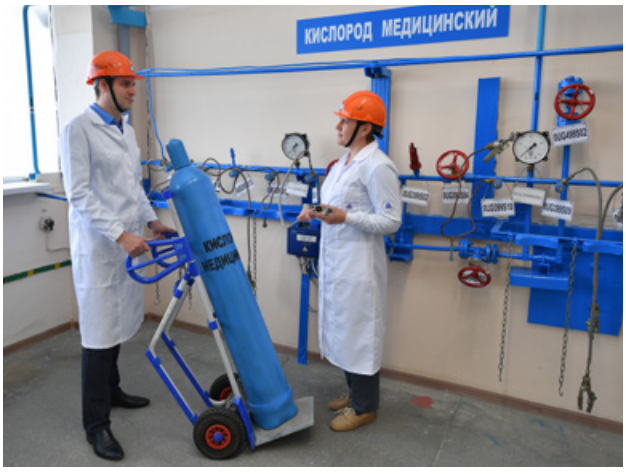
Sterion, a subsidiary of irradiation technology supplier Rusatom Healthcare,

provides sterilization services. As of May 19, the company sterilized over 24 million face masks and over 334,000 kits for the collection of COVID samples, with a total of 58 million face masks to be sterilized under the contract. In order to deliver the project, employees work in three shifts. The core machine is a 10 kW, 10 MeV linear particle accelerator, which uses an accelerated electron beam to treat products loaded onto a conveyor right in the carton box. It takes only 37 seconds to sterilize the whole box (980 masks).

At the request of the government of Zabaykalsky Krai, Priargunsky Industrial Mining and Chemical Union (PIMCU, a subsidiary of Rosatom's mining division) is making arrangements for the production of medical-grade oxygen. The production facility is ready; the license is pending. Production of medical-grade oxygen at PIMCU will help establish a reserve of oxygen for local hospitals.

Providing finance

Rosatom donated personal protective equipment and medical devices for the treatment of, and protection against coronavirus disease, including 192 mechanical ventilators, over 2,000 air sanitizer units, 29,000 protective coveralls, 30 non-invasive blood oxygen saturation measurement systems, and other medical supplies. They all will be distributed between 25 health facilities in host communities.



Rosatom's management, including the director general, his deputies, directors of divisions and major nuclear companies (more than 200 people overall), joined the national #WeTogether campaign and donated their monthly salary to the campaign fund. The #WeTogether campaign aims at supporting seniors, physically challenged people and medical workers during the coronavirus pandemic. Volunteers all over Russia deliver medicine and groceries; lawyers and social workers consult those in need; partner organizations provide free-of-charge services and donate goods. Over 90,000 volunteers are already taking part in the campaign.

Volunteering

Rosatom's volunteer movement spans across 32 Russian cities. Starting the first days of the outbreak of the epidemic, 689 nuclear industry workers have become volunteers. They were properly trained and provided with personal protective equipment. During just two weeks of April, they helped to buy food and medicine for nearly 1,500 people in self-isolation. Volunteers working in host communities seek to help the elderly and families of self-isolated nuclear power plant employees.

Fighting the virus abroad Rosatom follows the rules and takes safety measures as recommended by local authorities at its overseas construction sites. As many

employees as possible work from home; on-site workers have their body temperature taken regularly; special procedures are introduced to minimize contacts between workers in canteens or when transported to and from the construction site.

In March 2020, Rusatom Service delivered replacement parts for preventive repair and maintenance on the turbine generator of Kozloduy NPP Unit 5 in Bulgaria; maintenance and repairs are to be completed on schedule to meet the power generation plan.

In April 2020, hot tests were completed at Belarusian NPP Unit 1, followed by the nuclear fuel delivery in early May. Another batch of electrical components arrived at the International Thermonuclear Experimental Reactor (ITER) site in France.

Rosatom donated 50,000 face masks to health facilities in the Grodno Region of Belarus. Most of them were delivered to the Grodno Regional Hospital for Infectious Diseases; the rest was supplied to hospitals in the towns of Ostrovets (Astravets) and Smorgon (Smarhon) and other healthcare facilities.

Social care services in the Vysočina Region hosting the Dukovany NPP received bottled water and disinfectants free of charge. Rosatom's move was supported by Bioline, White Peopny and other companies.

Although coronavirus continues spreading globally, Rosatom keeps working on its international construction sites with no project interrupted. Other contractual obligations, such as supplies of machinery and equipment, nuclear fuel and medical isotopes, are also performed in due time.

Through Pandemic to Thermonuclear Fusion

In April, Rosatom carried out three shipments of equipment for the International Thermonuclear Experimental Reactor (ITER) megaproject. All the ten trucks arrived at the site near Marseille on time despite the restrictions imposed to prevent the spread of coronavirus.

Timely delivery of the Russian-made equipment was of great importance since without it, it was impossible to continue the installation of power supply systems at the ITER. Any quarantine-caused delay in delivery could have led to missing the commissioning date.

The trucks left Rosatom's Efremov Research Institute in St. Petersburg on April 9, 21 and 27, and their journey was in strict compliance with quarantine restrictions. Thanks to the seamless coordination between the institute, private company ITER-Center (Russia) and the ITER itself, all the ten trucks carrying electrical equipment

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arrived at the site near Marseille and were unloaded right on schedule. Russia supplied busbars for the central solenoid, poloidal field coils and correction coils, beams and supports for the installation of busbars, resistors, and auxiliary components.

In general, Russian engineers from 30 research organizations will develop 25 systems for the reactor, including switchgear, busbars, energy absorption resistors for the power supply and protection of superconducting magnets, one of the most expensive and complex systems of the experimental reactor.

Other ITER members are also contributing their fair share. In mid-April, Italy delivered a huge toroidal field coil, followed by another one from Japan. Production roles were distributed between the ITER members so that each country could develop competencies in different science fields (vacuum chambers, magnet systems, neutron diagnostics, and so on). Seven parties, namely, China, the European Union, India, Japan, Korea, Russia, and the United States signed the ITER Agreement.

The primary goal of the project is to demonstrate the feasibility of fusion energy for commercial use and secondly to test the technology and materials.

The initial idea to build a thermonuclear fusion reactor for the international research was proposed by Soviet scientist Evgeny Velikhov back in 1985. The idea was approved by Soviet leader Mikhail Gorbachev and presented at the Geneva Summit in November same year. US President Ronald Reagan and French President François Mitterrand supported the project. In 1992, the USA, Russia, Japan and the European Union signed a project agreement, joined by China, South Korea and India in 2001, 2003 and 2005, respectively. The European Union as a host party covers around 45% of the project costs with the other six parties contributing approximately 9% each.

The thermonuclear fusion reactor under construction is, in fact, a tokamak (a Russian acronym for 'toroidal chamber with magnetic coils'), a hot plasma confinement device developed by Soviet scientists Igor Tamm and Andrei Sakharov in the 1950s. The function of the reactor is to turn hydrogen isotopes into extremely hot plasma, which is necessary for thermonuclear fusion to begin, and keep it inside a doughnut-shaped (toroidal) vacuum chamber.

Construction of the building and site infrastructure is nearing completion with assembly of the reactor underway. The ITER is expected to be launched in 2025. NL

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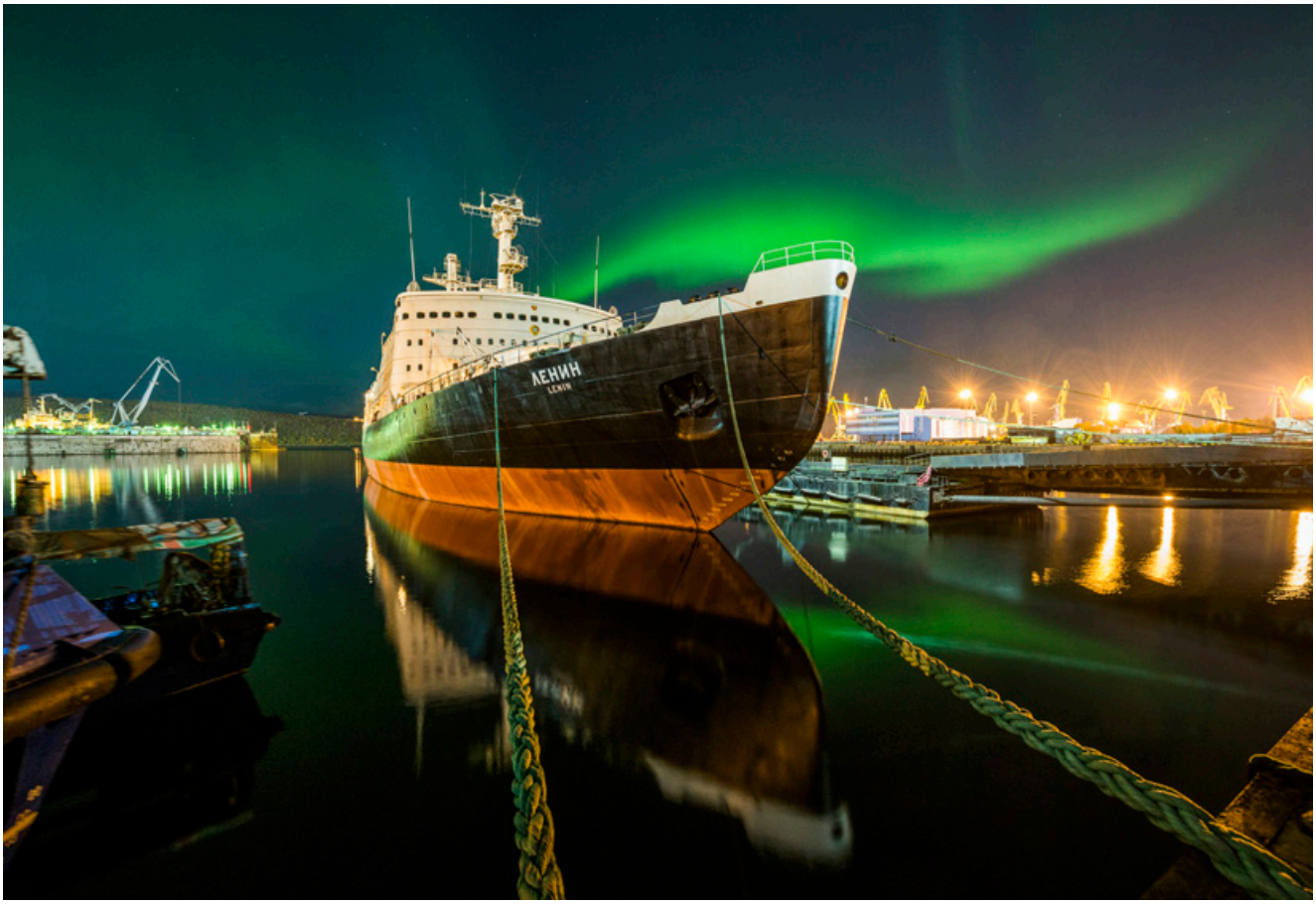


Atomflot: Sixty-Years-Long Road

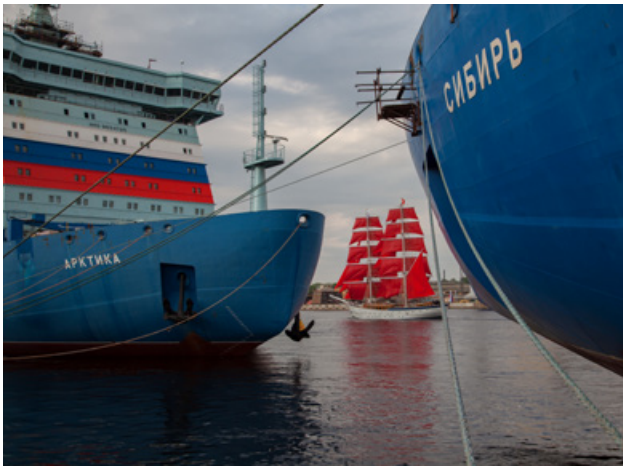
Rosatom Newsletter continues a series of stories about Rosatom's most prominent companies. This issue tells a story of Russian nuclear fleet operator Atomflot, which celebrated its 60th anniversary last year.

December 3rd is celebrated as the birthday of the Russian nuclear fleet. On this day in 1959, the world's first nuclear icebreaker Lenin run up the national flag. Since then, nuclear icebreakers have been efficiently performing their main function of escorting ships on the Northern Sea Route in the Arctic Ocean.

Why does the Arctic need nuclear icebreakers? Are diesel-powered ships not enough? No, they aren't. Nuclear icebreakers are much more powerful. For example, Project 10520 design icebreakers built in the 1970–1990s were able to travel through 2.25-meter ice. At the same time, Project 97A diesel-electric icebreakers built in the 1960–1980s could navigate through one-meter thick ice only. Another important advantage of nuclear icebreakers is that they do not need frequent refueling, which is not easy in the Far North. Nuclear icebreakers do not produce polluting emissions and oil spills are impossible.

On the long Northern Sea Route

In the early 1970s, icebreakers Lenin, Arktika and Sibir made year-round navigation along



the western part of Russia's Arctic coast possible. This was and still is essential for the delivery of food and equipment to and shipment of products from local companies. Atomflot's icebreakers are indispensable for the success of the Northern Sea Route. The development strategy approved by the Russian government in December 2019 provides for the year-round navigation to be established through the entire corridor. It is expected to become a national and international transportation route between Europe and Asia by 2035.

Here is a recent example of Atomflot's far-reaching routine. In March 2020, nuclear LASH (lighter aboard ship) carrier Sevmorput left Arkhangelsk for the Gyda Peninsula after scheduled dock repairs, carrying 20,000 tons of cargo for the Arctic LNG 2 project, including reinforced concrete structures, pipes, steel structures, construction machinery and electrical equipment. Already on April 22, Sevmorput set off for the Severnaya Bay (Alexandra Land Island, Franz Josef Land) to deliver concrete slabs, containers, construction materials and vehicles, reaching the destination three days later. Vaygach icebreaker prepared a passage for Sevmorput to approach the unloading point on fast ice. After that, Sevmorput returned to Murmansk to take the second shipment of cargo on board.

From construction to decommissioning

Atomflot is renewing its fleet in anticipation of much more freight traffic on the Northern Sea Route. Construction of new icebreakers began in the 2010s. Three Project 22220 icebreakers Arktika, Sibir and Ural are already afloat. The next icebreaker Yakutia will be laid down on May 26. On April 23, Atomflot and Zvezda Shipyard signed a contract for the construction of a next-generation icebreaker Lider, which is to be built according to the new Project 10510 design. The contract was signed remotely due to the coronavirus quarantine. Atomflot CEO Mustafa Kashka was in Murmansk, while Sergey Tseluyko, Managing Director of Zvezda, was in Vladivostok. According to the agreement, Lider will be commissioned before the end of 2027 to become the world's most powerful nuclear icebreaker: the total capacity of its propulsion system will amount to 120 MW. Given such immense power, Lider will be able to sail through more than 4-meter thick ice. Its main task will be to escort ships along the entire Northern Sea Route all year round and look for new high-latitude routes for commercial purposes.

Atomflot is also involved in disposal of spent nuclear fuel and nuclear waste from icebreakers and submarines. Two major ongoing projects in this field are dismantling of the Lepse depot ship and removal of spent nuclear fuel assemblies from the depot in the Andreev Bay. Dismantling of Lepse is planned to be completed in 2022. Spent fuel assemblies are already being unloaded from the radioactive waste repository in the Andreev Bay.

Nuclear icebreakers themselves are also decommissioned and dismantled. The Sibir icebreaker was towed to Nerpa Shipyard

for dismantling in 2016. This is where the nuclear propulsion unit was dismantled and the ship space was decontaminated. In October 2019, the icebreaker was delivered to Atomflot's mole, where it will be moored until late 2021 while the remaining contaminated systems and equipment will be dismantled. It is planned to auction off 'clean' structures as steel scrap in 2022. Dismantling of contaminated machinery on Arktika is still underway. NL

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Icebreaking legend

May 6, 1960: the world's first nuclear icebreaker Lenin is put into operation in Murmansk.

October 17, 1961: personnel of the drifting ice station disembark from the icebreaker for the first time ever. Until then, all drift stations were delivered by air, which was more difficult and expensive. Icebreakers allowed approaching the required point and delivering much more cargo and equipment, not just bare essentials.

November 14 — December 1, 1970: diesel electric powered freighter Gizhiga was escorted from Murmansk to Dudinka and back during the first winter navigation in the Arctic. The purpose of the voyage was to estimate the possibility of escorting ship convoys in winter to deliver goods to Norilsk Nickel and return with its products.

May 26 — June 22, 1971: Lenin makes its first non-stop high-latitude voyage to Pevek (Russia's northernmost town). The nuclear icebreaker escorted Vladivostok, a diesel electric icebreaker, to operate in the Chukchi Sea during the summer navigation. Icebreakers surveyed high-latitude routes to the north of the Novaya Zemlya Archipelago and the New Siberian Islands.

March 1976: diesel electric freighter Pavel Ponomaryov is escorted to Yamal to make the first voyage through ice in early spring.

1989: Lenin icebreaker is decommissioned with its reactors shut down, propellers dismantled

and the ice reconnaissance helicopter put out of operation. In thirty years of operation in the Arctic, Lenin escorted 3,741 ships, traveled 654,400 nautical miles, including 560,600 miles in ice-covered waters, which comparable with thirty voyages around the world along the equator.

February 29, 2000: Lenin Nuclear Icebreaker Foundation is established at the initiative of former captain Boris Sokolov and under the direction of Arctic explorer Anatoly Aleksandrovich.

May 5, 2009: Lenin is brought to anchor offshore Murmansk passenger terminal and converted into a museum.

October 2018: Lenin icebreaker is officially awarded the status of a national cultural heritage site.

Nuclear Power Generation During COVID-19

Economic slowdown during the coronavirus quarantine led to decline in electricity consumption. Rosatom Newsletter looks into the depth of this decline and its influence over the nuclear industry. Our analysis covers countries with the largest number of operating nuclear power plants, namely, the United States, France, Russia and China, which are also among the most affected by the pandemic.

Executive summary

Russia: electricity consumption in April decreased 2.9% to 82,900 GWh year-to-year.

China: electricity consumption in Q1 2020 decreased 6.5% to 1.57 million GWh year-to-year.

France: electricity consumption in Q1 2020 decreased 7.4% year-to-year.

US: daily weekday electricity demand in March and April decreased 9–13% compared to the average annual demand.

Any attempt at comparing national statistics is a challenging task due to different reporting periods and complexity of the data reported. Nevertheless, the body of this information is enough to get a general picture of what is happening during the pandemic in power generation, particularly in the nuclear power industry.

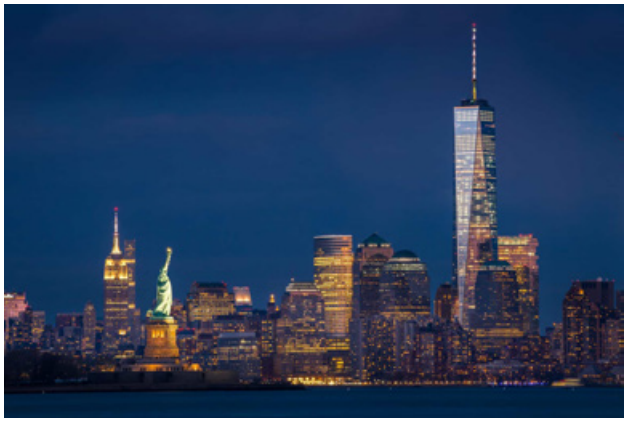
China

China reached its coronavirus peak in the winter 2020. According to the National Energy Administration and the National Bureau of Statistics, power generation in Q1 2020 dropped 6.8% year-over-year to 1.58 million GWh. Hydro power plants and CHP plants demonstrated the largest decline in power output. By contrast, China's nuclear stations increased electricity generation by 1.2% to 78,000 GWh. They operated at a maximum capacity factor for 1,599 hours, the longest period among all generating stations in China and almost two times the industry average.

Electricity consumption in China decreased 6.5% over the same period to 1.57 million GWh. The largest decline was observed in the processing industries (down 8.7% to 997,100 GWh) and in the service sector (down 8.3% to 979,400 GWh). Interestingly, power consumption in the mining industry grew 4% year-to-year to reach 16,700 GWh in Q1 2020. For example, coal production in March was at a record high of 340 million metric tons. Power consumption in households rose 3.5% over the same period to 293,200 GWh.

Recovery of electricity consumption began as soon as March. According to the National Energy Administration, consumption in that month was only 4.2% lower than in 2019, whereas in February electricity consumption in China was down as much as 10.1%.

In the first half of April, power consumption in China grew 1.5% year-to-year, while power output increased 1.2%, according to Reuters citing country's National Development and Reform Commission.



The United States

In the United States, the spread of coronavirus reached its peak in March-April 2020. New York is among the most affected cities with 185,000 confirmed cases as of May 11. The situation with the virus deteriorated in the second half of March and stabilized in April, when more than 10,000 new cases were registered daily.

According to the US Energy Information Administration (EIA), closing of businesses and changes in people's lifestyle over coronavirus restrictions brought the daily electricity demand down 11–14% on weekdays in March and April as compared to the multi-year average adjusted for seasonal temperature fluctuations. **"Electricity demand changes in New York state and in New York City, in particular, have been more pronounced than in other parts of the country, which may partly be caused by regional differences in how much electricity each end-use sector consumes and the varying effects of COVID-19 mitigation efforts on the sectors,"** the report read.

The EIA report compared daily demand for electricity on each weekday from January 1 until May 1, 2020 and the average demand on weekdays with the same average daily tem-

perature from January until June 2016–2019. Weekends and public holidays were not counted. The authors of the report explained that this methodology offsets the effect of seasonal temperature fluctuations and highlights the effect of unexpected events, such as coronavirus response measures.

The analysis showed that electricity demand in January and most of February was comparable to the observed historical levels. As the state began taking measures to prevent the spread of coronavirus, consumption fell. In the end of March, the New York Independent System Operator (NYISO) saw electricity demand on weekdays being approximately 13% lower than temperature-comparable historical demand, and it remained low throughout April. According to NYISO, **"the reduction in electric demand from commercial customers is a leading driver of overall reduced electricity consumption."**

The city of New York, which accounts for about a third of total power consumption in the State of New York, demonstrated a larger decline in consumption than the state in general. From late March through late April, daily electricity demand on weekdays was on average 16% lower than in 2019 at comparable temperature.

Electricity consumption across other states decreased as well, but the decline was not homogeneous. According to the Midcontinent Independent System Operator (MISO), epidemic-related closures and other anti-COVID measures resulted in a 9–13% decline in electricity consumption on weekdays as compared to the average demand. Since MISO works in the states where industrial enterprises account for the majority of electric power consumed, lower demand is an indicator of lower output, rather than shutdown. **"In MISO Zones 2 and 7, which cover most of Michigan and Wisconsin, demand has dropped slightly more than for MISO overall, averaging between 11–16% from late March through April. On March 18, the three major car manufacturers based in Detroit, Michigan — Ford, General Motors, and Fiat Chrysler — announced they would begin closing their manufacturing facilities. Other industrial facilities have also temporarily closed,"** a study published on May 7, 2020 read. On the other hand, according to the EIA, Florida demonstrated no major changes in electricity consumption, although demand stood at the lower level of 2019's average. The EIA explained that this was attributable to the consumption structure in Florida where households accounted for more than a half of total power consumption. As a result, growing consumption in households mitigated decline in other sectors to a larger extent than in the other states.

The aggregated US data showed that the reduction of electric power output was significant in April as compared to March 2020 with the total power output at 265,200 GWh in April vs. 293,500 GWh in March.

During the first 17 weeks of 2020, the share of nuclear in the total energy mix varied from 20% to 24%, and the lockdown did not make any difference.

France

France reached its coronavirus peak in March. **"The quarantine brought electricity consumption down 15–20% with other conditions being equal (consumption in comparable climatic conditions),"** the French grid operator RTE said quoting data from before April 5, 2020.

The Ministry of Ecology, Sustainable Development, Transport and Housing gave lower estimates of the consumption decline in Q1 2020. The ministry claimed that shutdowns and closures in the industrial and service sectors combined with higher temperatures than in Q12019 brought electricity consumption down 7.4% year-to-year.

The same report mentioned that France generated 2.2% less electricity in Q1 2020 (153,400 GWh) than a year before. Nuclear generation decreased to 101,160 GWh, down 9.1% (as indicated in the introductory part) or 9.5% (as specified in the section dealing with electric power) year-to-year.

Nuclear power generation depended in part on lower consumption in March 2020. In France, nuclear power plants always operate in the load following mode to compensate for the intermittency of renewable generation. As required by the French law, energy from renewable sources is always sold first.

Unscheduled outages were part of the decline but the main reason is that 880 MW Fessenheim-1 NPP was shut down permanently on February 22 as part of the state policy. In Q1 2020, nuclear accounted for 66% of electric power produced in the country. Generation at coal-fired plants decreased 9.8% over the same period (15,840 GWh in Q1 2020). By contrast, power output at hydro, wind and solar power plants grew 28.6%, 44.1% and 3% respectively, which is attributable to rainy and windy weather.

Russia

In Russia, the lockdown began in late March and lasted through April to May. In April, Russian power plants connected to the Russia's national power grid (Unified Energy System) generated 83.7 billion kWh, down 3.8% year-to-year. CHP plants demonstrated the largest decline (15.2%), whereas production at hydro power plants increased most of all (up 21.5%). Power output at nuclear power plants grew 8%.

Electricity consumption in March 2020 totaled 95.1 billion kWh, down 1.5% year-to-year. Total electricity output in Russia amounted to 95.9 billion kWh in March 2020 (down 2.7% year-to-year).

According to the Unified Energy System, electricity consumption in April 2020 totaled 82.9 billion kWh (down 2.9% year-to-year).

Weekly analysis of power generation at Russian nuclear stations shows that they were more affected by maintenance and repairs than by coronavirus.

"The reason for the difference in output is simple: two units were shut down in 2019 — Unit 3 for scheduled maintenance and Unit 2 for overhaul — as part of the life extension program. In 2020, only one unit — Unit 1 — was under maintenance," a representative of the Kola NPP said. The Novovoronezh NPP also mentioned maintenance as the main factor influencing power generation. In 2019, Units 4 and 5 were in operation, while Unit 6 was shut down for scheduled maintenance on April 15. In April 2020, Units 4, 5 and 6 were in operation; Unit 7 was under maintenance.

The total output at nuclear stations in April 2020 reached 16.515 billion kWh compared to April 2019 power of 15.277 billion kWh. It should be noted that 2020 figures also include the output of the floating nuclear power plant, which is already connected to the grid but has not been commissioned officially.

Rosatom's power distribution subsidiary Atomenergosbyt, which is also a supplier of last resort in four Russian regions, said that power consumption in April 2020 stood at 1.2 billion kWh, an amount comparable with April 2019. **"No doubt that some industrial enterprises reduced power consumption but weather conditions set off the decline to almost the last year's level. So we see no material effect of the lockdown on electricity consumption,"** CEO of Atomenergosbyt Pyotr Konyushenko said.

Conclusions

Our comparison of power production and consumption in different countries shows that energy demand at the time of the pandemic depends directly on whether businesses continue working or not. An increase in consumption by households levels off lower demand from industrial consumers only in part.

Coal-based generation declined during the lockdown in every country under consideration. One of the possible reasons is the mandatory requirement to buy renewable energy despite lower demand. That was why renewable generation was growing. The trend is confirmed by data published by the International Energy Agency. **"Amid today's unparalleled health and economic crises, the plunge in demand for nearly all major fuels is staggering, especially for coal, oil and gas. Only renewables are holding up during the previously unheard-of slump in electricity use,"** IEA Executive Director Fatih Birol said.

Analysis of nuclear power generation shows that ups and downs in the output depend on how many units are online or disconnected from the grid for maintenance and repairs rather than on lower demand for electricity.

The main danger of coronavirus for the nuclear industry is that certain repairs and refueling procedures are being postponed now but could become essential later, for

example, when demand would rise in cold season. **“Changes in the expected uranium consumption make us change refueling schedules, which is key to maintaining high performance in cold season. Changes in the refueling schedules might affect the system’s ability to follow annual fluctuations when cold weather comes,”** Le Mond wrote.

Rosenergoatom stressed that there has been no repair or refueling postponed at the Russian nuclear power plants. NL

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Power consumption in Hungary grows

Data provided by the Hungarian transmission operator MAVIR showed that power consumption in this EU country amounted to 12.16 TWh in the first three months of 2020, down 2.3% year-to-year. However, consumption was growing in March when the first cases of COVID-19 were registered in the country. That month, the country consumed 3.94 TWh of electricity, up 2.1% year-to-year.

The Paks nuclear power plant accounted for a half of electric power generated in Hungary. “Reliability of power supply in Hungary could only be guaranteed when the country has base load generating stations capable of producing electricity both day and night, in summer and in winter, regardless of the weather, while being environmentally safe,” an article published on Origo web portal reads.