



MAPPING NUCLEAR ENERGY



The state of play in Europe,
Northern America and Central Asia

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INTRODUCTION

In light of rising energy prices and the need to meet climate targets, **nuclear energy is once again experiencing a renaissance**. The Russian invasion of Ukraine and the concerns over the security of supply reinforced this trend, even though Russia is an important supplier of fuel and technology for the global nuclear industry. These current developments have a **major impact on the expansion of nuclear capacities or the development of nuclear technologies in the region** – for instance, Belgium delayed its nuclear phase-out and the Netherlands declared that it will increase its nuclear capacities.

This document provides a detailed overview, country by country, of **the state of play of nuclear energy for countries in Europe, Northern America and Central Asia**. It details the role of nuclear in the national energy mix and in the country's climate strategy and explains the latest developments in the nuclear sector – whether a phase-out of nuclear energy is planned, if new reactors are under construction, and if the country invests in new technologies like the small modular reactors (SMR).

SUMMARY

In Europe, Northern America and Central Asia, **most countries use nuclear energy** – 56% of the countries in our overview, which represents 22 out of 39 countries. It's worth noting that most of the power plants use fuel either from the American company Westinghouse or from the Russian company TVEL, explained by historical reasons. Most of the **countries from the post-Soviet space are still heavily dependent on the Russian nuclear industry** – like Hungary, Bulgaria, Ukraine, Romania, Slovakia, Czechia and Slovenia.

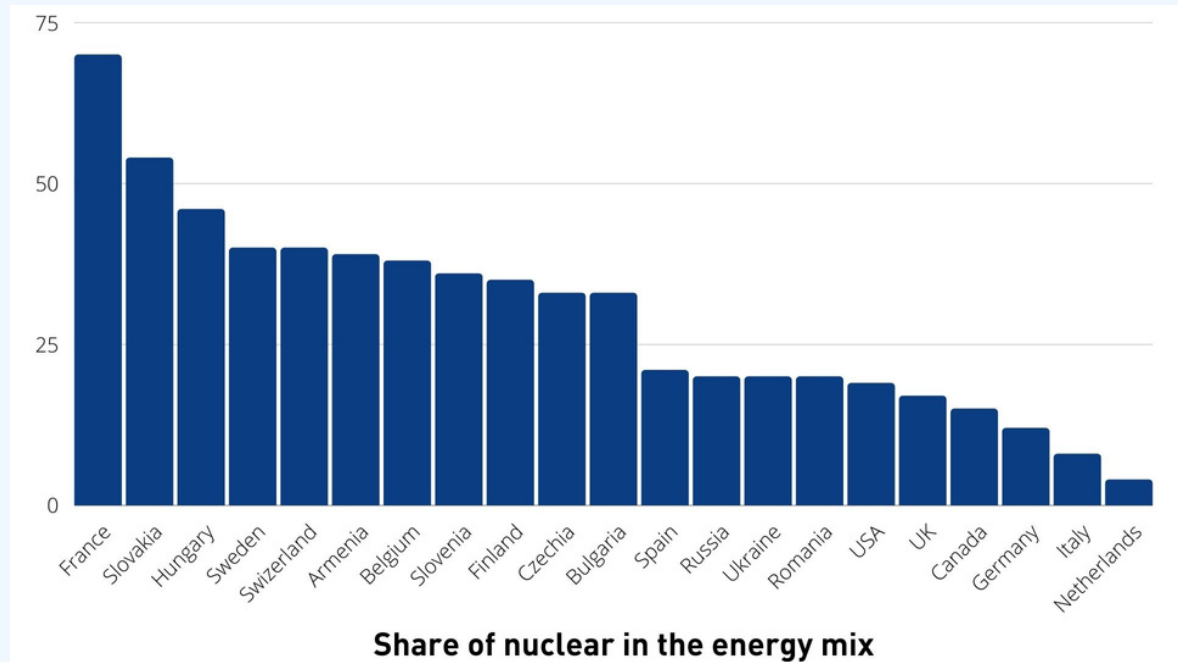
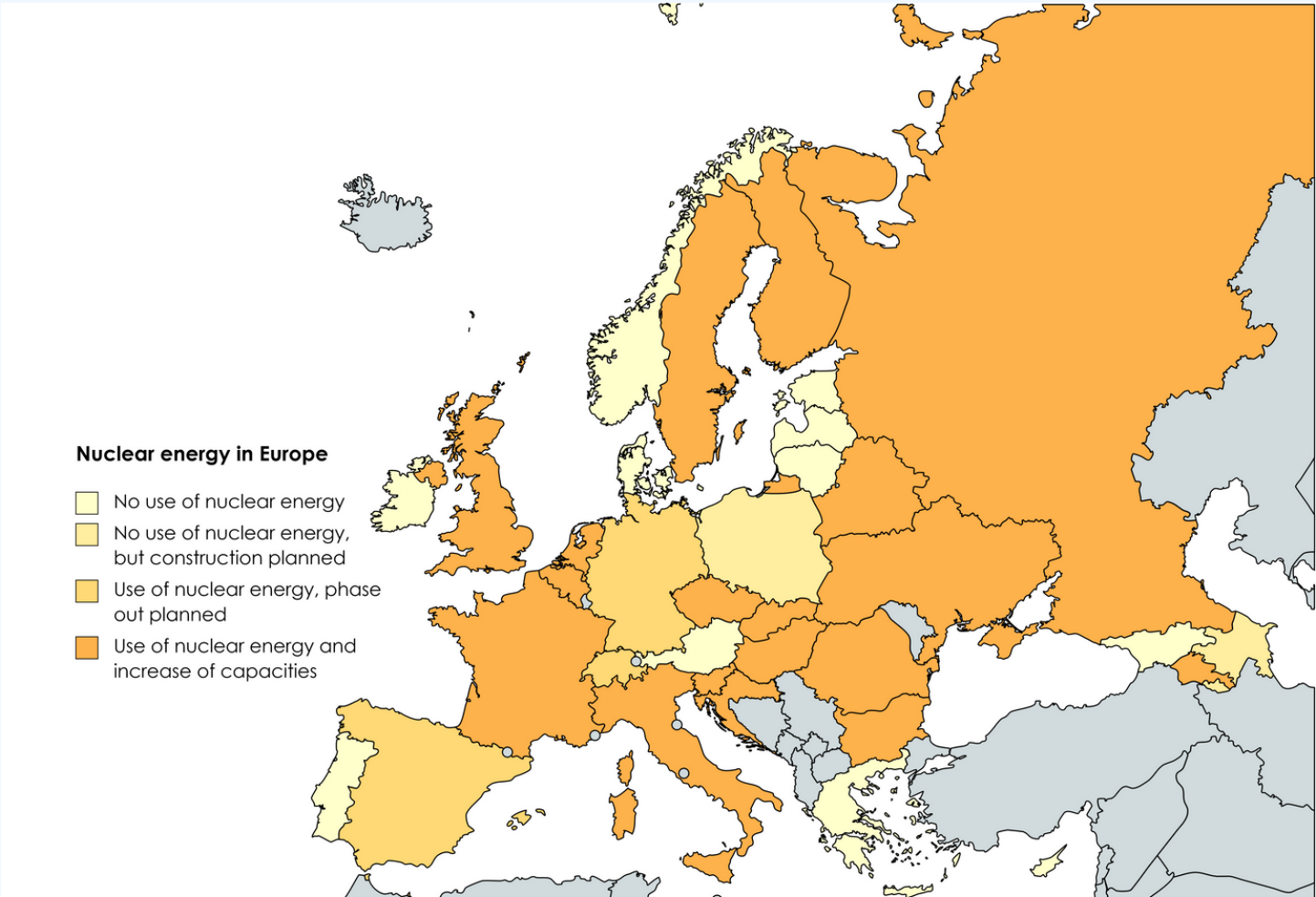
France, Slovakia, Hungary, Sweden, Switzerland and Belgium rely the most on nuclear energy in their energy mix. On the contrary, the **Netherlands, Italy and Germany** are the ones that use the least nuclear energy among those that use nuclear.

Among the countries that **do not use nuclear energy**, we can name Austria, Cyprus, Denmark, Estonia, Georgia, Greece, Latvia, Lithuania, Ireland, Poland, Portugal, Norway, Azerbaijan, Kazakhstan and Uzbekistan. However, **Poland and Azerbaijan** expressed their intention to build nuclear power plants in the near future.

Germany, Switzerland and Spain are planning to phase out nuclear energy. Germany will phase it out in 2022 and Spain in 2035, whereas Switzerland has not mentioned any date.

Finally, the Russian invasion of Ukraine **changed the dynamics in Europe**, as some countries with nuclear capacity are using nuclear energy to cut their dependency on Russian oil and gas. For example, **Belgium** announced it would backtrack its decision to phase out nuclear energy, while the **Netherlands** and **Bulgaria** declared that they will increase their nuclear capacities. On the other hand, **Germany** confirmed its phase out of nuclear power by the end of 2022.

MAPS & GRAPHS



AUSTRIA

Austria does not use nuclear energy. It actively lobbies against the European Commission's labelling nuclear as "green" in its EU taxonomy framework, threatening to sue the Commission at the ECJ. The Austrian 2030 energy strategy bets on renewables and plans to increase the use of renewable energy in order to reach its climate goals.

BELGIUM

Belgium owns two nuclear power plants with seven nuclear reactors, adding up to a total capacity of 6,000 MW. Accordingly, it uses mostly nuclear power to sustain its energy demand, as **nuclear power represents 38% of the country's energy mix.**

As early as 2003, Belgium took action to phase out nuclear energy. It started to officially move towards the complete phase-out of nuclear energy by 2025, planning to replenish the energy supply with renewable energy sources. However, in late March 2022, **Belgium backtracked and decided to extend the life of two of its seven nuclear reactors.** The government quoted concerns over security of supply, in light of the Russian-Ukrainian war. Previously, the 2003 federal act (mentioned above) prohibited the country from building new nuclear power plants and limited the lifespan of existing ones to 40 years.

BULGARIA

Bulgaria owns two nuclear power plants with two nuclear reactors, generating a total capacity of 2,006 MW. At the end of 2006, Bulgaria closed down two Soviet-designed 440-megawatt nuclear reactors at its Kozloduy power plant as part of its treaty to join the EU in 2007. The reactor units did not meet EU safety standards. **Nuclear energy accounts for one-third of the country's total energy mix.** Bulgaria approved plans for the construction of a new reactor, following its strategy to increase the amount of electricity generated by nuclear power plants. Moreover, Bulgaria is a major producer and exporter of electricity in the Balkans.

In April 2022, **Bulgaria and Greece made progress in talks to build a new nuclear power plant** near the Belene island. Bulgaria originally commissioned two Russian reactors of 620 million euros for this project. However, these reactors can not be used without Russian participation, which is impossible due to the Russian invasion of Ukraine. Bulgaria and Greece now agreed on commissioning an expert study after which the Bulgaria coalition could approve the plans. However, the question of liability in case of an accident has not be settled by the two parties.

During the COP26, Bulgaria's energy holding BEH and the US-based company Fluor signed a **memorandum of understanding** for research and development on new SMRs. However, concrete construction projects are not yet foreseen.

CROATIA

Croatia does not operate nuclear power plants on its territory. However, Croatia jointly owns the Krško nuclear power plant with Slovenia. Located on Slovenian territory, the Krško nuclear power plant has one reactor with a capacity of 688 MW. **It covers 10% of Croatia's electricity consumption.**

In order to meet its energy targets, Croatia plans to increase the share of renewables and in 2021 it announced that the country plans to co-fund a second nuclear reactor.

CYPRUS

There is no nuclear activity in Cyprus, and the Mediterranean island state does not plan to dedicate itself to a nuclear path.

CZECHIA

Czechia owns two nuclear power plants with an overall of six nuclear reactors adding up to a total capacity of 4,000 MW. **One third of Czechia's electricity comes from nuclear energy.** In order to achieve its climate goals, the government plans to replace coal-fired plants with nuclear energy, accordingly nuclear energy could make up more than 50% of the country's total energy mix by 2040.

Pursuant to its nuclear energy goals, Czechia plans to **expand the lifespan of old reactors and build three more reactors**. This will raise the power generation of the country to 7,600 MW. The contractor for the construction of the new reactors has not been decided. In April 2021, the Czech government barred Russia's state-owned energy company Rosatom from participating in the 6 billion euro tender, after it suspected Russian intelligence to be involved in explosions at an ammunition depot that killed two people in 2014. This means that the US group Westinghouse, the French company EDF and South Korea's KHNP are still in the race. At the same time, this does not mean that Russia cannot participate in the tender for nuclear fuel, even though this possibility could be ruled out in the future. The new reactors are scheduled to be operational in 2036.

Moreover, **Czechia is considering investing in the SMR technology**. It has signed contracts with Hitachi (Japan) and NuScale (USA) to install experimental SMRs of 300 MW and 77 MW. Further negotiations are ongoing with Rolls-Royce (UK) which is developing a SMR with a capacity of 400 MW.

DENMARK

Denmark has no nuclear power programme, as enshrined in a 1985 Parliamentary decision. The Danish energy strategy aims to achieve full independence from fossil fuel in the national energy mix by 2050, whereas they now represent 26%.

In the past, Denmark had **three nuclear research reactors**, the construction of which started between 1957 and 1960. The first one, of 2 kW (0.02 MW), was decommissioned in 2006; the second one, a 5 MW pool reactor, was closed in 1975, and the last, a 10 MW heavy water reactor was closed in 2000. The spent fuel has been transferred to the United States.

ESTONIA

Apart from a collaboration with the United States on a possible SMR development, **Estonia does not have a nuclear power programme**.

In early 2020, Estonia, Latvia and Lithuania issued a declaration **opposing electricity purchases from a newly built nuclear power plant in Belarus**.

Currently Estonia cooperates with the United States in the so-called **FIRST** (Foundational Infrastructure for Responsible Use of SMR programme). The goal of the partnership is to determine the possibility of introducing nuclear energy in Estonia. The country's nuclear energy working group (NEPIO) will present its conclusions and proposals in September 2022.

FINLAND

Finland operates two nuclear power plants with five nuclear reactors, generating a total capacity of 4394 MW. Out of five nuclear reactors, two are Russian-designed. **Nuclear power provides 35% of Finland's electricity**. Nuclear energy is expected to play a major role in Finland's energy strategy as the country plans to expand the lifespan of its nuclear reactors. Finland aims to become carbon neutral by 2035.

Finland's nuclear industry has direct ties with Russia. In 2013, Fennovoima, the Finnish consortium of energy and industrial companies, launched a call for tenders to build a new nuclear power plant. The consortium signed a contract with Rosatom, which acquired 34% of Fennovoima's shares. The project includes the construction of a 1,200 MW reactor, with total cost estimated at 7,5 billion euros – financed by 2 billion euros of Russian loans. The Finnish Economy Minister decided to halt the project on the day of the Russian invasion of Ukraine, declaring that it poses a risk for the project. Early May 2022, Fennovoima cancelled its deal with Rosatom to construct a new reactor in Finland.

A new reactor at the Olkiluoto nuclear power plant, of 1600 MW capacity, **went online in March 2022**. It was built by the international consortium of the German company Siemens and the French company Areva, for the Finnish electricity company TVO. The launching suffered a **12-year delay** due to technical and safety concerns. In consequence, the initial costs estimated at 3.2 billion euros eventually reached 8.4 billion euros. This led to disputes between the Finnish operator and Areva, as both parties looked to the International Chamber of Commerce in Stockholm to settle the question of who should pay for cost overruns.

Finland is also exploring the use of small modular reactors. The VTT Technical Research Centre of Finland is studying the potential use of SMRs for district heating and electricity generation. The first commercial use of SMRs is planned by 2030.

FRANCE

France has the **biggest share of electricity generated by nuclear energy in the EU**. It is also the third country in the world to have produced electricity based on nuclear energy. France owns 19 nuclear power plants with 56 nuclear reactors, generating 61,370 MW, which represents 70% of its energy mix. France's long term nuclear energy strategy aims to rely heavily on nuclear energy in order to achieve its climate targets and cut the dependency on Russian gas.

France and Russia are tied by several contracts of cooperation, initiated in 2018 by a partnership agreement between Vladimir Putin and Emmanuel Macron. These contracts have established cooperation in nuclear industries and energy policy strategies. This was followed by a contract signed between Rosatom and the French energy company CEA in 2019. Moreover, at the beginning of March 2022 there were discussions in the media that Rosatom could take a 20% stake in GEAST, a French manufacturer of nuclear power plant turbines. In the light of these developments, an embargo on Rosatom could lead to serious problems for the French nuclear industry.

France's myriad of announcements and subsequent re-adjustments regarding nuclear energy inevitably places the country at the **forefront of the nuclear movement**. This year, the country declared that it would build six new nuclear reactors, with construction to start in 2028. The costs are estimated at 50 billion euros. This marks an abrupt shift from the previous energy strategy, which planned to shut down 14 nuclear reactors in the next decade.

In October 2021, **France announced a 30 billion euro investment plan for 2030**, targeting French industrial development in the energy, automotive and space sectors. Energy technology investment in hydrogen and SMRs should receive a funding of 8 billion euros. The Nuward reactor, the French project to develop its own SMR, could reach a total capacity of 170 MW and aims to replace coal-fired power plants on the international market.

Amidst all new projects, the elephant in the room remains the country's ageing nuclear fleet. The average age of French reactors is 35 years. In the long term, the French partially state-owned *Électricité de France* (EDF) company committed to a vast programme of refurbishing its nuclear reactor fleet in order to extend their life span beyond 40 years. The French regulatory system does not set a nuclear power plant lifetime, but requires the licensee to perform an in-depth safety review every ten years. EDF estimates the cost of this refurbishing programme at 49.4 billion euros for 2014–2025. Moreover, the nuclear power reactor in Flamanville – which is already running 10 years late – is still suffering major delays, with total costs more than quadrupled to 12.7 billion euros since its first estimate.

EDF proposed to the government the **construction of six EPR2** (an optimised version of the third generation pressurised water reactor). The EPR2 builds on the original EPR design, of which three reactors are already generating electricity in China (Taishan) and Finland and three more are under construction in France (Flamanville) and the United Kingdom (Hinkley Point). EDF is currently exploring possibilities for new nuclear construction projects in Czechia, India and Poland.

GERMANY

Germany operates three nuclear reactors with a total capacity of 4,055 MW, accounting for **12% of the country's energy mix**. So far, Germany has shut down 33 reactors. By the end of 2022, Germany is set to complete its process of shutting down its nuclear power plants.

In light of the Russian invasion of Ukraine, **Germany will still proceed to the phase-out of nuclear by the end of 2022**. Vice-Chancellor Robert Habeck declared on 27 February, two days after Russia invaded Ukraine, that Germany would examine the reversal of the shutdown of the remaining nuclear reactors. However, in early March the German government ruled out prolonging its nuclear power plants. Experts pointed out that this decision would be difficult, first because it was too late to reactivate the plants that were already shut down and secondly, because the remaining three nuclear reactors would have run out of fuel by the end of 2022. Finally, the report cited legal and security concerns that would make it impossible to either prolong the functioning of reactor plants, or to reactivate former reactors.

GREECE

Greece has no nuclear power plants. Nuclear energy until recently was not considered an option. As of 2022 the country is in the process of shutting down one research reactor at the National Centre for Scientific Research. The Greek Prime Minister Mitsotakis declared that the country would develop renewable energy to become energy autonomous and competitive.

In April 2022, Euractiv reported that Greece made progress in its talks with Bulgaria regarding the construction of a **nuclear power plant on Bulgarian territory**. The project is estimated at 10 billion euros, and should be approved by the Bulgarian coalition after a year-long expert study. However, the question of liability in case of an accident is still unsolved.

HUNGARY

Hungary has one power plant and four nuclear reactors with a capacity of 1,902 MW – almost **half of the country's energy production**. Hungary is investing in nuclear power to achieve its climate goals.

Hungary is bound to Russia via financial obligations and its need for nuclear fuel. Despite the Russian invasion of Ukraine, the Hungarian government does not plan to drop the expansion of its Paks nuclear power plant sponsored by Rosatom, where construction is due to start this year. Back in 2014, the Hungarian government signed a contract with Rosatom to build 2 new reactors. The new reactors, type VVER-1000, are to have a combined capacity of 2400 MW, increasing the share of nuclear power in the energy mix to 60%. 14% of the domestically generated energy is planned to be exported abroad (Germany, Switzerland). The construction is expected to cost 12 billion euros, with 10 billion euros to be provided by Rosatom in bonds with a 4% annual interest, to be repaid from commissioning in 2031. Moreover, the Hungarian government is contractually bound to accept Rosatom as the sole supplier of nuclear fuel within the first 10 years after commissioning of the reactors.

The lifespan of all the Hungarian reactors should have expired 6 years ago, but the **Hungarian government decided in 2005 to extend their activity for another 20 years**. Thus, the reactors will remain in operation until 2032, or even 2037.

IRELAND

Ireland does not produce nuclear energy, as the country has prohibited it since 1999.

ITALY

Around 8% of Italy's electricity comes from imported nuclear power – it is the only G8 country without nuclear power plants and the world's second largest net importer of electricity. However the recent surge in energy prices and the Russian-Ukrainian war has led the current government to rethink its decision not to rely on nuclear energy.

In 2010 Italy's main **energy company Enel signed a memorandum of understanding** for cooperation in the nuclear power sector and technology innovation with the Russian company Inter RAO UES. More specifically, Enel took up 49% of shares in the new nuclear power plant built in Kaliningrad. This might result in a costly loss in the event that the Russian nuclear industry is sanctioned by the EU.

Italy was a pioneer in nuclear energy, but has now completely phased out nuclear energy. In the 1960s Enel announced a vast nuclear programme that built a total of 4 nuclear power plants. After the Chernobyl catastrophe, the reactors were all shut down and the country phased out nuclear energy. The Italian government planned to revive nuclear energy in 2010, but a referendum held in 2011 prohibited the use of nuclear energy in the country.

LATVIA

Latvia does not operate nuclear power plants nor does it plan to do so in the foreseeable future.

Considering the Baltic countries' stance towards the Belarusian construction of the Astravets Nuclear Power Plant, Latvia underlines the importance of energy grid connectivity to its Baltic neighbours and accordingly emphasises that its electricity demands will be increasing.

LITHUANIA

Lithuania does not operate nuclear power plants and does not foresee doing so, according to its National Energy Independence Strategy.

The public acceptance of nuclear power is low. In 2012 a state-wide nuclear power referendum stopped plans for the commission of a new nuclear power plant planned as a co-project between all three Baltic states, with just 34% of the voters supporting the construction of a new nuclear power plant.

To join the European Union, **the country was required to close down its Chernobyl-type reactors**, which it did in 2004 and 2009. The end date for the decommissioning process, which is co-sponsored by the EU with more than half of the total cost, has since 2011 been postponed to 2038. As it is the first time a Chernobyl-type reactor is being decommissioned, one of the main problems is the scarcity of qualified engineers in the specific field.

As mentioned above, with regard to Estonia, **all Baltic states are boycotting electricity produced by the newly built Belarusian power plant**. The Lithuanian National Energy Independence strategy sees the project as a danger, saying it poses threats to the national security and its energy system.

In an effort to reduce energy dependency from Russia, about half of the Baltic and Finnish gas needs are now met by Lithuania's floating Klaipeda LNG terminal, which started operations in 2013. Additionally, in 2015, the **country's energy grid was connected to Sweden and Poland**.

NETHERLANDS

The Netherlands own one nuclear power plant with a single reactor of a capacity of 482 MW, playing a minor role in Netherlands' energy strategy – representing about **4% of its energy mix**. The new coalition government formed in 2021 plans to rely increasingly on nuclear energy in order to meet its climate target and to guarantee its energy security.

The Netherlands plan to build two nuclear power plants for an estimate of 5 billion euros. It also aims to extend the lifespan of its existing power plant located in Borssele. The Netherlands excluded Russian and Chinese investors when building these power plants, citing security concerns. The coalition government agreement emphasised that nuclear energy will complement renewable energy to achieve carbon neutrality and decrease the dependence on gas from the Groningen gas field.

POLAND

In contrast to its neighbours, **Poland does not have any nuclear power plants**. But according to the country's new energy strategy, this will change rapidly. Poland is betting on **wind and nuclear energy** in order to meet its energy goals and to reduce the share of coal in the overall energy mix, which is currently 78%.

Financing the **gigantic nuclear construction of six nuclear power plants** in Poland is a challenge. Poland will invest around 33 billion euros for nuclear energy, but the bill is expected to increase. The main contractor is the American company Westinghouse Electric Company. It will build six reactors with an expected capacity of 9,000 gigawatts. The first nuclear power plant, located on the coast of the Baltic sea, would open in 2032, with the other reactors opening every 2 to 3 years later. The completion of all reactors is planned for 2043.

PORTUGAL

Portugal has no nuclear programme.

The country ran one nuclear research reactor, which is out of fuel since 2019, and that is in transition for decommissioning.

ROMANIA

Romania owns one nuclear power plant in Cernavoda, that consists of 2 reactors generating a total energy capacity of 1 300 MW. Nuclear power accounts for about **20% of Romania's energy mix**. The extension of the lifespan of the old nuclear power plant and the building of new reactors is part of Romania's Energy and Climate Plans to decarbonise the economy and replace the decommissioned coal-fired power plans after 2030. Romania's energy strategy includes other measures to maintain energy security and diversify energy sources.

The two old reactors were built in 1996 and 2007, after the collapse of the Soviet Union. Romania contracted the Canadian company Atomic Energy of Canada Limited to carry out the construction work. The lifetime of the first reactor will be extended by 30 years through renovations that should take place between 2026 and 2028 by an American contractor. The second reactor will undergo the same procedure until 2037. The estimated renovation costs amount to 1.3 million euros. In addition, Romania will build 2 new reactors, CANDU heavy water reactors, by 2031. The construction costs are estimated at 7.2 million euros.

Romania also heavily invests in research and development. Indeed, the Romanian state-owned company Nuclearelectrica signed an agreement with the American company NuScale Power in 2021. It plans to build a SMR plant that consists of 6 modules with a capacity of 462 MW. This reactor could start producing energy by 2028.

Slovakia owns two nuclear power plants that consist of 4 reactors, with a total capacity of 1832 MW. **Nuclear energy accounts for 54% of Slovakia's energy mix**, and will continue to dominate the energy production until 2050. The country committed to be climate neutral by 2050, and sees nuclear energy as a low-carbon energy source.

Slovakia is fully dependent on nuclear fuel from Russia. In early March 2022, as European airspace was closed to Russian aircrafts following the invasion of Ukraine by Russia, a plane carrying fuel for the two nuclear power plants landed in Slovakia. The contract with the Russian company providing fuel, TVEL, binds the country with Russia until 2026. This raises serious concerns on the dependency on Russian nuclear resources. The Slovak Economy minister qualified this fuel as "strategic commodity". He also added that the only viable alternative is the US company Westinghouse, which he considers expensive.

In order to achieve its climate goals, the Slovak government will **upgrade two of its reactors in the Mochovce power plant** - one construction just finished, and the other one is still ongoing. But it also **plans to build a new reactor** of 1200 MW, built in the Bohunice nuclear power plant by 2025. The estimated cost is of 3,32 billion euros. There are 6 potential contractors considered for this construction project: Westinghouse (USA), Atmea (France), Mitsubishi (Japan), Atomstroyexport (Russia), KHNP (South Korea) and Areva (France). The award was not finalised due to delays in financing.

SLOVENIA

Slovenia owns one nuclear power plant with one reactor that accounts for **38% of its electricity production**. The National Energy and Climate Plan considers nuclear power as a long-term energy option and plans to construct a new nuclear power plant.

Krško Nuclear Power Plant is the only nuclear power plant in operation in Slovenia. The one reactor plant, a 696 MW Westinghouse PWR, is co-owned by the Slovenian state-owned company Gen-Energija and the Croatian state-owned company Hrvatska elektroprivreda.

The 2021 World Nuclear Industry Safety Report **highlights safety concerns** as the plant is built in an earthquake zone. It cites the Austrian Environmental Group Global 2000 with a report that highlights the seismic vulnerability of the site and calls for further technical review as well as geological investigations.

According to the National Energy and Climate Plan, Slovenia wants to conclude examinations of the possibilities of **building a new nuclear power plant by 2027**. In July 2021, an energy permit was issued, thus opening the way for the implementation of administrative and preliminary planning procedures for investment decision-making. The responsible entity for the extension will be the French company Framatome.

Spain has five active nuclear power plants with seven reactors, generating a capacity of 7,121 MW. **Nuclear power accounts for 21% of the country's energy mix**, making it the third highest EU country in terms of nuclear power production. Spain's climate and energy strategy foresees a sequential **phasing-out of nuclear power by 2035**.

Spain does not have ties with Russia regarding its nuclear industry.

SWEDEN

Sweden owns 3 nuclear power plants with 6 reactors of a capacity of 6,882 MW. **Nuclear energy accounts for 40% of the country's energy mix**. Sweden's energy strategy plans to **phase out around 60% of its nuclear power** by 2040.

Sweden's nuclear industry operates with Russian nuclear power fuel. When Russia invaded Ukraine, Sweden's state-owned nuclear facility Vattenfall announced that it will not accept Russian fuel until further notice. Vattenfall declared that the nuclear power plants will not be affected by this decision, since the facility relies on multiple suppliers to ensure security of supply and energy independence.

After several nuclear accidents in the United States in the 1970's, **Sweden opened a public discussion on the status of its nuclear fleet**. The 1980 referendum on the future of nuclear energy allowed the previously planned reactors to be constructed, and decided that nuclear energy was to be phased out by 2010. The Swedish parliament in 2010 passed legislation that allows the replacing of old reactors by new ones. This would mean the construction of up to ten new nuclear reactors. Currently the nuclear operators are being upgraded to extend their lifetime up to 60 years, funded by 1.87 billion euros of investments.

Moreover, in March 2022 the Swedish government approved a plan to construct a spent **nuclear fuel repository**, near the Forsmark nuclear power plant. The cost of the facility is estimated at 1.8 billion euros. Currently, the storage facility claims to currently contain 6,500 tonnes of Spent Nuclear Fuel. By the time the country completely phases out nuclear energy, this could represent **12,000 tonnes** of nuclear spent fuel.

A deal for the construction of a SMR at the Oskarshamn site by 2030 was signed in 2021 by the German utility Uniper Sweden, the developer LeadCold and the Royal Institute of Technology. The reactor is designed to generate from 3 to 10 MW over a 10–30 year period without the need to refuel. The Swedish Energy Agency is supporting the project with 5.4 million euros of investments.

THE RUSSIAN FEDERATION (RUSSIA)

Russia operates 11 nuclear power plants of 38 reactors for a total capacity of 28,578 MW, which makes the country the 4th largest nuclear producer in the world, right after France. **Nuclear energy represents 19% of the country's energy mix.** Furthermore, Russia is one of the leading exporters of nuclear technologies, especially for developing and emerging countries.

According to its 2030 energy strategy, Russia plans to significantly **increase the role of nuclear** in the energy balance in order to increase energy security. Rosatom will be the major actor in the development of the nuclear industry.

Russia is an important supplier of raw material for uranium, which is the nuclear fuel. Moreover, 30% of the enrichment to make uranium suitable for power generation is done by Russian companies.

However, **the lifespan of a quarter of the current nuclear power plants in the country is soon expiring**. That's why in 2012, the Ministry of Energy planned to invest 14.8 billion euros in the development of nuclear energy. The "Proryv" (Breakthrough) strategy of the state-owned company Rosatom aims to **surge the nuclear power generation to 50% by 2050**, and by 70% by the end of the century. Russia will decommission a total of 10 old RBMK reactors, with a total capacity of 3,600 MW. As 7 reactors have already been shut down, 3 more will follow by 2027. At the same time, 27 new reactors are in the pipeline for 2027–2035.

Rosatom plans to transition to 4th generation reactors with a closed fuel cycle, which are supposed to be safer and can recycle nuclear waste. The construction of the first lead-cooled 4th generation reactor, the BREST-300 fast reactor, is scheduled to be completed by the mid-2020s, with the commissioning of the first reactor expected to take place in 2026. Investments will come both from Rosatom itself and from the state, which represent an additional amount of 2.7 billion euros.

UKRAINE

Nuclear energy represents **54% of Ukraine's energy mix**. It owns 4 nuclear power plants that consist of 15 nuclear reactors, generating a power capacity of 13,107 MW. The **Chernobyl power plant** has been shut down after the nuclear catastrophe of 1986. Ukraine's initial 2035 energy strategy focused on increasing the share of nuclear energy in the energy mix, considering it the most economic and low-carbon energy sources. However, the unprovoked Russian invasion of Ukraine on 24 February 2021 and later on the Russian continued shelling of nuclear power plants poses **extremely severe security risks** for the country and the region as a whole.

Most of Ukraine's reactors were built during the Soviet era and will soon expire. The most recent 3 reactors were commissioned in 1995, 2004 and 2008. The oldest reactors were modernised between 2015 and 2019, which extended their lifespan until the end of the 2020s. The cooperation with the Russian state-owned energy company Rosatom finished in 2014 after the annexation of Crimea and the war in Donbas.

The US company Westinghouse managed to substitute for the Russian fuel supply by designing nuclear fuel suitable for Russian-built nuclear reactors. As of 2020 Westinghouse supplied six of 15 Ukraine's VVER-1000 reactors. In the face of Russia's war on Ukraine, Russian-owned company TVEL vowed to keep up the supply for the remaining reactors.

In 2021, **Ukraine started a massive investment and construction plan to increase its nuclear capabilities**. Indeed, the Ukrainian state operator Energoatom signed contracts for maintenance and modernisation of its capacity with American Westinghouse. The contract planned the construction of one reactor at the Khmel'nitskii power plant, and 4 new reactors of type AP1000. The cost is estimated at 27.2 billion euros, mostly financed by the American bank Eximbank.

Ukraine also wants to develop and introduce SMRs to its nuclear power plants. It established a consortium in 2019 with the US company Holtec to build 6 SMR-160s, the fast neutron reactors, at the Rivne nuclear power plant. Moreover in 2021, Energoatom signed a memorandum with the US company NuScale to develop more SMRs in order to replace coal-fired power plants in the long term.

UNITED STATES OF AMERICA (US)

The United States of America is the world's largest producer of nuclear power. The country operates 56 nuclear power plants with 93 reactors, for a total capacity of 95,523 MW. Nuclear power accounts for 19% of the country's energy mix. In order to generate zero-carbon electricity, the USA plans to invest in extending the lifetime of existing power plants and new technologies. It considers nuclear energy a sustainable source of energy in order to reach its climate goals.

Russia's invasion of Ukraine is a challenge for the US nuclear industry. President Biden imposed a **ban on Russian oil and gas** in March 2022, however the sanctions did not target the nuclear sector. As Russia supplies 20% of the country's uranium, sanctions on Rosatom could cause the price of nuclear fuel to surge. Moreover, the US planned to put online advanced reactors by 2028, using low-enriched uranium (HALEU). Its technological expertise in the field of nuclear fuels makes Russia the only supplier of this fuel.

The Office of Nuclear Energy outlines **five main goals** for the US nuclear industry for the next decade: enabling the continued operation of existing reactors; deployment of advanced nuclear reactors; development of advanced nuclear fuel cycles; maintaining leadership in nuclear energy technology; and enabling a high-performing organisation.

Almost all of the US power reactors are likely to be licensed to operate for 60 years, with owners undertaking major capital works to upgrade them after around 30–40 years. 6 reactors have already been approved for 80 years' extension, and 21 are approving or applying for approval.

There are currently **2 Westinghouse AP-1000 reactors** of 2,500 MW capacity under construction, both at the same site. Georgia Power, one of the main shareholders, estimated in 2021 the total price of the project at 25.3 billion euros since the beginning of the construction in 2013. The Vogtle Units 3 and 4 reactors were scheduled to be constructed in November 2021 and 2022, but this will be postponed to 2022 and 2023.

The nuclear energy industry relies on the development of **hydrogen production**, where nuclear power plants can act as an electrolyser. This will allow for the further commodification of the nuclear energy industry in the heavy industry and transportation sectors.

From 2012, the US Department of Energy provides funding and opportunities for the **development of SMR technology**, through the SMR Licensing Technical Support and Advanced Reactor Demonstration Programme.

UNITED KINGDOM (UK)

The UK owns 8 nuclear power plants, operating 11 reactors generating 6,848 MW of power, **which accounts for 17% of the country's energy mix**. The UK is **betting on nuclear energy and renewables** to make its energy supply more sustainable and secure. Indeed, the country's plan to reach net-zero emissions by 2050 considers nuclear power as a reliable source of low-carbon electricity.

In light of the Russian war in Ukraine, the UK **plans to boost its nuclear capacity** in order to cut its dependence on Russian oil and gas – as it imports 8% of its oil from Russia, representing 4.7 billion euros in 2021. The boost also entails investments in SMR technology.

In 2006, the government approved a plan to commission **6 new power plants**, with 13 reactors of a total capacity of 15,456 MWe. The first one at Hinkley Point should be completed by 2025 after more than 10 years of construction and a 15-month delay. The other plants are set to be completed in the 2030s. The estimated costs amount to 68.9 billion euros for 3 of the 6 nuclear power plants. The major developers of UK's nuclear projects are EDF energy (France) and CGN (China). All reactors are of generation III and III+, with pressured water and boiling water reactors.

Moreover, the UK is conveying a **strong political will and financing capacity to deploy new SMR and Advanced Modular Reactor (AMR) technologies**. Rolls-Royce Group announced in November 2021 the establishment of Rolls-Royce SMR Limited for the deployment and commercialisation of its SMR technology, aiming to build 16 SMRs. The announcement came after it secured 249 million euros in funding from the UK government, adding to the 297 million euros of private investment. The consortium aims to complete its first unit in the early 2030s and build up to 10 reactors by 2035. The cost for the building of one reactor is estimated at 2.1 billion euros.

CANADA

Canada relies heavily on nuclear **not only for its energy but also for its economy**. It owns five power plants with 19 reactors, generating a capacity of 13,624 MW. **Nuclear represents 15% of Canada's energy mix**. Canada is the second largest producer of uranium worldwide. The North American country recognises nuclear power as a low-carbon and reliable source of energy.

Canada launched a programme to **extend the lifespan of four nuclear reactors** in the Darlington power plant and **six nuclear reactors** in the Bruce power plant. Running from 2015 to 2030, this programme will mobilise 18.1 billion euros of investments.

Canada is one of the world's leaders in developing SMR technology. In 2018 Natural Resources Canada launched a plan for the development of this nuclear technology, the SMR Roadmap. In 2019, the provinces of New Brunswick and Saskatchewan initiated a collaboration with the city of Ontario to advance the development of SMRs. The new reactors would address climate change, regional energy demand, economic development, and research and innovation opportunities.

In 2020, Natural Resources Canada published its SMR action plan, aiming to set up SMRs at home and abroad. This should allow the first SMRs to be set up in the late 2020s. Canada provided 1.8 million euros to finance this initiative. However, the amount of the potential additional costs is still unknown, especially regarding the development, deployment and maintenance of new SMRs.

NORWAY

Norway currently has no nuclear power plant in operation. Nevertheless, it developed its nuclear capacities very early on. The country has two research nuclear reactors that were built in 1951 and 1958. Norway's parliament discussed building nuclear plants in the 1970's, but this proposal was rejected due to the Three Mile Island accident in 1979. One of the research reactors is permanently shut down, and is used only for research purposes in the fields of physics and pharmaceuticals.

SWITZERLAND

Switzerland operates 4 reactors with an installed capacity of 2,960 MW which represent almost **40% of the country's energy mix**. The Swiss Energy Strategy 2050, approved via national referendum, includes a gradual withdrawal from nuclear power and a greater reliance on hydro and intermittent renewables. **No construction licences** will be issued for new nuclear power reactors. The country's existing reactors will be allowed to remain in operation as long as the Swiss Federal Nuclear Safety Inspectorate considers them safe.

However, Switzerland will sustain its nuclear research facilities considering possible development of new nuclear plants of the 4th generation after 2035.

ARMENIA

Currently **nuclear energy makes up 39% of Armenia's energy mix**. According to the 2020 energy strategy, nuclear is set to keep its major role throughout Armenia's energy transition.

Presently, **Armenia operates one Russian-designed nuclear power plant**, the Metsamor power plant. The plant consists of two VVER-440 nuclear reactors, generating a total of 815MW. As with almost all Russian-designed reactors it is exclusively run with nuclear fuel provided by Russia.

Metsamor was commissioned in 1976 and scheduled for a 30-year life expectancy. It was shut down for security reasons after the Chernobyl accident in 1986 and again after the 1988 earthquake. With the technical and financial assistance of Russia, the plant got a new lease on life in 1993.

The EU considers Metsamor as the **least reliable power plant built during the Soviet times**. Aside from its age, its geographic location in an earthquake-prone region is a source of great concern. Furthermore, the plant also remains a source of continual tension with neighbouring Azerbaijan. Amid **renewed fighting** between the countries, an Azerbaijani official threatened a missile strike against the operation.

Although the design lifespan has expired, the nuclear power plant's activities will be extended until 2026, **with plans to prolong its lifespan again for another ten years**. Russia is an important financial partner of Armenia's nuclear strategy, as it will sponsor the construction work and maintenance activities of the new reactor planned for 2036. Indeed, the Russian company **Rosatom has signed an agreement to build a new reactor in Metsamor**. It is also providing bonds for a total amount of 244 million euros. The total investment package is estimated at 298 million euros.

AZERBAIJAN

The Eastern Caucasus state **does not own any nuclear power plants**, but in 2014 it announced that it would **build a reactor by 2020** to curb the rising domestic energy demand. Furthermore, the International Atomic Energy Agency approved plans for the **construction of a nuclear research reactor in 2015**. Russian companies are also interested in building the power plant. This could cost Azerbaijan about 9 billion euros. Negotiations took place with the Russian state-owned company Rosatom and a site for construction was chosen. However, construction work has never begun.

When judging the prospects of nuclear energy in the Caspian Sea country, **the persisting tensions with Russia should not be overlooked**. As Russia supports Armenia in the Nagorno-Karabakh dispute, which turned into a six-week war in 2020, chances that Azerbaijan will turn to Russia for a nuclear kick-start are increasingly slim. Indeed, in the shadow of the war in Ukraine, Azerbaijan forces had entered a zone policed by Russian peacekeepers, prompting harsh critique in Moscow.

BELARUS

Commissioned and synchronised into the national power grid in June 2021, the Belarusian nuclear power plant is the **youngest in the entire post-Soviet space**. Based in Astravets, 40km from the Lithuanian capital Vilnius, it consists of 2 reactors of 1194 MW capacity.

With the second reactor construction to be completed by mid-2022, **the power plant's total capacity will amount to 2,400 MW**. The reactors were commissioned for two reasons. First, nuclear energy will replace 4.5 billion m³ of natural gas imported from Russia, which represents 97% of Belarus' energy mix. Second, it will increase energy exports and therefore revenues. However, **these scenarios today seem unlikely**, given the current grip of Russia over the country and the EU sanctions on the Lukashenko regime, as well as the embargo of all three Baltic countries with regard to energy produced in Belarus.

Belarus decided to build the plant in 2008. The process was met with strong opposition from civil society, which is still experiencing the consequences of the 1986 Chernobyl catastrophe, but also by the neighbouring country Lithuania, whose capital is located 40km away from the power plant. Nevertheless, construction began in 2012 by the Russian state company Atomstroieksport. Russia financed the project by providing bonds amounting to a total of 9 billion euros. The construction took particularly long – over 8 years between the start of construction and completion, with the second reactor being almost complete.

Belarus is one of the least energy self-sufficient countries in the world. In this respect, nuclear energy would help increase its energy independence and phase out the imports of fossil fuel.

GEORGIA

Currently Georgia is not operating any nuclear power plants, and does not plan to start a nuclear programme.

Owing to its Soviet legacy, the Caucasus state is home to a decommissioned nuclear reactor as well as three nuclear research institutes.

Kazakhstan does not currently operate a nuclear power plant. However, it has been debating the re-implementation of the energy source for over a decade.

During the Cold War, **the USSR used some remote areas of Kazakhstan as testing grounds for its own nuclear weapons.** Indeed, about 70% of Soviet nuclear tests were carried out in Kazakhstan – this represents 116 nuclear explosions between 1949 and 1986, including hydrogen bombs.

After a Russian push for expanded cooperation in the energy sector at the beginning of 2019, **nuclear energy was once again on the table in Astana.** A location for a nuclear power plant was found, for which the Kazakh ministry claimed it was studying proposals from five different countries.

In a change of momentum, in Summer 2019, Kanat Bozumbayev, the country's energy minister, declared that **the construction of a nuclear power plant was not in the immediate plans of the ministry.** At the same time, he did not rule out the possibility of the construction of a plant by 2025–2027. Regarding Putin's push for the construction of a nuclear power plant, the Kazakh site stated that the final decision on the construction will be made while taking into account the opinion of the country's residents. Given the country's history as the test ground for Soviet nuclear tests, and the position of the government after the wave of protests in January 2022, it seems unlikely that the Kazakh government would embark on an unpopular construction of a nuclear power plant.

The central Asian state is the largest world exporter of uranium, accounting for 40% of the world's uranium production. Therefore, Kazakhstan is virtually tied with the Russian Federation and Niger as the biggest uranium export countries to the EU in 2020, each of which account for about 20% of the overall share. Currently Kazakhstan only exports raw uranium, however, a fuel fabrication plant is being constructed with 49% Chinese equity.

UZBEKISTAN

Uzbekistan does not have nuclear power plants. However, the country is the 7th largest **uranium exporter** worldwide.

In 2017, a contract was signed between Uzbekistan and Rosatom for the **construction of two Gen III+ VVER-1200 nuclear reactors,** generating 2400 MW of power. The cost is estimated at 10 billion euros, which is supposedly financed by Russian bonds. Preliminary studies and the selection of the location have been completed and construction is expected to start in 2022 with an expected completion in 2028, and the first reactor should be finished in 2028.

By commissioning its first nuclear power plant, Uzbekistan hopes to save up to 3.5 billion cubic meters of natural gas. The move does not come without criticism, as critics cite renewables as the quicker and cheaper alternative.



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This publication is part of our **Nuclear Series**. It includes a mapping of nuclear energy in the OSCE region, the pros and cons of nuclear energy, as well as arguments for the debate.

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