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CONTACT: +49 178 1792352 E-MAIL: ECODEFENSE@GMAIL.COM

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Shunning Rosatom

Prospects of Russia's nuclear expansion in the context of widening global sanctions

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Though a state-owned corporation, the Russian nuclear giant Rosatom, unlike numerous Russian entities under state or private control, has not been directly hit with sanctions following Russia's February 24 invasion of Ukraine. However, calls to cut ties with the Russian nuclear industry have been made in Europe and the U.S., and certain ventures pursued by Rosatom outside Russia's borders have suffered since the start of the war.

Just like the billions Russia is still receiving from selling its gas, oil, and coal abroad, the money earned by Rosatom – a conglomerate of some 350 companies both offering commercial nuclear power products and services and overseeing production of nuclear weapons in Russia – eventually helps finance Russia's war machine. And just like the sanctions the West has imposed and plans to expand against the Russian gas, oil, and coal imports, stopping the Russian nuclear industry from continuing to earn money in Europe – even as the Kremlin continues to rain bombs and terror on a European country and threatens the world with nuclear annihilation – may help stop the brutal and unprovoked aggression Moscow has unleashed.

Certain sanctions, bans, and contract dissolutions will probably hurt Rosatom more than others.

Rosatom claims a robust portfolio of foreign reactor orders. In truth, however, only a handful of the 35 reactor construction projects it says it has in various stages of implementation have seen any development beyond a memorandum of understanding or an intergovernmental agreement. More to the point, most are in countries that would likely have been unable to carry them without the extremely generous financial backing from the Russian state. In an era when hydrocarbons and nuclear energy are inexorably fading into history, Rosatom's role is not corporate survival so much as it is that of a political tool. Vendor-specific technologies create a dependency for vendor-specific fuel and maintenance, and much like it does with gas deliveries, the Kremlin may wield this dependency as a weapon of political influence. With the near-inexhaustible state coffers at its disposal and the Russian president himself negotiating newbuilds in talks with foreign leaders,

Rosatom can offer cheap loans to attract poorer customers such as Egypt or Bangladesh that are then trapped in decades-long loan repayments to Russia as well. This is the competitive edge Rosatom has over its main rivals in the West. And where it has earlier tried to raise private foreign funding for its newbuilds – Turkey's Akkuyu, for instance, or the scrapped project of Baltic Nuclear Power Plant in Kaliningrad Region, which was meant to export power to Russia's European neighbors – it has failed to do so.

All the more important, then, the contracts Rosatom had or may have had in Europe – such as the now-defunct Hanhikivi project in Finland, a share in a fuel manufacturing facility in Germany, or the potential tender bids in the Czech Republic. Projects like these would have secured Russia a better foothold in the European power markets and provided it valuable bargaining chips, adding all the while to the lustrous reputation of a globally positioned market leader Rosatom has so carefully been cultivating.

Other setbacks, though less obvious, may eventually prove just as sensitive. A company with a claim to a global presence will necessarily end up vulnerable to its own dependencies on partners, and the blow rendered to Russia's monetary reserves and financial system may hamper both further financing of reactor construction and delivery of equipment sourced from third parties, such as in the Akkuyu project or that of Paks in Hungary – again hitting at Rosatom's main competitive advantage used to secure new deals.

A less visible side of sanctioning Rosatom is the likely reluctance of certain Rosatom partners to shut down cooperation for fear of ending up with stranded assets on their hands. Customer lock-in does not just create a fuel and maintenance dependency but makes it difficult to complete an unfinished construction project with a different contractor than the one that started it. Squeezed between the prospect of losing future revenues and possible secondary sanctions, such Rosatom customers as India, where Russia is building two new units at Kudankulam and has recently laid first concrete for two more, may opt to stay with Rosatom for the time being.

Finally, there is the issue of Rosatom's deliveries of fuel for some old reactors of Soviet design still operating in Europe. Hungary, which has been thwarting an otherwise almost unified sanctioning policy of the EU, is so far pressing ahead with its plans to build two more Rosatom reactors at Paks, but is apparently considering fuel supply diversification. For now, Rosatom's fuel manufacturing facility TVEL remains an irreplaceable fuel source for some of the VVERs running in Hungary, Slovakia, the Czech Republic, Finland, *and* Ukraine. But the U. S. firm Westinghouse has said it is seeking national approvals to start deliveries for fuel reloads at these plants as soon as 2023, so breaking free from this dependency may turn out to be possible after all.

This summary brief is an overview of some of Rosatom's foreign projects and contracts that have already been or may potentially be affected by sanctions or actions imposed by non-state entities since the start of the war in Ukraine or in direct connection with it. Future updates will be added as they become available.

Some Rosatom partners plainly state Moscow's war as the reason to end further cooperation, others cite security of supply as the underlying consideration. Some have announced their move, while other ties have been severed with no public notice.

Regardless, more will likely come – and *should* come, to defuel Russia's war machine and help end the war in Ukraine.

Turkey

In Turkey, Rosatom is building a 4,800-megawatt nuclear power plant in Akkuyu with four units of Russian VVER-1200 design.

The project is being implemented under a so-called Build, Own, Operate model, where Rosatom provides the construction funding, owns the completed plant, and sells the energy produced at a fixed price. Cost estimates range from $20bn[1] to up to $25bn[2]; Russian president Vladimir Putin estimated total investment at $22bn[3].

The intergovernmental agreement on joint construction and operation of the plant, signed between Russia and Turkey in 2010, provides for up to 49% of the venture to be available for sale to foreign investors. Yet, no deal of this kind has apparently been concluded to date, though negotiations with Turkish companies were held in 2018.

Delayed by about four years (construction was to commence in 2015, and commercial operation at the first unit in 2019,[4] but first concrete was only poured in April 2018[5]), the launch of the first unit is now scheduled for 2023. However, impediments to financing and equipment from third countries have threatened further setbacks to the project, *Al Jazeera* reported on May 16.[6]

Banks such as Sberbank, Russia's largest financial institution and a major backer of the nuclear plant, have been directly targeted by sanctions, *Al Jazeera*'s report pointed out.

Sberbank has previously been mentioned in Rosatom's press releases as a source of funding for the venture. In August 2019, Rosatom reported that Sberbank became one of the first creditors to provide Akkuyu Nuclear – a Rosatom subsidiary responsible for the design, construction, operation, maintenance, and decommissioning of the site – a seven-year loan of $400m. Previously, the report said, work at the site had been financed out of the Russian state budget and the corporation's own coffers.[7]

In 2015, according to a *Kommersant* report on Rosatom's offer to Turkey to build two more nuclear power plants – in Sinop and in İğneada – Rosatom had received 51bn rubles out of the Russian state budget.[8]

And on November 17, 2021, a press release by Rosatom said Sberbank opened two more seven-year lines of credit for Akkuyu, of $500m and $300m respectively.[9]

Russia's Sovcombank, another Akkuyu creditor subject to sanctions, gave loans valued at $300m in March last year, the *Al Jazeera* story said.

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[1] Rosatom, Apr. 2, 2018, https://www.rosatom.ru/en/press-centre/news/jsc-akkuyu-nuclear-designated-strategic-investor-in-turkey/.
[2] WNA, Country Profiles: Turkey, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/turkey.aspx.
[3] RBC, Feb. 6. 2018, https://www.rbc.ru/business/06/02/2018/5a7843899a79471f3a00b7f4.
[4] Reuters, May 3, 2013, https://www.reuters.com/article/turkey-nuclear-deal/update-1-turkey-japan-sign-22-bln-nuclear-power-plant-deal-idUSL6N0DK3A820130503.
[5] Rosatom, Apr. 4, 2018, https://www.rosatom.ru/en/press-centre/news/presidents-of-russia-and-turkey-vladimir-putin-and-recep-tayyip-erdo-an-kicked-off-large-scale-const/.
[6] Al Jazeera, May 16, 2022, https://www.aljazeera.com/news/2022/5/16/turkish-nuclear-plant-threatened-by-russian-sanctions.
[7] Rosatom, Aug. 21, 2019, https://www.rosatom.ru/journalist/news/sberbank-predostavit-finansirovanie-dlya-proekta-sooruzheniya-aes-akkuyu-v-turtsii-/. Though the link does not appear available any longer, a snapshot of it can be found in the Internet Archive, at https://web.archive.org/web/20190828074350/https://www.rosatom.ru/journalist/news/sberbank-predostavit-finansirovanie-dlya-proekta-sooruzheniya-aes-akkuyu-v-turtsii-//.
[8] Kommersant, Oct. 11, 2021, https://www.kommersant.ru/doc/5017068.
[9] Rosatom, Nov. 17, 2021, https://www.rosatom.ru/journalist/news/dochernyaya-kompaniya-rosatoma-poluchit-kredit-v-800-mln-doll-na-stroitelstvo-aes-akkuyu-turtsiya/.

Possible sanctions against Rosatom could also affect the flow of equipment to Akkuyu, the story added.

In an interview with Turkish broadcaster *NTV*, aired on February 23, Akkuyu Nuclear CEO Anastasia Zoteeva highlighted the "large amount of equipment" produced for the plant in countries such as the Czech Republic, Hungary, and South Korea. A key component was manufactured by GE Steam Power, a branch of General Electric, in France while French company Assystem is also involved in construction supervision, the *Al Jazeera* report read.

The story also cited a March report by *Bloomberg*[10] saying Turkish and Russian officials have discussed potential problems, including finance and procuring equipment from third countries.

Experts quoted in *Al Jazeera*'s story suggest Russia, given the sanctions imposed against its international reserves, the general atmosphere of a new Cold War, and Turkey's own economic problems, will be hard-pressed to find either additional funding domestically or investors willing to buy a share in Akkuyu.

In January, Russian news agency *Interfax*, citing a Rosatom presentation, said the corporation may issue a $1bn bond to raise funding for the Akkuyu construction. The report also mentions an earlier loan of up to $500m issued by Otkrytiye bank – another Russian bank currently under sanctions.[11]

An April 2, 2022 report by a Rosatom corporate outlet *Strana Rosatom*, having mentioned Bloomberg's story on possible complications at Akkuyu stemming from sanctions against Russia, insisted, however, that the nuclear corporation "has the resources for successful implementation of the Akkuyu project even without outside investors."[12]

Sweden

The Swedish energy company Vattenfall announced on the very first day of the Russian war in Ukraine that it has stopped nuclear fuel deliveries from Rosatom. The company also said it would not place any new orders from Russia to its nuclear power plants until further notice.[13]

Vattenfall, whose stated procurement policy is based on cooperation with multiple vendors from different countries to ensure supply security, had an agreement with Rosatom's fuel-manufacturing wing TVEL to supply fuel for Units 3 and 4 of its Ringhals Nuclear Power Plant, said a February 25 report by *NyTeknik*. Deliveries were to begin in one to two years and cover up to 20% of the plant's fuel needs.[14]

According to *World Nuclear News (WNN)*, TVEL in 2016 signed a commercial contract with Vattenfall to supply TVS-K (TVS-Kvadrat) fuel for the Ringhals plant with delivery of commercial reloads of nuclear fuel assemblies to start from 2021. A new fabrication facility for pressurized water reactor fuel in Novosibirsk was launched in 2021 to supply modified versions of TVS-K fuel to PWR plants around the world, *WNN* said, citing TVEL.[15]

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[10] Bloomberg, Mar. 31, 2022, https://www.bloomberg.com/news/articles/2022-03-31/war-sanctions-snag-russia-s-building-of-nuclear-plant-in-turkey.
[11] Interfax, Jan. 19, 2022, https://www.interfax.ru/business/816294.
[12] Strana Rosatom, Apr. 2, 2022, https://strana-rosatom.ru/2022/04/03/rosatom-obladaet-resursami-dlya-str/.
[13] Vattenfall, Feb. 24, 2022, https://group.vattenfall.com/press-and-media/newsroom/2022/vattenfall-stops-delivieries-of-russian-nuclear-fuel.
[14] Ny Teknik, Feb. 25, 2022, https://www.nyteknik.se/samhalle/sa-kan-utokade-sanktioner-mot-ryssland-sla-mot-svenska-foretag-7029341.
[15] World Nuclear News, Dec. 29, 2021, https://world-nuclear-news.org/Articles/TVEL-starts-PWR-fuel-fabrication-at-Novosibirsk.

The contract with Vattenfall would have been Rosatom's first delivery of such fuel abroad, Russian *Kommersant* newspaper pointed out in a February 24 story detailing the impact of the Russian invasion of Ukraine on Rosatom's deals in Europe. A pilot shipment had passed tests earlier at Ringhals, the paper said, but Vattenfall now intended to use fuel from France's Areva or the U. S. company Westinghouse. Meanwhile, the Novosibirsk plant's current production capacity was around 60 fuel assemblies a year, with a potential expansion to 300 assemblies a year.[16]

An earlier *Kommersant* report, of June 2021, said Rosatom's plans to export nuclear fuel to reactors of non-Russian design included a goal of four contracts and deliveries of TVS-Kvadrat fuel assemblies to 18 PWR units by 2030. Besides the Vattenfall deal, Rosatom had a contract for pilot operation of such fuel with an NPP-running company in the United States. By 2030, the nuclear corporation aimed to increase its 17% share in the global nuclear fuel supply market to 24%.[17]

Rosatom, however, had been supplying nuclear fuel to Ringhals since 2011, according to a recent report in *Norra Halland*. The story, describing concerns expressed by a number of Swedish parliament members over potential security and other risks of such cooperation, said the agreement then in place was to expire in 2025.[18]

NyTeknik also noted that enriched uranium is imported from Russia as raw material for production of nuclear fuel. Most of it goes to the Westinghouse nuclear fuel factory in Västerås, the publication said, which refines uranium on behalf of nuclear power plants both in Sweden and other countries.

Czech Republic

Westinghouse Electric Co. and Framatome were in April selected to deliver fuel supplies for the Czech Republic's Temelín NPP, a two-unit site with reactors of Soviet VVER-1000 design.

State-controlled power company ČEZ said Westinghouse and Framatome will deliver the fuel for about 15 years, starting in 2024. TVEL, the plant's current supplier, had also bid to supply the fuel, according to *Manufacturing and Business Technology*. [19]

Temelín currently has reserves of TVEL's fuel for two years, until the end of the current contract, according to the Czech press.

ČEZ said the decision was made so that it could reliably ensure a continuous supply of fuel while "minimizing the risks of a possible supply outage," *Manufacturing and Business Technology*'s report said.

In March, ČEZ also launched its planned tender for a new reactor at Dukovany NPP, from which Russia's Rosatom and China's CNG had been excluded on security grounds.

The decision not to allow Rosatom submit its bid to build the new Dukovany unit had been made in April 2021, shortly after Prague accused Russian special services of involvement in 2014 explosions at an ammunition depot in the village of Vrbětice.[20]

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[16] Kommersant, Feb. 24, 2022, https://www.kommersant.ru/doc/5230339.
[17] Kommersant, June 8, 2021, https://www.kommersant.ru/doc/4848474.
[18] Norra Halland, Feb. 1, 2022, https://norrahalland.se/nyheter/ryskt-karnbransle-till-ringhals-kritiseras/28472.
[19] Manufacturing Business Technologies, Apr. 12, 2022, https://www.mbtmag.com/global/news/22171958/westinghouse-framatome-to-supply-fuel-to-czech-nuclear-plant.
[20] See, for instance, here: Nuclear Engineering International, Apr. 22, 2022, https://www.neimagazine.com/news/newsrosatom-excluded-from-dukovany-tender-8690375.

Prime Minister Petr Fiala said in March Russian participation in the Dukovany tender – a key project for the country's energy security – was "unimaginable" following the Kremlin's invasion of Ukraine. The Dukovany expansion cost is estimated at around €6bn.[21]

TVEL, however, which has historically been and in most cases still is the sole supplier of fuel rods for the Soviet-built VVER reactors in Europe, including several in Ukraine, continues to supply fuel assemblies for the four old VVER-440s operating at Dukovany.

More importantly, while fuel used by the newer VVER-1000 series can and has been sourced in several cases from Westinghouse, VVER-440s are for engineering reasons particularly vulnerable to their dependency on TVEL as just one irreplaceable source of fuel.[22]

Dukovany currently has enough fuel to last for almost three years, and a contract with TVEL for future supplies is valid until the end of the plant's lifetime, ČEZ said in April. The fuel for Dukovany is specific and the ability of non-Russian producers to supply it is not high, ČEZ CEO Daniel Beneš said. [23] Another delivery from Russia should take place later in 2022, a mid-May report by *Nuclear Engineering International (NEI*) said, citing Dukovany director Roman Havlín.[24]

However, the European Commission recently announced it will assist Prague and other EU nations where VVERs are in operation to speed up the process of licensing alternative fuel, in line with the union's goal of stopping all supplies of Russian energy by 2027.

Westinghouse has also confirmed it is seeking quick approval from the governments of the Czech Republic, Hungary, Slovakia, Finland, and Bulgaria (which operates two VVER-1000s), for a replacement fuel that would work in their VVERs, the *Financial Times* reported on May 19.

Westinghouse told the paper the company was "on a fast-track program to certify our VVER-440 [fuel] design in all the countries where those reactors are operated in order to be in a position to supply reloads in 2023."

EU officials expect the green light by 2024 at the latest.[25]

Media reports indicate the Czech Republic has been considering replacing TVEL's fuel at Dukovany for some time.

The *NEI* report said that the decision to secure fuel supplies for Dukovany from companies other than TVEL was expected in the coming months, citing May 5 remarks by Dana Drábová, chairwoman of the State Office for Nuclear Safety, although, according to Drábová, ČEZ will have to come to terms with the fact that the fuel from the new supplier will not be optimized for performance, as was the case with the fuel from TVEL."

ČEZ CEO Beneš was also described as saying in March that switching to another fuel producer for Dukovany was, ultimately, a solvable problem, and within three years, if the crisis in Russia and Ukraine continued, it would be possible to solve it in some way and get fuel from elsewhere.[26]

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[21] ABC News, Mar. 17, 2022, https://abcnews.go.com/Business/wireStory/czech-republic-opens-tender-nuclear-reactor-83503697.
[22] Patricia Lorenz, Russian Grip on EU Nuclear Power, May 4, 2022, https://res.cloudinary.com/dhymuyvek/image/upload/v1651650585/Russian_Grip_on_EU_Nuclear_Power_Report_c48cccad81.pdf.
[23]Prague Stock Exchange, source stated: ČTK, Apr. 4, 2022, https://www.pse.cz/en/news/us-westinghouse-french-framatome-to-supply-nuclear-fuel-for-temelin.
[24] Nuclear Engineering International, May 13, 2022, https://www.neimagazine.com/news/newsdukovany-npp-to-change-fuel-suppliers-9696032.
[25] The Financial Times, May 19, 2022, https://www.ft.com/content/fcce8ccc-31bd-4dab-8532-12cd0948fc5d.
[26] iROZHLAS.cz, Mar. 18, 2022, https://www.irozhlas.cz/ekonomika/podcast-vinohradska-12-jaderna-elektrarna-dukovany-dostavba-trachtova_2203180600_miz.

"I can't imagine being dependent on just one supplier in the future. Some negotiations are underway, I can't say the details yet," *NEI* quoted Dukovany director Havlín as saying.

The old Dukovany plant has roughly 20 years of operation left, according to Drábová.

The Czech Republic also has provisional plans to build Units 3 and 4 at Temelín, but Rosatom's participation in such a project appears doubtful. The exclusion of Russia and China from the tender for the new Dukovany unit was written into legislation approving new nuclear construction that was adopted in September 2021. Minister of Industry and Trade Karel Havlícek said at the time that the two new reactors at Temelín could be built by the company that wins the tender for the Dukovany unit. A non-binding option for the possible construction of one or two units in Temelín will be part of the tender documentation for the project, according to Havlícek.[27] That such options were in fact included in the Dukovany tender was confirmed by ČEZ CEO Beneš shortly after the tender procedure commenced in March this year.[28]

Germany

The first day of the war also saw the dissolution of a planned deal between Rosatom and Framatome in which Rosatom expected to buy 25% in Framatome's nuclear fuel manufacturing facility Lingen in Lower Saxony. The application for an investment review procedure for a joint TVEL/Framatome venture had been withdrawn a few days prior, *Spiegel* reported on February 24.[29]

The deal, according to *Spiegel*, was to provide a cash injection to Framatome's subsidiary Advanced Nuclear Fuels for expanded production (even as Germany itself is phasing out nuclear generation, Framatome had plans to continue producing nuclear fuel in Lingen at least until 2032 for exports to other European countries) while also giving TVEL better access to the European market, *Spiegel*'s story said.

Though the reasons for the withdrawal of the application were unknown, *Spiegel* notes the prospect of a TVEL/Framatome consortium had been viewed critically as a potential threat to public order and suggests the German Ministry of Economics may have banned Rosatom's entry. Imminent lawsuits, in *Spiegel*'s information, as well as political considerations in light of Germany's nuclear phaseout may have played a role.

The February 24 story by *Kommersant* plainly states that Germany "has now definitively forbidden Rosatom" to buy the 25% share in the Lingen facility.

Rosatom's activity in Germany also included longtime imports of depleted uranium from a uranium enrichment facility run in Gronau by Urenco, a uranium enrichment company owned by Germany's RWE and E.ON as well as the governments of the Netherlands and the UK.

Rosatom refers to depleted uranium as a "valuable strategic resource" imported for further re-enrichment.[30] But while some of the reprocessed material was returned to Gronau (with the radioactive waste generated during reprocessing left in Russia), most of the shipments had for years accumulated in storage in less than ideal conditions in Russia's Siberia – thus remaining, environmentalists have insisted, nothing but nuclear waste, even as import of nuclear waste to Russia

[27] Nuclear Engineering International, Sept. 30, 2021, https://www.neimagazine.com/news/newsczech-energy-law-adopted-temelin-expansion-may-follow-new-dukovany-unit-9120810.
[28] World Nuclear News, Apr. 1, 2022, https://www.world-nuclear-news.org/Articles/Space-allocated-at-Temelin-for-future-SMR.
[29] Spiegel, Feb. 24, 2022, https://www.spiegel.de/wirtschaft/unternehmen/lingen-einstieg-von-rosatom-in-deutsche-atomfabrik-vorerst-geplatzt-a-f355e411-7635-4a44-8d4f-c9c9061888fb.
[30] See, for instance, Rosatom's press release of Nov. 13, 2019 at https://rosatom.ru/en/press-centre/news/members-of-the-public-council-of-rosatom-and-representatives-of-environmental-organizations-discusse/.

is banned under Russian law.[31] Over a period of 25 years, Urenco delivered more than 45,000 tons of depleted uranium to Russia from Germany alone (shipments were also made from Urenco's enrichment facilities in Almelo in the Netherlands and Capenhurst in the UK[32]).

In early March 2022, prompted by the Russian aggression against Ukraine, Urenco terminated its contract with Russia. "We are deeply concerned about the current developments in Ukraine [...]. We terminated the contract with our supplier in Russia and stopped all deliveries in both directions," the company said.[33]

The last transports of the highly hazardous material were carried out in 2019 and 2020 amid, as in the previous years, protests mounted by environmental groups both in Russia and in Germany.

Finland

The same February 24 *Kommersant* story said Rosatom's Hanhikivi NPP project in Finland was now in doubt because of the war. On May 2, Hanhikivi's project owner, the Finnish company Fennovoima, announced it has terminated its contract with Rosatom.

The company – a consortium of Finnish industrial firms and mostly municipal energy companies – cited significant delays and Rosatom's "inability to deliver the project," and added that the war in Ukraine has further exacerbated the risks of the project, the Finnish publication *Yle News* reported.[34]

The project was in effect suspended on the very next day after Russia attacked Ukraine, as Finland's Minister of Economic Affairs Mika Lintilä told parliament on February 25 that he would not present Fennovoima's construction permit application for Hanhikivi – pending since 2015 – to the government, *Yle News* said.

From the point of view of Finnish stakeholders, the publication added, continuing cooperation with Rosatom became even more untenable after Rosatom took control of the Zaporizhzhia Nuclear Power Plant in Ukraine, which was captured by Russian forces in early March.

Rosatom representatives arrived at the six-unit plant, the largest NPP in Europe, a few days after the Russian military seized the site and "about ten Rosatom staff members were still there" in late April, according to a summary report by International Atomic Energy Agency (IAEA) Director General Rafael Mariano Grossi.[35] An IAEA press release of April 29, citing information provided by Ukraine, said that Rosatom's specialists "demanded daily reports from plant management about 'confidential issues' on the functioning" of the plant and that personnel were "working under unbelievable pressure."[36]

Previously, numerous media reports showed or described Russian troops shelling plant buildings at Zaporizhzhia, and the IAEA director general's report also said two of the four high-voltage lines providing external power supply to the plant (which is critical to the safety of its operation) were damaged in the early days of Russian control of the site, and the plant also lost a third line for a period of time.

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[31] DW, Oct. 25, 2019, https://www.dw.com/en/germany-shipping-depleted-uranium-to-russia/a-50995522.
[32] WISE Uranium Project, https://www.wise-uranium.org/edisstr.html.
[33] Westfälische Nachrichten, Mar. 8, 2022, https://www.wn.de/muensterland/urenco-kundigt-vertrag-2540841.
[34] Yle News, May 2, 2022, https://yle.fi/news/3-12425648.
[35] IAEA, Apr. 28, 2022, https://www.iaea.org/sites/default/files/22/04/ukraine-report.pdf.
[36] IAEA, Apr. 29, 2022, https://www.iaea.org/newscenter/pressreleases/update-67-iaea-director-general-statement-on-situation-in-ukraine.

A contract between Rosatom and Fennovoima to build a nuclear power plant with a Russian VVER-1200 reactor was signed in 2013. Rosatom also holds a majority 34% share in Fennovoima.

By 2018, construction was to be in full swing, but, *Yle News* says, calling the project "a 15-year saga," a construction license has not been granted, though preliminary work at the site continued despite the war. An early 2019 story by *Interfax* said, citing a Finnovoyma-released schedule, that the project, already delayed by four years, was to see a construction license obtained in 2021 and commercial operation to start in 2028.[37]

An earlier *Yle News* story said final building permits were due to be granted in 2022.

Although the Hanhikivi project survived Russia's annexation of Crimea in 2014, concerns were voiced to *Yle News* over the risks involved in cooperation with Rosatom – which also produces nuclear munitions for the Russian nuclear arms complex – even before the start of the war, just as Russia had amassed almost 200,000 troops near Ukraine's border but Moscow's high-level officials insisted the country had no plans to attack its neighbor.

A February 22 *Yle News* story quoted Veli-Pekka Tynkkynen, a professor in Russian environmental policy, as saying that if Finland invests in Russian nuclear power "in this current Fennovoima structure, then we directly support Russian nuclear weapons production and therefore also Vladimir Putin's geopolitical goals."

Tynkkynen disagreed that energy markets and trade ties could promote peace between Putin's Russia and the West, pointing instead to a dependency on Russia's energy supplies that could only grow with Hanhikivi and suggesting that Russia's ownership stake in Fennovoima "should be seen as a loaded weapon, in a way," one that could provide Russia leverage over Finland.[38]

In 2015, the *Interfax* story said, a decision was made to provide around €2.4bn for the Hanhikivi project out of the Russian National Wealth Fund, a sovereign wealth fund set up to support the public pension system. Total construction costs were estimated at €7bn.

Hanhikivi's reactor pressure vessel, according to *Yle News*, was to have been built in Kramatorsk, eastern Ukraine.

Rosatom, however, still supplies fuel to the two VVER-440s operating at Finland's Loviisa. whose operator company, Fortum, has a deal with TVEL for the duration of the current operating licenses.[39]

VVER-440s are dependent on TVEL as their sole fuel provider, and, to further complicate matters, fuel assemblies manufactured for different VVER-440s are designed specially to fit a particular reactor. Still, in the case of Loviisa, attempts have been made to switch to a different provider, with Westinghouse supplying fuel rods to the plant for several years until 2008.[40]

Some other unresolved questions remain with regard to fuel diversification for Loviisa, according to a Finnish official who spoke with the *Financial Times* in May. Westinghouse fuel is likely to be more expensive than Russian, the official said, and there would also need to be a waste plan, as Rosatom is also responsible for handling Loviisa's spent fuel.[41]

Just like most other VVER reactors in Europe, Loviisa's units are quite old. Their current operating licenses, already extended once – in 1998, for Unit 1, and in 2007, for Unit 2 – expire at the end of

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[37] Interfax, Jan. 4, 2019, https://www.interfax.ru/business/644029.
[38] Yle News, Feb. 22, 2022, https://yle.fi/news/3-12328641.
[39] The Financial Times, May 19, 2022, https://www.ft.com/content/fcce8ccc-31bd-4dab-8532-12cd0948fc5d.
[40] Patricia Lorenz, Russian Grip on EU Nuclear Power, May 4, 2022, https://res.cloudinary.com/dhymuyvek/image/upload/v1651650585/Russian_Grip_on_EU_Nuclear_Power_Report_c48cccad81.pdf.
[41] The Financial Times, May 19, 2022, https://www.ft.com/content/fcce8ccc-31bd-4dab-8532-12cd0948fc5d.

2027 and 2030, and Fortum said in March it was planning to apply to renew the licenses until the end of 2050. Investments related to the continued operation and lifetime extensions, it said, will amount to an estimated €1bn until that year.[42] Unless Loviisa switches to a different fuel provider – something that will surely require additional effort and investment – some of that money will eventually end up on Rosatom's accounts. As Patricia Lorenz, author of *Russian Grip on EU Nuclear Power* points out, "a well-prepared phaseout of nuclear power would be the economically and politically most sustainable answer."[43]

France

The French nuclear industry, based as it is in a nation with a heavy reliance on nuclear power, maintains several close partnerships with Rosatom through the partially state-owned utility EDF and nuclear fuel cycle company Orano.

A swift parting of the ways with Rosatom would be hard to expect in the case of France, but, *Politico* reported on April 29, Orano said it "has suspended all new shipments of nuclear materials to and from Russia" since the end of February, and pointed out that it has "very limited activities" in Russia, which represents less than 0.1% of its orders.[44]

Orano sends reprocessed uranium to a Russian nuclear military facility in Siberia. After the uranium is cleaned up there, the radioactive waste remains in Russia, while the cleaner uranium is used to produce nuclear fuel.

Deals for two deconversion plants for depleted uranium have been signed with Rosatom, the latest in 2019.[45] Equipment for this project was sent from France to Russia in December 2021. Reporting on that shipment, *WNN* said plant operations were scheduled to start in 2023, and TVEL expected a third deconversion facility built later to further handle depleted uranium accumulated at its sites.[46]

EDF's subsidiary Framatome, a Rosatom partner in a number of ventures, will now no longer be able to sell Rosatom a 25% share in the fuel manufacturing facility in Germany's Lingen, but the status of some other dealings between EDF and Rosatom is not clear at present.

In March, the French press raised the issue of Rosatom's possible participation in EDF's acquisition of General Electric's turbine business GEAST in Belfort. The state was ready to sell Rosatom 20% in the company, *Le Figaro* reported on March 8. "As long as the sanctions against Russia do not concern nuclear power, Rosatom's entry in the capital of GEAST remains relevant," a government source told the paper.[47] GEAST's cooperation with Rosatom represents 50% of the turnover of the Belfort plant, which supplies turbines for EPR reactors in Europe, with nearly 70% of the value chain

[42] World Nuclear News, Mar. 3, 2022, https://www.world-nuclear-news.org/Articles/Fortum-to-seek-licence-extension-for-Loviisa-plant.
[43] Patricia Lorenz, Russian Grip on EU Nuclear Power, May 4, 2022, https://res.cloudinary.com/dhymuyvek/image/upload/v1651650585/Russian_Grip_on_EU_Nuclear_Power_Report_c48cccad81.pdf.
[44] Politico, Apr. 29, 2022, https://www.politico.eu/article/russia-nuclear-power-uranium-plants-europe-imports-germany-sanctions-ukraine-war/.
[45] Rosatom, Dec. 11, 2019, https://rosatom.ru/en/press-centre/news/rosatom-and-orano-subsidiaries-sign-contract-to-grow-russian-capacities-for-depleted-uranium-reconve/.
[46] World Nuclear News, Dec. 23, 2021, https://www.world-nuclear-news.org/Articles/Equipment-for-deconversion-arrives-at-Zheleznogors.
[47] Le Figaro, Mar. 8, 2022, https://www.lefigaro.fr/societes/nucleaire-l-etat-pret-a-ceder-20-d-arabelle-au-russe-rosatom-20220308.

provided in France, noted *La Tribune*, saying for Rosatom acquiring the 20% stake would be "of major strategic interest."[48]

In April, though, *L'Usine Nouvelle* reported France's cooperation with Rosatom was on hold. All discussions have been suspended, according to a source close to the matter.[49]

Hungary

Hungary for now seems intent on keeping alive its cooperation with Rosatom on construction of two new units, of VVER-1200 design, at Paks Nuclear Power Plant, where four VVER-440 reactors are in operation, built in 1974 to 1987. As is the case with some other projects, Paks Phase II has suffered from delays and is now also potentially facing financing uncertainties. The €12.5bn project is supported by a Russia-provided loan of up to €10 bn, covering 80% of the construction cost, and Russian President Vladimir Putin earlier said Russia was prepared to finance 100% of the plant if necessary.[50]

On May 5, 2022, Hungarian Foreign Minister Peter Szijjártó said Hungary received Rosatom's assurances that the corporation remains able to deliver the new units, *Reuters* reported. Szijjártó said the planned construction served Hungary's strategic interests and that once requests for permits submitted by Rosatom to the Hungarian regulator were approved, the project could enter its next phase.[51] According to Szijjártó, Hungary aims to speed up the work and have the new units up and running by 2030.[52] Earlier, opposition parties in Hungary called for Prime Minister Viktor Orbán to cancel the deal, *Bulletin of the Atomic Scientists* noted in a May 17, 2022 piece on Rosatom's prospects amid the tightening sanctions against Russia.[53]

But just like the Akkuyu project, the one at Paks may run into funding difficulties or problems with third-party suppliers. *Euractiv* points out Russia's state bank Vnesheconombank, which is financing the Paks expansion, is among the banks hit with a SWIFT ban. As András Perger, a climate & energy campaigner with Greenpeace Hungary, told *Euractiv*, the issue may arise at a later stage, during actual construction work, when Rosatom will be expected to pay its Hungarian and Western subcontractors.[54]

The turbine generator for Paks II is to be supplied by General Electric, and the automated process control system by a Franco-German consortium of Framatome and Siemens.[55]

As for the fuel for the currently operating four units at Paks, Hungary may prove more amenable to a change. A spokesman for the plant told the *Financial Times* in May Paks still had "enough fuel for

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[48] La Tribune, Mar. 9, 2022, https://www.latribune.fr/entreprises-finance/industrie/energie-environnement/nucleaire-pourquoi-le-geant-russe-rosatom-pourrait-prendre-20-des-turbines-arabelle-905779.html.
[49] L'Usine Nouvelle, Apr. 13, 2022, https://www.usinenouvelle.com/article/pourquoi-le-nucleaire-russe-n-est-pas-vise-par-les-sanctions-occidentales.N1992997.
[50] World Nuclear Association, updated Dec. 2021, https://world-nuclear.org/information-library/country-profiles/countries-g-n/hungary.aspx.
[51] Reuters, May 5, 2022, https://www.reuters.com/article/ukraine-crisis-hungary-rosatom/update-1-rosatom-reassures-hungary-on-paks-nuclear-plant-minister-idUKL2N2WX0J8.
[52] Nuclear Engineering International, May 20, 2022, https://www.neimagazine.com/news/newshungary-seeks-to-speed-up-paks-npp-expansion-9712752.
[53] Bulletin of the Atomic Scientists, May 17, 2022, https://thebulletin.org/2022/05/five-reasons-that-russias-nuclear-exports-will-continue-despite-sanctions-and-the-ukraine-invasion-but-for-how-long/.
[54] Euractiv, Mar. 9, 2022, https://www.euractiv.com/section/politics/short_news/cee-future-of-russian-nuclear-unclear/.
[55] Rosatom, Dec. 20, 2021, https://rosatom.ru/en/press-centre/news/rosatom-s-director-general-alexey-likhachev-held-talks-with-hungarian-prime-minister-viktor-orban/.

the long term, which we procured from TVEL. Of course, in line with the current situation, we are working with similar nuclear power plants to diversify fuel procurement."[56]

The four VVER-440s at Paks are quite old as well: Their 30-year design lifetimes were to last until between 2012 and 2017. But extensions have been granted for all four reactors, with the latest, for Unit 4, ending in 2037.[57]

Slovakia

Moscow's earnings from nuclear fuel exports are not high, says the April 29 *Politico* story. Indeed, according to Rosatom's annual report for 2020 (the latest available on Rosatom's website), the foreign revenue of the corporation's fuel division totaled about $0.7bn that year. But it may be worth considering TVEL's financial plans for the future and its share in the global fuel manufacturing market.

TVEL's 10-year portfolio of overseas orders reached $15.7bn, according to the report, and its share in the global nuclear fuel fabrication market was 17%. In 2020, TVEL supplied fuel to Armenia, Belarus, Bulgaria, Hungary, Slovakia, the Czech Republic, India, China, Ukraine, and Finland. In cooperation with Framatome, Rosatom also supplied fuel and components manufactured in Russia from reprocessed uranium to Western European nuclear power plants, the report said.[58]

Of these 11 partnerships, seven now have either been dissolved or are under threat of dissolution following, in part, the European Union's plan to help EU countries switch to an alternative fuel source and Westinghouse's previous experience in, and willingness to expedite, replacement fuel supplies.

Slovakia, which currently remains completely dependent on TVEL fuel, has four VVER-440 reactors in operation – two units running at Mochovce and two at Bohunice, all built in the 1980s and 1990s. Two more VVER-440s are being built as well at Mochovce. This construction began in 2009, and last January, Slovakian regulators said they were going to permit commissioning of the third VVER-440 unit at Mochovce pending public comments expected until March 21.[59] First grid connection is slated for later this year.[60] Earlier, Rosatom was also reportedly considering entering into the construction project for a new unit at Bohunice.[61]

Slovakia, however, has said it would switch to a different provider once an alternative to TVEL fuel was available, according to the May 19 report by the *Financial Times*. It has around two years' worth of fuel stockpiled after the last delivery.

Karol Galek, state secretary at Slovakia's Ministry of Economy, told the paper the country wanted to switch to alternative fuel for its VVER-440s as soon as possible, adding Slovakia was "already in discussion with other companies." But Bratislava could not support a ban on Russian nuclear fuel until there was a certified alternative. "We will see what happens with discussions," the *Financial Times* quoted Galek as saying.[62]

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[56] The Financial Times, May 19, 2022, https://www.ft.com/content/fcce8ccc-31bd-4dab-8532-12cd0948fc5d.
[57] World Nuclear Association, updated Dec. 2021, https://world-nuclear.org/information-library/country-profiles/countries-g-n/hungary.aspx.
[58] Rosatom, https://rosatom.ru/upload/iblock/e7d/e7d0c99cb1a447fa716e49eacba42f14.pdf.
[59] World Nuclear News, Jan. 26, 2022, https://www.world-nuclear-news.org/Articles/Mochovce-3-to-get-commissioning-licence.
[60] Reporting Democracy, Mar. 15, 2022, https://balkaninsight.com/2022/03/15/war-in-ukraine-triggers-energy-dilemma-in-central-europe/.
[61] Nuclear Engineering International, June 11, 2019, https://www.neimagazine.com/news/newsrussia-and-slovakia-agree-to-continue-co-operation-7254850.
[62] The Financial Times, May 19, 2022, https://www.ft.com/content/fcce8ccc-31bd-4dab-8532-12cd0948fc5d.

Bulgaria

Bulgaria operates two Soviet-built VVER-1000s at Kozloduy – two units of a design better suited for fuel substitution from Westinghouse.

With enough TVEL fuel left for around two and a half years of operation, Bulgaria confirmed it was in talks with Westinghouse and was working to certify the company's fuel quickly, the May 19 *Financial Times* report said.

The idea of continued development – after 15 years of negotiations, a cooperation agreement between Rosatom, Framatome, and GE Steam Power for a joint tender bid, as well as some equipment deliveries by Rosatom – of a project of two units at a new site, Belene, was finally abandoned shortly before the war, with Sofia now considering building small modular reactors at Kozluduy with the help of U.S.-based NuScale Power.[63]

Egypt

In Egypt, Rosatom has contracted to build four VVER-1200 reactors at El Dabaa by 2029. The construction cost is estimated at $30bn. Russia, according to President Putin's remarks in 2018, was extending a $25bn credit on favorable terms.[64]

Egypt now expects the plant to be fully operational by 2031, with an 18-month delay caused by the COVID-19 pandemic. Construction work on the first unit is scheduled to start in July, according to *Al-Monitor*, which also cites the $25bn Russian loan covering 85% of the cost.[65]

But the publication describes experts' anticipation of possible disruptions and risks to the Egyptian economy as an emerging market because of the war in Ukraine and the resulting sanctions. The project is very long-term and therefore delays are of little consequence, one analyst told *Al-Monitor*, adding, however, that the war "may affect the project's start date due to the economic sanctions affecting the Russian firms." Another, an Egyptian politician, called the potential impact "very likely" and said he expects work at El Dabaa to be suspended and to resume after the war, perhaps with a country other than Russia.

One expert quoted by *Al-Monitor* also said Cairo hopes that Washington will consider the various political factors influencing Egypt's decisions, as well as Cairo's vote in favor of the UN resolution condemning Moscow's aggression in Ukraine, before sanctioning Egypt – indicating that such pressure is not ruled out.

In an earlier *Al-Monitor* story an expert told the publication the war has created several challenges for Egypt, which would like to maintain a degree of neutrality but may struggle to do so.

As part of its economic reform plan, Egypt since 2016 has secured tens of billions of dollars of financing from Western-controlled international financial institutions like the International Monetary Fund and the European Bank for Reconstruction and Development, *Al-Monitor* said, quoting the expert as saying that "[t]his is support Russia cannot replace" and that the "shareholders of these

[63] Balkan Green Energy News, Feb. 16, 2022, https://balkangreenenergynews.com/bulgaria-abandons-belene-announces-new-reactors-at-kozloduy/.
[64] Interfax, Dec. 29, 2018, https://www.interfax.ru/business/644565.
[65] Al-Monitor, Mar. 27, 2022, https://www.al-monitor.com/originals/2022/03/ukraine-war-could-delay-egypts-first-nuclear-power-plant.

institutions can impose far stricter conditions on future loans and investments for Egypt while reducing the scale of their financial support."[66]

Somewhat of a more immediate nature, apprehensions have surfaced with regards to future payments to Korea Hydro & Nuclear Power, which is expected to provide secondary system equipment for the project.[67] In January, Rosatom pre-authorized the South Korean company as the sole bidder for the construction of the main and auxiliary buildings as well as structures of the El Dabaa turbine islands. Another supplier is a joint venture of Rosatom and General Electric, with the latter expected to manufacture steam turbines and generators for all four of El Dabaa's reactors.[68]

In 2018, Russian Finance Minister Anton Siluanov suggested that the money for El Dabaa might be drawn from the Russian National Wealth Fund.

"According to the credit agreement, the yearly credit amounts [starting in 2020-2021] are on the level of $3bn to $4bn for the plant alone. Where do we get this money? On the market? It's unclear at the moment how the situation will be developing," the Russian business publication *RBC* quoted Siluanov as saying in October that year, adding that the reference was to the new sanctions against the Russian sovereign debt under discussion at the time.

The same approach was used to finance Finland's Hanhikivi, Siluanov said. The National Wealth Fund's investment guidelines dictate that countries where its assets can be invested must have a credit rating of AA- or higher on the scale of the rating agencies Fitch or S&P, or Aa3 or higher on the scale used by Moody's. Unlike Finland's, Egypt's credit rating did not fit the guidelines, but, according to Siluanov, the government may make an exception.[69]

The National Wealth Fund's value stood at $154.95bn as of mid-May, down from $175bn in early February.[70]

India

Just like Egypt, worried that Russia's pariah status may hurt its economic, military, and security ties with Moscow and its own national interests[71], India may find itself between a rock and a hard place with Kudankulam Nuclear Power Plant Rosatom is building in that country. Unlike Egypt, however, where the project is at a stage of preparatory work at the site,[72] construction is ongoing at Kudankulam's Phases II and III, the four more units with VVER-1000s in addition to Unit 1 and 2 already in operation. As of late April 2022, the reactor pressure vessel was installed at Unit 3; last December, first concrete was laid for the reactor building of Unit 6.[73]

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[66] Al-Monitor, Mar. 11, 2022, https://www.al-monitor.com/originals/2022/03/egypt-seeks-middle-ground-between-us-russia-ukraine-fighting-rages.
[67] Business Korea, Mar. 25, 2022, http://www.businesskorea.co.kr/news/articleView.html?idxno=88454.
[68] World Nuclear News, Jan. 12, 2022, https://www.world-nuclear-news.org/Articles/Applications-made-to-build-El-Dabaa-units-3-and-4.
[69] RBC, Oct. 18, 2018, https://www.rbc.ru/economics/18/10/2018/5bc862fe9a79470ecbe623cf.
[70] Reuters, May 16, 2022, https://www.reuters.com/markets/europe/russian-rainy-day-fund-shrinks-slightly-15495-bln-april-2022-05-16/.
[71] Al-Monitor, March 11, 2022, https://www.al-monitor.com/originals/2022/03/egypt-seeks-middle-ground-between-us-russia-ukraine-fighting-rages.
[72] Rosatom, Apr. 18, 2022, https://rosatom.ru/en/press-centre/news/ase-president-alexander-lokshin-and-nppa-board-chairman-amged-el-wakeel-visit-the-el-dabaa-npp-const/.
[73] Rosatom, Apr. 30, 2022, https://rosatom.ru/en/press-centre/news/reactor-vessel-installed-at-kudankulam-npp-unit-3/; Dec. 21, 2022, https://rosatom.ru/en/press-centre/news/india-has-started-construction-of-kudankulam-npp-unit-6/.

As with other projects, construction is aided with Russia's loans: As of 2019, $3.4bn was to be provided on credit out of the estimated overall cost of $6.4bn for Units 3 and 4, and $4.2bn to cover most of the cost of Reactor Units 5 and 6, at over $5bn.[74]

The Indian press wrote in March about worries connected with the logistical and ocean freight problems affecting Rosatom's equipment shipments to Kudankulam as one reason for possible delays in the project, and also expressed concern over potential sanctions against Rosatom from the U.S.

It remains unclear whether the Russian banks will be able to fulfill their announced loans for various Rosatom projects, what actions the countries and companies involved with Rosatom are taking to shield themselves from potential exposure to the U.S. or EU sanctions, or to what extent the United States or the European Union will pursue sanctions violations on countries for cooperation with Russian nuclear entities and associated financing vehicles, *Bulletin of the Atomic Scientists* wrote in May.

But should major disruptions bring India's project to a halt, the investments into Kudankulam may turn out to be sunk costs, the publication warned, reflecting on the effects of secondary sanctions if a ban on cooperation with Rosatom is imposed.

Because of the difficulties and costs involved in finishing or servicing a newbuild after a different contractor, the project in India, and Turkey as well, could end up extremely expensive stranded assets, *Bulletin of the Atomic Scientists* wrote. It provided as an example the first unit of Iran's Bushehr, which Russia was only able to complete – picking up where Germany left off after the Islamic Revolution and the Iran-Iraq War – 37 years after construction started in 1975. Facing such impacts, India could choose to continue working with Rosatom at least in the near term, according to the publication.[75]

Units 3 and 4 at Kudankulam were in February completed to 58.22%, with the end of the construction expected in 2027, and Units 5 and 6 were at 8.12%.[76]

[74] Ecodefense, Dreams and Reality of the Russian reactor export, March, 2019, https://ecdru.files.wordpress.com/2019/03/rosatom-report2019.pdf.

[75] Bulletin of the Atomic Scientists, May 17, 2022, https://thebulletin.org/2022/05/five-reasons-that-russias-nuclear-exports-will-continue-despite-sanctions-and-the-ukraine-invasion-but-for-how-long/.

[76] Business Standard, Mar. 31, 2022, https://www.business-standard.com/article/current-affairs/ukraine-conflict-to-hit-kudankulam-nuclear-project-schedules-centre-122033101246_1.html; Money Control, Mar. 1, 2022, https://www.moneycontrol.com/news/business/economy/ukraine-conflict-russias-rosatom-doesnt-foresee-any-disruptions-in-kudankulam-nuclear-power-plant-execution-8180161.html;

Conclusion

In the three months since the start of Russia's invasion of Ukraine, several Rosatom partnerships have been terminated and a sizable number of ventures have come under threat of falling apart further down the line. Rosatom lost its contract for the construction of Hanhikivi Nuclear Power Plant in Finland, Sweden's Vattenfall refused to accept further deliveries of nuclear fuel from Russia and the same was done by the Czech Republic, the multinational company Urenco and Orano in France ended cooperation (uranium services), and the deal with France's Framatome to buy 25% in a German fuel manufacturing facility in Lingen was aborted, likely banned by the German government. A number of European countries, backed by the European Commission, are on a path to part ways with Rosatom's fuel producing company TVEL and switch to Westinghouse's fuel, which, if and when achieved, will all but end TVEL's presence on the European fuel assembly market.

Other major Rosatom projects – those where the corporation has been contracted to build nuclear power plants abroad – will likely suffer in the long run. One reason is that the sanctions rolled out against Russia's financial reserves and its banks may potentially severely hamper Rosatom's ability to raise construction funding and keep extending the loans Russia has promised its reactor-buying clients. Another is that the same sanctions may hurt Rosatom's ability to pay third-party vendors participating in the construction. Turkey, India, Egypt may eventually find these disruptions affecting the progress of the Russian reactors being built on their soil.

In the business of the nuclear industry perhaps more than in any other, investments are strategic, with one successfully completed project securing the market for decades of fuel deliveries and servicing. With those comes political clout. A dozen million's worth of one fuel contract lost is billions in lost revenue and lost leverage in the future.

In the end, the longer Russia is waging its brutal war against Ukraine, the more money it is spending on it and losing due to sanctions, the less money it has to invest in new "strategic" nuclear deals to keep earning from the sale of its nuclear products and services to then spend on war. Sanctions can have a cumulative effect to end this vicious circle.

But this is not to say that the steps already taken are sufficient. Targeted sanctions must be imposed against Rosatom, which is as much a part of the Russian state as Russia's oil and gas industry, for pragmatic reasons, if not moral ones. Companies involved with Rosatom via nuclear construction or fuel cycle deals - General Electric, EDF, Siemens, Korea Hydro & Nuclear Power, and others - must join those that have already severed ties with Rosatom. The effects of sanctioning Russian banks are deferred, while the war is taking more lives every day.

The world does not need more nuclear – certainly not at that cost.