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Nuclear Energy in Finland[2]

Abstract

Finland has an ambitious decarbonisation agenda aiming for climate neutrality by 2035. The country relies significantly on nuclear power to meet its energy needs. Finland operates five nuclear reactors across two power plants, with a combined capacity of over 4,000 MWe. Finland is also a global leader in nuclear waste management, hosting the world's first permanent underground repository for spent nuclear fuel at Onkalo. This article provides a comprehensive overview of nuclear energy in Finland, focusing on its current state, regulatory framework, and future prospects. The regulatory framework governing nuclear energy in Finland is robust, involving multiple authorities and a detailed licensing procedure. Recent trends indicate a growing interest in small modular reactors for district heating and power production, necessitating potential legislative reforms to accommodate these technologies.

Keywords: nuclear, small modular reactors, decision-in-principle, nuclear waste management

1. Introduction

Finland is an EU member state located in Northern Europe, with neighbouring countries Norway, Sweden, Estonia, and Russia. The country has a vast land area covered in forests and lakes. It is scarcely populated, with the majority of the population located in the south. Finland has relatively long winters, with several months of cold, sometimes even extreme cold, periods, with a milder climate in the south. In 2023, electricity consumption in Finland was about 14,000 kWh/yr per capita.[3]

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3 | IEA.

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Finland features a highly developed and predominantly free-market economy. This economic structure is marked by significant industrialisation and a high standard of living, combined with a Nordic welfare state model, as evidenced by the high gross domestic product per capita.

Finland also has a very ambitious decarbonisation agenda: climate neutrality by 2035.[4] This objective is part of a broader strategy to transition to a low-carbon economy. Naturally, this objective has wide implications for the energy sector as well. The climate neutrality target also foresees the complete phase-out of coal by 2029. As a result, some coal-fired power production facilities have already been shut down.[5]

Finland participates in the Nordic wholesale electricity market, Nord Pool, which encompasses the Nordic countries as well as the Baltic States. Following the enactment of the Electricity Market Act (588/2013) in 1995, Finland's electricity market underwent a gradual liberalisation process. By late 1998, this deregulation allowed all electricity consumers, including private households, to select their preferred electricity suppliers.

A unique national characteristic of the country is that energy-intensive industries have invested heavily in large-scale energy production. Energy-intensive companies have adopted a strategy of jointly investing in electricity production facilities, selling power to shareholders at a cost price. This financing method, known as the Mankala model, helps mitigate the impact of rising prices and market volatility in liberalised electricity markets, effectively distributing risk.[6] Approximately one-third of the electricity produced in Finland is produced under the Mankala model.[7] The Mankala model was also significant in the 1970s, enabling the financing of the first major nuclear power facility projects in Finland.

These characteristics of Finland have dictated the choices made in the country's energy sector. The national energy mix is very diversified, relying on multiple sources of energy. The current electricity generation in Finland relies on nuclear and hydropower, in particular. Figure 1 illustrates the electricity generation sources in Finland in 2023.[8]

4 | State Treasury 2021.
5 | See e.g. Helen 2021.
6 | On the Mankala principle and competition law, see Talus and Guimaraes-Purokoski 2011.
7 | TVO 2023.
8 | IEA.

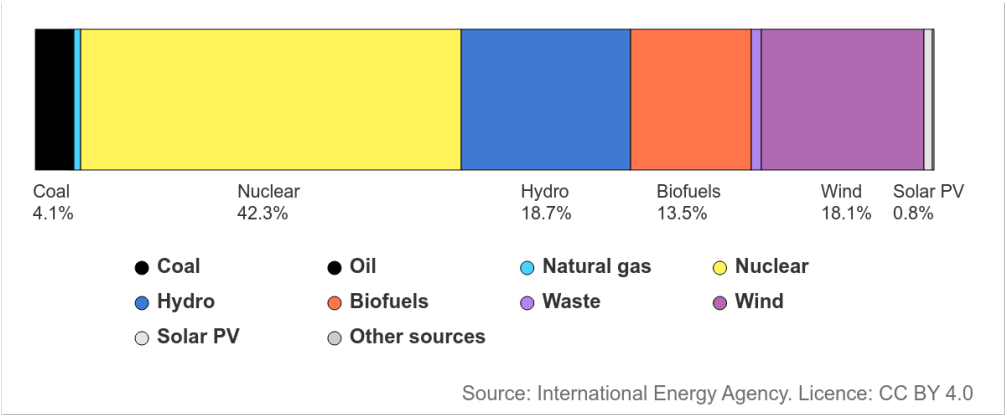

Figure 1. Electricity generation sources, Finland, 2023

This article discusses the current state of play regarding the regulation of nuclear energy in Finland.[9] The following section, Section 2, provides an overview of the nuclear reactors in Finland. Section 3 discusses the current institutional and legislative framework on nuclear energy, whereas Section 4 details the licensing framework for nuclear energy. Section 5 provides an overview of the nuclear waste management and the state-of-the-art final nuclear waste disposal facility in Finland. Section 6 discusses some recent trends that have led to the discussion on the need for legislative reforms before conclusions.

2. Nuclear reactors in Finland

Finland currently has five nuclear reactors in operation. Two reactors are in a nuclear power plant in Loviisa in southern Finland, and three in the Olkiluoto Nuclear Power Plant in the south-west of Finland. The total capacity of these reactors is 4,394 MWe.

Both of the Loviisa reactors and Olkiluoto 3 are pressurised water reactors, whereas Olkiluoto 1 and 2 are boiling water reactors. Loviisa 1 was the first nuclear reactor in Finland. It was brought online in 1977, with Loviisa 2 following in 1980. The peculiarity of Loviisa nuclear facility is that, while the reactors are Russian pressurised water reactors, they were modified at the request of the owner to comply with Western safety standards of the day.[10] Loviisa Nuclear Power Plant is owned and operated by Fortum, a large energy utility with main operations in the

9 | On the development of nuclear law in the EU, see Engstedt 2020; on the regulation of nuclear power at an international level, see Negri della Torre 2020, 565–568.
10 | Hyvärinen, Riikonen, Telkka, Hujala, Kouhia et al. 2024, 112935.

Nordics. Both Loviisa 1 and 2 reached their original design lifetime of 30 years in 2007 and 2010, respectively. Both reactors were granted a lifetime extension, i.e. new operating licenses in 2007, allowing the Loviisa nuclear facility to continue operation until the end of 2050.[11]

Loviisa nuclear facilities will undergo a modernisation process starting in 2026, which is planned to be carried out in conjunction with the normal annual outages. The project entails the replacement of eight low-pressure turbine housings and their internal components. This process is expected to substantially enhance the efficiency of the facility's electricity generation, while maintaining the reactor's thermal output at its current level.[12] In addition, steam turbines' protection systems and control systems are being upgraded as the current systems are reaching the end of their technical service life, and the availability of spare parts is limited.[13] These modernisation projects rely on a multi-package contract model, involving multiple contracts for different aspects of the project, allowing for greater flexibility and the involvement of various specialised contractors.

Olkiluoto 1 and 2 are identical nuclear reactors. Power production in Olkiluoto 1 started in 1978 and Olkiluoto 2 in 1980. Olkiluoto Nuclear Power Plant is owned and operated by an energy company, Teollisuuden Voima (TVO). The construction of the Olkiluoto 3 reactor began in 2005. The plant supplier consortium companies Areva NP, Areva GmbH, and Siemens AG, as well as the Areva Group parent company Areva SA, built the plant unit according to a fixed-price turnkey contract.[14] Olkiluoto 3 became a world-famous project for being delayed by over 10 years from its original schedule.[15] It was initially planned to be completed in 2009, and finally to go online in 2022. The reactor is currently the biggest nuclear reactor in Europe, with a net capacity of 1,600 MWe, making it a part of the top ten also on a global scale.[16] Figure 2 illustrates the evolution of electricity generation sources in Finland since 2000.[17] The sharp spike in nuclear energy production is due to Olkiluoto 3 finally coming online in 2022. Wind has also increased its share in the generation mix, while hydro has served and continues to serve as the backbone of the electricity generation portfolio.

11 | Valtioneuvoston päätös 2023.
12 | Fortum 2024a.
13 | Fortum 2024b.
14 | TVO 2021.
15 | Vanttinen 2020.
16 | Statista.
17 | IEA.

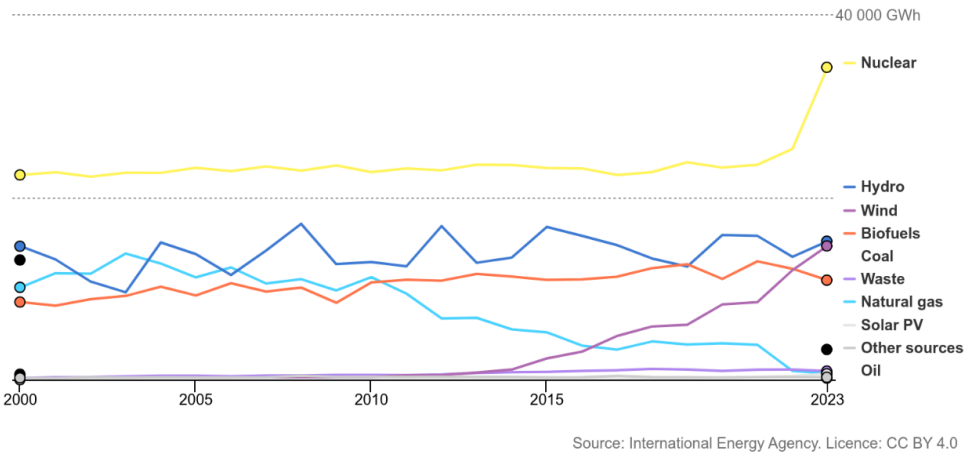

Figure 2. Evolution of electricity generation sources in Finland since 2000.

In addition to actively increasing the share of nuclear energy by building new reactors, Finland also hosts the world's first permanent underground repository for nuclear waste, discussed in more detail in Section 4.

In addition to these commercial-scale power production facilities, a 250-kW reactor was commissioned in 1962 from the USA for research and educational purposes. Furthermore, towards the end of its operational life, it was also used for healthcare. Located on the Aalto University campus in Otaniemi, the reactor was shut down in 2015 and provided much-needed know-how concerning the decommissioning of a nuclear facility.[18]

In March 2020, Fortum, the owner of the Loviisa facility, entered into an agreement with VTT[19], the owner of the research reactor. Following the agreement, the planning and approval processes for the demolition commenced. As the main contractor, Fortum was responsible for decommissioning planning, preparatory measures, reactor decommissioning, and waste management, including the final disposal of radioactive decommissioning waste. VTT managed the transportation of spent fuel to the US for further use – an exception allowed under the Nuclear Energy Act for research reactors.[20]

Nuclear power production facility construction can follow various approaches, the first most common one being a so-called turnkey project (Engineering, Procurement, and Construction) where the facility supplier or a consortium takes full responsibility for the project's implementation. The second most common

18 | Radiation and Nuclear Safety Authority.
19 | VTT.
20 | Fortum 2024c.

approach is decentralised procurement, where the owner manages the project and is responsible for ensuring the overall functionality of the facility. In the 1970s, both procurement procedures were relied on in Finland for nuclear new builds. The initial owner of the Loviisa nuclear facility, Imatran Voima Oy, constructed the Loviisa facility by using a decentralised procurement approach. The reason for this is that the then-Soviet main equipment supplier would not take overall responsibility for modifying the plant to meet Western safety standards. On the other hand, TVO built the Olkiluoto 1 and 2 units with the Swedish company Asea Atom, which delivered the plans on a turnkey basis. Olkiluoto 3 was also purchased as a turnkey facility, but as described above, it suffered from serious challenges in terms of implementation.[21]

As there are no active uranium mines, Finland relies on an external fuel supply. TVO sources uranium for its nuclear facilities from Canada, Australia, and Kazakhstan. Fuel fabrication takes place in Germany, Sweden, and Spain.[22] Fortum's Loviisa nuclear facilities were fueled by a Russian fuel supply, but in November 2022, Fortum partnered with American company Westinghouse to develop, license, and provide a new fuel type for the Loviisa Nuclear Power Plant.[23] One of the permit conditions for the extension of the operating licenses for Loviisa units was to ensure the diversification of fuel supplies.[24]

Under the Nuclear Energy Act, exporting spent fuel is prohibited, and Finland lacks a spent nuclear fuel reprocessing facility. Additionally, it has been held that reprocessing is not economically feasible for Finnish nuclear power plants at current prices and that the small amount of used fuel generated in Finland makes reprocessing not cost-effective.[25]

In the 2000s, there were two nuclear projects planned. The first one, a consortium of 67 companies, led by E.On and Voimaosakeyhtiö SF formed Fennovoima Ltd to build a new nuclear power plant in Finland. A decision-in-principle was granted to the consortium, and the project came to be Hanhikivi 1 project, located in Pyhäjoki, on the Gulf of Bothnia, in 2010.[26] E.On left the project in 2012, reducing its potential capacity.[27] In 2013, Fennovoima signed a contract with Rusatom Overseas for an AES-2006 reactor (different from the one originally approved for Fennovoima's nuclear plant), and Rusatom acquired a 34% share in Fennovoima.[28] Local stakeholders committed 50.2% of the plant. By mid-2015, Finnish ownership was confirmed at 65.1%. Major excavation began in 2016, with the Russian Titan-2

21 | Hujala, Hyvärinen, Rintamaa, Suikkanen et al. 2022, 64.
22 | TVO.
23 | Fortum 2024d.
24 | Valtioneuvoston päätös 2023.
25 | TVO.
26 | Valtioneuvoston periaatepäätös 2010.
27 | World Nuclear News 2012.
28 | Yle 2023.

as the general contractor.[29] The Russian invasion of Ukraine in 2022 posed significant risks, leading to the termination of the EPC contract with Rusatom. The project faced numerous challenges, including changes in ownership, design modifications, geopolitical issues, and delays, ultimately leading to its uncertain future.[30]

In 2008, TVO sought approval to construct a new nuclear unit, Olkiluoto 4, with a capacity ranging from 1000 to 1800 MWe. The decision-in-principle was granted in May 2010.[31] TVO evaluated several reactor designs, formal bids were requested in March 2012, and five proposals were received by January 2013.[32] Initially, TVO planned for the unit to be operational by 2020. However, delays with Olkiluoto 3 project led TVO to request a five-year extension of the government approval in 2014. This extension was not granted, leaving TVO with a deadline of June 2015 to apply for a construction license.[33] Due to the ongoing delays with Olkiluoto 3, TVO concluded that it was not feasible to make the necessary decisions for Olkiluoto 4 within the given timeframe. Consequently, TVO decided not to proceed with the project at that time, although it acknowledged the importance of Olkiluoto 4 and expressed an intention to seek a new decision-in-principle in the future.[34]

Currently, there are no ongoing nuclear power projects in Finland. Despite this, nuclear energy plays a crucial role in Finland's energy portfolio, from the security of supply and the decarbonisation perspectives. The public perception of nuclear power as an energy source was at an all-time high in a study made in 2023. This was most likely due to the energy crisis that led to high electricity prices, together with the Russian invasion of Ukraine. These events underlined the importance of domestic energy sources from the energy security perspective, and with the regular electricity production starting in Olkiluoto 3 with approximately 1,600 MW, it had an impact on the prices as well.

3. An overview of the competent authorities and the legislative framework on nuclear energy

3.1. The competent institutions

The Government is the ultimate decision-making body, responsible for all critical decisions regarding the utilisation of nuclear energy, whereas the Ministry of Economic Affairs and Employment (hereinafter referred to as the Ministry) holds the primary authority over nuclear energy matters in Finland at a more practical

29 | Yle 2015.
30 | Fennovoima 2022.
31 | Valtioneuvoston periaatepäätös 2010.
32 | TVO 2013.
33 | TVO 2014.
34 | Arola 2015.

level. Pursuant to the Nuclear Energy Act – the main legislative instrument regulating nuclear energy in Finland – the Ministry is responsible for formulating licensing decisions pertaining to the construction and operation of nuclear facilities in Finland, before submitting them to the Government for approval. Additionally, the Ministry ensures the Nuclear Energy Act is up to date and proposes legislative enhancements to the government for decision-making.

The Ministry acts as Finland's representative in international nuclear energy organisations and engages in negotiations concerning international agreements within this sector. Additionally, it oversees and monitors the implementation of these international agreements.

Nuclear waste management and the safe operation of nuclear energy are the most critical components of regulating nuclear energy use. The Ministry directs and oversees the planning and execution of nuclear waste management, ensuring compliance with national requirements and international regulations.

The Nuclear Energy Act also acknowledges the pivotal role of the Ministry of the Environment as the primary and coordinating authority for environmental issues.

Official duties are carried out both within the Ministries and their subordinate organisations with a commitment to official responsibility. Independence is ensured under the Act on Public Officials in Central Government (750/1994), which requires that public servants exercising public power must strictly comply with the law, act in a neutral, independent and impartial manner, and observe the secrecy obligation. Public servants are subject to liability for acts in the office. Therefore, operations are free from political influence and adhere to the principles of legality and good governance.

In addition to the Ministry, another important institution is the Radiation and Nuclear Safety Authority, the main competence of which relates to the other critical component of nuclear energy regulation, safety. The Radiation and Nuclear Safety Authority's aim is to mitigate and prevent the adverse effects of radiation. The primary objective of the Authority is to ensure that the radiation exposure of the Finnish population is minimised to the lowest feasible levels through the application of practical measures, adhering to the ALARA principle (As Low As Reasonably Achievable). Additionally, the Authority aims to prevent radiation and nuclear incidents with a very high degree of certainty, in accordance with the SAHARA principle (Safety As High As Reasonably Achievable).[35] The Radiation and Nuclear Safety Authority is an independent state administrative. The independence of the organ is ensured in Section 1(2) of the Radiation Act (1164/2022).

The Radiation and Nuclear Safety Authority monitors compliance with the Radiation Act (859/2018), the Nuclear Energy Act (990/1987), and the decrees issued

35 | Ojanen, Ollikkala, Reiman, Ruokola and Tiippana 2004.

pursuant to them. It also participates in the preparation of regulations and issues statements in the preparation of regulations concerning its industry. Based on Section 7q of the Nuclear Energy Act, the Radiation and Nuclear Safety Authority also has the authority to issue more detailed regulations on the technical details of the principles and requirements.[36]

Furthermore, according to Section 7r of the Nuclear Energy Act, the Radiation and Nuclear Safety Authority shall specify detailed safety requirements concerning the implementation of the safety level. The guiding principle in drafting new safety requirements is enshrined in Section 7a of the Nuclear Energy Act, according to which the safety of nuclear energy use shall be maintained at as high a level as practically possible. According to Section 7r(3) of the Nuclear Energy Act, the safety requirements of the Radiation and Safety Authority are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations.

The Radiation and Nuclear Safety Authority is supported by four advisory committees, consisting of external members. Most important from the perspective of the use of nuclear energy is the Advisory Committee on Nuclear Safety, which is appointed by the Government. According to the Decree on the Advisory Committee on Nuclear Safety (164/1988), it is an advisory body involved in the preparation of issues pertaining to the safety of nuclear energy.

3.2. The legislative framework

The Nuclear Energy Act (990/1987) is the primary legislative instrument that governs nuclear energy production, first adopted in 1987. The Act repealed the Act on Atomic Energy (356/1957), adopted in 1957. According to Section 2 of the Act, it applies to the following nuclear-related activities:

(1) the construction, operation and decommissioning of a nuclear facility;
(2) mining and milling operations aimed at producing uranium or thorium;
(3) the possession, manufacture, production, transfer, handling, use, storage, transport and import of nuclear material;
(4) the possession, manufacture, production, transfer, handling, use, storage, transport and import of nuclear material;
(5) disposal of nuclear waste that is of a lesser extent than large-scale disposal of nuclear waste;
(6) in cases to be provided for by a government decree, the possession, manufacture, assembly, transfer and import of certain materials, devices, equipment, or information, should they prove pertinent to the proliferation of

36 | For example, based on the authorisation, the Radiation and Safety Authority has issued regulations on nuclear power plant safety (STUK Y/1/2018), contingency arrangements (STUK Y/2/2018), security arrangements for the use of nuclear energy (STUK Y/3/2020), nuclear waste disposal safety (STUK Y/4/2018), and the safety of mining and beneficiation of uranium or thorium (STUK Y/5/2016).

nuclear weapons or should the obligations under Finland's international treaties in the field of nuclear energy have a bearing on them; and
(7) export and import of uranium-containing or thorium-containing ores.

The Nuclear Energy Act aims to achieve two primary objectives: (1) to ensure that the use of nuclear energy aligns with the overall good of Finnish society, and (2) to ensure that the utilisation of nuclear energy is safe for the population and the environment. To reach this objective, the Act lays down provisions on the general principles for the use of nuclear energy, the implementation of nuclear waste management, the licensing and control of the use of nuclear energy, and the competent authorities.

The above-mentioned objectives constitute the general principles of the Nuclear Energy Act. According to these principles, the utilisation of nuclear energy must serve the overall benefit of Finnish society (Section 5 of the Nuclear Energy Act) and ensure safety, avoiding harm to individuals, the environment, and property (Section 6 of the Nuclear Energy Act). Furthermore, Section 4 prohibits the import of nuclear explosives, their manufacture, possession, and detonation in Finland. Given the numerous facets involved in large nuclear energy projects, it is deemed justified that the regulation of nuclear energy use prioritises the overall benefit of society. This concept of overall benefit was novel in legislative terms, introduced upon the adoption of the Nuclear Energy Act. Defining this concept necessitates careful consideration of its appropriateness.

The Nuclear Energy Act also lists the obligations of the operator of the facility. The most important of these are the responsibility for the safety of the use of nuclear energy, the obligation to take care of security and preparedness arrangements and other arrangements necessary to limit nuclear damage that do not fall within the scope of responsibility of the authorities, the obligation to take care of nuclear waste management, and the obligation to cover the costs of nuclear waste management.

In the context of nuclear waste management, the general principles enshrined in the Nuclear Energy Act also provide rules on the management of nuclear waste generated in Finland. According to Section 6a of the Nuclear Energy Act, as the main rule, nuclear waste generated in connection with or because of the use of nuclear energy in Finland must be handled, stored, and permanently disposed of in Finland. Because of this provision, Finland is globally the forerunner in nuclear waste management, discussed in more detail in Section 4.

The Nuclear Energy Act is complemented by the Nuclear Energy Decree (161/1988), providing more detailed rules on certain measures. In addition, to the extent necessary, the Government is required to issue general regulations concerning the safety of nuclear energy use, regulations on security, emergency arrangements, and rescue services. The supervisory authority, the Radiation and Nuclear Safety Authority, is authorised to provide detailed regulations on the use

of nuclear energy and establish specific requirements for operations as stipulated by in the permitting procedure. Additionally, the license holder is bound by the conditions introduced in the licences.

The new Radiation Act (859/2018) entered into force on 15 December 2018. Together with related decrees, it transposes the obligations arising from the EU's Basic Safety Standard Directive on radiation protection[37] into the national legislation. The main objective of the Act is therefore to protect health from any harm caused by radiation. In addition to health protection, the Act seeks to prevent and reduce environmental harm and any other harm caused by radiation. Section 2a of the Nuclear Energy Act further specifies the provisions of the Radiation Act that apply to the use of nuclear energy.

Finally, the Nuclear Liability Act (484/1972) mandates that the licensee must maintain nuclear liability insurance to compensate for injuries sustained by third parties as a result of a potential nuclear accident in accordance with the requirements set out in the law.

4. Nuclear licensing in Finland

4.1. Energy infrastructure licensing framework

The Finnish permitting framework is characterised by the involvement of multiple authorities, each operating under distinct legislative mandates. Various permits and authorisations are required for different infrastructure projects, with several sector-specific authorities responsible for processing these applications. The specific steps, assessments, and permits necessary for the approval of energy infrastructure projects are contingent upon the project's nature. While the procedural steps are largely consistent across infrastructure projects, variations arise due to factors such as project location and the specific works required.

Throughout the permitting process, particularly during the pre-permitting stage but also subsequently, there is active collaboration between the permitting authorities and project promoters. This collaboration includes informal meetings and guidance provided by the authorities, both at the pre-permitting stage and throughout the entire process.

The Finnish permitting framework for energy infrastructure projects can be divided into two main phases the pre-applications or preparatory phase and the statutory permit-granting phase.

The pre-application or preparatory phase relates to land use planning. Land use planning is conducted at regional and local levels, involving regional councils and municipalities. These plans, which consider the National Land Use Guidelines, as

37 | Council Directive 2013/59/Euratom.

stipulated by the Land Use and Building Act, project 10 to 20 years into the future. The environmental impact assessment (EIA) process, mandated by the Environmental Impact Assessment Act (468/1994), is required for large-scale projects. The EIA serves as a planning tool, independent of permit procedures, and is evaluated solely on its adequacy. During this phase, various project alternatives must be presented, and public participation is integral. Although the EIA is a separate process, its findings are later utilised in various permit applications.

The statutory permit-granting phase involves the construction permits, essential for all types of energy infrastructure projects. The applicable laws, competent authorities, and specific application details vary depending on the type of infrastructure. Typically, the construction permit is the final permit granted before construction begins, as it incorporates the outcomes of other permitting procedures. Land access for energy infrastructure projects is achieved through negotiations with landowners. If agreements cannot be reached, the project promoter must seek the right to expropriate the land via a 'redemption permit' as outlined in the Act on the Redemption of Immoveable Property and Special Rights. While the EIA, construction permit, and land access processes are universally applicable to all energy infrastructure projects, additional permits or licenses may be required on a case-by-case basis. The specific assessments, authorisations, or permits needed depend on the unique circumstances of each project.

The establishment of a new nuclear power facility in Finland is governed by a distinct regulatory framework established under the Nuclear Energy Act. In comparison to other energy technologies, activities related to nuclear energy necessitate a specific license. According to Section 8 of the Nuclear Energy Act, the utilisation of nuclear energy without a mandatory license is prohibited. Chapter 5 of the Nuclear Energy Act delineates the licensing framework for nuclear energy. The Act specifies the conditions for granting a permit, which have been compiled into a uniform set of regulations for each type of permit.

In accordance with Section 16 of the Act, licenses are mandatory for the (1) construction, (2) operation, and (3) decommissioning of a nuclear facility. The licenses are required by the government. Only minor research and development activities are exempted from the licensing requirements.[38] If requested, the competent Ministry must give a binding advance ruling on the necessity to apply for a license. The primary mechanism for ensuring compliance with the provisions of the Nuclear Energy Act is the licensing system.[39] This system encompasses the entire life cycle of nuclear facilities, from construction to decommissioning.

The Finnish licensing framework for nuclear energy generation is structured into three distinct stages. The initial stage is political, while the subsequent stages

38 | According to Section 8 of the Nuclear Energy Act, the operator of these small-scale activities must nevertheless annually submit a notification, the details of which are in the Government Decree, to the Radiation and Safety Authority.
39 | HE 16/1985 vp.

are technical and administrative. These stages are interconnected through the pivotal role of the Government in the decision-making process and their shared mandate to consider the general principles as provided in the Nuclear Energy Act, such as the overall benefit to Finnish society and safety.

The integration of political decision-making is crucial, given the profound, long-term impacts, political controversies, and far-reaching consequences of nuclear power. The unique nature of nuclear energy demands a level of democratic engagement far beyond what a mere administrative process can offer. Yet, this democratic process must be fortified with stringent administrative oversight of any nuclear project.[40]

The licensing framework for a new nuclear power plant unfolds in three pivotal stages: (1) decision-in-principle; (2) construction license; and (3) operating license. These decisions are made by the government, with parliament's involvement required for the decision-in-principle. The licensing framework follows a one-step-at-a-time (step-by-step) procedure, meaning that the license can only be applied after the previous stage of the licensing process has been cleared, as illustrated in Figure 1.

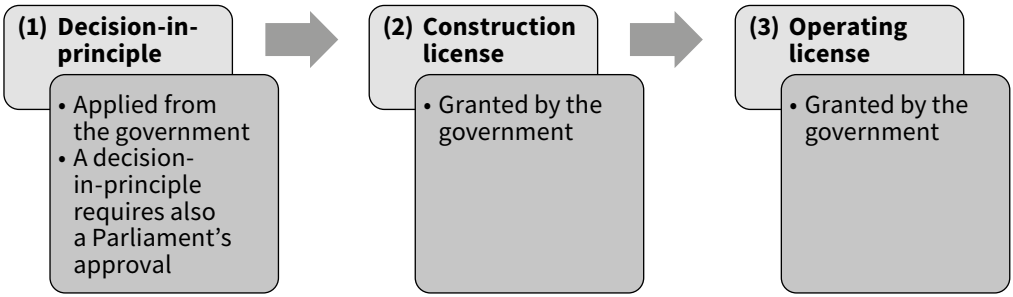

Figure 3. The three stages of the nuclear-specific licensing process in Finland

In addition to the nuclear-specific licensing regime, nuclear energy projects may also need other permits, depending on the project. It is up to the project promoters to identify the applicable permits and competent authorities and apply for these separately. The following list illustrates permits that might be required depending on the project in question.

- The EIA, pursuant to the Environmental Impact Assessment Act (252/2017);
- The Natura assessment, pursuant to the Nature Conservation Act (5.1.2023/9);
- Permits pursuant to the Environmental Protection Act (527/2014);
- Permits pursuant to the Water Act (587/2011);
- Construction permit for high voltage power line, pursuant to the Electricity Market Act (588/2013);

40 | Talus and Guimaraes-Purokoski 2011.

- Redemption permit, pursuant to the Act on the redemption of Immoveable Property and Special Rights (603/1977);
- Construction or operation permit, pursuant to the Land Use and Building Act (132/1999);
- Permits pursuant to the Antiquities Act (925/1963);
- Permits pursuant to the Act on the Safety of Handling Dangerous Chemicals and Explosives (390/2005).

However, as this contribution will focus on nuclear energy projects, the nuclear-specific licensing regime as established in the Nuclear Energy Act will be examined in more detail in the following sub-sections.

4.2. The decision-in-principle

At the first stage of the licensing framework, the construction of a new nuclear power plant of significant general importance requires a decision-in-principle from the government. The purpose of this decision-in-principle is to ensure that the construction aligns with the broader public interest of Finnish society, thus following the general principles outlined in the Nuclear Energy Act. According to Section 11 of the Nuclear Energy Act, nuclear facilities deemed to be "of considerable general significance" are: (1) all nuclear power plant projects intended to generate nuclear energy with a thermal capacity exceeding 50MW; (2) facilities used for the disposal of nuclear waste; and (3) facilities operated for purposes other than the generation of nuclear energy and the possession, at any given time, of an amount of nuclear material or waste or involving radiation risks comparable with nuclear facilities as defined in paragraph 1. All these facilities require a decision-in-principle from the government.

The application for a decision-in-principle is submitted by the applicant to the government. According to the Nuclear Energy Decree (161/1988), the application for a decision-in-principle must state at least (1) the name of the applicant or the business name and domicile used in business; and (2) for each nuclear facility its intended location, its intended use, and the scope of the activity carried out in it or, if it is a nuclear facility intended for the production of nuclear energy, its efficiency class and its planned operating time.

In addition, the application must include proof that the applicant is a Finnish or EU citizen or entity. According to Section 24 of the Nuclear Energy Decree, if the applicant is a company, it should provide copies of its articles of association, partnership agreement, and shareholder register, or, for other entities or foundations, copies of their rules. The application should also detail the applicant's expertise, explain the significance and necessity of the nuclear facility project for the country's energy supply and nuclear waste management, and provide information

on the applicant's financial conditions and the project's business profitability. Additionally, a general financing plan for the nuclear facility project is required.

According to Section 24 of the Nuclear Energy Decree, the application for each nuclear facility project must include a description of the technical operating principles, an explanation of the safety principles, and a statement of the ownership and management relationships of the planned location. It should also contain a report on the planned location, including details about the population, activities in the vicinity, and zoning arrangements. Furthermore, the application must provide an assessment of the suitability of the location considering local conditions' impact on safety, security and preparedness, as well as the facility's environmental effects. An environmental impact assessment report, an outline plan for nuclear fuel supply, and a statement on nuclear waste management plans are all required. If the applicant is from another EU member state, a statement of citizenship and corresponding documents must be included. The applicant must also provide the Radiation and Nuclear Safety Authority with information on the preliminary safety assessment as required by the Nuclear Energy Act.[41]

The documentation provided by the applicant must enable a preliminary safety assessment. However, at the application stage, organising a tender is not required, meaning there may not yet be a specific facility option, and the application could cover alternative locations. The Radiation and Nuclear Safety Authority's preliminary safety assessment will rely on generally available information about potential nuclear power plant alternatives, without detailed plant design specifics. If the government deems multiple alternatives to be in the overall interest of society and Parliament does not overturn this decision, the choice of which alternative project to proceed with for construction license processing is left to the applicant.[42]

The responsibility of the competent ministry is to process the application and prepare the decision-in-principle. First, the ministry must obtain a preliminary opinion on the security of the proposed nuclear facility from the Finnish Radiation and Nuclear Safety Authority. Moreover, according to Section 12 of the Nuclear Energy Act, it must seek the opinion from the Ministry of Environment, the municipal council of the municipality where the facility is to be located, and from neighbouring municipalities. In this regard, the Nuclear Energy Act provides for a very extensive consultation of citizens, municipalities, and authorities to ensure that in the consideration of the decision-in-principle, all possible perspectives regarding the overall interest of society would be taken into account.

The Ministry is also required to coordinate the environmental impact assessment (EIA) procedure for the construction of a new nuclear facility. The EIA procedure precedes the decision-in-principle, as the Nuclear Energy Decree requires

41 | Sections 12 and 14 of the Nuclear Energy Act, Section 25 of the Nuclear Energy Decree and YVL A 1 (Regulatory oversight of safety in the use of nuclear energy, 17.3.2020, <https://www.stuklex.fi/en/ohje/YVLA-1>

42 | HE 16/1985 vp.

the environmental impact assessment report as part of the application for the decision-in-principle. Essentially, this means that if an applicant has multiple potential sites at the application stage for a decision-in-principle, an EIA must be conducted for each of these sites.[43] The inclusion of environmental impact assessment at the first stage of the licensing framework has been criticised because, at this stage, the project planning is still in progress.[44] However, Section 15 of the Environmental Impact Assessment Act (252/2017) mandates that the planning of the EIA procedure should begin as early as possible, while project alternatives are still considered. This timing allows for influencing the selection of alternatives and the decisions regarding environmental impacts made by the project leader.[45]

According to Section 13 of the Nuclear Energy Act, before the government issues a decision-in-principle, the applicant must publicly disclose a general explanation of the planned nuclear facility, including its estimated environmental impact and safety aspects. The ministry must also organise a public hearing at the proposed site of the nuclear facility. All opinions expressed during these preparatory stages must be forwarded to the government as part of the procedure.

A prerequisite for the decision-in-principle is the approval of the municipality where the nuclear facility is to be located, along with sufficient conditions regarding the safety aspects of the proposed plant. This seeks to ensure the right of municipal self-determination, as the positive opinion of the municipality where the nuclear facility is located is an absolute prerequisite for the adoption of the decision-in-principle.

Finally, depending on the location of the planned facility, consultation with neighbouring countries is required. This obligation arises from the Agreement on communication related to the safety issues of nuclear facilities to be built near the borders between Finland, Norway, Sweden, and Denmark.[46]

If these conditions are met, the government will consider the decision-in-principle based on the general principles of the Nuclear Energy Act, weighing the benefits and disadvantages of the nuclear facility. Specifically, it will consider (1) the necessity of the nuclear facility project for the country's energy supply; (2) the suitability of the intended site and its environmental impact; and (3) arrangements for nuclear fuel and waste management.[47]

43 | In 2008, Fennovoima Ltd conducted environmental impact assessments for three potential sites for a nuclear facility before applying for a decision-in-principle. The decision-in-principle was granted in 2010. However, in 2011, the confirmed site for the nuclear facility was different from the initially considered alternatives. Consequently, the competent ministry mandated the company to update the project's environmental impact assessment through the EIA procedure for the new location. See <https://tem.fi/documents/1410877/2445107/Yhteenveto+2013>

44 | Pölönen 2024, 34–55.

45 | Hujala, Hyvärinen, Rintamaa, Suikkanen et al. 2022, 38.

46 | SoPS 19/1977.

47 | Section 14 of the Nuclear Energy Act.

The decision-in-principle must encompass the conditions essential for implementing the general principles outlined in the Nuclear Energy Act, as well as the safety requirements stipulated by the Nuclear Energy Act.[48] Furthermore, the government is required to consider the recommendations presented in the preliminary safety assessment conducted by the Radiation and Nuclear Safety Authority.[49] The Nuclear Energy Act is silent on the modification of these conditions.

The government's decision is based on policy discretion rather than legal consideration[50], although it is framed by legal requirements. This policy discretion allows for freedom in consideration behind the decision and excludes the right of appeal. Section 14 of the Nuclear Energy Act outlines the focus areas of the government's decision-making process, requiring it to consider the decision-in-principle based on the overall good of Finnish society.

The decision-in-principle must be scrutinised and approved by the parliament by a majority vote. Under the Nuclear Energy Act, the parliament can either approve or reject the decision-in-principle as it stands, without making amendments or setting further conditions. Section 75(3) of the Nuclear Energy Act specifies that the decision-in-principle is not subject to appeal, and this also applies to the subsequent decision by the parliament. The decision by which the parliament has left the decision-in-principle without revoking, factually only means permission to continue preparatory activities, and that the condition for granting a construction permit exists in this regard.[51]

It should be noted that the Finnish Parliament has only been involved in the decision-making process for the construction of nuclear facilities since 1992. Since then, one decision-in-principle for additional nuclear power construction has been rejected, while four have been approved. The four oldest nuclear power facilities were constructed before the legislation required parliamentary approval for the decision-in-principle.

Despite the criteria stipulated by the Nuclear Energy Act, some requirements allow for considerable discretion by the government, particularly regarding the project's alignment with the overall good of Finnish society and its contribution to the security of the country's energy supply.

The Nuclear Energy Act does not provide for the alteration of a decision-in-principle or a permit. In practice, it has been necessary to carry out a case-by-case assessment as to whether proposed changes necessitate a new decision and when it is feasible to supplement the existing decision.[52]

Finally, the applicant is prohibited from taking any measures that could, due to their economic significance, impede the government's or parliament's ability

48 | Section 14a(1) of the Nuclear Energy Act.
49 | Section 14a(2) of the Nuclear Energy Act.
50 | Koutaniemi, Reponen, Salminen, Sandberg and Varjoranta (2004).
51 | HE 16/1985 vp.
52 | Liukko, Slant and Välimäki 2020, 70.

to exercise their discretion in decision-making. Such measures include commitments entailing significant economic obligations related to plant construction, nuclear fuel, or nuclear waste. Under Section 30 of the Nuclear Energy Decree (161/1988), these include: (1) entering into financially binding agreements concerning the delivery or manufacture of the nuclear facility or essential parts, components, or structures thereof; (2) manufacturing said parts, components, or structures by the applicant; (3) excavating substantial underground facilities for the nuclear facility. However, measures resulting in only minor financial losses if the project is not carried out are excluded from this prohibition.

4.3. Construction license

Following the approval of the decision-in-principle by the parliament, the construction of a new nuclear facility necessitates a construction license issued by the government. This license can only be granted to a natural person, a legal entity, or an authority under the jurisdiction of an EU member state. In addition to the decision-in-principle, the conditions for the construction license encompass safety plans, site selection, environmental protection, nuclear waste management, and the final disposal of high-level radioactive waste. Furthermore, a designated area for the nuclear facility must be reserved in a local detailed plan based on the Building Act. This area must also be in the possession of the applicant. At this stage, it is essential that the applicant's plans are significantly more detailed than those in the decision-in-principle application, particularly concerning the location of the facility.

The application for the construction license is submitted to the government, with its contents regulated under Sections 31 and 32 of the Nuclear Energy Degree in a non-exhaustive manner. According to Sections 31 and 32 of the Nuclear Energy Decree, the applicant must include in their application, *inter alia*, details of the applicant, the specific site where the nuclear facility is situated, the intended use of the facility and the basic operational principles, a statement of the quality and quantity of nuclear materials or waste, an outline of technical operating principles and safety arrangements, plans for nuclear fuel maintenance, financial documentation, an explanation of the applicant's expertise, documentation of the type of nuclear facility to be built and the planned suppliers, as well as an explanation of the facility's environmental effects and design principles to avoid damage.

Additionally, the applicant must provide certain risk-related information to the Finnish Radiation and Nuclear Safety Authority. These include a preliminary safety report detailing the design and safety principles of the nuclear facility, a probability-based risk analysis, and a proposal for a classification document that categorises structures, systems, and equipment based on their safety significance. Furthermore, a report on quality management procedures, a plan for periodic inspections, and preliminary plans for security and preparedness arrangements

are required. The applicant must also provide a plan for preventing the spread of nuclear weapons, a statement of specific arrangements as per the Nuclear Energy Act, a program for determining the environmental baseline of the facility, and a decommissioning plan.[53]

The Ministry prepares the decision regarding the construction license for the government. Section 37 of the Nuclear Energy Decree mandates that the Ministry requests opinions on the construction license application from various government entities, including ministries, authorities, and municipalities. The content of these requests is not legally stipulated and is tailored to each entity's function and competencies. For instance, the local municipality is asked to provide information on the potential impact of the construction phase on the municipality and its residents, while the Ministry for the Environment assesses the project from the perspective of Section 19(2) of the Nuclear Energy Act, which pertains to safety and environmental protection. The content of the decision regarding a construction license was provided in a non-exhaustive manner in the Nuclear Energy Decree.

Once the construction license application is ready for a decision, the Ministry presents it to the government. Then, the government makes the final decision on the grant of the construction license.[54] As this matter falls within the general competence of the Ministry, the government's decision on the construction license is signed by the Minister. The Ministry notifies various ministers, authorities, and municipalities of the decision to grant the construction license.

According to Section 26 of the Nuclear Energy Act, the construction license, once granted, can be partially or wholly revoked if the implementation of the general principles for the use of nuclear energy is fundamentally endangered. This could occur if (1) the licensee violates the conditions of the construction license or regulations issued under the Nuclear Energy Act; (2) the licensee neglects the financial provision obligations referred to in Chapter 7 of the Nuclear Energy Act or violates the Nuclear Liability Act (484/1972); or (3) the licensee dies, loses legal capacity, or if the corporation or foundation holding the construction license is dissolved, discontinues operations, or goes bankrupt.

According to Section 8 of the Administrative Judicial Procedure Act (808/2019), the government's decision on the construction license can be appealed before the Supreme Administrative Court. Based on Section 13 of the same Act, the appeal must be based on the legality of the decision, specifically whether the law was followed in granting the license and whether the application met legal requirements. Appeals cannot be based on the exercise of political discretion, as this falls within the government's purview.

53 | Section 35 of the Nuclear Energy Act.

54 | The plenary sessions of the government make decisions on nuclear matters, with minor exceptions; see Section 6 of the Government Rules of Procedure (262/2003).

4.4. Operating license

The third and final stage of the licensing procedure for a new nuclear facility involves obtaining an operating license, which is issued by the government. As with the construction license, the Ministry is responsible for preparing the operating license. It may only be issued to a natural person, a legal entity, or an authority under the jurisdiction of an EU member state.

The license may be granted if the nuclear facility and its operation comply with the safety requirements provided in the Nuclear Energy Act, ensuring the safety of both employees and the public. The applicant must also demonstrate adequate provisions for nuclear waste management, the final disposal of nuclear waste, and the decommissioning of the nuclear power unit. Additionally, the applicant must possess sufficient expertise and the necessary resources to operate the nuclear facility in a safe manner and in accordance with the international treaty obligations.

When applying for the operating license, the applicant must submit several documents to the Radiation and Nuclear Safety Authority. These include: a final safety data sheet, a probability-based risk analysis, and a classification document that categorises structures, systems, and equipment based on their safety significance. Moreover, the quality management program for the facility's use, safety-technical conditions of use, and a summary program of periodic inspections are required. Plans for security and preparedness arrangements, a report on the control measures to prevent the spread of nuclear weapons, and the management rules of the facility must also be provided. Furthermore, a report on the basic state of environmental radiation, a program for radiation monitoring, a report on the fulfilment of safety requirements, an aging management program, and a decommissioning plan are necessary.

The government will reassess whether the nuclear facility aligns with the overall good of Finnish society and meets the other general principles as outlined in the Nuclear Energy Act. Thus, compliance with the general principles as enshrined in the Nuclear Energy Act is assessed in every licensing stage to ensure that the nuclear project serves the overall good of Finnish society. Similarly, as can be seen from the documents required to be submitted with the application, various aspects in relation to safety, preparedness, environmental impact, waste management, and decommissioning are re-assessed through every licensing stage both by the competent ministry in preparing the decisions, the government as well as the Radiation and Nuclear Safety Authority. Considering that nuclear facility projects are long-term projects, the potentially changing circumstances can be taken into account throughout the application procedure.

The nuclear facility cannot initiate its operations until the Finnish Radiation and Nuclear Safety Authority has approved its safety requirements and the Ministry has verified the applicant's preparedness for the costs of nuclear waste management.

The operating license is issued for a fixed period. Its validity may expire if the nuclear facility does not begin operations within a specified period from the date of issue. The conditions of the operating license may be modified to ensure compliance with the general principles of the Nuclear Energy Act and the requirements of the license. Like the construction license, the operating license can also be revoked. As with the construction license, appeals against the operating license can be based on the legality of the decision but not on the exercise of political discretion.

4.5. Decommissioning license

Section 7g of the Nuclear Act provides that the license applicant and license holder – thus depending on the timeline of the licensing/operation of the nuclear facility – must have a plan for the decommissioning of the nuclear facility. The license holder is also required to update the plan at least every six years, unless otherwise specified in the license terms. The updated plan must be approved by the Ministry. During the operations requiring a license for decommissioning, the plan must be kept up-to-date, and the updated plan must be approved by the Radiation and Safety Authority.

When operations at the nuclear facility come to an end, the licensee is obligated to ensure that the decommissioning process is conducted in strict accordance with the decommissioning license, the established safety requirements, and the plan approved by the Radiation and Nuclear Safety Authority. Furthermore, the operating license holder must apply for a license for the decommissioning of the nuclear facility. The objective of the decommissioning project is to decontaminate the nuclear facility's structures and systems of radioactive materials, thereby releasing the licensee from all associated obligations.

Section 20a of the Nuclear Act requires the licensee to apply for the decommissioning license well in advance so that the authorities have adequate time to assess the application before the termination of the operating license of the nuclear facility. Detailed provisions on various documents to be included in the application for the decommissioning license and on the submission of those documents are enshrined in the Nuclear Energy Decree. These required documents include a report on the quality and maximum quantity of nuclear materials and waste accumulated, processed, and stored during decommissioning. An outline of the technical principles and solutions for decommissioning, along with safety arrangements and an assessment of their implementation, is required. The EIA report, supplementary information to limit environmental impact, and an explanation of the applicant's expertise and organisation for the decommissioning phase must also be provided. Furthermore, the application should include plans and methods for nuclear waste management, including final disposal, along with a schedule and estimated costs. An explanation of the applicant's financial position, a management plan for financing the decommissioning, and financial statements

for the year of the application and the previous five years, or information on where these documents can be accessed electronically, are also necessary.[55]

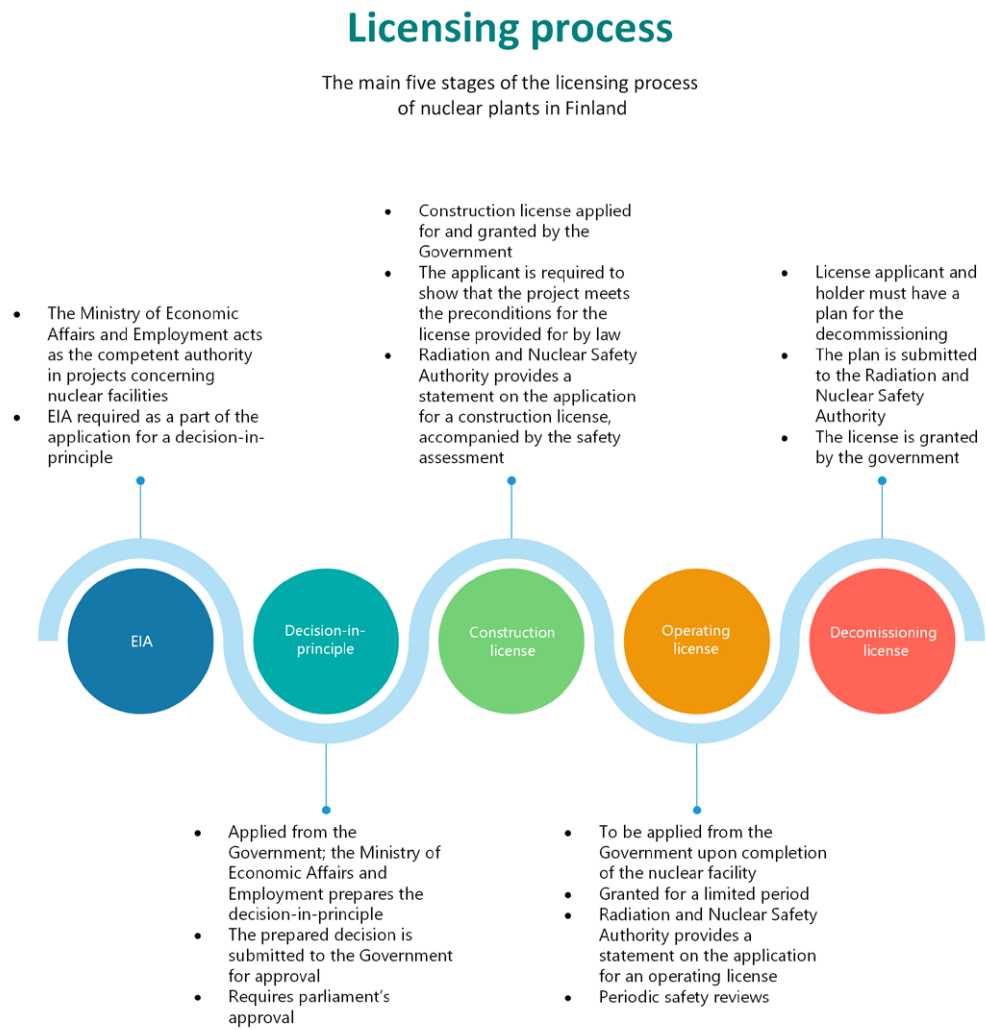

Figure 4: Licensing process of nuclear facilities in Finland

In addition to the decommissioning application submitted to the government, the applicant must provide the necessary documentation to the Radiation and Nuclear Safety Authority. These include the final decommissioning plan, a decommissioning risk review, and a safety statement. Additionally, a classification

55 | Section 34a of the Nuclear Energy Decree.

document that categorises structures, systems, and equipment based on their safety significance, and the nuclear facility's quality management program are required. The application must also include technical requirements of use relating to safety, a summary program of periodic inspections, and plans for security and preparedness arrangements. The Radiation and Nuclear Safety Authority provides a detailed explanation of these documents to the licensing authority in its statement regarding the decommissioning license. Figure 3 provides an illustration of the nuclear licensing procedure.

5. Nuclear waste management

5.1. Legislative framework

The Nuclear Energy Act provides for the primary principles guiding nuclear waste management in Finland. First, according to Section 6a of the Nuclear Energy Act, "nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland". Second, according to Section 27a of the Nuclear Energy Act, the amount of nuclear waste generated in the use of nuclear energy shall be kept as small as reasonably achievable.

A national nuclear waste management program outlines the policy and management of spent nuclear fuel, including general goals, principles, waste quantities, locations, cost, and schedule estimates. The program will be developed by the Ministry in collaboration with the Radiation and Nuclear Safety Authority. Public input will be solicited during the drafting process. The program is subject to updates based on the Nuclear Energy Act.

The responsibility for nuclear waste management lies with the waste producers, who must manage nuclear waste in accordance with the Nuclear Energy Act. According to Section 28 of the Nuclear Energy Act, the management of spent nuclear fuel is a duty of the nuclear facility license holder. To this end, the party responsible for waste management is required to submit a plan for nuclear waste management to the licensing authority for evaluation. The plan must be presented at regular three-year intervals throughout the duration of the licensed operations, unless otherwise specified in the license terms. Additionally, the plan must include a general outline for the next six years.

Furthermore, the entity responsible for nuclear waste management must meet its financial obligations by making annual payments into the National Nuclear Waste Management Fund. It is also required to provide the State with the specified collateral security to safeguard against potential insolvency, based on Section 36 of the Nuclear Energy Act.

The National Nuclear Waste Management Fund aims to ensure that society possesses adequate financial resources and expertise to manage nuclear waste under all circumstances. The Fund operates independently of the state budget and falls under the jurisdiction of the Ministry. It comprises two distinct funds: the Financial Provision Fund and the Research Fund for Nuclear Energy Expertise.

The Fund is responsible for collecting, storing, and reliably investing the necessary funds for future nuclear waste management. Additionally, it annually finances research related to nuclear safety and waste management, as well as the development of research infrastructure.

The capital of the National Nuclear Waste Management Fund is derived from annual payments made by operators with waste management obligations, as well as the returns generated by the fund. Each year, the Ministry sets the annual fee to be paid into the Fund, ensuring that it consistently has sufficient assets to cover the costs of all remaining nuclear waste management activities.

The disposal of nuclear waste is deemed complete once the Radiation and Nuclear Safety Authority has verified that the waste has been permanently disposed of in an approved manner. Similarly, a nuclear facility is considered decommissioned when the Radiation and Nuclear Safety Authority confirms that the levels of radioactive materials remaining in the buildings and soil at the facility site meet the requirements outlined in the Nuclear Energy Act. When the license holder's waste management obligation has ceased, the ownership of the nuclear waste is transferred to the State, which then assumes responsibility for the waste. If necessary, after disposal, the State retains the right to undertake all needed measures at the disposal site to monitor and control the nuclear waste and to ensure the safety of the repository as stated in Section 31 of the Nuclear Energy Act.

5.2. The final disposal of spent nuclear fuel in Onkalo

Finland employs a once-through nuclear fuel cycle[56], meaning that spent nuclear fuel is not reprocessed. Instead, after being removed from reactors, the spent fuel is stored in the interim pool-type storage facilities at the power plant sites in Loviisa and Olkiluoto. This storage period lasts for 30–50 years. However, a water pool storage does not fulfil the requirements for permanent disposal in Finnish soil or bedrock, as stipulated by Section 6 of the Nuclear Energy Act and Section 76 of the Nuclear Energy Decree. Given the long-term safety concerns associated with soil disposal under Finland's conditions, geological disposal in bedrock was considered a viable option. Following the interim 'cooling period', the spent fuel will be disposed of deep within the Finnish bedrock, in Onkalo.

56 | On the nuclear fuel cycle, see World Nuclear Association.

In 2020, the Government adopted a decision-in-principle according to which, among the various options for final disposal of high-level nuclear waste, geological disposal deep in bedrock is the most effective and realistic method to isolate the waste from the biosphere.[57] In Finland, this involves depositing the waste in crystalline bedrock, which makes up the majority of the country's bedrock and is among the oldest in the world.

Onkalo ('pothole' in English) is situated in Olkiluoto, Eurajoki, Finland, where three of the five nuclear facilities are located. Onkalo is operated by Posiva Ltd, a company owned by Teollisuuden Voima Ltd (60%) and Fortum Power and Heat Oy (40%). The company's primary responsibility is to manage the maintenance of spent nuclear fuel from its owners' nuclear power facilities (Olkiluoto 1, 2, and 3 as well as Loviisa 1 and 2) following interim storage at the power plant sites (the cooling period).

Onkalo consists of (1) an encapsulation plant above ground and (2) a final disposal repository underground. At the above-ground encapsulation plant, spent nuclear fuel is securely sealed in final disposal canisters, which are then transported to the underground final disposal repository. The underground section extends to a depth of approximately 450 meters, with the actual final disposal repository situated between 400 and 430 meters deep. In the final disposal tunnel, each canister is placed in a designated deposition hole, with each tunnel containing 30 to 40 such holes. Once all holes are filled and the canisters are isolated with bentonite clay buffers, the entire tunnel is backfilled with clay and sealed. Onkalo has the capacity to accommodate 6,500 tons of spent nuclear fuel. The safety of the final disposal relies on the multibarrier principle, ensuring long-term safety through multiple redundant release barriers. These engineering barriers include the condition of the fuel, the final disposal canister, the bentonite buffer, and the tunnel backfill, with the bedrock serving as a natural barrier. The final disposal of spent nuclear fuel is anticipated to start operations in the mid-2020s, although the exact start date has yet to be determined.[58]

The Finnish legislation currently allows the final disposal of nuclear waste generated in connection with or as a result of the use of nuclear energy in Finland. Despite the interest in Finnish spent nuclear fuel disposal technology, current national legislation prohibits the import and disposal of spent nuclear fuel. Although there is considerable potential to monetise this pioneering disposal method, the political sensitivity of the issue suggests that legislative amendments are unlikely to be proposed in the near future.

57 | The decision-in-principle is available at <https://www.eduskunta.fi/FI/vaski/Documents/m_7+2000.pdf> (in Finnish only).
58 | Posiva 2024.

6. Recent trends

6.1. Small modular reactors

Small modular reactors (SMRs) are considered to represent a promising advancement in nuclear power technology, offering significant benefits in terms of safety, economic efficiency, and diverse applications. The current Government Programme provides clear guidelines for the development of nuclear energy. The current Government is especially advocating for the use of SMRs for district heating purposes, and this area is currently being examined by energy companies. Furthermore, the current level of social acceptance for nuclear energy use in Finland is unprecedentedly high. This favourable public perception is regarded as a significant opportunity for the advancement and development of SMRs.

However, the legislative framework on nuclear power, currently in force in Finland, is built on the notion that nuclear power facilities are constructed infrequently and consist of large units with intricate safety mechanisms and numerous custom-manufactured components. While the licensing and constructing SMRs in Finland is considered to be, in principle, feasible under the existing legislation, practical implementation remains challenging.

As the current nuclear energy legislation and the regulations issued by the Radiation and Nuclear Safety Authority are primarily designed for large-scale power plant reactors and major operators, there are certain requirements within the Radiation and Nuclear Safety Authority's regulations that are not well-suited for SMRs, particularly those intended for district heat production.[59] These issues relate particularly to the streamlining of licensing because the current framework, as discussed above, is designed for the risk management and safety of large-scale nuclear facilities. As the risks and safety aspects associated with SMR are on a different scale compared to large-scale nuclear facilities, it has been held that both safety requirements and licensing and control measures must be calibrated to correspond to the level of risk associated with the activity.[60] More specifically, a discussion on the need to revise the Nuclear Energy Act currently in force to also better encompass SMR issues related to the location and type-approval of SMRs.

As held above, the deployment of SMRs in Finland is envisioned to relate to district heating, in addition to power production. Using SMRs for the combined production of electricity and district heat, or heat production alone, requires placing the facility closer to the population. Therefore, the SMRs most likely entail geographical decentralisation, resulting in multiple new plant locations. The current Nuclear Energy Act and other relevant regulations do not delineate a distinct process for determining the

59 | Ydinturvallisuusneuvottelukunta 2019.
60 | Negri della Torre 2020, 573.

suitability of a site for nuclear power plant use. Formally, the site-specific planning criteria are only validated when the Government issues a construction permit for the nuclear facility, which is suboptimal for timely facility procurement. Therefore, it is recommended that the Nuclear Energy Act be amended to include a separate approval process for the location of nuclear facilities.[61]

The decision-in-principle procedure is not intended for the technical evaluation of plant alternatives. The Advisory Committee of Nuclear Safety has recommended adding an alternative stage in the process that would entail the technical evaluation of plant alternatives. To facilitate this, the legislation should allow for the pre-approval of plant designs through a design certification process. According to this proposed mechanism, prospective plant suppliers seeking pre-approval should engage with the Radiation and Nuclear Safety Authority prior to the construction permit phase to ensure that the technical solution of their plant alternatives complies with Finnish safety requirements and the necessary approval documentation. The type-approval process should be contingent upon the plan supplier having a customer in Finland who is interested in the technology and is deemed to have realistic conditions for utilising the technology once type approval has been granted.

The government is currently considering the implementation of a type approval-based procedure, particularly for SMRs. In relation to SMR, the possibility of eliminating the onerous permit-in-principle procedure is being examined, while still ensuring the verification of project owner details prior to construction.

In 2020, a working group authorised by the Ministry recommended a comprehensive reform of the Nuclear Energy Act.[62] According to the working group, a central focus of this reform is the suitability of Finland's licensing system for future nuclear energy needs, including nuclear waste management, facility decommissioning, and the construction of new and innovative nuclear facilities such as SMRs. The working group recommended the necessity of introducing pre-approvals for both plant locations and reactor types. Specifically concerning SMRs, pre-approval might concern, for example, new types of locations and/or the construction and use of modular technology.[63]

6.2. NATO and the Finnish Nuclear Act

Amidst turbulent times due to the Russian invasion of Ukraine, Finland decided to join the North Atlantic Treaty Organisation (NATO), submitting the official application in May 2022, and became a full member of NATO in 2023. The NATO membership has provoked discussion as to the need to reform the Nuclear Energy Act currently in force.

61 | Ibid.
62 | Työ- ja elinkeinoministeriö (2023).
63 | Hujala, Hyvärinen, Rintamaa, Suikkanen et al (2022).

This discussion relates to Section 4 of the Nuclear Energy Act, according to which the import of nuclear explosives as well as their manufacture, possession, and detonation in Finland are prohibited.[64] Since Finland decided to join NATO without any conditions for Finland's membership in the military alliance, the Section is problematic from this perspective. At the moment, there are no amendments proposed that would address the problems in relation to Section 4 of the Nuclear Energy Act, but the ongoing comprehensive reform of the Nuclear Energy Act might also lead to amendments with regard to Section 4.

7. Conclusion

Finland currently operates five nuclear reactors across two power plants, Loviisa in Olkiluoto, with a combined capacity of over 4,000 MWe. Finland has a solid track record in terms of nuclear safety, and the modernisation and lifetime extensions of these reactors highlight Finland's commitment to maintaining and enhancing its nuclear capabilities.

The Finnish Nuclear Energy Act, complemented by the Nuclear Energy Decree and the Radiation Act, provides a comprehensive regulatory framework for the construction, operation, and decommissioning of nuclear facilities. The involvement of multiple authorities is critical in ensuring a robust oversight mechanism.

The licensing process for nuclear facilities in Finland involves multiple stages: a decision-in-principle, a construction license, and an operating license. This process ensures that all aspects of safety, environmental impact, and societal benefit are thoroughly evaluated. Furthermore, Finland is a global leader in nuclear waste management, with the world's first permanent underground repository for spent nuclear fuel.[65]

In conclusion, Finland's approach to nuclear energy is characterised by a strong regulatory framework, a commitment to safety and environmental protection, and a forward-looking strategy that includes the development of new technologies like SMRs.

64 | Penalties for infringement are also set in the Criminal Code 39/1889.
65 | On the global trends of spent nuclear fuel and waste management see IAEA 2022.

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