Management of spent fuel and radioactive waste in Finland – national programme in accordance with Article 12 of the Council Directive 2011/70/Euratom

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Preface

Well-organised, safe and effective management of nuclear waste is part of the use of nuclear power as a source of energy and the use of radiation sources in health care, industry and research. This publication presents an overview of nuclear and radioactive waste management in Finland and discusses the formulation of Finland's national strategy, the principles followed and regulation in the society.

This document takes into account the Council Directive 2011/70/Euratom on the responsible and safe management of spent fuel and radioactive waste. This document provides the Commission with information on the Finnish programme for the management of spent fuel and radioactive waste.

The chapter headlines correspond to the subparagraphs (a) to (k) of Article 12(1) of the above-mentioned Directive. Chapter 1 focuses on the national policy in respect of spent fuel and radioactive waste management (Article 12(1)(a)). Chapter 2 presents significant milestones and timeframes (Article 12(1)(b)). Chapter 3 presents an inventory of waste and estimates for future waste quantities (Article 12(1)(c)). Chapter 4 discusses the waste management concept, plans and technical solutions (Article 12(1)(d)). Chapter 5 discusses the concept for the post-closure period of the disposal facility (Article 12(1)(e)). Chapter 6 describes the research, development and demonstration activities that are needed in order to implement solutions for the management of spent fuel and radioactive waste (Article 12(1)(f)). Chapter 7 discusses the responsibilities for the implementation of the national programme and key performance indicators (Article 12(1)(g)). Chapter 8 discusses cost assessments (Article 12(1)(h)). Chapter 9 presents the financing schemes in force (Article 12(1)(i)). Chapter 10 focuses on transparency policies (Article 12(1)(j)). Chapter 11 presents key agreements (Article 12(1)(k)).

This document has been drawn up by the Ministry of Employment and the Economy. The Finnish Radiation and Nuclear Safety Authority (STUK), the Ministry of Social Affairs and Health, the Ministry of the Environment, Fennovoima Oy, Fortum Power and Heat Oy, Posiva Oy, Suomen Nukliditekniikka Oy, VTT Technical Research Centre of Finland Oy and Teollisuuden Voima Oyj were invited to participate in the preparation process.

The Ministry of Employment and the Economy is responsible for notifying the Commission of any significant changes to the national programme and for sending a national report to the Commission every three years. The Ministry of Employment and the Economy is also responsible for arranging the assessments required by the Council Directive 2011/70/Euratom. STUK is responsible for the self-assessment of its operations concerning nuclear waste management.

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Introduction

The first nuclear power plants in Finland were commissioned at the turn of the 1970s and 1980s. The currently operating four reactor units have produced a significant share of the electricity annually consumed in Finland. The construction of the fifth nuclear power plant unit was begun in the early 2000s. Plans are under way to add new plant units in Finland's nuclear power production capacity, and it seems evident that nuclear power will continue to play an important role in the production of electricity in Finland.

Finland began planning and preparing for nuclear waste management measures in the 1970s, during the procurement and construction phase of the first nuclear power plants. In 1983, the Finnish Government made a policy decision on the principles and schedules of nuclear waste management. Accordingly, disposal facilities for the low and intermediate level operational waste generated at Olkiluoto and Loviisa were taken in use in the 1990s. In 2000, the Government adopted a favourable Decision-in-Principle (DiP) allowing the construction of a disposal facility for spent fuel from the Finnish nuclear power plants in Olkiluoto and Loviisa. This DiP was confirmed by the Parliament in 2001. A construction licence application for the encapsulation and disposal facility was submitted to the Government in 2012.

In light of current plans, it seems likely that the management of nuclear waste will continue far into the future – to the next century if necessary, depending on decisions concerning the operation of nuclear power plants.

In medical care, sources of radiation have been used in Finland since the beginning of the last century. The use of radiation for industrial and research purposes has significantly increased since the 1970s. Even though the focus of developing new radiation applications is shifting to devices that generate radiation electrically, there are still numerous established uses for radioactive substances and sources containing radioactive substances that cannot be replaced with other technologies. Thus, the need for using radioactive substances and managing used sources of radiation will continue in the long term.

A national programme for the management of nuclear waste, as referred to in the Council Directive 2011/70/Euratom, was initially prepared in Finland in the 1970s and 1980s. The contents of the national programme are mainly determined in the Nuclear Energy Act (990/1987), the Nuclear Energy Decree (161/1988), the Radiation Act (592/1991) and the government decrees, decisions or guidelines issued under them. Some programme contents are also defined in other pieces of legislation.

The national programme referred to in the Council Directive 2011/70/Euratom does not lay down a framework for decisions on granting licences or approving projects. For example, it does not include criteria or conditions to be taken into account when considering a licence or approval. Thus, the national programme drawn up to comply with the Radioactive Waste and Spent Fuel Management Directive does not require an environmental assessment as referred to in the Directive 2001/42/EC of the European Parliament and of the Council ('SEA Directive'). The criteria and conditions to be taken into account in the consideration of a project licence or approval are laid down in the Nuclear Energy Act and the decrees and decisions issued under it.

1 Overall objectives of the policy on the management of nuclear waste and other radioactive waste

Direct disposal of nuclear waste

The Finnish Government decided on the principles of arranging nuclear waste management as early as 1978, in the early stages of nuclear power utilisation. In the management of low and intermediate level operational waste, the Government prepared for domestic measures, as they were considered the easiest to implement. In the management of spent fuel, permanent exportation or exportation for reprocessing were considered primary options.

In 1994, a significant amendment was made to the Nuclear Energy Act. Nuclear waste generated in connection with or as a result of the use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland. Correspondingly, nuclear waste generated in connection with or as a result of the use of nuclear energy elsewhere than in Finland shall not be handled, stored or permanently disposed of in Finland. The principle does not apply to nuclear waste that has been generated in connection with or as a result of the operation of a research reactor in Finland. In 2008, a further amendment was introduced to the Nuclear Energy Act to allow small amounts of nuclear waste to be delivered abroad for research purposes or for treatment in an appropriate manner.

In Finland, the management of spent nuclear fuel is based on the once-through use of fuel. The oncethrough or open fuel cycle means that spent fuel is removed from the reactor for interim storage and ultimately for disposal, as such, deep in the bedrock, sealed in durable canisters.

Licensee's obligations

According to the 1978 decision of the Finnish Government, each producer of nuclear waste – in practice the nuclear power companies – is responsible for the management of spent fuel and other radioactive waste generated in connection with their operations and for the costs incurred. Nuclear waste management includes the handling, storage and disposal of waste and the decommissioning of nuclear facilities.

Since 1988, the responsibility has been laid down by the Nuclear Energy Act (990/1987). The Act introduced in the late 1980s included the nuclear waste management responsibilities and obligations that were already in use at the time and provided that a nuclear power company is responsible for the costs of waste management. Once a licensee under a waste management obligation has closed its disposal facilities in the approved manner and paid a fee to the State for the future monitoring and control of the nuclear waste, the ownership right to and the responsibility for the nuclear waste is transferred to the State. All in all, final disposal must be carried out so that no long-term post-closure monitoring is needed to ensure safety.

In Finland, nuclear waste management covers the handling, storage, transport and final disposal measures required for low and intermediate level operational waste, spent fuel and the decommissioning of plants.

Systematic nuclear waste management

In 1983, the Finnish Government made a general decision on the objectives and schedules of the research, investigation and planning activities concerning nuclear waste management at the existing nuclear power plant units. The objective was to be sufficiently prepared for the timely implementation of nuclear waste management measures, meeting safety standards. The decision was influenced by the international state of

nuclear waste management and the outlook of the sector. The supply of commercial reprocessing services did not seem to be increasing or the costs of the services decreasing. Moreover, several countries began to gradually prepare for the final disposal of spent fuel, as such, in suitable geological formations within their own territories.

The above-mentioned general decision of 1983 presented two basic options for the management of spent fuel. The first option involved centralised international final disposal solutions and contract arrangements that would have allowed reprocessing waste or spent fuel, as such, to be irrevocably located abroad. In the other option, power companies had to prepare for final disposal of spent fuel in Finland, meeting safety and environmental protection standards. The final disposal measures were to begin around 2020. Before that, the companies had to survey and select the final disposal site by the end of 2000 and be prepared to present plans for the final disposal facility and encapsulation plant required for the construction licence. The schedule for construction plans was adjusted in 2003, requiring the plans to be presented by the end of 2012.

The basic principle in planning the management of operational waste was to be prepared to handle, store and permanently dispose of the waste in Finland and to commission the final disposal repositories by the end of 1992, if necessary. Moreover, the companies also had to prepare for disposing decommissioning waste arising from the dismantling of nuclear power plants in the waste repositories.

Overall good of the society

The legislation was reformed in the 1980s, and the old Atomic Energy Act was replaced with the Nuclear Energy Act in 1988. The objective of the Nuclear Energy Act is to keep the use of nuclear energy in line with the overall good of society and in particular to ensure that the use of nuclear energy is safe for man and the environment and does not promote the proliferation of nuclear weapons.

Phased decision making

The new Nuclear Energy Act also included provisions on the procedures of granting licences for nuclear facilities. As the licence procedure involves several administrative branches, it was considered justified for the decision-making power to be vested in the Government. Currently, the Ministry of Employment and the Economy is the authority responsible for the licence procedure and preparing decisions for the Government.

The Nuclear Energy Act also introduced a Decision-in-Principle procedure for nuclear facilities having considerable general significance. The process precedes the construction and operating licence procedures. A Decision-in-Principle is a high-level political decision made at the earliest possible stage of project planning. Before the Decision-in-Principle is discussed at the Parliament, the applicant may not engage in any measures which might impede the Government's and the Parliament's possibilities to determine the issue at their own discretion.

The Decision-in-Principle is made by the Government. Before the Government can discuss the project, the project must have the support of the municipality intended to be the site of the facility and it must receive a favourable statement from the safety authority. The Government's favourable Decision-in-Principle must be submitted to the Parliament for approval.

The generation, handling, transportation, storage and disposal of nuclear waste require licences in accordance with the Nuclear Energy Act. One of the principles of the decision-making process and the licensing system is that the assessment of safety is continuous and the assessments are further specified as projects progress.

Building a nuclear waste facility also requires several other licences, such as a construction licence from the municipality and licences required under the Water Act. The transport of spent fuel requires, for example, permits in accordance with the legislation governing the transport of dangerous goods.

Minimising the amount of waste

The Nuclear Energy Act and the Radiation Act were amended in 2013 to accommodate the requirements of the Radioactive Waste and Spent Fuel Management Directive (2011/70/Euratom). The following guiding principle was introduced in the management of nuclear waste: the amount of waste generated shall be kept to the minimum which is reasonably practicable. The principle means that the aim in the design and operation of a nuclear facility is to give priority to solutions that enable the amount of waste generated in different stages of the facility's life cycle to be kept as small as reasonably possible in practice. Moreover, the amount of waste generated shall be reduced by recycling and reusing materials where possible. The principle does not imply changes to the management of spent fuel, which is implemented by permanently disposing of high-level spent fuel in the bedrock as planned, employing appropriate encapsulation and other technical and natural barriers.

Retrievability

The purpose of final disposal is to isolate spent fuel from living nature, and it does not serve the purpose to facilitate the reopening of the repositories. On the other hand, spent fuel can be retrieved from the repositories for final disposal at any point of the final disposal process, if necessary. However, accessibility and retrievability may not compromise long-term safety.

The objective of final disposal is to process spent fuel so that it will not cause any damage or waste management obligation in the future. Ultimately, this means that future generations would not necessarily need to know about the existence and location of the disposal facilities. To prevent any future misuse and accidental access to the repositories, placing the waste deep in the bedrock entails the benefit and requirement of ensuring that the retrieval of the canisters is difficult. At the same time, retrievability requires that records of where and how the canisters are stored must be kept for future generations.

Other radioactive waste

The Radiation Act (592/1991) lays down the key principles to be followed in the management of radioactive waste generated in the use of radiation and in other radiation practices.

The guiding principle is that the amount of waste generated in the use of radiation and other radiation practices shall be kept to the minimum which is reasonably practicable without compromising the general principles of radiation protection (justification, optimisation and dose limitation).

The responsible operator shall take the measures necessary to render harmless any radioactive waste arising from its operations. A similar obligation to manage radioactive waste also applies to mining and ore processing operations as well as other operations that utilise natural resources containing radioactive substances.

If the operator fails to discharge the duty of care concerning radioactive waste, the State has a secondary duty to render the waste harmless. The operator shall compensate the State for the expenses incurred. The State also has the duty to manage radioactive waste when the origin of the waste is unknown or no responsible operator can be found.

The holder of a safety licence shall furnish a financial security if the expenses of rendering harmless the radioactive waste generated in its operations are assessed to be considerable.

The operator's responsibility for the radiation source expires when the source has been returned to the supplier, the radiation source has been surrendered to a so-called recognised installation for transfer to the State long-term storage in Olkiluoto, or the radiation source has been transferred to some other operator with a safety licence for the use of the radiation source in question.

Disused radiation sources that were not manufactured in Finland may not be imported to Finland as radioactive waste.

The amounts of waste generated in mining and enrichment operations and other similar operations that utilise natural resources may be considerable. In practice, this means that the waste must be disposed of at the site of operation. In that case, arrangements such as the technical solutions concerning stacking, must be planned and implemented on a case-by-case basis to effectively prevent the release of radioactive substances in the environment.

International recommendations

Finland complies with international recommendations concerning nuclear and radiation safety. Requirements and measures concerning nuclear and radiation safety are scaled and targeted according to the risks involved in the use of nuclear energy and radiation (graded approach), taking into account normal operations and potential operational occurrences and accidents.

Nuclear safety standards are based on, for example, the recommendations of the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators Association (WENRA).

Radiation safety standards are based on EU Directives on radiation protection and the recommendations of the IAEA. They take into account the radiation protection principles of the International Commission on Radiological Protection (ICRP).

2 Significant milestones and timeframes

Low and intermediate level nuclear waste

When Finnish nuclear power plants became operational in the late 1970s, the basic principle was that the disposal facilities for their low and intermediate level waste are excavated in the bedrock of the power plant sites. The power companies decided to build separate disposal facilities for operational waste. Studies to determine the disposal sites were conducted in the 1980s. The disposal facilities for operational waste at the Olkiluoto site in Eurajoki and the Hästholmen site in Loviisa were commissioned in the 1990s.

The low and intermediate level waste generated during the future decommissioning of the Olkiluoto power plant units OL1, OL2 and OL3 are to be placed in the Olkiluoto disposal facility for operational waste (VLJ repository) during the 2070s and 2080s. The Olkiluoto interim storage for spent fuel (KPA storage) will be decommissioned and the decommissioning waste permanently disposed of at the beginning of the 2100s.

According to current plans, the licence process for decommissioning the Loviisa power plant will be initiated at the beginning of the 2020s by conducting an environmental impact assessment of the decommissioning process and the disposal facility and submitting the licence applications required for expanding the final disposal repository. The preparation phase of the decommissioning process begins after power production at the facility has ended in 2027. The preparations will last approximately three years for each plant unit and are followed by the actual dismantling phase. According to current plans, the aim is to decommission the spent fuel storage, solidification plant and liquid waste storage in the 2060s after all spent fuel has been transferred to Olkiluoto for disposal. The low and intermediate level waste generated during the decommissioning of the Loviisa plant units LO1 and LO2 is intended to be placed in the Loviisa disposal facility for operational waste.

Fennovoima has planned to build a final disposal facility for low and intermediate level operational waste in the bedrock at the Hanhikivi site in Pyhäjoki. According to present plans, the construction of the disposal facility for operational waste will begin around the year 2030, and the facility will be commissioned at the earliest in 2035. Fennovoima is also planning to build an above-ground disposal facility for very low level waste. It will be taken in use approximately in 2026, two years after the power plant becomes operational.

VTT Technical Research Centre of Finland is negotiating the nuclear waste management arrangements associated with the decommissioning of the FiR 1 research reactor with Finnish nuclear power companies. The negotiations concern cooperation in dismantling the reactor and the interim storage and final disposal of the dismantling waste. The objective is to submit a licence application for the decommissioning of the FiR 1 research reactor to the Government in 2016. The application shall also describe the nuclear waste management arrangements. It would be beneficial for VTT to have the decommissioning waste stored in interim storage at a nuclear power plant site and under the management of the plant, which requires processing and the power company to submit an application for amending the plant's operating licence. VTT is also investigating the possibility of organising the interim storage of dismantling waste in an underground interim storage facility used by the research centre in Otaniemi, Espoo. The decision on the disposal arrangements can be made and the related application drawn up around the period 2025–2030. Before that, separate solutions for certain types of dismantling waste have to be prepared (aluminium, reactor graphite and the Fluental used at the radiotherapy unit).

Spent nuclear fuel

Until the mid-1990s, Finnish power companies had different arrangements for the management of spent fuel. Fortum (formerly Imatran Voima) had negotiated an opportunity to repatriate the spent fuel generated at the Loviisa plants to the Soviet Union (to Russia since 1990). In 1994, the Nuclear Energy Act was amended by prohibiting the imports and exports of nuclear waste. Thus, the last consignments of spent fuel from the Loviisa plants were sent to Russia in 1996 after the transition period. Teollisuuden Voima (TVO) investigated in the 1970s and 1980s the possibility of permanently exporting spent fuel abroad. These arrangements turned out to be impossible, because at least the waste generated in the reprocessing would have had to be returned to Finland. At the same time, TVO decided to build an interim storage for spent fuel with a capacity that would ensure progress in accordance with the timeframe presented in the Government's general decision and the company's preparedness for final disposal in Finland.

Due to the amendments to the Nuclear Energy Act, Fortum and TVO engaged in collaboration and established in 1995 Posiva Oy to manage the final disposal of spent fuel. Under the Nuclear Energy Act, Fortum and TVO remain the licensees under a waste management obligation and are thus responsible for their own spent fuel. Posiva arranges the final disposal on behalf of its owners.

The licence procedure of a nuclear facility is preceded by an environmental impact assessment (EIA) procedure. The environmental impacts of constructing and operating an encapsulation and disposal facility were assessed in 1999. The EIA procedure concerning the expansion of the disposal facility was conducted in 2008–2009.

Encapsulation and disposal facilities for spent fuel constitute nuclear facilities of considerable general significance as referred to in the Nuclear Energy Act. Building a nuclear facility requires a positive project-specific Decision-in-Principle (DiP) from the Government, stating that the construction of the facility is in line with the overall good of society. The Government issued DiPs on the disposal of spent fuel on 21 December 2000 and 17 January 2002. The DiP issued in 2000 on the construction of a disposal facility applies to the spent fuel generated by the operations of the four nuclear power plant units currently in use in Finland, totalling a maximum of approximately 4,000 tons of uranium (tU) of spent fuel. The 2002 DiP on an extension to the disposal facility concerns the spent fuel from the Olkiluoto 3 plant unit, meaning a maximum of 2,500 tU of spent fuel.

The Government DiP is followed by the construction licence and operating licence phases. The construction of an encapsulation and disposal facility requires a construction licence granted by the Government. Prerequisites for granting the construction licence include that the plans concerning the facility are sufficient in terms of safety, and that the safety of workers and the population and environmental protection have been appropriately taken account of when planning the operations, and that the location is appropriate with respect to the planned operations. A construction licence application for the disposal facility for spent fuel was submitted in 2012.

Operating a nuclear facility requires an operating licence issued by the Government. Processing the operating licence of the encapsulation and disposal facility for spent fuel will become relevant around the year 2020.

Fennovoima intends to dispose of its spent fuel in the Finnish bedrock using the KBS-3 method. According to the conditions of the 2010 DiP, Fennovoima must by the end of June 2016 either present an agreement on cooperation with Posiva and its owners concerning the disposal of spent fuel or initiate an EIA procedure for its own disposal site. Fennovoima has estimated that it will commence the disposal of its spent fuel approximately in the 2090s.

VTT Technical Research Centre of Finland Ltd intends to return the spent fuel of the FiR 1 research reactor to an Idaho-based research centre in the United States, which requires an agreement (DOE/EIS 0218F) between VTT and the United States Department of Energy (U.S. DoE). The fuel for the research reactor was originally acquired from the United States in connection with the purchase of the reactor. The research reactor was permanently shut down on 30 June 2015. According to the repatriation programme, the deadline for returning the fuel to the United States is in May 2019.

VTT and Posiva have concluded an agreement in principle. According to the agreement, VTT shall notify Posiva within five years of the permanent shutdown of the reactor if it needs to engage in collaboration with Posiva to prepare disposal in Finland. In addition to technical project planning, this also entails the preparation and processing of applications in accordance with the Nuclear Energy Act, starting with the Decision-in-Principle that also requires the approval of the municipality of the intended site.



The overall timeframe for the management of nuclear and other radioactive waste is presented in the following figure.

Figure. Overall timeframe (source: STUK).

Other radioactive waste

Until 2010, radiation users could hand over used radiation sources containing radioactive substances to the Finnish Radiation and Nuclear Safety Authority (STUK). The radiation sources received were initially stored

in the facilities of the Finnish Defence Forces in Helsinki until 1996 when the State rented a storage facility for small user waste at the Olkiluoto disposal facility for operational waste.

In 2005, the Radiation Act was amended to include the role of so-called recognised installations in the management of radioactive waste. The added provisions ensure that waste from radiation sources is effectively managed under all circumstances. However, the objective was to find other possible solutions for the reception of waste so that the authority STUK would not have to be involved in offering waste management services to licensees subject to a charge. As a result, STUK ceased to accept small user waste in 2010, when a private company called Suomen Nukliditekniikka Oy began operating the service.

According to the conditions of the Olkiluoto disposal facility for operational waste that were updated in 2012, most of the small user waste stored in the storage rented by the State may also be permanently disposed of as low and intermediate level waste at Olkiluoto, in TVO's disposal facility for low and intermediate level waste. However, the final disposal method of certain high-level radiation sources remains to be solved.

Requirements under the so-called HASS Directive (Directive on the control of high-activity sealed sources) entered into force at the beginning of 2006. They aim to ensure the appropriate management of disused sources. To be granted a security licence, the applicant must present the source manufacturer's commitment to take the source back when its use ends. Moreover, a financial security must be lodged to ensure waste management if the activity of the source exceeds the activity level specified in the HASS Directive by a factor of 100 times or more.

The Radiation Act that entered into force in 1992 also takes into account exposure to natural radiation, providing a foundation for the regulatory control of waste containing natural radioactive substances, such as mining waste. Under the Act, the operator shall investigate the radiation exposure caused by its practices, after which STUK shall, where necessary, issue instructions on limiting the exposure to radiation. The operator shall also ensure that waste containing natural radioactive substances poses no hazard to health or to the environment during operations or after their termination.

3 Quantities of spent fuel and radioactive waste and estimates for future quantities

Nuclear waste

The radioactive waste generated in the use of nuclear energy is nuclear waste, which is further classified in Finland into low and intermediate level waste and spent nuclear fuel.



Figure. Classification of nuclear waste (source: STUK).

The current power plant units at Olkiluoto (OL1 and OL2) and Loviisa (LO1 and LO2) are estimated to generate in total approximately 4,000 tU of spent fuel. The OL3 plant unit under construction is estimated to generate a total of approximately 2,500 tU of spent fuel during its 60 years of operation.

The planned Fennovoima nuclear power plant is estimated to generate in total up to 1,800 tU of spent fuel during its 60 years of operation.

The total mass of spent fuel generated by the VTT FiR 1 research reactor is approximately 340 kg, of which uranium accounts for some 25 kg.

The operation of nuclear power plants also generates low and intermediate level radioactive waste, which is classified as nuclear waste. The Olkiluoto power plant generates approximately 150–200 m³ and the Loviisa power plant approximately 100–150 m³ of low and intermediate level waste per year. At Olkiluoto, the commissioning of the OL3 plant unit will increase the annual amount of waste to approximately 300 m³.

The Fennovoima nuclear power plant is estimated to generate approximately 90 m^3 of low and intermediate level waste per year.

During its operation, the FiR 1 research reactor generated a very small amount (approximately 600 kg) of low level resin used in the purification of the reactor water. The dismantling of the reactor will also produce

approximately 30 m³ nuclear waste originating from concrete, metal structures and reactor graphite. The amount will be specified by characterisation measurement, which will be done after reactor shutdown.

The disposal of spent fuel from the Loviisa and Olkiluoto power plants is estimated to generate approximately 4 m³ of liquid waste per year during the operation of the encapsulation plant and approximately 100 m³ of dismantling waste during the decommissioning. After being dried and packed, the liquid waste will total approximately 3 m³. The disposal facility will begin generating operational waste when it becomes operational approximately in 2022 and decommissioning waste when its operations end, which is estimated to take place in 2110. The decommissioning is estimated to last approximately six years, after which the disposal facility will be closed down.

Other radioactive waste

Other radioactive waste is similarly classified according to disposal routes. Used sealed sources and other solid radioactive waste must be returned to the supplier or surrendered to Suomen Nukliditekniikka for transfer to the State's interim storage in Olkiluoto. The waste may be discharged to sewers or into the atmosphere or disposed of as regular municipal waste in a waste incineration plant only if the activity level of the waste remains below the criteria laid down in legislation or the derived activity levels.

The maximum capacity of the storage for small user waste rented by the State in the Olkiluoto disposal facility for operational waste is 100 m³, of which 56 m³ had been used at the end of 2013. The overall activity was approximately 50 TBq at the end of 2013, with the main radionuclides including ³H, ¹³⁷Cs, ⁸⁵Kr, ²⁴¹Am and ²³⁹Pu. Approximately 1–3 m³ of new waste is generated each year.



Figure. Classification of other radioactive waste (source: STUK).

In Finland, there is no radioactive waste for which no owner or licensee under a waste management obligation is known (so-called legacy waste). The management and final disposal of radioactive waste generated in small-scale experiments associated with uranium mining and ore processing operations have been carried out in compliance with requirements and under the regulatory oversight of STUK.

4 Concepts, plans and technical solutions

Low and intermediate level operational waste

Low level operational waste includes, for example, various packaging, scaffolding, protecting, insulating and cleansing materials used in maintenance and repair work. At Olkiluoto and Loviisa, low level waste is packed into steel drums. Some of the waste is compressed to allow more waste to be placed in the final disposal containers than without compression. At Olkiluoto, the drums are also packed into concrete containers before their final disposal. Low level waste requires no radiation protection.

Intermediate level operational waste includes, for example, ion-exchange resins used in the cleansing of process water. Intermediate level waste is wet or in liquid form; thus, it is solidified before treatment. At Olkiluoto, the intermediate level waste generated by the OL1 and OL2 plant units is solidified by mixing it with bitumen in steel drums. At the OL3 plant unit, intermediate level ion-exchange resin will be dried together with low level evaporator concentrates directly in 200-litre drums using vacuum heating. Before the final disposal concept is approved, the drums containing dried resin waste are placed in an interim storage at the plant site. At Loviisa, liquid intermediate level waste will be solidified by cementation. When disposed of, intermediate level waste requires radiation protection.

At Olkiluoto, prior to final disposal, operational waste is stored in interim storage at the power plant units₇: waste building storages, interim storages for low and intermediate level waste and in the interim storage for spent fuel. At Loviisa, operational waste is stored at the power plant and in an interim storage built in connection with the final disposal tunnels.

The final disposal of operational waste takes place at the power plant sites. The Olkiluoto disposal facility (VLJ repository) was commissioned in 1992. The repository is excavated into the bedrock 60–100 metres below ground, and it consists of two separate silos (one for low level and one for intermediate level waste), a hall connecting the silos, and auxiliary facilities. The facility also includes an interim storage for radioactive waste in the possession of the State, generated mainly by hospitals and industry. The current capacity of the VLJ repository is insufficient for the final disposal of the operational and decommissioning waste of all Olkiluoto power plant units. Thus, the repository must be expanded. According to current estimates, the expansion of the Olkiluoto VLJ repository will be relevant in the 2030s.

According to plans, the liquid operational waste generated during the final disposal of spent fuel from the Loviisa and Olkiluoto power plants will be vacuum dried in drums or similar containers. The drums containing intermediate level waste will be placed in a special concrete waste container, designed to function for at least 500 years. The current plan is to place operational and decommissioning waste in a separate hall located along the access tunnel of the disposal facility for spent fuel, at a depth of approximately 180 metres.

The Loviisa disposal facility for low and intermediate level waste was commissioned in 1998. The repositories for final disposal of wastes are excavated in the bedrock, at a depth of approximately 110 metres. They consist of two maintenance waste tunnels (HJT1 and HJT2) and a disposal tunnel for solidified waste (KJT). In addition, the facility also includes a separate space for the long-term interim storage of maintenance waste (HJT3). The Loviisa power plant's decommissioning plan includes a plan for expanding the disposal facility to enable the final disposal of decommissioning waste.

The operational phase of the Olkiluoto VLJ repository will end after all power plant units at Olkiluoto have been decommissioned. When the VLJ repository is closed, filling materials and closing structures will be installed in the final disposal repositories to prevent the flow of groundwater and the release of radioactive substances. Moreover, the purpose of the structures is to prevent accidental access to the repositories after the facility has been closed. The final closure plan will be further specified closer to the time of closing the disposal facility. After the VLJ repository is closed, the final disposal site does not require controlling for radiation safety reasons.

According to current plans, the Loviisa disposal facility for operational waste will be closed after the final disposal of decommissioning waste in the 2060s. In the closure phase, the repositories are partly filled and the necessary concrete closing structures are built in the tunnels and shafts.

Fennovoima plans to store and permanently dispose of its operational waste at the power plant site by building repositories for final disposal of low and intermediate level waste in the plant site bedrock at the power plant site. Furthermore, Fennovoima will build a surface repository on ground level for very low level waste.

Spent nuclear fuel

At Loviisa and Olkiluoto, spent fuel assemblies are cooled down for a few years in water pools in the reactor hall or fuel building of the nuclear power plant unit. From there, fuel assemblies are transferred in a transport cask to water-filled pools in the on-site interim storage for spent fuel (KPA storage). The fuel assemblies are stored under water in the KPA storage pools for approximately 40 years. During this time, the radioactivity and heat generation of the spent fuel decrease to the level required for final disposal.

A project for expanding the Olkiluoto KPA storage was launched in 2009. The commissioning inspections of the extension were carried out at the end of 2014. A licence application for increasing the storage capacity was submitted to STUK in 2013, and STUK issued a favourable decision in 2015. The licence application covers the future needs of the plant units OL1, OL2 and OL3.

In recent years, the capacity of the KPA storage at Loviisa has been increased by replacing the original fuel racks with dense racks. After the installation of the dense racks, the storage capacity is sufficient for the current operating life of the plant. Interim storage at the plant site continues as long as all spent fuel has been transported to Olkiluoto for final disposal by Posiva. According to current plans, the final disposal of all spent fuel from the Loviisa power plant will be completed during the 2060s.

Fennovoima is also planning to build an interim storage for spent fuel at the plant site. The interim storage may be a dry or water pool storage. According to Fennovoima's preliminary plans, spent fuel will be stored in the interim storage for several decades. The first fuel assemblies removed from the reactor are estimated to be held in the interim storage for nearly 70 years before their final disposal begins in the 2090s. The last fuel assemblies, on the other hand, will be permanently disposed of as soon as practicable, meaning that their time in interim storage will be somewhat shorter.



Figure. Interim storage of spent fuel (source: TVO).

The disposal concept planned to be used in Finland is the KBS-3 concept. In the concept, fuel assemblies are sealed in tight metal containers, or canisters, with a cast-iron insert and a copper outer casing. The purpose of the sturdy, corrosion-resistant canister is to isolate the spent fuel and prevent radioactive substances from being released into the bedrock where they could be transported into living environment by groundwater. In disposal rooms, the canisters are isolated from the bedrock with a barrier of bentonite clay. The purpose of bentonite clay is to ensure that the conditions remain favourable for final disposal, maintain the isolation capacity of the canister and, as far as possible, prevent the bedrock groundwater from affecting the canisters.



Figure. Concept image of the KBS-3V final disposal solution (source: Posiva).

In the early 2000s, the Olkiluoto island in the municipality of Eurajoki was selected as the final disposal site for the spent fuel of the Olkiluoto and Loviisa power plants in a decision-making process that complied with the Nuclear Energy Act. Based on the Decision-in-Principle made by the Government and approved by the Parliament, construction work was launched to build an underground research facility in Olkiluoto. The facility was named ONKALO. ONKALO consists of an access tunnel reaching the final disposal depth and vertical shafts that are connected to the tunnel. The purpose of ONKALO has been to enable detailed characterisation on the bedrock at the site before applying for a construction licence for the encapsulation and disposal facility. It also provides an opportunity to test the final disposal technique in realistic conditions and an authentic operating environment. The construction of the research facility began in 2004. Under the Decision-in-Principle, STUK has regulated ONKALO as if it were a nuclear facility under construction. The ONKALO underground facility is used to perform installation tests for the final disposal system and demonstrate the operations in full scale before beginning the final disposal.

The encapsulation and disposal facility consists of two nuclear waste facilities. The spent fuel is transferred from interim storage to the encapsulation plant in order to be packed in canisters. The canisters are tightly closed and transferred through a vertical shaft to the underground disposal tunnels to be placed in disposal holes. The spent fuel must be cooled down in an interim storage before final disposal. The heat generation of each canister is limited to an acceptable level by always selecting for disposal fuel assemblies with suitable heat generation levels.

The encapsulation plant is designed to meet the encapsulation needs of the entire disposal phase. The underground repository will be expanded as spent nuclear fuel has cooled down and becomes available for encapsulation. The objective is to optimise the disposal process as efficiently as possible in terms of time, space and resources available.

Spent fuel is transported from the nuclear power plants in Loviisa and Olkiluoto to the Olkiluoto encapsulation plant. The transportations require licences from the supervisory authorities. For transportation, the spent fuel assemblies are placed in a massive transport cask, which protects the transportation staff from radiation from the spent fuel. The fuel may be transported by road, rail or sea, or a combination of these transport forms.

According to current plans, Fennovoima's spent fuel will also be placed in Finnish crystalline bedrock using the KBS-3 concept. Under the conditions of the Finnish Government's 2010 Decision-in-Principle, Fennovoima must by the end of 2016 either present an agreement on cooperation with Posiva and its owners concerning the final disposal of spent fuel or initiate an EIA procedure for its own final disposal site.

Dismantling waste generated during decommissioning

The Loviisa and Olkiluoto plants are planning to permanently dispose of their decommissioning waste by placing it into the expanded repositories for final disposal of operational wastes. The extensions will be granted licences and constructed later on.

Decommissioning plans are based on both immediate and delayed dismantling, meaning that radioactive systems will be dismantled and materials transferred from the plant either as soon as possible or sometime after the operations have ended. The decommissioning plans of the Olkiluoto OL1 and OL2 plant units are based on delayed dismantling. The delayed approach is justified because it reduces the radiation doses of the dismantling personnel and the quantity of waste destined for final disposal. It can also be reasonably

implemented, because during the supervised storage of the OL1 and OL2 plant units, the OL3 unit and the KPA storage are still operated in Olkiluoto. Thus, Olkiluoto will have the organisation necessary for operating the plants. The plans for the Olkiluoto OL3 plant unit and the Loviisa power plant are based on immediate decommissioning. No final decisions have been made on the decommissioning strategies. Final decisions will be made when the facilities have ceased their operations, but before decommissioning is commenced.

The decommissioning strategy of the Loviisa power plant is based on the immediate decommissioning of those parts of the plant that are not needed for the interim storage of spent fuel. The intention is to permanently dispose of the decommissioning waste by placing it in the extended VLJ repository at the plant site. The general principle is to decommission and permanently dispose of the major components in complete form, including the pressure vessel and steam generators.

Fennovoima's preliminary decommissioning strategy is based on immediate decommissioning. The radioactive waste generated during decommissioning will be placed in the extension to be built to the underground disposal facility for operational waste.

In 2012–2014, VTT conducted an environmental impact assessment concerning the decommissioning of the FiR 1 research reactor. It also included an assessment of the dismantling of the reactor and the management of the waste generated in the process. The dismantling will begin after the spent fuel has been removed from the plant. VTT is also exploring the possibility of organising the interim storage of the dismantling waste at the research centre site.

Other radioactive waste

The concepts, plans and technical solutions concerning other radioactive waste have been described in Chapter 3 on the quantities of spent fuel and radioactive waste and estimates for future quantities.

5 Concepts and plans for the post-closure period of a disposal facility

The design of a nuclear facility shall provide for the facility's decommissioning. The decommissioning plan must be kept up to date. Dismantling the facility and other measures taken for the decommissioning of the facility may not be postponed without due cause.

Closure means closing disposal facilities in a manner intended as permanent. The closure must be implemented so that the characteristics of the bedrock that are deemed important in terms of long-term safety are retained as far as possible.

The closure of disposal tunnels for spent fuel is planned to be implemented in stages. The closure of the disposal facility's central tunnels shall only begin after decades and the closure of other rooms only at the end of the operating phase. Detailed closure plans are developed based on experiences gained during final disposal.

The waste management obligation of an operator producing nuclear waste expires when STUK has confirmed that the final disposal of nuclear waste has been implemented safely and in the approved manner. When the waste management obligation has ceased, the responsibility for the nuclear waste is transferred to the State. Should it become necessary after the final disposal, the State has the right to take all measures required for the monitoring and control of the final disposal and for ensuring its safety.

STUK shall arrange the permanent archiving of information concerning the spent fuel destined for final disposal. No detailed plans for the permanent archiving of information have yet been made, because the closure of the first sections of the disposal facility and the arrangement of the permanent archiving of information are currently estimated to take place in the 2060s. Thus, according to current estimates, the final closure of the whole disposal facility for spent fuel and the permanent archiving of information will not take place until the 2100s.

When the operation ends, final disposal rooms are closed in accordance with a plan approved by the authority. The most important operational requirements concerning the closure include isolating the final disposal rooms from changes taking place above ground and from human activities. The objective is to return the conditions to a state that corresponds, as far as possible, to the conditions that according to research-based data prevailed in the bedrock before the construction and operation of the facility and that are favourable to the long-term performance and safety of the disposal system. The above-ground facilities at the final disposal area shall be landscaped to blend in the surrounding nature. The monitoring of the final disposal rooms shall continue until the facility has been closed in accordance with the YVL Guides in force and in a manner approved by STUK.

When granting the licence for the closure of the final disposal facility, land use restrictions may be imposed. The restriction shall be recorded in the appropriate registers. Once a licensee under a waste management obligation has closed the disposal facility in the approved manner and paid a fee to the State for the future monitoring and control of the nuclear waste, the ownership right to and the responsibility for the nuclear waste is transferred to the State. Under the Nuclear Energy Act, final disposal must overall be implemented in a manner that ensuring safety does not require post-closure control.

6 Research, development and demonstration activities needed for implementation

Activities by licensees under waste management obligation

When the Finnish nuclear power plants were commissioned, the power companies IVO (presently Fortum) and TVO set up the Nuclear Waste Commission of Finnish Power Companies (Voimayhtiöiden ydinjätetoimikunta, YJT) for research and investigation activities. As one of its first tasks, the Nuclear Waste Commission published in 1978 a report on nuclear waste, including a presentation of different alternatives for the management of spent fuel. Before the Nuclear Energy Act entered into force, the commission also prepared annual operational programmes for nuclear waste management in accordance with the operating licence conditions and the Finnish Government's general decision in 1983.

Under the Nuclear Energy Act, the users of nuclear energy are responsible for managing the nuclear waste that their operations generate and for the related measures, preparations and costs. These must be described in the overall plan for carrying out nuclear waste management, which must also include research and development activities (R&D). R&D activities in the field of nuclear waste management concern the storage and final disposal of spent fuel, the treatment, storage and final disposal of operational waste, decommissioning of power plants, final disposal of decommissioning waste and new solutions for nuclear waste management.

Operators under a waste management obligation shall regularly submit their plans to the Ministry of Employment and the Economy for evaluation and approval. Provisions on the contents of nuclear waste management plans are laid down in the Nuclear Energy Decree.

Activities by the State

The State started its nuclear waste research in the 1970s. At that time, VTT Technical Research Centre of Finland conducted research on the treatment of operational waste, alternatives for the management of spent fuel and the safety of final disposal. In the 1970s, the Geological Survey of Finland (GTK) launched a nuclear waste project to examine questions concerning final disposal. GTK's strengths included its knowledge of the Finnish bedrock and its geological survey data. Other nuclear waste related research was conducted for example at the Department of Radiochemistry at the University of Helsinki.

The Finnish public administration has been implementing coordinated nuclear waste management research programmes since 1989. The purpose of these programmes (JYT and KYT) has been to ensure that nuclear waste management authorities have access to expertise independent of licensees and licence applicants. Current research topics include, for instance, different types of waste, safety aspects of geological disposal and technological alternatives for the implementation of final disposal.

In regulating safety, STUK uses the necessary external experts and, when necessary, commissions research or analyses directly associated with the regulation. STUK's support programme for regulatory oversight has mainly focused on the final disposal of spent fuel, and its purpose has been to produce assessments and analyses on issues concerning the safety of final disposal.

International cooperation

Finland also participates in international cooperation regarding nuclear waste research. Finnish research organisations, licensees, Posiva and STUK participate in EU research programmes. Posiva was actively involved in establishing the Implementing Geological Disposal - Technology Platform (IGD-TP). The Finnish power companies also participate in IGD-TP activities.

Finland is also active in the Radioactive Waste Management Committee (RWMC) of the OECD Nuclear Energy Agency (NEA) and its working groups. Of the working groups, the Forum on Stakeholder Confidence (FSC) focuses on the social acceptability of nuclear waste management. The Integration Group for the Safety Case (IGSC) concentrates on different aspects of the safety of final disposal and on developing the safety case of final disposal. The Working Party on Decommissioning and Dismantling (WPDD) focuses on decommissioning strategies and regulation, dismantling techniques as well as decommissioning waste, financing and costs.

Finland participates in the International Atomic Energy Agency's (IAEA) work on safety standards and its cooperation projects. In the field of safety standards, Finland participates in the following committees preparing the standards: NUSSC (nuclear safety), WASSC (safety of radioactive waste), RASSC (radiation safety), NSGC (security arrangements) and TRANSSC (transport safety). Finland also participates in several information exchange systems maintained by the IAEA in the field of nuclear energy.

Posiva and the Swedish nuclear waste management company SKB (Svensk Kärnbränslehantering Ab) have since 2001 had a bilateral agreement on broad research and development collaboration concerning the final disposal of spent fuel. Depending on the topic, the forms of collaboration have varied from the exchange of information to joint projects.

Competence and infrastructure

The objective of duties related to nuclear waste management is to ensure the safe and economic processing of the waste in the power plants and their safe long-term final disposal in accordance with existing requirements.

The work requires, for example, understanding the factors affecting the generation of nuclear waste, waste processing and storage methods, and assessment of the suitability of the final disposal site from the perspectives of construction, operation and long-term safety.

Competence in the in-service safety of nuclear waste processing and final disposal includes similar competence in nuclear safety and radiation protection as required of the operators of nuclear power plants.

A national nuclear waste management course (YJH course) is organised in Finland each year. The first course was organised in 2010. The objective of the course is to ensure and improve competence in the field of nuclear waste management.

Each year, the course includes some 20–25 participants who represent the authorities, the operators and research institutes in the field and are less familiar with the practical management of nuclear wastes. The course is organised as a collaborative effort by the authorities and operators in the field.

The course provides the participants with basic information on activities in the field and a broad picture of the diversity of nuclear waste management. The topics covered during the course include the regulation and supervision of nuclear waste management, official regulations, nuclear fuel cycle, radiation safety, types of nuclear waste and their classification, management of operational waste, decommissioning, and the management of spent fuel. Moreover, the course includes special themes such as the recycling and transportation of nuclear waste. During the course, the participants also have the opportunity to familiarise themselves with the research equipment used in the field.

Nuclear waste management is also discussed in the annual national nuclear safety course (YK Course) organised in Finland. The first course was organised in 2003. The objective of the course is to increase understanding of the factors affecting nuclear safety.

Posiva has constructed an underground bedrock research facility (ONKALO) for its own use to conduct verifying site investigations. The objective is to collect accurate data for designing the disposal facility and assessing the related safety and construction engineering solutions. In connection with the research, Posiva has developed equipment for pressurised groundwater sampling and measuring groundwater flow.

7 Responsibility for the implementation of the national programme and key performance indicators

In Finland, responsibility for the management of nuclear waste lies with those who hold a licence to operate a nuclear facility. Currently, the licensees under a waste management obligation include Fortum Power and Heat, Teollisuuden Voima and VTT. Fennovoima, which is preparing the construction of a new nuclear power plant in Pyhäjoki, will become subject to the waste management obligation when it is granted an operating licence for the planned power plant. Licensees under a waste management obligation regularly submit their nuclear waste management plans for evaluation and approval.

The responsibility for rendering harmless other radioactive waste lies with the holder of a safety licence or some other operator of radiation practices whose operations generate radioactive waste (e.g. mining that utilises natural resources containing radioactive substances). A plan for managing radioactive waste must be presented in the application for a safety licence (use of radiation) or before commencing operations (e.g. mining).

The Ministry of Employment and the Economy is responsible for the supreme command and control of nuclear energy matters. The Ministry prepares the Decisions-in-Principle made by the Government and subsequently approved by the Parliament as well as decisions on construction and operating licences after consulting authorities, communities, municipalities and citizens. The Ministry decides on the principles of nuclear waste management, after hearing the Ministry of the Environment and the Finnish Radiation and Nuclear Safety Authority (STUK), and approves plans for nuclear waste management.

The Ministry of Social Affairs and Health has the supreme authority concerning the supervision of activities subject to the Radiation Act. However, supreme authority in matters concerning mining is vested in the Ministry of Employment and the Economy.

STUK is responsible for the regulatory oversight of the safe use of nuclear energy and radiation and the safety of other radiation practices. STUK also grants safety licences.

Performance indicators may be considered to include the implementation of the technical solutions and timeframes of waste management, the actual waste management costs incurred and the effectiveness of the related financial provision system.

8 Assessment of costs

The overall costs of nuclear waste management (OL1, OL2, OL3, LO1 and LO2) are estimated to total approximately EUR 6.5 billion over the entire operating time of the power plants (2012 price level). Of this, the costs of the final disposal of spent fuel account for approximately EUR 3.5 billion. The costs of managing operational waste are expected to be approximately EUR 100 million. The decommissioning costs of the plants total approximately EUR 1 billion. The remaining costs consist of, for example, R&D costs, interim storage costs, fees charged by authorities and taxes.



Figure. Nuclear waste management costs of the Olkiluoto and Loviisa nuclear power plants (source: TVO).

For the FiR 1 research reactor, the confirmed estimate of nuclear waste management costs in 2014 is EUR 9.7 million.

For the use of radiation sources, the operator is responsible for the costs incurred in the appropriate processing of the radiation source. The costs depend on, for instance, the radionuclides and activity of the source and its form and usability for other purposes. The costs may range from hundreds to hundreds of thousands of euros per radiation source.

9 Financing schemes in force

Under the Nuclear Energy Act, the licensees under a nuclear waste management obligation (nuclear power companies and the operator of the research reactor) are responsible for the nuclear management measures concerning the nuclear waste they have generated, as well as for the preparation and costs of the measures. In practice, the plans for carrying out nuclear waste management cover the entire planned operating time of the nuclear facilities. The typical planned operating life of a nuclear power plant is 50–60 years. According to current plans, the decommissioning and closure of the nuclear waste facilities managing spent fuel would take place in approximately 100 years (by 2120).

Finland has taken measures to ensure that the necessary funds exist and are available when nuclear waste management measures shall be implemented. To that end, funds are annually collected from licensees under a waste management obligation to the financial provision fund of the State Nuclear Waste Management Fund. The payment amounts depend on the amount of nuclear waste and the state of its management each year. Moreover, preparations are made each year for the event that the nuclear power plants in operation are decommissioned earlier than planned, at the end of the year in question. If the annual quantity of waste increases, the necessary funds must also be increased; on the other hand, implemented waste management measures reduce the need to increase the funds.

The State Nuclear Waste Management Fund was established under the Nuclear Energy Act (990/1987), which entered into force in 1988, and the Government Decree on the State Nuclear Waste Management Fund (162/1988) issued under the Act. The Fund was expanded with an amendment (1131/2003) to the Nuclear Energy Act, which entered into force in 2004. The State Nuclear Waste Management Fund consists of three separate funds: financial provision fund, nuclear safety research fund and nuclear waste research fund. The funds collected in the three separate funds can only be used for the purposes defined in the relevant provisions of the Nuclear Energy Act.

The purpose of the final provision fund is to collect, store and securely invest the funds that are collected from licensees under a nuclear waste management obligation for the future management of nuclear waste. The fund ensures that the necessary funds exist and are available when nuclear waste management measures shall be implemented. The funds are used for nuclear waste management only if a licensee under a waste management obligation fails to fulfil its legal waste management obligation. Funds are refunded to the licensees as the implementation of waste management measures progresses.

The tasks of the nuclear safety research fund concern ensuring the availability of expertise and maintaining the research infrastructure. Should there emerge such new factors concerning the safe operation of nuclear facilities that could not be foreseen, the authorities should have such sufficient and comprehensive nuclear engineering expertise and other facilities at their disposal that can be used, when necessary, to analyse without delay the significance of such factors. The nuclear safety research fund annually grants the funds it has collected to research projects on nuclear safety.

The objectives of the nuclear waste research fund are also associated with ensuring the availability of expertise and maintaining the research infrastructure by ensuring that the authorities have such sufficient and comprehensive nuclear engineering expertise and other facilities at their disposal that are needed for assessments of the various ways and methods of carrying out nuclear waste management. The nuclear waste research fund annually grants the funds it has collected to research projects on nuclear waste.

To ensure that the highest waste costs of sealed sources are met, a financial security shall be furnished. The security amount is determined in the Radiation Decree, taking into account the activity and radionuclide of the source. The amount usually ranges from EUR 10,000 to EUR 100,000 per source.

10 Transparency policies

Nuclear waste management is governed by the Nuclear Energy Act (990/1987). The Act entered into force in 1988. It includes provisions on general principles, obligations, procedures concerning Decisions-in-Principle and licensing, nuclear waste management procedures, financial provision for the costs of nuclear waste management, ensuring the availability of expertise, and supervision. The Nuclear Energy Decree (161/1988) further specifies the definitions and procedures laid down in the Nuclear Energy Act. Finnish nuclear energy legislation includes a broad-based hearing procedure, involving citizen participation in the Decision-in-Principle and licencing procedures.

Provisions on nuclear waste management are also included in other decrees issued under the Nuclear Energy Act. Key decrees presently include the Government Decree on the Safety of Disposal of Nuclear Waste (736/2008), under which STUK has issued detailed safety requirements concerning the implementation of safety level in accordance with the Nuclear Energy Act (YVL Guides). The State Nuclear Waste Management Fund is also steered by Government decrees.

All other legislation also applies to nuclear waste management, unless in certain respects otherwise provided. Examples of other legislation include the Act on Environmental Impact Assessment Procedure (468/1994), Act on the Transport of Dangerous Goods (719/1994), Land Use and Building Act (132/1999), Environmental Protection Act (527/2014), Occupational Safety and Health Act (738/2002) and Rescue Act (379/2011). In particular, provisions on citizen participation are laid down in the Act on Environmental Impact Assessment Procedure, the Land Use and Building Act and the Environmental Protection Act.

The activities of authorities are governed by, for example, the Administrative Procedure Act (434/2003) and the Act on the Openness of Government Activities (621/1999). Due to these Acts, the licensing procedure of nuclear facilities includes a broad-based hearing and documents are mainly public and easily accessible on the authorities' websites.



Figure. Licensing procedure concerning nuclear facilities (source: Ministry of Employment and the Economy).

11 Agreements on the management of spent fuel and radioactive waste

Finland has been a member of the International Atomic Energy Agency (IAEA) since 1957. Finland signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management in 2000. The IAEA was party the 1961 agreement (INFCIRC/24) between Finland and the United States under which the United States was the supplier of the FiR 1 research reactor.

Finland has been a member of the Organisation for Economic Cooperation and Development (OECD) since 1969 and is involved in the activities of the Nuclear Energy Agency operating under OECD. The actual work is carried out in the agency's committees, one of which concerns nuclear waste (Radioactive Waste Management Committee). With regard to nuclear liability, Finland joined the Paris Convention in 1972, under which it has adopted the Nuclear Liability Act (484/1972). The Act was further specified in 2012.

In 1976, Finland, Norway, Sweden and Denmark concluded an agreement on guidelines concerning the communication on safety issues of nuclear facilities near the borders between the countries. According to the agreement, the authorities of the other countries must be informed of planned nuclear facilities.

In 1979, Finland joined the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, 1972).

In 1995, Finland ratified the Convention on Environmental Impact Assessment in a Transboundary Context (United Nations Economic Commission for Europe, Espoo Convention). Under the Espoo Convention, Finland has the obligation to notify and consult other countries on, for instance, nuclear facility projects.

In 2004, Finland ratified the Aarhus Convention on Access to Information, Public Participation in Decisionmaking and Access to Justice in Environmental Matters. In Finland, the convention applies to those nuclear facility projects that have been initiated after the ratification of the convention.

Nuclear power plants and research reactor

Olkiluoto, Eurajoki

- Owner: Teollisuuden Voima Oyj
- Reactor units: Olkiluoto 1 (OL1), Olkiluoto 2 (OL2), BWR 2 x 880 MWe
- Operation started: 1979, 1982
- Under construction: Olkiluoto 3 (OL3), EPR (PWR) 1600 MWe

Hästholmen, Loviisa

- Owner: Fortum Power and Heat Oy
- Reactor units: Loviisa 1 (LO1), Loviisa 2 (LO2), PWR 2 x 488 MWe
- Operation started: 1977, 1981

Planned: Hanhikivi, Pyhäjoki

- Owner: Fennovoima Oy
- Reactor unit: Hanhikivi 1, VVER (PWR) 1200 MWe

Otaniemi, Espoo

- Owner: VTT Technical Research Centre of Finland Oy
- Reactor unit: Triga II Mark, 250 kW
- Operation started: 1962, final shutdown 30 June 2015