Nuclear Technology Development and Economics
2021

Nuclear Energy Data

2021

OECD
BETTER POLICIES FOR BETTER LIVES

NEA
NUCLEAR ENERGY AGENCY

Nuclear Technology Development and Economics

Nuclear Energy Data

2021

NEA No. 7608

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 38 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 34 countries: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia (suspended), the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

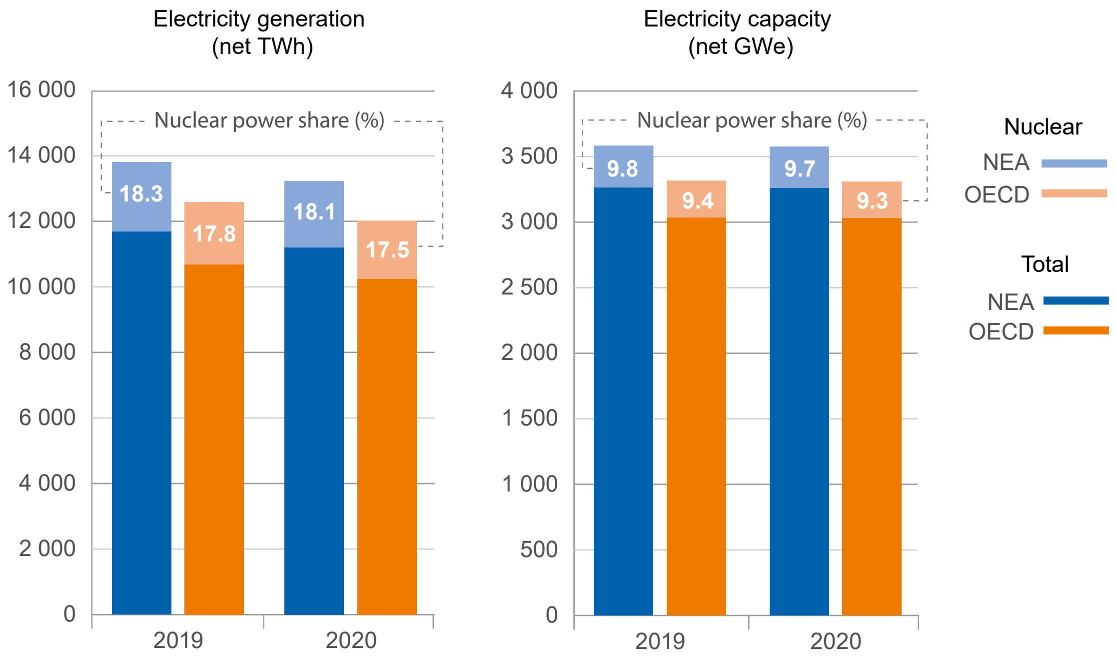
Cover photos: Artist's rendering of a small modular reactor (NuScale Power, Creative Commons); Sizewell nuclear power station, Suffolk, United Kingdom (Love all this photography, ShutterStock).

Overview

The 2021 edition of *Nuclear Energy Data* contains official information provided by NEA and OECD member countries,[1] including projections of total electrical and nuclear generating capacities, along with fuel cycle requirements and capacities to 2040. Also included are short narrative country reports that give updates on the status, trends and issues in nuclear energy programmes. In 2020 and 2021, the COVID-19 pandemic highlighted the importance of electricity security in modern societies. Although the long-term implications for electricity generation are difficult to assess, during the recent crisis, nuclear power continued to support security of supply and has been, together with renewables, one of the most resilient low-carbon electricity sources.

Nuclear electricity generation

Following the outbreak of the coronavirus pandemic, total electricity generation in NEA member countries decreased by 4.1% from 2019 to 2020 and electricity production at nuclear power plants decreased by 5% over the same period. Similarly, in the OECD area, total electricity generation decreased by 4.2% over the same period, and nuclear electricity production decreased by 6.1%. The share of electricity production from nuclear power plants in NEA member countries decreased from 18.3% in 2019 to 18.1% in 2020, and total nuclear capacity declined by 1.6%, from 319.9 GWe in 2019 to 314.9 GWe in 2020. The share of nuclear electricity production in the OECD area decreased slightly, from 17.8% to 17.5%, while total nuclear capacity declined by 1.4% from 284.6 GWe in 2019 to 280.6 GWe in 2020.



1. Argentina, Australia, Austria, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States are members of the NEA. Chile, Colombia, Estonia, Israel, Latvia and New Zealand have been included for OECD area calculations.

Despite a slight decrease in total nuclear capacity and the total amount of electricity produced in NEA member countries, nuclear power plants in Bulgaria, the Czech Republic, Korea, Romania, Russia and Slovenia actually increased their output of electricity generation in 2020, compared to 2019.

Among the 20 NEA member countries with nuclear capacity, 9 countries had more than a 30% share of nuclear energy in their electricity production in 2020.

Reactor highlights

As of 1 January 2021, 336 operational reactors were connected to the grid in NEA member countries. A total of 21 reactors were under construction, although the construction of 3 reactors in Japan has been halted temporarily. By contrast, 36 reactors are planned to be retired from service by 2024, which will reduce NEA nuclear generating capacity by a total of 28 GWe. Included are the closures in Germany – as part of the plan to phase out nuclear power by the end of 2022 – along with potential reactor closures in Belgium, Korea, Russia, the United Kingdom and the United States.

As outlined in the country reports in this publication, nuclear development programmes have, in general, nonetheless advanced in NEA member countries. In the following section, some of the most noteworthy developments are listed:

- In Argentina, work continues on the Carem-25 small modular reactor (SMR) at the site adjacent to the Atucha Nuclear Power Plant. In July 2021, a contract was signed between Nucleoelectrica (NA-SA) Argentina and the country's National Atomic Energy Commission to complete the construction of the Carem-25 within three years. NA-SA plans to submit a request to the Argentinian Nuclear Authority to extend the licence of the Atucha 1 pressurised heavy reactor by 20 years. The plant began operating in 1974 and currently has a licence to operate until 2024.
- In Bulgaria, in January 2021, the government approved a plan for the potential building of a new nuclear power plant at the existing Kozloduy site, and announced discussions with external partners for the potential roll-out of SMRs.
- In Belgium, the government agreed to close all seven of the country's reactors operating at Doel and Tihange. It maintains, however, the possibility of extending the operating lives of Doel 4 and Tihange 3 if required for the security of energy supplies. In addition, the government plans to dedicate EUR 100 million over four years to investigate the potential to build new SMRs.
- In Canada, the CAD 26 billion refurbishment plan for Ontario's nuclear reactors will see the sequential refurbishment of four units at the Darlington site and six units at the Bruce site. The refurbishment of the Darlington Nuclear Generating Station began with work on the first reactor in 2016 and is expected to be completed by 2026; and the Bruce project started with unit 6 in early 2020 and will be completed by 2033. Ontario's third operating nuclear power plant was originally scheduled to shut down in 2020, but will continue to operate until 2024. The Canadian Nuclear Safety Commission (CNSC) extended the plant's licence from 2018 to 2028. The federal government and other partners have advanced efforts in SMR research and in the development and exploration of business partnerships for potential deployment in the late 2020s. The CNSC continues to work to ensure readiness so as to regulate SMRs in Canada. As of June 2021, 12 SMR technology companies applied to the CNSC for the Pre-Licensing Vendor Design Review process.
- In the Czech Republic, the utility ČEZ applied to the State Office of Nuclear Safety to construct two new reactors at its Dukovany site. Under the current schedule, the reactor supplier is to be selected by the end of 2022, with commissioning expected by 2036. In a first step, the Czech government would loan 70% of the cost of building a single 1 200 MWe unit, with ČEZ responsible for supplying the remaining 30%.
- The government of Finland granted the operating licence for the Olkiluoto 3 (OL3) unit on 7 March 2019 and fuel was loaded into the reactor in April 2021. First criticality was reached at the OL3 in December 2021 and regular electricity production will start in July 2022. Preparatory work continues at the new nuclear site in Pyhäjoki. Nuclear energy company Fennovoima is anticipating that the government will make a decision on the construction licence application in 2022. Commissioning of the plant is thus planned to take place in 2029.

- In France, repairs to welds in the Flamanville 3 Evolutionary Power Reactor (EPR) were completed and deemed compliant by the French Nuclear Safety Authority (ASN). Fuel loading is now scheduled to start in early 2023 following start-up tests and granting authorisation from the ASN. In February 2020, unit 1 at Fessenheim was closed, followed by the closure of unit 2 in June 2020. The closure of the Fessenheim reactors was imposed as part of the energy policy objective to reduce the share of nuclear power to 50% by 2035. Électricité de France (EDF) has proposed the construction of six EPR-2 units and, in late 2021, the French President stated that France would pursue the construction of new reactors in order to maintain its energy security and to meet climate goals.
- In Germany, the Federal Ministry for Economic Affairs and Energy presented its new project funding programme in the field of safety research for nuclear facilities for the years 2021 to 2025 with a budget of approximately EUR 38 million per year. The objective of the research and development (R&D) is to improve the safety of nuclear facilities and to establish and further develop the scientific basis for the safe management of radioactive waste. These objectives will continue to remain relevant after Germany's decision to phase out the commercial use of nuclear energy by 2022.
- In Hungary, plans are well advanced for the construction of two new VVER-1200 reactors at the Paks site. The preliminary work began in June 2019 and the construction phase is expected to start in 2022-2023. The construction licence application for the two nuclear power units is currently under review by the Hungarian Atomic Energy Authority.
- In Japan, Kansai Electric Power Company in June 2021 restarted operation of its Mihama 3 reactor, which had been idle since 2011. However, in October 2021 the utility took the reactor offline to implement antiterrorism measures, a requirement of new regulations introduced by the Nuclear Regulation Authority. Mihama 3 had been granted a licence extension in 2016 to operate beyond 40 years. Unit 3 of the Ikata Nuclear Power Plant restarted operation in early December 2021 following a prolonged outage due to inspections and a court injunction.
- In Korea, four nuclear power plants are currently under construction, and the earliest grid connection is expected to occur in 2022 for Shin-Hanul unit 1. The loading of fuel assemblies into the core of unit 1 was completed in October 2021. On the other side, Kori units 2 and 3 will be permanently shut down by the end of 2024.
- The Netherlands' incoming coalition government plans to spend EUR 35 billion by 2030 to reach new climate targets. The climate targets, aimed at a 50% cut in emissions compared to 1990 levels, include EUR 500 million in support for two new SMRs.
- In Poland, the government recommitted in 2021 to launching a nuclear programme with the release of a draft consultation that aims to have construction start on the first of four to six reactors by 2033.
- In Romania, the project to complete Cernavoda units 3 and 4 was revived and Nuclearelectrica, the state-owned utility that operates the Cernavoda Nuclear Power Plant, has estimated that unit 3 will start commercial operations in 2030 followed by unit 4 in 2031. Cernavoda unit 1 is expected to be refurbished between 2026 and 2028 to extend operation for another 30 years. In November 2021, Romania announced the potential roll-out of SMRs in the country by 2028.
- In Russia, unit 6 of Leningrad Nuclear Power Plant was connected to the grid in 2020 and started commercial operations in March 2021. In 2021, Rosatom was granted a construction licence for the BREST-OD-300 reactor, a Generation IV lead-cooled fast reactor type. The reactor is due to start operating in 2026 and is part of a pilot demonstration at the Siberian Chemical Combine aimed at closing the nuclear fuel cycle. The programme called "Nuclear science, engineering and technology for the period up to 2024" is being developed with new reactor and technological systems in the field of nuclear energy, reactor engineering, and the production and processing of nuclear materials. The programme will include the development of technologies for two-component nuclear power with a closed nuclear fuel cycle, controlled thermonuclear fusion and plasma technology, and new materials and technologies for advanced energy systems, as well as the design and construction of reference SMR power units.
- In Slovenia, numerous modifications and improvements have been implemented at the Krško Nuclear Power Plant in the past few years, based on industry developments and changes in international standards and regulatory practices. An ambitious programme of safety upgrades, called the Safety

Upgrade Programme, has been in place since the Fukushima Daiichi Nuclear Power Plant accident and was completed in 2021. The government of Slovenia will make a decision by 2027 on whether to build a second unit at the Krško Nuclear Power Plant site.

- In Spain, the government approved in March 2021 the national energy and climate plan, which includes the phasing out of nuclear energy by 2035. In May 2020, the Spanish Nuclear Safety Council granted permission for Almaraz 1 and 2 to operate until 2027 and 2028, respectively. In addition, Vandellós 2 applied for a licence extension until 2030. In May 2020, the State Company for Radioactive Waste and Decommissioning, Enresa, applied for the phase 1 dismantling authorisation of the Santa Maria de Garoña Nuclear Power Plant.
- In Sweden, the Ringhals 1 reactor went offline for a maintenance outage in March 2020 but returned to service in June to provide grid stability, and finally ceased operations on 31 December 2020. For the remaining reactors at the Ringhals Nuclear Power Plant (Ringhals 3 and 4), the plan remains to continue operations for at least 60 years.
- In Turkey, the Akkuyu Nuclear Power Plant comprises four VVER-1200 units and is the first project to be implemented under a Build-Own-Operate model. Construction of the first, second and third reactor units at the Akkuyu Nuclear Power Plant began in 2018, 2020 and 2021, respectively. The first unit is expected to be in operation by 2023. In 2021, preparations began for the construction of the fourth unit with excavations under way for the reactor building, turbine hall, auxiliary reactor building and other main facilities. In March 2021, Akkuyu Nuclear, a subsidiary of Russia's Rosatom received two loans from Sovcombank to finance the construction of the Akkuyu Nuclear Power Plant.
- In the United Kingdom, EDF, China General Nuclear Power Group (CGN) and the development vehicle NNB Generation Company HPC Limited are constructing two EPRs at Hinkley Point C (3.2 GWe). In January 2021, the United Kingdom also entered into negotiations with EDF in relation to the Sizewell C project in Suffolk. In December 2020, the United Kingdom published the response to the consultation on a Regulated Asset Base (RAB) model for private investment in new nuclear generation. Having assessed the consultation responses, the UK government believes that a RAB model remains a credible model for large-scale nuclear projects. The UK government is thus continuing to explore a RAB model with developers. On the other side, the UK's advanced gas-cooled reactor (AGR) nuclear power stations have been scheduled to progressively reach the end of their operational lives by 2030. The two-unit Dungeness B was shut down in June 2021, while Hunterson B-1 in Scotland ceased operations in November 2021.
- In the United States, construction in Georgia continued on Vogtle units 3 and 4, with start-up forecast for mid-2022 (unit 3), while the second unit is expected to come online in 2023. During 2020, two nuclear power plants permanently shut down: the Indian Point-3 Nuclear Power Plant (998 MWe) in April 2020 and Duane Arnold-1 (601 MWe) in October 2020. A total of 6.8 GWe of nuclear capacity in eight states has thus closed before the end of the licensed operating period between 2013 and 2021. However, states and utilities are acting in support of nuclear power. As an example, the New Jersey Board of Public Utilities voted in 2021 to extend zero emissions credits for nuclear power plants and the Illinois state legislature passed a law that includes about USD 700 million in subsidies over five years to keep the Byron, Dresden and Braidwood nuclear power plants in operation. On the industry side, TerraPower recently announced plans to build its Natrium reactor at a retiring coal plant in Wyoming, which currently receives almost 90% of its electricity generation from fossil fuels. The US Department of Energy is investing nearly USD 2 billion to support the licensing, construction and demonstration of this first-of-a-kind reactor by 2028.

Fuel cycle updates

Depressed uranium market prices in recent years have reduced exploration and development activities and led to uranium production cuts at a number of facilities in Canada, Kazakhstan, Niger, Namibia and the United States. In addition, uranium production at Energy Resources of Australia's (ERA's) Ranger mine in Australia ceased in January 2021, in accordance with the Ranger Authority Act. Progressive rehabilitation of the mine continued during 2021. At the end of March 2021, the Cominak mine in Niger also officially ceased uranium production after nearly 50 years of operation. Some of this decline was offset by production gains in Australia and the continuing ramp-up of the Husab project in Namibia. During 2020 and 2021, the COVID-19 pandemic had a significant impact on world uranium production, with some mines temporarily closing or having some supply chain issues. The uranium output for 2020 was the lowest in the last decade (about 48 000 tU). World uranium production is estimated to have increased by 20% in 2021. The partial suspension of uranium mining activity in 2020 and 2021 is nevertheless not expected to cause performance disruptions for nuclear power reactors in the near term because of the significant inventories and stocks held by utilities and fuel cycle producers.

Imports will continue to be needed in order to meet total NEA and OECD uranium reactor requirements, as has been the case in the past several years. In 2020, in addition to primary mining production, uranium demand was met by secondary supplies. These secondary sources include stocks and inventories, underfeeding, tails re-enrichment, or nuclear fuel from the reprocessing of spent reactor fuels.

Commercial uranium conversion facilities were in operation in Canada, France, Russia and the United States. However, the Honeywell (Converdyn) commercial plant in Metropolis, Illinois, which is the only conversion plant in the United States, continues to remain in "idle-ready status", which means that production has been idle while operations to support a restart when business conditions improve have been maintained. The recently commissioned new "Philippe Coste" uranium conversion facility in France incorporates technological innovations in relation to safety, the environment and improved industrial performance. The conversion sector was also not immune to production issues, with COVID-19 causing a four-week outage at Cameco's Blind River and Port Hope in Canada during the spring of 2020.

High-efficiency uranium centrifuge enrichment plants continued commercial operations through 2020 and 2021 in France, Germany, the Netherlands, Russia, the United Kingdom and the United States. The Urenco centrifuge facility in the United States – the only commercial enrichment plant in operation in North America – has an annual capacity of 4.9 million separative work units (SWU) from 64 production cascades. In the United States, construction activity is not proceeding either on the Global Laser Enrichment (GLE) Uranium Enrichment Facility in North Carolina or on the Fluorine Extraction Process and Depleted Uranium Deconversion Plant in New Mexico. In 2020 and 2021, high-assay low-enriched uranium (HALEU) attracted a great deal of attention from global nuclear fuel cycle producers, utilities and governments. Many companies around the world are developing advanced reactors with smaller and more flexible designs, many of which will require HALEU fuels that are not yet available at the commercial scale.

In 2020, conversion and enrichment capacities exceeded requirements in OECD Europe. On the other hand, enrichment services needed to be imported to OECD America and the Pacific regions, and conversion services had to be imported to the Pacific region. As with uranium, reactor requirements were in part covered by secondary supplies.

The expected completion of the Rokkasho Reprocessing Plant in Japan was delayed to 2022-2023, owing to the implementation of new safety standards, including the construction of a new cooling tower. In Russia, the Mining and Chemical Combine in Zheleznogorsk received a five-year licence for the industrial production of uranium-plutonium mixed oxide fuel for the Beloyarsk-4 BN-800 fast neutron reactor.

Storage capacity for irradiated fuels in NEA member countries is sufficient to meet requirements and is expected to be expanded as required to meet operational needs until permanent repositories are established. Several governments, including those of Canada, Finland, France, Germany, Korea, Spain and the United Kingdom, reported progress in the establishment of permanent repositories for the long-term management of spent fuel and other forms of radioactive waste. Finland became the first country to begin construction of a permanent repository for high-level waste. In this process, Finnish radioactive waste management company Posiva Oy submitted in 2021 its application for an operating licence for the used fuel encapsulation plant and final disposal facility under construction at Olkiluoto.

Policy highlights

The Clean Energy Ministerial (CEM) promotes policies, programmes and best practices that encourage the transition to a global, clean energy economy. Since 2019, nuclear energy and the "Nuclear Innovation: Clean Energy Future" (NICE Future) initiative were major topics of discussion at the CEM meetings. NICE Future, in particular, encourages discussion between CEM member countries about the role of nuclear energy in integrated, clean energy systems. CEM11 was hosted by Saudi Arabia in September 2020.

The event launched a major new technical report by the NICE Future "Flexible Nuclear Campaign for Nuclear-Renewables Integration" that engaged experts from various countries and multi-governmental organisations. Chile hosted CEM12 from 31 May to 6 June 2021, featuring the launch of an important nuclear energy publication led by the NICE Future initiative called "Pathways to Net Zero Using Nuclear Innovation". The publication features perspectives on pathways to net zero from ministers and multi-governmental organisation leaders from various member countries.

The European Commission (EC) established a Technical Expert Group on Sustainable Finance (TEG) to assist in the development of a unified classification system for sustainable economic activities (i.e. the EU Taxonomy). In a 2019 report, the TEG recognised the potential contribution of nuclear energy to climate mitigation objectives and low-carbon energy supply. The TEG recommended that more studies be undertaken on the "do no significant harm" (DNSH) aspects of nuclear energy, as well as on the potential environmental impacts across all objectives. The EC has asked the Joint Research Centre (JRC) to draft a technical assessment report on the DNSH aspects of nuclear energy, including aspects related to the long-term management of high-level radioactive waste and spent nuclear fuel. The JRC concluded in April 2021 that nuclear energy does not cause more harm to human health or to the environment than other electricity production technologies already included in the Taxonomy. The EC asked two more expert groups, the so-called "Euratom Article 31 Expert Group" (on radiological protection) and the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), to review the JRC report. Both expert groups agreed with the JRC's main findings that nuclear power activities do not represent unavertable harm to human health or to the environment. At the end of December 2021, the EC put forward a draft delegated act that includes both nuclear and natural gas in the Taxonomy framework of the EU and sets out the technical screening criteria they need to meet to be eligible in the context of the Taxonomy framework.

In December 2020, Canada's Minister of Natural Resources announced the release of Canada's SMR Action Plan, which was developed in partnership with more than 100 organisations, including seven provincial and territorial governments. The Action Plan outlines progress and ongoing efforts by these organisations to support the development and roll-out of SMRs.

In France, a development strategy for nuclear power was included as a core objective in the French President's "France 2030" plan for re-industrialisation and innovation. Announced in October 2021, the "France 2030" plan includes a EUR 1 billion programme to demonstrate SMR technology and hydrogen production using nuclear electricity. In November 2021, the French President also announced plans to build new nuclear reactors.

In Germany, the federal government concluded negotiations on a draft of the 18th amendment to the Atomic Energy Act and in March 2021 signed a contract with the owners of nuclear power plants in Germany. The draft act and the accompanying contract foresee compensation payments for the nuclear phase-out decision made in 2011 and clarifications concerning the use of production rights for the remaining time until final shutdown. The total expected compensation payment is about EUR 2.4 billion. As a result, both sides – companies owning the nuclear power plants and the federal government – intend to forego all further legal proceedings in this context.

In Hungary, the government approved in January 2020 the new National Energy Strategy and the National Energy and Climate Plans 2030, with an outlook up to 2040. The revised strategic framework is based on three pillars: clean, smart and affordable energy. The new strategy includes more than 40 measures and foresees a 95% reduction in greenhouse gas (GHG) emissions by 2050, compared to 1990 levels. Nuclear energy will be essential to ensure sector integration and a net zero emissions economy. The preservation of nuclear generation capacity by replacing existing units at the Paks Nuclear Power Plant, which are nearing the end of their lifetimes, is one of the key strategic measures for further decarbonisation of the electricity sector.

In Korea, according to the Long-Term Basic Blueprint for Power Supply for 2020-2034, renewable energy capacity is to be expanded from the current 15% to 40% of total power capacity by 2034, while nuclear generation is to be reduced over the same time frame. Only 17 reactors would remain operational by 2034, with a total of 19.4 GWe installed nuclear capacity. Under this plan, nuclear generation would peak in 2024 with 26 reactors in operation.

In Japan, the government approved the sixth Strategic Energy Plan in October 2021. The plan sets the share of nuclear power in the generation mix target for 2030 at 20-22%, unchanged from the previous revision.

In Mexico, to satisfy the demand for clean energy, the National Electric System Development Program (2019-2033) outlines the diversification of the energy mix, in which nuclear has a significant share. In recent years, the Laguna Verde Nuclear Power Plant has taken part in the Clean Energy Certificates programme, an innovative instrument to integrate clean energies into power generation at lower costs and develop investments in clean electricity generation.

In February 2021, Poland's Ministry of Climate and Environment released a new draft of the "Polish Energy Policy until 2040". According to this policy, Poland's first nuclear power plant – with a capacity of 1.0 to 1.6 GWe – will be in operation by 2033. Up to six reactors, with a combined capacity of 6-9 GWe, would then be put into operation by 2043.

In Slovenia, the Parliament adopted the "Resolution on Slovenia's Long-Term Climate Strategy until 2050" in April 2021. In line with the strategy, Slovenia is to cut greenhouse gas emissions by 80-90% by 2050 compared to 2005 and boost the implementation of policies related to climate change. The strategy sets the goals for each sector by 2040 and 2050. The role of nuclear energy would be addressed in the Slovenian Energy Concept, a plan for energy policy that is to be aligned with the broader climate strategy mentioned above.

The Spanish nuclear energy programme is based on the Integrated National Energy and Climate Plan 2021-2030, which was approved by the Council of Ministers in March 2021. This strategic planning tool integrates the energy and climate policies, and reflects Spain's contribution towards achieving the objectives established at the European Union level. The document provides forecasts on the evolution of nuclear energy's contribution to the energy mix, as well as information on a phased shutdown of the country's nuclear reactors during the period 2027-2035.

The Swiss Federal Office of Energy updated its plan called Energy Perspectives 2050+ (EP 2050+). The EP 2050+ analyses how to develop an energy system that is compatible with the long-term climate goal of net-zero greenhouse gas emissions by 2050 and, at the same time, ensure a secure energy supply.

In 2020, the UK government published the Energy White Paper and the 10 Point Plan for a Green Industrial Revolution, demonstrating a commitment to nuclear power. The 10 Point Plan sets out significant funding to help develop large and smaller-scale nuclear energy as well as R&D for advanced nuclear technology, including GBP 215 million for SMRs and GBP 170 million R&D for Advanced Modular Reactors (AMRs). The 10 Point Plan highlights the key role of nuclear energy in delivering deep decarbonisation of the electricity system, alongside renewables and other technologies. On 31 December 2020, the European Atomic Energy Community (Euratom) safeguards arrangements in the United Kingdom ceased to apply and the Office for Nuclear Regulation became the United Kingdom's nuclear safeguards regulator and part of the UK State System of Accounting for, and Control of, Nuclear Materials. In early 2022, the UK House of Commons passed the Nuclear Energy Financing Bill, which introduces a new model for financing nuclear energy infrastructure projects, the Regulated Asset Base (RAB) model. Under the new financing model, eligible nuclear companies will be able to receive a regulated revenue stream during construction, commissioning and operation of a new nuclear power project.

In the United States, the Infrastructure Investment and Jobs Act (signed into law on 15 November 2021) includes USD 1.2 trillion of federal funding to address President Biden's agenda. Key elements of this Infrastructure Act include: i) a credit programme for operating reactors; ii) advanced reactor demonstration funding; and iii) new demonstrations. Through the Civilian Nuclear Credit programme, USD 6 billion is to be allocated to nuclear plants in competitive markets that are projected to cease operations due to economic factors. The Advanced Reactor Demonstration Funding programme authorises and appropriates funding for the Advanced Reactor Demonstration Program, with USD 2.4 billion of funding appropriated over 4 years for advanced nuclear reactors and USD 3.2 billion authorised for two demonstration advanced reactors. Under the New Demonstrations programme, at least four regional clean hydrogen hubs will be established (USD 8 billion total funding), with one hub required to produce hydrogen from nuclear energy. In addition, the programme includes USD 500 million towards a new clean energy demonstration on mine lands with advanced nuclear technology considered a "clean energy" option.

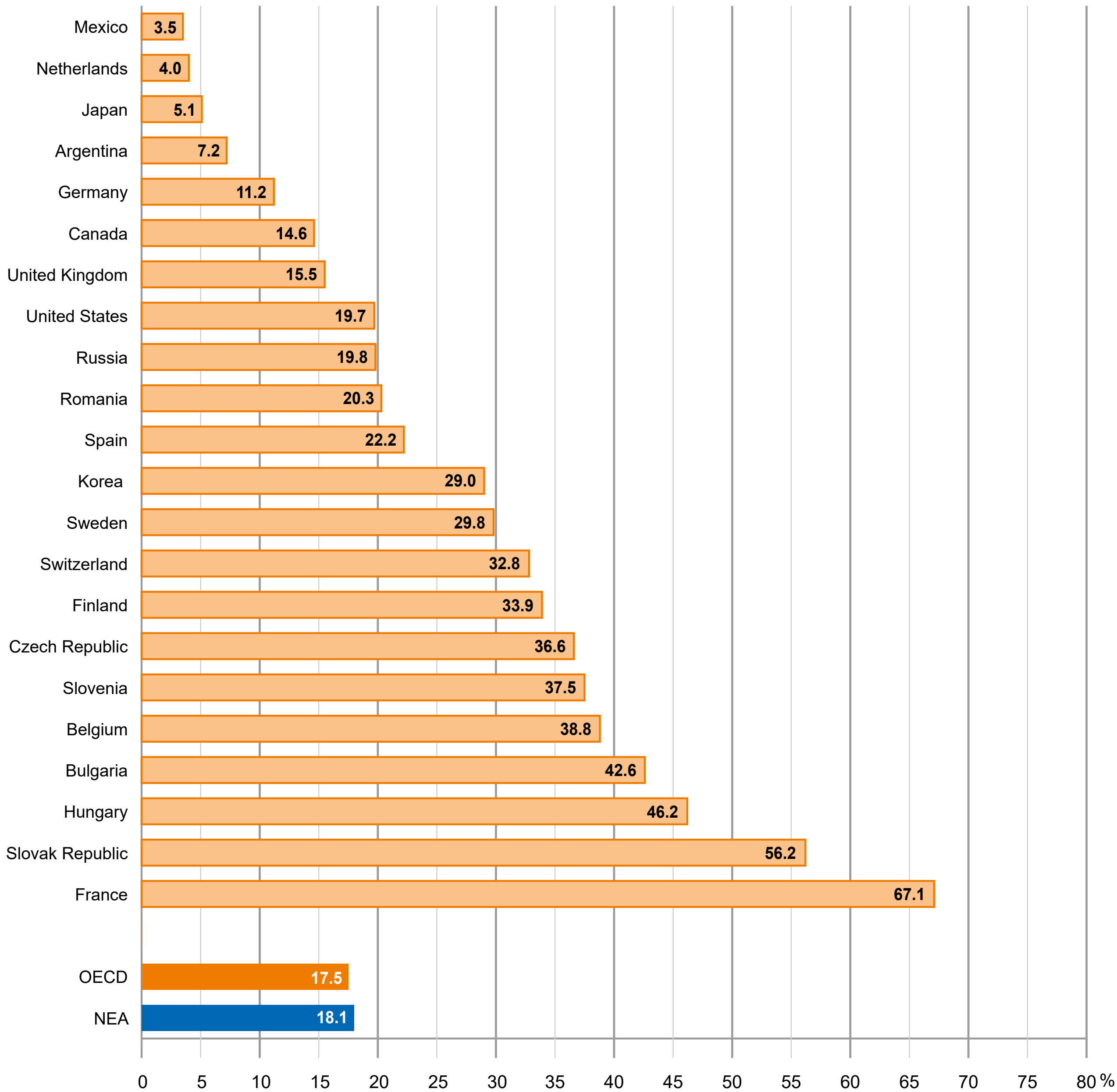
Table of contents

Tables

Figures

1. Nuclear capacity and electricity generation

Figure 1.1: Nuclear power share of total electricity production (as of 1 January 2021)



StatLink www.oecd-nea.org/statlinks-2021

Table 1.1: Total and nuclear electricity generation (net TWh) (a)

Country	2019			2020			2025		
	Total	Nuclear	%	Total	Nuclear	%	Total	Nuclear	%
Americas	**5 385.7**	**923.7**	**17.2**	**5 244.3**	**903.5**	**17.2**			
Nuclear countries	**5 235.6**	**923.7**	**17.6**	**5 095.0**	**903.5**	**17.7**			
Argentina	137.0 *	7.9 *	5.8	138.9 *	10.0 *	7.2	N/A	N/A	N/A
Canada	640.4	95.5	14.9	635.6	92.7	14.6	655.8-660.0	62.6-65.3	9.5-9.9
Mexico	330.3 *	10.9 *	3.3	311.4 *	10.9 *	3.5	N/A	N/A	N/A
United States	4 127.9	809.4	19.6	4 009.1	789.9	19.7	4 271.6-4 851.4	749.8	15.5-17.6
Non-nuclear countries	**150.1**	**0.0**	**0.0**	**149.3**	**0.0**	**0.0**			
Chile	80.0 *	0.0	0.0	80.0 *	0.0	0.0	N/A	N/A	N/A
Colombia	70.1	0.0	0.0	69.3	0.0	0.0	80.5-85.0	0.0	0.0
Eurasia	**4 692.0**	**1 000.5**	**21.3**	**4 550.0**	**920.7**	**20.2**			
Nuclear countries	**3 481.1**	**1 000.5**	**28.7**	**3 336.9**	**920.7**	**27.6**			
Belgium (c)	90.0	41.0	45.6	85.0 (b)	33.0 (b)	38.8	69.0-74.0	5.0	6.8-7.2
Bulgaria	40.3	15.7	39.0	37.1	15.8	42.6	45.8-46.0	14.9-15.8	32.6-34.4
Czech Republic	81.1	28.6	35.3	82.3	30.1	36.6	77.3-77.4	30.1-30.2	38.9-39.0
Finland	66.0	22.9	34.7	66.1 (b)	22.4 (b)	33.9	88.0	25.5-26.4	29.0-30.0
France	537.5	379.5	70.6	500.1	335.4	67.1	574.0	382.0-393.0	66.6-68.5
Germany	579.0	72.0	12.4	544.0 (b)	61.0 (b)	11.2	587.0-600.0	0.0	0.0
Hungary	32.0	15.4	48.1	32.9	15.2	46.2	25.7-35.5	14.8	41.7-57.6
Netherlands	104.2	4.2	4.0	104.2 (b)	4.2 (b)	4.0	133.9	4.2	3.1
Romania	54.9 *	10.3	18.8	51.2 *	10.4	20.3	N/A	10.4-10.5	N/A
Russia	1 047.3 *	194.8	18.6	1 016.2 *	201.2	19.8	N/A	207.7	N/A
Slovak Republic	27.4 *	14.2	51.8	24.9 *	14.0 (b)	56.2	34.5-34.8	22.4	64.3-64.9
Slovenia	15.2	5.5	36.1	16.0 (b)	6.0	37.5	15.9-16.5	5.2-6.1	33.3-37.0
Spain	260.8	55.9	21.4	251.2 (b)	55.8	22.2	297.4	55.4	18.6
Sweden	165.5	64.3	38.9	158.8 (b)	47.3 (b)	29.8	180.0	52.0	28.9
Switzerland	71.9	25.2	35.0	69.9	22.9	32.8	65.0-75.0	20.0-23.0	30.7-30.8
United Kingdom	308.0	51.0	16.6	297.0 (b)	46.0 (b)	15.5	286.0	43.0	15.0
Non-nuclear countries	**1 210.9**	**0.0**	**0.0**	**1 213.1**	**0.0**	**0.0**			
Austria	71.0	0.0	0.0	71.0 (b)	0.0	0.0	80.0	0.0	0.0
Denmark	28.5	0.0	0.0	28.6	0.0	0.0	39.6	0.0	0.0
Estonia	6.4	0.0	0.0	4.8	0.0	0.0	5.3-5.7	0.0	0.0
Greece	52.1	0.0	0.0	49.9	0.0	0.0	57.0-58.5	0.0	0.0
Iceland	19.0 *	0.0	0.0	18.0 *	0.0	0.0	N/A	0.0	0.0
Ireland	30.5	0.0	0.0	30.8	0.0	0.0	34.5-39.6	0.0	0.0
Israel	72.5	0.0	0.0	72.8	0.0	0.0	84.8	0.0	0.0
Italy	283.0 *	0.0	0.0	272.0 *	0.0	0.0	N/A	0.0	0.0
Latvia	6.2	0.0	0.0	6.1 (b)	0.0	0.0	6.1-12.1	0.0	0.0
Luxembourg	1.9	0.0	0.0	2.1	0.0	0.0	N/A	0.0	0.0
Norway	133.4	0.0	0.0	154.2	0.0	0.0	N/A	0.0	0.0
Poland	152.0	0.0	0.0	146.0 (b)	0.0	0.0	170.1	0.0	0.0
Portugal	50.5	0.0	0.0	51.4 (b)	0.0	0.0	50.1-51.1	0.0	0.0
Turkey	303.9	0.0	0.0	305.4 (b)	0.0	0.0	366.0-373.0	17.5-21.0	4.8-5.6
Pacific	**1 880.0**	**209.8**	**11.2**	**1 685.3**	**203.3**	**12.1**			
Nuclear countries	**1 587.0**	**209.8**	**13.2**	**1 397.3**	**203.3**	**14.5**			
Japan	1 024.0	63.8	6.2	845.1 *	43.1 *	5.1	N/A	N/A	N/A
Korea	563.0	146.0	25.9	552.2	160.2	29.0	N/A	N/A	N/A
Non-nuclear countries	**293.0**	**0.0**	**0.0**	**288.0**	**0.0**	**0.0**			
Australia	250.0 *	0.0	0.0	243.0 *	0.0	0.0	N/A	0.0	0.0
New Zealand	43.0 *	0.0	0.0	45.0 *	0.0	0.0	N/A	0.0	0.0
OECD	**10 678.2**	**1 905.3**	**17.8**	**10 236.2**	**1 790.1**	**17.5**			
NEA	**11 679.5**	**2 134.0**	**18.3**	**11 201.6**	**2 027.5**	**18.1**			

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Including electricity generated by the user (autoproduction) unless stated otherwise.
(b) Preliminary data.
(c) Data from EU reference scenario and ELIA studies.
* NEA estimate; N/A: Not available.

2030			2035			2040		
Total	Nuclear	%	Total	Nuclear	%	Total	Nuclear	%
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
690.3-699.5	75.4-77.2	10.9-11.0	727.1-730.6	82.4-89.2	11.3-12.2	751.0-754.8	82.4-88.2	11.0-11.7
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4 233.6-5 127.9	510.0-706.4	9.9-16.7	4 140.3-5 326.3	460.1-711.3	8.6-17.2	4 120.5-5 499.8	428.4-713.1	7.8-13.0
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
91.17-96.2	0.0	0.0	103.7-109.4	0.0	0.0	N/A	N/A	N/A
72.0-74.0	0.0	0.0	76.0-122.0	0.0	0.0	86.0-149.0	0.0	0.0
47.5-47.7	14.9-15.8	31.4-33.1	49.7-49.9	22.7-24.0	45.7-48.1	51.0	30.4-32.2	59.6-63.1
76.8-76.9	31.5-31.6	41.0-41.1	74.8-74.9	30.7-30.8	41.0-41.1	69.6-79.7	31.5-41.6	45.3-52.2
90.0	39.4-41.2	43.8-45.8	102.0	36.2-38.1	35.5-37.4	102.0	21.7-38.1	21.3-37.4
627.0	360.0-371.0	57.4-59.2	652.0	326.0	50.0	N/A	N/A	N/A
585.0-592.0	0.0	0.0	571.0-646.0	0.0	0.0	552.0-696.0	0.0	0.0
40.8-54.0	24.3-33.8	59.6-62.6	29.5-39.8	26.5	66.6-89.8	26.4-38.1	19.0	49.9-72.0
134.7	4.2	3.1	N/A	0.0	0.0	N/A	0.0	0.0
N/A	20.8-21.0	N/A	N/A	20.8-21.0	N/A	N/A	20.8-N/A	N/A
N/A	209.1	N/A	N/A	211.6-228.8	N/A	N/A	N/A	N/A
34.5-34.8	22.4	64.3-64.9	35.4-37.3	22.3-23.1	62.0-63.0	38.8-40.1	22.4-23.2	57.7-57.9
16.4-17.0	5.2-6.1	31.7-35.9	20.0-20.6	5.2-6.1	26.0-29.6	22.5-32.5	5.2-15.4	23.1-47.4
336.1	23.8	7.1	346.8	0.0	0.0	397.3	0.0	0.0
185.0	52.0	28.1	200.0	52.0	26.0	207.0	52.0	25.1
65.0-75.0	20.0-23.0	30.7-30.8	65.0-75.0	15.0-20.0	23.8-26.7	65.0-75.0	10.0-15.0	15.4-20.0
296.0	55.0	18.6	308.0	64.0	20.8	333.0	86.0	25.8
89.0	0.0	0.0	92.0	0.0	0.0	92.0	0.0	0.0
47.6	0.0	0.0	47.6	0.0	0.0	47.6	0.0	0.0
6.7-8.4	0.0	0.0	6.9-10.4	0.0	0.0	9.5-12.0	0.0	0.0
60.7-64.8	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
37.1-46.5	0.0	0.0	40.1-47.5	0.0	0.0	43.0-49.5	0.0	0.0
97.3	0.0	0.0	111.7	0.0	0.0	128.1	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
6.6-13.1	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
181.1	0.0	0.0	191.9	16.7	8.7	204.2	33.4	16.4
52.7-55.8	0.0	0.0	57.2-61.1	0.0	0.0	61.7-66.3	0.0	0.0
427.0-450.0	35.0-42.0	8.2-9.3	485.0-527.0	35.0-42.0	7.2-8.0	545.0-636.0	35.0-42.0	6.4-6.7
1 065.0	217.0-232.0	20.4-21.8	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0

Table 1.2: Total and nuclear electricity capacity (net GWe) (a)

Country	2019			2020			2025		
	Total	Nuclear	%	Total	Nuclear	%	Total	Nuclear	%
Americas	**1 407.3**	**114.1**	**8.1**	**1 373.3**	**111.8**	**8.1**			
Nuclear countries	**1 360.8**	**114.1**	**8.4**	**1 326.8**	**111.8**	**8.4**			
Argentina	36.1 *	1.7 *	4.7	36.1 *	1.7 *	4.7	N/A	N/A	N/A
Canada	149.9	12.7	8.5	152.4	11.9	7.8	150.8-153.6	8.5	5.5-5.6
Mexico	75.7 *	1.6	2.1	75.7 *	1.6	2.1	N/A	N/A	N/A
United States	1 099.1	98.1	8.9	1 062.6	96.6	9.1	1 184.2-1 195.4	91.9	7.7-7.8
Non-nuclear countries	**46.5**	**0.0**	**0.0**	**46.5**	**0.0**	**0.0**			
Chile	29.0 *	0.0	0.0	29.0 *	0.0	0.0	N/A	N/A	N/A
Colombia	17.5	0.0	0.0	17.5	0.0	0.0	N/A-23.15	0.0	0.0
Eurasia	**1 417.3**	**150.9**	**10.6**	**1 439.5**	**148.2**	**10.3**			
Nuclear countries	**1 011.9**	**150.9**	**14.9**	**1 022.8**	**148.2**	**14.5**			
Belgium (c)	24.0	6.0	25.0	26.0 (b)	6.0	23.1	22.0-24.0	0.0	0.0
Bulgaria	12.4	2.0	16.1	12.4	2.0	16.1	12.7-12.8	2.0	15.6-15.7
Czech Republic	22.0	3.9	17.7	21.1	3.9	18.5	21.2	3.9	18.4
Finland	12.0	2.8	23.0	12.0	2.8	23.0	14.0	4.4	31.3
France	135.6	63.0	46.5	136.2	63.0	46.3	N/A	61.0-63.0	N/A
Germany	221.0	9.5	4.3	227.0	8.1	3.6	204.0-219.0	0.0	0.0
Hungary	9.3	1.9	20.4	10.1	1.9	18.8	10.1-11.3	1.9	16.8-18.8
Netherlands	33.0	0.5	1.5	33.0 (b)	0.5	1.5	51.0	0.5	1.0
Romania	21.0 *	1.3	6.2	21.0 *	1.3	6.2	N/A	1.2-1.3	N/A
Russia	240.0 *	30.3	12.6	240.0 *	29.3	12.2	N/A	29.8	N/A
Slovak Republic	7.7	1.8	23.5	7.7 *	1.8	23.6	8.3-8.8	2.7	30.7-32.5
Slovenia	3.8	0.7	18.4	4.0 (b)	0.7	17.5	4.0-4.6	0.7	15.2-17.5
Spain	110.0	7.1	6.5	110.8 (b)	7.1	6.4	131.4	7.1	5.4
Sweden	40.8	7.8	19.1	42.1	7.8	18.5	N/A	6.9	N/A
Switzerland	15.3	3.3	21.6	15.4 (b)	3.0	19.5	16.6-16.7	2.5-2.9	15.1-17.4
United Kingdom	104.0	9.0	8.7	104.0 (b)	9.0 (b)	8.7	119.0	6.0	5.0
Non-nuclear countries	**405.4**	**0.0**	**0.0**	**416.7**	**0.0**	**0.0**			
Austria	26.0	0.0	0.0	25.0 *	0.0	0.0	32.0	0.0	0.0
Denmark	15.1	0.0	0.0	13.6	0.0	0.0	17.7	0.0	0.0
Estonia	3.0	0.0	0.0	2.7	0.0	0.0	2.3-2.4	0.0	0.0
Greece	18.5	0.0	0.0	21.1 (b)	0.0	0.0	23.1	0.0	0.0
Iceland	3.0 *	0.0	0.0	3.0 *	0.0	0.0	N/A	0.0	0.0
Ireland	7.6	0.0	0.0	7.5	0.0	0.0	N/A	0.0	0.0
Israel	16.6	0.0	0.0	16.9	0.0	0.0	17.4	0.0	0.0
Italy	115.0 *	0.0	0.0	115.0 *	0.0	0.0	N/A	0.0	0.0
Latvia	3.0	0.0	0.0	3.0 (b)	0.0	0.0	3.1-3.4	0.0	0.0
Luxembourg	1.7	0.0	0.0	1.8	0.0	0.0	N/A	0.0	0.0
Norway	35.8	0.0	0.0	37.7	0.0	0.0	N/A	0.0	0.0
Poland	47.4	0.0	0.0	51.9 (b)	0.0	0.0	51.4	0.0	0.0
Portugal	21.4	0.0	0.0	21.6 (b)	0.0	0.0	26.0-27.8	0.0	0.0
Turkey	91.3	0.0	0.0	95.9	0.0	0.0	111.0	3.6-3.8	3.2-3.4
Pacific	**517.3**	**55.0**	**10.6**	**525.9**	**55.0**	**10.5**			
Nuclear countries	**432.0**	**55.0**	**12.7**	**440.6**	**55.0**	**12.5**			
Japan	306.7	31.7	10.3	312.8	31.7	10.1	339.0-N/A	33.1-N/A	9.8-N/A
Korea	125.3	23.3	18.6	127.8	23.3	18.2	165.9	25.4	15.3
Non-nuclear countries	**85.3**	**0.0**	**0.0**	**85.3**	**0.0**	**0.0**			
Australia	76.0 *	0.0	0.0	76.0 *	0.0	0.0	N/A	0.0	0.0
New Zealand	9.3 *	0.0	0.0	9.3 *	0.0	0.0	N/A	N/A	N/A
OECD	**3 032.3**	**284.6**	**9.4**	**3 029.2**	**280.6**	**9.3**			
NEA	**3 263.5**	**319.9**	**9.8**	**3 260.3**	**314.9**	**9.7**			

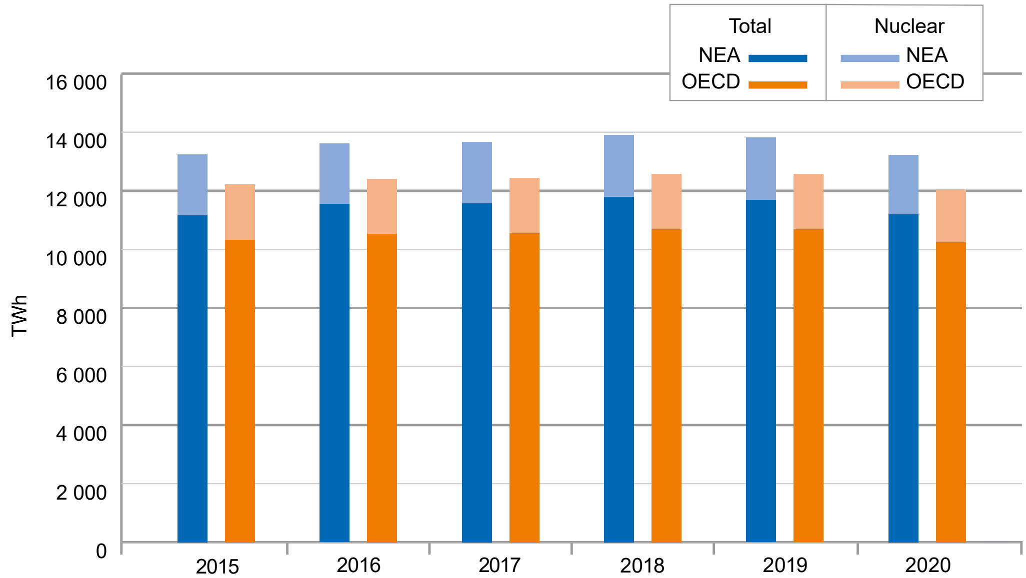
StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Includes electricity generated by the user (autoproduction) unless stated otherwise.
(b) Provisional data.
(c) Data from EU reference scenario and ELIA studies.
* NEA estimate; N/A: Not available.

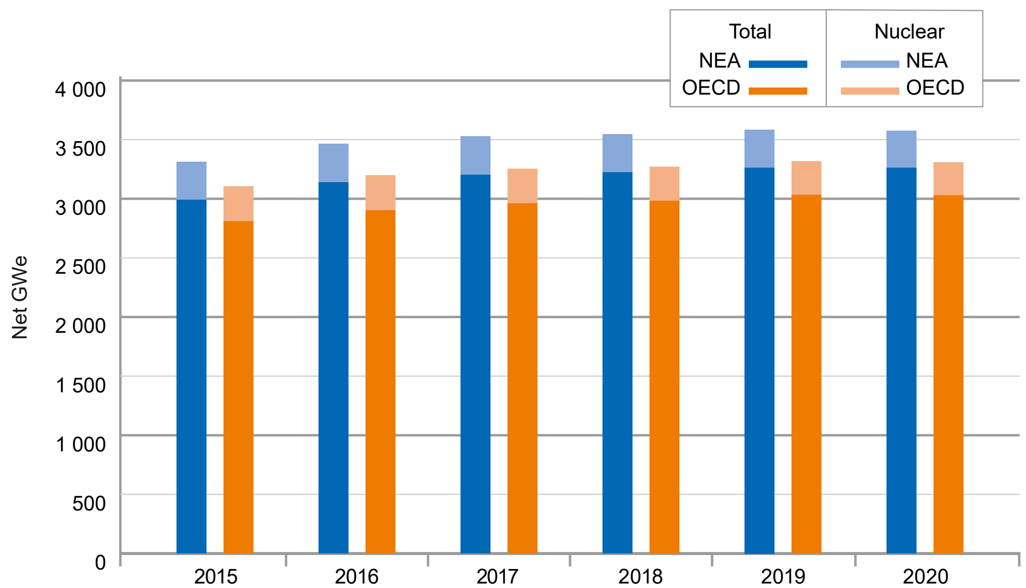
2030			2035			2040		
Total	Nuclear	%	Total	Nuclear	%	Total	Nuclear	%
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
163.9-170.3	10.2	6.0-6.2	170.7-188.4	11.1	5.9-6.5	173.6-197.5	11.1	5.6-6.4
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1 259.1-1 347.8	61.8-86.2	4.9-6.4	1 334.6-1 446.5	55.6-86.8	4.2-6.0	1 421.4-1 558.4	51.9-87.0	3.7-5.6
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A-25.36	0.0	0.0	N/A	N/A	N/A	N/A	N/A	N/A
22.0-24.0	0.0	0.0	23.0-29.0	0.0	0.0	25.0-33.0	0.0	0.0
13.9	2.0	14.4	14.0	2.0-3.0	14.3-21.4	15.6-15.8	2.0-4.0	12.8-25.3
21.1	3.9	18.5	22.5	3.9	17.3	22.1-23.0	3.9-5.1	17.6-22.2
13.0	5.1	39.1	14.0	4.6	32.7	13.0	2.8-4.6	21.5-35.4
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
222.0-255.0	0.0	0.0	225.0-294.0	0.0	0.0	231.0-348.0	0.0	0.0
9.3-12.5	3.1-4.3	33.3-34.4	7.1-11.5	3.4	29.6-47.9	7.3-13.2	2.4	18.2-32.9
59.0	0.5	0.8	N/A	0.0	0.0	N/A	0.0	0.0
N/A	2.4-3.0	N/A	N/A	2.4-3.0	N/A	N/A	2.4-N/A	N/A
N/A	30.7	N/A	N/A	31.5-35.3	N/A	N/A	N/A	N/A
8.6-9.3	2.7	29.0-31.4	9.2-9.7	2.7	27.8-29.3	9.4-9.9	2.7	27.3-28.7
4.3-5.1	0.7	13.7-16.3	6.3	0.7	11.1	8.7-9.8	0.7-1.8	8.0-18.4
158.0	3.1	2.0	196.6	0.0	0.0	228.5	0.0	0.0
N/A	6.9	N/A	N/A	6.9	N/A	N/A	6.9	N/A
16.8-17.1	2.0-2.9	11.9-17.0	16.9-18.0	1.5-2.9	8.9-16.1	17.0-19.3	1.0-2.9	5.9-15.0
130.0	6.0	4.6	142.0	9.0	6.3	155.0	11.0	7.1
38.0	0.0	0.0	39.0	0.0	0.0	39.0	0.0	0.0
21.5	0.0	0.0	21.5	0.0	0.0	21.5	0.0	0.0
2.8-3.2	0.0	0.0	2.9-3.7	0.0	0.0	3.6-4.2	0.0	0.0
26.2	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	6.1-6.3	0.0	0.0	6.3-6.8	0.0	0.0
19.9	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
3.4-4.0	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
56.6	0.0	0.0	51.6	2.2	4.3	60.0	4.4	7.3
26.4-31.0	0.0	0.0	27.7-35.2	0.0	0.0	29.0-39.5	0.0	0.0
130.1	4.8-5.0	3.7-3.8	N/A	5.0	N/A	N/A	5.0	N/A
349.1-N/A	33.1-N/A	9.5-N/A	N/A	N/A	N/A	N/A	N/A	N/A
173.0	20.4	11.8	N/A	N/A	N/A	N/A	N/A	N/A
N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0	0.0
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Figure 1.2: Trends in total and nuclear electricity generation



StatLink www.oecd-nea.org/statlinks-2021

Figure 1.3: Trends in total and nuclear electricity capacity



StatLink www.oecd-nea.org/statlinks-2021

Table 1.3: Nuclear power plants by development stage (net GWe) (as of 1 January 2021)

Country	Connected to the grid*		Under construction		Firmly committed**		Planned to be retired from service***		Units using MOX	
	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity
Americas	**118**	**113.4**	**3**	**2.2**	**-**	**-**	**14**	**11.3**	**-**	**-**
Argentina	3	1.7	1	0.03	-	-			-	-
Canada	19	13.6	-	-	-	-	6	3.1	-	-
Mexico	2	1.6	-	-	-	-	-	-	-	-
United States	94	96.5	2	2.2	-		8	8.2	-	-
Eurasia	**161**	**145.1**	**11**	**13.6**	**4**	**4.9**	**20**	**15.3**	**23**	**20.4**
Belgium	7	5.9	-	-	-	-	2	2.0	-	-
Bulgaria	2	2.0	-	-	-	-	-	-	-	-
Czech Republic	6	3.9	-	-	-	-	-	-	-	-
Finland	4	2.8	1	1.6	1	1.2	-	-	-	-
France	56	61.0	1	1.6	-	-	-	-	22	19.9
Germany	6	8.1	-	-	-	-	6	8.1	-	-
Hungary	4	1.9	-	-	2	2.4	-	-	-	-
Netherlands	1	0.5	-	-	-	-	-	-	1	0.5
Romania	2	1.3	-	-	-	-	-	-	-	-
Russia	38	30.5	2	2.4	-	-	4	1.0	-	-
Slovak Republic	4	1.8	2	0.9	-	-	-	-	-	-
Slovenia	1	0.7	-	-	-	-	-	-	-	-
Spain	7	7.1	-	-	-	-	-	-	-	-
Sweden	6	6.9	-	-	-	-	-	-	-	-
Switzerland	4	2.9	-	-	-	-	-	-	-	-
Turkey	-	-	3	3.8	1	1.3	-	-	-	-
United Kingdom	13	7.8	2	3.3	-	-	8	4.2	-	-
Pacific	**57**	**55.0**	**7**	**9.7**	**-**	**-**	**2**	**1.6**	**4**	**3.8**
Japan	33	31.7	3	4.1	-	-	-	-	4	3.8
Korea	24	23.3	4	5.6	-	-	2	1.6	-	-
OECD	**291**	**277.9**	**18**	**23.1**	**4**	**4.9**	**32**	**27.0**	**27**	**24.2**
NEA	**336**	**313.4**	**21**	**25.5**	**4**	**4.9**	**36**	**28.0**	**27**	**24.2**

StatLink *www.oecd-nea.org/statlinks-2021*

Notes

* Including operating floating reactors.
** Plants for which sites have been secured and main contracts placed.
*** Plants expected to be retired from service by the end of 2024.

Table 1.4: Nuclear power plants connected to the grid (as of 1 January 2021; net GWe)

Country	BWR		PWR		Others (a)		HWR		FNR		Total	
	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity
Americas	**33**	**34.5**	**63**	**63.6**	**-**	**-**	**22**	**15.3**	**-**	**-**	**118**	**113.4**
Argentina	-	-	-	-	-	-	3	1.7	-	-	3	1.7
Canada	-	-	-	-	-	-	19	13.6	-	-	19	13.6
Mexico	2	1.6	-	-	-	-	-	-	-	-	2	1.6
United States	31	32.9	63	63.6	-	-	-	-	-	-	94	96.5
Eurasia	**9**	**9.9**	**122**	**116.7**	**26**	**15.7**	**2**	**1.3**	**2**	**1.5**	**161**	**145.5**
Belgium	-	-	7	5.9	-	-	-	-	-	-	7	5.9
Bulgaria	-	-	2	2.0	-	-	-	-	-	-	2	2.0
Czech Republic	-	-	6	3.9	-	-	-	-	-	-	6	3.9
Finland	2	1.8	2	1.0	-	-	-	-	-	-	4	2.8
France	-	-	56	61.0	-	-	-	-	-	-	56	61.0
Germany	1	1.3	5	6.8	-	-	-	-	-	-	6	8.1
Hungary	-	-	4	1.9	-	-	-	-	-	-	4	1.9
Netherlands	-	-	1	0.5	-	-	-	-	-	-	1	0.5
Romania	-	-	-	-	-	-	2	1.3	-	-	2	1.3
Russia	-	-	22	19.9	14	9.1	-	-	2	1.5	38	30.9
Slovak Republic	-	-	4	1.8	-	-	-	-	-	-	4	1.8
Slovenia	-	-	1	0.7	-	-	-	-	-	-	1	0.7
Spain	1	1.1	6	6.0	-	-	-	-	-	-	7	7.1
Sweden	4	4.7	2	2.2	-	-	-	-	-	-	6	6.9
Switzerland	1	1.0	3	1.9	-	-	-	-	-	-	4	2.9
United Kingdom	-	-	1	1.2	12	6.6	-	-	-	-	13	7.8
Pacific	**17**	**17.6**	**37.0**	**35.3**	**-**	**0.0**			**-**	**0.0**	**54**	**52.9**
Japan	17	17.6	16	14.1	-	-	-	-	-	-	33	31.7
Korea			21	21.2			3	2.1			24	23.3
OECD	**59**	**62.0**	**198**	**194.0**	**12**	**7.0**	**19**	**14.0**	**-**	**-**	**288**	**276**
NEA	**59**	**61.9**	**222**	**215.6**	**26**	**15.7**	**24**	**16.6**	**2**	**1.5**	**333**	**311.7**

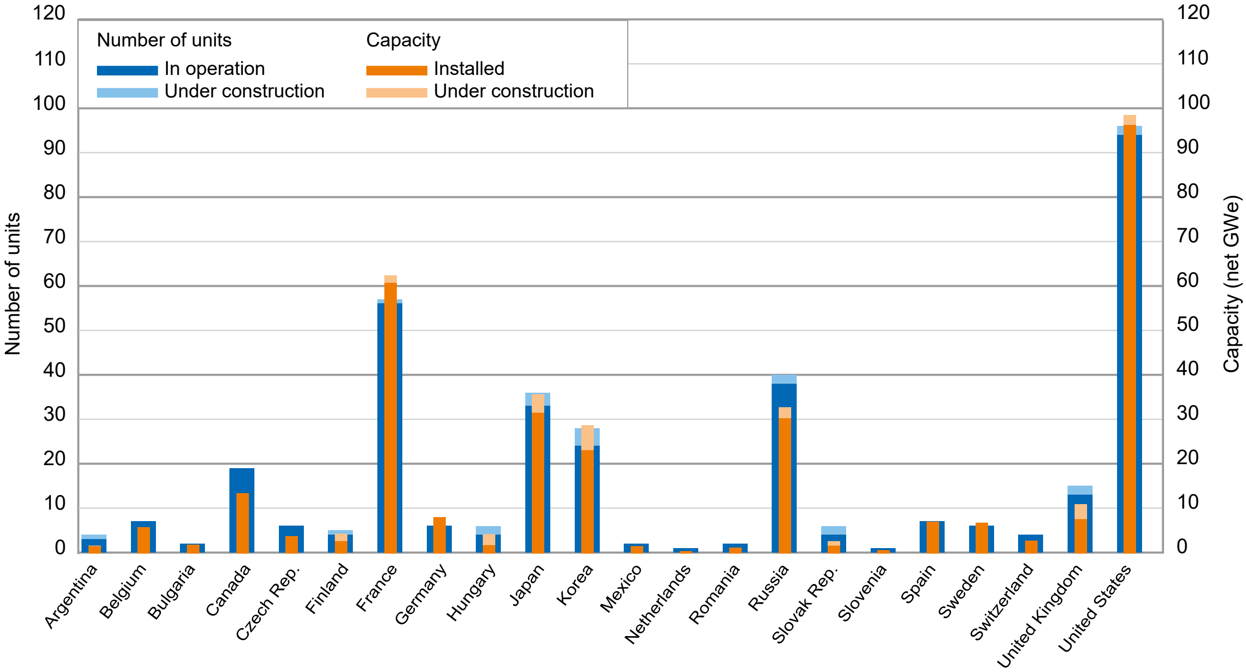
StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Including AGRs, Russian RBMK and floating reactors.

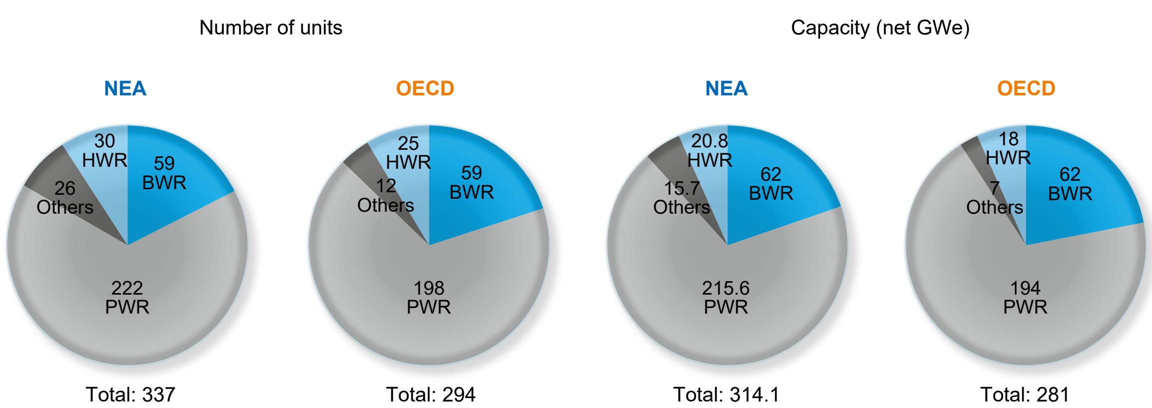
(BWR) boiling water reactor; (PWR) pressurised water reactor; (HWR) heavy water reactor; (FNR) fast neutron reactor; (AGR) advanced gas-cooled reactor; (RBMK) graphite moderated reactor.

Figure 1.4: Number of units and nuclear capacity (as of 1 January 2021)



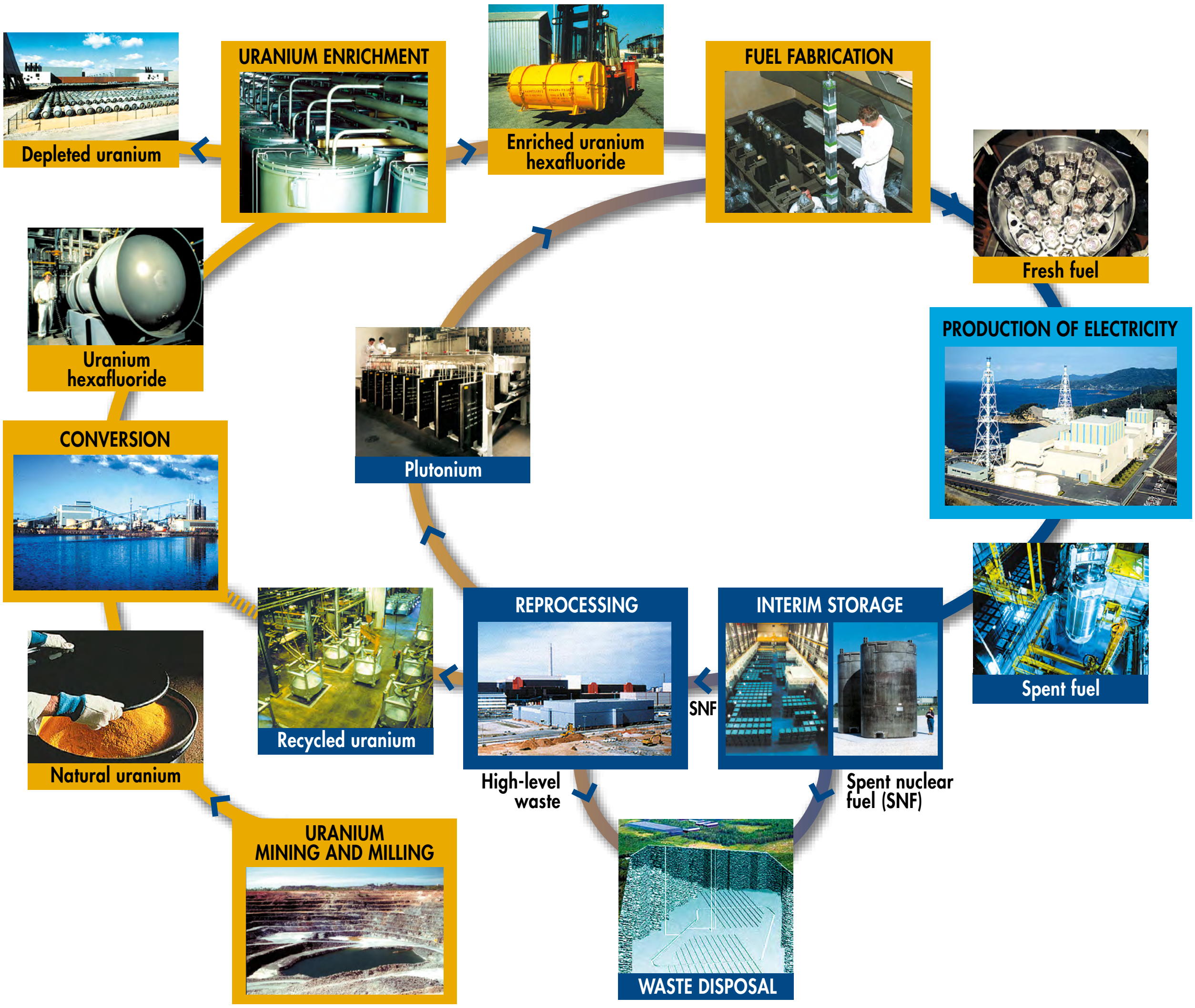
StatLink www.oecd-nea.org/statlinks-2021

Figure 1.5: Number of units and capacity connected to the grid by type of reactor (as of 1 January 2021)



StatLink www.oecd-nea.org/statlinks-2021

Figure 1.6: The nuclear fuel cycle



This figure summarises the main steps of the nuclear fuel cycle for a light water reactor. It illustrates the various activities that constitute the nuclear energy sector. The details of fuel cycle steps and levels vary from reactor type to reactor type but the main elements remain similar for current nuclear power plants. The fuel cycle of a nuclear power plant can be divided into three main stages: the "front end", from mining of uranium ore to the delivery of fabricated fuel assemblies to the reactor; power production; and the "back end", from the unloading of fuel assemblies from the reactor to final disposal of spent fuel and/or radioactive waste from reprocessing.

2. Nuclear fuel cycle requirements

Table 2.1: Uranium resources (1 000 tonnes U) (a)

Region	RAR*	Inferred**	Total
OECD	1 909	756	2 665
NEA	2 134	1 063	3 197
World	3 792	2 356	6 148

StatLink *www.oecd-nea.org/statlinks-2021*

Notes

(a) Data from *Uranium 2020: Resources, Production and Demand* (NEA/IAEA).

* Reasonably assured resources with recovery costs <USD 130/kgU.

** Inferred resources with recovery costs <USD 130/kgU.

Table 2.2: Uranium production (tU/year) (a)

Country		2019	2020*	2025**	2030**	2035**	2040**
Americas		7 273	3 884	17 030	13 830	12 680	12 680
Argentina		0	0	0	0	0	0
Canada		6 996	3 878	12 330	12 330	12 330	12 330
United States		277	6	4 700	1 500	350	350
Eurasia		2 943	2 890	4 260	4 260	2 080	1 770
Czech Republic		34	34	50	50	30	20
Finland	(b)	0	0	250	250	250	250
France	(c)	0	0	0	0	0	0
Germany	(c)	0	7	0	0	0	0
Hungary	(c)	5	3	0	0	0	0
Russia		2 904	2 846	3 960	3 960	1 800	1 500
Pacific		6 526	6 203	5 800	3 623	3 540	3 500
Australia		6 526	6 203	5 800	3 623	3 540	3 500
OECD		13 838	10 131	23 130	17 753	16 500	16 450
NEA		16 742	12 977	27 090	21 713	18 300	17 950
World		53 516	48 000	77 425	64 238	64 735	56 625

StatLink *www.oecd-nea.org/statlinks-2021*

Notes

(a) Data from *Uranium 2020: Resources, Production and Demand* (NEA/IAEA).

(b) By-product of nickel production from low-grade, black schist unconventional resource.

(c) Recovered from environmental clean-up operations.

* Secretariat estimate.

** Projected production capability of existing and committed production centres supported by RAR and inferred resources with recovery costs <USD 130/kgU.

Table 2.3: Uranium requirements (tU/year)

Country	2019	2020	2025	2030	2035	2040
Americas	**20 004**	**19 220**				
Argentina	150 *	219 *	N/A	N/A	N/A	N/A
Canada	1 770	1 715	1 160-1 210	1 395-1 430	1 525-1 650	1 525-1 630
Mexico	400 *	400 *	N/A	N/A	N/A	N/A
United States	17 684	16 886	10 738-14 630	10 040-15 755	8 025-17 589	7 499-16 728
Eurasia	**18 373**	**18 841**				
Belgium	800	500	0	0	0	0
Bulgaria	325	343	343	343	343	343
Czech Republic	652	594	532-552	623-643	900-920	633-827
Finland	426	720	690-750	700-750	700-770	450-770
France	5 039	6 034	7 000-7 300	5 700-N/A	4 500-N/A	N/A
Germany	1 225	1 293	0	0	0	0
Hungary	352	348	341	574-807	615	466
Netherlands	0	0	33-65	65-76	0	0
Poland	0	0	0	0	40-60	60-80
Romania	230	230	230-240	460-480	460-480	460-N/A
Russia	5 000	5 100	4 700-5 300	4 500-5 600	4 400-5 300	4 300-5 400
Slovak Republic	290 *	290 *	N/A	N/A	N/A	N/A
Slovenia	149	0	119-179	119-179	119-179	119-179
Spain	1 562	946	1 400-1 550	350-500	N/A	N/A
Sweden	950	950	800-1 020	800-1 020	800-1 020	500-1 020
Switzerland	338	693	240-285	320-370	320-370	180-220
Turkey	0	0	380-570	720	720	720
United Kingdom	1 035	800 (a)	1 199-1 379	689-754	399	N/A
Pacific	**5 148**	**5 802**				
Japan	448	802 (a)	N/A	N/A	N/A	N/A
Korea	4 700	5 000	5 200-5 500	3 900-4 200	3 800-4 000	3 200-3 400
OECD	**37 820**	**37 971**				
NEA	**43 525**	**43 863**				

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Provisional data.

* NEA estimate.

N/A: Not available.

Table 2.4: Conversion capacities (tU/year) (a)

Country		From U_3O_8 to	2019	2020	2025	2030	2035	2040
Americas		**UF_6**	**28 360**	**26 760**				
Argentina	*	UF_6	60	60	60	60		
		UO_2	150	150	230	230	230	230
Canada		UF_6	13 300	11 700	12 500	12 500	12 500	12 500
		UO_2			2 800	2 800	2 800	2 800
United States	(b)	UF_6	15 000	15 000	15 000	15 000	15 000	15 000
Eurasia		**UF_6**	**26 000**	**33 500**				
France		UF_6	7 500	15 000	15 000	15 000	15 000	15 000
Romania	*	UO_2	300	300	300	300	300	300
Russia	*	UF_6	12 500	12 500	N/A	N/A	N/A	N/A
United Kingdom	(c)	UF_6	6 000	6 000	0	0	0	0
OECD		**UF_6**	**41 800**	**47 700**				
NEA		**UF_6**	**54 360**	**60 260**				

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Nominal capacities and not real productions.

(b) In January 2017, Converdyn announced that they would reduce the capacity from 15 000 to 7 000 tU/year. In November 2017, Converdyn announced suspension of production at Metropolis plant

(c) Springfield Fuels Ltd's has not restarted the UF_6 conversion facilities, but they continue to remain in standby, and the plant has ceased commercial operation.

* NEA estimate.

N/A: Not available.

Table 2.5: Conversion requirements (tU/year)

Country		From U_3O_8 to	2019	2020	2025	2030	2035	2040
Americas		UF_6	16 014	18 814				
Argentina	*	UF_6	0	0	N/A	N/A	N/A	N/A
		UO_2	196	196	N/A	N/A	N/A	N/A
Canada		UO_2	1 770	1 715	1 160	1 395	1 525	1 525
Mexico	*	UF_6	392	392	N/A	N/A	N/A	N/A
United States		UF_6	15 622	18 422 (a)	16 736	14 051	13 163	14 570
Eurasia		UF_6	20 427	19 889				
Belgium		UF_6	795	495	0	0	0	0
Bulgaria		UF_6	325	343	343	343	343	343
Czech Republic		UF_6	649	592	540	630	906	823
Finland		UF_6	426	710	690-750	510-550	510-550	271-761
France		UF_6	6 046	6 199	7 200	6 700	5 800	N/A
Germany		UF_6	1 225	1 293	0	0	0	0
Hungary		UF_6	330	439	341	574	615	466
Netherlands		UF_6	0	0	33	65	0	0
Romania	*	UO_2	240	240	240	480	480	480
Russia	*	UF_6	6 270	6 270	N/A	N/A	N/A	N/A
Slovak Republic	*	UF_6	290	290	N/A	N/A	N/A	N/A
Slovenia		UF_6	186	186	186	186	186	186
Spain		UF_6	1 562	946	1 500	400	N/A	N/A
Sweden		UF_6	950	950	1 000	1 000	1 000	700
Switzerland		UF_6	338	376	325	325	325	180
United Kingdom		UF_6	1 035	800 (a)	1 520	737	795	0
Pacific		UF_6	4 000	4 500				
Japan		UF_6	0	0 (a)	N/A	N/A	N/A	N/A
Korea		UF_6	4 000	4 500	4 400	3 500	3 300	2 800
		UO_2	250	250	250	0	0	0
OECD		UF_6	34 171	36 933				
NEA		UF_6	40 441	43 203				

StatLink *www.oecd-nea.org/statlinks-2021*

Notes

(a) Provisional data.
* NEA estimate.
N/A: Not available.

Table 2.6: Enrichment capacities (tSWU/year)

Country	Method	2019	2020	2025	2030	2035	2040
Americas		**4 904**	**4 904**				
Argentina *	Diffusion	4	4	N/A	N/A	N/A	N/A
United States	Diffusion	0	0	0	0	0	0
	Centrifuge	4 900	4 900	4 900	4 900	4 900	4 900
	Laser	0	0	0	0	0	0
Eurasia		**47 200**	**47 100**				
France	Centrifuge	7 500	7 500	7 500	7 500	7 500	7 500
Germany	Centrifuge	3 900	3 900	3 900	3 900	3 900	3 900
Netherlands	Centrifuge	6 200	6 200	6 200	6 200	6 200	6 200
Russia *	Centrifuge	25 000	25 000	N/A	N/A	N/A	N/A
United Kingdom	Centrifuge	4 600	4 500	N/A	N/A	N/A	N/A
Pacific		**450**	**450**				
Japan	Centrifuge	450	450	N/A	N/A	N/A	N/A
OECD		**27 550**	**27 450**				
NEA		**52 554**	**52 454**				

StatLink *www.oecd-nea.org/statlinks-2021*

Notes

* NEA estimate.

N/A: Not available.

Table 2.7: Enrichment requirements (tSWU/year)

Country		2019	2020	2025	2030	2035	2040
Americas		**13 611**	**12 307**	**11 800**	**11 552**	**8 702**	**9 758**
Argentina	(a)	3	3 *	17	142	155	155
Mexico		286	286 *	305	137	144	288
United States		13 322	12 018	11 478	11 273	8 403	9 315
Eurasia		**17 992**	**16 747**				
Belgium		670	455	0	0	0	0
Bulgaria		293	297	293	293	293	293
Czech Republic		482	444	403	470	671	610
Finland		347	585	565-715	591-631	591-631	471-631
France		6 222	5 506	6 400	6 100	5 300	N/A
Germany		1 112	1 174	0	0	0	0
Hungary		285	402	312	470	453	316
Netherlands		0	0	25	54	0	0
Poland		0	0	0	0	500	700
Russia	*	5 100	5 100	N/A	N/A	N/A	N/A
Slovak Republic	*	276	276	N/A	N/A	N/A	N/A
Slovenia		106	106	106	106	106	106
Spain		1 313	801	1 450	400	N/A	N/A
Sweden		750	735	750	750	750	550
Switzerland		261	284	264	264	264	125
United Kingdom		775	582 (b)	1 135	633	726	0
Pacific		**2 700**	**3 100**				
Japan		0	0 (b)	N/A	N/A	N/A	N/A
Korea		2 700	3 100	3 200	2 600	2 500	2 100
OECD		**29 200**	**27 051**				
NEA		**34 303**	**32 154**				

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Data from 2019 edition of NEA *Nuclear Energy Data*.
(b) Provisional data.
* NEA estimate.
N/A: Not available.

Table 2.8: Fuel fabrication capacities (tonnes HM/year)

Country	Fuel type	2019	2020	2025	2030	2035	2040
Americas							
Argentina (a)	PWR	50	50	50	50	50	50
	HWR	320	320	320	320	320	320
Canada	HWR	1 770	1 715	3 000	3 000	3 000	3 000
United States	LWR	5 000	5 000	5 000	5 000	5 000	5 000
	MOX	0	0	0	0	0	0
Eurasia							
Belgium	PWR	0	0	0	0	0	0
France	PWR	1 400	1 400	1 400	1 400	1 400	1 400
	PWR MOX	195	195	195	195	195	195
	FBR MOX	0	0	0	0	0	0
Germany	LWR	650	650	650	650	650	650
Romania	HWR	240	240	240	480	480	480
Spain	BWR	100	100	100	100	100	100
	PWR	300	300	300	300	300	300
Sweden	LWR	600	600	600	600	600	600
United Kingdom	GCR	240	240	120	0	0	0
	PWR	200	200	200	400	400	400
Pacific							
Japan	PWR	724	724	N/A	N/A	N/A	N/A
	BWR	870	724	N/A	N/A	N/A	N/A
	P+B MOX	0	0	N/A	N/A	N/A	N/A
	FBR MOX	0	0	N/A	N/A	N/A	N/A
Korea	PWR	550	550	700	700	700	700
	HWR	200	200	200	200	N/A	N/A

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Data from 2019 edition of NEA *Nuclear Energy Data*.

N/A: Not available.

Table 2.9: Fuel fabrication requirements (tonnes HM/year)

Country	Fuel type	2019	2020	2025	2030	2035	2040
Americas							
Argentina	PWR	N/A	N/A	N/A	N/A	N/A	N/A
	HWR	N/A	N/A	N/A	N/A	N/A	N/A
Canada	HWR	1 770	1 715	1 160	1 395	1 525	1 525
Mexico	BWR	N/A	N/A	N/A	N/A	N/A	N/A
United States	BWR	689	716 (a)	608	664	762	371
	PWR	N/A	N/A	N/A	N/A	N/A	N/A
Eurasia							
Belgium	PWR	98	59	0	0	0	0
Bulgaria	PWR	38	41	40	40	40	40
Czech Republic	PWR	79	72	54	63	91	100
Finland	BWR	34	35	37	37	37	0-37
	PWR	21	64	52-55	55	55	55
France	PWR	1 018	988	1 000	920	750	N/A
	PWR MOX	60	76	125	125	125	N/A
	FBR MOX	0	0	0	0	0	0
Germany	BWR	19	24	0	0	0	0
	PWR	130	134	0	0	0	0
Hungary	PWR	38	51	39	62	63	46
Netherlands	PWR	0	0	9	9	0	0
	PWR MOX	4	4	4	4	0	0
Poland	PWR	0	0	0	0	40	100
Romania	HWR	220	220	220	440	440	440
Slovak Republic *	PWR	N/A	N/A	N/A	N/A	N/A	N/A
Slovenia	PWR	15	15	15	15	15	15
Spain	BWR	46	0	46	0	N/A	N/A
	PWR	134	106	130	47	N/A	N/A
Sweden	BWR	117	100	105	105	105	75
	PWR	80	60	60	60	60	60
Switzerland	BWR	21	25	22	22	22	22
	PWR	16	29	29	29	19	0
United Kingdom	GCR	159	123	90	0	0	0
	PWR	39	0	168	108	47	0
Pacific							
Japan	PWR	0	0	N/A	N/A	N/A	N/A
	BWR	0	0	N/A	N/A	N/A	N/A
	PWR+BWR MOX	0	0	N/A	N/A	N/A	N/A
	FBR MOX	0	0	N/A	N/A	N/A	N/A
Korea	PWR	490	470	750	410	390	330
	HWR	155	240	240	N/A	N/A	N/A

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Provisional data.
* NEA estimate.
N/A: Not available.

Table 2.10: Spent fuel storage capacities (tonnes HM) (a)

Country	Fuel type	2019	2020	2025	2030	2035	2040
Americas							
Argentina	LWR	N/A	N/A	N/A	N/A	N/A	N/A
	HWR	N/A	N/A	N/A	N/A	N/A	N/A
Canada	HWR	70 893	78 266	85 223	96 459	108 315	108 315
Mexico	LWR	N/A	N/A	N/A	N/A	N/A	N/A
United States	LWR	N/A	N/A	N/A	N/A	N/A	N/A
	Others (b)	2 400	2 400	2 400	2 400	2 400	2 400
Eurasia							
Belgium	LWR	3 830 (c)	3 830 (c)	N/A	N/A	N/A	N/A
Bulgaria	LWR	1 695	1 695	1 695	1 695	1 694	2 042
Czech Republic	LWR	4 100	4 100	4 100	4 100	5 550	6 450
Finland	LWR	2 985	2 985	3 395	3 515	4 275	4 275
France	LWR	26 000	26 000	26 000	N/A	N/A	N/A
Germany	LWR	24 808	24 764	22 370	22 370	22 370	22 370
Hungary	LWR	1 690	1 690	2 034	2 808	3 153	3 272
Italy	LWR	N/A	N/A	N/A	N/A	N/A	N/A
Netherlands	LWR	121	121	121	121	121	0
Poland	LWR	0	0	0	0	0	500
Romania	HWR	3 531	3 759	4 899	6 039	7 179	8 319
Russia	LWR	58 753	58 753	58 753	58 753	58 753	58 753
	Others	160	160	160	160	160	280
Slovak Republic	LWR	N/A	N/A	N/A	N/A	N/A	N/A
Slovenia	LWR	596	596	826	1 056	1 056	1 056
Spain	LWR	6 855	7 043	7 243	13 275	10 169	10 594
Sweden	LWR	8 000	8 000	11 000	N/A	N/A	N/A
Switzerland	LWR	3 999	4 045	3 742	3 978	3 639	3 639
Turkey	LWR	0	0	1 145	1 356	1 356	1 356
United Kingdom	LWR	606	684	838	993	1 070	1 070
	GCR	9 200	8 300	8 300	8 200	8 200	8 200
Pacific							
Japan	LWR	21 400	21 250	N/A	N/A	N/A	N/A
	HWR	0	0	N/A	N/A	N/A	N/A
	Others	0	0	N/A	N/A	N/A	N/A
Korea	LWR	11 350	11 308	17 351	17 351	17 351	17 351
	HWR	9 481	9 254	12 428	12 428	12 428	12 428

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Including at-reactor and away-from-reactor storage.

(b) "Others" includes spent fuel from defense-related activities including naval reactors, research and test reactors (both domestic and foreign) and a high-temperature gas reactor. Approximately 2 100 tHM are from Hanford's N-reactor. Most of the projected 2 400 tHM already exists.

(c) Wet storage capacity of all units at Doel and Tihange of 1 360 tHM exists, next to above-mentioned figures.

* NEA estimate.

N/A: Not available.

Table 2.11: Spent fuel arisings and cumulative in storage (a)

Country		2019		2020		2025	
		Arisings*	In storage**	Arisings*	In storage**	Arisings*	In storage**
Americas							
Argentina		N/A	N/A	N/A	N/A	N/A	N/A
Canada		1 592	57 440	1 718	59 158	1 306	65 688
Mexico		N/A	N/A	N/A	N/A	N/A	N/A
United States		1 972	83 873	2 362	86 235	2 025	106 327
Eurasia							
Belgium		77	3 818	138	3 955	N/A	N/A
Bulgaria		41	955	41	957	41	918
Czech Republic		61	2 041	70	2 111	56	2 483
Finland		55	2 267	53	2 321	91	2 713
France	(b)	N/A	14 056	N/A	13 936 (e)	N/A	N/A
Germany		149	9 104	262	9 350	0	10 098
Hungary		37	1 397	50	1 447	38	1 639
Italy		N/A	N/A	N/A	N/A	N/A	N/A
Netherlands		9	34	9	43	9	30
Poland		0	0	0	0	0	0
Romania		190	3 407	190	3 597	190	4 547
Russia	(b)	708	24 669	776	25 260	754	27 610
Slovak Republic		N/A	N/A	N/A	N/A	N/A	N/A
Slovenia		22	513	0	513	15	600
Spain		150	5 396	106	5 502	149	6 216
Sweden		140	6 805	180	6 985	N/A	N/A
Switzerland		24	1 488	76	1 584	16	1 768
Turkey		0	0	0	0	34	34
United Kingdom	(c)	539	3 577	165	3 577	341	4 407
Pacific							
Japan		710	16 060	180	16 240	N/A	N/A
Korea	(d)	507	16 719	533	15 252	686	20 678

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Including at reactor and away-from-reactor storage.
(b) Including LWR fuel and FR fuel.
(c) Including LWR, GCR fuel and others
(d) Including LWR fuel and HWR fuel.
(e) Preliminary data
* tHM/a.
** tHM cumulative.
N/A: Not available.

2030		2035		2040	
Arisings*	In storage**	Arisings*	In storage**	Arisings*	In storage**
N/A	N/A	N/A	N/A	N/A	N/A
1 248	71 928	1 393	78 893	1 459	86 188
N/A	N/A	N/A	N/A	N/A	N/A
1 524	114 561	1 596	122 344	1 360	129 925
N/A	N/A	N/A	N/A	N/A	N/A
41	1 123	41	1 328	41	1 533
70	2 849	102	3 181	100	3 551
92	3 221	92	3 685	92	4 146
N/A	N/A	N/A	N/A	N/A	N/A
0	10 098	0	10 098	0	10 098
38	1 827	69	2 172	76	2 551
N/A	N/A	N/A	N/A	N/A	N/A
9	20	0	40	0	0
0	0	0	0	0	50
380	5 687	380	7 587	380	9 487
660	28 860	670	28 060	693	25 313
N/A	N/A	N/A	N/A	N/A	N/A
15	665	15	730	15	817
237	7 051	84	7 445	0	7 445
N/A	N/A	N/A	N/A	N/A	N/A
16	2 053	19	2 287	N/A	2 535
69	445	103	925	103	1 370
236	6 247	156	6 377	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A
575	23 552	382	25 462	53	27 228

Table 2.12: Reprocessing capacities (tonnes HM/year)

Country	Fuel type	2019	2020	2025	2030	2035	2040
Americas							
United States	LWR	0	0	0	0	0	0
Eurasia							
France	LWR	1 700	1 700	1 700	1 700	1 700	1 700
Russia	LWR	400	400	610	610	800	1 200
	Others						
United Kingdom	Others	600	600	0	0	0	0
	Magnox	1 500	1 500	0	0	0	0
Pacific							
Japan	LWR	0	0	N/A	N/A	N/A	N/A

StatLink www.oecd-nea.org/statlinks-2021

Notes

N/A: Not available.

Table 2.13: Plutonium use (tonnes of total Pu)

Country	Fuel type	2019	2020	2025	2030	2035	2040
Americas							
United States	LWR	N/A	N/A	N/A	N/A	N/A	N/A
Eurasia							
Belgium	LWR	N/A	N/A	N/A	N/A	N/A	N/A
France	LWR	6.3	6.8	11.0	N/A	N/A	N/A
Germany	LWR	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	LWR	0.4	0.4	0.4	0.0	0.0	0.0
Russia (a)	LWR	0.0	0.0	0.1	0.1	1.7	3.4
	FBR	0.4	0.4	1.9	1.9	3.7	7.4
Pacific							
Japan	LWR	0.0	0.0	N/A	N/A	N/A	N/A

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Data from 2020 edition of NEA *Nuclear Energy Data*.

N/A: Not available.

Table 2.14: Re-enriched tails production (tonnes natural U equivalent)

Country	Total to end of 2018	2019	2020	Total to end of 2020	2021 (expected)
Americas	**5 677.8**	**0.0**	**0.0**	**5 678.0**	**0.0**
United States (a)	5 677.8	0.0	0.0	5 678.0	0.0
Eurasia	**21 135.0**	**3 439.0**	**3 712.0**	**28 286.0**	**2 834.0**
Netherlands	21 135.0	3 439.0	3 712.0	28 286.0	2 834.0

StatLink www.oecd-nea.org/statlinks-2021

Note

(a) Data provided by Energy Northwest, owner-operator of the Columbia generating station.

Table 2.15: Re-enriched tails use (tonnes natural U equivalent)

Country		Total to end of 2018	2019	2020	Total to end of 2020	2021 (expected)
Americas		**1 940**	**0**	**0**	**1 940**	**0**
United States	(a)	1 940	0	0	1 940	0
Eurasia		**4 888**	**200**	**0**	**5 088**	**0**
Belgium		345 (b)	0	0	345	0
Finland		843	0	0	843	0
Sweden		3 700	200	0	3 900	0

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Data provided by Energy Northwest, owner-operator of the Columbia generating station.

(b) Purchased for subsequent re-enrichment.

Table 2.16: Reprocessed uranium production (tonnes natural U equivalent)

Country		Total to end of 2018	2019	2020	Total to end of 2020	2021 (expected)
Eurasia		**43 960**	**1 026**	**1 026**	**46 012**	**1 026**
France	(a)	28 960	1 026	1 026	31 012	1 026
United Kingdom		15 000 (b)	0	0	15 000	0
Pacific		**645**	**0**	**0**	**645**	**N/A**
Japan		645	0	0	645	N/A

StatLink www.oecd-nea.org/statlinks-2021

Notes

(a) Cumulative in storage.

(b) Data from 2020 edition of NEA *Nuclear Energy Data*.

N/A: Not available.

Table 2.17: Reprocessed uranium use (tonnes natural U equivalent)

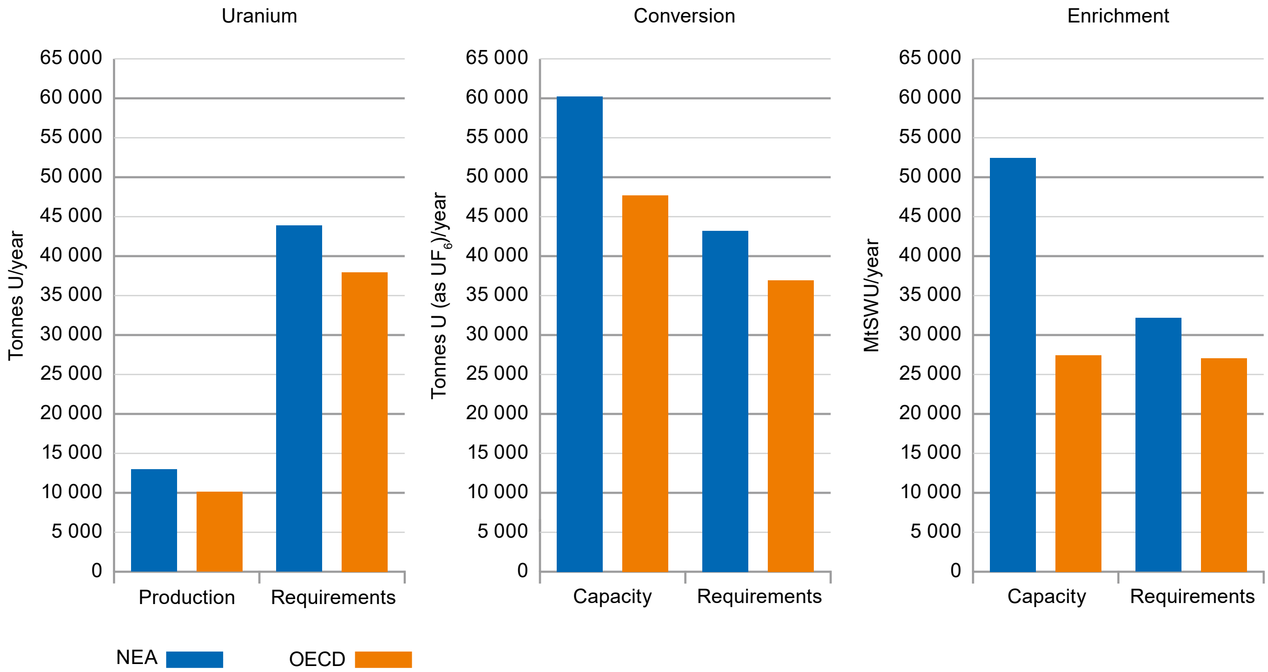
Country	Total to end of 2018	2019	2020	Total to end of 2020	2021 (expected)
Eurasia	**11 185**	**295**	**94**	**11 574**	**225**
Belgium	508	0	0	508	0
France	5 300	0	0	5 300	0
Germany	0	0	0	0	0
Netherlands	171	0	21	192	32
Sweden	300	140	40	480	110
Switzerland	4 750	116	33	4 899	45
United Kingdom	156	39	0	195	38
Pacific	**217**	**0**	**0**	**217**	
Japan	217	0	0	217	N/A

StatLink www.oecd-nea.org/statlinks-2021

Note

N/A: Not available.

Figure 2.1: Fuel cycle supply and demand comparisons in OECD countries (as of 1 January 2021)



StatLink www.oecd-nea.org/statlinks-2021

3. Country reports

Bulgaria

National nuclear policy

Nuclear energy plays a key role in the national energy mix in Bulgaria. Nuclear power is a proven source of safe, secure, low-carbon and affordable energy. It also contributes significantly to achieving the European Union's targets of a 55% reduction in greenhouse gas (GHG) emissions by 2030 and net-zero emissions by 2050.

The share of nuclear energy in the nation's gross energy production is around 33-35%, and is expected to increase gradually as the existing nuclear capacity is maintained where possible and the nuclear portfolio is diversified. For over 45 years, Bulgaria operated the Kozloduy Nuclear Power Plant, which provides clean energy at competitive prices, in strict compliance with the highest levels of nuclear safety, radiological protection and nuclear security, while remaining in line with the leading and internationally recognised practices in this area.

Nuclear power's essential role is recognised in the Bulgarian National Energy and Climate Plan (NECP) developed under the EU Regulation on the Governance of the Energy Union and Climate Action.

The operation of nuclear power units, the management of spent fuel and radioactive waste, and decommissioning activities are regulated by the independent Bulgarian Nuclear Regulatory Agency (BNRA) based on a legislative, regulatory and institutional framework. The framework also incorporates international nuclear commitments and EU requirements.

National nuclear programme

The Bulgarian nuclear programme began in 1974 with the consecutive commissioning of six nuclear units at the Kozloduy site. The Kozloduy Nuclear Power Plant suspended the operation of its first four units (1 760 MW in total) before the end of their design lifetime, as part of Bulgaria's accession to the European Union. At present, the Kozloduy Nuclear Power Plan remains the only nuclear power plant in the country with 2 000 MW installed capacity. There are two types of spent nuclear fuel storage facilities at the Kozloduy Nuclear Power Plant site: a wet spent fuel storage facility designed for the long-term storage (no less than 50 years) of spent fuel from VVER-440 and VVER-1000 reactors; and a dry spent fuel storage facility designed for the long-term storage (no less than 50 years) of spent fuel assemblies from VVER-440 reactors only.

Nuclear power facilities in operation

Two nuclear units (of the VVER-1000 reactor type, model B-320, with 1 000 MW installed capacity each) are in operation at the Kozloduy Nuclear Power Plant. They were commissioned in 1987 and 1991, respectively. The units have been modernised and upgraded continuously since the beginning of their operation.

A large modernisation programme to justify the design lifetime extension was implemented at Kozloduy units 5 and 6. The modernisation was a strategic priority in the national nuclear programme from 2012 to 2019. It consisted of 212 measures applied in a two-stage approach. Based on the analyses and studies conducted, it was concluded that it was safe to extend the operating timeframe for unit 5 until 2047 and for unit 6 until 2051. This allowed for the renewal of the operating licences of Kozloduy units 5 and 6. Pursuant to the national legislation, the BNRA granted a 10-year operational licence for unit 5 in 2017 and a 10-year operational licence for unit 6 in 2019.

Nuclear power facilities under decommissioning

Following the political commitments undertaken in the negotiating process of Bulgaria's accession to the EU, four units of the Kozloduy Nuclear Power Plant were shut down, two in December 2002 (VVER-440 and model B-230) and two in December 2006 (VVER-440 and advanced model B-230) prior to the expiry of their design lifetime. Their decommissioning process is supported by EU financial solidarity. In December 2012, the four units were transferred to the State Enterprise Radioactive Waste (SERAW), which was entrusted with their decommissioning. The BNRA issued decommissioning licences to units 1 and 2 in 2014, and to units 3 and 4 in 2016.

The decommissioning strategy adopted goals surrounding the immediate dismantling of the four units, with a target completion date of all decommissioning activities by 2030. Key milestones in the decommissioning programme have been reached, several of them ahead of schedule. For instance, all dismantling activities in the turbine hall were finalised in August 2019. The most challenging task remaining is to decontaminate and dismantle contaminated equipment in controlled areas. An excellent relationship has been established with the Bohunice decommissioning programme (Slovak Republic), which is critical in terms of exchanging experience, knowledge and lessons learnt, as well as equipment.

New nuclear builds

Belene Nuclear Power Plant Project

On 22 May 2019, the call to select a strategic investor for the Belene Nuclear Power Plant project was published in the Official Journal of the European Union. The call also provided an opportunity to declare interest in acquiring a minority share in the project, and/or to purchase electricity from the power plant.

By the deadline of 19 August 2019, 13 companies had submitted their applications. On 19 December 2019, a short list was published of candidates to whom a call for binding tenders was submitted. The shortlisted companies included the China National Nuclear Corporation (CNNC), Atomenergoprom AD as part of Rosatom (Russia), Korea Hydro & Nuclear Power, Framatome SAS (France), and General Electric (United States). The selection procedure envisages conducting negotiations with the shortlisted companies to structure the Belene Nuclear Power Plant project. The implementation of the selection process has been delayed due to restrictions imposed by the COVID-19 pandemic.

Kozloduy Nuclear Power Plant-New Build

The Council of Ministers agreed in principle in April 2012 on the construction of new nuclear power capacity at the Kozloduy Nuclear Power Plant. In August 2013, the Nuclear Regulatory Agency (NRA) issued a permit to select the site for the new nuclear power unit. The following activities were also implemented: technical-economic analysis for the construction of a new nuclear power unit at the Kozloduy Nuclear Power Plant; research and determination of the location of the preferred site for the construction of the new nuclear unit at the Kozloduy Nuclear Power Plant; and an environmental impact assessment (EIA) of the investment proposal to build the new nuclear power unit at the Kozloduy site. In 2016, a procedure was launched to appeal the EIA decision before the Supreme Administrative Court (SAC) of Bulgaria. In April 2019, the SAC rejected the appeal and the EIA Decision was adopted. In early April 2019, the Kozloduy Nuclear Power Plant-New Build submitted a request for approval of the selected site. On 21 February 2020, the Chairman of the NRA issued an order to determine the location of the site selection (site 2).

On 20 January 2021, the Council of Ministers authorised the Minister for Energy to take all necessary steps to start exploring the possibility of constructing a new nuclear reactor at the recently licensed second site of the Kozloduy Nuclear Power Plant. Work on this project continues.

Detailed information about the Kozloduy Nuclear Power Plant-New Build management and staffing, as well as the activities carried out by the company, is available at the following link: https://npp-nb.bg/?page_id=1491&lang=en.

Nuclear fuel cycle and waste management

The nuclear fuel cycle and radioactive waste management policy is outlined in the "Updated Strategy for the Management of Spent Nuclear Fuel and Radioactive Waste by 2030". The strategic document, which is currently under revision, is available at the following link: www.me.government.bg/bg/themes/aktualizirana-strategiya-za-upravlenie-na-otraboteno-yadreno-gorivo-i-radioaktivni-otpadaci-do-2030-g-1657-0.html.

Bulgaria applies a closed nuclear fuel cycle. All front-end fuel cycle services (uranium mining and milling, conversion, enrichment and fuel assembly fabrication) and partially back-end fuel cycle services (spent fuel reprocessing) are performed abroad. Currently, Bulgaria is implementing an extension to the long-term contracts signed with Russia on the supply of fresh nuclear fuel for irradiation in units 5 and 6, and subsequent shipment of the spent fuel assemblies to Russia for reprocessing. Following EU requirements and in light of Euratom policy, Bulgarian authorities undertook key steps towards nuclear fuel diversification in terms of fuel suppliers and routes. The safety assessment of alternative fresh nuclear fuel supplies is ongoing.

Radioactive waste management activities are carried out by administrative units with clearly defined functions and tasks, and with a clear allocation of the rights, obligations, and responsibilities of the two site operators, the Kozloduy Nuclear Power Plant and SERAW. Within each production unit, a radioactive waste tracking system registers data on the characterisation of radioactive waste and inventories, overseeing intradepartmental compliance with the necessary regulations, procedures, instructions, programmes, schedules and orders relating to the implementation of the radioactive waste management activities.

As well as implementing the decommissioning programme, SERAW performs all the activities related to the entire life cycle of the radioactive waste management existing and planned.

National Disposal Facility for Low- and Intermediate-level Radioactive Waste

The project to build a national disposal facility for radioactive waste is underway. This facility is intended for the disposal of conditioned, short-lived, low- and intermediate-level waste from the nuclear facilities and nuclear applications. The Radiana site, selected for that purpose, is located in the vicinity of the Kozloduy Nuclear Power Plant.

Canada

Canada is a nuclear nation, with over 75 years of experience with nuclear energy and a full-spectrum supply chain. Canada's nuclear programme is based on its unique heavy water natural uranium reactor technology, the CANDU (CANadian Deuterium Uranium) reactor. Canada's expertise spans the entire fuel cycle, from uranium mining to research and development (R&D), reactor design, decommissioning, and waste management. As of 2019, the nuclear sector contributed CAD 17 billion to the Canadian economy and provided approximately 76 000 jobs across the nation. In addition, Canada is the world's second-largest producer and exporter of uranium. Nuclear energy is an important component of Canada's electricity supply and will continue to play an important role in achieving Canada's target of reducing greenhouse gas (GHG) emissions to 30% below 2005 levels by 2030 and reaching net-zero emissions by 2050. Nuclear energy provides 15% of Canada's total electricity supply. Ontario's 18 reactors, operated by OPG (10 reactors) and Bruce Power (8 reactors), produce approximately 60% of the province's electricity needs, while NB Power generates almost 40% of New Brunswick's electrical needs from its one operating reactor.

Leadership on small modular reactors (SMRs)

SMRs are a new class of nuclear reactors that are considerably smaller in size and lower in power output than conventional nuclear power reactors, with enhanced safety features. The technology is expected to unlock new and significant domestic and global market opportunities for non-emitting electricity in a number of different applications, including power grids (to replace coal plants), heavy industries such as mining and petroleum production, and remote communities. SMRs are emerging as a game-changing technology for the nuclear industry.

In 2018, Natural Resources Canada (NRCan) convened the SMR Roadmap project with interested provinces and territories, industry, Indigenous communities, and civil society to chart a path forward for this technology in Canada. Over the course of ten months, through a series of expert working groups and workshops, the Roadmap gathered feedback on the direction for the possible development and roll-out of SMRs in Canada. The SMR Roadmap was released in November 2018 and contains 53 recommendations for a number of partners, including the federal government.

In alignment with Roadmap objectives, a number of initiatives are being pursued in Canada to support SMR development.

- In 2018, Canadian Nuclear Laboratories (CNL) initiated an Invitation for Demonstration, inviting further discussions with SMR vendors interested in building a demonstration unit at a site managed by Atomic Energy of Canada Limited (AECL). Four SMR proponents are currently at various stages of the process, with one vendor in stage three having initiated an environmental assessment (EA) and licensing processes (see below).
- As of June 2021, 12 SMR technology companies have applied to the Canadian Nuclear Safety Commission (CNSC) for the pre-licensing vendor design review (VDR) process, which is a feedback mechanism that enables CNSC to provide feedback early in the design process based on a vendor's reactor technology. This review does not certify a reactor design or involve the issuance of a licence under the *Nuclear Safety and Control Act*. The objective of a review is to verify, at a high level, the acceptability of a nuclear power plant design with respect to Canadian nuclear regulatory requirements and expectations, as well as compliance with Canadian codes and standards.
- In March 2019, one SMR proponent submitted an application to the CNSC seeking a licence to prepare a site for its proposed project for a micro modular reactor (MMR), to be located at AECL's Chalk River Laboratories. In June 2020, the CNSC held its first hearing on this application, which focused on the scope of the EA. After taking into consideration public comments, the CNSC outlined the factors to be considered in the environmental assessment project. As of June 2021, the proponent had yet to submit additional documentation to the CNSC in support of its application to prepare a site. Prior to issuing such a licence, a public hearing (date to be confirmed) must be carried out.

In December 2020, Canada's Minister of Natural Resources announced the release of Canada's SMR Action Plan, which was developed in partnership with more than 100 organisations, including seven provincial and territorial governments (Alberta, Saskatchewan, Ontario, New Brunswick, Prince Edward Island, Yukon, Nunavut), municipalities, utilities, industry, civil society, academia and some Indigenous voices. The Action Plan outlines progress and ongoing efforts by these organisations to support the development and roll-out of SMRs, while responding to and exceeding recommendations in Canada's SMR Roadmap. In 2021, NRCan will continue to advance priorities outlined in the government of Canada chapter of the Action Plan together with partners from across government.

The Provinces of Alberta, Ontario, Saskatchewan and New Brunswick in December 2019 signed a Memorandum of Understanding to advance the demonstration and deployment of SMRs in Canada. The Province of Alberta formally became a signatory in April 2021. These provinces have agreed to collaborate on the advancement of SMRs as a clean energy option to address climate change and regional energy demands, while simultaneously supporting economic growth and innovation.

Regulatory activities

The CNSC continues to work to ensure readiness to regulate SMRs in Canada. The CNSC has been approached by a number of SMR vendors to initiate an optional preliminary step before the licensing process, called a vendor design review (VDR). The VDR is completed at a vendor's request and expense to assess their understanding of Canada's regulatory requirements and the acceptability of a proposed design. As of June 2021, there are 12 SMR proposals undergoing the VDR process.

Refurbishments and licence renewals

Maintaining nuclear energy as a key component of Canada's baseload electricity supply will be important to realising Canada's climate change goals. In the province of Ontario, utilities are investing CAD 26 billion during the period 2016-2031 to extend the life of 10 nuclear reactors by approximately 30 years to maintain nuclear power capacity at 9.9 gigawatts electric (GWe). This refurbishment at the Darlington and Bruce facilities, being one of the largest public infrastructure projects in Canada, will ensure that nuclear energy continues to play a key role in achieving Canada's low carbon future.

The overall refurbishment plan for the Ontario nuclear generating stations entails the sequential refurbishment of four units at the Darlington site and six units at the Bruce site. The first refurbishments at Darlington began with unit 2 in 2016 and are expected to finish in 2026; and the Bruce project began with unit 6 in early 2020 and will be completed by 2033. Ontario's third operating nuclear power plant was originally scheduled to shut down in 2020, but will continue to operate until 2024. The CNSC extended the plant's licence from 1 September 2018 to 31 August 2028. This 10-year licence includes 3 stages: i) continued commercial operation until 2024; ii) stabilisation activities (e.g. post shutdown defueling and dewatering); and iii) safe storage with surveillance. These refurbishments follow the life extensions of Ontario's Bruce units 1 and 2 and New Brunswick's Point Lepreau nuclear station in 2012.

Throughout the COVID-19 pandemic, Canada's nuclear power plants continued to provide clean, safe and reliable power for homes, hospitals and businesses, while taking additional health and safety precautions to protect workers and donating stockpiles of protective equipment where needed. As an essential service, emergency procedures and policies were in place to ensure electricity sector supply chains remained operational throughout the pandemic. Supply chain impacts and disruptions have been minimal to date. The refurbishment of Ontario's nuclear reactors was paused during COVID-19, with work restarting later in the year. Refurbishments are now proceeding according to plan, and the refurbishment of the Darlington 2 unit was completed on time and on budget in June 2020.

Uranium

Since 2009, Canada had been the world's second-largest producer of uranium; however, production was reduced significantly in 2020 as a result of the COVID-19 pandemic. Production for 2020 was 3 878 tonnes of uranium metal (tU), a 45% reduction from the 6 996 tU produced in 2019, and approximately 8% of the total world production in 2020. All current production is sourced from the Cigar Lake mine and McClean Lake mill, both located in northern Saskatchewan. On average, about 85% of Canada's uranium production is exported annually. The remaining production is used to fuel CANDU reactors in Canada.

Production from the Cigar Lake mine totalled 3 878 tU in 2020, ranking it as one of the world's largest uranium producers, despite production being suspended for 6 months as a result of the COVID-19 pandemic. All ore from the Cigar Lake mine, which is operated by Cameco Corporation, is processed at the McClean Lake mill, operated by Orano Canada Inc. Cigar Lake is the world's second-largest high-grade uranium deposit. The mine opened in 2014 and began full production in 2017.

McArthur River is the world's largest high-grade uranium deposit. Both the McArthur River mine and the Key Lake mill, which processes all McArthur River ore, are operated by Cameco Corporation. Production at these two facilities has been suspended since January 2018 as a result of low uranium prices. Prior to 2017, McArthur River and Key Lake were the world's largest uranium mine and mill in terms of annual production. Operations are expected to resume when market conditions improve.

Operations at the Rabbit Lake mine and mill, which are wholly owned and operated by Cameco, have been suspended since July 2016 as a result of low uranium prices.

Decommissioning

On 28 December 2012, the Gentilly-2 generating station ceased operations. The station has been put in a safe storage state and in June 2016, the CNSC announced its decision to issue a power reactor decommissioning licence to Hydro-Québec for the facility, valid from 1 July 2016 to 30 June 2026.

On 31 March 2018, the National Research Universal (NRU) reactor was taken offline. Since then, the NRU has been placed into a safe shutdown state to be followed by storage with surveillance. The reactor will remain in that state until decommissioning, which is currently scheduled to begin in 2028.

The CNL is continuing decommissioning of the Whiteshell Laboratories in Pinawa, Manitoba. The CNL has proposed in situ decommissioning of the WR-1 research reactor at Whiteshell Laboratories, which was shut down in 1985. The CNL has also proposed in situ decommissioning of the Nuclear Power Demonstration facility site, which consists of a shutdown prototype reactor near Rolphton, Ontario. Both projects are currently in the EA process under the Canadian Environmental Assessment Act, 2012. As a result, the CNL submitted revised versions of the documents to the CNSC to respond to the feedback received. Following completion of the environmental assessment documents and regulatory review, each project will be considered at a CNSC public hearing before it may proceed.

In May 2018, the Saskatchewan Research Council (SRC) submitted an initial application to the CNSC for authorisation to decommission its SLOWPOKE 2 reactor facility. The SRC SLOWPOKE 2 reactor has been in operation in Saskatoon since 1981. The decommissioning was completed in October 2020. The SRC is seeking a Licence to Abandon from the CNSC to allow unrestricted access of the site previously occupied by the reactor.

Nuclear fuel waste

Deep geological repository (DGR) for nuclear fuel waste produced in Canada

The Nuclear Waste Management Organization (NWMO) was established in 2002 by Canada's nuclear electricity producers pursuant to the Nuclear Fuel Waste Act, and is responsible for implementing a plan for the long-term management of the nation's nuclear fuel waste. In 2007, the government of Canada selected the Adaptive Phased Management (APM) approach, which involves isolating and containing Canada's nuclear fuel waste in a DGR, at a suitable site in an informed and willing host community. The NWMO's role in implementing a long-term solution for nuclear fuel waste, on behalf of waste owners, is in line with Canada's current Policy Framework on Radioactive Waste, which is built on the "polluter pays" principle and requires waste owners to be responsible for radioactive waste management planning.

In 2010, the NWMO launched a voluntary site selection process to identify a suitable site and a willing host community. This process started with 22 municipalities and Indigenous communities that expressed interest in learning more and exploring their potential to host the project. As of June 2021, two communities are participating in an NWMO site selection process to determine whether they would like to host a DGR.

The NWMO continues its field investigations to assess the geological suitability of siting areas. In 2018, the NWMO completed its first borehole on the potential repository site in the Ignace area, one of the three communities in the siting process. In 2019, two additional boreholes were drilled to confirm the geological features of the potential repository site in the Ignace area. Further investigation has continued into 2021.

The next steps include working with municipal and Indigenous communities to conduct progressively more detailed technical site evaluations and social studies. The work will further assess safety, continue meaningful discussions around partnerships, and explore how the project can be implemented in a manner that will enhance the well-being of municipal and Indigenous communities in each area. The NWMO remains on track to identify a single, preferred site by 2023.

Nuclear Liability and Compensation Act

The *Nuclear Liability and Compensation Act* (NLCA) replaced the *Nuclear Liability Act* (NLA) and entered into force on 1 January 2017. The NLCA established the absolute and exclusive liability limit of nuclear operators to be CAD 1 billion, permitting Canada to become a signatory to, and implement, the International Convention on Supplementary Compensation for Nuclear Damage (CSC). The NLCA includes a provision for a review of the liability limit for power reactors every five years so that the limit can remain current and relevant.

In June 2019, the government of Canada hosted the Inaugural meeting of the Parties and Signatories to the CSC, and has agreed to act as the Chair to the Second Meeting of the Parties and Signatories to CSC, expected to take place in early 2022. The CSC is an international treaty that sets out obligations for civil liability and compensation arising from nuclear incidents that occur within member countries and during nuclear material transport.

Radioactive waste management

Near Surface Disposal Facility (NSDF) for low-level radioactive waste (LLW)

The CNL has proposed to construct a near-surface disposal facility at the Chalk River Laboratories (CRL) property for large quantities of low-level radioactive waste from past, present and future activities at the CRL and other AECL locations.

The CNL's proposal is undergoing an EA conducted under the *Canadian Environmental Assessment Act* (2012). As part of this process, the CNL prepared an Environmental Impact Statement (EIS) for public comment in March 2017. Following substantive comments and requests for additional information by the CNSC, the CNL revised the EIS and formally submitted a new draft on 4 December 2020. Upon receipt of this revised document, CNSC staff determined it did not provide sufficient requested additional information related to Indigenous engagement. Upon the successful completion of the EA documents and regulatory review, the project will be considered at a CNSC public hearing before it may proceed.

Modernising Canada's Radioactive Waste Policy

In September 2019, the International Atomic Energy Agency (IAEA) undertook an Integrated Regulatory Review Service (IRRS) Mission, and concluded that Canada has a comprehensive framework for nuclear and radiation safety, as well as noting six good practices for other countries to consider. The review also included a recommendation that the government enhance the existing policy and establish the associated strategy to give effect to the principles stated in the Canadian Radioactive Waste Management Policy Framework.

In November 2020, NRCan launched a broad engagement process to modernise Canada's current policy for radioactive waste. NRCan is engaging Canadians to seek their perspectives and views on what should be included in a modernised policy. The policy review is targeted to conclude in autumn 2021.

This review provides an opportunity to stimulate discussion on the safe, effective and environmentally acceptable management of radioactive waste in Canada, as well as to listen and obtain views from Canadians on how to elaborate on the existing radioactive waste policy to provide clearer direction and greater leadership on radioactive waste management over the long term.

International collaboration

Bilateral agreements

The government of Canada facilitates international collaboration in the peaceful uses of nuclear technology through three mechanisms: Nuclear Cooperation Agreements (NCA), Memoranda of Understanding (MOU) and Action Plans. Canada currently has 32 NCAs in place, covering 48 countries, including members of the European Atomic Energy Community (Euratom). Canada's NCAs are a key requirement of its policy on nuclear non-proliferation, and are the responsibility of Global Affairs Canada (GAC). NCAs establish the legal framework for collaboration with partner countries to ensure responsible nuclear trade that upholds the highest standards of safety, security, safeguards and non-proliferation.

Once an NCA is in place, Canada's best practice is to develop an MOU, a non-legally binding instrument, which serves to establish a structured dialogue and to focus co-operation in areas of mutual interest and benefit (all within the legal bounds of the NCA). The MOU is followed by the development of an Action Plan to frame concrete activities. Canada presently has these types of overarching MOUs and Action Plans in place with six countries, and several more are under negotiation.

The government of Canada had two bilateral agreements enter into force in the past year, an NCA with the United Kingdom following the United Kingdom's withdrawal from Euratom, and an agreement with the ITER Organization related to co-operation in fusion energy. In addition, multiple bilateral meetings were organised in order to foster relations and promote commercial interests, such as the signing of a Canada-United Kingdom Action Plan in March 2020.

In March 2021, a two-day virtual trade mission on partnerships in nuclear technologies between Canada and Romania took place, furthering the long-standing collaborative relationship on nuclear energy with Romania. Following the virtual conference, Canadian and Romanian businesses held business-to-business meetings to continue the dialogue and further explore opportunities for partnerships.

Multilateral engagement

Canada is an active member of the OECD Nuclear Energy Agency (NEA), the IAEA, the SMR Regulators' Forum, the Generation IV International Forum (GIF), the International Framework for Nuclear Energy Cooperation (IFNEC), the Nuclear Suppliers Group (NSG) and the Multinational Design and Evaluation Programme (MDEP).

In 2018, Canada, along with France, Japan and the United States, co-led the Nuclear Innovation: Clean Energy (NICE) Future as an international initiative at the Clean Energy Ministerial (CEM). The initiative is an international collaboration designed to advance the role that innovative nuclear energy technologies can play in meeting climate change goals. The initiative aims to expand use of nuclear energy technologies by building greater awareness among CEM member countries of the roles that clean and reliable nuclear energy can play in enabling clean energy systems. Other members include Argentina, Brazil, Jordan, Kenya, Poland, Romania, Russia, the United Arab Emirates and the United Kingdom.

Nuclear Innovation: Clean Energy (NICE) Future and the Clean Energy Ministerial (CEM)

Canada hosted the 10th Clean Energy Ministerial (CEM10) in Vancouver in May 2019, where for the first time, nuclear energy and the NICE Future initiative were a fully integrated topic of discussion within multiple CEM10 deliberations, roundtables and side events. Now in its 11th year, with 25 member countries as well as the EU, the CEM continues to serve as a high-level global forum that promotes policies and programmes to advance clean energy technology, to share lessons learnt and best practices, and to encourage the transition to a global clean energy economy. CEM11 was hosted by Saudi Arabia in September 2020 as an entirely virtual event, open to all via live webcast. The theme of CEM11 was "Supporting the Recovery, Shaping the Future," and its unofficial mantra was "bring actions, not words". The event was co-located with the G20 Energy Ministerial for the first time and included 16 high-level pre-events, culminating with its Ministerial Plenary.

Notably, NICE Future took part in CEM11 by hosting a side event where speakers discussed how emerging nuclear energy breakthroughs can improve system flexibility, support the integration of higher shares of variable renewable energy, and ultimately lead to cleaner, more resilient power. The event launched a major new technical report by the NICE Future Flexible Nuclear Campaign for Nuclear-Renewables Integration (FNC), which engaged experts from 9 ministries, 5 multi-governmental organisations and 14 other organisations.

Most recently, Chile hosted CEM12 from 31 May to 6 June 2021. The event was delivered virtually, utilising different formats through an online platform featuring both live and on-demand content. Notably, CEM12 featured the launch of an important nuclear energy publication led by the NICE Future initiative called *Pathways to Net Zero Using Nuclear Innovation*. The publication features perspectives on pathways to net zero from ministers and multi-governmental organisation leaders from various member countries.

Generation IV International Forum (GIF)

Canada is a founding member of the Generation IV International Forum (GIF), a multinational effort to develop the next generation of nuclear energy systems with enhanced safety, security and economics, while addressing waste, proliferation and public perception concerns. In 2001, ten countries, including Canada, initiated GIF to collaboratively develop the next generation of nuclear energy systems that will provide competitively-priced and reliable energy in a safe and sustainable way. Work is focused on six nuclear reactor types, or "systems", that could best meet the Generation IV objectives. Canada joined one such system in 2021, meaning that as of June 2021 it participates in three of the six systems. Canadian industry representatives also participate in GIF's Senior Industry Advisory Panel (SIAP), which aims to incorporate industry advice at the earliest phases of GIF research.

Currently, GIF brings together 13 countries, as well as Euratom – representing the 28 European Union members – to co-ordinate research and development on Generation IV systems. Participation in the GIF, through its contributions to international efforts, allows Canada to gain access to research done by participating nations, which significantly leverages any research monies spent in Canada. Canadian participation in GIF activities is aligned with the current development of advanced modular reactor projects being planned in Canada. Participation also ensures that Canada remains a significant player in both domestic and international nuclear technology development.

Czech Republic

Nuclear policy

The Czech Republic currently has six nuclear power reactors at two sites in operation (four units at the Dukovany Nuclear Power Station, and two units at the Temelín Nuclear Power Station). The State Energy Policy (SEP) published in 2015 plans for nuclear energy to constitute 46-58% of total electricity production in the long term to steadily replace coal, whose share is expected to decline. As part of the SEP, the government has announced plans to build new nuclear units at an existing nuclear power plant site, with a total output of up to 2 500 MWe, by 2030-2035.

In the SEP, the government foresees only limited expansion of renewable sources in the electricity sector; therefore, new nuclear capacity is increasingly seen as a key solution to fill the expected capacity gap in the mid-2030s.

Nuclear new build financing proposal for Dukovany II unit 1

As reported in the country's 2021 Energy Policy Review published by the International Energy Agency, the Czech government in July 2019 released a resolution highlighting its commitment to provide loan guarantees to the utility ČEZ to allow it to secure cheaper financing. However, the resolution confirmed that the government would not provide a return on investment guarantee. In November 2019, the Czech Prime Minister announced that a supplier would be selected for the new reactor at Dukovany by 2022. In May 2020, the Czech government agreed to a state loan covering 70% of the costs of building the new reactor. The loan would be interest-free during construction, followed by a rate of 2% once the plant begins operation.

In parallel, in July 2020, the Czech cabinet approved a proposed new law that would allow the government and ČEZ to agree to a minimum 30-year power purchase agreement (PPA) for Dukovany II unit 1. The PPA is framed for projects of over 100 MWe that would be commissioned after 2030. The price should allow ČEZ to make a return on investment. However, the PPA does not offer a guaranteed return, notably in the event of construction cost overruns that may have to be carried by ČEZ, depending on the contractual arrangements with the reactor vendor. The electricity will be resold by the state-owned company on the wholesale market. The difference between the off-take and wholesale electricity prices will be passed on to final consumers, either as a surcharge or a rebate. This financial support is aimed at significantly reducing the cost of capital and ensuring competitive costs for consumers. It will also alleviate potential concerns related to ČEZ's dominant position in the electricity market as the company will not be responsible for marketing the output of the new plant.

As reported in the country's 2021 Energy Policy Review published by the International Energy Agency, this financing framework for nuclear new build is meant to address specific market failures of electricity and financial markets related to unpriced societal benefits and long construction times. Such issues will be reviewed by the European Commission in accordance with its state aid rules. Investments in long-term, highly capital-intensive, low-carbon technologies such as nuclear energy are related to long-term societal objectives such as climate change mitigation. Hence, they have characteristics similar to strategic infrastructure investments with large positive externalities at the system level that require specific linkages between public and private objectives. One specificity of nuclear energy, as opposed to variable renewables (wind, solar PV), relates to the construction lead-time. Today, in OECD countries, the construction duration of a proven nuclear reactor can be assumed to last seven to ten years, with several additional years required for project development. The risk of construction delays can also be perceived as high based on recent experiences with first-of-a-kind (FOAK) projects. Additional policy support is therefore warranted to overcome this uncertainty. Direct financing support, especially during the construction phase as envisaged by the Czech Republic, would therefore be an effective way to align nuclear new build financial conditions with the country's long-term energy policy objectives.

Long-term operation of nuclear power plants

In March 2020, ČEZ submitted an application to extend the licence of unit 1 of Temelín, which was issued by the State Office for Nuclear Safety (SONS) in September 2020. In June 2020, ČEZ stated that it expects to invest about USD 2.3 billion in capital expenditure over the next 27 years to extend the operating lifetime of Dukovany by 20 years to a total of 60 years, i.e. until 2045-47.

Radioactive waste management and decommissioning

In December 2020, the Czech cabinet announced that it had approved a shortlist of four potential sites for a deep geological repository for used nuclear fuel and high-level radioactive nuclear waste. The government also approved a new schedule calling for the site to be selected by 2030, five years later than originally planned. The repository is expected to be operational by 2065.

Finland

Teollisuuden Voima Oyj (TVO), a non-listed public limited company, owns and operates two nuclear power plant units, Olkiluoto 1 and 2, in Eurajoki, Finland, and a new unit, Olkiluoto 3, which is under construction at the same nuclear power plant. In September 2018, the government of Finland approved the extension of the operating licence of Olkiluoto 1 and 2 until the end of 2038.

TVO was granted a construction licence for the Olkiluoto 3 (OL3) pressurised water reactor (EPR) in February 2005. The reactor's thermal output will be 4 300 megawatts (MW) and its electric output about 1 600 MW. The Finnish government granted the operating licence to the plant unit on 7 March 2019. The fuel was loaded into the reactor in April 2021. First criticality was reached at OL3 in December 2021.

In 2007, Fortum Power and Heat Oy (Fortum) received a 20-year operating licence for 2 Loviisa pressurised water reactors (PWRs) in operation since 1977 and 1980. Fortum expects that both units will have at least a 50-year operational lifetime, extending their service life until approximately 2030. Fortum will announce its plans for a possible further life extension of the Loviisa plant in the coming year, after completing an environmental impact assessment (EIA) of a possible lifetime extension or decommissioning.

Also in 2007, Fennovoima Oy, a new company, initiated a nuclear new build project. This company was created by a consortium of industrial and energy companies with the aim of constructing a new nuclear power plant in Finland that could be operational later this decade.

According to the energy and climate strategy adopted by Finland, nuclear power is an option, but the initiatives must come from the industry. As stipulated in the Nuclear Energy Act, an EIA process must be completed before an application for a decision-in-principle (DIP) can be submitted to the government. The Fennovoima EIA process (co-ordinated by the Ministry of Economic Affairs and Employment, or the Ministry or MEAE) was completed in 2009 and again in 2014.

In December 2013, Fennovoima signed a turnkey plant supply contract with Rosatom Overseas for the AES-2006-type 1 200 MW VVER reactor located in Hanhikivi in the municipality of Pyhäjoki. At the same time, an integrated fuel supply contract was signed with TVEL to cover the first nine operating years. Additionally, shareholders signed an agreement to sell 34% of Fennovoima's shares to Rosatom Overseas.

Because Rosatom was not mentioned as an alternative in Fennovoima's original DIP application, Fennovoima started a new EIA process in autumn 2013 and submitted it in February 2014. In March 2014, Fennovoima also submitted a supplement to the DIP that was approved by the government in September 2014 and ratified by the Parliament in December 2014.

Fennovoima submitted the construction licence application to the MEAE at the end of June 2015. The preparatory work has started at the Pyhäjoki site. In 2016, Fennovoima started the third EIA process concentrating on its spent fuel handling. Fennovoima expects the government will make a decision on the construction licence application in 2022, after the Radiation and Nuclear Safety Authority (STUK) has delivered its safety review of the project. Commissioning of the plant is thus scheduled to take place in 2029.

In 2019, Posiva's final disposal project progressed to a new phase, when the decision was made on the construction of an encapsulation plant and underground final disposal facility designed for the final disposal of spent fuel. The EKA project entails the implementation of the encapsulation plant as a whole and the additional excavations required for the final disposal repository, the installation of the systems needed for the start of final disposal, the operating licence process, and the setting up of the supply chains necessary for production operation.

The foundation stone of the encapsulation plant was laid in September 2019. The progress made in the construction project included concreting works for frame systems. The foundations, first-floor slabs and walls measuring up to 2.9 metres above sea level were poured. The suppliers of most of the main equipment for the encapsulation plant were selected and the design phase of the plant's main equipment proceeded on schedule.

As reported in the *2019 Posiva Annual Report*, the excavation of the first two safety-classified central tunnels began in the underground final disposal repository and included entrances to the first deposition tunnels branching out from the central tunnels. The reinforcement project of the personnel shaft progressed to two-thirds of completion. Installations required for the Full-Scale In-Situ System Test (FISST) of final disposal were completed. The test is designed to demonstrate that Posiva's concept for safe final disposal can be implemented according to the existing plan. The monitoring phase of the test will continue for several years. Posiva is now preparing its operating licence application.

In 2017, Terrafame mine (nickel, zinc, copper and cobalt) in the Kainuu region announced that it would start uranium extraction from the polymetallic ore; and that it had submitted an application to the government in October 2017 for uranium exploitation in accordance with the Nuclear Energy Act. Annual production was projected to be 150-250 tonnes of uranium (yellow cake) and the motivation for uranium extraction would be both yellow cake and, more importantly, the improvement in the quality of the other extraction products of the mine, above all nickel sulphide. The government approved the application in 2020, but this was appealed and the decision by the Highest Administrative Court is due soon.

France

Political aspects

France has 56 nuclear power reactors in operation (supplying 61 370 MWe) and one EPR reactor under construction at the Flamanville site. The development strategy for nuclear power is related to the goals set forth by the Energy Transition for Green Growth Act and the Multiyear Energy Plan (MEP), which was published in April 2020. It will depend, in particular, on developments in renewable energy and the decisions of the Nuclear Safety Authority regarding the potential lifetime extension of existing power plants.

The MEP describes plans to shut down a total of 14 power reactors to reduce the share of nuclear energy in France's electricity generation mix from the current 75% to 50% by 2035.

Beyond 2035, with technology in its current state, it is not possible to determine with certainty whether new nuclear power or renewable energy, coupled with storage and other flexibility solutions, will be most competitive to replace the existing nuclear power plant system. To facilitate decisions on any potential launch of a programme to construct new reactors, the French government conducted a complete work plan with the sector in 2021.

Industrial and technological aspects

Orano commissions new conversion facility

In 2019, the ramping up of the Philippe Coste plant was disrupted by a technical fault in the crystallisers, one of the main components of the facility. These act as a heat exchanger for crystallising or liquefying the material produced by the process before transfer into transport packaging. The swift response of the teams cushioned the impact on the ramping up of the plant and demonstrated the capacity of the other parts of the facility to operate at their nominal production level. In the first half of 2020, the crystallisers were replaced with new ones. The ramp-up of the new electrolyzers continued in 2021 and the plant will have an installed capacity of 15 000 tonnes.

EPR

In France, the COVID-19 pandemic had a limited impact on the on-site work on the Flamanville 3 EPR reactor in 2020. Following quality deviations identified by the Nuclear Safety Authority (ASN) in 2019, the ASN has been examining EDF's proposed methods for repairing the most difficult to access secondary circuit welds. These repairs cannot begin until the ASN makes a final decision, which has been postponed to 2021, on whether to grant approval for the entire process involving remote-controlled robots. This is one of the key tasks for on-schedule completion of the Flamanville 3 EPR project. In parallel, the first fuel assemblies were placed in the fuel building pool in October 2020, following ASN approval.

In the United Kingdom, despite being affected by the COVID-19 health crisis, Hinkley Point C made significant progress in 2020 on site, on both the design execution plans and in equipment manufacturing. The start of electricity generation from unit 1 is now expected in June 2026, contrary to the initial date of end-2025, which had been announced in 2016. The project is focused on the objective of lifting the unit 1 dome by the end of 2022. In June 2020, a nuclear site licence application was submitted to the Office for Nuclear Regulation (ONR) for the Sizewell C project, which covers the development, construction and operation of two EPR units with a total capacity of 3.2 GW in Suffolk, England.

In India, EDF is preparing to hand over in the second quarter of 2021 a binding technical-commercial offer for the construction of six EPR reactors on the Jaitapur site.

EDF will use reprocessed uranium fuel

In 2018, EDF signed contracts for the recycling of reprocessed uranium (RepU) for use in PWRs starting in 2023. This solution enables EDF to diversify its uranium supply sources, allowing for savings of around 10-15% of its natural uranium requirements. It also ensures completeness of the French nuclear cycle, by reusing 96% of the nuclear material contained in spent fuel.

Safety

EDF permanently shut down 920 MWe of capacity at Fessenheim-1 in February and Fessenheim-2 in June 2020. It also began testing the emergency diesel generators at 55 out of 56 of France's reactors, fulfilling a requirement made by the nuclear regulator ASN after the Fukushima Daiichi accident.

Developments of near-surface repositories

Despite the COVID-19 pandemic, nuclear waste management agency Andra pursued industrial activities on its three existing near-surface disposal sites in 2020:

- the CSM, a closed disposal facility for low-level waste (LLW) that is located near La Hague (Manche) and has been monitored since 2003;
- the CSA, a disposal facility for LLW that is located near Soulaines-Dhuys (Aube) and has been in operation since 1992; and
- the CIRES a disposal facility of very low-level waste (VLLW) that is located near Morvilliers (Aube) and has been in operation since 2003.

In parallel, Andra has been planning and developing a near-surface disposal facility (shallow depth) dedicated to low-level long-lived waste (LLW-LL).

- The CSM was the first radioactive waste disposal facility to be operated in France. The CSM is in the process of closing down. It has not received any new waste since 1994, but continues to be subject to active monitoring and permanent controls: environmental monitoring, industrial safety checks, logistics, maintenance of installations, etc. These activities are fundamental for security and will continue to be so for several hundred years, on top of work around the acceptance of the facility by the public and public information. In December 2020, the Nuclear Safety Authority (ASN) carried out an inspection visit to the CSM to verify that Andra is fulfilling its regulatory obligations regarding environmental monitoring. The ASN concluded that “the organisation defined and implemented on the site to meet nuclear safety issues appears satisfactory and has made it possible to ensure the continuity of essential activities at the center”.

- At the CSA, operation of the 10th stage of disposal is ongoing and by the end of 2020, about 353 000 m^3 had been disposed of (for a total capacity of 1 000 000 m^3). A full operating licence was granted in 2019 for a new waste package control facility, providing the CSA with more efficient means for inspecting the quality of packages received. Following the submission of the CSA safety reassessment technical files in 2017, the ASN published its positive assessment results on its website in 2018. The conclusions of the periodic safety review of the CSA, used to assess the safety of the facility based on the predicted development of its activities over the next ten years, are expected to be published in 2021/2022.
- At the CIRES, the second construction stage, the disposal of the VLLW in trenches, has begun. About 63% of the licensed disposal capacity (650 000 m^3) has been used. The outlook provided by the national inventory of radioactive material and waste for 2018 confirms that there will be an increase in the volume of VLLW in the future, linked to the dismantling of nuclear facilities. These volumes exceed the facility’s current capacity. Andra will apply for authorisation to increase the VLLW disposal capacity from 650 000 m^3 to potentially 950 000 m^3, using the same surface area at the site.

Deep geological repository (Cigéo) construction licence application status

France plans to construct the Centre Industriel de Stockage Géologique (Cigéo) repository, an underground system of disposal tunnels in a natural layer of clay, at 500 m depth, near Bure in the Meuse/Haute Marne area. The facility is designed for the disposal of some 75 000 m^3 of intermediate-level long-lived waste (ILW-LL) and 10 000 m^3 of high-level waste (HLW).

In 2020, Andra engaged the licensing process of the Cigéo. In August 2020, Andra officially handed over to state services a public inquiry file needed for the declaration of public utility (DUP) of Cigéo. If delivered, the DUP will authorise Andra to acquire the land necessary for the establishment of the Cigéo in the event of failure of amicable negotiations. It will also pave the way for other applications for authorisations related to preparatory work for the construction of the Cigéo (preventive archaeology work, construction of road and rail networks, electricity, water, etc.). Many other authorisations will be needed, in particular the decree of authorisation of creation (DAC), for which Andra’s plan is to issue an official application between the end of 2021 and the first semester of 2022.

Andra actively contributes to a consultation/concertation programme aiming to involve local participants in themes related to the local management of the water cycle, transport infrastructures, energy supply, spatial planning and living environment.

Decommissioning

France participates in the Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM) of the NEA established in October 2018. The French Delegation is composed of representatives from the ASN, the General Directory on Energy and Climate (DGEC), IRSN, Andra, EDF, Orano and CEA. The latter is the head of the French Delegation and is a member of the Bureau. France also participates in the RWMC Radioactive Waste Management Committee (RWMC), for which the head of delegation is Andra.

R&D

The 2020 French Recovery Plan in support of the nuclear sector

The CEA’s R&D remains consistent with the Multiannual Energy Programme (PPE), which was implemented in 2020. Two French nuclear power plants were shut down in 2020 at Fessenheim, as scheduled. As France remains committed to the closed fuel cycle policy, R&D will allow for multi-recycling of MOX fuels in PWRs in the mid-term and industrial deployment of fast neutron reactors on the long term. Other important fields of R&D, such as SMR development and deployment, as well as radioactive waste management studies, were emphasised in 2020. These important R&D fields were especially supported by the French government in its 2020 Recovery Plan.

By the end of 2020, the French government had devoted EUR 470 million to support the nuclear sector as part of the French Recovery Plan following the COVID-19 crisis. This support is divided as follows:

- EUR 100 million to support SMEs and mid-tier companies, topped up by EUR 100 million by EDF (for EUR 200 million in total).
- EUR 100 million for the reinforcement of critical skills (especially welding) and support for the modernisation of industrial capacities and relocation projects.
- EUR 200 million dedicated to R&D, including:
  - multi-recycling of fuel;
  - creation and renovation of experimental facilities (safety studies);
  - "Factory of the Future" projects;
  - development of innovative solutions for radioactive waste management.
- EUR 70 million dedicated to specific projects:
  - completion of the preliminary design of the Nuward SMR;
  - the Technocentre project for the recovery of very low-level radioactive metals during dismantling.

Germany

Competence building and developing talent for nuclear safety

The federal German government released its new strategy paper in August 2020 to promote competence building and the development of future talent for nuclear safety.

The decision to phase out the use of nuclear energy for the commercial generation of electricity by the end of 2022, the reorganisation of responsibilities in nuclear waste management, and the continued development of radiological protection have triggered significant changes in Germany in recent years. All carry with them a complex set of challenges. At the same time, nuclear energy will continue to be used in other countries for the generation of electricity in the years ahead.

One of the central challenges Germany faces is to preserve its vast reservoir of knowledge and experience, amassed over decades of research and practical applications in various fields of nuclear safety, for future generations while also expanding it appropriately as part of a state service of general interest. To safeguard German safety interests, broad and interdisciplinary expertise in these fields will remain necessary in the future. Areas to be considered in this context are reactor safety, including the security, decommissioning and dismantling of nuclear facilities; nuclear waste management, including interim and final storage; and protection against ionising radiation in these areas.

It is in Germany's safety interests to follow global developments from a technical perspective, particularly with regard to existing and planned nuclear facilities in neighbouring countries, and to be able to help shape safety and preventive emergency preparedness measures.

BMWi research funding for nuclear safety

In December 2020, the Federal Ministry for Economic Affairs and Energy (BMWi) presented its new project funding programme in the field of safety research for nuclear facilities for the years 2021 to 2025 with a budget of approximately EUR 38 million per year. The objective of the research and development (R&D) is to improve the safety of nuclear facilities and to establish and further develop the scientific basis for the safe management of radioactive waste. These objectives will continue to remain relevant after Germany's decision to phase out the commercial use of nuclear energy by 2022 and will continue to determine the focus of nuclear safety research. The identified R&D needs relating to nuclear safety were structured according to research areas. Each of the research areas (reactor safety research; research on extended interim storage and treatment of high-level radioactive waste; repository research) and the intersectional issues related to these research areas, are made up of various research topics.

Atomic Energy Act, compensation according to the decision of the Federal Constitutional Court

As a result of a ruling of the German Federal Constitutional Court, the federal government approved the draft of the 18th amendment to the Atomic Energy Act and in parallel, in March 2021, signed a contract with the owners of nuclear power plants in Germany. The draft act and the contract foresee compensation payments for the phase-out decision made in 2011 and clarifications for the use of production rights for the remaining time until final shutdown. The total expected compensation is about EUR 2.4 billion. The companies that own the nuclear power plants and the federal government intend to withdraw all legal action in this context.

Export of nuclear fuels by Framatome GmbH and Advanced Nuclear Fuels GmbH (ANF)

Export authorisations for nuclear fuel elements issued by the Federal Office for Economic Affairs and Export Control (BAFA) for plants in Belgium (Doel I, II) and Switzerland (Leibstadt) were challenged by citizens and environmental associations. Recent decisions by the Higher Administrative Court of Hessia and the Administrative Court Frankfurt (Main) state that the opposition by citizens and environmental associations do not have a suspensive effect. In accordance with these court decisions, the fuel deliveries were carried out in the meantime. The final court decisions in the main proceedings on the legality of these export licences are still pending.

Preliminary assessment of regions suitable for disposal of high-level waste

The search for and selection of a site for disposal of high-level waste in Germany is governed by the Site Selection Act. It defines a science-based, participative, transparent, self-questioning and learning process. The search area is to be narrowed down gradually over the course of three phases: starting with the entire federal territory; then surface exploration regions and subsurface exploration of sites; and, finally, a proposal for a site offering the best possible safety conditions for the disposal of high-level radioactive waste. Eligible host rock formations are rock salt, claystone and crystalline rock.

The Bundesgesellschaft für Endlagerung mbH (BGE) is responsible for conducting the site selection procedure as the German Waste Management Organisation. In its interim report published in September 2020, the BGE identified 90 sub-areas that are expected to have favourable geological conditions for the final disposal of high-level radioactive waste. The Gorleben salt dome is not among the sub-areas.

Helmholtz Research and Technology Platform for the Decommissioning of Nuclear Facilities and for the Management of Radioactive Waste (HOVER)

HOVER was approved for funding in 2020 by the Helmholtz Association and provides technical facilities and new state-of-the-art nuclear laboratories for the development of innovative technologies and fundamental research related to nuclear waste management topics.

HOVER is a decentralised research infrastructure (RIS) providing unique large-scale facilities (currently not available in Germany) for the optimisation and demonstration of innovative decommissioning and predisposal technologies focused on the limitation of environmental contamination, the minimisation of waste volumes, and related waste management. Nuclear laboratories equipped with state-of-the-art instrumentation are fundamental to investigate nuclear waste forms as well as radionuclides, including a-emitting actinides, and to study the processes that determine their behaviour in interim storage facilities and deep geological repositories. The linked research of the KIT, FZJ and HZDR labs performed as part of HOVER covers technical developments and fundamental scientific challenges dealing with specific aspects pertaining to the entire chain of decommissioning, nuclear waste conditioning, as well as interim storage and disposal. It is in line with the Nuclear Waste Management, Safety and Radiation Research (NUSAFE) programme of the Helmholtz Association. It will further strengthen the infrastructure and capabilities of the participating centres and support NUSAFE research activities. The provision of state-of-the-art technical and laboratory infrastructures creates an attractive educational, training and working environment for young engineers and scientists.

Hungary

In January 2020, the Hungarian government approved the new National Energy Strategy and the National Energy and Climate Plans 2030, with an outlook up to 2040. The revised framework is based on three strategic pillars: clean, smart and affordable energy. It focuses on energy consumers in order to make the energy sector more climate-friendly, further strengthening security of supply, and innovation and economic development. The new strategy includes more than 40 strategic measures and foresees a 95% reduction in greenhouse gas emissions by 2050 from 1990 levels. Nuclear energy is viewed as essential to ensure sector integration and reach a net zero emissions economy. The preservation of nuclear generation capacity by replacing the units at the Paks Nuclear Power Plant that are nearing the end of their lifetimes is one of the key strategic measures to further decarbonise the electricity sector.

MVM Paks Nuclear Power Plant Ltd

In 2020, the MVM Paks Nuclear Power Plant generated 16 054 GWh of electricity, which accounted for 48% of gross electricity generation and 35.6% of domestic electricity consumption.

By the end of 2020, the total amount of electricity generated by the nuclear power plant after the connection of unit 1 to the power grid had exceeded 509.6 TWh. The unit capability factor has been: 87.9% for unit 1, 91.3% for unit 2, 93.1% for unit 3, 90.9% for unit 4, and an average of 90.8% for the plant.

In 2020, there were no international reviews (e.g. by the World Association of Nuclear Operators or the Operational Safety Review Team) at the MVM Paks Nuclear Power Plant besides the regular International Atomic Energy Agency (IAEA) inspections. The planned 2020 revisions were rescheduled for 2021 due to the pandemic.

Paks II. Nuclear Power Plant Private Limited Company (Paks II. Ltd)

Paks II. Ltd submitted a construction licence application to the Hungarian Atomic Energy Authority (HAEA) on 30 June 2020. The authority has 12 months to carry out an inspection, with a possible extension of 3 months. The HAEA involved international experts via the IAEA in its investigation.

The Hungarian Energy and Public Utility Regulatory Authority (HEA) issued the so-called electrical industry implementation licence to Paks II. Ltd on 19 November 2020.

With a construction licence from the HAEA and the implementation licence of the HEA, the project can obtain the additional licences required to begin construction, production, procurement and installation of the new units.

In 2020, two office buildings and a cafeteria for 100 people were constructed. Also in 2020, construction of a third office building, the Power Plant Investment Centre, was begun in the immediate vicinity of the site. In 2020, 25 buildings of the construction and erection base received a construction licence from the authority. These include the concrete mixing facility complex, the reinforcement facilities with anticorrosion work complex, and a cafeteria for 500 people.

Japan

The Japanese electricity market was deregulated in April 2016 at the distribution level and the Revised Electricity Business Act 2015 required legal separation of generation from transmission and distribution by April 2020. As the first step towards this shift, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was set up in April 2015 to assess generation adequacy and to ensure that adequate transmission capacity is available. Before the liberalisation, in September 2015, the Electricity Market Surveillance Commission (EMSC) was established as the regulatory authority for electricity under the Ministry of Economy, Trade and Industry (METI).

The Strategic Energy Plan of Japan was revised in July 2018 and stated that:

"On the premise that safety comes before everything else and that every possible effort is made to resolve the people's concerns, judgment as to whether nuclear power plants meet the new regulatory requirements will be left to the Nuclear Regulation Authority (NRA) and in the case that the NRA confirms the conformity of nuclear power plants with the new regulatory requirements, which are of the most stringent level in the world, the Japanese government will follow the NRA's judgment and will proceed with the restart of the nuclear power plants."

The plan also strengthens measures for the steady realisation of the 2030 energy mix that was set in 2015 and calls for nuclear energy to account for 20-22% of power generation in 2030. This energy mix is consistent with the nationally determined contribution (NDC) agreed at the COP21 climate conference to reduce greenhouse gas (GHG) emissions by 26% from 2013 to 2030.

Korea

Nuclear policy on energy transition

The nuclear energy policy of Korea is established by the Ministry of Science and ICT (MSIT), the Ministry of Trade, Industry and Energy (MOTIE) and the Nuclear Safety and Security Commission (NSSC). Each plays a role in R&D implementation, promotion of nuclear industry and safety regulation.

In December 2020, the government presented the four main areas of focus of the 6th Nuclear Energy Promotion Plan (CNEPP): i) maximising the safety of operating nuclear power plants for long-term operation and laying the foundation for safe spent fuel management; ii) expanding nuclear exports and pioneering new emerging markets by strengthening domestic industrial capabilities and promoting technological innovation; iii) actively promoting convergence with other fields and new technologies, expanding basic and fundamental research, and maximising the use of large-scale nuclear research facilities; and iv) strengthening public participation and communication, and continuing efforts to enhance the nation's status through international co-operation.

In addition, the government has devised three step-by-step strategies to respond to changes in the global nuclear power market by utilising its accumulated nuclear reactor technology development capabilities: i) construction of the first System-integrated Modular Advanced ReacTor (SMART) and creation of an initial small modular reactor (SMR) market through international co-operation; ii) promotion of the development of Korea's unique innovative-SMR (i-SMR), which can have a competitive advantage in the global market in the 2030s; and iii) pre-emptively securing non-LWR type SMR technology and promoting nuclear research in preparation for the diversification of the SMR market, which is expanding from power generation to the non-power generation market.

Nuclear power plant status

There are 24 nuclear power plants in operation in Korea, with an installed capacity of 23.230 GWe. Four units are under construction, with Shin-Hanul unit 1 expected to connect to the grid in 2022 at the earliest. The other three units under construction are expected to connect to the grid between 2022 and 2024. Kori units 2 and 3 will be permanently shut down by the end of 2024.

Nuclear safety and regulation

After the Fukushima Daiichi accident, the NSSC revised the Nuclear Safety Act in June 2015 to set out in the legislation clear rules on accident management, including severe accidents. Through revision of the Act, the NSSC expanded the scope of accident management from design basis accidents to severe accidents and made it mandatory for the licensee, Korea Hydro & Nuclear Power (KHNP), to submit accident management programmes (AMPs) for all operating nuclear power plants and for all new nuclear power plants when applying for an operating licence. Accordingly, KHNP submitted the AMPs for four APR1400 reactors – Shin-Hanul units 1 and 2 and Shin Kori units 3 and 4 – in January 2020 after reviewing the documents to ensure they are in line with the AMPs. The NSSC began its safety review on the AMPs and examined 455 responses to the first round questions. In addition, the NSSC conducted on-site inspections of the AMPs for APR1400 reactors – for Shin-Hanul units 1 and 2 in July 2020 and Shin Kori units 3 and 4 in September and October 2020 – and revised the Safety Review Guidelines in December 2020 to establish a comprehensive safety review system for the AMPs. The NSSC plans to review and supplement the AMPs submitted by the licensee to ensure safety against severe accidents.

Radioactive waste management

The Basic Plan for High-Level Radioactive Waste (HLW) Management and the Basic Plan for Low-and-Intermediate Level Radioactive Waste (LILW) Management were established in 2016 and 2020, respectively, by the Ministry of Trade, Industry, and Energy (MOTIE).

Since the first LILW disposal facility began operating in 2015, 27 339 waste packages (each 200 litres in size) have been accepted as of December 2020 and 21 882 waste packages have been properly disposed of.

A review of the 2016 Basic Plan is currently underway in the area of high-level waste management. The Korean government has been collecting opinions from experts as well as from the public and local communities close to nuclear power plants to amend the 2016 Basic Plan by reflecting public views.

Netherlands

Elections

After the elections of 15-17 March 2021, the process to form a new government in the Netherlands began. The conservative liberal party (VVD) of Prime Minister Mark Rutte won 34 seats (out of the 150 seats). The second biggest party, D66 social liberals, won 24 seats. A record of seventeen parties now have a seat in the House of Representatives (at least four parties are needed to gain a majority in Parliament).

Nuclear energy

Because the government formation talks are still ongoing, nothing can be said about the future position of a new government with regard to the role of nuclear energy in the Netherlands. Nevertheless, a small majority of parliamentarians is in favour of nuclear energy. Energy and climate change are central topics in the government formation talks.

Nuclear energy is not excluded as part of the energy mix in the Netherlands in accordance with the policy principle of “managing CO_2 emissions”.

The possibility of keeping the Borssele Nuclear Power Plant in operation after 2033 is being explored. The license holder of the Borssele Nuclear Power Plant has stated that on the basis of previous studies there do not appear to be any technical obstacles. However, this still needs to be investigated in more detail. The Dutch Nuclear Energy Act should be adapted to allow for a lifetime extension.

In addition, a market consultation will be conducted to investigate under which conditions market actors are prepared to invest in nuclear power plants in the Netherlands. It will try to determine what level of public support is required for this and in which regions there is interest in the construction of a nuclear power plant.

Poland

Nuclear power has not been used for electricity production in Poland so far. The research reactor Maria, which is located in Otwock-Świerk (operated by the National Centre for Nuclear Research [NCBJ]) and is used for educational and research purposes as well as for commercial production of medical radioisotopes, is the only operating nuclear reactor in the country.

Nuclear energy nevertheless plays a prominent role in Poland's energy security and clean energy plans. The Polish government has determined that nuclear power will play a significant role in its future energy mix, particularly as it looks to increase the country's energy security and decrease the carbon intensity of its electricity production.

Detailed plans to introduce nuclear power were put in place in 2014, when the Council of Ministers adopted the Polish Nuclear Power Programme (PNPP), a strategic document that sets roles and responsibilities in the institutional framework. In 2020, the programme was updated and the revised version was approved by the Council of Ministers on 2 October 2020. The objective is the construction and commissioning of nuclear power plants with a capacity between 6 and 9 GWe by 2043, which will represent about 15% of total generation capacity in the country. The objective of the PNPP was reaffirmed in the strategy for the reconstruction and transformation of the energy sector, called "Poland's Energy Policy until 2040" (PEP2040), which was approved by the Council of Ministers on 2 February 2021.

The above strategy responds to the challenge of ensuring decarbonisation in a responsible manner. In decarbonising its mix of energy sources, Poland wants to take advantage of the opportunities arising from diversified sources, including renewable energy, nuclear energy and natural gas in a transitional role. According to the PEP2040, the first 1-1.6 GWe nuclear unit is scheduled to be commissioned in 2033 and the entire Polish Nuclear Power Programme is to be completed by 2043.

Updated Polish Nuclear Power Programme

The programme details the scope of activities to be taken for the safe deployment of nuclear power in Poland and sets a timetable for the construction of nuclear power plants and the preparation of the regulatory and organisational infrastructure for these investments.

The possible sites for the construction of nuclear power plants are the same as those specified in the 2014 PNPP. The first location will be selected from among the coastal locations of Żarnowiec and Lubiatowo-Kopalino, as the siting and environmental studies in those locations are advanced.

The updated PNPP recommends choosing the pressurised water reactor (PWR) technology with a capacity of 1 000-1 650 MWe net, as those reactors are backed by extensive operational experience and ensure excellent safety characteristics. The approximate schedule provides for the choice of technology and the selection of the first location in 2022. Construction of the first reactor is to be started in 2026 with the aim of commissioning it in 2033. The next units are expected to be connected to the grid every two years, with the last reactor added in 2043. Poland will select the same reactor technology for all planned units.

Having a single strategic co-investor linked to the technology provider will facilitate low-cost project financing. It is also expected that the co-investor will become a shareholder in the special purpose vehicle (SPV) for the construction of the nuclear power plants, while the State Treasury will retain at least a 51% stake in the SPV.

The governmental administration will carry out tasks to help with implementation of the PNPP. The five basic tasks are:

- **Human resources development**: It is necessary to prepare qualified personnel for the construction and operation of nuclear power plants as well to fulfil the tasks of the nuclear regulatory body.
- **Infrastructure development**: This includes special preparations for the sites where nuclear power plants are to be built, such as making changes in the Polish power system and investing in transport infrastructure.
- **Support of the national industry**: This includes important measures to strengthen the participation of domestic entities in the nuclear sector.
- **Strengthening the nuclear regulatory system**: This includes staffing reinforcement and investments in co-operation with technical support organisations and equipment.
- **Communication and social information**: Key to implementing the nuclear programme are public support, knowledge and efficient communication.

The legal framework for the development of nuclear power in Poland consists of two main laws:

- the Atomic Law Act, with its implementing regulations substantially amended in 2011 and 2014;
- the Law on the Preparation and Implementation of Investments in Nuclear Facilities and Accompanying Investments, which entered into force on 1 July 2011 (also known as the Nuclear Investment Act).

In February 2021, an agreement between the governments of Poland and the United States went into effect. The *Cooperation Towards the Development of a Civil Nuclear Power Program and the Civil Nuclear Power Sector in the Republic of Poland* had been signed in Warsaw and Upper Marlboro on 19 and 22 October 2020. According to the agreement, the US shall prepare within 18 months a concept and execution report that will enable Poland to choose the appropriate technology and strategic partner for the nuclear power plant construction.

Institutional framework

A change occurred in the institutional framework when the Ministry of Climate in October 2020 merged with the Ministry of Environment to become what is now the Ministry of Climate and Environment. This had no influence on the competences with regard to energy policy, however.

The commercial and industrial aspects of the nuclear power introduction in Poland are handled by a special purpose vehicle (SPV), the PGE EJ 1 Sp. z o.o. The company is responsible for investment preparations, site characterisation work, and receipt of all relevant decisions, licenses and permits required for nuclear power plant construction in Poland.

The SPV was originally established within the Capital Group of PGE "Polish Energy Group" – which is state-controlled and the most prominent enterprise in the Polish energy sector. However, in line with the recommendation formulated in the updated PNPP, the State Treasury acquired a 100% share in SPV and gained direct control of it in March 2021. The acquisition of the SPV by the Polish government will provide direct control over the decision-making process and will enable effective ownership supervision of the company as it invests in nuclear power. This move will also help limit risks, lowering the financial costs and the investment requirements of the nuclear project.

Russia

Russia's nuclear power industry continues to develop, with its contribution to the country's energy mix increasing to 20.3% in 2020.

The main reactor designs currently deployed are the RBMK-1000 graphite-moderated reactor and the VVER-440 and VVER-1000 pressurised water reactors. Russia is planning on gradually replacing all RBMK reactors with VVER reactors, which will represent the majority of the nuclear reactors. Development of a Generation III+ standardised VVER-1200 reactor design followed thereafter, and it acts as the basis of the AES-2006 power plant with an increased service life of 60 years. The VVER-TOI represents a further evolution with a slightly higher output.

Russia has 33 operating nuclear power reactors, comprised of 5 units of VVER-440 type, 17 units of VVER-1000/1200 types, 9 units of RBMK-1000 type, one BN-600 fast reactor and one BN-800 fast reactor. Five small nuclear reactor units are also in operation: three units of EGP-6 type reactors and two units of floating nuclear power plants. Two units of VVER-1200 are under construction while four units of nuclear power reactors of different types are in various stages of decommissioning. The planned layout of future nuclear power plants on the Russian territory was set by the Government Order of the Russian Federation № 1634-r of 1 August 2016. The nuclear power plants scheduled for construction until 2030 include 13 new power units.

It is expected that from 2030 there will be large-scale deployment of fast neutron power reactors, initiating the transition to a closed nuclear fuel cycle, which would enable the two-component energy system to resolve the problem of spent nuclear fuel and radioactive waste accumulation. In order to recycle the minor actinides (MA) that are extracted from reprocessed VVER spent nuclear fuel (SNF), an experimental molten salt reactor (MSR) for the first phase and a large-scale MSR with a spent nuclear fuel reprocessing module for industrial application are being developed. There are plans for long-term research on applying thermonuclear fusion technology and large-scale hydrogen production using nuclear energy.

A comprehensive R&D programme "Nuclear science, engineering and technology for the period up to 2024" has been approved, which includes the development of the aforementioned nuclear technologies along with the development and application of new nuclear structural materials and experimental facilities.

Russia is particularly interested in the development of fast reactor designs with a liquid-metal coolant: sodium, lead and lead-bismuth.

The BN-600 Sodium-cooled Fast Reactor (SFR), in operation since 1980, is a commercial power unit that has been upgraded for a 15-year operating lifetime extension to 2025. The BN-800 fast reactor was started in 2015 and utilises MOX fuel with reactor-grade plutonium extracted from VVER spent nuclear fuel. The unit is intended to demonstrate the use of MOX fuel at an industrial scale in a closed fuel cycle strategy.

Russia has been pursuing next-generation reactor and closed nuclear fuel cycle technologies through its industry-wide "Proryv" project. The reactors being developed are intended to ensure high levels of safety that would eliminate the possibility of severe accidents leading to the evacuation of the local community. They are also intended to be economically competitive with current thermal reactor designs such as the VVER. Combined with a closed nuclear fuel cycle, these new designs should enable the full utilisation of uranium fuel's energy potential, radiation-neutral management of radioactive waste disposal, and technological support of non-proliferation (no uranium enrichment and plutonium separation; breeding ratio of about 1).

For 2024, there are plans to develop the industrial fast neutron reactors with the sodium coolant BN-1200M technical design with industrial closed nuclear fuel cycle technologies.

The BREST-OD-300 is a prototype power unit with a lead-cooled fast reactor featuring enhanced proliferation resistance. In 2021, the reactor was granted a construction licence as part of a pilot-demonstration complex, which would include on-site fuel fabrication and reprocessing facilities to demonstrate closed nuclear fuel cycle technologies. The fabrication module and a launch complex for the re-fabrication of dense mixed uranium-plutonium (U, Pu)N fuel are planned to be put into operation by 2022. The lead-cooled fast neutron BREST-OD-300 reactor is expected to be commissioned by 2026. The SNF reprocessing module is planned to be online by 2029. The lead-cooled BR-1200 design, which is based on the BREST-OD-300, is also being developed and envisions a commercial fast reactor to expand large-scale nuclear power.

Construction of a research nuclear facility is planned to be completed in 2024. The facility will consist of a multi-purpose fast neutron research reactor, the MBIR, and a complex for the development of technologies for reprocessing spent nuclear fuel, radioactive waste management and a closed nuclear fuel cycle.

RT-1 plant at "PO Mayak"

Industrial-scale SNF reprocessing is performed at RT-1 (PA Mayak), a plant that has been operating since 1977. So far, about 6 400 tonnes of SNF have been processed. The processed SNF inventory includes almost all the existing uranium and plutonium compositions and covers all the fuel assembly (FA) dimensions. The design capacity is 400 tonnes per year. At present, the SNF of the VVER-440s, VVER-1000s, BN-600s, and research reactors and the defective fuel from the RBMKs (which cannot be accommodated in dry storage) are reprocessed at the RT-1 plant. The necessary infrastructure is being set up to enable AMB and EGP-6 SNF reprocessing. Mixed oxide uranium-plutonium (MOX) and irradiated nuclear fuel (SNF) of the FN-600 reactor was reprocessed at the RT-1 plant in 2012 and 2014. Reprocessing is based on the PUREX process ("modified PUREX"), involving the extraction of recycled uranium and plutonium as target reprocessing products with the possibility of extracting neptunium as well as a broad range of other isotopes (e.g. Cs-137, Kr-85, Am-241, Pu-238, Sr-90 and Pm-147). A great deal of attention has been paid in recent years to environmental issues surrounding the rehabilitation of legacy sites: Open radioactive waste (RW) pools were decommissioned, and a new complex of cementation and a new vitrification furnace were put into operation. Alumo-phosphate glass is used for the vitrification of the high-level waste (HLW) after reprocessing. Borosilicate glass will also be used in the near future. The world's first semi-industrial facility for partitioning of HLW was put into operation at RT-1 in August 1996. SNF reprocessing is accompanied by the production of radioactive wastes that are subjected to treatment. The current practice for intermediate-level waste (ILW) and HLW management from SNF reprocessing at the RT-1 plant involves HLW vitrification in an EP-500 ceramic melter with a design capacity of 500 litres of concentrated HLW per hour. An alumophosphate matrix of the radioactive glass is produced using a direct evaporation-calcination-vitrification technology. Vitrified wastes are placed in steel canisters and stored in a dry vault-type storage facility.

The integrated complex for SNF management at the Mining and Chemical Combine (MCC)

At the same time, an integrated complex for SNF management is being created at the site of the Mining and Chemical Combine, which includes: centralised water cooled ("wet") SNF storage; centralised air-cooled ("dry") SNF storage; a pilot demonstration centre for the reprocessing of SNF based on innovative technologies; and MOX-fuel fabrication for fast neutron reactors (BN-800 type). An underground research laboratory will be set up to develop the technologies for the HLW's final isolation.

MOX-fuel fabrication for fast neutron reactors

The facility is in operation and produces fuel for reactor plant BN-800 (Beloyarsk Nuclear Power Plant). The facility allows for FA fabrication with the separated Pu from power reactors' SNF.

The Pilot Demonstration Center (PDC) on SNF reprocessing based on innovative technologies

The PDC is an key component of the integrated complex for SNF management at the MCC. The PDC is designed to reprocess light water reactor (LWR) SNF (VVER-1000, RBMK, PWR and BWR SNF). The main goal of the PDC in developing new technologies is to make reprocessing technologies more ecological and economically efficiency. The PDC is being constructed in two stages. In 2016, a licence was granted to operate the first start-up complex of the PDC. This unit involves hot research cells, analytical facilities, and other necessary infrastructure. An R&D programme aimed at further developing innovative SNF reprocessing technologies was launched in 2016. The purpose is to confirm the designed parameters of the new technological scheme, further improve new technologies for reprocessing of SNF, and develop HLW partitioning technologies to reduce the radiotoxicity of ultimate disposal waste.

The construction of a second PDC section with a design capacity of 250 tonnes of SNF per year is underway. It is scheduled to be commissioned in 2022. The reprocessing technologies were developed (based on the simplified PUREX process) to eliminate liquid radioactive waste (effluents) and discharge. The main products of the PDC are mixed oxides of plutonium, neptunium and uranium for the manufacture of fast reactor fuel or U-Pu mixture for REMIX fuel for multi-recycling in LWR, as well as reprocessed uranium (RepU). The PDC is also ready to deliver fuel product for REMIX. HLW is vitrified in borosilicate glass for further ultimate disposal.

Recycling technologies development

In Russia, regenerated nuclear materials (RepU and Pu) have been traditionally used separately. Since 1996, RepU has been reused in Russian commercial nuclear reactors (RBMK, BN, VVER–440, and VVER–1000 types). At present, the Russian fabrication plant, MSZ, has a licence for reprocessing nuclear materials based on RepU with ^{232}U content up to $5 \cdot 10^{-7}$%.

Separated plutonium from LWR SNF has the potential to be reused in the nuclear fuel cycle as a component of MOX fuel for fast reactors (for starting loading and feeding during the first ten years of operation of fast reactors). The concept of a two-component nuclear energy system has been approved in Russia, including both reactor types (VVER and BN). The transition period may include reuse of reprocessed nuclear materials as mixed fuel for LWRs (like VVERs) as a more effective use than MOX fuel with partial core loading.

REMIX conception

The technology of multi-recycling plutonium and RepU from LWR SNF in the form of fuel for the existing and future fleet of thermal reactors (VVER-1000 type) is being developed (REMIX-concept). REMIX fuel is the mixture of U and Pu from LWR SNF reprocessing, with the addition of enriched uranium (natural or reprocessed U). REMIX fuel enables multiple recycling of the full quantity of U and Pu from spent fuel (up to seven recycles), with 100% core charge and saving of natural uranium in each cycle. The main advantage of REMIX technology is that U-Pu mix can be incorporated into the reactor fuel enabling multiple recycling of uranium and plutonium in thermal reactors.

Rosatom is developing a programme for REMIX fuel implementation. In the framework of this programme, 3 experimental REMIX fuel assemblies (FA) containing 18 REMIX fuel elements have been manufactured. Since 2016, they are being irradiated at the Balakovo Nuclear Power Plant. In parallel, ampoules for FA irradiation in the MIR research reactor and post-irradiation investigations were manufactured – some of them have already been removed and are being studied. In 2018, Rosatom started the safety case development programme for REMIX fuel use in VVER-1000 and WWER-1200 reactors. The programme includes the development and validation of computer codes for nuclear and radiation safety demonstrations of REMIX fuel. In 2021, six full-size FAs with REMIX fuel for VVER-1000 reactors will be manufactured.

Slovak Republic

Energy policy

In December 2019, the Slovak government approved the National Energy and Climate Plan for 2021-2030. Building a competitive low-carbon economy is a long-term priority of the Slovak energy policy. The key to achieving this is the optimal use of renewable energy sources, nuclear energy, decarbonised gases and innovative technologies that will contribute to the efficient use of energy resources.

Status and performance of nuclear power plants

Nuclear energy represents more than 50% of electricity production in the Slovak Republic. There are four units of the VVER-440/213 type reactors (pressurised water reactor) in operation, including two units at the Jaslovské Bohunice site and two at the Mochovce site. There are also two units with VVER-440/V213 type reactors under construction at the Mochovce site (Mochovce 3 and 4). A multi-contractual strategy has been adopted to complete Mochovce 3 and 4, with more than 100 contracts. The owner, Slovenské elektrárne a.s, also has the role of architect-engineer. The World Association of Nuclear Operators (WANO) and International Atomic Energy Agency (IAEA) missions from late 2019 and early 2020 provided an important added value for Slovenské elektrárne a. s. through proposed recommendations and identified best practices. The main focus of these recommendations was on the need for a full transition from construction to operation at unit 3 and a resulting transition in leadership by the operating organisation.

The joint stock company Slovenské elektrárne a. s is the owner and holder of the licence for operation of all nuclear units currently in operation along with units under construction. The state regulatory authority charged with supervising the safety of nuclear installations, including radioactive waste management, spent fuel management, and nuclear materials inspection and registration, is the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR).

Decommissioning of nuclear installations

According to Act No. 541/2004 Coll. on Peaceful Use of Nuclear Energy (Atomic Act) and the amendment and supplement of certain acts, the disposal of radioactive waste or spent nuclear fuel, long-term storage of spent nuclear fuel, decommissioning, and management of radioactive waste from decommissioning may be performed only by an established legal entity, or authorised by the Ministry of Economy of the Slovak Republic. The licensee for decommissioning and radioactive waste management activities is the state-owned joint stock company Jadrová a vyraďovacia spoločnosť (Nuclear and Decommissioning Company, JAVYS, a. s.). The decommissioning of nuclear installations represents a set of administrative and technical activities to be completed after operation has ended, with the aim of excluding the nuclear installation from the scope of the Atomic Act. The licence holder is obliged to ensure successful decommissioning, including ensuring the necessary financial means to complete the project. The decommissioning stage can start with the authorisation of the ÚJD SR. The holder of a licence for the decommissioning stage is responsible for the decommissioning process. Three nuclear units at the Jaslovské Bohunice site are under decommissioning, specifically the first Czech-Slovak unit, the Bohunice A-1 Nuclear Power Plant (heavy water gas-cooled reactor [HWGCR]), and two units at the Bohunice V-1 Nuclear Power Plant (VVER-440/V230 type).

The basic concept of spent nuclear fuel and radioactive waste management is provided by the National Policy and the National Programme for spent nuclear fuel and radioactive waste management. The National Nuclear Fund was established to accumulate and manage financial sources earmarked for the back end of nuclear installations and for spent nuclear fuel and radioactive waste management. The administrator of the National Nuclear Fund is the Ministry of Economy of the Slovak Republic.

Slovenia

The most prominent piece of legislation regulating, inter alia, the safe use of nuclear energy, is the Act on Protection against Ionising Radiation and Nuclear Safety (hereafter "the 2017 Act"), which was published in December 2017 and entered into force in January 2018. The previous act was adopted in 2002 and revised four times. It should be noted that after the adoption of the 2017 Act, substantial work was devoted to updating the entire set of secondary legislation (the so-called "Rules"). The Act has undergone minor changes in recent years due to alignment with the EU acquis and other changes driven by the needs surrounding the safe and efficient conduct of administrative requirements.

Slovenia has one operating nuclear power plant, one research reactor, a central radioactive waste storage facilty for low- and intermediate-level solid radioactive waste from institutional users (i.e. all users, excluding nuclear power plants), and one uranium mine currently being decommissioned. In July 2009, consent was given by the local municipality for a final, low- and intermediate-level radioactive waste repository to be located at the Vrbina site near the Krško Nuclear Power Plant. In December 2009, the government adopted a decree on the National Spatial Plan for this repository. The procedure for obtaining the environmental consent for the repository began in 2017, when the Agency for Radwaste Management (ARAO) filed an application with the Slovenian Environment Agency (ARSO). The repository's cross-border environmental impact assessment has since been successfully concluded.

During the past few years, numerous modifications and improvements to the Krško Nuclear Power Plant have been implemented based on developments in the industry, and following changing international standards and regulatory practices. An ambitious programme of safety upgrades, called the Safety Upgrade Programme, or SUP, has been in place since the Fukushima Daiichi Nuclear Power Plant accident. The SUP includes modifications such as an alternative design for spent fuel pool cooling, the construction of an operation support centre, installation of a ventilation and habitability system in the new emergency control room, creation of a new technical support centre, installation of an additional heat removal pump, as well as a system dedicated to design extension conditions (DEC). Within the SUP, during the 2021 annual refuelling outage, the installation of additional trains of the safety systems such as the alternative safety injection (ASI), the alternative auxiliary feedwater (AAF) and the alternative residual heat removal system (ARHR) was completed. With these modifications, the SUP was practically complete, and the only remaining item was the construction of the spent fuel dry storage (SFDS). The construction licence for the SFDS facility was issued in December 2020. After the completion of nuclear licensing, the construction of the SFDS was still ongoing as of May 2021. The SFDS is expected to begin to accept spent fuel in early 2023. The Periodic Safety Review (PSR) programme was adopted in December 2020 and the Krško Nuclear Power Plant is currently working on producing the PSR documents. The PSR is planned to be concluded in 2023 as the main input for the long-term operation.

The Parliament adopted in April 2021 the "Resolution on Slovenia's Long-Term Climate Strategy until 2050". In line with the strategy, Slovenia is to cut greenhouse gas emissions by 80-90% by 2050 compared to 2005 levels and boost the implementation of policies to adjust to climate change. The strategy sets the goals for each sector by 2040 and 2050. Nuclear energy would need to be addressed in the Slovenian Energy Concept, which is to be aligned with the aforementioned strategy.

Spain

Spanish policy

Spain's nuclear energy programme is based on the Integrated National Energy and Climate Plan 2021-2030 (INECP), which was approved by the Council of Ministers in March 2021. This strategic planning tool integrates the energy and climate policy, and reflects the contribution of Spain to the achievement of common objectives established in the European Union. The document provides forecasts on the evolution of the contribution of nuclear energy to the energy mix, as well as information on an orderly and phased shutdown of Spain's nuclear reactors for the period 2027-2035.

Based on this draft plan, the owners of Spanish nuclear power plants and the State Company for Radioactive Waste and Decommissioning, Enresa, signed a Protocol in March 2019 establishing an orderly shutdown schedule for the plants.

This schedule has also been considered in the first draft of a new General Radioactive Waste Plan (GRWP), which should be approved by the government. The procedure for the adoption of the 7th GRWP started in March 2020 and should include a strategic environmental assessment, which is ongoing. The 7th GRWP will replace the 6th GRWP, which has been in force since June 2006.

Nuclear capacity and electricity generation

Spain has five nuclear power plants with seven power reactors in operation and three shut down reactors. The operative reactors are Almaraz I and II, Ascó I and II, Cofrentes, Trillo and Vandellós II. The reactors that are shut down are Vandellós I (since 1990), José Cabrera (since 2006) and Santa María de Garoña (since 2013).

In 2020, the net nuclear electricity capacity (7.1 GWe) represented a 6.4% share of the total net capacity, and the net electricity generated was 55 757 GWh, or 22.2% of total production. The Spanish nuclear reactors have demonstrated overall good performance, providing a time availability factor of 92.39% and an unplanned unavailability factor of 1.58%.

In 2017, the Santa María de Garoña nuclear power plant definitively ceased its operation after the issuance of the Ministerial Order ETU/754/2017 of 1 August 2017. In May 2020, Enresa applied for the Phase 1 dismantling authorisation of this nuclear power plant and the transfer of licensee status. A two-phase dismantling process has been proposed for the plant as follows: Phase 1, comprising the dismantling of the turbine building equipment, along with the evacuation of all other fuel elements that remain stored in the irradiated fuel pool, and transfer thereof to the individual storage facility; and Phase 2, which will comprise the dismantling of the rest of the nuclear power plant.

Front end of the fuel cycle

In 2020, the Juzbado nuclear fuel fabrication facility manufactured 907 fuel assemblies containing 294.1 tU. Out of this total, 770 fuel assemblies containing 230.8 tU were exported to Belgium, Finland, France and Sweden, representing 78% of the total production. Acquisitions of uranium concentrates were made from Russia (38.7%), Canada (22.3%), Niger (19.5%), Kazakhstan (11.0%), Namibia (3.7%), Uzbekistan (2.5%) and Australia (2.3%).

Back end of the fuel cycle

The Spanish strategy for the management of spent fuel (SF) and high-level waste (HLW) includes the licensing and construction of a deep geological repository (DGR) facility for the disposal of SF and HLW with a target date of 2073. Meanwhile, there are plans for the licensing and construction of a centralised storage facility (CSF). According to the Regulation on Nuclear and Radioactive Facilities, licensing starts with preliminary and construction authorisations, which Enresa applied for in January 2014. In August 2013, Enresa had submitted an application to initiate the required environmental impact assessment. However, in 2018, the licensing activities were temporarily suspended by the government to analyse in further detail the circumstances and carry out more precise planning.

In March 2020, the Ministry for the Ecological Transition and the Demographic Challenge released a draft update of the GRWP to initiate its approval procedure, which is still ongoing. The draft update includes the CSF for SF and HLW as the strategy basis, at a site to be determined by the government. It also includes the agreed nuclear power plant shutdown schedule.

Individual storage facilities (ISFs) for SF in the Trillo, José Cabrera (in the dismantling phase), Ascó, Almaraz and Santa María de Garoña nuclear power plants are in operation. An additional ISF for the Cofrentes nuclear power plant has been recently licensed. The ISF authorisation at the Santa María de Garoña nuclear power plant should be reviewed to increase its capacity to host all of its SF.

El Cabril, the facility for the management and disposal of low- and intermediate-level waste (LILW), continued routine operation in 2020. As of 31 December 2020, the inventory of radioactive waste disposed in the facility amounted to 34 927 m^3, equivalent to 80% of the total authorised capacity.

The El Cabril facility has a dedicated very low-level waste (VLLW) disposal area consisting of two constructed cells that entered into operation in 2008 and 2016. Another two cells have been authorised and together the four cells would complete the authorised capacity of 130 000 m^3. As of 31 December 2020, 19 397 m^3 had been disposed of in the facility, equivalent to 43% of the current available capacity.

Sweden

Policy changes

The 2021 charge for the nuclear waste fund is approximately SEK 0.04 per kWh. The tax on thermal capacity had been set at SEK 14 440 SEK per MW per month in 2016, which is approximately SEK 0.07-0.08 per kWh. After a 2016 energy agreement, the tax on thermal capacity was reduced to SEK 1 500 from 1 July 2017 and then removed as of 1 January 2018.

Status update of nuclear power reactors

Ringhals: In the spring of 2015, the owner decided that two of the Ringhals reactors, R1 and R2, would not continue operation for 50 years as previously indicated. On 15 October 2015, a decision was made for R1 to be shut down at the end of 2020, and R2 to be shut down at the end of 2019. On 30 December 2019, R2 shut down operations and on 31 December 2020, R1 was taken out of service.

For the remaining reactors, R3 and R4, the plan remains to continue operation to at least 60 years. A decision was made to invest in independent core cooling. Preparatory work was carried out during inspections in 2017, 2018 and 2019. In the meantime, new buildings alongside the reactors are being constructed. During the 2020 audits, all the systems were linked together. The system is designed to cope with the loss of all electricity, total loss of seawater and extreme natural phenomena.

Oskarshamn: In June 2015, the owner took a policy decision to close two of the three reactors in Oskarshamn, O1 and O2. On 14 October 2015, this decision was confirmed.

When the decision was made, the O2 reactor was in revision for major modernisation work. This decision meant that ongoing investments in O2 were interrupted and that the plant would not be restarted. O2 is thus already out of service.

On 16 February 2016, a decision was made to cease operation of O1, and thus the reactor was shut down in June 2017.

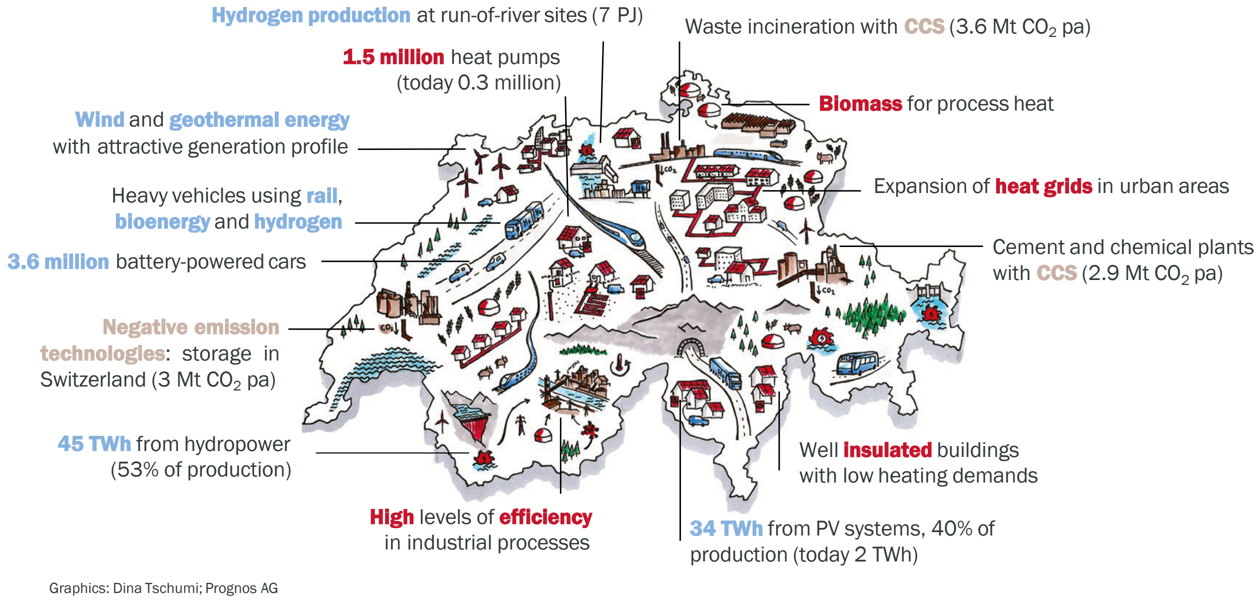
For the remaining reactor, O3, the plan remains to continue operation to at least 60 years. A decision to invest in independent core cooling systems was made in 2017 and the system is now up and running.

Forsmark: A decision to invest in independent core cooling in the three reactors at Forsmark was made in June 2016. Preparatory work was carried out during the outages in 2017, 2018 and 2019, and in the meantime, new buildings alongside the reactors are being constructed. As with Ringhals, during the 2020 inspections, all the systems were linked together. The system is designed to cope with the loss of all electricity, total loss of seawater and extreme natural phenomena.

Switzerland

Switzerland is constantly reviewing its energy landscape, taking into account the latest framework data and technology developments in the energy sector. The Swiss Federal Office of Energy (SFOE) developed an updated its report Energy Perspectives 2050+ (EP 2050+)[1]. The EP 2050+ analyses in a net-zero emissions scenario (ZERO) how to develop an energy system that is compatible with the long-term climate goal of net-zero greenhouse gas emissions by 2050 while ensuring a secure energy supply. Several variants of this scenario are considered. They differ in their combination of technologies and the speed of the renewable energy transition in the electricity sector.

The figure below shows the Energy Perspectives 2050+ and uses the latest framework data and technology developments and sets the goal of net-zero greenhouse gas emissions by 2050.



Source: See note 1 below.

Turkey

Turkey has no operating nuclear power plants currently but is planning to install 3 with a total of 12 nuclear reactor units.

The first nuclear power plant (Akkuyu Nuclear Power Plant) will comprise four units of VVER-1200-type reactors and will be constructed and operated in Mersin Province under the intergovernmental agreement signed with Russia in 2010. Construction of the first, second and third reactor units of the Akkuyu Nuclear Power Plant began in 2018, 2020 and 2021, respectively. The construction licence for the fourth reactor unit has been requested. The first unit is expected to be in operation by 2023. The other units are planned to enter commercial operation at subsequent one-year intervals until the end of 2026.

The second nuclear power plant is the Sinop project on the Black Sea coast, based on an agreement signed with Japan in 2013. However, following a feasibility study conducted by Mitsubishi Heavy Industries, the Turkish government decided not to move forward with the project and is in talks with other potential partners to develop the project. The site selection process for the third nuclear power plant is still ongoing.

1. See www.bfe.admin.ch/bfe/en/home/policy/energy-perspectives-2050-plus.html.

In July 2018, with a referendum amending the constitution, the Turkish government decided to become a presidential republic. Consequently, all governmental institutions underwent changes to adapt to the new system. Meanwhile, the Statutory Decree on Organization and Duties of Nuclear Regulatory Authority and Amendments to Certain Laws, Decree-Law No. 702 (DL 702) was issued by the cabinet on 9 July 2018 as one of the transition decree laws. DL 702 is a comprehensive nuclear law regulating nuclear safety, security, safeguards and radiological protection, and other related subjects. With DL 702, the regulation and research functions of the former Turkish Atomic Energy Agency (TAEA) were separated and an independent nuclear regulatory body, the Nuclear Regulatory Authority (NRA), was established. The former TAEA – restructured as a "subsidiary organisation" under the Ministry of Energy and Natural Resources to carry out nuclear research, waste management, training and any other related activities – was merged with the Turkish Energy, Nuclear and Mining Research Institute (TENMAK) established by Presidential Decree No. 57, which was issued by the cabinet on 28 March 2020.

DL 702 also contains provisions on general principles of and national policy on spent fuel (SF) and radioactive waste (RW) management and decommissioning (DECOM). According to DL 702, the TENMAK had to prepare a draft national radioactive waste management plan and submit it to the Ministry of Energy and Natural Resources (MENR) for approval. The national plan was approved by MENR at the end of 2020.

On the other hand, a dedicated board will be established to manage the revenue from the special funds and to approve expenses to be paid from special funds that will be opened for SF and RW management and DECOM. At present, MENR is developing regulation on the establishment of the special funds board. It covers the procedures and principles of the activities of the special funds board, including acquiring, following, collecting, accounting, and auditing revenues of the special funds and seeking recognition of special funds as an expense.

The draft law on third party liability for nuclear damage was drafted in accordance with the Paris Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, together with amendments and supplements, including the 2004 Protocol. This law was adopted by the Grand National Assembly of Turkey at the end of 2021.

United Kingdom

Recent developments in UK policy on nuclear energy

In 2020, the UK government published the Energy White Paper and the 10 Point Plan for a Green Industrial Revolution, demonstrating its commitment to the further implementation of nuclear power. Nuclear power continues to be an important source of reliable, clean electricity, supplying around 16% of the United Kingdom's total needs as of 2020.

The 10 Point Plan sets out significant funding to help develop large and smaller-scale nuclear energy as well as research and development (R&D) for advanced nuclear technology, including GBP 215 million for small modular reactors (SMRs) and GBP 170 million R&D for advanced modular reactors (AMRs). The 10 Point Plan highlights the key role of nuclear energy in delivering deep decarbonisation of the electricity system, alongside renewables and other technologies.

The Energy White Paper builds on the 10 Point Plan and sets out a vision for the transformation of the energy system, continuing to lessen dependency on fossil fuels. The United Kingdom aims to bring at least one large-scale nuclear project to the point of Final Investment Decision (FID) by the end of the current Parliament (2024), subject to clear value for money and all relevant approvals.

The UK government also published a statement of its policies for radiological safety in chapter 2 of its guidance document, "How we regulate radiological and civil nuclear safety in the UK" (www.gov.uk/government/publications/how-we-regulate-radiological-and-civil-nuclear-safety-in-the-uk). This addressed a recommendation from the International Atomic Energy Agency (IAEA) mission team following the 2019 Integrated Regulatory Review Service (IRRS) mission.

The United Kingdom remains committed to expanding diversity in the nuclear workforce. The Nuclear Sector Deal, published in 2018, seeks to address the UK skills challenges and promote a more diverse workforce. The UK government has been clear that diversity is not merely meeting the headline commitment of achieving a 40% female workforce in the nuclear sector by 2030 but also encouraging more diverse ways of thinking to enhance innovation and enable the sector to meet current and future challenges.

The UK government and Devolved Administrations are working together (via the United Kingdom's Radiological Safety Group, and its working group) to design new governance arrangements to ensure continued high value contributions to co-create and co-maintain international safety standards. In "How we regulate radiological and civil nuclear safety in the UK", the UK government published its ambitions and policy outcomes for radiological and civil nuclear safety to maintain UK leadership at the relevant international standards setting bodies, primarily the International Atomic Energy Agency (IAEA).

Some aspects of radiological safety policy, such as those relating to radioactive waste management policy, are devolved to the national administrations of Scotland, Wales and Northern Ireland. There are no nuclear power plants in Northern Ireland, nor are any planned for the future

Euratom withdrawal

On 31 December 2020, the European Atomic Energy Community (Euratom) safeguards arrangements in the United Kingdom ceased to apply; and the Office for Nuclear Regulation became the United Kingdom's nuclear safeguards regulator and part of the UK State System of Accounting for, and Control of, Nuclear Materials.

The new safeguards regime has been operating since 31 December 2020 and ensures a robust and tailored regime that reflects both UK and international requirements in applying safeguards to protect civil nuclear material. It implements the United Kingdom's new bilateral safeguards agreements with the International Atomic Energy Agency (IAEA), and the requirements in the Nuclear Safeguards (EU Exit) Regulations 2019.

The United Kingdom also signed new bilateral Nuclear Cooperation Agreements with Australia, Canada and the United States and confirmed the operability of the existing UK-Japan NCA to ensure that civil nuclear trade continues between those countries. A wide-ranging Nuclear Cooperation Agreement between the United Kingdom and Euratom was agreed and signed on 30 December 2020.

The United Kingdom has all the appropriate nuclear-specific measures in place to ensure co-operation and trade in the civil nuclear sector can continue. This sector continues to be of key strategic importance to the United Kingdom. The United Kingdom's withdrawal from Euratom has in no way diminished the country's nuclear ambitions or its commitment to global nuclear security, safety and non-proliferation.

Legislative and regulatory changes

The European Union (Withdrawal Agreement) (Relevant International Agreements) (EU Exit) Regulations 2020 was laid out in September 2020. It is a statutory instrument ensuring that the United Kingdom complies with provisions relating to nuclear safeguards in the Withdrawal Agreement after Euratom regulations ceased to apply in the United Kingdom.

Under Article 37 of the Euratom Treaty, member states are required to submit data on radioactive waste disposal plans to the European Commission. Following the end of the Transition Period, the Euratom Treaty no longer applies to the United Kingdom. The United Kingdom has replicated certain elements of the process to provide continued transparency on plans (and amendments to plans) for radioactive waste disposal. Directions have been made in both England and Scotland, which require that the relevant regulator in determining certain applications considers whether the planned disposal of radioactive waste is liable to result in transboundary radioactive contamination. The Transfrontier Shipment of Radioactive Waste and Spent Fuel (Amendment) (EU Exit) Regulations 2020 were laid on 14 October 2020. The statutory instrument amends the Transfrontier Shipment of Radioactive Waste and Spent Fuel (EU Exit) Regulations 2019 to implement the Protocol on Ireland/Northern Ireland to the Withdrawal Agreement ("the Protocol"). The Protocol requires that the EU Council Directive 2006/117/Euratom (the "Euratom Directive") shall continue to apply to the United Kingdom with respect to Northern Ireland from the end of the transition period. The instrument amends the 2019 Regulations to provide for continued application of the Euratom Directive in Northern Ireland and to change references to "exit day" in the 2019 Regulations to "IP completion day".

Future development of nuclear energy

As part of the commitments outlined above, the UK government is contributing up to GBP 215 million to develop a domestic SMR design that could potentially be built in factories and then assembled directly on site. It is expected to unlock up to GBP 300 million in private sector match-funding. As the first major commitment of the programme, the United Kingdom announced in 2021 that it was opening the Generic Design Assessment (GDA) to SMR technologies (www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies).

The GDA is one of the facilitative actions set out in the Energy White Paper 2020 and is being undertaken by the Office for Nuclear Regulation (ONR) and the Environment Agency (EA). The GDA is a voluntary process that allows regulators to begin consideration of the generic safety, security and environmental aspects of designs for nuclear power plants prior to applications for site-specific licensing and planning consents. Any reactor deployed in the United Kingdom must meet the United Kingdom's robust and independent regulatory requirements, which include meeting design safety requirements via the GDA process.

The UK government is also committing up to GBP 170 million for an R&D programme on AMRs. The aim is to build a demonstrator by the early 2030s at the latest to prove the potential of this technology.

To help bring these technologies to market, the United Kingdom will invest an additional GBP 40 million in developing the regulatory frameworks and supporting UK supply chains.

The United Kingdom has also committed GBP 400 million towards fusion R&D programmes. While fusion is not currently expected to play a significant role in energy generation before 2050, it is expected to play an important role in sustaining net zero over the longer-term.

The Scottish government has made clear it will not grant planning consent to any forthcoming proposal to build new nuclear power plants in Scotland under current technologies, though it recognises that lifetime extensions for the pre-existing operational power stations could help maintain security of supply while the transition to renewable and alternative thermal generation takes place.

The Welsh government is supportive of new build on former nuclear sites, having recognised the job creation, supply chain development, and research and innovation potential of the sector. The Welsh government is in the process of creating a new site development company (Cwmni Egino) at the former nuclear power plant site at Trawsfynydd, which will pursue a first-of-a kind SMR deployment within the United Kingdom at the site location.

There are no nuclear power plants in Northern Ireland, nor are any planned.

New build power plants

The UK government decided to proceed with Hinkley Point C in September 2016, signing contracts with EDF, China General Nuclear Power Group (CGN) and the development vehicle, NNB Generation Company (HPC) Limited, to enable the investors to build two EPR reactors at the site (3.2 GW).

These contracts include directing the Low Carbon Contracts Company to offer a contract for difference for Hinkley Point C with a strike price of GBP 92.50 per megawatt hour. EDF has confirmed construction remains on track to meet their target of commissioning the first unit in 2026. Hinkley Point C will deliver around 7% of the country's current electricity needs.

With the existing nuclear reactors largely retiring over the next decade, the United Kingdom is aiming to go further to meet its net zero targets. The United Kingdom is aiming to bring at least one further large-scale nuclear project to the point of Final Investment Decision by the end of this Parliament (2024), subject to clear value for money for consumers and taxpayers and all relevant approvals. In January 2021, the United Kingdom entered into negotiations with EDF in relation to the Sizewell C project in Suffolk.

In December 2020, the United Kingdom published the response to the consultation on a Regulated Asset Base (RAB) model for private investment in new nuclear generation. Having assessed the consultation responses, the UK government believes that a RAB model remains a credible model for large-scale nuclear projects. The UK government is continuing to explore a RAB model with developers. It will also continue to consider the potential role of government finance during construction, provided there is clear value for money for consumers and taxpayers, subject to all relevant approvals.

Waste management policy

The UK government is committed to implementing geological disposal for the long-term, safe and secure management of higher activity radioactive waste. A process for identifying a suitable site for a geological disposal facility (GDF) is underway in England and Wales. This is focused on a consent-based approach that requires a willing community to be a partner in the project's development. Two working groups have been formed and more are anticipated. This is the first formal step in the process. It is focused on fact-finding and identifying the geographical area in which Radioactive Waste Management Ltd (RWM), the developer, will search for a potentially suitable site. No sites have yet been selected.

Northern Ireland's response to the 2018 consultation, Implementing Geological Disposal – Working with Communities, was published in January 2019. Northern Ireland is not participating further in this stage of the process to identify a site for a GDF and there are no plans to site a GDF in Northern Ireland.

The Scottish government has a distinct policy for the management of higher activity radioactive waste. This policy, published in 2011, stipulates that the long-term management of higher activity radioactive waste should be in near-surface facilities. Facilities should be located as near to the site where the waste is produced as possible. For safety reasons, developers in Scotland will need to demonstrate how the facilities will be monitored and how waste packages or the waste, could be retrieved. All long-term waste management options will be subject to robust regulatory control.

In 2016, the Scottish government published an Implementation Strategy on waste management decisions, expanding on the framework provided by its 2011 policy, to ensure that relevant policy is implemented in a safe, environmentally acceptable and cost-effective manner. The Implementation Strategy includes an illustrative timeline towards a long-term solution for the final disposal of waste.

United States

General policy changes relevant for nuclear energy

The US Department of Energy (DOE) recently released its Fiscal Year 2022 (FY22) Congressional Budget request, which seeks a record USD 1.8 billion for the Office of Nuclear Energy (NE) (www.energy.gov/articles/statement-energy-secretary-granholm-presidents-us-department-energy-fiscal-year-2022). The NE's budget request is more than 50% higher than the FY21 request, and is the largest request ever made by the office. In accordance with the government's priorities for nuclear energy, the request recognises the role new reactors could play in helping to mitigate climate change and the need for investments to deploy new technologies to market.

The FY22 request includes nearly USD 700 million to help drive innovative US advanced reactor technologies to market within the decade. That includes USD 245 million to support the demonstration of two US reactors (www.energy.gov/ne/articles/us-department-energy-announces-160-million-first-awards-under-advanced-reactor) in the near future and USD 305 million to support the maturation of additional reactor designs (www.energy.gov/ne/articles/infographic-advanced-reactor-development). It will also further develop microreactors and small modular reactor technologies.

Nuclear energy generates 20% of the nation's electricity and more than half of its carbon-free power (www.energy.gov/ne/articles/5-fast-facts-about-nuclear-energy). To further drive the government's goal of cutting US electricity emissions in half by 2030, the FY22 budget request seeks USD 175 million to help improve the economics for current nuclear reactors. This includes USD 115 million to further develop new accident tolerant fuels that have the potential to improve the performance of today's reactors and reduce fuel costs over a reactor's lifetime (www.energy.gov/ne/articles/these-accident-tolerant-fuels-could-boost-performance-todays-reactors).

Nuclear energy policy changes

The US Nuclear Regulatory Commission (NRC) recently approved Centrus Energy's request to make high-assay low-enriched uranium fuel (HALEU) at its enrichment facility in Piketon, Ohio. The plant is currently the only licensed HALEU production facility in the United States.

The US DOE is supporting a three-year, USD 170 million cost-shared demonstration project with Centrus (www.energy.gov/ne/articles/department-energy-preps-fuel-advanced-reactors). The company has already built 16 advanced centrifuge machines for uranium enrichment and expects to begin HALEU production by early next year.

The amended licence allows the facility to produce HALEU by enriching uranium up to 20% with uranium-235 – the main fissile isotope that produces energy during a nuclear reaction. Current reactors are typically enriched up to 5%. Under the DOE demo project, the company will provide up to 600 kilograms of HALEU by June 2022. The material will be used to support the testing and demonstration of new reactor designs.

Main events in the field of nuclear energy

TerraPower recently announced plans to build its Natrium reactor at a retiring coal plant in Wyoming, which currently receives almost 90% of its electricity generation from fossil fuels. The Natrium design represents the future of advanced nuclear reactor technology and is well-suited to provide clean and efficient power to communities across the United States, including the Mountain West. The US DOE is investing nearly USD 2 billion to support the licensing, construction and demonstration of this first-of-a-kind reactor by 2028 (www.energy.gov/ne/articles/its-time-united-states-demonstrate-advanced-reactors).

TerraPower leads one of two teams awarded initial funding through the Advanced Reactor Demonstration Program to test, licence and build an advanced reactor within the next seven years (www.energy.gov/ne/articles/us-department-energy-announces-160-million-first-awards-under-advanced-reactor). The Natrium reactor offers significant improvements over today's nuclear power plants and will help set the tone for a new portfolio of US advanced reactors under development to ultimately compete in the US and global markets (www.energy.gov/ne/articles/infographic-advanced-reactor-development).

Once it is in operation, the Natrium plant is estimated to produce nearly 3 million megawatt hours of carbon-free power each year and avoid emission of almost 2 million tonnes of carbon. It will also avoid emission of other pollutants that lead to smog and acid rain to improve the overall air quality in the region.

The Western United States currently has three nuclear power plants in operation. By siting this advanced reactor in Wyoming, TerraPower is also expanding access to communities in the state and the Mountain West that have not had the opportunity to benefit from the clean and reliable attributes of nuclear power.

Reporting organisations and contact persons

We would like to thank our numerous contacts worldwide in national administrations and in public and private companies for their helpful co-operation.

NEA	Nuclear Technology Development and Economics Luminita Grancea (*Scientific Secretary*) / Hiroyuki Goto
Australia	Department of Industry, Science, Energy and Resources Caitlin McCluskey / Valerija Tot
Austria	Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology Thomas Augustin
Belgium	FPS Economy, SMEs, Self-Employed and Energy Alberto Fernandez Fernandez Synatom Françoise Renneboog
Bulgaria	Ministry of Energy Marina Kadreva
Canada	Natural Resources Canada Daniel Brady
Colombia	Unidad de Planeacion Minero Energetica (UPME) Christian Jaramillo Subdirección de Energía Eléctrica William Martinez / Jhon Zarate
Czech Republic	Ministry of Industry and Trade Sebastián Poche
Denmark	Danish Energy Agency Ali Zarnaghi
Estonia	Ministry of Economic Affairs and Communications – Energy Department Irje Möldre
Finland	Ministry of Economic Affairs and Employment Jorma Aurela
France	French Alternative Energies and Atomic Energy Commission Sophie Gabriel
Germany	Federal Ministry for Economic Affairs and Energy Fernando Oster
Greece	Regulatory Authority for Energy Marina Kapsali
Hungary	Hungarian Atomic Energy Authority Gábor Körmendi
Ireland	EirGrid plc – Transmission System Operator
Israel	Public Utility Authority (PUA) Muhamad Haj Yihia

Japan	Ministry of Economy, Trade and Industry Anna Kiyokawa
Korea	Korea Nuclear International Cooperation Foundation Myungsook AN
Latvia	Ministry of Economics of Latvia Ilze Margeviča
Luxembourg	National Institute of Statistics and Economic Studies of the Grand Duchy of Luxembourg Olivier Thunus
Netherlands	Ministry of Economic Affairs and Climate Policy Hedwig Sleiderink
Norway	Norwegian Ministry of Petroleum and Energy Erlend Røshol Åsheim
Poland	Ministry of Climate and Environment Krzysztof Szymański
Portugal	Directorate General for Energy and Geology (DGEG) Manuela Fonseca
Romania	Nuclear Agency and Radioactive Waste Eugen Banches / Georgiana Ramona Popescu
Russia	ROSATOM Alexey Prosyanov
Slovak Republic	Ministry of Economy of the Slovak Republic Martin Vanek
Slovenia	Krško Nuclear Power Plant Andrej Kavčič / Igor Grlicarev
Spain	Ministry for the Ecological Transition and the Demographic Challenge Irene Dovale Hernandez
Sweden	Ministry of Infrastucture, Division for Energy Björn Telenius Swedish Energy Agency Anna Andersson
Switzerland	Swiss Federal Office of Energy Ralf Straub
Turkey	Ministry of Energy and Natural Resources Çisem Tuba Ünaldi
United Kingdom	Department for Business, Energy and Industrial Strategy (BEIS) John Bilton
United States	Energy Information Administration Slade Johnson

NEA publications and information

The **full catalogue of publications** is available online at www.oecd nea.org/pub.

In addition to basic information on the Agency and its work programme, the **NEA website** offers free downloads of hundreds of technical and policy-oriented reports. The professional journal of the Agency, **NEA News** – featuring articles on the latest nuclear energy issues – is available online at www.oecd-nea.org/nea-news.

An **NEA monthly electronic bulletin** is also distributed free of charge to subscribers, providing updates of new results, events and publications. Sign up at www.oecd-nea.org/bulletin.

Visit us on **LinkedIn** at www.linkedin.com/company/oecd-nuclear-energy-agency or follow us on **Twitter @** OECD_NEA.

STATLINKS

This publication contains “StatLinks”. For each StatLink, the reader will find a URL which leads to the corresponding spreadsheet. These links work in the same way as an Internet link.

OECD/NEA PUBLISHING, 2 rue André-Pascal, 75775 PARIS CEDEX 16

Nuclear Energy Data – 2021

Nuclear Energy Data is the Nuclear Energy Agency's annual compilation of statistics and country reports documenting nuclear power status in NEA member countries and in the OECD area. Information provided by governments includes statistics on total electricity produced by all sources and by nuclear power, fuel cycle capacities and requirements, and projections to 2040, where available. Country reports summarise energy policies, updates of the status in nuclear energy programmes and fuel cycle developments.

In 2020 and 2021, the COVID-19 pandemic has highlighted the importance of electricity security in modern societies. Although the long-term implications for electricity generation are difficult to assess, during the crisis nuclear power continued to support the security of supply and has been, together with renewables, one of the most resilient low-carbon electricity sources. Governments committed to having nuclear power in the energy mix advanced plans for developing or increasing nuclear generating capacity, including plans for small modular reactor and advanced reactors. Further details on these and other developments are provided in the publication's numerous tables, graphs and country reports.

This publication contains "StatLinks". For each StatLink, the reader will find a URL which leads to the corresponding spreadsheet. These links work in the same way as an Internet link.

Nuclear Energy Agency (NEA)
46, quai Alphonse Le Gallo
92100 Boulogne-Billancourt, France
Tel.: +33 (0)1 73 21 28 19
nea@oecd-nea.org www.oecd-nea.org

NEA No. 7608