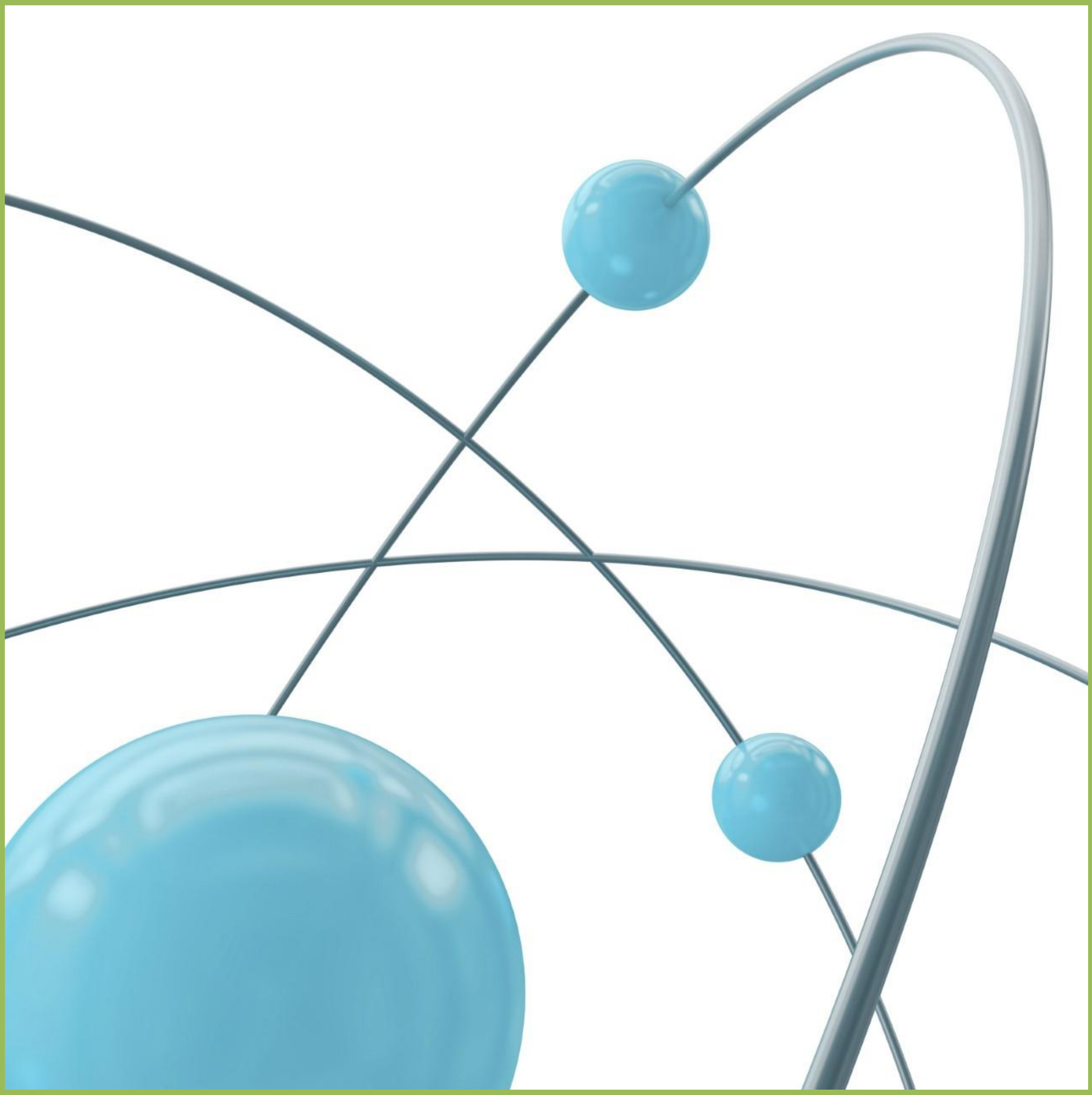
Russian nuclear power – 2017

Updated as of 30.05.2017



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The Bellona Foundation is an international environmental NGO based in Norway. Founded in 1986 as a direct action protest group, Bellona has become a recognized technology and solution-oriented organizations with offices in Oslo, Brussels, Kiev, St. Petersburg and Murmansk. Altogether, some 60 engineers, ecologists, nuclear physicists, economists, lawyers, political scientists and journalists work at Bellona.

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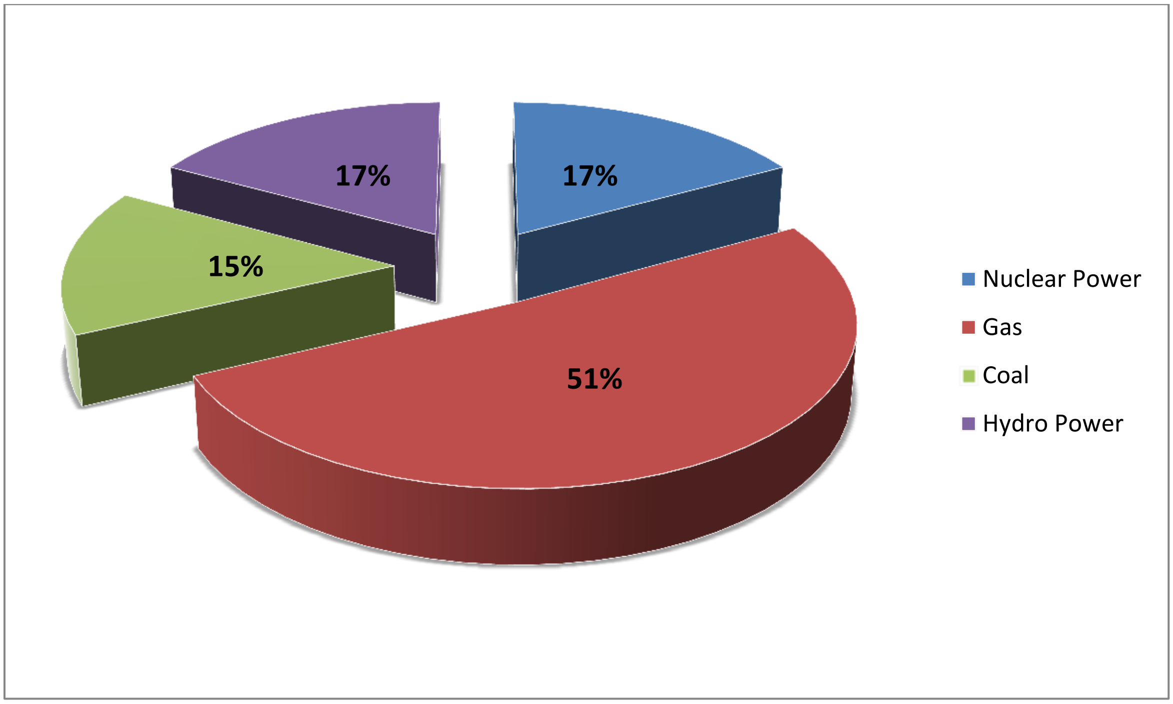
2 The place of nuclear power in Russia

As of 2014, Russia's 10 nuclear power plants produced a total of 181 TWh of power. This places the country as the third largest nuclear power producer in the world, after the USA and France. [1] In the same year, 18.6% of the country's electricity production came from nuclear power, which is close to the average of 18% over the last several years. [2] The total nuclear power production in 2014 was 1064 TWh. [3]

Figure 1 - Power usage in Russia by energy source



[1] http://www.world-nuclear.org/ (Retrieved 17.10.2016)
[2] Rosenergatom, 2016 (http://www.rosenergoatom.ru) (Retrieved 17.10.2016)
[3] http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx (Retrieved17.10.2016)

3 The nuclear power plants of Russia

Russia's nuclear power industry began with a reactor at Obnisk (5 MWe), which came online in 1954. It was the first nuclear power plant (NPP) in the world that produced electricity. The first full size commercial reactors were put into operation around 10 years later, in 1963-64. [4]

Today, Russia runs 10 NPPs, [5] eight of which are located in the European part of Russia. Two are located east of the Ural mountain range.

Eleven of the currently operational reactors are graphite moderated reactors of the RBMK model, which is the same type that exploded in Chernobyl in 1986. Of the remaining reactors, 17 are conventional light-water reactors of the VVER-model.

Most of the reactors in Russia were put into operation in the late 1970s and the early 1980s. The average run time of those reactors are now just over 33 years, with the longest running in operation for 45 years.

The NPPs of Russia are owned and run by the nuclear utility Rosenergoatom. The utility is 100% owned by the state nuclear agency Rosatom, which itself oversees more than 200 enterprises and science institutes and which employs 250,000 people. Rosatom is also an international stakeholder. It currently occupies around 36% of the world market for uranium enrichment and it produces 17% of all nuclear fuel worldwide. [6]

According to the latest figures from Rosatom, 35 reactors are currently in operation at NPPs in Russia, with a total capacity of 27,127 GW. This includes the newest addition, Novovorenezh-6, which was put into operation on October 27, 2016.

Picture 1 - Russian NPPs[7]

[4] http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx (Retrieved 17.10.2016)
[5] Ibid
[6] http://rosatom.ru/en/about-us/ (Retrieved 17.10.2016)
[7] https://www.iaea.org/INPRO/10th_Dialogue_Forum/Day3/Session4/02.Khaperskaya_Russia.pdf

Table 1 - Nuclear power in Russia per April 2017[8]

NPP	Type	Reactors	Start of operation	Capacity (MWe)	Run time permit
Balakovo NPP	VVER-1000	Balakov-1	28.12.1985	988	2045
		Balakov-2	08.10.1987	988	2033
		Balakov-3	25.12.1988	988	2034
		Balakov-4	04.11.1993	988	2023
Beloyarsk 1 NPP	BN-600	Belyoarsk-3	08.04.1980	560	2025
	BN-800	Beloyarsk-4	17.08.2016	789	2046
Bilibino NPP	EGP-6	Bilibino-1	12.01.1974	12	2018
		Bilibino-2	30.12.1974	12	2018
		Bilibino-3	22.12.1975	12	2021
		Bilibino-4	27.12.1976	12	2021
Kalinin NPP	VVER-1000	Kalinin-1	09.05.1984	1000	2025
		Kalinin-2	03.12.1986	1000	2032
		Kalinin-3	16.12.2004	1000	2034
		Kalinin-4	26.09.2012	1000	2042
Kola NPP	VVER-440	Kola-1	29.06.1973	432	2018/2033(?)
		Kola-2	08.12.1974	411	2019/2034(?)
		Kola-3	24.03.1981	411	2026
		Kola-4	11.10.1984	411	2039
Kursk NPP	RBMK-1000	Kursk-1	19.12.1976	971	2022
		Kursk-2	28.01.1979	971	2024
		Kursk-3	17.10.1983	925	2029
		Kursk-4	02.12.1985	925	2030
Leningrad NPP	RBMK-1000	Leningrad-1	21.12.1973	925	2019
		Leningrad-2	11.07.1975	971	2021
		Leningrad-3	07.12.1979	925	2025
		Leningrad-4	09.02.1981	925	2026
Novovorenezh NPP*	VVER	~~Novovorenezh-3~~	~~27.12.1971~~	~~385~~	~~2016~~
		Novovorenezh-4	28.12.1972	385	2032
		Novovorenezh-5	31.05.1980	950	2035
		Novovorenezh-6	27.10.2016	1114	2046
Rostov	VVER-1000	Rostov-1	30.03.2001	990	2030
		Rostov-2	18.03.2010	990	2040
		Rostov-3	17.09.2015	1011	2045
Smolensk NPP	RBMK-1000	Smolensk-1	09.12.1982	925	2028
		Smolensk-2	31.05.1985	925	2040
		Smolensk-3	17.01.1990	925	2045

*Novovoronezh-3 was permanently shut down on the 25th of December 2016. It was replaced by the newly opened Novovoronezh-6.[9]

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[8] http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx (Retrieved 17.10.2016)

4 Life time extensions and NPPs under construction

Since the Chernobyl disaster of 1986, the collapse of the Soviet Union in 1991, and the following collapse of the Russian economy, few reactors have been built and put into operation. During the 1990s, two reactors where put into operation; Smolensk-3 (1990) and Balakovo-4 (1993). Since the year 2000, 5 reactors have been put into operation; Rosatov-1 (2001), Kalinin-3 (2004), Rostov-2 (2010), Kalinin-4 (2012), Rostov-3 (2016) and Novovoronezh-6 (2016).

When first put into operation, Russian reactors receive a run time permit of 30 years. But because reactors were slow to roll out in the 1990s, it became clear to the industry that many would quickly reach the end of their permits. In 2000, then, the industry laid the groundwork for drastically extending reactor run times. Today, it's common to see a VVER-440 or an RMBK reactor receive operational extension permits of 15 years. The newer VVER-1000s receive extensions of 20 years.

Run time extensions for Russian reactors have provoked protest from environmentalists because the extensions are granted without environmental impact assessments. Such assessments are required by Russian legislation, making the run time extensions something of a legal gray area[10]

In March 2017, the Kola Nuclear Power Plant took its No 3 reactor off the grid for a 50-day upgrade period. Plant officials say they will eventually modernize all four of the Kola NPP's reactors, with an eye to increasing their security, but details of what, exactly, this enhanced security will entail remains sketchy. In total, the Kola NPP's website says all reactor modernizations will take a total of 249 days.[11]

For many years the Russian government has presented ambitious plans for nuclear power development via so-called *Federal Target Programs*. The first of these Federal Target Programs (FTP) was initiated by a presidential decree from Boris Yeltsin in December 1996. It would take more than three years before this program – called "Nuclear and Radiation Safety in 2000 to 2006" – to finally get approved in February of 2000. [12] We will have a closer look at the current FTP in the next chapter on planned reactors and increased capacity.

[9] http://www.world-nuclear.org/reactor/default.aspx/NOVOVORONEZH-3 (retrieved 18.05.2017)
[10] Bellona Position Paper, http://www.bellona.org/position_papers/Life_Extension_Russian_NPPs, 2006
[11] http://www.kolanpp.rosenergoatom.ru/about/press-center/news/ff8a7c004043014ebde6fdc46330c020 (Retrieved 17.04.2017)
[12] Bellona Report, http://www.bellona.org/filearchive/fil_larin-report-english-fedprog.pdf, 2009

Table 2 - Nuclear power plants under construction in Russia:

Name	Type	Total reactors (planned)	Existing reactors	Under construction	Construction start	To be completed	Total capacity being built (MWe)
Kaliningrad	*VVER-1200*	*2*	*0*	*2*	*2010*	*?*	*2 x 1170*
Kursk-2	*VVER-TOI*	2	0	0	*2016/2017*	2023/24	*2 x 1115*
Leningrad-2	*VVER-1200*	4	0	2	*2008*	2018/19	*2 x 1085*
Novovoronezh-2	*VVER-1200*	2	1	1	*2008*	2019	*2 x 1114*
Rostov	*VVER-1000*	4	3	1	*2010*	2017	*1 x 1011*
Akademik Lomonosov	*KLT-40C*	2	0	2	*2006*	2018	*2 x 150*

In this table, the *Akademik Lomonosov*, the world's first floating nuclear power plant (FNPP), deserves special note. Rosatom is building a FNPP based on its experience with nuclear reactors in the naval industry, in submarines and icebreakers. The construction started as long ago as 2006, and the FNPP "*Akademik Lomonosov*" will be equipped with two 35 MWe reactors of the KLT-40S type. It can use fuel with an enrichment of up to 20%. The FNPP was originally slated to go into operation in 2010, but has been postponed, and is now scheduled to be operational in 2019. The floating nuclear power plant will be transported to the city of Pevek in the Kamchatka-region in Russia's Far East. There, it will replace the Bilibino NPP, which is slated for decommissioning. [13]

In 2011, Rosatom publicized the cost of building the FNPP "*Akademik Lomonosov*," saying it would amount to 16,2 billion rubles. [14] Today, that has increased to 21,5 billion rubles.[15]

4.1 Nuclear safety

In 2015, Rosatom presented the latest Federal Target Program (FTP) for nuclear safety for the period from 2016 to 2020. The Program involves eight federal departments and has a budget of 131,8 billion rubles. In 2007, when the first FTP was adopted, there were major risks presented by accumulated waste and used fuel, according to former Rosatom chief Sergey Kirienko. The main goal of the FTP was to decrease the risk of large-scale accidents, to establish the safe condition of radioactive waste and ensure control and stable operation. This includes dealing with the nuclear heritage from the Soviet Union, which generated radioactive waste for more than 50 years.[16]

Kirienko also said that the bulk of the program's funding – 73% - would go toward decommissioning commercial reactors, as well as taking facilities at Mayak Production

[13] https://en.wikipedia.org/wiki/Akademik_Lomonosov (Retrieved 17.10.2016)
[14] Bellona Report, http://www.bellona.org/filearchive/fil_fnpp-en.pdf, 2011
[15] http://bellona.org/news/nuclear-issues/nuclear-russia/2016-01-russian-floating-nuclear-power-plants-port-to-cost-58-million
[16] http://www.world-nuclear-news.org/NP-Russia-approves-nuclear-and-radiation-safety-program-17111501.html (Retrieved 18.10.2016)

Association, Siberian Chemical Combine, Angarsk Electrolysis and Chemical Complex, as well as Novosibirsk Chemical Concentrates Plant, out of operation. These facilities have been involved in the state defense program. Around 20% of the funding would go toward handling RAW and SNF, creating infrastructure for their processing and final disposal. Five percent would go to monitoring and nuclear- and radiation safety and around 2% would go towards scientific and technological support.[17]

[17] http://www.world-nuclear-news.org/NP-Russia-approves-nuclear-and-radiation-safety-program-17111501.html (Retrieved 18.10.2016)

5 The future: Planned reactors and increased capacity

Another important document, the latest version of Rosatom's plan for long-term development, was approved and signed by Russian president Vladimir Putin in July 2009. The program envisions an increase of NPP installed capacity from 23.1 GWe in 2009 to 43.3 GWe in 2020. To achieve this, a new reactor would have had to go into operational every year from 2011 to 2013, and two reactors would have to go online each year from 2013 to 2020. [18]

Rosenergoatom plans to increase nuclear power generation by the following figures, according to Nuclear Engineering International:

Rosatom's draft annual report sets a power target for 2018 at 205.9TWh, and for 2019 at 213.8TWh. The utility said generation from Russia's fleet of 35 commercial nuclear power reactors increased by 5.89%, or 3.06TWh to 55.02TWh during the first quarter of 2017. This compares with 51.96TWh in the same period in 2016. The fleet's capacity factor so far in 2017 has been 92.62%, Rosenergoatom said. The growth of electricity production in 2016 was due to the start-up of unit 1 at the Novovoronezh II NPP and the start of commercial operation at unit 4 of the Beloyarsk NPP, which is the BN-800 fast neutron reactor. The power generation uptick also owed to optimized repair durations. [19]

The construction of new reactors in Russia is to be financed partially by the state budget, and partially by Rosatom's own development fund. The revenue that goes into this development fund is based on the surpluses arising from the sale of energy from existing nuclear power plants and other commercial activities. [20]

There are exceptions: The nuclear power plant that was planned for construction in Kaliningrad, known as the Baltic NPP, was to be financed partly by private investors, including investors from outside Russia. These private investments were supposed to finance 49 % of the build, with the rest coming from Rosatom. Construction began in 2010, but has since been put on hold over a lack of investor interest.[21]

In August 2016, a document describing the future of energy production in Russia was made public. [22]This includes plans for construction of new NPPs and expansions of old ones with new reactors. We refer to *Table 4* on the next page for details.

[18] WNA, Nuclear Power in Russia, 28/11 2011
[19] http://www.neimagazine.com/news/newsrussia-plans-to-boost-nuclear-power-generation-5789303 (Retrieved 18.05.2017)
[20] Bellona report, http://www.bellona.org/reports/russian-nuclear-economics, 2011
[21] Ibid
[22] http://government.ru/media/files/eFBHWjAwsi3waUcgX5Cg0F4RPlbmItHe.pdf (Retrieved 19.10.2016)

Table 3 - Planned Nuclear power plants in Russia[23]

Name	Location	Purpose	Reactor type	Capacity (MWt)	Start of operation
Kola-2	Polyarnie zori, Murmansk	Replace old reactors	1 x VVER-600	**600**	**By 2030**
Tsentralny	Buj, Kostromsk Oblast	Enhance the energy supply in the region	2 x VVER-TOI	**2 x 1250**	**By 2030**
Smolensk-2	Desnogorsk, Smolensk Oblast	Replace old reactors	1 x VVER-TOI	**1250**	**By 2030**
			2 x VVER-TOI	**1250**	**By 2030**
Nizhegorodskaya	Nizhegorodskaya Oblast	Enhance the energy supply in the region	1 x VVER-TOI	**1255**	**By 2030**
			2 x VVER-TOI	**1255**	**By 2030**
Tatarskaya	Tatarstan	Enhance the energy supply in the region	1 x VVER-TOI	**1250**	**By 2030**
Beloyarsk	Zarechniy, Sverdlovsk Oblast	Enhance the energy supply in the region	5 x BN-1200	**1200**	**By 2030**
Juzhnoural	Chelabyinsk Oblast	Compensate for the energy deficit in the region	1 x BN-1200	**1200**	**By 2030**
Severskaya	Seversk, Tomsk Oblast	Replace old reactors	1 x BREST-300	**300**	**By 2025**

As *Table 4* shows, Russia is looking to build primarily Fast Neutron reactors, like the BN-1200, as well as the purposed VVER-TOI, water pressurized reactors in the future. The VVER-TOI is planned as a two-unit NPP-design, and is slated for serial construction for both domestic and export purposes. It will have a 60 year life time, up from the older VVER-type's 30 year life time span. The VVER-TOI concept is supposed to be a universal design blueprint that can be easily parameterized to suit any geographical or security environment. [24]

[23] http://government.ru/media/files/eFBHWjAwsi3waUcgX5Cg0F4RPlbmItHe.pdf (Retrieved 19.10.2016)
[24] https://en.wikipedia.org/wiki/VVER-TOI

6 Russian nuclear power abroad:

Within the framework of the state agency Rosatom, the company *Atomstroyexport (ASE)* is responsible for exporting Russian nuclear technology. Today, the company is involved in the construction of several reactors of the VVER-1000 and VVER-1200 type worldwide.

Over the last decade, Rosatom has committed to exporting nuclear power to other countries in the form of vast loans to cover nuclear power plant construction. The loans are mainly given to projects where Rosatom itself is involved as the primary developer. Such development deals have been signed with China, India, Vietnam, Hungary, Turkey, Belarus, Iran, Bangladesh and Finland. [25]

Russia is also pursuing talks with Namibia, Chile, Morocco, Egypt, Algeria and Kuwait.[26] A proposed $76 billion deal with South Africa, however, was halted by local courts after public outcry.[27]

Rosatom is currently promoting what it calls "prepackaged" nuclear reactors to its customer's abroad in the form of its new VVER-1200 reactor. Originally billed as the AES-2006, Rosatom says the new reactor is a step up on Russia's workhorse VVER-1000. The first VVER-1200 was launched domestically at the Novovoronezh-2 NPP, and reached full commercial operation in February 2017. A second of these units is expected to come online at the plant in 2018. Both will replace two reactors at the older Novovoronezh-1, which will soon be decommissioned.

The VVER-1200 is a pressurized water reactor with a designed net capacity of 1114 MWe, which is a 20% increase on the capacity of its predecessor. The engineered life expectancy of its main components – the pressure vessel and the steam generators – is 60 years, twice as long as the VVER-1000. The reactor's highly automated systems are supposed to reduce the number of personnel required to run it by 20% fewer than the VVER-1000. The unit also offers numerous passive safety measures, and incorporates post-Fukushima safety upgrades such as hydrogen recombiners, passive heat removal and a core melt trap, also called a core catcher. The International Atomic Energy Agency has said the design complies with its post-Fukushima requirements.[28]

In October 2016, Rosatom announced that the total value of their contracts abroad was 110 billion USD during the first part quarter of 2016. Rosatom's director, Alexey Likhachev, has said that, over the long term, he expects the worth of Rosatom's contracts abroad to nearly double to 200 billion USD. [29]

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[25] http://bellona.org/news/nuclear-issues/2016-10-the-future-of-russian-nuclear-power-plants-rosatom-abroad (Retrieved 17.10.2016)

[26] WNA, Nuclear Power in Russia, 28/11 2011

[27] http://citizen.co.za/news/news-national/1497616/high-court-puts-brakes-on-sas-nuclear-deal-with-russia/

[28] http://www.world-nuclear-news.org/NN-First-VVER-1200-reactor-enters-commercial-operation-02031701.html (Retrieved 12.05.2017)

[29] https://rg.ru/2016/10/11/medvedev-prizval-sohranit-dostizheniia-v-atomnoj-otrasli-rf.html (Retrieved 12.05.2017)

7 Countries buying Rosatom-built NPPs

In this chapter, you can find additional information on the different projects of Rosatom outside Russia.

Table 4 - Nuclear power plants being planned by Rosatom abroad

Name (Country)	Type	Total reactors	Existing reactors	Under construction	Start of construction	Planned completion	Total capasity planned (MWe)
Akkuyu (Turkey)	*VVER-1200*	*4*	*0*	*0*	*2016*	*2022*	*4800*
Belarusian (Belarus)	*VVER-1200*	2	0	2	*2013*	2020	*2400*
Bushehr (Iran)	*VVER-1000*	3	1	2	*2017*	2024/2026	*3000*
Kudankulam (India)	*VVER-1000*	4	2	2	*2016*	?	*4000*
~~Ninh Thuận 1 (Vietnam)*~~	~~*VVER-1200*~~	~~2~~	~~0~~	~~0~~	~~*2020*~~	~~?~~	~~*2400*~~
Paks-2 (Hungary)	*VVER-1200*	6	4	0	*2018*	?	*4400*
Ruppur NPP (Bangladesh)	*VVER-1200*	2	0	0	*2017*	2023/2024	*2400*
Tianwan (China)	*VVER-1000*	4	2	2	*2012/2013*	2018	*2100*
Hanhikivi (Finland)	*VVER-1200*	1	0	0	*2018*	2024	*1200*

*The plans were cancelled in November 2016. See below.

7.1 Vietnam:

In November 2016, the government of Vietnam announced it had decided against building NPPs in the country, including the one planned by Rosatom. The country said it no longer viewed nuclear power as competitive compared with other energy sources. [30]

7.2 Belarus:

In 2016, there was an incident at the construction site the Ostrovets NPP in Belarus, where Rosatom is building two VVER-1200 reactors. According to a whistleblower, a reactor pressure vessel (RPV) weighing 330 tonnes fell from a height of about 4 meters during a crane test in July 2016. The Belarusian government demanded Rosatom exchange the unit for another one, citing safety fears. Although Rosatom's then-director Sergei Kiriyenko said the RPV was undamaged, the company nonetheless took it back, possibly to avoid negative publicity.[31] The Ostrovets NPP received a new RPV in April 2017. This RPV was originally meant to be used at the Baltic NPP in Kaliningrad. Before it was installed, it passed inspections with ASE and the Belarusian Nuclear Power Plant Company, and it was replaced without any additional expense to Belarus, but for delivery.[32]

In January of 2017, The International Atomic Energy Agency (IAEA) concluded a five-day Site and External Events Design (SEED) mission to Belarus. In its preliminary

[30] http://avmalgin.livejournal.com/6593471.html (Retrieved 14.11.2016)
[31] http://www.neimagazine.com/news/newsbelarus-returns-rpv-to-russia-from-unit-1-of-the-belarus-npp-5023181
[32] http://www.world-nuclear-news.org/NN-Russia-installs-RPV-at-Belarus-plant-03041701.html

findings, the SEED team said the plant's design parameters accounted for site-specific external hazards. The first unit of the Ostrovets plant is scheduled to go online in November 2018, and the second unit in July 2020, and they will deliver 2340 MWe net capacity.[33]

7.3 Iran:

In 1994, Russia and Iran signed an agreement to build a VVER-1000 reactor at Bushehr. After several delays, the reactor was finally put into operation in 2011, and it was officially transferred from Russian to Iranian control in 2013. It represents the first nuclear power plant in the Middle East. The next year, Russian and Iranian authorities inked another agreement, this one on building a second reactor at the Bushehr site. They further agreed to explore building six more reactors at various locations throughout Iran at an unspecified future date.[34] A contract for construction of two more units was later signed in 2014. The first foundation stone for Bushehr units 2 and 3 was laid in a ceremony held at the construction site in southern Iran in September 2016. The two VVER-1000 units will be built with Generation III+ technology, which includes the latest safety features, and they have a combined capacity of 2100 MWe. Bushehr units 2 and 3 are to be completed in 2024 and 2026, respectively. [35]

Iran's Bushehr-1 NPP has over the last three years delivered around 6.2TWh of energy to the grid. During the same period, the number of Russian experts at the site has been reduced from around 300 to about 25.[36]

In January 2017, Rosatom announced that two of its other subsidiaries - the Russian Research Institute for Nuclear Power Plant Operation (VNIIAES) and the Rusatom Service – were considering starting a company to offer Russian technical assistance to the Bushehr plant. This entity would provide methodological and technical assistance to Bushehr personnel on nuclear fuel handling, neutron physics calculations, devising a plant maintenance strategy, and helping to commission mobile equipment.

7.4 China:

ASE has also sold two reactors to China at Lianyungan. Both are now in operation. Chinese and Russian authorities have signed on to build two more reactors in China at Tianawan,.[37] Their construction began in 2012 and 2013 respectively. Both are expected to be complete by 2018. [38]

[33] http://www.world-nuclear-news.org/RS-IAEA-completes-SEED-mission-to-Belarus-23011701.html
[34] https://rg.ru/2016/10/11/medvedev-prizval-sohranit-dostizheniia-v-atomnoj-otrasli-rf.html
[35] http://www.world-nuclear-news.org/C-Russia-and-Iran-forge-closer-ties-20011702.html and http://www.world-nuclear-news.org/NN-Iran-starts-building-unit-2-of-Bushehr-15031701.html
[36] http://www.neimagazine.com/news/newsiran-gradually-reducing-russian-support-at-bushehr-5756299
[37] WNA, Nuclear Power in Russia, 28/11 2011
[38] http://bellona.org/news/nuclear-issues/2016-10-the-future-of-russian-nuclear-power-plants-rosatom-abroad (Retrieved 17.10.2016)

7.5 India:

ASE has built two reactors in India (Kudankulam), which were originally supposed to start operation in 2011. In 2014, an additional agreement was signed to build two more reactors at Kudankulam. [39] The first unit of the four that were planned was put into operation in December of 2014. The second of the four VVER-1000 units at Kudankulam reached 100% criticality in January 2017.[40]

7.6 Hungary

Russia signed a contract with Hungary in 2014 to supply two VVER-1200 units at the Paks-2 NPP. The reactors are financed by a €10.0 billion Russian state loan, which will to cover 80% of the project. In February of 2017, Russia announced it was willing to finance the entire project, but Hungarian officials, declined, saying they didn't want to renegotiate the original 2014 contract.[41]

Before the agreement was signed, the Paks NPP consisted of four Russian-supplied VVER-440 pressurized water reactors, which started operation in 1982 and 1987. [42]

7.7 A more in-depth look at Paks NPP:

The Paks NPP presents an interesting case. At first, the European Commission launched a probe into the Paks expansion over procurement issues and to weigh whether Russia's funding of the project amounted to state aid. In November 2016, the EC closed its procurement procedure, but the investigation of the state aid issue continues. At a joint press conference with Vladimir Putin, Hungarian President Viktor Orban said the EC investigation was the reason the project was not yet underway, and that it would start as soon as it received EU approval.[43]

In making its case to the European Commission for Paks-2, Hungary argued it needed the plant to ensure power for the next two decades while the four reactors at the original Paks-1 plant – which supply half of the country's electricity – are phased out. Hungary insisted that because the reactors at Paks-1 are Soviet-built Russian models, it made sense to bring in Rosatom for Paks-2. It further said that the VVER-1200 reactor was the only model that could meet its power needs. And it was this argument that the European Commission eventually accepted. EU guidelines state that competitive tenders can be forgone when there are technical reasons to prefer a particular contractor. Hungary is not the first country to make use of that loophole.[44]

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[39] Bellona Web, http://bellona.org/articles/articles_2011/India_secondthoughts, 2011

[40] http://www.world-nuclear-news.org/NN-Kudankulam-2-enters-commercial-operation-0304177.html

[41] http://www.world-nuclear-news.org/NN-Putin-Russia-ready-to-fund-entire-Paks-II-project-03021703.html

[42] http://www.world-nuclear-news.org/NN-Putin-Russia-ready-to-fund-entire-Paks-II-project-03021703.html

[43] Ibid

[44] http://www.politico.eu/article/commission-gives-orban-his-nuclear-deal/

In March 2017, the EU granted Hungary a waiver for the Paks-2 construction to go forward. But the waiver came with three conditions. First, profits have to be spent on Paks-2 itself, not invested in additional power capacity. Second, the company operating Paks-2 must be legally separate from the company operating Paks-1, and finally, 30 percent of the electricity Paks-2 generates has to be sold on open energy markets. Hungary is gambling on power prices remaining steadily high, but should they drop, the Paks-2 plant will be less profitable than hoped.[45]

[45] http://www.politico.eu/article/commission-gives-orban-his-nuclear-deal/

8 Climate goals and Russian nuclear power

Nuclear power is often characterized as a potential solution to the climate crisis. According to its proponents, nuclear power could replace fossil fuels in many sectors of the economy, and does not require easy access to raw materials.
As such, say its supporters, plants can be built wherever power is needed, regardless of fuel availability.

Before the landmark 2015 climate summit in Paris, Russia declared it would not hamper the global climate agreement forged at COP-21. [46] That announcement inflated expectations that Russia would ratify the emerging document quickly. But that hasn't been the case: As of this writing, Russia still hasn't signed on. Still, Russia's push to increase nuclear power's role in is energy mix has nothing to do with the global fight against climate change.

The main argument made by Russia for building more nuclear power plants center on expending fewer fossil fuels– mainly natural gas – on domestic needs to make them available for export, primarily to Europe. The Russian state offshore company *Gazprom* has said that it makes five times as much on gas exports than it does on the Russian market. [47]

Additionally, building nuclear power plants abroad is a convenient way to expand Russian political influence. Although Rosatom says it will eventually hand over control of the plants it builds to local authorities, countries will remain beholden to Rosatom while they pay back the enormous state funded loans. These deals also include exclusive fuel sales from Russia for the first 10 operating years of any plant it builds. The most recent example of this is Rosatom's deal with Hungary on the Paks-2 plant to build a VVER-1200 reactor. The €12 billion deal will be 80% financed by a Russian state loan, and Rosatom will operate the plant for 50 years.[48]

[46] https://www.theguardian.com/environment/2015/dec/07/russia-pledges-not-to-stand-in-the-way-of-paris-climate-deal (Retrieved 17.10.2016)
[47] WNA, Nuclear Power in Russia, 28/11 2011
[48] http://www.politico.eu/article/russias-nuclear-attack-on-europe/

9 Research and development

An important goal in Russia's nuclear power development is the so-called fast breeder reactor, which uses plutonium as fuel. The first of these is the new Beloyarsk-4 reactor, which is of the BN-800-type.

Russia plans to develop a new 4th generation of fast breeder reactors. According to earlier plans, this reactor type should be commercially available between 2025-2030. This will, in turn, fulfil Rosatom's goal of operating only fast breeder reactors that will run on MOX fuel by 2050. The concept will, according to Rosatom, lead to a completely closed fuel cycle. The development program was pushed back to an unspecified date, according to a statement by Rosatom in January 2017.[49]

Russia is replacing its BOR-60 experimental fast reactor at the Research Institute of Atomic Reactors (NIIAR) at Dmitrovgrad in the Ulyanovsk, where the reactor went online in 1969. It will be replaced by an MBIR reactor, which is a 150 MWt sodium-cooled fast reactor with an engineered run time of 50 years.

The MBIR will be a multi-loop research reactor capable of testing lead, lead-bismuth and gas coolants, and running on MOX (mixed uranium and plutonium oxide) fuel. NIIAR intends to set up on-site closed fuel cycle facilities for the MBIR, using pyrochemical reprocessing that has been developed on a pilot scale. The company responsible for constructing the research reactor is AEM-Technology. AEM is part of Atomenergomash, itself a subsidiary of Rosatom. The MBIR project is to be open to foreign collaboration, in conjunction with the International Atomic Energy Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).[50]

[49] http://bellona.org/news/nuclear-issues/2017-01-russian-fast-reactor-program-stalls-while-economy-plummets
[50] http://www.world-nuclear-news.org/NN-Russia-starts-to-build-MBIR-vessel-27031702.html

10 Government agencies and their role

The supervision of Russian civilian NPPs is the responsibility of Rostekhnadzor (The Russian Federal Service for Ecological, Industrial and Nuclear Oversight), which answers directly to the Russian government. Rostekhnadzor took over nuclear power plant oversight from the former Gosatomnadzor, which was shuttered in 2004. Nuclear power plant supervision and oversight in Russia has traditionally been weak and hamstrung by limited budgets under both Rostekhnadzor and its predecessor.[51]

When the law "On introducing amendments to the Federal Law 'On the State Atomic Energy Corporation Rosatom'" was approved in November 2010, Rosatom assumed the authority to issue construction and operating licenses for nuclear power plants, including reactors and facilities for storing RAW in Russia. This used to be Rostekhnadzor 's mandate. [52] In practical terms, that means that Rosatom is now licensing itself.

RAW and SNF in Russia are handled by several entities as outlined below:

NO RAO – The national operator for RAW handling is responsible for handling and disposing of nuclear waste in Russia. It designates locations where fuel is to be stored and is responsible for building them. NO RAO is also responsible for the security at the facilities they operate, as well as closing down and decommissioning them. Recently, NO RAO began the practice of publishing an annual environmental report.[53]

RosRAO – The company responsible for the treatment of RAW. Its mandate is as follows: Collection, transport, reprocessing of RAW, as well as temporary storage of low level and intermediate level RAW. In addition, they are responsible for dealing with the radioactive legacy of the Soviet Union, in the form of remnants from, for instance, the nuclear Northern Fleet. This includes submarines, nuclear icebreakers, and related vessels. RosRAO is involved in cleanup operations at Andreyeva Bay, Gremikha and in some locations in the Far East. They are also responsible for the rehabilitation of areas polluted with radioactivity. [54] Recently, RosRAO began publishing an annual environmental report. [55]

The allocation of responsibilities within the nuclear sector in Russia is seemingly a bit unclear. But briefly, this is how it works:

The RAW from the NPPs in Russia is the responsibility of the respective NPPs. The RAW is stored temporarily on site, after which it is transported to central storage facilities by RosRAO. The responsibility for further handling and deposit of RAW then lies with NO RAO. The storage facilities built and operated by NO RAO are described in detail in the next chapter on nuclear waste.

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[51] http://www.nti.org/db/nisprofs/russia/govt/nucleara.htm
[52] http://www.bellona.org/articles/articles_2011/rosatom_soviet_supremacy
[53] http://bezrao.ru/n/124
[54] http://rosrao.ru/predpriyatie/o-fgup-%C2%ABrosrao%C2%BB.html
[55] http://bezrao.ru/n/135

11 Radioactive waste and spent nuclear fuel

Russia has expressed the goal of pursuing a so-called closed nuclear fuel cycle, meaning SNF will be reprocessed so elements of it can be used as fuel. Reprocessing involves dissolving SNF in an acid bath and chemically separating out uranium and plutonium from other high-level radioactive waste. The Uranium and plutonium from this process can, in theory, be used to produce new nuclear fuel. The high-level radioactive waste, a byproduct of the reprocessing process, has historically led to challenges for the facilities that conduct these operations. The chemical bath is contaminated by the process as well, increasing the total amount of RAW that has to be handled and stored.

In Russia, reprocessing of SNF from the civilian NPPs is conducted at the RT-1 facility at the Mayak Chemical Combine in the Southern Urals. It is located near Chelyabinsk and its one-million-strong population. The Mayak Chemical Combine was originally built to produce plutonium for the Soviet nuclear weapons program. The production of weapons grade plutonium at Mayak started in 1948, and that contributed to the development of the first Soviet nuclear bomb, which was tested in 1949. [56]

Mayak was also the location of the little known "Kyshtym" nuclear catastrophe in 1957. A cooling system for a tank storing tens of thousands of tons of dissolved nuclear waste exploded. The radioactive cloud that followed contaminated an expansive territory in the eastern Urals. The Kyshtym disaster is second only to the Chernobyl and Fukushima disasters in scale, rated at 6 on the seven-level INES scale. There have also been several other less severe incidents at Mayak since the 1940s.[57]

The RT-1 reprocessing facility at Mayak started operation in 1977, and is today the only facility for reprocessing of civilian SNF in Russia. The facility can only process SNF from VVER-440 reactors and the reactors at the Bilibino NPP, and fuel from research reactors and maritime reactors. The annual throughput of SNF at RT-1 is 400 tons. [58]

Since the only facility for reprocessing in Russia is unable to treat SNF from RBMK and VVER-1000 reactors, the bulk (between 80% and 90%) of the SNF from Russian NPPs is in temporary storage on the sites of the NPPs that produced it. SNF stored near the NPPs is kept in spent fuel pools. Some is stored at the central storage facility for VVER-1000 fuel at the Zheleznogorsk Mining and Chemical Combine in central Siberia. [59]

Uranium reprocessed from VVER-440-produced spent fuel is used to make new fuel for RBMK reactors. Fuel from RMBKs is, in turn, not reprocessed at all. That's because reprocessing RBMK has, until recently, not been considered economical due to its low quality and enrichment. Over the past few years, however, Russia has made technological advances that could make it profitable. New methods are being tested, and if successful, they'll be put to use at Zheleznogorsk, where SNF from RMBK reactors is stored.

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[56] Bellona Rapport, http://www.bellona.org/filearchive/fil_Bellona_2004_RedReport.pdf, 2004
[57] https://en.wikipedia.org/wiki/Mayak
[58] Bellona Report, http://www.bellona.org/filearchive/fil_Bellona_2004_RedReport.pdf
[59] Bellona report, http://www.bellona.org/reports/russian-nuclear-economics, 2011

In the 1970s it was thought that reprocessed plutonium would be used in fast breeder reactors, but that technology was still far off. Its recent arrival has been long in the coming. Several countries have large quantities of plutonium that they have shored up in hopes it would prove useful as nuclear technology advanced. In some places, specially modified pressurized water reactors can run on MOX fuel. One of those is the BN-600 reactor at Beloyarsk, which was originally intended as a fast breeder running on plutonium fuel.[60]

[60] https://en.wikipedia.org/wiki/Fast-neutron_reactor (Retrieved 18.05.2017)

12 Spent nuclear fuel storage:

A report from Rostekhnadzor in 1999 revealed that the storage pools around the RBMK reactors were between 80% and 90% full. Since then, the storage situation has not been dealt with. The storage pools at Zheleznogorsk are also nearly full. [61] By the end of 2010, 19,000 tons of spent nuclear fuel was stored in Russia, 13,190 ton of which was stored in storage pools near the different NPPs. Six thousand and fifty tons of SNF from VVER-1000 reactors were stored in Zheleznogorsk. [62]

Currently, a dry storage for spent nuclear fuel is being built in Zheleznogorsk, with a total capacity of 38,000 ton of SNF. This will be sufficient for housing all SNF from the Russian VVER and RBMK reactors for the next 30 years. The first section of this storage was put into operation in 2010, and has a capacity of 5,000 ton of SNF. The cost of constructing this facility is said by Rosatom to be around 10 billion rubles. [63]

In late 2016, Russia's first ever repository was put into operation. The 48,000 cubic meter facility in the Sverdlovsk Region's close nuclear city of Novouralsk lies at shallow depth and operates as a repository for what Rosatom classifies as type 3 and 4 wastes. The new facility will be able to store solid waste in isolation from the outside environment for 300 years, ten times longer than any other current storage schemes in Russia.[64]

We will examine the current plans for radioactive waste repositories in Russia on the next page.

[61] Bellona report, http://www.bellona.org/reports/russian-nuclear-economics, 2011
[62] ROSATOM, Annual report 2010
[63] ROSATOM, Annual report 2010
[64] http://bellona.org/news/nuclear-issues/2016-12-russias-first-nuclear-waste-repository-starts-operation

12.1 Storage areas currently under discussion:

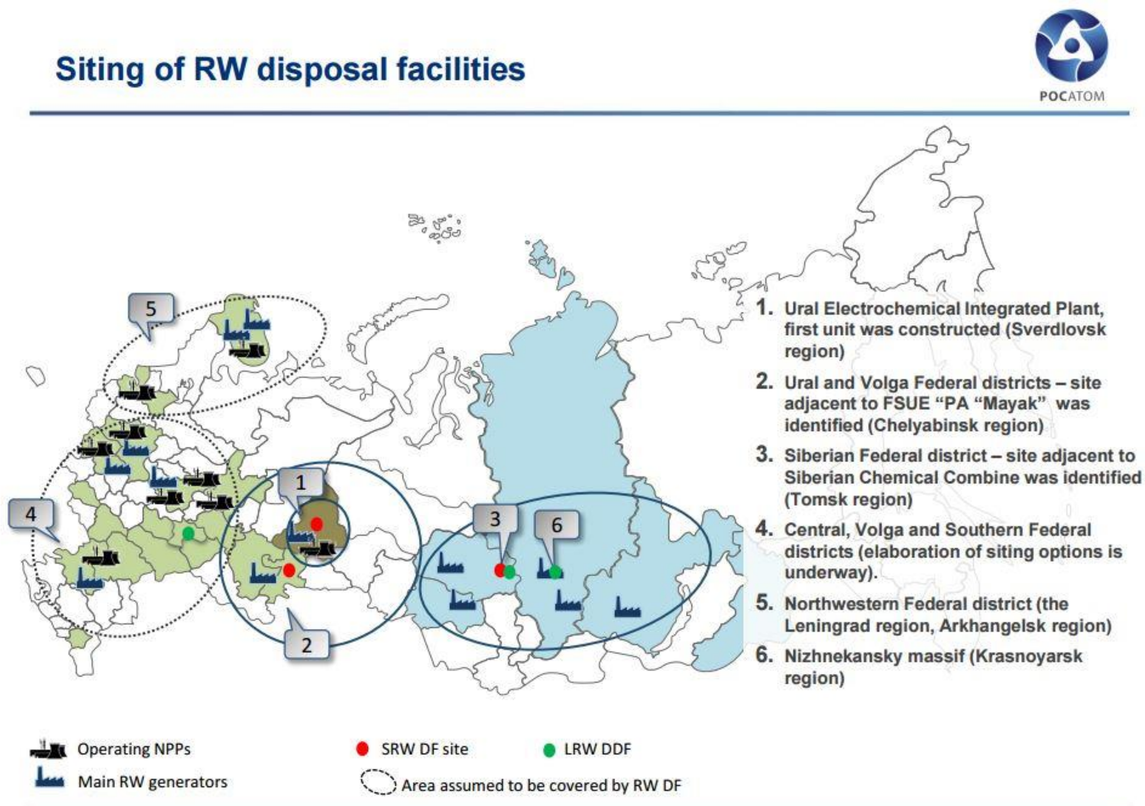

Illustration borrowed from Rosatom presentation[65]

1: A repository is operating at the "Ural Electro-Chemicial Combine" in Novouralsk in the Sverdlovsk region. That repository has several near-surface ditches, and is 46,449 m^3. It has space for 48,000 m^3 of 3rd and 4th class RAW. [66] The facility received its first shipment of RAW on November 28, 2016 and the second followed on December 2. [67]

2: A repository at the Mayak Chemical Combine is also being considered. If this option is chosen, the prospective repository would be a ground level bunker occupying 13,000 m^2 and housing house 100 000 m^3 of 3rd and 4th class RAW. [68]

3.1: Russia's biggest plans are for what it calls called "Repository 18" and "18A," which it plans to build at the closed nuclear city of Seversk in the Tomsk region. This repository will also consist of tunnels and shafts. Its total space will be 110,000,000 m^2 and it will

[65] https://www.iaea.org/INPRO/10th_Dialogue_Forum/Day3/Session4/02.Khaperskaya_Russia.pdf
[66] http://bezrao.ru/n/190
[67] https://ria.ru/atomtec/20161206/1482923380.html
[68] http://bezrao.ru/n/190

house up to 500,000,000 m^3 of waste. [69] The beginning of construction is set for 2019, and the facility should be ready by 2021 if current plans hold. [70]

3.2: Another repository is planned for Tomsk region, also in Seversk. This will a bunker at ground level, occupy 36,000 m^2 of land, and house 200,000 $m^3$of 3rd and 4th class waste. [71]

5: NO RAO is currently weighing options for a repository that would put all of Northwest Russia's RAW in one place. One location under consideration is Sosnovy Bor in the Leningrad region. The site would hold 50,000 m^3 of waste, with a potential to expand to 150,000 m^3. The repository would take shape as a network of tunnels not far below the surface. It would house low-level and intermediate-level RAW separately. [72] There are, however, doubts as to whether the geological environment at Sosnovy Bor is suitable for a repository, so the issue is not decided. Sosnovy Bor isn't the only place that is under consideration. The waste handler is said to be considering the Novaya Zemlya Archipelago in the Barents Sea, and the Murmansk region as sites for the potential repository. [73]

6: NO RAO has selected the Nizhnekansky Rock Massive in the Krasnoyarsk region as the site for a deep geologic repository of the type being built in Finland. If results from an underground laboratory under construction at the site indicate the geology is suitable, the repository will go forward. According to the most recent plans, the repository would consist of horizontal tunnels accessible via shafts from the surface. Its total space would be 238,680 m^2 and it would hold 45,000 m^3 of 1st class RAW, and another 155 000 m^3 of 2nd class RAW. [74] As of 2016, Russia had ear marked 1 billion rubles to build the underground lab to study the geological conditions and their suitability for long-term nuclear waste storage. [75]

[69] http://bezrao.ru/n/190
[70] http://bezrao.ru/n/353
[71] http://bezrao.ru/n/190
[72] Ibid
[73] http://bezrao.ru/n/95
[74] Ibid
[75] http://bezrao.ru/n/311

13 Categories of radioactive waste in Russia:

Russia has its own system for categorizing radioactive waste. NO RAO uses this categorization when they systemize the waste for storage in different locations, using different methods. [76] NO RAO differentiates between two types of depositories for storage of waste: Near-surface (up to a 100 meters below ground level), and deep depositories (more than a 100 meters below surface level).

Table 5 - Categories of RAW in Russia

1st class	•High-level waste with heat exhaustion •Requires storage in deep geological formation (more than a 100 meters bellow ground).
2nd class	•High-level, solid waste •Sources of ionizing radiation of 1st and 2nd grade. •Long lived, intermediate-level waste. •Demands storage in deep geological formations
3rd class	•Intermediate-level, solid waste •Sources of ionizing radiation of 3rd grade. •Long lived, low-level waste. •Requires permanent near-surface storage.
4th class	•Solid waste •Sources of ionizing radiation of 4th and 5th grade. •Very low-level waste. •Demands permanent near-surface storage with simplified demands.
5th class	•Intermediate-level, liquid waste •Low-level waste •Requires deep storage.
6th class	•Waste that originates from the search for and treatment of uranium. •Requires surface-near storage with simplified demands on-site where the waste originates.

[76] www.Norao.ru

13.1 Where does RAW come from? North-West Russia as an example

NO RAOs deputy director, Denis Egorov, has said the total amount of RAW that will need to be stored in Northwest Russia is about 200 000 m^{3}. That figure is based on the following three factors:

1: RAW accruing from Rosatom's daily activities [presumably, power production at NPPs] – 35 000 m^3
2: RAW resulting from decommissioning processes: 138 000 m^3, 130 000 m^3 of which will come from the decommissioning the Leningrad-1 NPP. All four units of this NPP will be decommissioned between 2019 and 2025 according to current plans.
3: RAW produced by extracting and storing 1st and 2nd class waste, which will amount to a total of 32 000 m^3 by 2030.[77]

[77] http://www.mvestnik.ru/eco/pid201610259l/

14 Decommissioning

Several reactors have been taken out of operation in Russia, and more are waiting to be decommissioned. Rosatom's roadmap from 2015 shows decommissioning plans toward 2030 as follows;

Figure 2 - Rosatom's decommissioning plans 2015-2030

14.1 How decommissioning projects are supposed to work in Russia:

According to Russian law, decommissioning programs are to be developed no later than 3 years before the end of the lifetime of a unit. A special commission must develop proposals for the project, based on examinations of the unit.

The costs for decommissioning projects are to be paid by a fund gathered especially for this purpose. The fund's income comes from different sources; among them are the federal and regional budgets, revenue from public and private sources, and payments from the operating organization.

The last part is the interesting one, as it is comparable to the principle of "the polluter pays", and more so, in Russia, than in other comparable countries, according to a report by Friends of the Earth Norway[78]. In other countries, the payments from the operating organization are collected by adding a sum on top of the price of electricity that is generated by an NPP. In Russia, the operator pays a percentage of revenue (not more than 3,2%). The revenue from sales of electricity from a NPP shall, according to Russian law, lead to a steady stream of money being put into the decommissioning fund from the first day of operation of any given NPP.

These rules were made law only in 1995, and as such, many of the reactors in Russia have had little time to accumulate a sufficient amount of finances for a decommissioning project. Today, the Russian decommissioning fund does not have enough money to finance the decommissioning of all power plants that have extended their life time period. One reason for the lack of available funds being that much of the money in the fund is being spent on reactors that are already closed, including those that were closed before the law that gave life to the decommissioning fund was put into force. Extending the life time of a reactor thus means it is given more time to accumulate the funds needed to take it out of operation. Building new NPPs will also increase the revenues added to the fund, which might make it easier to pay for decommissioning for reactors that are coming of age.

According to Friends of the Earth Norway, spending more money over the state budget to finance the fund might be a way to solve the problem of lacking financial capabilities. In any case, it is hard to assess how much money is actually needed. A lack of transparency and information, including a lack of insight into actual decommissioning plans, makes it hard to know how much such projects actually do cost in Russia.[79]

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[78] Naturvernforbundet/Friends of the Earth Norway, Report: *How to pay? Financing decommissioning of nuclear power plants*, 2017 https://naturvernforbundet.no/__cpcategoryid__::2847::/eksempler-til-etterfolgelse-article36861-3400.html

[79] Ibid

14.2 Completed decommissioning projects and the future:

Two reactors at Beloyarsk NPP were taken out of operation in 1981 and 1989. Their fuel was removed, and the reactors themselves were sealed for long-term safety purposes, but the final decommissioning process has not been completed. [80]

The decommissioning process for two reactors at Novovoronezh NPP that were put into operation in 1988 and 1990 respectively was started in 2011. This will represent the first full scale decommissioning of an NPP in Russia. Rosatom has said the project will yield valuable experience for future decommissioning work. [81]

If we compare the available information on NPPs being built, those that are planned, and those that are slated for decommissioning before 2030, it does seem that Rosatom is planning to replace reactors that are running on extended lifetime permits. Leningrad NPP, Kursk NPP, Novovoronezh NPP and Rostov NPP have reactors under construction that might be able to replace the old ones. In addition, Rosatom is planning to build new reactors at Smolensk NPP and, it seems, at Kola NPP, to replace the old reactors. Still, only old reactors at Kursk NPP, Leningrad NPP and Novovoronezh NPP are slated for decommissioning in the near future. This might mean that we will not see only modern NPPs running in Russia before 2030.

[80] http://www.rosatom.ru/wps/wcm/connect/rosenergoatom/belnpp_en/about/history/
[81] http://bellona.org/articles/articles_2011/novovornezh_decommission

References and sources:

http://avmalgin.livejournal.com/6593471.html

Bellona Position Paper: *Life Extension of Russian Nuclear Power Plants* (2006): http://www.bellona.org/position_papers/Life_Extension_Russian_NPPs

Bellona Rapport, *The Russian Nuclear Industry* (2004): http://www.bellona.org/filearchive/fil_Bellona_2004_RedReport.pdf

Bellona report, *The Economics of the Russian Nuclear Power Industry* (2011): http://www.bellona.org/reports/russian-nuclear-economics

Bellona Working Paper, *THE MOST EXPENSIVE PROGRAM: How to rescue Russia from its nuclear past* (2009): http://www.bellona.org/filearchive/fil_larin-report-english-fedprog.pdf

Bellona Report, *Floating Nuclear Power Plants* (2011): http://www.bellona.org/filearchive/fil_fnpp-en.pdf

Bellona Web, http://bellona.org/articles/articles_2011/India_secondthoughts, 2011

Bellona Web, http://www.bellona.org/articles/articles_2011/rosatom_soviet_supremacy, 2011

Bellona Web, http://bellona.org/articles/articles_2011/novovornezh_decommission, 2011

Bellona Web: http://bellona.org/news/nuclear-issues/2016-10-the-future-of-russian-nuclear-power-plants-rosatom-abroad

Bellona Web: http://bellona.org/news/nuclear-issues/2017-01-russian-fast-reactor-program-stalls-while-economy-plummets

Bellona Web: http://bellona.org/articles/articles_2011/India_secondthoughts

Bellona Web: http://bellona.org/news/nuclear-issues/nuclear-russia/2016-09-academian-lomonosov-mooring-trials-now-being-conducted

Bellona Web: http://bellona.org/news/nuclear-issues/2016-12-russias-first-nuclear-waste-repository-starts-operation

Bezrao.ru
http://bezrao.ru/n/95
http://bezrao.ru/n/124
http://bezrao.ru/n/135
http://bezrao.ru/n/161
http://bezrao.ru/n/190
http://bezrao.ru/n/268
http://bezrao.ru/n/311
http://bezrao.ru/n/322
http://bezrao.ru/n/353
http://bezrao.ru/n/360
http://bezrao.ru/n/383

Frankfurter Allgemeine
http://www.faz.net/aktuell/wirtschaft/unternehmen/atomenergie-siemens-sagt-allianz-mit-rosatom-ab-11230408.html (18.09.2011),

Gallup International 2011: Global Barometer of views on nuclear energy after Japan Earthquake:
http://www.gallup.com.pk/JapanSurvey2011/TabularPresentation.pdf

The Guardian
https://www.theguardian.com/environment/2015/dec/07/russia-pledges-not-to-stand-in-the-way-of-paris-climate-deal

IAEA
https://www.iaea.org/INPRO/10th_Dialogue_Forum/Day3/Session4/02.Khaperskaya_Russia.pdf

Kola NPP
http://www.kolanpp.rosenergoatom.ru/about/press-center/news/ff8a7c004043014ebde6fdc46330c020

Murmansk Vestnik
http://www.mvestnik.ru/eco/pid201610259l/

Naturvernforbundet / Friends of the Earth Norway,
Report: *How to pay? Financing decommissioning of nuclear power plants*, 2017 -
https://naturvernforbundet.no/__cpcategoryid__::2847::/eksempler-til-etterfolgelse-article36861-3400.html

NEI Magazine
http://www.neimagazine.com/news/newsiran-gradually-reducing-russian-support-at-bushehr-5756299

http://www.neimagazine.com/news/newsrussia-plans-to-boost-nuclear-power-generation-5789303

http://www.neimagazine.com/news/newsbelarus-returns-rpv-to-russia-from-unit-1-of-the-belarus-npp-5023181

NO RAO:
www.Norao.ru

NTI, The Nuclear Threat Initiative: *Russia: Nuclear-Related Administrative Bodies*
http://www.nti.org/db/nisprofs/russia/govt/nucleara.html

Politico:
http://www.politico.eu/article/russias-nuclear-attack-on-europe/

RIA NOVOSTI
https://ria.ru/atomtec/20161206/1482923380.html

Rossiskaya Gazeta
https://rg.ru/2016/10/11/medvedev-prizval-sohranit-dostizheniia-v-atomnoj-otrasli-rf.html

ROSATOM:
http://rosatom.ru/en/about-us/

http://www.rosatom.ru/wps/wcm/connect/rosatom/rosatomsite.eng/about/activities/power_complex/electricitygeneration/

http://www.rosatom.ru/wps/wcm/connect/rosenergoatom/belnpp_en/about/history/

Rosenergoatom:

http://www.rosenergoatom.ru,

ROSRAO
http://rosrao.ru/predpriyatie/o-fgup-%C2%ABrosrao%C2%BB.html

The Russian government:
http://government.ru/media/files/eFBHWjAwsi3waUcgX5Cg0F4RPlbmItHe.pdf

Wikipedia:
https://en.wikipedia.org/wiki/Akademik_Lomonosov

https://en.wikipedia.org/wiki/Fast-neutron_reactor

https://en.wikipedia.org/wiki/Mayak

https://en.wikipedia.org/wiki/VVER-TOI

World Nuclear News
http://www.world-nuclear-news.org/NP-Russia-approves-nuclear-and-radiation-safety-program-17111501.html

http://www.world-nuclear-news.org/NN-First-VVER-1200-reactor-enters-commercial-operation-02031701.html

http://www.world-nuclear.org/reactor/default.aspx/NOVOVORONEZH-3

http://www.world-nuclear-news.org/NN-Iran-starts-building-unit-2-of-Bushehr-15031701.html

http://www.world-nuclear-news.org/NN-Kudankulam-2-enters-commercial-operation-0304177.html

http://www.world-nuclear-news.org/RS-IAEA-completes-SEED-mission-to-Belarus-23011701.html

http://www.world-nuclear-news.org/NN-Russia-installs-RPV-at-Belarus-plant-03041701.html

http://www.world-nuclear-news.org/C-Russia-and-Iran-forge-closer-ties-20011702.html

http://www.world-nuclear-news.org/NN-Russia-starts-to-build-MBIR-vessel-27031702.html

http://www.world-nuclear-news.org/NN-Putin-Russia-ready-to-fund-entire-Paks-II-project-03021703.html
(retrieved 19.04.2017)

WNA, World Nuclear Organization, *Nuclear Power in Russia*,
http://www.world-nuclear.org/info/inf45.html.

World Nuclear Association
http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx

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