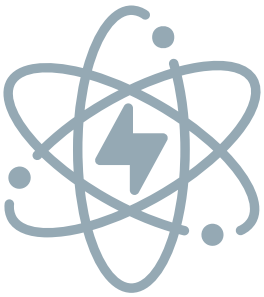
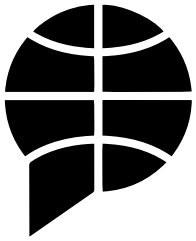
NUCLEAR ENERGY IN V4— THE CURRENT SITUATION AND PERSPECTIVES





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NUCLEAR ENERGY IN V4—THE CURRENT SITUATION AND PERSPECTIVES

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Executive summary

This paper examines the current status and future prospects of nuclear energy in the Visegrad Group (V4) countries (the Czech Republic, Hungary, Poland and Slovakia). All four countries recognize the importance of decarbonizing the energy system, the trend of electrification, and the need to improve energy security. In light of these considerations, nuclear power is an attractive carbon free, reliable technology that can be complimentary to intermittent renewable energy. Together, nuclear and renewables will be crucial for achieving the European Union climate policy objectives.

The Czech Republic, Hungary and Slovakia have already established significant nuclear power capacities with advanced infrastructure and plans for expansion. Hungary's planned nuclear power plant (NPP) is encountering significant political and logistical challenges stemming from close cooperation with Russia. Poland is advancing plans for the development of its first NPP and already focusing on public acceptance and international partnerships for long-term expansion.

The nuclear projects in V4:

- **The Czech Republic** operates two NPPs (Dukovany and Temelín) which collectively account for 39.4% of the country's electricity production. The partnership with South Korean KHNP for the construction of two additional reactor units is facing legal challenges. The country is also cooperating with Rolls-Royce on small modular reactors (SMRs).
- **Hungary's** Paks NPP provides approximately 45% of the nation's electricity. The planned Paks 2 expansion with two Russian-built VVER-1200 reactors (2,400 MW capacity) is facing challenges due to ongoing geopolitical tensions with Russia and delays in the implementation process.
- **Poland** is targeting 2036 for the commissioning of its first large-scale NPP using AP1000 reactors developed by Westinghouse and Bechtel. It is in the very early stages of exploring partnerships and regulatory frameworks for a second NPP and SMRs.
- **Slovakia**: The country's energy mix is heavily reliant on nuclear energy, with 61.8% of electricity generated from nuclear power plants. The Mochovce Unit 4 is scheduled to commence operation in 2025/2026, while plans for a new 1,200 MW unit at Bohunice are advancing. Additionally, SMR pilot projects are being investigated.

Public and political support: Public approval is high for nuclear energy across all V4 countries: (70–80% in the Czech Republic, Slovakia and Hungary and 90% in Poland) owing to the perceived energy security and decarbonization benefits. Similarly political backing is robust, with only small pockets of opposition typically from green parties. Across the EU27 it is mixed, with countries like France and Finland strongly supporting nuclear, while Germany and Austria vehemently oppose it.

Major challenges: Delays and related cost overruns are the main challenges for current project development (e.g. in the case of Mochovce Units 3 and 4 in Slovakia or Paks 2 in Hungary). There are also regulatory hurdles at the EU level and insufficient financing models for long-term nuclear investments. Since February 2022, dependence on Russian nuclear fuel and components has emerged as a new challenge, with focused efforts underway to diversify.

Finally, there is only limited V4 nuclear cooperation when it could be more robust and useful, mainly due to Hungary's continued alignment with a Russia.

Future developments: While Poland begins constructing its first ever NPP and plans for the second, all V4 countries are exploring SMRs as a potential game-changing nuclear technology, where the Czech Republic, Slovakia and Poland are active in the initial planning. Strategic international partnerships are central to all nuclear projects. South Korean KHNP is a major partner for the Czech Republic and potentially Slovakia, with possible overlapping project bids. The U.S. (Westinghouse) is the main partner for Poland's first NPP and considered a key partner for diversifying nuclear fuel supplies in the Czech Republic and Slovakia. French Framatome also plays an important role in diversification for Hungary, the Czech Republic and Slovakia, and has become more involved in Hungary's Paks NPP. Russian Rosatom remains central to Hungary's Paks 2 NPP while its role has diminished in the region due to geopolitical tensions and possible sanctions.

EU framework and regional cooperation: At the EU level, V4 countries have advocated for equal treatment of nuclear energy as a 'green' technology alongside renewables, improved financing mechanisms, and streamlined regulatory approvals. Regional collaboration on nuclear energy is hindered by political divisions, but bilateral and broader Central and Eastern European partnerships could offer alternative paths for cooperation. Furthermore shared challenges, such as regulatory compliance issues and financing models, could foster future collaboration, at least at a working technical level—particularly in areas like nuclear safety, workforce development, and SMR technology. At the same time, there is also competition among these countries for securing strategic partnerships.

Nuclear energy features prominently in V4 energy and climate strategies, contributing to energy security, decarbonization and economic stability. While the V4 countries share similar goals and challenges, collaboration remains weak due to national interests and geopolitical factors. If these differences could be put aside, a common approach to regulatory and technological issues could unlock synergies and bolster nuclear energy's role in the region's energy future.

Introduction

Nuclear energy plays a prominent role in the energy mix of three out of four Visegrad Group (V4) countries with Poland set to join. The role of nuclear energy is expected to grow in all V4 countries in the coming decades to meet European Green Deal decarbonisation commitments and anticipated growth in electricity demand. Electricity is expected to almost double as a share of the EU's final energy consumption by 2040[1] with the electrification of the transport sector, heating and industry. Moreover, the strategic goal of developing a hydrogen market depends on more power generation.

Nuclear energy is seen in all countries of the region as an essential element of their increasingly cleaner energy mix, supplementing renewables and guaranteeing baseload power supply at competitive prices. At the same time, despite the need to import uranium and at least some nuclear services,[2] nuclear energy does help to reduce import dependency of fossil fuels and is thought to bolster energy security. Additionally, ensuring viable financing options for these projects and implementing EU and national regulations that ensure a level playing field for clean energy technologies will be crucial for plans to build new nuclear capacities in the region. Consequently, V4 countries have an interest in jointly lobbying for this type of shift in EU policies and regulations.

This paper presents the current status of nuclear energy for each V4 country, plans for further development, and prospects for V4 cooperation in this field. It goes on to identify major obstacles to nuclear development before analysing the importance of the EU framework as well as bilateral and regional formats of cooperation to overcome them.

1 EUR-Lex (2024). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Securing our future Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2024%3A63%3AFIN (accessed 20 November 2024).

2 World Nuclear Association (2024). Nuclear Power in the European Union, https://world-nuclear.org/information-library/country-profiles/others/european-union (accessed 20 November 2024).

THE CZECH REPUBLIC

1. Nuclear energy—state of affairs

a. Overview of operational NPPs

Two NPPs operate in the Czech Republic. In 2023, the Dukovany NPP produced 14.3 TWh of electricity and the Temelín NPP produced 16.1 TWh, accounting for 39.4% of the country's electricity production.[3] The output was down slightly from the year before (of 0.4 TWh y-o-y and 0.2 TWh y-o-y respectively), which set the record for the highest annual output in the history of the Czech energy sector.

Czech NPPs are used for heating purposes on a limited scale. The Temelín NPP has supplied hot water for the small town of Týn nad Vltavou (8,500) since 1998, and in October 2023 began supplying the regional capital of České Budějovice (97,000). In the first year it provided 663,000 GJ of heat supply to the latter, compared to 168,000 GJ to the former over the same period.[4] A project connecting the Brno district heating network to the Dukovany plant was resumed in 2022 and should begin providing heat supply in 2030/2031.

The Dukovany NPP operates four production units with VVER (water-water energy reactor) reactors from 1985–1987 (Table 1). The combined capacity was gradually expanded to 4 × 510 MW net and 4 x 525 MW gross (from 4 × 440 MW). The plant is scheduled to operate until 2035–2037, when it can be extended for ten years.

Table 1. Existing nuclear reactors in the Czech Republic

Reactor name	Model	Net capacity (MWe)	Construction start	First grid connection	Expected year of decommissioning
Dukovany 1	VVER V-213	510	1979-01	1985-02	2035, possibly extended to 2045
Dukovany 2	VVER V-213	510	1979-01	1986-01	2036, possibly prolonged to 2046
Dukovany 3	VVER V-213	510	1979-03	1986-11	2036, possibly prolonged to 2046
Dukovany 4	VVER V-213	510	1979-03	1987-06	2037, possibly prolonged to 2047
Temelín 1	VVER V-320	1086	1987-02	2000-12	2060
Temelín 2	VVER V-320	1086	1987-02	2002-12	2062

Source: World Nuclear Association and own compilation based on media & published company documents

3 International Energy Agency (2024). Czechia, https://www.iea.org/countries/czechia/energy-mix (accessed 20 November 2024).

4 ČEZ (2024). Za rok provozu dodal Temelín do Českých Budějovic 663 tisíc gigajoulů tepla, https://www.cez.cz/cs/pro-media/tiskove-zpravy/za-rok-provozu-dodal-temelin-do-ceskych-budejovic-663-tisic-gigajoulu-tepla-201546 (accessed 20 November 2024).

The Temelín NPP operates two production units with VVER-1000 reactors which were connected to the electricity grid in 2002–2003 after construction commenced in 1987. Their installed gross capacity now totals 2 × 1125 MW (2 x 1086 MW net). The plant can operate until 2060–2062 depending on the unit.

b. The attitude towards nuclear energy in society and politics

Nuclear energy enjoys long standing support of the Czech society, which is mirrored in the positive attitude of major Czech political forces. According to the IBRS poll published in June 2024, 70% of Czechs are in favour of expanding nuclear capacities.[5] The CVVM survey published in December 2023 revealed only 13% of Czechs want to reduce the role of nuclear energy compared to 80% that want to either maintain or increase it.[6] According to the same study, 65% of inhabitants are in favour of building new units in the NPPs (up from 44% in 2015). In contrast, relatively few Czechs (33%) trust the government to properly manage nuclear energy projects. This is a result of the numerous project delays, changes in the procurement, and cancellations, like the withdrawal of the Temelín NPP expansion project in 2014.

Across the political spectrum there is a widespread consensus regarding the need to not only keep but also increase nuclear capacities. While Greens/EFA political parties in the European Parliament oppose nuclear energy, their Czech Pirate Party members, part of the ruling coalition until October 2024, have supported it.[7]

c. Main players in the national energy sector

Both NPPs are owned and operated by the ČEZ Group, the national energy utility that plays a dominant role in Czech Republic's energy sector. Although the state owns 70% of the company's shares, minority shareholders can make effective, coordinated efforts to resist decisions carrying high investment risks which undermine the share price. The centre-right Petr Fiala government tried to carve out a state-owned entity from the company that would be responsible for energy production to create a pathway for nuclear expansion but has been unsuccessful.[8]

Apart from ČEZ itself, numerous Czech and Czech-based companies are involved with subcontracting in the development of new NPP units. Some of the larger companies are directly owned by ČEZ, for example the Plzeň-based Škoda JS, which manufactured the VVER-440 reactors for the third and fourth unit of the Mochovce NPP (Slovakia) and produces storage containers for radioactive materials, mostly for spent nuclear fuel. ČEZ also owns ÚJV Řež, which provides industrial design and engineering services. Meanwhile Sigma Group, which manufactures pumps for nuclear power plants, is controlled by

5 OENERGETICE (2024). Průzkum: Rozvoj jaderné a obnovitelné energie podporuje v ČR přes 70 % lidí, https://oenergetice.cz/energetika-v-cr/pruzkum-rozvoj-jaderne-a-obnovitelne-energie-podporuje-v-cr-pres-70-pct-lidi (accessed 20 November 2024).

6 CVVM (2023). Veřejnost o jaderné energetice, https://cvvm.soc.cas.cz/cz/tiskove-zpravy/ostatni/ekologie/5763-verejnost-o-jaderne-energetice-srpen-zari-2023 (accessed 20 November 2024).

7 Piráti (2021). Pirátská jaderná energie, https://jadro.pirati.cz/ (accessed 20 November 2024).

8 J. Nádoba (2023). Půjde znárodnění ČEZ k ledu? Buď se Fiala uřekl, nebo dostal rozum, https://www.seznamzpravy.cz/clanek/ekonomika-pujde-znarodneni-cez-k-ledu-bud-se-fiala-urekl-nebo-dostal-rozum-236383 (accessed 20 November 2024).

Czech private capital through a Cypriot company. I & C Energo, a supplier of command-and-control systems, is owned by a Slovak investor with strong business ties to the Czech Republic.

Apart from the PM, the crucial entities and individual positions in the public administration for overseeing nuclear energy are: the Ministry of Finance (executing state-ownership rights in ČEZ); the Ministry of Industry and Trade (responsible for energy policy); the State Office for Nuclear Safety ((SÚJB) chaired by Dana Drábová since 1999, who enjoys high public approval), Special Envoy for Energy Security (held by Václav Bartuška since 2006); and National Security Advisor (a post created in December 2022 and since held by Tomáš Pojar).

2. Plans for developing the nuclear energy

a. Unpacking national strategic documents

All adopted and draft national strategic documents related to energy policy envisage development of nuclear energy generation. The most recent, *The Economic Strategy of the Czech Republic* from 10 October 2024, states in the *"Energy infrastructure and decarbonisation"* section that developing nuclear energy, including SMRs, is critical for achieving the strategy's goals, notably energy security.[9] It also highlights the role of nuclear energy in the transition towards the circular economy, describing the construction of new nuclear sources as a "key tool to ensure safety, stability and decarbonisation of the electricity system, while benefiting the national economy".

The new energy strategy (*The Energy Concept of the State*) replacing the 2015 document was intended to be finalized in 2023 but remains unfinished as of November 2024.[10] A leaked draft from early 2024, focused on the increasing role of nuclear energy in electricity generation and its growing importance in the heating system. It also advocates for the swift development of renewables, transitional utilization of gas, and gradual phasing out of coal[11]. It projects nuclear energy to grow as a share of energy consumption from 18% currently to 22% in 2030, 30-40% in 2040, and 32–42% in 2050, and as a share of electricity production from 39% currently to 45% in 2030, 47–65% in 2040, and 36–50% in 2050[12].

The Czech National Energy and Climate Plan (NECP) submitted to the European Commission in 2023 [13] set 2040 targets the share of nuclear energy of 46–58% (from 29% in 2016) in gross electricity production and 25–33% of total primary energy sources (15% in 2016).

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9 Ministry of Industry of the ČR (2023). Hospodářská strategie České republiky: Česko do top 10, https://www.mpo.gov.cz/assets/cz/rozcestnik/pro-media/tiskove-zpravy/2024/10/Hospodarska-strategie-Ceske-republiky_Cesko-do-top-10.pdf (accessed 20 November 2024).

10 Ministry of Industry of the ČR (2015). Státní energetická koncepce, https://www.mpo.gov.cz/dokument158059.html (accessed 20 November 2024).

11 Ministry of Industry of the ČR (2024). Aktualizace Státní energetické koncepce (SEK), https://www.mpo.gov.cz/cz/rozcestnik/pro-media/tiskove-zpravy/aktualizace-statni-energeticke-koncepce-sek--279668/ (accessed 20 November 2024).

12 Ibid.

13 European Commission (2023). Czech—Draft Updated NECP 2021-2030, https://commission.europa.eu/publications/czech-draft-updated-necp-2021-2030_en (accessed 20 November 2024).

b. Current and planned projects

In July 2024, the Czech government closed the bidding process for the expansion of both nuclear power plants, declaring the South Korean KHNP as the winner. The plan is to construct two additional units for each power plant, first Dukovany, followed by the Temelín NPP as an option awarded for up to five years. The final contract should be signed in March 2025, with construction of the Dukovany units starting within five years. This would put the units on track for testing in 2036 and commercial operation in 2038. The second unit is expected to commence two years later. Each new unit will have a nameplate capacity of 1050 MW at a cost of 200 billion CZK (EUR 7.9 billion), though some expert assessments believe the cost will be significantly higher.[14]

Table 2. Planned nuclear reactors in the Czech Republic

	Planned capacity	Planned start date	Cost	Investors & partners	State of affairs
Dukovany 5 & 6	2 x 1050 MW	2038–2040 for full grid connection	7.9 bn €	KHNP	Contract to be signed, deal suspended by the Czech anti-trust office.
Temelín 3 & 4	2 units of unspecified capacity	Unclear	Unclear	Most probably KHNP	The Czech government contracted an option with KHNP for up to five years, during which it can decide on the construction of two more units at the Temelín site.
SMRs	470 MW for the first one (in Temelín), 7 such units altogether	2035 for the first one, 2050 for all seven	Unclear	Rolls-Royce (in cooperation with ČEZ)	ČEZ signed an agreement with Rolls-Royce which is in the final stage of licensing its nuclear technologies in the UK.

Source: own compilation based on publicly available information from media, companies and the Czech government

However, the contract agreement was challenged by French EDF and American Westinghouse, and the Czech Office for Competition (ÚOHS) issued a pre-emptive decision in October 2024 to block the government from signing nuclear contracts with KHNP. Moreover, the State Office for Nuclear Safety is expecting delays in the Dukovany project, for months or possibly years.[15] Additionally, EDF filed a complaint with the European Commission under the European regulation on foreign subsidies.[16]

14 O. Sklenář (2021). Náklady spojené s novým jaderným zdrojem Dukovany, AMO, https://www.amo.cz/cs/klimatym/naklady-spojene-s-novym-jadernym-zdrojem-dukovany/ (accessed 20 November 2024).

15 F. Titlbach (2024). Zpoždění tam na jistotu bude. Jde o to, jestli měsíce, nebo deset let, říká o dostavbě Dukovan Drábová, Deník N, https://denikn.cz/1480628/zpozdeni-tam-na-jistotu-bude-jde-o-to-jestli-mesice-nebo-deset-let-rika-o-dostavbe-dukovan-drabova/ (accessed 20 November 2024).

16 A. Zachová and P. Messad (2024). Exkluzivně: Do českého jaderného tendru může vstoupit Evropská komise, EDF podala stížnost, Euractiv, https://euractiv.cz/section/energetika/news/exkluzivne-do-ceskeho-jaderneho-tendru-muze-vstoupit-evropska-komise-edf-podala-stiznost/ (accessed 20 November 2024).

In October 2024, ČEZ provided details of the SMR projects in cooperation with Rolls-Royce, with the first unit (470 MW) planned for 2035 and the second in 2040. The media is reporting this could be completed even earlier, by 2034 and 2038.[17]

c. Strategic foreign partners

Korea Hydro & Nuclear Power (KHNP), part of the Korea Electric Power Corporation (KEPCO), was selected as the winning bidder for the new nuclear units, as best "in all criteria under assessment" according to Prime Mister Petr Fiala[18]. Per the agreement Czech companies will be among KHNP subcontractors, notably Škoda Power to produce the turbines, as well as likely Škoda JS, Metrostav Diz and Sigma Group.

While Russian TVEL**,** a Rosatom's subsidiary, remains the sole supplier of nuclear fuel, the government plans to diversify and eventually become independent from Russian fuel supplies. In April 2022, the government determined that nuclear fuel supplies to the Temelín NPP would be provided by Westinghouse and Framatome instead of TVEL beginning in 2024. They signed an agreement in June 2022 with the owner and operator of the power plant (ČEZ Group) for fuel supplies "over 10 years". During the initial phase (first five years), Framatome will continue supplying fuel based on the TVEL license, with its production taking place in Germany. In March 2023 ČEZ Group announced that from 2024 the supplier structure for the Dukovany NPP would be altered, with Westinghouse replacing TVEL by 2028. In early 2024, ČEZ announced that Westinghouse supplies to the Dukovany NPP would begin the same year, while its first deliveries to the Temelín NPP are planned for 2025. Framatome supplies to the Temelín NPP will follow in 2025, and possibly also to the Dukovany NPP at a later date; a memorandum between the company and ČEZ to develop nuclear fuel to the plant was signed in October 2024. Westinghouse has delivered fuel to the Temelín NPP in the past and supplied the control system during construction in the 1990s.

Cooperation between British Rolls-Royce and ČEZ for the development of SMRs was approved by the Czech government in September 2024, which included the Czech company's acquisition of shares in Rolls-Royce.

d. Major challenges

Among the challenges that need to be resolved most urgently is the KHNP's legal dispute with Westinghouse over intellectual property in the field of nuclear energy. A KHNP-Westinghouse agreement from the 1970s stipulates that KHNP needs explicit consent from the US for use of their technology in foreign projects. This was granted for its project in the United Arab Emirates, but not yet for the European market. The final decision from an international court of arbitration is expected to be issued at the end of 2025. The two companies have cooperated closely for decades, with Westinghouse overseeing

17 D. Tramba (2024). Jaderné reaktory od Rolls-Royce? Do roku 2040 chce ČEZ postavit rovnou dva, Ekonomický Deník, https://ekonomickydenik.cz/jaderne-reaktory-od-rolls-royce-do-roku-2040-chce-cez-postavit-nejmene-dva/ (accessed 20 November 2024).

18 D. Tramba (2024). Korejská nabídka byla ve všem lepší. Vláda potvrdila KHNP jako vítěze velkého jaderného tendru, Ekonomický deník, https://ekonomickydenik.cz/korejska-nabidka-byla-ve-vsem-lepsi-vlada-potvrdila-khnp-jako-viteze-velkeho-jaderneho-tendru/ (accessed 20 November 2024).

maintenance and supplies for some KHNP power plant components in South Korea. The Czech Republic is therefore expecting an amicable solution, with media reports suggesting that the issue is not expected to be a serious stumbling block and only constitutes part of the US business strategy.

Water sufficiency for cooling purposes is another challenge, especially for the Dukovany NPP, since the nearby Jihlava river is relatively small. Draughts, like those experienced between 2014 and 2020, can further limit available water supply. Furthermore, if new units are connected to the grid before older units are decommissioned it can exacerbate the situation. According to the current schedule the two new units should be fully connected by 2040 with the four older ones decommissioned in 2037, although a 10-year extension is being seriously debated. One possible solution is to use dry cooling technology for the new blocks.[19]

Another pending issue is getting the European Commission's approval for a state aid mechanism that will enable the funding of the construction and operation of further units. So far, only one new unit at the Dukovany NPP received approval from the EC in April 2024.[20] However, given that the financing model accepted for the fifth unit of the Dukovany NPP was presented by the EC as a benchmark for other member states, this should only be a formality.

The financing model for the new unit, under which all costs and risks are borne by the state, has the potential to downgrade the credit rating of the Czech Republic. Project delays could lead to more expensive financing of state debt and result in a debt spiral with profound consequences for the domestic macroeconomic situation. Fortunately, the Czech Republic among the better performing EU member states as far as public debt and budget deficit.

19 D. Hyklová (2024). Nové bloky v Dukovanech mají mít suché chlazení, maďarská firma nabízí řešení, iDNES, https://www.idnes.cz/ekonomika/domaci/jaderna-elektrarna-dukovany-temelin-edf-khnp-mvm-egi.A240220_163811_ekonomika_hyk (accessed 20 November 2024).

20 European Commission (2024). Commission approves State aid to support construction of nuclear power plant in Czechia, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_2366 (accessed 20 November 2024).

HUNGARY

1. Nuclear energy—state of affairs

a. Overview of operational NPPs

Hungary has one nuclear power plant located in Paks, 100 km south of Budapest. The power plant was built using Soviet design and technology (VVER 440) and the four reactors were connected to the electricity grid in 1982-1987 with a 30-year lifetime and nameplate capacity of 479/510 MWE. Their lifetime was extended for 20 years, meaning that the four units are set to be phased out between 2032 and 2037. However, another extension of 10-20 years was authorized by the Hungarian Parliament in 2022. In December 2023, János Horváth Péter, the head of the MVM Paks Nuclear Power Plant Ltd, announced that start of the 20 year extension process for all four blocks of the power plant.[21]

The Paks NPP produced almost 16 TWh of electricity in 2023, 45% of Hungary's electricity generation, compared to 21% from natural gas, 20% from solar, 7% from coal, and 4% from biofuels. Nuclear energy accounted for 18% of the total energy supply.

Table 3. Existing nuclear reactors in Hungary

Reactor	Model	Net capacity (MWe)	**Construction start**	**First grid connection**	**Expected year of decommissioning**
Paks-1	VVER-440/213	479	1974	1982	2032*
Paks-2	VVER-440/213	479	1974	1984	2034*
Paks-3	VVER-440/213	479	1979	1986	2036*
Paks-4	VVER-440/213	479	1979	1987	2037*

Source: Paks Nuclear Power Plant, World Nuclear Association
*Aimed to be extended by another 20 years

b. The attitude towards nuclear energy in society and politics

Nuclear energy is widely supported by the Hungarian public. In 2023, 70% of the adult population supported the operation of the Paks NPP, with 62% supporting the construction of additional units at Paks.[22]

Nuclear energy is supported by the political establishment, with only small green parties dissenting. The vast majority of MEPs have supported the development of nuclear energy in key votes, first approving the Paks expansion

21 Á. Kéfer (2023). Még 2057-ben is üzemelhet a Paksi Atomerőmű, Index, https://index.hu/gazdasag/2023/12/05/mvm-paks-atomenergia-atomeromu-uzemido-hosszabbitas-2057/ (accessed 20 November 2024).

22 Magyar Társadalomkutató Kft. (2023). Atompárti elmozdulás: jelentősen nőtt az atomenergia és az atomerőművek támogatása, https://tarsadalomkutato.hu/atomparti-elmozdulas-jelentosen-nott-az-atomenergia-es-az-atomeromuvek-tamogatasa/ (accessed 20 November 2024).

in 2009 and eventually authorizing the extension of the operational units in 2022. However, the implementation process for Paks 2 under the Fidesz government has been heavily criticized by the opposition for failing to administer an open tender procedure, lack of transparency, and cooperation with Russia.

c. Main players in the national energy sector

The Paks NPP is owned and operated by the MVM Paks Nuclear Power Plant Ltd, a subsidiary of the state-owned MVM Group, the largest player on the Hungarian electricity market. Under the Fidesz government, the presence of the state in the energy sector has grown, with nuclear energy under particularly strong supervision of the government. Since 2022, a separate ministry for energy was established, which oversees the Paks NPP in operation. However, the construction of Paks 2 NPP is under the supervision of the Ministry of Foreign Affairs and Trade, due to the geopolitical dimension of Russian cooperation.

2. Plans for developing the nuclear energy

a. Unpacking national strategic documents

According to the NECP from 2023, nuclear energy is considered a clean energy source contributing to Hungary's energy security. The document anticipates a significant increase in nuclear energy after 2030 with the addition of two new units at the Paks NPP, more than doubling from 2000 MW to 4400 MW, about two thirds of electricity generation, before dropping to 42% in 2050 with rising electricity demand and the rollout of renewables.

b. Current and planned projects

The intergovernmental agreement for the Paks 2 expansion (two new VVER-1200 units with a total capacity of 2,400 MW) was signed with Russia in 2014. Under the terms, 80% of the financing will be provided by a € 10 billion loan from Russian banks. The main contractor for the Paks 2 NPP is the Russian state-owned company Rosatom. In the 10 years since the agreement was signed, the project has encountered several difficulties, modifications and stoppages due to objections from the EC and delays in the domestic licencing, among others. In 2022, the Hungarian Atomic Energy Authority issued the construction licence for the new Paks 2. Commissioning of the fifth unit is expected in 2032 at the earliest. So far (by November 2024), only preparatory ground works have begun for Paks 2. A core catcher, the first large technical unit, arrived from Russia in summer 2024.[23]

Hungary's government has also expressed interest in small modular reactors (SMRs), but no binding decisions have been taken.

23 Atomszféra (2024). Paksra érkezett, https://www.paks2.hu/documents/d/guest/atomszfera_2024_2 (accessed 20 November 2024).

Table 4. Planned nuclear reactors in Hungary

Reactor	Type	Planned capacity	Planned start date	Cost	Investors & partners	State of affairs
Paks-5	VVER-1200	1200 MW	2032	12,5 bln euro	Rosatom	The project has faced significant delays, with several regulatory, financial and political obstacles remaining
Paks-6	VVER-1200	1200 MW	2032			

Source: Paks 2 Nuclear Power Plant, World Nuclear Association

c. Strategic foreign partners

Rosatom, the state-owned Russian company, plays a key role in the Hungarian nuclear energy sector. Rosatom and its subsidiaries are the main partners for the Paks 2 project under the 2014 intergovernmental agreement and three subsequent implementation contracts signed later that year. TVEL, a subsidiary of the Rosatom, is currently the only nuclear fuel supplier for the Paks NPP and, according to the contracts, it will remain so for the first 10 years of Paks 2 operations.

Framatome, which EDF, a French state owned company has a controlling 80,5% share, has a growing role in the Hungarian nuclear sector. In 2019 the Framatome-Siemens consortium signed a contract to supply automated process control systems (ACS TP) to Paks 2. However, after the Russian invasion of Ukraine, the German government refused to grant permission for Siemens to supply the components. Subsequently, the role of Framatome has grown, culminating in a contract signed with MVM in October 2024 for the supply of nuclear fuel to the Hungarian Paks VVER reactors from 2027.

d. Major challenges

The Paks 2 project has faced many regulatory, financial and political obstacles. The European Commission made several objections to the project for incompatibility with the EU rules on public procurement, state aid and fuel supplies.[24] Finally, after the Hungarian government made several amendments to the project, the European Commission approved its implementation. The licencing process also encountered several delays, postponing the final permitting by the Hungarian Atomic Energy Authority.

Given the delay, the loan agreement had to be amended. In 2019, the parties agreed that Hungary will start repaying the loan only by the time the units are operational. The Hungarian government announced that the repayment of the loan will start in 2031 instead of 2026 as initially planned. At the same time, the costs of the project have increased significantly, fuelled by high inflation in recent years.

Finally, the geopolitical situation surrounding the project has changed dramatically over the past decade. Shortly after the 2014 Hungarian–Russian intergovernmental framework agreement was signed, Russian hostilities towards Ukrainian began with the illegal annexation of Crimea, leading to

24 European Commission (2015). November infringements package: key decisions, https://ec.europa.eu/commission/presscorner/detail/en/memo_15_6006 (accessed 20 November 2024).
D. Keating (2015). EU rejects Hungary-Russia nuclear fuel supply deal, Politico, https://www.politico.eu/article/eu-rejects-hungary-russia-nuclear-fuel-supply-deal/ (accessed 20 November 2024).

a deterioration of relations with the EU and NATO. The geopolitical context became even more challenging for the project since the full-scale Russian invasion of Ukraine in 2022, resulting in the introduction of EU sanctions and the gradual decoupling of Europe's energy sector from Russia. Continuing the project with Russia as a partner comes at a growing political cost for Hungary among EU and NATO partners. It also makes financial and logistical cooperation with Russian entities more difficult, although nuclear energy has not yet been sanctioned by the EU.

Even though the Hungarian government and the main players in the project remain committed, several experts question whether it can be realized. This is likely to provide an opportunity for France to have a bigger role in the Hungarian nuclear sector going forward.

POLAND

1. Nuclear energy—state of affairs

a. Overview of operational NPPs

There are currently no nuclear power plants in Poland.

b. The attitude towards nuclear energy in society and politics

Despite deep divisions within the Polish political landscape and society on a number of issues, nuclear energy enjoys broad popular support. According to an annual survey commissioned by the Ministry of Climate and the Environment at the end of 2023 conducted by the DANAE company, a record 90% of respondents say they support the construction of NPPs, with only 7.2% opposed. Moreover, 76% of respondents are in favour of building nuclear reactors near their place of residence.[25]

Virtually all political parties in Poland support the development of nuclear energy. Both the ruling Civic Coalition (KO) and the main opposition Law and Justice (PiS) believe it necessary to meet the EU's climate goals of climate neutrality by 2050 while ensuring affordable and stable energy supply for the country. Only the Greens, a small party belonging to the ruling Civic Coalition, are in opposition to nuclear energy, but this does not affect the position of the coalition government.

c. Main actors in the national energy sector

Since national elections at the end of 2023, there have been ongoing changes to the supervision and management of the energy and climate sector, including nuclear energy. A new Ministry of Industry was established in March 2024 and subsequently gained competency over nuclear energy policy. The government's plenipotentiary for the implementation of strategic energy infrastructure, which oversees the nuclear program, reports directly to this ministry.

The key company responsible for building Poland's first nuclear power plant is the fully state-owned company Polskie Elektrownie Jądrowe (PEJ).[26] According to a 2021 government regulation, the company is supervised by the Government Plenipotentiary for Strategic Energy Infrastructure. State-owned energy companies are also likely to be responsible for the construction of the second full-scale NPP, as outlined in the current nuclear strategy. Beyond this, SMRs would most likely be built by private entities.

25 Ministry of Climate and Environment (2023). Kolejny rekord—niemal 90% Polaków za budową elektrowni jądrowych w Polsce, https://www.gov.pl/web/klimat/kolejny-rekord-niemal-90-polakow-za-budowa-elektrowni-jadrowych-w-polsce (accessed 20 November 2024).

26 Polskie Elektrownie Jądrowe (2024). O spółce, https://pej.pl/o-spolce (accessed 20 November 2024).

2. Plans for developing the nuclear energy

a. Unpacking national strategic documents

Poland is currently still operating under the 2020 Polish Nuclear Energy Program (PPEJ),[27] which sets the framework and strategic goals for the technology. According to the document, nuclear energy will help achieve three key energy objectives for safe, affordable, and clean electricity that will transform and develop Poland's economy. The program is targeting a total installed capacity of approximately 6 to 9 GW of nuclear capacity based on proven, large-scale, Generation III(+) pressurized water reactors.

It is already clear that not all goals will be realized. For instance, it is unclear whether both of the planned full-scale NPPs will be built by the same partner. Additionally, delays have caused changes to the original investment schedule. Furthermore, a number of external circumstances have changed, including conditions in the European and global energy markets. An updated program is expected by the end of 2024, while media reports have confirmed that the first NPP will be constructed in Pomerania, as previously planned, and the second to be determined from a short list of proposed locations.[28]

Poland's updated NECP[29] from February 2024 reaffirms the plans to build NPPs, with the first reactor expected to be operational between 2030 and 2035. According to this document, all blocks of the first nuclear plant are to be completed by 2037[30], and those of the second plant by 2043. The total installed capacity of large-scale nuclear units could reach nearly 7.4 GW by 2040 and about 9.7 GW (with two additional blocks) after 2040.

The plan stipulates actions to support the launch of large-scale nuclear power, including preparation of regulations, development of human resources, and completion of works on the financing model, all in line with the Polish Nuclear Energy Program (PPEJ). This should incentivize private investments in both large- and small-scale nuclear energy projects. Ensuring stable fuel supplies for these power plants is also crucial. The ambitious transition scenario (WAM) in the NECP should be concluded by the end of 2024, at which point the PPEJ will be updated.

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27 Ministry of Climate and Environment (2024). Program polskiej energetyki jądrowej, https://www.gov.pl/web/klimat/program-polskiej-energetyki-jadrowej1 (accessed 20 November 2024).

28 Business Insider (2024). Rząd zmieni plany w sprawie elektrowni jądrowych. Końcowa faza prac nad aktualizacją programu, https://businessinsider.com.pl/wiadomosci/aktualizacja-programu-polskiej-energetyki-jadrowej-na-ukonczeniu/ggwl149 (accessed 20 November 2024).

29 European Commission (2024). Poland—Draft updated NECP 2021–2030, https://commission.europa.eu/publications/poland-draft-updated-necp-2021-2030_en (accessed 20 November 2024).

30 However, according to a statement by the government's plenipotentiary for the implementation of strategic energy infrastructure on December 11, 2024, the first reactor of the first nuclear power plant is expected to be commissioned for commercial use in 2036, followed by the next two blocks in 2037 and 2038. See: Energetyka24 https://energetyka24.com/atom/wiadomosci/pierwszy-blok-elektrowni-jadrowej-zacznie-prace-w-2036-r-nowy-pelnomocnik-pokazuje-harmonogram

Table 5. Planned nuclear reactors in Poland

Project	Reactors						
	Type	Planned capacity	Planned start date	Cost	Investors—partners	State of affairs	
In the implementation phase							
Choczewo	AP 1000	3 x 1250 MW	I block 2035, The rest -...	115—150 bln PLN[31]	PEJ, technological partners—Westinghouse & Bechtel	Design phase; Environmental and location decisions made First agreements with technology partners have been signed.	No official strategy from the new government, relying on media statements from government representatives; Construction is expected to begin in 2028. Costs: 30% equity contribution, 70% debt financing (including EXIM Bank).
Planned							
-	-	3	2043 (according to 2020 programme)			Second NPP planned by previous government	According to the 2020 program, the NPP should be built using the same technology as the first NPP; currently no decision on the location or technical partner.
-	-	-	-	-	Świętokrzyska Grupa Przemysłowa INDUSTRIA S.A., technology providor—Rolls Royce	Early stage, plan just approved by ministry	Possible localisation in Kostrzyńsko-Słubicka Specjalna Strefa Ekonomiczna (KSSSE)
Postponed/frozen/cancelled plans							
Ostrołęka (OSGE)	BWRX-300 (SMR)	4x300MW			Synthos and Orlen—partner to form Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	On hold for explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.
Włocławek (OSGE)	BWRX-300 (SMR)	4x300MW			Synthos and Orlen—partner to form Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	On hold—explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.

31 Statements in the media by the government's plenipotentiary for the implementation of strategic energy infrastructure.

Tarnobrzeg—Stalowa Wola (OSGE)	BWRX-300 (SMR)	4x300MW	Synthos and Orlen—partner to form Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	On hold—explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.
Nowa Huta (OSGE)	BWRX-300 (SMR)	4x300MW	Synthos & Orlen—partners in Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	on hold—explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.
Stawy Mon owskie (OSGE)	BWRX-300 (SMR)	4x300MW	Synthos and Orlen—partner to form Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	On hold for explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.
Dąbrowa Górnicza (OSGE)	BWRX-300 (SMR)	4x300MW	Synthos and Orlen—partner to form Orlen Synthos Green Energy (OSGE), technology by GE Hitachi	On hold for explanatory proceedings	Investigation in to nuclear reactor projects by Orlen Synthos has been initiated by Tusk's government. Business model of OSGE under revision. OSGE planned a fleet of (6) SMRs with the most advanced in the planning phase.
Pątnów	APR1400	2x1400MW	ZE PAK, PGE (PGE-PAK) & KHPN	Frozen?	Was supposed to be completed by 2035 (first unit), but after the change of government in Poland, the decision has been effectively frozen. On hold until government's strategic decisions taken
KGHM			KGHM with NuScale technology	Cancelled	

Source: company websites, media information, Global Energy Monitor

b. Current and planned projects

The transfer of responsibilities from the Ministry of Climate and Environment to Ministry of Industry and incomplete strategic documents, including the new government's nuclear energy strategy, has caused confusion, particularly in terms of information about the future of specific projects. Additionally, the lack of clear state support along with technological challenges have led to the suspension of work on the second planned NPP in Pątnów, as well as SMR projects. KGHM withdrew from the project with NuScale while Orlen Synthos Green Energy's (OSGE) plans were put on hold due to an ongoing explanatory proceeding. While the CEO of ORLEN publicly supports SMRs, the OSGE business model is expected to change, and discussions are ongoing between ORLEN and Synthos.[32]

So far, OSGE has identified seven potential locations for its planned fleet of BWRX-300 SMR units (Ostrołęka, Włocławek, Stawy Monowskie, Dąbrowa Górnicza, Nowa Huta, Tarnobrzeg Special Economic Zone—Stalowa Wola, Warsaw), six of which gained approval by the ministry.[33] According to GE Hitachi, three of these locations have advanced to the environmental permitting stage, with Stawy Monowskie the most advanced.[34] However, any binding decisions will require clarification of OSGE's operational principles and ORLEN's detailed strategy for building the fleet of SMRs. In May 2024, the Świętokrzyska Industrial Group INDUSTRIA S.A plan for constructing a Rolls-Royce SMR was approved by the government, marking the first step in the administrative process for the project's implementation.[35]

Meanwhile, the most advanced large-scale NPP project in Choczewo has been progressing. At the end of August 2024, Prime Minister Donald Tusk confirmed the start of preparatory work at the selected location[36] after the Engineering Service Contract was signed by the project's technological partners Westinghouse and Bechtel. However, the Engineering, Procurement and Construction contract remains unsigned. According to information provided by the Ministry of Industry, the launch date for the first of the three planned blocks will be delayed by three years to 2036.

32 Money (2024). Ten projekt był oczkiem w głowie Obajtka. Co się z nim stanie? Prezes Orlenu ujawnia plany, https://www.money.pl/gospodarka/ten-projekt-byl-oczkiem-w-glowie-obajtka-co-sie-z-nim-stanie-prezes-orlenu-ujawnia-plany-7060016933714752a.html (accessed 20 November 2024).

33 ORLEN (2024). SMR—małe reaktory modułowe, https://www.orlen.pl/pl/zrownowazony-rozwoj/projekty-transformacyjne/smr (accessed 20 November 2024).

34 A. Pełka (2024). Prace dot. wdrożenia SMR-ów w Polsce przebiegają zgodnie z planem—GE Hitachi Nuclear (wywiad), Strefa Inwestorów, https://strefainwestorow.pl/wiadomosci/20240916/prace-dot-wdrozenia-smr-ow-w-polsce-przebiegaja-zgodnie-z-planem-ge-hitachi-0 (accessed 20 November 2024).

35 Ministry of Climate and Environment (2024). Decyzja zasadnicza MKiŚ dot. budowy elektrowni jądrowej z zastosowaniem reaktorów modułowych typu SMR, https://www.gov.pl/web/klimat/decyzja-zasadnicza-mkis-dot-budowy-elektrowni-jadrowej-z-zastosowaniem-reaktorow-modulowych-typu-smr (accessed 20 November 2024).

36 Business Insider (2024). Projekt budowy pierwszej elektrowni atomowej zbliża się do szeregu „krytycznych momentów", https://businessinsider.com.pl/biznes/pierwsza-polska-elektrownia-atomowa-blisko-krytyczne-momenty/9yyhw2x (accessed 20 November 2024).

c. Strategic foreign partners

The US is Poland's key strategic partner for implementing its nuclear energy program, as evidenced by signed political agreements[37] between the two countries, contracts with technical partners Westinghouse and Bechtel, and the launch of the Polish-U.S. Regional Clean Energy Training Center in 2024 which will contribute to skills development for the Polish workforce.[38]

There are good reasons to build the second NPP with the same technological partner, taking advantage of economies of scale, a trained workforce, developed supply chains, and subcontractors, all of which should reduce costs of the project. At the same time, due to the strategic and long-term political nature of such a partnership, Warsaw is seriously considering cooperation with a different partner. A few years ago, South Korea's KHNP was being considered for the second NPP, and now reportedly, the French company EDF has become a contender.

d. Major challenges

Poland's lack of experience with nuclear energy is the biggest challenge for such a large and strategic investment. Poland must not only construct the plants but also establish the institutional, regulatory, and operational frameworks necessary to safely manage them. This involves training a skilled and specialized workforce, creating emergency response protocols, and strengthening the regulatory body expertise to oversee nuclear safety standards (Panstwowa Agencja Atomistyki—Polish Nuclear Energy Agency[39]). Furthermore, the long-term nature of nuclear energy requires commitment to ensuring supplies for plant construction with a local content and nuclear waste management and storage.[40]

With the increasing pace of energy transition policy implementation across the EU and globally, ambitious expansion plans for both renewables and nuclear energy face bottlenecks in materials, service providers, and the labour force. This could be particularly challenging for new players in global nuclear energy-related supply chains, like Poland. Such issues could further delay the implementation timeline, increasing investment costs and the risk of a generation capacity gap that could be filled by competing sources, including renewables.

Additionally, the key short term challenge hindering NPPs projects is the absence of updated, strategic documents clearly defining the role of nuclear

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37 Wolters Kluwer (2021). UMOWA między Rządem Rzeczypospolitej Polskiej a Rządem Stanów Zjednoczonych Ameryki w sprawie współpracy w celu rozwoju programu energetyki jądrowej wykorzystywanej do celów cywilnych oraz cywilnego przemysłu jądrowego w Rzeczypospolitej Polskiej, https://sip.lex.pl/akty-prawne/mp-monitor-polski/usa-polska-umowa-w-sprawie-wspolpracy-w-celu-rozwoju-programu-19096651 (accessed 20 November 2024).

38 Republic of Poland (2024). Opening of the Polish-American Regional Training Center for Clean Energy Technologies, https://www.gov.pl/web/paa-en/opening-of-the-polish-american-regional-training-center-for-clean-energy-technologies (accessed 20 November 2024).

39 Republic of Poland (2024). Państwowa Agencja Atomistyki, https://www.gov.pl/web/paa/ (accessed 20 November 2024).

40 Poland's sole National Radioactive Waste Repository (KSOP) is located in the town of Różan and is intended solely for the disposal of short-lived, low- and intermediate-level radioactive waste generated in Poland, as well as for the temporary storage of long-lived radioactive waste (eg from Poland's sole research reactor).
Republic of Poland (2024). Krajowe Składowisko Odpadów Promieniotwórczych, https://www.gov.pl/web/polski-atom/krajowe-skladowisko-odpadow-promieniotworczych (accessed 20 November 2024).

energy in Poland's broader energy transition and future energy mix, which creates uncertainty. All indications are that this will be resolved in the near future.

Finally, there is still no agreed financial model for the first Polish NPP. On a broader level, to ensure the success and profitability of the project, it is important to improve the EU regulatory and legal environment to improve access to financial support while ensuring a level playing field with other clean technologies, including renewables.

SLOVAKIA

1. Nuclear energy—state of affairs

a. Overview of operational NPPs

Slovakia's two NPPs, Mochovce and Bohunice, combined to produce 18.3 TWh of electricity in 2023, accounting for 61.8% of the country's electricity (second highest in the world after France at 64.2%), the country's largest total annual output and second highest share of nuclear output to date.[41] This was achieved with the connection of the third unit in the Mochovce NPP between January and September 2023. However, the role of nuclear in heating is expected to be stagnant, increasing from the current 2,5% to 2,7% in 2030.

The Mochovce NPP operates three production units with VVER-440 reactors (4 × 500 MW and 1× 471 MW) that were connected to the grid in 1998, 1999, and most recently in 2023. The first two units are scheduled to operate until 2058–2060, and the third until 2083. The Bohunice NPP operates two production units with VVER-440 reactors (2 × 505 MW) which began construction in 1976, were connected to the electricity grid in 1984–1985, and are expected to operate until 2044–2045.

Table 6. Existing nuclear reactors in Slovakia

Reactor name	Model	Net capacity (MWe)	Construction start	First grid connection	Expected year of decommissioning
Bohunice 3	VVER V-213	466	1976-12	1984-08	2044
Bohunice 4	VVER V-213	466	1976-12	1985-08	2045
Mochovce 1	VVER V-213	467	1983-10	1998-07	2058
Mochovce 2	VVER V-213	469	1983-10	1999-12	2060
Mochovce 3	VVER V-213	440	1987-01	2023-01	2083

Source: World Nuclear Association

b. The attitude towards nuclear energy in society and politics

The operation and development of NPPs has near unanimous political support and is popular in society. 73% of Slovaks agree with the construction of a new nuclear unit in Bohunice NPP according to the Resolution Group survey published in September 2024. Almost 61% of Slovaks consider NPPs safe (as of mid-2022), which is 15 percentage points more than in 2015 (ACRC opinion poll).[42]

41 IEA (2024). Slovak Republic, https://www.iea.org/countries/slovak-republic/energy-mix (accessed 20 November 2024).

42 ACRC (2022). Vnímanie jadrovej energetiky, https://www.seas.sk/wp-content/uploads/2022/08/PrieskumACRC_energetika_2022_SFPA_SE_premedia.pdf (accessed 20 November 2024).

c. Main players in the national energy sector

Both NPPs are owned and operated by the national utility company Slovenské elektrárne. The Slovak government owns 34% of the company, with rest under Slovak Power Holding, jointly owned by Czech EPH and Italian Enel. It was reported as recently as August 2024 that the EPH group, owned by the second richest Czech Daniel Křetínský, was interested in buying the Italian stake, and most assume it will be concluded once unit 4 of the Mochovce NPP is connected to the grid, although no further details as to the timeline or estimated cost have been provided. This acquisition would remake the landscape for investment into Slovakia's nuclear energy sector with major implications for project financing and regional energy strategy.

JAVYS (*Jadrová a vyraďovacia spoločnosť*) is a state-owned company specializing in decommissioning NPPs and management of nuclear waste. It holds a 51% stake (the rest is owned by ČEZ) in JESS company (*Jadrová energetická spoločnosť Slovenska*), which manages plans for new NPP units.

Outside of the Prime Minister and the Office of the Government, the Ministry of Economy plays the most important role in the nuclear sector with state-ownership rights in Slovenské elektrárne and the mandate to shape Slovakia's energy policy. The Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR) is tasked with ensuring nuclear safety and security, overseeing licensing, operational standards, and compliance of nuclear facilities.

2. Plans for developing the nuclear energy

a. Unpacking national strategic documents

The Slovakian NECP, submitted in late 2023, emphasizes the role of nuclear energy for providing competitive, secure and decarbonised energy, declaring "the safe use of nuclear energy is a fundamental safety concern of the Slovak Republic."[43] It anticipates that by 2030, Slovakia will have an export balance of approx. 20% of electricity consumption in 2030. The government concedes that its singular focus on nuclear energy makes renewables objectives more challenging, but maintains that nuclear is the better option to decarbonize the economy.

The updated NECP follows the *Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050* that was adopted in March 2020.[44] The latter emphasizes the role of nuclear energy and renewables in decarbonising the economy and argues that the projected long-term growth in electricity demand due to electrification of heating and transport will require the construction of another nuclear reactor before 2050.

43 European Commission (2023). Slovakia—Draft Updated NECP 2021-2030, https://commission.europa.eu/publications/slovakia-draft-updated-necp-2021-2030_en (accessed 20 November 2024).

44 Ministry of Environment (2019). Nízkouhlíková stratégia rozvoja Slovenskej republiky do roku 2030s výhľadom do roku 2050, https://www.minzp.sk/files/oblasti/politika-zmeny-klimy/nus-sr-do-roku-2030-finalna-verzia.pdf (accessed 20 November 2024).

b. Current and planned projects

Mochovce Unit 4 (471 MW) will be connected to the grid in late 2025 at the earliest and operate to 2085.[45] The new government under Prime Minister Robert Fico is preparing for the construction of a new nuclear unit at the Bohunice NPP in addition to completing Mochovce Unit 4[46]. In May 2024, the government confirmed intentions to build a new 1,200 MW unit. The Minister of Economy announced it will publish a tender ruling out Russian technology.[47]

The government programme also supports SMR pilot projects in cooperation with international partners. In October 2024, Slovenské elektrárne announced it received a $5 million grant from the US Nuclear Expediting the Energy Transition (NEXT) programme and will provide a list of the best SMR sites by the end of 2025. Slovakia will receive another $2 million US grant after joining the Phoenix programme in 2023, which supports energy transition from coal to SMRs. Moreover, state-owned Slovakian JAVYS signed memoranda with Westinghouse and EDF both in 2023 and joined the European Industrial Alliance on SMRs, initiated by the European Commission, in 2024.

Table 7. Planned nuclear reactors in Slovakia

	Planned capacity	Planned start date	Cost	Investors & partners	State of affairs
Mochovce 4	440 MW (net)	2025–2026	6.3 bn € for two similar units (3.15 bn for one)	EPH, Enel	Grid connection to the in 2025 or 2026
Bohunice 5	1200 MW	Unclear	Unclear	To be chosen	Timeline to be specified, all major decisions expected to be taken by 2027
SMRs	To be specified	To be specified	To be specified	To be chosen	Identifying best locations

Source: Publicly sources media and company information

c. Strategic foreign partners

Czech EPH and Italian Enel are majority owners of Slovenské elektrárne and operate the NPPs.

Russian TVEL remains the sole supplier of the nuclear fuel, while the government (as states its programme) is "looking for opportunities to diversify nuclear fuel supplies". The government has since recommitted to the previous government's framework agreement on future nuclear fuel supplies with Westinghouse. Slovenské elektrárne has not provided specific dates for this, while JAVYS is seeking to include Slovakia in a consortium to develop European nuclear fuel supplies under the leadership of the French Framatome.

45 STVR (2024). Spustenie štvrtého bloku v Mochovciach meška. Každé zdržanie znamená miliónové straty, https://spravy.rtvs.sk/2024/08/jadrova-elektraren-mochovce-stvrty-blok-meska/ (accessed 20 November 2024).

46 Ministry of Foreign and European Affairs (2023). Programové vyhlásenie vlády SR, https://www.mzv.sk/documents/10182/19777627/programove-vyhlasenie-vlady-SR.pdf/7c47ab5b-7532-4d6b-7a81-3c67a802993e (accessed 20 November 2024).

47 R. Drexler (2024). AKTUÁLNE: Na Slovensku vznikne nová atómová elektráreň. Projekt odobrila vláda, štát bude miliardy eur!, techbyte, https://www.techbyte.sk/2024/05/slovensko-nova-atomova-elektraren/ (accessed 20 November 2024).

Slovenské elektrárne is expecting the Mochovce Unit 4 will be launched in 2025/2026 using non-Russian fuel.

Prime Minister Robert Fico announced in September 2024 that Slovakia will negotiate with South Korea, France and the USA for the construction of the future nuclear unit.[48] In the same month, during his visit to South Korea, he signed a memorandum with the South Korean president on a complex energy cooperation for non-emission power sources, and Korean KHNP has expressed interest in participating in the future Slovak tender.

The construction of Units 3 and 4 was carried out by a consortium of companies: the civil works were provided by the Slovak company Inžinierske stavby Košice; mechanical works for the production and delivery of both VVER-440 reactors by Czech Škoda JS, Slovak ENSECO and Slovak VUJE; electrical systems and equipment by Slovak PPA Energo; and control system by the French German Areva- Siemens consortium. Other suppliers include Polish ASE for fire protection design documentation systems; delivery of a neutron instrumentation system by British Rolls-Royce; and full-scope simulators by American GSE.

d. Major challenges

The main problems related to Mochovce Units 3 and 4 were lengthy construction delays and significant cost increases. The units were first planned to be completed in 2012–2013, yet Units 3 was not connected to the grid until 2023 and Unit 4 is not expected until 2025. The final estimated cost is more than twice the original estimate. This raises questions about project management and oversight throughout the construction phases, as well as the effectiveness of measures aimed at preventing cost overruns and timeline extensions. The Mochovce project highlights the challenges that large-scale nuclear infrastructure projects can encounter, including technical complexities, regulatory hurdles, and financial impacts of protracted schedules. It remains to be seen whether the stakeholders involved have identified and addressed the root causes of these issues to prevent similar occurrences in future projects.

Another important challenge related to developing new conventional units is the financing model. Robert Fico indicated that the state would not finance the project itself and would instead rely on external sources, which could be problematic.[49] To date most legal permissions including site approval and the environmental impact assessment for Bohunice 5 NPP have been addressed.

Neighbouring Austria has consistently tried to obstruct and slow nuclear operations and development in Slovakia and the Czech Republic, with limited success. Over the years, Austrian resistance has led to public protests, diplomatic interventions and legal challenges, all aimed at influencing nuclear policies in Slovakia and the Czech Republic. This has caused friction and often delayed the progress of nuclear developments in both countries.

48 Reuters (2024). Slovakia's PM Fico to discuss nuclear power plans in S Korea visit, https://www.reuters.com/business/energy/slovakias-pm-fico-discuss-nuclear-power-plans-s-korea-visit-2024-09-27/ (accessed 20 November 2024).

49 M. Dargaj (2024). Bez vlastných zdrojov elektriny nepreżijeme, vyhlásil Fico. So Sakovou bude v Južnej Kórei preberať výstavbu novej jadrovky, SITA, https://sita.sk/venergetike/bez-vlastnych-zdrojov-elektriny-neprezijeme-vyhlasil-fico-so-sakovou-bude-v-juznej-korei-preberat-vystavbu-novej-jadrovky-video/ (accessed 20 November 2024).

The winner of Austria's 2024 parliamentary election, the right-wing Freedom Party, fiercely opposed the Temelín NPP in the Czech Republic. Given the party's history and position, Austria's nuclear opposition may intensify in the coming years, further complicating efforts to advance nuclear infrastructure in Slovakia and the Czech Republic. This could lead to increasing diplomatic tensions, more rigorous scrutiny of nuclear projects, and increased pressure on Slovakia and the Czech Republic to adopt alternative energy strategies.

PROSPECTS FOR V4 COOPERATION IN THE FIELD OF NUCLEAR ENERGY

Main similarities and differences

All V4 countries agree on the need to develop nuclear energy as a stable low-emission source of electricity with high public acceptance. That approach includes SMRs and prioritizes nuclear safety systems. If these plans succeed, nuclear energy will help shape—or in the case of Poland transform—the national energy mixes, potentially also impacting district heating and influencing how these sectors interact.

It requires enormous investments and access to technology, both related to conventional NPPs and the still-in-development SMRs. Poland's first NPP will likely be the country's largest investment in recent decades. This requires appropriate regulations, meticulous strategic planning and action, as well as access to financing—not only on the level of individual countries but also at the regional and EU level. Moreover, Slovakia is the only V4 country with decommissioning experience (Bohunice V1).

At the same time, the implementation of new nuclear projects faces significant financial and regulatory hurdles. Problems include the lack of a long-term financing model for such a costly investment, regulatory uncertainty in the EU, difficulty in accessing EU funds, and significant opposition to nuclear energy by some EU member states. As a result, numerous nuclear projects have been put on hold or significantly delayed over the last decade. One example is the tender for the expansion of the Czech Temelín NPP which ended without a conclusion in 2014. The only reactor completed in the region during this period is the Unit 3 of Slovakia's Mochovce NPP, even though it was launched back in the 1980s and reactivated after the system transformation in 2009.

Both the Czech Republic and Slovakia have much in common when it comes to nuclear energy, resulting from years of shared experience under the state of Czechoslovakia. Thus, these companies operate at various levels of subcontracting in specific areas and conduct joint research in nuclear energy. Slovakia emphasizes research focused on nuclear safety and spent fuel disposal, as well as on fourth generation reactors and nuclear fusion (active participation of Slovak experts in the global ITER and DEMO projects). Slovakia also has the unique experience of navigating the whole nuclear cycle, shutting down two units of the older V1 nuclear power plant (2006 and 2008) before actively developing NPPS in the early 2010s and 2020s. Czech companies, on the other hand, are higher in the subcontracting tiers, especially Škoda JS.

Hungary is the only country in Europe seeking to build a new NPP in cooperation with Rosatom, while all other countries rule this out, along with China. The Czech Republic and Slovakia are actively working to diversify away from Russian nuclear fuel and are switching to Western alternatives. Hungary also took steps to at least diversify its nuclear fuel supplies by signing a contract with Framatome for deliveries starting from 2027.

The EU framework

All V4 countries are seeking equal treatment under EU law for nuclear energy with other non-emission energy sources. They also advocate for stable nuclear-friendly financing rules, including greater access to EU funds and instruments currently available to other energy sources/technologies. All V4 countries are members of the France-led European Nuclear Alliance. Together with other members of the Alliance they lobby for the recognition of nuclear alongside renewable energy in providing sustainable energy solutions for the EU's decarbonization goals and for ameliorating the EU framework for nuclear development.[50]

V4 countries are unified in support for the development of nuclear energy. If cooperation with Russia does not increase divisions within the V4, Visegrad collaboration would enhance nuclear energy use and advocate for more favourable EU policies and measures, including:

- utilization of nuclear energy for the production of low-carbon hydrogen and the implementation of hydrogen valleys as a tool to support the production and use of low-carbon and renewable hydrogen;
- interconnection of the EU energy system to ensure better market prices;
- stabilising EU regulatory framework and making it more predictable;
- support the allocation of EU funds for nuclear development as a means to fulfil EU climate policy targets, and avoid sanctions for non-compliance;
- shorten the time requirement for the notification process at the European Commission.

Bilateral and regional formats

V4 countries used to speak with the same voice on nuclear at the EU-level, but Hungary's continued cooperation with Rosatom and Russia has eroded trust and fractured the political dimension. Therefore, it is perhaps worth considering lower level cooperation in technical areas, like regulatory harmonisation. This could enable the exchange of experience and effective knowledge sharing, including workforce education.

The Slavkov Triangle (S3), a format for cooperation between the Czech Republic, Slovakia and Austria, has been an alternative for Prague and Bratislava in times of tensions within the V4, but has no use in this context with Austria's fierce opposition towards nuclear energy.

50 Ministère de l'Économie, des Finances et de l'Industrie (2024). Declaration of the EU Nuclear Alliance, meeting of March 4th, 2024, https://presse.economie.gouv.fr/declaration-of-the-eu-nuclear-alliance-meeting-of-march-4th-2024/ (accessed 20 November 2024).

Austria also stands out for its position on nuclear energy within larger CEE regional formats, such as the Three Seas Initiative (TSI). Apart from the Czech Republic, Hungary, Poland and Slovakia, nuclear energy is an important part of the energy mix for Bulgaria, Croatia, Romania and Slovenia, and generally supported by the Baltic countries (Estonia, Latvia, Lithuania). Greece, which joined TSI in 2023, does not have any plans to develop nuclear energy but does not oppose it.

Thus, cooperation around nuclear energy usually takes place in the wider fora of like-minded countries or on a bilateral basis. It is therefore conceivable to have wider cooperation among a broader group of Central and Eastern European countries in a V4+ format which includes the Western Balkans, Bulgaria, and Romania, or depoliticized collaboration, for example, at the level of nuclear energy regulators in the V4. This could help to address the major common challenge of preparing the regulatory framework for the deployment of SMRs.