STUK-B 259 / OCTOBER 2020

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

7th Finnish National Report as referred to in Article 32 of the Convention

ISBN 978-952-309-488-8
ISSN 2243-1896

stuk

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

7th Finnish National Report as referred to in Article 32 of the Convention

ISBN 978-952-309-488-8
ISSN 2243-1896

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. 7th Finnish National Report as referred to in Article 32 of the Convention. STUK-B 259, Helsinki 2020, 157 p.

KEYWORDS: national report, Joint Convention, Finland, spent fuel management, radioactive waste management

Summary

Introduction

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was adopted on 29 September 1997 at the Vienna Diplomatic Conference. Finland signed the Convention on 2 October 1997 and deposited the tools of acceptance on 10 February 2000. The Convention entered into force on 18 June 2001. This report is the 7th Finnish National Report under the Joint Convention in accordance with the provisions of Article 32. It will be subject to review in May 2021 in the seventh Review Meeting of the contracting parties in Vienna. The fulfilment of the obligations of the Convention and the development of waste management after the Sixth Review Meeting, during the reporting period 2017–2019, are assessed in this report.

There are currently two nuclear power plants operating in Finland: Loviisa and Olkiluoto plants. The Loviisa plant comprises two pressurised water reactor units (VVER-440) operated by Fortum Power and Heat Oy (FPH). The Olkiluoto plant comprises two boiling water reactor units (BWR 75) operated by Teollisuuden Voima Oyj (TVO) and a third unit, a pressurized water reactor (EPR) is in the commissioning phase. In addition, Fennovoima Oy (Fennovoima) has applied for a construction license for one pressurised water reactor (AES-2006) at Pyhäjoki.

Spent fuel from the nuclear power plant units is stored in interim pool type storages at the power plant sites for tens of years until disposal. The interim spent fuel storages have already been in operation for about 30 years. The safety of the interim storages was enhanced during the reporting period. The spent nuclear fuel disposal project has progressed as planned. The construction license for the encapsulation and disposal facility was granted by the Government to Posiva in November 2015 and the construction of the geological disposal facility started in Olkiluoto in December 2016. Fennovoima started the Environmental Impact Assessment (EIA) of its own spent nuclear fuel disposal in summer 2016.

Geological disposal facilities for low and intermediate level waste have been in operation since the 1990s in Olkiluoto and Loviisa NPP sites. In the future, the Olkiluoto facility is planned to be extended for operational waste from the OL3 unit and decommissioning waste from all reactor units at Olkiluoto. The future at Olkiluoto includes also a new near-surface facility of the very low-level waste. Olkiluoto disposal facility is also the current route for radioactive waste originating from use of radiation in industrial, medical and research applications. The disposal facility in Loviisa will be extended for decommissioning waste from

the Loviisa NPP units. Fennovoima has planned to build a geological disposal facility for its low and intermediate level waste at the Pyhäjoki site.

Major developments in Finland since the 6th Review Meeting are as follows: there has been progress in construction of the spent nuclear fuel disposal facility, in addition improvements have been made in NPP's Low and Intermadiate Level Waste (LILW) management and non-nuclear radioactive waste disposal. There has been significant progress in the licensing of research reactor decommissioning. Furthermore, the legislative and regulatory framework has been enhanced. STUK has published a new strategy in 2018 covering the period of 2018–2022. The objective of the strategy is related to enchancing risk informed and performance-based regulation and oversight highlighting licensee's responsibility for safety. More detailed information on the latest developments in the various topics of the Convention is provided in connection with the relevant articles. Section K summarises the main achievements from the reporting period and presents Finland's future challenges in radioactive waste and spent nuclear fuel management.

Since the 6th Review Meeting

The 6th Review Meeting in 2018 identified challenges and recorded some planned measures to improve the safety of nuclear waste management in Finland. On request of the Review Meeting these issues and the responses are included in this 7th National Report of Finland. The challenges and planned measures to improve the safety are listed below with the related references provided in brackets. A summary of how Finland has proceeded with the identified challenges during the reporting period is given in Section K.

Finland – Challenges

- Construction and oversight of the spent fuel (SF) disposal facility (Section H, Annexes L.2 and L.3).
- Decommissioning and waste management of the FiR 1 research reactor (Article 9, Article 26).
- Ensuring adequate resources and competence in tough economic situations (utilities, waste management organizations, and Government) (Article 20, Article 22).
- Communication with public and stakeholders to maintain confidence in safe waste management and regulatory framework (Article 20).
- Disposal of a few High-Activity Sealed Sources (HASS), which are not suitable for disposal in existing LILW repositories (Section J).

Finland – Planned Measures to Improve Safety

- Construction and oversight of the spent fuel disposal facility (Section H, Annexes L2 and L3).
- Renewal of the ageing infrastructure of nuclear energy related research (new VTT Centre for Nuclear Safety building, thermohydraulic laboratory at Lappeenranta University of Technology). For this purpose, the research funding between 2016 and 2025 has been increased. (Article 20, *National research programmes*).
- Licensing of FiR 1 research reactor decommissioning and preparations to dismantling activities starting in 2022. (Article 9, Article 26).

Conclusion

In conclusion, based on the information presented in the report, Finland complies with the obligations and objectives of the Joint Convention. Challenges for the future have been recognized, regularly reviewed and addressed. The required efforts for continuous improvement have been made.

Contents

List of acronyms

CNS	VTT Centre of Nuclear Safety
DiP	Decision-in-Principle by the Government, to be approved by the Parliament
EIA	Environmental Impact Assessment
FiR 1	Finland Reactor 1 – A research reactor currently in extended shutdown state
FPH	Fortum Power and Heat Oy (NPP utility)
FSAR	Final Safety Analysis Report
HASS	High Activity Sealed Source
ILW	Intermediate level waste
IRRS	IAEA facilitated Integrated Regulatory Review Service
LILW	Low and intermediate level waste
LLW	Low level waste
LO1, LO2	Loviisa NPP units 1 and 2
LUT	Lappeenranta-Lahti University of Technology
MEAE[1]	Ministry of Economic Affairs and Employment
NORM	Naturally occurring radioactive materials
NPP	Nuclear power plant
OL1, OL2	Olkiluoto NPP units 1 and 2
OL3	Olkiluoto NPP unit 3
ONKALO®[2]	Former Olkiluoto Underground Rock Characterization Facility, now registered trademark for Nuclear Waste Disposal Facility
Posiva	Posiva Oy (joint company for spent fuel disposal of TVO and FPH)
PSAR	Preliminary Safety Analysis Report
R&D	Research and Development
RD&D	Research, Development and Design
SNF	Spent Nuclear Fuel
ST Guide	STUK guidance subject to radiation legislation
STUK	Radiation and Nuclear Safety Authority
TVO	Teollisuuden Voima Oyj (NPP utility)
URCF	Underground Rock Characterization Facility
VAL Guide	Protective Actions Guidelines in Case of Radiological or Nuclear Emergency
VLLW	Very low level waste
VTT	VTT Technical Research Centre of Finland Ltd
VYR	State Nuclear Waste Management Fund
YVL Guide	Safety regulation issued by STUK subject to nuclear energy legislation

1 In 2016, the Ministry of Employment and Economy (MEE) changed its name to the Ministry of Economic Affairs and Employment (MEAE). The MEE was established in 2008 when the the duties of the Ministry of Trade and Industry (MTI) were transferred to the MEE.

2 ONKALO® is a registered trademark of Posiva Oy.

SECTION A
Introduction

Purpose and structure of the report

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was adopted on 29 September 1997 at the Vienna Diplomatic Conference. Finland signed the Convention on 2 October 1997 and deposited the tools of acceptance on 10 February 2000. The Convention entered into force on 18 June 2001. This report is the 7th Finnish National Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. It will be subject to review in May 2021 in the seventh Review Meeting of the contracting parties in Vienna.

The fulfilment of the obligations of the Joint Convention and the developments during 2017–2019 are assessed in this report. The self-assessment is mainly based on Finnish legislation and regulations and on the status of the current and planned spent nuclear fuel and radioactive waste management activities in Finland. The self-assessment includes also the plans for the decommissioning of nuclear facilities and the regulation and management of radioactive waste generated outside the nuclear fuel cycle.

The structure of the report is in accordance with the Guidelines Regarding the Form and Structure of National Reports (INFCIRC 604/Rev 3). The report is a stand-alone document and does not require familiarity with the earlier reports. The fulfilment of the obligations is described in general in addition to the latest developments since the 6th Review Meeting which are described in more detail. Table 1 provides a cross reference of the sections in this report and the specific reporting provisions in the Joint Convention.

TABLE 1. The content of the national report sections.

National Report Section	Joint Convention Section
Section A: Introduction	
Section B: Policy and Practises	Article 32, paragraph 1
Section C: Scope of Application	Article 3
Section D: Inventories and Lists	Article 32, paragraph 2
Section E: Legislative and Regulatory System	Articles 18–20
Section F: Other General Safety Provisions	Articles 21–26
Section G: Safety of Spent Fuel Management	Articles 4–10
Section H: Safety of Radioactive Waste Management	Articles 11–17
Section I: Transboundary Movement	Article 27
Section J: Disused Sealed Sources	Article 28
Section K: General Efforts to Improve Safety	Multiple Articles
Section L: Annexes	Multiple Articles

The main developments during the reporting period 2017–2019 are shortly summarised in Section A. The current status of the interim spent fuel storages is described in Section G. As Finnish legislation defines spent nuclear fuel as waste, the development of the disposal of spent nuclear fuel is presented in Section H. Section H also describes the developments in nuclear waste management, as well as development of other than nuclear energy related radioactive waste management, and decommissioning. Section K summarises safety issues identified earlier and actions to address them. It also summarises the results from the 6th review meeting. The identified future challenges and planned improvements are also presented in Section K.

More detailed information about currently ongoing projects is included in the Annexes. Firstly, the legal background to nuclear waste management and radioactive waste management is described in Annex L.1. Annexes L.2 and L.3 describe the Posiva Oy (Posiva) spent nuclear fuel disposal project. L2 concentrates on the regulatory oversight of the project and L3 describes the current status of the disposal project. The outcomes of national coordination group activies on radioactive waste management are presented in Annex L.4.

The nuclear energy sector is currently very active in Finland. There are two nuclear power plants operating in Finland at the Loviisa and Olkiluoto sites. The Loviisa plant comprises two pressurised water reactor units (VVER-440), operated by Fortum Power and Heat Oy (FPH). The Olkiluoto plant comprises two boiling water reactors units (BWR 75) operated by Teollisuuden Voima Oyj (TVO) and a third unit, European Pressurized water Reactor (EPR) unit is planned to be commissioned in 2021 at the Olkiluoto site. In addition, Fennovoima Oy (Fennovoima) has applied for a construction license for one pressurized water reactor (AES-2006) in Pyhäjoki (Figure 1). Finland also has a research reactor called Finland Reactor 1 (FiR 1) in Otaniemi, which is currently in an extended shutdown state. The decommissioning license is expected to be granted during 2020. At the other end of the nuclear fuel cycle, a mining company Terrafame Oy was granted to produce U_3O_8 (yellow cake) by a Government decision in February 2020. However, appeals have been made about this decision to the The Supreme Administrative Court of Finland and the fate of the decision is yet to be resolved.

Geological disposal facilities for low and intermediate level operating waste exist in Olkiluoto and Loviisa. They have been in operation since the 1990s. Fennovoima aims to build its own disposal facility for low and intermediate level waste at Hanhikivi site during the 2030s.

The construction license of the encapsulation plant and disposal facility for spent nuclear fuel (deep geological repository) was granted by the Government to Posiva in November 2015. The construction of the disposal facility started in Olkiluoto in December 2016. Posiva is responsible for the preparations for and later implementation of spent fuel disposal for its owners TVO and FPH. The scope of disposal project and granted construction license covers spent fuel from five reactor units: Loviisa 1 and 2 (LO1, LO2), Olkiluoto 1, 2 and 3 (OL1, OL2, OL3). In December 2016, Ministry of Economic Affairs and Environment (MEAE) accepted Environmental Impact Assessment (EIA) programme for Fennovoima's spent fuel disposal facility. Earlier in 2016, Fennovoima presented a co-operation agreement with Posiva Solutions Oy, a subsidiary of Posiva, to ensure that the knowledge developed during Posiva's disposal project for spent nuclear fuel and other nuclear waste management will also be available for Fennovoima.

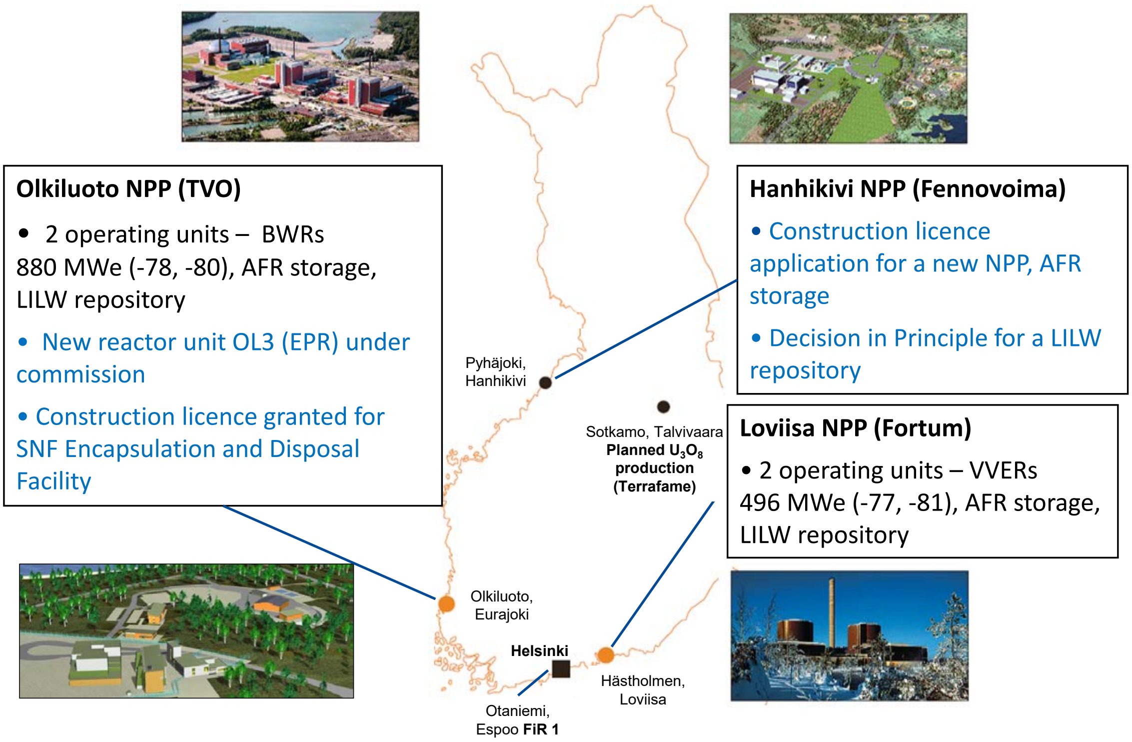


FIGURE 1. Nuclear Energy in Finland.

Among many energy issues, general pubic acceptance of geological disposal of nuclear wastes is regularly evaluated by Finnish Energy association. Repeated interviews of the public, extending by now to almost four decades, indicate trend-like growth of the public trust to geological disposal (Figure 2). In the 2019 interview, majority of answers indicated trust to geological disposal (37%). This was the first time when the sceptic view was in minority (36%). Slowly but steadily growing confidence to geological disposal is seen as a result from long-lasting systematic work both on implementer and regulator side to communicate with public and other stakeholders.

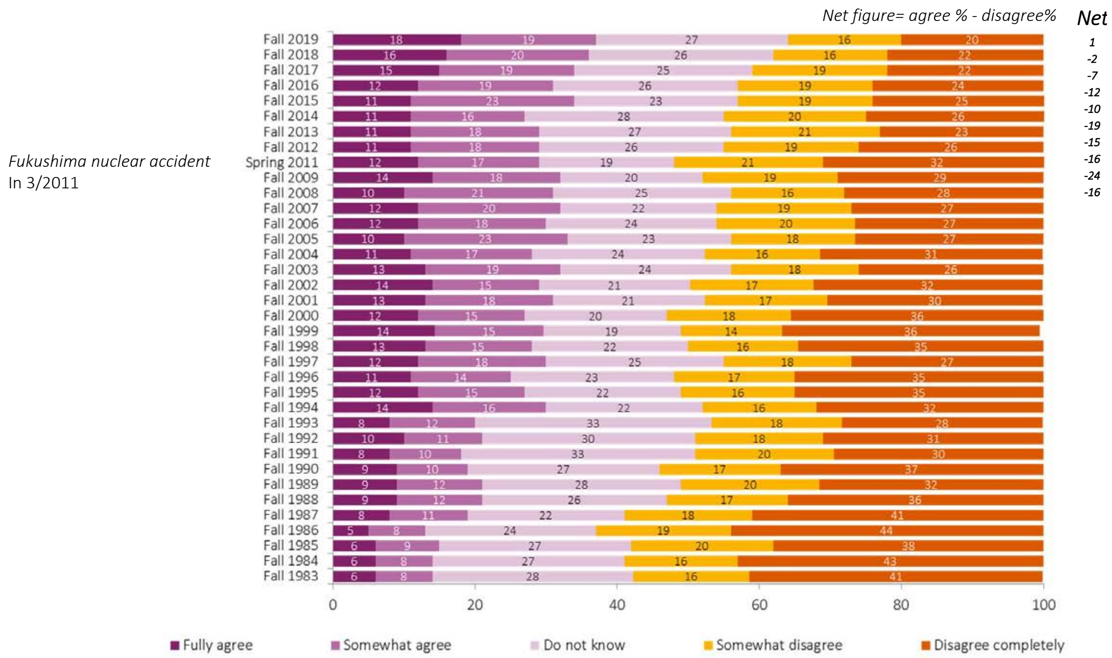


FIGURE 2. Time series of general public opinions on the safety of nuclear waste disposal (Courtesy of Finnish Energy).

SECTION B
Policies and practices

Article 32 Reporting, paragraph 1

In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

(a) spent fuel management policy;
(b) spent fuel management practices;
(c) radioactive waste management policy;
(d) radioactive waste management practices;
(e) criteria used to define and categorize radioactive waste.

Spent fuel and radioactive waste management policy

General

The Finnish Government decided on the first principles of arranging nuclear waste management in 1978. According to this decision, each producer of nuclear waste is responsible for the management of spent fuel and other radioactive waste generated in connection with their operations and for the costs incurred. In the management of low and intermediate level operational waste (LILW), 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 1983, the Finnish Government enacted a law on Radiation and Nuclear Safety Authority (STUK) and made a general decision on the objectives and schedules of the Research and Deveopment (R&D) activities concerning nuclear waste management at the existing nuclear power plants. For the first time, the 1983 decision presented an option that power companies had to consider disposal of spent fuel in Finland. Later in 1991, decision by a predecessor to MEAE lauched more serious research and evaluation of the spent fuel disposal option within Finnish territory. Finally, a significant amendment to the Nuclear Energy Act in 1994 prohibited the imports and exports of nuclear waste to and from Finland. The 1983 decision outlined that, if a national spent fuel disposal solution will be implemented, the disposal measures were to begin around 2020. Before that, the companies had to survey and select the disposal site by the end of 2000 and be prepared to present plans for the disposal facility and encapsulation plant required for the construction license. The schedule for construction plans was adjusted in 2003, requiring the plans to be presented by the end of 2012.

Currently nuclear and radioactive waste management policy is defined in Finnish legislation. The most essential laws, decrees, safety regulations and guides are listed in Annex L.1. At end of Annex L.1, an internet reference is also made to summary of Finnish national programme that has been sent to European Commission in 2015 in accordance with Article 12 of the Council Directive 2011/70/Euratom.

Responsibilities

The Nuclear Energy Act (Section 9) prescribes that the generators of nuclear waste are responsible for all nuclear waste management measures and their appropriate preparation, and for their cost. The State has the secondary responsibility in case any producer of nuclear waste is incapable of fulfilling its nuclear waste management obligations (Nuclear Energy Act, Sections 31 and 32). When the licensee's waste management obligations have ceased as the disposal of the nuclear waste has been carried out in an approved manner, the ownership of the waste is transferred to the State, which shall be responsible thereafter for the nuclear waste (the Nuclear Energy Act, Sections 32–34).

The Radiation Act (Section 79) provides that the organization engaged in a radiation practice shall take the measures necessary to render harmless any radioactive waste arising from its operations. Rendering radioactive waste harmless means any measure needed to treat, isolate, or dispose of the waste, or to restrict its use so that it does not endanger human health or the environment. Moreover, the responsible party utilizing natural resources containing radioactive substances must ensure that radioactive waste poses no hazard to health or to the environment neither during operations nor at their conclusion. The State has the secondary responsibility in case a producer of radioactive waste is incapable of fulfilling its management obligations (the Radiation Act, Section 80).

Political decision-making and public consultation

According to the Nuclear Energy Act (Section 11), the construction of a nuclear facility of considerable general significance requires, as a first step, a Government's Decision-in-Principle (DiP) to show that the construction project is in accordance with the overall good of society. Such facilities include major nuclear waste management facilities. Before making the DiP referred to in Section 11, the Government must ascertain that the municipality where the nuclear facility is planned to be located, is in favour of the facility (Section 14 of the Nuclear Energy Act), and that with the available knowledge, safety is not compromised (STUK's veto right). The DiP approved by the Government must be forwarded, without delay, to the Parliament. The Parliament may only reverse the DiP or may decide that it will remain in force (Section 15 of the Nuclear Energy Act).

The Nuclear Energy Decree (Section 24) provides that an application for a DiP must be appended by an assessment report drawn up according to the Act on Environmental Impact Assessment Procedure and by a statement from the coordinating authority (MEAE). There must also be a description of the design criteria that will be observed by the applicant to avoid environmental damage and to restrict the burden on the environment. The Environmental Impact Assessment Procedure is a consultative and participative process facilitating public involvement and information transfer to the people affected as a part of good governance practice. It considers a wide scope of potential impacts, such as human health and comfort, the natural environment and biodiversity, municipal structures and the use of natural resources. The international hearing is conducted according to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991).

Section 23 a of the Nuclear Energy Act stipulates that before granting a nuclear facility construction license and operating license, or a license for decommissioning a nuclear facility, MEAE shall reserve the public an opportunity to express their opinions in writing in the matter relating to the license.

Spent fuel and nuclear waste management principles

Nuclear waste is defined in the Nuclear Energy Act (Section 3) as radioactive waste in the form of spent fuel or in some other form generated in connection with or as a result of the use of nuclear energy, materials, objects and structures, which having become radioactive in connection with or as a result of the use of nuclear energy and having been removed from use, require special measures because of the danger arising from their radioactivity.

According to the Nuclear Energy Act (Section 27 a) the amount of nuclear waste generated in the use of nuclear energy must be kept as low as is reasonably achievable with practical measures, both regarding its volume and activity, without compromising the general principles set forth in Sections 5–7 of the Act.

According to the Nuclear Energy Act (Section 6 a), nuclear waste generated in Finland must be handled, stored, and permanently disposed of in Finland. Respectively, nuclear waste generated elsewhere than in Finland, shall not be handled, stored, or permanently disposed of in Finland. There are only minor exemptions to these principles, notably concerning the nuclear waste arising from the use of a research reactor in Finland (Section 6 a of the Nuclear Energy Act). As stipulated in Section 7 b of the Nuclear Energy Decree, the spent fuel from a research reactor in Finland may be handled, stored, and disposed of outside Finland, if justified on grounds of safety or due to a significant economic or other cogent reason.

Management principles for non-nuclear radioactive waste

Non-nuclear radioactive waste is regulated in Finnish legislation within the framework of the Radiation Act. According to the Radiation Act (Section 4), the term radioactive waste denotes radioactive substances, and various items that are of no further use and need to be rendered harmless due to their radioactivity. The definition also includes equipment, goods and materials that are contaminated by radioactive materials. Radioactive substances and radiation appliances containing radioactive substances are also be regarded as radioactive waste in case the owner of the substances or the appliances cannot be found.

According to the Radiation Act (Section 83), the operator is responsible to return the disused sources subject to safety license to the manufacturer or supplier or to surrender them to an operator holding safety license. The Radiation Act (Section 80) specifies that the State shall discharge the function of rendering radioactive waste harmless where there is no operator of the kind. In that case the operator is responsible to compensate the costs to the State. STUK takes care of the rendering waste harmless on behalf of the State (Section 32 of the Government Decree on the Ionizing Radiation).

Principles for decommissioning of nuclear facilities

The Nuclear Energy Act (Section 7 g) requires that provisions for the decommissioning of a nuclear facility must be considered in its design. The decommissioning plan must be updated regularly as prescribed in the Act (Section 28). After the permanent shut-down of the facility, it must be decommissioned in accordance with the plan approved by STUK. The dismantling of the facility and other actions related to decommissioning may not be unjustifiably postponed.

Safety principles and control

The Nuclear Energy Act (Section 7 a) prescribes that the safety of the use of nuclear energy (including waste management) must be as high as reasonably achievable. To further enhance safety, all actions justified by operational experience, safety research, and the progress in science and technology shall be taken. Additionally, nuclear waste must be managed so that no radiation exposure will occur after disposal that would exceed the levels considered acceptable during the implementation of disposal. The disposal of nuclear waste in a manner intended as permanent must be planned giving priority to safety and so that ensuring its long-term safety does not require surveillance of the disposal site (Section 7 h of the Nuclear Energy Act).

The Nuclear Energy Act (Section 55) designates STUK as the regulatory body for the control of the safe use of nuclear energy. STUK's regulatory tasks include the oversight of safety, security, emergency preparedness and non-proliferation of nuclear materials. More specifically STUK's tasks include participation in the licensing process (e.g. for the assessment of safety), issuance of general and detailed safety requirements, and the control of compliance with the safety requirements and license conditions. Respectively, the Radiation Act (Section 14) states that compliance with the Act shall be supervised by STUK. The Act (Section 48) states that safety licences shall be granted by STUK upon application.

Costs and funding

The Nuclear Energy Act (Chapter 7) addresses the financial provision for nuclear waste management. According to the Nuclear Energy Act (Section 9), the nuclear waste producer is responsible for the costs of the nuclear waste management and decommissioning and for the provisions of the future costs. Furthermore, based on the Nuclear Energy Act (Sections 35–36), nuclear waste producer is obligated to make payments and deposit securities into the State Nuclear Waste Management Fund (VYR Fund). The purpose of the VYR Fund is to collect, store and reliably invest the funds that are going to be needed to take care of nuclear waste in the future. The VYR fund consists of three separate funds: a major financial provision fund (this Article, see below) and two minor funds, i.e. nuclear safety research fund and nuclear waste research fund (see Section E, Article 20). 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 plans for carrying out nuclear waste management cover the entire planned operating time of the nuclear facilities. According to current plans, the decommissioning and closure of the nuclear waste facilities managing spent fuel would take place in approximately 100 years (cf. Figure 4).

Funds are annually collected from licensees under a waste management obligation to the financial provision fund of the VYR 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 financial provision fund operates under the MEAE, and it is managed by its board and a director.

To ensure that financial liability is fully secured, every third year the nuclear power companies producing nuclear waste and the operator of the research reactor are obliged to present cost estimates for the future management of their currently exsisting nuclear waste and decommissioning of facilities and must take care that the required amount of money is set aside in the financial provision fund. In addition, they shall provide securities to the State for that part of their financial liability, which is not yet secured by the Fund (Section 45). Costs of the waste management are not paid from the Fund, but deposited equities are returned to the license holder as it progresses in its waste management activities. Additionally, in the case of the research reactor, the operator is responsible for the planning and implementation of spent nuclear fuel and other nuclear waste management. In the case of the research reactor, the State initially funded the necessary provision from the VYR Fund.

The Radiation Act (Section 54) provides for the financial security for radioactive waste management for non-nuclear practices as follows: the Act ensures that the licensee meets the costs incurred for rendering radioactive waste harmless and for carrying out any decontamination measures that may be needed in the environment, and ensures that the licensee shall furnish collateral security if the operations produce or are liable to produce radioactive waste that cannot be rendered harmless without incurring substantial cost.

Criteria used to categorize radioactive waste

The Finnish radioactive waste classification system includes two main categories: nuclear waste, and radioactive waste not originating from the use of nuclear energy and the associated nuclear fuel cycle (non-nuclear radioactive waste). Waste classification according to disposal route is illustrated in Figure 3.

Spent fuel from nuclear facilities

The Nuclear Energy Act defines spent fuel from the operation of nuclear reactors as nuclear waste. The Nuclear Energy Act (Section 6 a) defines that the nuclear waste generated in connection with or as a result of the use of nuclear energy in Finland must be handled, stored and permanently disposed of in Finland. In practice, this means that the disposal of spent fuel in a permanent manner is the only waste management option for spent nuclear fuel arising from the use of nuclear energy. Due to its high radioactivity and heat generation, spent fuel is regarded as high-level waste.

The main exception to the general principles described above regard spent fuel and other nuclear waste that has been generated in connection with or as a result of the operation of a research reactor in Finland. As stipulated in Section 7 b of the Nuclear Energy Decree, the

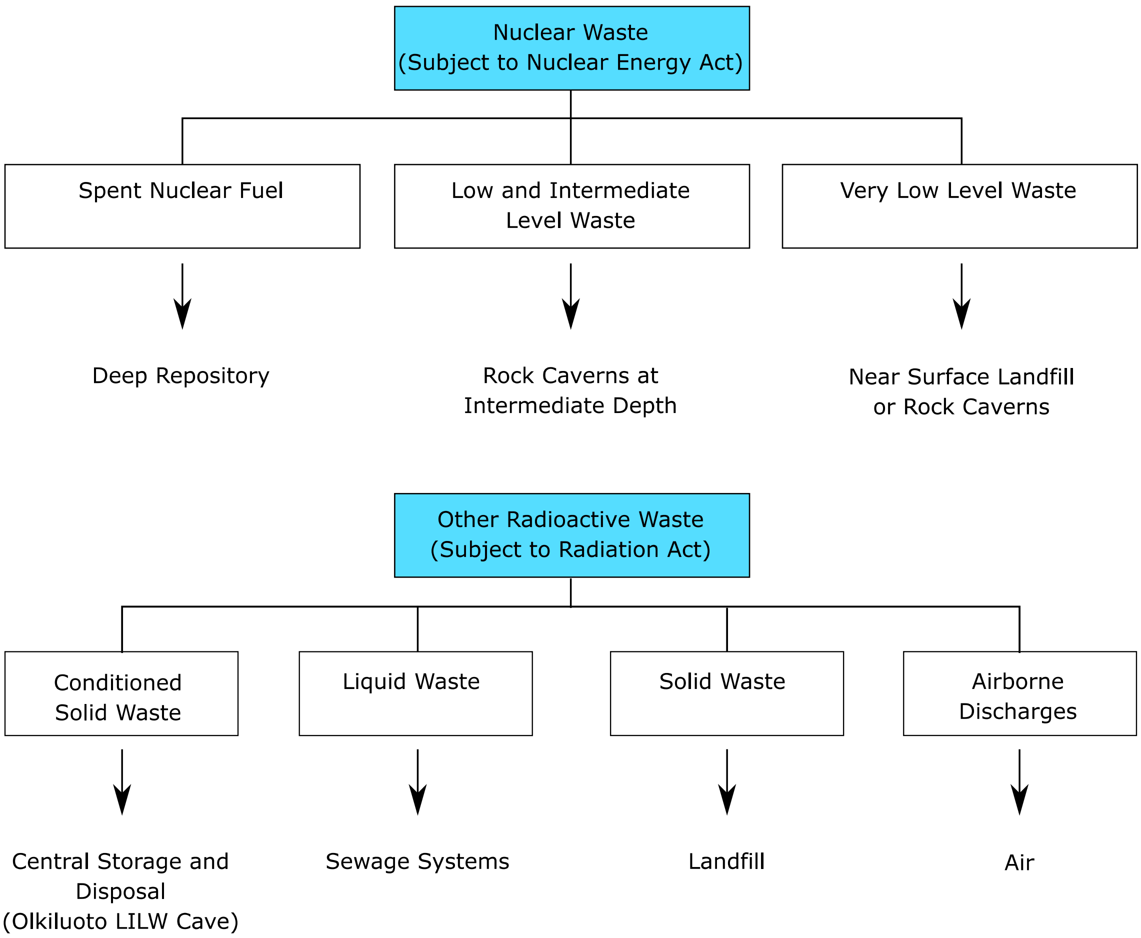


FIGURE 3. Classification of radioactive waste for disposal purposes

spent fuel from the research reactor in Finland can be handled, stored, and disposed of outside Finland.

Very low, Low and Intermediate level waste from nuclear facilities

The classification system for the purpose of the predisposal management of LILW from nuclear facilities, including NPPs, is based on activity concentrations, given in Regulation STUK Y/4/2018. Solid and liquid waste arising from the controlled area of an NPP contain almost exclusively short-lived beta and gamma emitters and are grouped into the following activity categories:

- Very low-level waste (VLLW) refers to waste whose average activity concentration of significant radionuclides does not exceed the value of 100 kBq/kg and the total activity does not exceed the values laid down in Section 6(1) of the Nuclear Energy Decree (161/1988) (Total activity < 1TBq, α activity < 10 GBq).
- Low level waste (LLW) contains so little radioactivity that it can be treated without any special radiation protection arrangements. The activity concentration in the waste must then not be more than 1 MBq/kg, as a rule.
- Intermediate level waste (ILW) contains radioactivity to the extent that effective radiation protection arrangements are needed when the waste is processed. As a rule, the activity concentration in the waste is from 1 MBq/kg to 10 GBq/kg.

The classification for the disposal purpose is given in Regulation STUK Y/4/2018. It distinguishes short-lived and long-lived waste accordingly:

- Short-lived waste refers to nuclear waste of which the activity concentration after 500 years will be below the level of 100 megabecquerels (MBq) per kilogram in each disposed waste package, and below an average value of 10 MBq per kilogram of waste in one emplacement room;
- Long-lived waste refers to nuclear waste, of which the activity concentration after 500 years will be above the level of 100 MBq per kilogram in a disposed waste package, or above an average value of 10 MBq per kilogram of waste in one emplacement room.

The Regulation STUK SY/1/2018 provides criteria for the general clearance. Nuclear Safety Regulation (YVL) Guide YVL D.4 provides for the general and case-specific clearance of nuclear waste in more detail. Both clearance options are founded on the criteria for a trivial dose; the radiation protection requirement for both clearance procedures is that the annual dose to any member of the public or worker processing the material, must not exceed 10 μSv and that that otherwise the radiation exposure arising from the cleared material must be as low as reasonably achievable.

Mass and surface concentration-based activity values for general clearance are given by the Regulation SY/1/2018 and the Guide YVL D.4. One set of values is for unlimited amounts of material and the values are taken from IAEA Safety Guide RS-G-1.7. In addition, the Guide YVL D.4 provides another set of values that are applied for limited waste quantities not exceeding 100 tonnes per year for one NPP or other nuclear installation. For case-specific clearance, the activity concentration values are determined on a case-by-case basis.

Guide YVL D.4 also covers the clearance of regulated buildings and sites in the context of decommissioning nuclear facilities. The radiation protection requirement for such clearances is that the annual individual dose must not exceed a constraint between 10 μSv and 100 μSv, to be determined based on optimization. The relevant IAEA safety standards and guides have been used as reference for the guide.

Discharges from nuclear facilities

Some liquid and airborne discharges arise from the operation of nuclear facilities. The discharge limits are specific to nuclides or nuclide groups and they must be in conformity with the annual dose constraints for the most exposed individual of the population. The dose constraint for NPPs is 0.1 mSv per year (Nuclear Energy Decree Section 22 b) and 0.01 mSv per year for nuclear waste facilities (Nuclear Energy Decree Section 22 d, YVL D.3 and YVL D.5).

Radioactive waste from medical use, research and industry

For non-nuclear radioactive waste, constraints to transfer the waste to be handled according to the Waste Act (646/2011) or release into sewage systems are provided in the Regulation S/2/2019. The criteria are based on the Basic Safety Standards Directive (2013/59/Euratom).

According to Regulation S/2/2019, liquid waste may be disposed of into a sewage system and solid waste may be transferred to be handled according to the Waste Act, as long as the activity levels are below the exemption levels. Sealed sources with activity levels below the clearance level may be disposed of as non-radioactive waste (Regulation STUK SY/1/2018). Other ways the source needs to be disposed of as radioactive waste through an operator holding a safety license.

Spent fuel and radioactive waste management practices and plans

The current main sources of radioactive waste in Finland are the nuclear waste generated from the operation of the two nuclear power plants (including four reactor units) and one small research reactor. Non-nuclear radioactive waste arises from several facilities using radioisotopes for medical, research and industrial applications. The management practices for nuclear and non-nuclear radioactive waste are shortly described below. A concise overview of the management strategies is provided in the text box.

The NPP utilities FPH and TVO themselves take care of the interim storage of spent fuel, of the management of LILW including disposal, and of the planning for and implementation of the decommissioning of the NPPs. Their jointly owned company, Posiva, takes care of the preparation for and later implementation of spent fuel encapsulation and disposal. Fennovoima has plans to construct and operate its own nuclear waste manament and disposal facilities. Technical Research Centre of Finland Ltd (VTT) is responsible for nuclear waste produced during the operation of the research reactor (FiR 1) and during decommissioning.

Producers of non-nuclear radioactive waste perform some waste management operations, such as initial storage, clearance and disposal into landfill type sites. According to the Radiation Act, recognized licensees can receive radioactive wastes and sealed sources if they have safety licences approved by STUK for their operations. If there are no recognized pathway for conditioning, storage and disposal of non-nuclear waste, then STUK will be responsible

NUCLEAR AND NON-NUCLEAR RADIOACTIVE WASTE MANAGEMENT STRATEGY

Responsibilities

The Nuclear Energy Act (Section 9) prescribes that the generators of nuclear waste are responsible for all nuclear waste management measures and their appropriate preparation, as well as for their cost. The State has the secondary responsibility in case any producer of nuclear waste is incapable of fulfilling its nuclear waste management obligation (Nuclear Energy Act, Sections 31 and 32).

Current and future producers of nuclear waste must take care of the interim storage of spent fuel, and of conditioning and disposal of low and intermediate level waste and of planning for and implementation of the decommissioning of NPPs. Posiva Oy, a jointly owned company by FPH and TVO, is responsible for the preparations for and later implementation of its owners' spent fuel disposal. VTT, as an operator of the research reactor FiR 1, is responsible for planning and implementation of the waste management and decommissioning of the facility, including the arrangements for disposal of the waste. Fennovoima Oy will be responsible for its own spent fuel disposal as well as for other nuclear waste management and decommissioning activities.

Producers of non-nuclear radioactive waste must manage their waste within the limits of their technical capability while ensuring safety and security. Non-nuclear radioactive waste that cannot be cleared, including spent sealed sources that cannot be returned to the manufacturer, must be handed over to an installation licensed to receive waste for the conditioning and transfer of radioactive waste to a central storage operated by STUK and later for disposal.

Waste management and decommissioning objectives

Low and intermediate level nuclear waste and non-nuclear radioactive waste that meets the acceptance criteria for the repositories at the NPP sites must be disposed of without unnecessary delay. Waste that cannot yet be disposed of must be stored safely. Furthermore, other low and intermediate level waste, such as decommissioning waste, is envisaged to be disposed of in disposal facilities at the NPP sites.

Disposal of TVO's and FPH's spent fuel is under preparation in accordance with a strategic plan, which is in line with the 1983 Government Policy Decision and the 2003 Decision of the Ministry of Trade and Industry (now the MEAE). The disposal operations are expected to begin in the 2020s. The spent fuel disposal programme is subject to a continuous regulatory review. The construction license was granted in 2015. The operation license application is expected to be submitted to the Government by the end of year 2021.

The prospective nuclear utility Fennovoima submitted an Environmental Impact Assessment Programme at the end of June 2016 for a spent nuclear fuel disposal facility of its own. At the same time, it presented a co-operation agreement with Posiva Solutions Oy, a subsidiary of Posiva, to ensure that the knowledge developed during Posiva's disposal project for spent nuclear fuel will also be available for Fennovoima. Co-operation started in 2016.

The implementation of decommissioning the NPPs will be optimized considering the technical aspects, radiological impacts, future use of the site, availability of a competent workforce and the

costs. The strategy takes advantage of options for clearance of very low-level waste and structures of the plant and on-site disposal of decommissioning waste.

Financial provisions

The purpose of the State Nuclear Waste Management Fund (VYR Fund) is to collect, store and reliably invest the funds that are going to be needed to take care of nuclear waste in the future. Through the fund, the society has a financial guarantee that nuclear waste management can be arranged under all circumstances.

The capital of the fund is composed of annual payments made by operators under a waste management obligation and the returns of the fund. The Ministry of Economic Affairs and Employment (MEAE) determines the annual fee to be paid to the fund each year, ensuring that the fund always has enough assets to secure the costs of all nuclear waste management measures that still have to be carried out.

The fund is not included in the state budget, and it operates under the MEAE. The fund was established in 1988 under the Nuclear Energy Act (990/1987). The fund is managed by its board and a director. The board makes all key operative decisions.

for rendering the radioactive waste harmless. STUK may agree with the custodian of the waste that custody of the waste will be permanently assigned to the Government for a fixed payment (for more information see Section J Disused Sealed Sources).

Spent fuel management

Spent nuclear fuel from NPPs is stored at the power plant sites until it is disposed of. Initially, the fuel is cooled for one to five years in storage pools inside the reactor buildings. The Loviisa NPP has, in addition to the storage pools in the reactor buildings, a separate integrated pool type storage facility. The Olkiluoto NPP has a separate on-site facility for spent fuel storage common for all reactor units. A summary of current stored spent fuel inventory is presented in Section D.

In practice, before disposal, the spent fuel will be stored in water pools for 30 to 50 years. More details on pool storages are given in Section G. After cooling down in storage pools, spent fuel is going to be transported or transferred to the encapsulation and disposal facilities in Olkiluoto. Further details of the past and future milestones on the implementation of spent fuel disposal programme are given in Section H and in Annexes L.2 and L.3. In 2015, the granted construction license for Nuclear Disposal Facility (ONKALO) enables disposal of in total 6500 tonnes of uranium (spent fuel) in Olkiluoto. The estimated total is based on the following expectations of operational lifetimes of LO1 and LO2 (50 years), and OL1, OL2 and OL3 (60 years) – cf. Figure 4.

Spent fuel is planned to be encapsulated in copper-iron canisters. The canister design consists of a cast iron insert as a load-bearing element and an outer container made of copper to provide protection against corrosion. The canisters will be emplaced into the disposal facility that consists of technical rooms and other auxiliary spaces, shafts and of a network of central and deposition tunnels (the repository), which will be constructed at a depth of 400 to 455 m in crystalline bedrock.

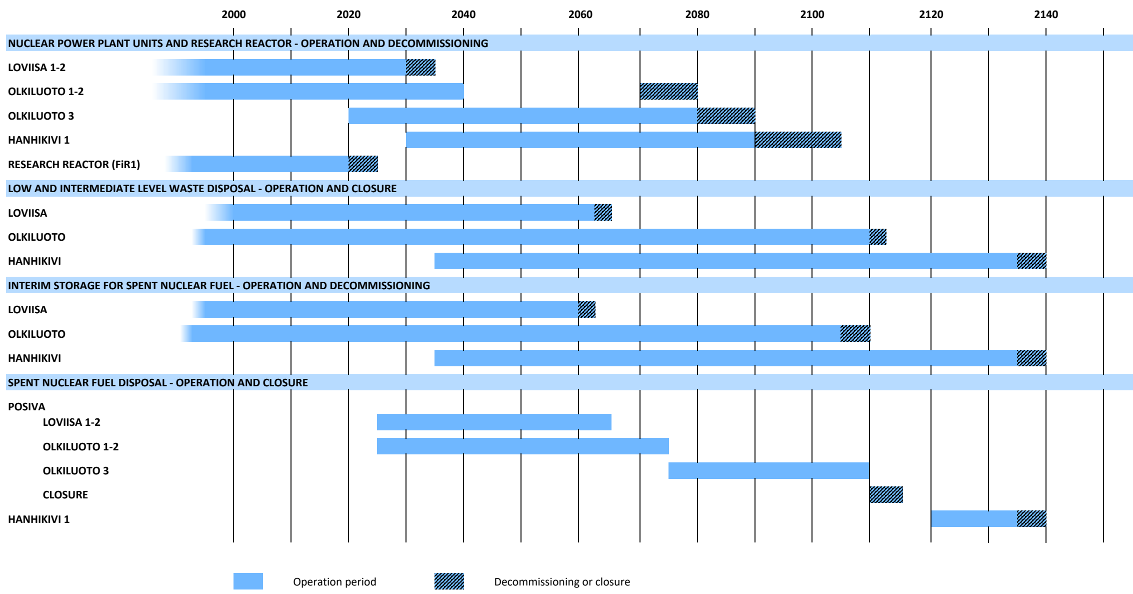


FIGURE 4. Timetable for the management of spent fuel from the nuclear power plants at Loviisa and Olkiluoto

The annulus between the canister and the deposition hole walls will be filled with a compacted bentonite buffer material. A schematic layout of the underground disposal facility and the network of tunnels at Olkiluoto are illustrated in Figure 5 and an individual deposition tunnel with two canister emplacement variants are illustrated in Figure 6.

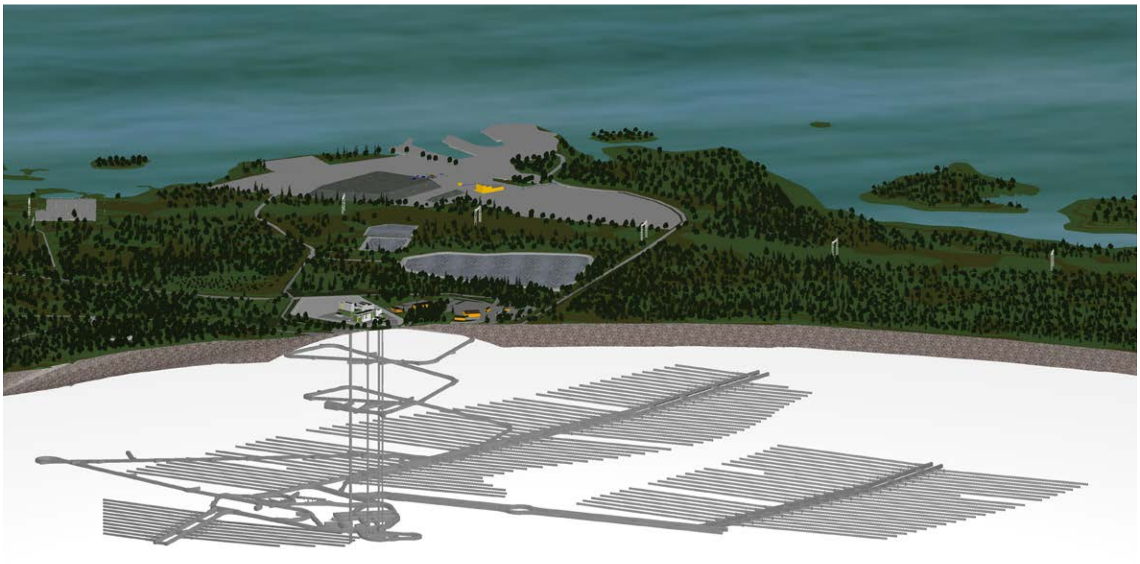


FIGURE 5. A schematic presentation of the layout of the underground disposal facility and the network of disposal tunnels for vertical disposal option. (© 2019 Posiva Oy)

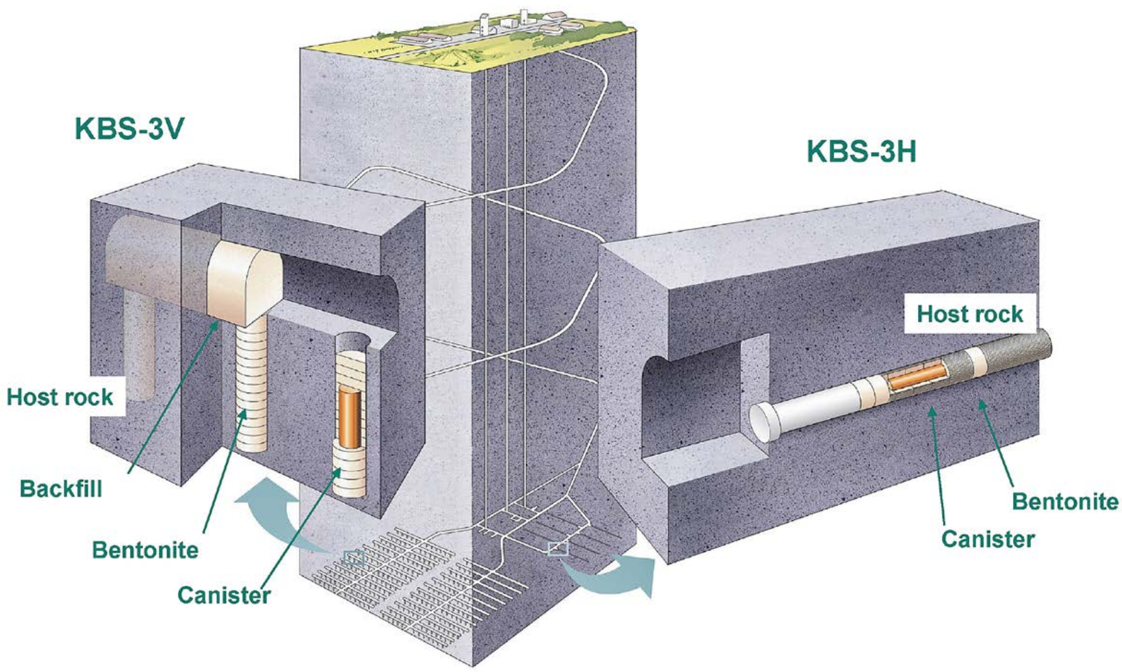


FIGURE 6. Disposal tunnel and canisters with both the vertical (KBS-3V) and horizontal (KBS-3H) disposal options depicted.

Spent fuel from the FiR 1 is currently stored on site. The primary option for its spent fuel management before dismantling the research reactor is to return the fuel to the United States according to Foreign Research Reactor Spent Nuclear Fuel (FRR SNF) Acceptance Program of U.S. Department of Energy (DoE). A secondary option is interim storage in Finland and later disposal in the Olkiluoto spent fuel disposal facility. This would require that VTT shall have agreements with both the company responsible for the interim storage and Posiva. Currently, VTT and FPH have a 5-year agreement on interim storaging (starting from licensing) of the FiR 1 spent fuel in Loviisa. However, the operational storaging and disposal activities will also need granted licenses before operations can start. The total amount of spent nuclear fuel of the research reactor is about 340 kg (ca. 25 kgU).

Management of LILW from nuclear facilities

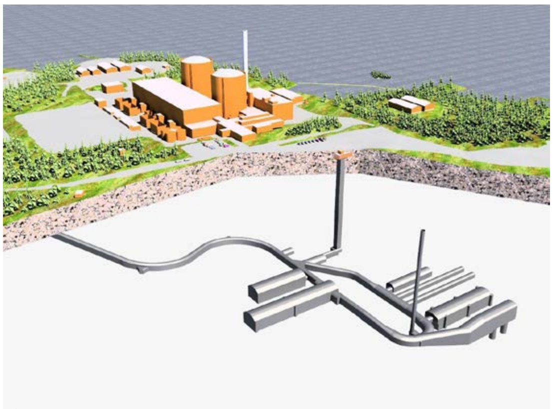
The predisposal management of LILW currently takes place at the NPPs under their operating licences and other provisions. The waste is segregated, treated, conditioned, packaged, monitored and stored, as appropriate, before they are transferred to the site-specific disposal facilities.

At Loviisa, for the time being, the majority of wet LILW (radioactive concentrates, such as spent ion exchange resins, evaporator concentrates and sludges) is stored in tanks at the NPP. The Loviisa plant uses FPH's innovative selective ion exchange method to reduce the volume of liquid radioactive waste. FPH started liquid waste solidification in 2016 in Loviisa NPP after STUK gave authorization for operation in February 2016. The aim is to solidify all wet waste stored in the tanks in the future. At Olkiluoto, wet LILW is immobilized in bitumen before transfer to the disposal facility. It is planned that sludge, radioactive concentrates and spent ion exchange resins from liquid waste treatment in Olkiluoto 3 (OL3) will be dried in drums or solidified in concrete.

At both currently operating NPPs, solid LLW is transferred after conditioning to the disposal facility. Options for the management of waste below clearance level are either general clearance or case-specific clearance. Such waste can be reused, recycled or disposed of in landfills. The Olkiluoto NPP has a landfill on site, while the Loviisa NPP has an agreement with a regional landfill to dispose of cleared waste. TVO is planning to replace its landfill by near-surface disposal facility for VLLW.

Activated metal waste consists of irradiated components and devices that have been removed from inside of the reactor vessel. So far, this kind of highly activated waste has not been conditioned but is stored at the NPPs and is expected to be conditioned and disposed of together with similar types of decommissioning waste.

According to the strategy adopted by the Finnish nuclear power plant operators, low and intermediate level wastes from reactor operations should be disposed of in the bedrock at the power plant sites. At Olkiluoto the operation of the LILW disposal facility started in 1992 and in Loviisa in 1998. The disposal facilities are operated by the nuclear power plant personnel, FPH at Loviisa and TVO at Olkiluoto.



a)

b)

c)

The Loviisa disposal facility is located at a depth of approximately 110 m in granite bedrock. The facility consists of three halls for solid LLW and a cavern for immobilised ILW (Figure 7). Inside the cavern for ILW, the waste packages are emplaced in a pool-shaped structure made of reinforced concrete. One of the halls (HJT3) has been licensed only for storage that also facilitates the sorting of waste, allowing clearance from regulatory control of some of the waste. HJT3 is also used for temporary storage of the solidified waste. Licensing of HJT3 is planned later for the disposal of operational or decommissioning waste.

The Olkiluoto disposal facility for LILW consists of two silos at a depth of 60 to 95 m in tonalite bedrock, one for solid LLW and the other for bituminized ILW (Figure 8). The silo for solid LLW is a shotcrete rock silo, while the silo for bituminized waste consists of a thick walled concrete silo inside a rock silo where concrete boxes containing drums of bituminised waste will be emplaced. Currently, a licensing process is being prepared for an Olkiluoto VLLW near surface disposal facility. TVO started these plannings at the end of 2018 and the EIA phase of the planned facility is about be launched during 2020. The LILW disposal facility will be extended in the 2030s, to be able to receive all the LILW from OL1, OL2 and OL3 reactor units during their planned 60 years of operation. Further extension of the disposal facility is also planned for decommissioning wastes of existing NPP units at Olkiluoto.

FIGURE 7. Loviisa disposal facility. a) Cross-sectional view of the disposal facility for LILW and the planned extension for decommissioning waste, b) drums of LLW from reactor operation waste in the disposal hall and c) commissioned disposal hall for solidified waste.

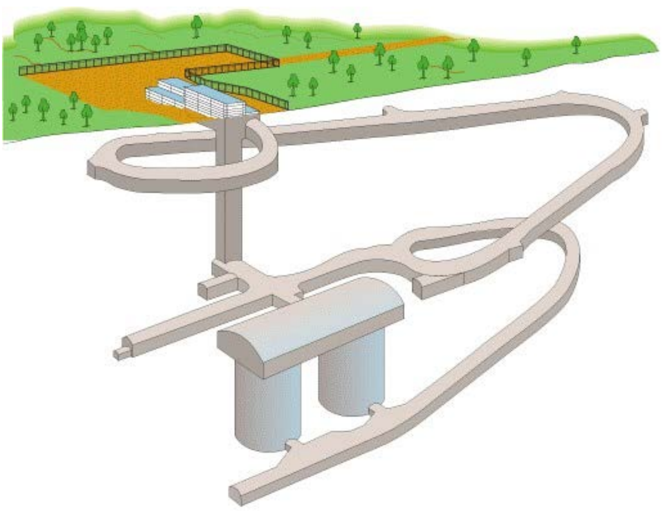
LILW generated from the operation of the research reactor FiR 1 is currently stored at the reactor facility in Otaniemi. At the end of March 2020, VTT signed a contract with FPH on storage and disposal of operational and decommissioning wastes in Loviisa NPP site. The estimated total amount of decommissioning waste is about 75 tons with a total activity of less than 5 TBq.

Based on Fennovoima's plans, LILW will be collected, stored, handled and disposed of at the power plant site. Fennovoima has made an early estimate of amounts of different LILW types based on information given by the plant supplier for the chosen reactor type (AES-2006). The plans include waste handling methods for dry, wet, liquid and metallic waste. LILW will be disposed of in a disposal facility which will be constructed on the plant site at a depth of several tens of meters in the bedrock. Fennovoima is also considering a surface-based facility as an option for the disposal of VLLW. The management of the operational waste is currently only presented on a conceptual level. The waste management plans will be developed further during the next licensing phases.

Management of non-nuclear radioactive waste

An applicant for a license for the use of sealed sources is required to present a plan for the management of the disused sources. The two available options are either to return the sources to the supplier/manufacturer of the source, or delivery to the national long-term storage facilities operated by STUK's Department of Environmental Radiation Surveillance. This role in operating the storage facilities is defined in Government Decree on the Ionizing Radiation, Section 32 (for more information see Section J Disused Sealed Sources).

Radioactive waste is stored in an interim storage cavern attached to the LILW disposal facility at Olkiluoto. Operations by STUK's Department of Environmental Radiation Surveillance are conducted under the regulatory control of STUK's Department of Nuclear Waste Regulation and Safeguards. The organisational structure of STUK clearly separates



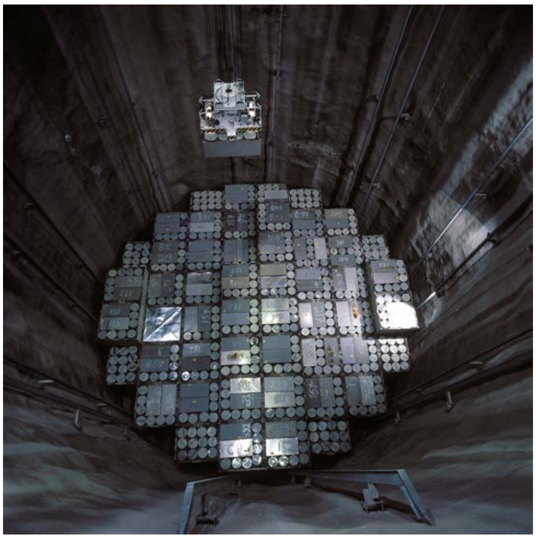


FIGURE 8. The Olkiluoto LILW repository. Cross-sectional view of the repository lay-out (left) and LLW drums in the disposal silo (right).

its duties in operating the centralised storage facility from its functions as the regulatory authority for radioactive materials and waste management. The disposal of sealed sources and other non-nuclear radioactive waste is included in the operating license for the Olkiluoto LILW disposal facility. The license was granted by the Government in 2012. The disposal of this waste started at the end of 2016.

A licensee can be exempted from preparing a waste management plan if the operations are arranged in such a manner that the prerequisites set in the Section 28 of the Government Decree on the Ionizing Radiation are met. However, even in this case STUK may order monitoring of discharges and reporting thereof, if this is considered necessary due to environmental considerations, the nature of the work or the nature and amount of radioactive substances in use. In addition to being below the limits, all discharges to the environment must be kept as low as reasonably achievable.

In practice, most of the waste from the use of unsealed sources in Finland arise in such low activity concentrations or amounts that it is not necessary to arrange the disposal of the generated waste in the same way as for sealed sources. A common practice is that radionuclide laboratories store their short-lived radioactive waste at their premises until they have decayed below the levels set for discharge in the Regulation S/2/2019. However, some waste resulting from radiochemical research at VTT have been sent to STUK for storage in Olkiluoto. Some materials, e.g. reactor vessel materials used in studies conducted by VTT, are returned to the owners of the sample materials for their interim storage and disposal.

A specific waste issue arises from disused smoke detectors. There are currently over 3 million detectors in use, each containing about 40 kBq of Am-241. The disposal of an individual detector into normal municipal waste was earlier considered, from the radiological point of view, as the optimum waste management option. However, the Council Directive 2002/96/EC of 27 January 2003 defines disused smoke detectors as waste electronic equipment subject to recycling requirements. Nowadays, a private entrepreneur takes care of removing the radiation sources from recycled smoke detectors and hands them over to an installation licensed to receive, condition and transfer radioactive waste to a central storage operated by STUK.

Decommissioning plans for nuclear facilities

Loviisa NPP has operational license until 2027 (unit 1) and 2030 (unit 2). FPH is currently evaluating feasibility for applying license for extended operation. If operation ends Loviisa NPP decommissioning will start during this decade. The utilities have updated the decommissioning plans of NPPs for regulatory review every six years (the Nuclear Energy Act, Section 7 g). FPH submitted an updated plan for the decommissioning of the Loviisa NPP for regulatory review in 2018. TVO will submit the Olkiluoto NPP decommissioning plan for regulatory review by the end of 2020. The decommissioning plan for the Loviisa NPP is based on immediate dismantling, within eleven years from shutdown while for the Olkiluoto NPP; a safe storage period of about 30 years prior to dismantling is envisaged. The justification for postponed dismantling is based on a decrease in radioactivity and the availability of nuclear site infrastructure, since the OL3 unit will be operational while the OL1 and OL2 units are being dismantled. The disposal plans for waste arising from the decommissioning of the NPPs are based on the extension of the existing on-site repositories for LILW. Besides the dismantling waste, also activated metal components accumulated during the operation of the reactors are planned to be disposed of in those repositories. The engineered barriers will be selected taking into account the radiological and other safety related characteristics of each waste type. A special feature of the decommissioning plans is the emplacement of large components, such as pressure vessels and steam generators, in the disposal rooms as whole entities, without cutting them into pieces.

VTT decided to decommission its research reactor (FiR 1) due to insufficient funding for continued operation in 2012. The EIA procedure for the decommissioning ended in February 2015, when the MEAE gave its statement on the EIA report. VTT applied for a license for decommissioning the research reactor in June 2017. The decommissioning license is expected to be granted during 2020. The cost estimate for the decommissioning has been updated yearly since 2014 as required by the MEAE. The dismantling will be regulated by STUK concerning the radiation and nuclear safety aspects.

Decommissioning plans for non-nuclear facilities

Revised Radiation Act (Section 83) states that authorization is required for decommissioning of radiation sources facilities. VTT compiled a decommissioning plan of an old hot cell laboratory in 2017. It included a risk assessment and descriptions of the decommissioning phases, the possible demolition techniques, management and processing of radioactive and contaminated materials as well as radioactive waste management plans. In 2019 VTT applied for a safety license for decommissioning of hot cell laboratory facilities. The license was granted in autumn 2019 for the handling and storage of radioactive waste. The license covers the disposal or transfer (for further use) of radioactive research samples, removal of radioactive materials and contaminated equipment and structures, surface cleaning, and handling and storage of radioactive waste.

SECTION C
Scope of Application

Article 3 Scope of Application

This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

Reprocessing and military or defence programmes

Finland has adopted a once-through nuclear fuel cycle. There is no reprocessing facility in Finland. It is not permitted to send spent fuel for reprocessing to another country as the Nuclear Energy Act (990/1987, Section 6 a) denies it. Thus, all spent nuclear fuel, after it has been permanently removed from the reactor, falls in the scope of the Convention.

No spent nuclear fuel of military or defence origin exists in Finland.

Airborne and liquid discharges from nuclear and radioactive waste management facilities, notably from NPPs, are included in the scope of this Convention.

Naturally occurring radioactive materials

Waste outside the nuclear fuel cycle, containing only Naturally Occurring Radioactive Materials (NORM), except sealed radium sources, is not declared as radioactive waste for the purposes of the Convention. Some information on managing NORM waste related to conventional mining industry is given in section H. Minor legacy sites generated in prospective uranium extraction experiments are listed in section K.

SECTION D
Inventories and Lists

Article 32 Reporting, paragraph 2

This report shall (also) include:

(a) a list of the spent fuel management facilities subject to this convention, their location, main purpose and essential features;

(b) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain the description of the material and if available, give information on its mass and its total activity;

(c) a list of radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

(d) an inventory of radioactive waste that is subject to this Convention that:

- *is being held in storage of radioactive waste management and nuclear fuel cycle facilities;*
- *has been disposed of; or*
- *has resulted from past practices;*

this inventory shall contain the description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

(e) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

The total inventory on spent fuel and radioactive waste

The major part of the radioactive waste and spent nuclear fuel has been produced in the currently operating nuclear power plants at Olkiluoto (OL1 and OL2) and Loviisa (LO1 and LO2). Small amounts of spent fuel and radioactive waste has been produced during the operation of the FiR 1 research reactor in Otaniemi. The total inventory of spent fuel and radioactive waste at the end of 2019 are presented in Tables 1 and 2. The detailed information on spent fuel and radioactive waste inventory and existing waste and spent fuel management facilities are presented in the report from IAEA Spent Fuel and Radioactive Waste Information System (SRIS) database in Annex L.5.

TABLE 2. Total spent fuel inventory.

Spent fuel	Total Stored Amount	Total Disposed Amount
Spent fuel from NPP's	2261 tHM	0
Spent fuel from research reactor	21,3 kgHM	1)

1) The first option is to send the fuel back to USA according existing returning agreement.

TABLE 3. Total radioactive inventory at the end of 2019.

Waste Class	Total Stored Amount m³	Total Disposed Amount m³
VLLW	204	1)
LLW	1691	6541
ILW	1970	2117
HLW	0	0

1) Currently VLLW is disposed to LILW repository and is included in the total inventory of disposed LLW.

Non-nuclear radioactive waste

The licensing database maintained by STUK includes source-specific information on each sealed source in the licensee's possession. This information is updated continuously according to the licensee's notifications and to observations made during inspections. Small users of radioisotopes have some radiation sources on their premises which are no longer in use but have not yet been declared as radioactive waste. The number of such sources is relatively limited, whereas it is prohibited to unnecessarily store sources for which no use is foreseen. Disposed non-nuclear wastes are included in Table 3.

Waste from past practices

There are no significant amounts of waste from past practices requiring further management.

Decommissioning

The decommisiong plans and the current status of of the VTT FiR 1 research reactor have been described in more detail in Sections A and B, and further dealt in the following Sections below. The estimated total amount of decommissioning waste of FiR 1 reactor is about 75 tons (unpacked volume about 40 m³) with a total activity of less than 5 TBq.

The decommissioning plans of the old VTT hot cell laboratory has been discussed in more detail in Section B. The estimated total amount of radioactive waste from dismantling of old hot cell laboratory is 26 m³ with total activity of 130 MBq.

SECTION E
Legislative and Regulatory system

Article 18 Implementing measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

The necessary legislative, regulatory and other measures to fulfil the obligations of the Convention have been taken and are discussed in this report.

Article 19 Legislative and regulatory framework

Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

This legislative and regulatory framework shall provide for:

(a) the establishment of applicable national safety requirements and regulations for radiation safety;

(b) a system of licensing of spent fuel and radioactive waste management activities;

(c) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a license;

(d) a system of appropriate institutional control, regulatory inspection and documentation and reporting; the enforcement of applicable regulations and of the terms of the licences;

(e) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.

When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

National safety requirements and regulations for radiation safety

In Finland, the legislation for the use of nuclear energy and for radiation protection was established in 1957. The current Nuclear Energy Act and the Radiation Act were issued in 1987 and 2018, respectively. Since, several amendments to the Nuclear Energy Act and new detailed regulations have been issued. The 2018 Radiation Act meant a full revision of the whole radiation safety legislation including all subsequent decrees and regulations.

Nuclear legislation and regulations

The current Finnish nuclear legislation is based on the Nuclear Energy Act from 1987, together with a supporting Nuclear Energy Decree from 1988.

The scope of this legislation covers e.g.

- The construction, operation and decommissioning of nuclear facilities; nuclear facilities refer to facilities for producing nuclear energy, including research reactors, facilities performing extensive disposal of nuclear waste, and facilities used for extensive manufacturing, production, use, handling or storage of nuclear materials or nuclear waste;
- Mining and milling operations aimed at producing uranium or thorium;
- The possession, manufacture, production, transfer, handling, use, storage, transport, import of nuclear material and nuclear waste, and export of nuclear waste as well as the export and import of ores and ore concentrates containing uranium or thorium.

A significant amendment to the Nuclear Energy Act was passed in 1994 to reflect a new policy which emphasises the national responsibility to manage nuclear waste generated in Finland. In general, the export and import of nuclear waste, including spent fuel, is prohibited in the revised Act. A notable exception is allowed for the FiR 1 research reactor. Thus, according to the Nuclear Energy Act (Section 6 a) the provisions forbidding export of nuclear waste do not apply to spent fuel that has been generated in connection with or as a result of the operation of a research reactor in Finland. However, in conformance with Nuclear Energy Decree (Section 7 b) possibility to export does not apply to any other nuclear waste resulting from FiR 1.

The nuclear energy legislation was updated and reformed in 2008 to correspond to the current level of safety requirements and the new Finnish Constitution, which came into force in 2000. The new Constitution required that the general principles for the protection of citizens should be provided for in the level of Acts.

In 2011 two further revisions were made to the Nuclear Energy Act. The first was due to the Nuclear Safety Directive (Council Directive 2009/71/EURATOM) and the second one includes provisions on mining and milling operations aimed at producing uranium or thorium. The licensee's obligation to assure the safe use of nuclear energy was already stipulated in the Act, but the first amendment added the requirement that the obligation may not be delegated or transferred to another party. The licensee's obligation to arrange necessary training for nuclear safety personnel and the responsibility of the MEAE to arrange self-assessment and international peer reviews to evaluate the national framework were also included in the Act.

In 2012, the Nuclear Energy Act was amended to make some minor clarifications and to extend the role of inspection organisations.

Finland was active in the process of developing a proposal for a European Council Directive on the management of spent fuel and radioactive waste. In 2013, the Nuclear Energy Act and the Radiation Act were amended to implement Directive 2011/70/EURATOM on 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and other nuclear and radioactive waste. The principles of a graded approach and maintaining the generation of radioactive waste to the minimum amount reasonably practicable were included in both Acts. In the Nuclear Energy Act the provisions of self-assessment and peer review were updated to also cover radioactive waste management.

In 2012, the Finnish regulatory framework for nuclear and radiation safety was reviewed in the Integrated Regulatory Review Service (IRRS) peer review process. According to the IRRS recommendations, some amendments needed to be considered for the legislation mainly concerning the independence of STUK. The Nuclear Energy Act was revised in 2015 to enable STUK to issue legally binding regulations. The updated Radiation Act was delivered in 2018.

Minor amendments were made in the Nuclear Energy Act in 2017 due to changes in environmental impact assessment legislation. Also, in 2017 the Nuclear Energy Act was amended to clarify the licensing of decommissioning of nuclear facilities. A decommissioning license was added into the legislation based on IRRS recommendations from 2012. Before the amendment, the decommissioning of nuclear facilities was licensed as a renewal of the operating license of a nuclear facility. Previously required license renewal documentation did not reflect the different and lesser risks of decommissioning projects. Some other minor amendments were also made in nuclear and radiation legislation to reflect changes in other legislation (e.g. labour safety, and the criminal code). Amendments in other national legislation have not caused essential changes to the regulatory control for waste management or to the safety requirements set for it.

The Basic Safety Standards Directive was implemented in Finland in 2018. Due to changes to the Radiation Act and related Decrees, references to said legislation were updated in Nuclear Energy Act in 2018.

The provisions for the use of nuclear energy in the Nuclear Energy Act also address spent fuel and nuclear waste management. The Nuclear Energy Act Section 9 stipulates that a licensee whose actions result in the generation of nuclear waste shall be responsible for all associated waste management operations and their related costs. Further specific requirements on nuclear waste management are given in Sections 27 a to 34) and requirements for the financial provision for nuclear waste management are specified in Sections 35–53. Sections 35 to 53 describe the VYR Fund and its operating principles. The MEAE determines the annual fee to be paid to the fund each year, ensuring that the VYR fund always has enough assets to secure the costs of all nuclear waste management measures that still must be carried out.

Based on the Nuclear Energy Act, in 2016 STUK issued regulations which are legally binding according to Section 7 q of Nuclear Energy Act. The Regulations currently in force are:

- Radiation and Nuclear Safety Authority Regulation on the Safety of Nuclear Power Plants (Y/1/2018)
- Radiation and Nuclear Safety Authority Regulation on Emergency Response Arrangements at Nuclear Power Plants (Y/2/2018)
- Radiation and Nuclear Safety Authority Regulation on the Security in the Use of Nuclear Energy (Y/3/2016)
- Radiation and Nuclear Safety Authority Regulation on the Safety of Disposal of Nuclear Waste (Y/4/2018)
- Radiation and Nuclear Safety Authority Regulation on the Safety of Mining and Milling Operations Aimed at Producing Uranium or Thorium (Y/5/2016).

The Regulations Y/1/2018 (Safety of a Nuclear Power Plant, Y/2/2018 (Emergency Arrangements of a Nuclear Power Plant) and Y/3/2016 (Security in the Use of Nuclear Energy) are applied to nuclear power plants, which are defined as any nuclear facility equipped with a nuclear reactor and other related nuclear facilities located on the same plant site. Regulations Y/2/2018 and Y/3/2016 are also applied to other nuclear facilities to the extent applicable, based on the graded approach.

STUK's Regulations include changes to safety requirements arising from the Fukushima Dai-ichi accident and WENRA (Western European Nuclear Regulators' Association; see also chapter Nuclear Regulatory Guidance) Safety Objectives and Safety Reference Levels.

As described above, the nuclear legislation has been amended several times. The MEAE has in 2019 started an evaluation of the possible need of a comprehensive reform of the legislation.

Nuclear Regulatory Guidance

Detailed safety requirements on the management of spent nuclear fuel and radioactive waste resulting from the production of nuclear energy are provided in the YVL Guides. The YVL Guides also provide administrative procedures for the regulation. The YVL Guides are issued by STUK, as stipulated in the Nuclear Energy Act. The YVL Guides are rules an individual licensee or any other organisations concerned must comply with, unless some other acceptable procedure or solution has been presented to STUK through which the required level of safety stipulated in the Nuclear Energy Act, the Nuclear Energy Decree and STUK Regulations is achieved.

The procedure to apply new or revised guides to existing nuclear facilities is that the publication of a YVL Guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL Guide is applied to a nuclear facility in operation, or to those under construction, and to the licensee's operational activities, as well as to other nuclear facilities related to nuclear waste management and disposal and to Finland's research reactor. For new nuclear facilities, however, the guides apply as such.

Nowadays the most important references considered in the rulemaking are the IAEA safety standards, WENRA (Western European Nuclear Regulators' Association) Safety Reference Levels and WENRA's latest statement on the Safety Objectives for New NPPs. Other sources of safety information are worldwide co-operation with other countries using nuclear energy, e.g. with the member countries of OECD/NEA. The Finnish policy is to participate in the international discussion on developing safety standards and to adopt or adapt new safety requirements into national regulations. The Finnish policy is to include all WENRA Safety Reference Levels in the regulatory framework while updating regulatory guides through a systematic approach.

STUK currently has 45 YVL Guides. In the area of waste management, the most important changes are that the requirements concerning spent fuel interim storages were updated to take account of the lessons from the Fukushima Dai-ichi accident, and that the requirements concerning the decommissioning of nuclear facilities were included in the YVL guidance. STUK issued a new Guide YVL D.7 Release barriers of spent nuclear fuel disposal facility in 2018. The Guide YVL D.7 addresses the detailed technical design, manufacture, construction, installation, inspection, testing and verification of conformity of barriers intended for the disposal of spent nuclear fuel, and the monitoring of the impacts of their construction during construction and operation.

Legislation and regulations for the use of radiation sources

A full revision of the Finnish radiation safety legislation took place in 2018 through the adoption of the Radiation Act (859/2018) and subsequent legislation ja regulations:

- the Decree of the Government on Ionizing Radiation (1034/2018),
- the Decree of the Ministry of Social Affairs and Health on Ionizing Radiation (1044/2018), and
- a set of STUK regulations.

At the same time the Radiation Act of 1991 and subsequent legislation, regulations and regulatory guides, namely all the ST Guides, were all repealed.

The new Radiation Act authorizes STUK to issue legally binding regulations on specified matters. During 2018–2019 STUK issued the following regulations (list below contains only those in force and with relevance to radioactive waste):

- SY/1/2018 Regulation on exemption and clearance
- S/1/2018 Regulation on plans for radiation safety deviations and actions during and after radiation safety deviations
- S/3/2018 Regulation on security of radiation sources subject to authorization
- S/6/2018 Regulation on radiation measurements
- S/2/2019 Regulation on radioactive waste and releases in the use of unsealed sources
- S/3/2019 Regulation on practices involving exposure to natural radiation
- S/5/2019 Regulation on radiation safety of radiation sources during use and decommissioning of radiation sources and facilities
- S/6/2019 Regulation on practices subject to authorization.

It should be noted that the nature and contents of these new regulations are very different from the previous ST Guides which included both legally binding provisions but also regulatory guidance. Now it is foreseen that no traditional type of regulatory guides in printed form will be issued anymore. However, there is an on-going project to issue regulatory guidance in an on-line database enabling the linkage of legal provisions and regulatory guidance through searches on different types of practices and substance matters.

The main reason for the full revision was to bring the radiation safety legislation in line with the EU Council Directive 2013/39/Euratom. At the same time the concordance with the revised Constitution of 2000 and various other important updates to the Finnish legal system including the Administrative Procedure Act (434/2003) were ensured.

The new radiation safety legislation emphasizes the responsibility of the licensee in all respects of safety and in all phases of operations, the optimization of protection and the application of graded approach to regulation.

Several upgrades regarding management of radioactive waste was established compared to the previous legislation ja regulations:

- Decommissioning of radiation sources and radiation sources facilities is now specifically addressed.
- The legislation now addresses waste which is not classified as radioactive waste but in the management of which provisions on the protection of workers and members of the public shall applied. These wastes include e.g. NORM-waste from mining and milling activities (those not related to the production to uranium or thorium) and waste arising from existing exposure situations e.g. from long term remediation activities after accidental large spread of contamination to the environment.
- Licensees shall conduct a safety assessment on all their activities, including waste management.
- Licensees shall use a radiation protection expert in matters related to waste management.
- Classification of practices based on the activity of wastes to be disposed in land fillings, separate heaps or among other types of waste.
- The requirement for financial security was extended to the conditioning of radioactive waste.
- Authorization of facilities continuously confronting orphan sources.

Licensing of spent fuel and radioactive waste management activities

The licensing of the currently operating disposal facilities for LILW at Loviisa and Eurajoki NPP sites were iniatiated according to the legislation that was in force before 1987. Therefore, their licensing processes are not comparable with the current licensing process.

The current licensing process is defined in the exisiting legislation. The construction and operation of a nuclear facility is not permitted without a license and licences are prepared by the MEAE and granted by the Government. For any nuclear reactor unit, spent nuclear fuel storage, nuclear waste disposal facility, or another significant nuclear facility there are four different licensing steps:

- Decision-in-Principle – made by the Government and ratified by Parliament
- Construction License – granted by the Government
- Operating License – granted by the Government
- Decommissioning License – granted by the Government.

The conditions for granting a license are prescribed in the Nuclear Energy Act (Sections 18–20 a). The operating licences of a nuclear facility are granted for a fixed term, generally for 10–20 years. Construction and decommissioning license do not have a fixed term. In case the operating license is granted for a longer period than 10 years, or 15 years in case of disposal facilities for nuclear waste, a periodic safety review is required to be presented to STUK. The periodic re-licensing or review has allowed good opportunities for a comprehensive safety review.

Before a Construction License for a nuclear reactor unit, spent fuel storage, nuclear waste disposal facility, or other significant nuclear facility can be applied for, a Decision-in-Principle by the Government and a subsequent ratification of the DiP by Parliament are required. The

EIA procedure shall be conducted prior to the application for the DiP. Also, the EIA report and the coordinating authority's statement on the assessment report must be annexed to the DiP application. A condition for granting the Decision-in-Principle is that the construction of the nuclear facility in question must be for overall good of society. Further conditions are as follows:

- The municipality of the intended site of the nuclear facility must be in favour of constructing the facility (the municipality has a veto right)
- No factors must have arisen which would indicate that the proposed facility could not be constructed and operated in a safe manner (STUK has a veto right).

The entry into force of the Government's Decision-in-Principle further requires ratification by Parliament. Based on established practice, Parliament does not make any changes to the Decision; it only approves or rejects it as such. The authorization process for a nuclear facility is described in Figure 9. In the construction and operating license application handling processes, the acceptance of Parliament and of the hosting municipality are no longer required.

The Decision-in-Principle procedure was implemented for the first time for a nuclear waste management facility during the period November 1999 – May 2001 when Posiva applied for a Decision-in-Principle for a disposal facility for spent nuclear fuel originating from the Loviisa and Olkiluoto nuclear power plants. The Government made the DiP in December 2000 and Parliament ratified the decision in May 2001. The same DiP procedure was repeated in 2002 for

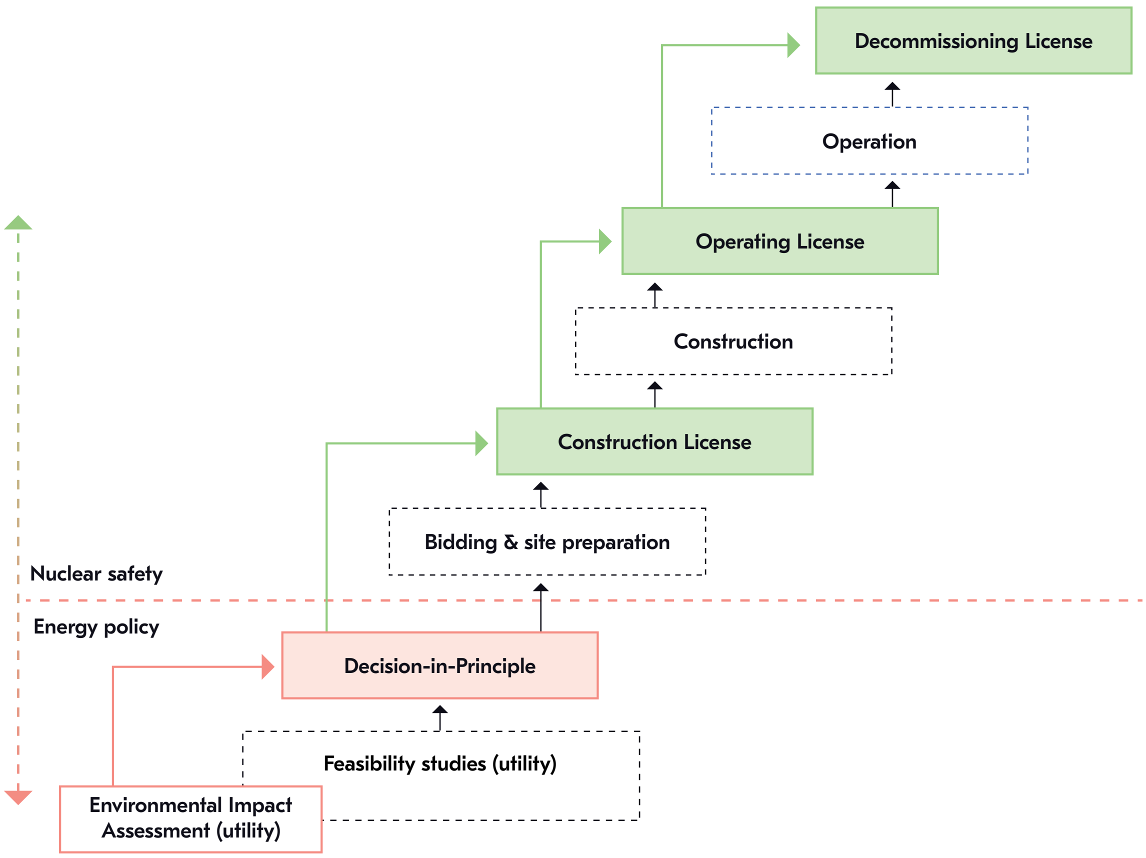


FIGURE 9. Authorization of nuclear facilities in Finland.

the extension of the capacity of the spent fuel disposal facility to include spent fuel from the new reactor unit OL3. Therefore, Posiva has a DiP, as well as Construction License, in force for the disposal of spent fuel from two reactor units in Loviisa and three reactor units in Olkiluoto.

The licensing system was assessed in the IRRS peer review mission conducted in Finland in October 2012. The IRRS team gave a recommendation that the Finnish Government should seek to modify the Nuclear Energy Act so that the law clearly and unambiguously stipulates STUK's legal authority in the authorization process for nuclear and radiation safety. In particular, the amendments should ensure that STUK has the legal authority to specify any license conditions necessary for safety. The Nuclear Energy Act, Sections 23 and 25 were amended in 2015 for this purpose. The IRRS also recommended clarifying the licensing for decommissioning nuclear facilities by setting a decommissioning license, which was implemented into the Nuclear Energy Act in 2017.

Based on the Nuclear Energy Act (Section 16), minor licences for spent fuel and nuclear waste management activities (near-surface disposal facilities for VLLW, export, import, transfer and transport licences and licences for operations) are granted by STUK.

The licensing system for practises under the Radiation Act is described in Section 48 of the Act. The use of radiation requires a safety license, which can be granted by STUK upon application. A safety license can be issued for the different phases of a practice and can be subject to extra conditions needed to ensure safety. The license will be issued if it complies with the principles of justification, optimization and dose limitation and it is demonstrated through a safety assessment that the practice can be conducted safely. In addition, Sections 49–50 provide for exemption from licensing of some minor radiation sources and exposures.

Prohibited operation without a license

The use of nuclear energy without a license provided by the Nuclear Energy Act is prohibited. Simarly, the unauthorized use of radiation sources that need a safety license, in accordance with the Radiation Act, is prohibited.

Institutional controls and enforcement of regulations

According to the Nuclear Energy Act (Section 55), STUK is responsible for the regulatory control of the safety of the use of nuclear energy. The rights and responsibilities of STUK are provided in the Nuclear Energy Act (Sections 55 and 63). The regulatory activities include authorization, review and assessment, inspection and enforcement, development of regulations and guides, national registers and inventories, information and public communication.

The most important documents of the nuclear facility licensee, which shall comply with the regulations and other safety requirements and are reviewed by STUK, are the Preliminary and Final Safety Analysis Reports (PSAR and FSAR), and for disposal facilities also the post-closure Safety Case documentation in support of PSAR and FSAR. STUK's on-site inspections aim at verifying that the actual operations at the nuclear facilities comply with the regulations and the documents of the licensee, for example.

The Radiation Act (Section 11) provides that adherence to the Act (and thus the decrees and regulations issued in accordance with it) shall be regulated by STUK. The regulatory rights of STUK are described in the Act (Sections 176–184).

The Nuclear Energy Act and the Radiation Act define the enforcement system and rules for suspension, modification or revocation of a license. The enforcement system includes provisions for executive assistance if needed and for sanctions in case the law is violated.

Clear allocation of responsibilities for spent fuel and radioactive waste management

According to the Section 54 in Nuclear Energy Act, the overall authority in the field of nuclear energy is the MEAE. STUK is responsible for the supervision of the safe use of nuclear energy according to Nuclear Energy Act (Section 55). In addition, STUK is responsible for attending to the supervision of security and emergency planning, and for the necessary control of the use of nuclear energy to prevent proliferation of nuclear weapons (for more information see Article 20).

According to the Nuclear Energy Act (Section 9), a licensee, whose operation generates or has generated nuclear waste, shall be responsible for all nuclear waste management measures and their appropriate preparation as well as for the arising expenses.

The Radiation Act (Chapter 11) provides for the management of radioactive waste from non-nuclear applications. The responsible party (i.e. the licensee or any company or organization which uses radiation sources in its practices) is required to take all measures needed to render the radioactive waste arising from its operation harmless. In cases where a practice produces or may produce radioactive waste that cannot be rendered harmless without considerable expense, a financial security shall be furnished to ensure that these costs and those arising in performing any necessary environmental decontamination measures are met.

The state has the secondary responsibility in case a producer of nuclear waste (the Nuclear Energy Act, Sections 31 and 32) or non-nuclear radioactive waste (the Radiation Act, Section 80) is incapable of fulfilling its management obligation.

The regulatory responsibilities are discussed under Article 20.

Article 20 Regulatory body

Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.

Bodies of the regulatory framework

According to the Nuclear Energy Act, the overall authority in the field of nuclear energy is the MEAE. The Ministry prepares matters concerning nuclear energy to the Government for decision-making. Among other duties, the MEAE is responsible for the formulation of a national energy policy.

According to the Radiation Act (859/2018, Section 13), the Ministry of Social Affairs and Health has the highest command and control over compliance with the Act. STUK supervises compliance with the Radiation Act and subsequent decrees and regulations.

The mission of STUK is 'to protect people, society, environment, and future generations from harmful effects of radiation'. STUK is an independent governmental organisation for the regulatory control of radiation and nuclear safety, as well as nuclear security and nuclear materials. STUK is administratively under the Ministry of Social Affairs and Health. Interfaces with ministries and governmental organisations are described in Figure 10. It is emphasized that the regulatory control of the safe use of radiation and nuclear energy is independently carried out by STUK. No Ministry can make decisions on a matter that has been defined by law to be on the responsibility of STUK. STUK has no responsibilities or duties which would conflict with regulatory control.

The current Act on STUK was given in 1983 and the Decree in 1997. According to the Decree, STUK has the following duties:

- regulatory oversight of safety of the use of nuclear energy, emergency preparedness, security and nuclear materials
- regulatory control of the use of radiation and other radiation practices
- monitoring of the radiation situation in Finland, and maintaining preparedness for abnormal radiation situations
- maintaining national metrological standards in its field of activity
- research and development work for enhancing radiation and nuclear safety

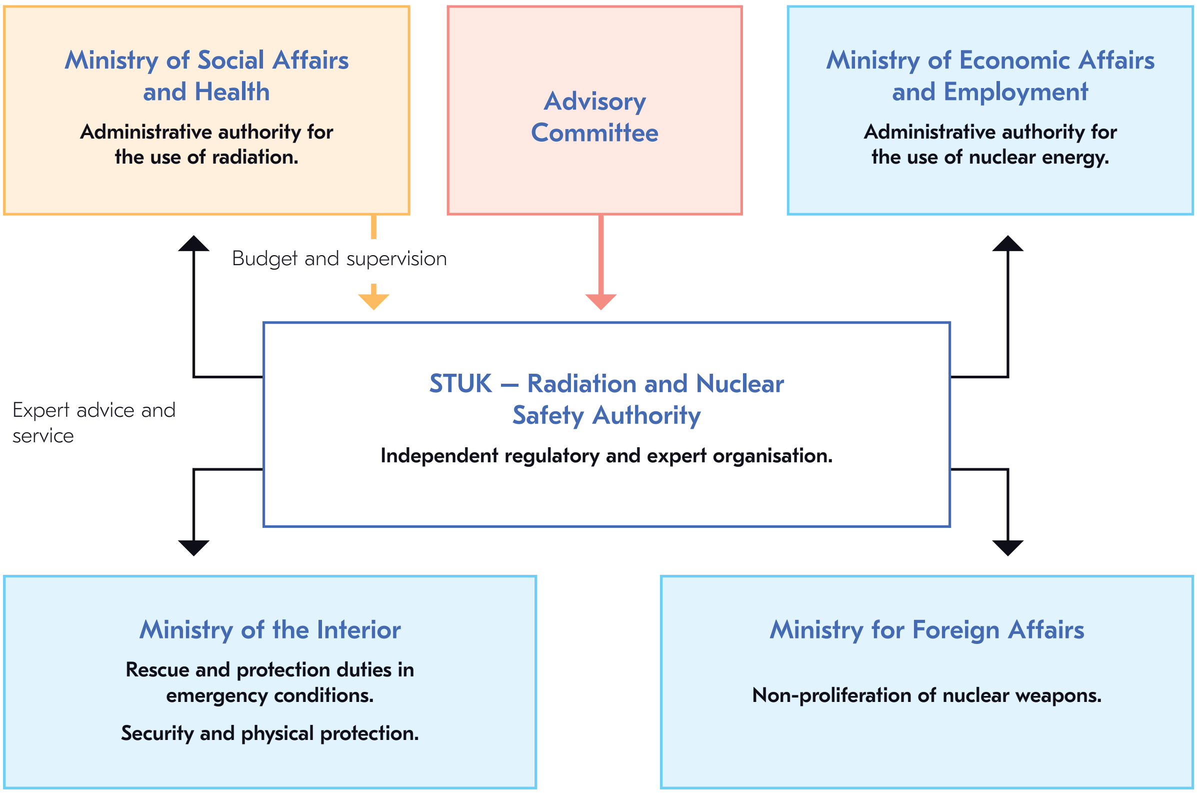


FIGURE 10. Co-operation and interfaces between STUK, ministries and other organisations.

- informing on radiation and nuclear safety issues, and participating in training activities in the field
- producing expert services in the field of its activity
- making proposals for developing the legislation in the field, and issuing general guidelines concerning radiation and nuclear safety
- participating in international co-operation in the field, and taking care of international control, contact or reporting activities as enacted or defined.

STUK has the legal authority to carry out regulatory oversight. The responsibilities and rights of STUK, as regards the regulation of the use of nuclear energy and use of radiation are provided in the Nuclear Energy Act and Decree and in the Radiation Act and Decree. STUK's responsibilities and rights include the following main regulatory activities: authorization, review and assessment, inspection and enforcement, development of regulations and guidelines, national registers and inventories, information and public communication. STUK does not grant construction or operating licences for nuclear facilities. However, in practice no such license would be issued without STUK's statement, where the fulfilment of the safety regulations is confirmed as described in Article 19. The regulatory oversight is described in detail in Guide YVL A.1.

STUK's Advisory Committee was established in March 2008. The Advisory Committee supports STUK to develop its functions as a regulatory, research and expert organisation in such a way that the activities are in balance with society's expectations and the needs of citizens. The Advisory Committee can also make assessments of STUK's actions and give recommendations to STUK.

The Advisory Committee on Nuclear Safety was established in 1988 by a Decree. This Committee gives advice to STUK on important safety issues and regulations. The Committee also gives its statements on license applications. The Committee has two international sub-committees, one for reactor safety (RSC) and one for safety issues related to radioactive waste (NWSC). In addition, an Advisory Committee on Radiation Safety has been established. The committee gives statements on important radiation safety issues and regulations. The members of the Advisory Committee on Nuclear Safety and the Advisory Committee on Radiation Safety are nominated by the Government.

To assist STUK's work in nuclear security, the Advisory Committee on Nuclear Security was established in 2009. The members of the committee come from various Finnish authorities, and the nuclear licensees also have their representatives as experts. The duties of the committee include the assessment of threats in the nuclear field as well as consulting STUK on important security issues. The committee also aims to follow and promote both international and domestic co-operation in the field of nuclear security issues. The members of the Advisory Committee on Nuclear Security are nominated by the Government.

To assist STUK's work in nuclear security, the Advisory Committee on Nuclear Security was established in 2009. The members of the committee come from various Finnish authorities, and the nuclear licensees also have their representatives as experts. The duties of the committee include the assessment of threats in the nuclear field as well as consulting STUK on important security issues. The committee also aims to follow and promote both international

and domestic co-operation in the field of nuclear security issues. The members of the Advisory Committee on Nuclear Security are nominated by the Government.

STUK is responsible communicating with the public and media on radiation and nuclear safety. STUK aims to communicate proactively, openly, timely and understandably. A prerequisite for successful communication is that STUK is known among media and general public, and the information given by STUK is regarded as truthful. Communication is based on best available information. STUK's own web site is an important tool in communication. STUK also uses social media platforms for two-way public communication. Internal communication informs the personnel about STUK's activities, and this supports STUK's capability to communicate with public.

STUK's role and responsibilities have been assessed by a peer review. An IRRS mission (IAEA's Integrated Regulatory Review Service) was carried out in October 2012 and a follow-up mission in June 2015.

In June 2015, the follow-up mission, 5 international experts and 4 IAEA staff members reviewed regulatory activities in Finland based on IAEA Safety Standards, international best practices and experiences and lessons learned from the TEPCO Fukushima Dai-ichi accident. The purpose of the IRRS follow-up was to review the measures undertaken following the recommendations and suggestions of the 2012 IRRS mission. The scope of the follow-up mission was the same as in 2012, i.e. to cover nuclear facilities, except the research reactor FiR 1 (due to the decision on decommissioning), radiation sources and transport.

As a result of the follow-up mission the review team concluded that the recommendations and suggestions from the 2012 IRRS mission have been implemented systematically in a comprehensive action plan. Significant progress has been made in most areas and many improvements have been implemented in accordance with the action plan. The IRRS team determined that 7 out of 8 recommendations and 19 of 21 suggestions made by the 2012 IRRS mission had been effectively addressed and therefore could be considered closed.

The recommendation left open in the 2015 follow-up mission deals with STUK's position related to the Government which will be discussed further in Finland but for the time being without changes in STUK's position. Two new recommendations were raised to amend the legislation to clarify that the decommissioning of a nuclear installation and closure of a disposal facility require a license amendment; and to address the arrangements for research in radiation safety.

Recommendation on clarifying the legislation related to decommissioning of nuclear installations and closure of a disposal facility is partly addressed. Decommissioning license was introduced to the Finnish legislative framework in the beginning of 2018. Future work needs still to be carried out for clarifying the licensing of closure of disposal facilities.

To establish a sound base for radiation protection research, the co-operation with Finnish universities and international research platforms has been reinforced. Research funding opportunities have been exploited and STUK is in an active role in shaping research agendas of many of these platforms to ensure that national aspects of research funding are considered at European level. STUK has also set up an internal research funding mechanism. The income from expert services is partly reserved for research projects and researchers can apply funding for their projects biannually.

One of the open suggestions in the 2015 IRRS follow -up mission was related to STUK's management system. The evaluation of the management system has been started as indicated in Article 23.

The next IRRS mission is planned for 2022. Also, the IAEA mission Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) has been agreed to take place in 2022. The next IAEA International Physical Protection Advisory Service (IPPAS) mission has been invited and will be carried out in 2021.

Finance and resources of the regulatory body

The organisational structure and the responsibilities within STUK are described in the Management System of STUK. Additionally, processes for regulatory oversight and other activities of STUK are presented in the Management System. The organisation of STUK is described in Figure 11.

In 2019, the overall costs of STUK were 41.5 million €, and it received about 40% of its financial resources through the State budget. However, the costs of nuclear regulatory oversight are charged in full of the licensees. The model for financing the nuclear regulatory work is called a net-budgeting model and it has been applied since 2000. In this model, the licensees of the nuclear industry pay the regulatory oversight fees directly to STUK. In 2019, the cost of the regulatory oversight for nuclear safety was 18.4 million €. The cost of the regulatory oversight of the use of radiation and non-nuclear waste was 3.3 million € in 2019. This was covered partly by licensee fees and partly by state budget.

STUK has adequate resources to fulfil its responsibilities in regulatory oversight. The net-budgeting model makes it possible, for example, to increase personnel resources flexibly based on needs.

At the beginning of 2020, the number of staff in the department of Nuclear Waste Regulation and Safeguards came to 25. The regulatory oversight of waste management facilities is supported by the Nuclear Reactor Regulations department with 123 experts from different disciplines. At the beginning of 2020, the number of staff in the Radiation Practices Regulation Department was 58. Non-nuclear radioactive waste is mainly regulated by the Radiation in Industry section, which has a staff of 12. The expertise of STUK covers all the essential areas needed in the oversight of the use of nuclear energy. As needed, STUK orders independent analyses, reviews, and assessments from technical support organisations to complement its

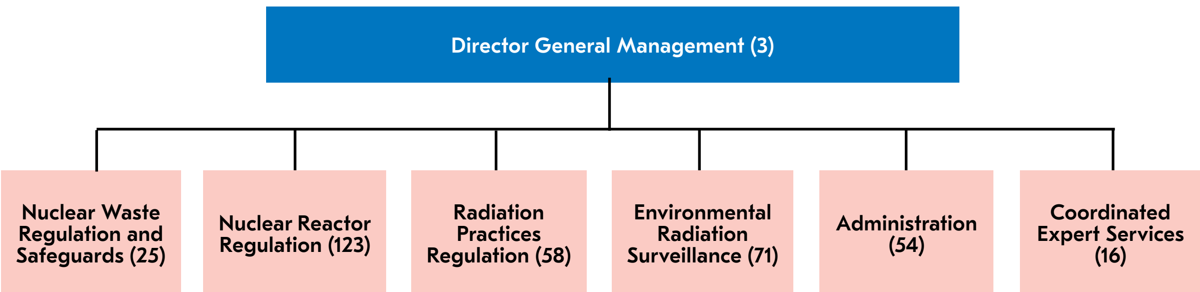


FIGURE 11. Organisation of STUK. The total number of staff in January 2020 was 350.

own review and assessment work. The main technical support organisation of STUK is VTT, but also Lappeenranta-Lahti University of Technology (LUT) and Aalto University (former Helsinki University of Technology) are important. Furthermore, international technical support organisations and experts are used.

Ensuring competence of the regulatory body

The management of STUK highlights the need for a competent workforce. To this end STUK has adopted a competence management system. Nuclear and radiation safety and regulatory competencies are also emphasised in STUK's strategy. Implementation of the strategy is reflected in the annual training programmes, on the job training and new recruitment. The national nuclear safety (SAFIR) and waste management research (KYT) programmes play an important role in the competence building for all essential organisations involved in nuclear energy. The funding of the programme according to the Nuclear Energy Act (Articles 53 d and 53 e) comes from the license holders via the VYR. These research programmes have two roles: firstly, ensuring the availability of experts and tools for regulatory oversight, and secondly, ensuring the on-line transfer of research results to the organisations participating in the steering of the programmes and fostering the expertise. STUK has an important role in the steering of these programmes.

Most of the professional staff at STUK conducting review, assessment and inspections hold a university level degree. The average experience of the staff is about 15 years in the nuclear field. A competence analysis is carried out on a regular basis and the results are used as the basis for training programmes and new recruitments. The training programme includes internal courses as well as courses organised by external organisations. On average, 5% of the annual working hours have been used to enhance competence.

An induction programme is set up at STUK for all newly recruited inspectors. In addition to administrative issues, the induction programme includes familiarisation with legislation, regulatory guidance and regulatory oversight practices. The programme is tailored to each new inspector and its implementation is followed by the superior of the employee. STUK has also participated in the preparation and execution of a basic professional training course on nuclear safety and nuclear waste management with other Finnish organisations in the field (described in more detail in Article 22).

National research programmes

During the recent years, the total volume of nuclear energy research in Finland has been at a level 75 million € annually (estimate of MEAE). Over 70% of these funds are direct investments of power companies to nuclear energy research, and around two thirds of the total volume focus on nuclear waste management.

The Nuclear Energy Act was amended in 2003 to ensure (see Section B) funding for a long-term nuclear safety and nuclear waste management research in Finland. Funds are collected annually from the license holders to special funds. Regarding nuclear safety research, the amount of money is proportional to thermal power of licensed power plants. In regard nuclear waste research, those who are responsible for nuclear waste management pay annually a fixed portion of their respective assessed total liability. In 2016, the Nuclear Energy Act was amended, and a temporary increase of the payments collected to the nuclear safety research fund was introduced. The purpose of the temporary increase of the research funding is to renew the ageing infrastructure for the nuclear safety related research. The increased funding is collected in between the years 2016 and 2025. At the first stage the additional funding has been allocated for the hot cells at VTT Centre of Nuclear Safety (CNS) and at the second stage it will be allocated for the thermohydraulic laboratory at Lappeenranta University of Technology. Since the year 2016, the annual funding of NPP nuclear safety projects has been around 9 million €, of which around 5 and 4 million € are used for infrastructural improvements and research, respectively. During recent years, the annual level of funding of the nuclear waste management has been around 3 million €.

The funds collected are used for national publicly funded safety research programs called SAFIR2022 (nuclear safety) and KYT2022 (nuclear waste). The research projects in these programs have been selected so that they support and develop the competence in nuclear safety and nuclear waste management and create preparedness for the regulator to be able to respond to safety issues. However, research projects also do have supplementary funding mostly from research institute budgets.

Most national publicly funded research takes place at VTT, which is the largest research organization in the field of nuclear energy. Other major research institutes include Aalto University, LUT, Geological Survey of Finland, Finnish Meteorological Institute, and Universities of Helsinki, Jyväskylä and Tampere.

The objective of KYT2022 is to ensure the enough and comprehensive availability of nuclear technological expertise and other capabilities required by the authorities when comparing different nuclear waste management approaches and implementation methods. The new KYT2022 programme was planned and initiated in year 2018. The programme continues the traditions of previous periods with the main research areas of:

- safety research in spent nuclear fuel management
- near-surface disposal
- low and intermediate nuclear waste management
- decommissioning
- new and alternative technologies in nuclear waste management and
- social science studies related to nuclear waste management.

National competence in radiation protection research is strengthened via consortium of Finnish Universities, VTT and STUK. The purpose of the consortium is to coordinate and strengthen the radiation safety research in Finland. It also maintains the national radiation safety research programme that describes the research needs and the role of each member. STUK is an active member of European radiation research platforms and European association of national metrology institutes and participates in shaping their strategic research agendas at the European level. In addition, STUK has set up an internal research funding mechanism. The income from expert services is partly reserved for research projects and researchers can apply funding for their projects biannually.

In conclusion, Finnish regulations and regulatory practices are in accordance with Article 20.

SECTION F
Other General Safety Provisions

Article 21 Responsibility of the license holder

Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant license and shall take the appropriate steps to ensure that each such license holder meets its responsibility.

If there is no such license holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

The responsibility for safety rests with the licensee as prescribed in the Nuclear Energy Act. Also, according to the Act (Section 9), each licensee, whose operations generate or have generated nuclear waste, are responsible for all nuclear waste management measures and their appropriate preparation, and are responsible for their costs. If the license holder is found not to be capable of carrying out the waste management completely or partly, the Government shall order that such nuclear waste be transferred to the responsibility of the State. The waste management obligation of the licensee will expire when the disposal of nuclear waste has been completed and STUK has confirmed that the nuclear waste is permanently disposed of in an approved manner (Sections 31–34 of the Nuclear Energy Act).

Furthermore, the licensee is responsible for security and emergency preparedness arrangements and other necessary arrangements for the limitation of nuclear damage. The authorities regulate these arrangements, but the responsibility belongs to the licensees. To ensure that the financial liability for the future management and disposal of nuclear waste and for the decommissioning of nuclear facilities is secured, the licensees under a waste management obligation must fulfil the financial provision obligation by making payments into the VYR, and furnish the State with securities as a precaution against insolvency. Further information about funding arrangements are given in Section B.

As a precondition for granting a safety license for the use of radiation, the Radiation Act requires (Section 51) that the applicant presents valid proof on the safe management of any radioactive waste which may be generated. Further, the Radiation Act (Section 79) requires that the responsible party must organize the practice so that it meets all radiation safety requirements prescribed in the Act and must take all the measures needed to render radioactive waste arising from its operation harmless. The Act also provides for the responsibility for decontamination of the environment if radioactive material is released to such an extent that the resulting health or environmental hazards require action (Section 138). According to the Act (section 147), in the utilization of natural resources containing radioactive materials, the responsible party shall ensure that radioactive waste does not pose any health or environmental hazard during operations, including measures taken while finally stopping these activities.

The Radiation Act (Section 80) provides that if the responsible party does not meet the requirements set for radioactive waste management, the State has the secondary obligation in managing the radioactive waste or residues. The same applies if the origin of the waste is unknown, or no primary responsible party can be found.

It is the responsibility of the regulatory body to verify that the licensees fulfil their responsibilities set in the regulations. This verification is carried out through safety reviews and assessments as well as inspection programmes established by STUK.

Article 22 Human and financial resources

Each Contracting Party shall take the appropriate steps to ensure that:

(a) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;

(b) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;

(c) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

Human resources

The licensee has the prime responsibility for ensuring that his employees are qualified and authorized for their jobs. According to the Nuclear Energy Act (Section 55) STUK shall set qualification requirements for persons involved in the use of nuclear energy, including activities important to nuclear safety, and also verify that the requirements are met. The regulatory requirements for human resources are stated in the Nuclear Energy Act (Sections 7 i, 7 k, 7 l, 7 p, 19 20 and 20 a), Nuclear Energy Decree (Sections 119, 122 and 125), STUK Regulations (STUK Y/1/2018 and STUK Y/4/2018) and Guide YVL A.4.

The requirements for the licensees' personnel are set out in the Nuclear Energy Act Section 7 i, which stipulates that the personnel should be well suited for their duties, competent and well trained. Further according Nuclear Energy Act Section 7 k, a nuclear facility must have a responsible director for construction, operation and decommissioning of the nuclear facility. According to Section 7 i, licensee must have responsible persons for emergency preparedness, security and safeguards and their deputies – all approved by STUK. Sections 7 l and 7 p contain regulatory requirements for security organisation and emergency response organisations, respectively. Nuclear Energy Decree (Sections 119, 122 and 125) specifies and clarifies the requirements set in the Nuclear Energy Act.

Human resources are also verifed in the licensing phases of nuclear facilities. According to the Nuclear Energy Act (Section 19), a necessary condition for granting a construction license for a nuclear facility is the availability of the necessary expertise. According to the Nuclear Energy Act (Section 20), an operating license of a nuclear facility may be granted if the applicant has the necessary expertise available and, in particular, the operating organisation and the competence of the operating staff are appropriate. According to the Nuclear Energy

Act (Section 20 a), a license for decommissioning of a nuclear facility may be granted if the applicant has the necessary expertise available, and especially if the competence of the nuclear facility personnel and the organisation of the nuclear facility are appropriate and suitable for decommissioning.

According to Section 25 of the STUK Regulation STUK Y/1/2018 and Section 38 of the STUK Regulation STUK Y/4/2018, significant functions with respect to safety within nuclear power plants and disposal facilities shall be designated, and the competence of the persons performing these functions shall be verified. The licensee shall have a sufficient number of competent personnel suitable for the related tasks for ensuring the safety of the nuclear facility. The licensee shall have access to the professional expertise and technical knowledge required for the safe construction, operation and decommission of the nuclear facility, the maintenance of equipment important to safety, and the management of accidents. In addition, the licensee of disposal facilities shall have access to the professional expertise and technical knowledge required for the long-term safety of disposal, including closure.

The Guide YVL A.4 sets out the requirements for qualifications and training of the personnel working in functions that are important for facility safety. The Guide also has more specific requirements for safety critical positions, e.g. for the responsible director and persons responsible for safeguards, emergency preparedness and security arrangements. It also has specific requirements on management and leadership competences. The guide is also applied for the waste management company, Posiva, as it is a licensee of a nuclear facility.

NPP utilities and Posiva have special training programmes including waste management for their personnel. Staff training at Posiva is based on personal training and development plans in addition to company-level plans, which are updated annually. In addition, Posiva co-operates with other European waste management organizations in the framework of the Technology Platform for Implementing Geological Disposal of Radioactive Waste (IGD-TP) and has bilateral agreements or understandings on international co-operation with several research and implementing organizations acting in the area of nuclear waste management. Posiva also participates in the EURATOM projects under the Horizon 2020 research framework programme and in various working groups and projects of the Nuclear Energy Agency of the OECD.

STUK's inspection programmes are one of the key instruments for regulatory oversight of construction, commissioning and operation of licensees and license applicants. The overall functionality of lisensee's management system, organization structure, processes, and procedures are included in STUK's inspection programmes for the different phases of nuclear facility project.

In activities related to the use of radiation and nuclear energy, the Radiation Act (Sections 33 and 34) and the Nuclear Energy Act (Sections 7 i and 20) prescribe that the responsible party is required to ensure that all workers participating in radiation or nuclear activities or whose duties otherwise require special expertise in radiation protection, have competence required by the operation and duties as well as radiation protection training and introduction to the duties. The responsible party must also ensure that workers participating in radiation activities will have supplementary radiation protection training adequately and on regular basis.

In all activities requiring a safety license, the responsible party shall consult a radiation safety expert when planning, implementing and monitoring radiation safety measures concerning workers and members of the public in accordance with the nature and extent of the responsible party's activities according to Section 32.

According to Section 28, the responsible party must appoint a radiation safety officer to assist the responsible party to carry out implementation of radiation protection arrangements. In safety license application, the applicant must provide documents proving qualifications of the radiation safety expert and the radiation safety officer (Section 51).

The competense requirements and requirements for qualifications of radiation safety experts and officers are set in Chapter 6 in Radiation Act. More detailed requirements of radiation safety experts and officers as well as further training of workers are given in the decree of the Ministry of Social Affairs and Health on ionizing radiation.

STUK performes regulatory oversight of human resources in use of radiation according to Radiation Act (Section 14). STUK also accepts the radiation safety experts on request (Section 39), if the requirements set in Section 37 is met.

Strengthening and maintaining competence building in Finland

Ensuring an adequate national supply of experts in nuclear science and technology and a high-quality research infrastructure is recognized as a continuous challenge in Finland as the resource need in the nuclear area is currently high due to many ongoing projects in the country (e.g. the OL3 project, the new reactor project Hanhikivi 1, and the spent nuclear fuel disposal project and decommissioning of the research reactor). The long timescales especially associated with the spent fuel disposal also underline the importance of the availability of qualified domestic experts in the field in the future. The availability of competent human resources has been instigated by training young experts in the nuclear safety field in different ways, e.g. on doctoral programmes and separately arranged courses. Also, as indicated at the end of Section E, one of the objectives of publically funded safety research programmes (SAFIR2022, KYT2022) is to ensure availablility of nuclear safety and technology experts for Finnish society. Further information about the challenges related to competence building are also given in Section K.

The basic training on nuclear area is provided by LUT and in the metropolitan area by Aalto and Helsinki universities. LUT offers M.Sc. Major program in Nuclear Engineering; Aalto University offers a minor program in nuclear engineering, and Helsinki University offers degrees in radiochemistry.

The main organisations in the nuclear energy area in Finland have developed and organized the basic professional training course on nuclear safety and nuclear waste management ("YJK course"). The course is annualy held approximately 6-week training programme for students and staff members of the participating organisations (STUK, nuclear power companies, nuclear waste management companies, universities providing basic training on nuclear area and the Ministry of Economic Affairs and Employment).

YJK course was built from former YK and YJH courses starting from autumn 2017. The first YK course on nuclear safety commenced in September 2003 and it was an annually held approximately 6-week training programme. During the 14 years, over 900 newcomers and junior experts participated in the courses. The first YJH course on nuclear weaste management commenced in 2010. The course with a six-day curriculum ran since 2011 for around 20–25 students at a time with around 100 participants altogether by the end of 2016.

When noticing the former cources, 17th YJK cource started in the autumn of 2019. To date, over 1200 newcomers and junior experts have participated in these courses. The content and structure of the course have been enhanced according to feedback received from the participants. The merged YJK cource has brought training and education of nuclear waste management to larger audience.

During 2010–2012 a committee set up by the MEAE worked on a report to provide recommendations and steps to be taken until the 2020s for ensuring competence and resources needed for the nuclear sector. One of the recommendations of the committee was that the future needs and focus areas for research in the Finnish nuclear energy sector must be accurately defined and a long-term strategy must be drawn up for further development of research activities. This calls for a separate joint project among research organisations and other stakeholders in the field. The competence review was updated in 2017 to reflect the current changes in the operating environment. The updated competence review (http://urn.fi/URN:ISBN:978-952-327-410-5) revealed that there is still a clear need for development of competent human resources in the nuclear waste management sector.

There is a sustained common view among institutional and industrial parties in Finland that 1) nuclear energy research shall be wide-ranging and safety relevance based, 2) scientific level of national research shall to be high, 3) active participation to international research and multidisciplinary collaboration is vital for national research, 4) continuous support to doctoral level education is needed, and 5) possibilities for feasible business opprotunities, and international activities should to be supported with instutional instruments or securities whenever possible. The MEAE calls and sets up in an irregular manner working groups of interested parties to consider national research and development strategies. A joint conclusion of a working group has been published e.g. in 2014 (MEAE report "Nuclear Energy Research Strategy").

Financial resources

In Finland, each licensee and responsible party is responsible for all on-going costs caused by nuclear and non-nuclear radioactive waste management including the future decommissioning of the facilities. If a licensee or a responsible party is unable to fulfil its obligations, the Finnish Government will take care the costs.

Finnish Government has prepared measures to make sure that nuclear waste management can be arranged under all circumstances. Preparations are made by collecting funds to VYR Fund. The funds are collected from the nuclear waste generators during the operating lifetime of their nuclear power plants. Thus, the society has a financial guarantee that nuclear waste management can be arranged under all circumstances.

The Nuclear Energy Act (Section 35 to 53) provides detailed regulations for the funding arrangements and provisions for nuclear waste management and the Nuclear Energy Decree (Section 86 to 98) further specifies the system for financial provisions. The financial provisions are described in greater detail in the Government Decree on Financial Provisions for the Cost of Nuclear Waste Management (991/2017).

The producers of nuclear waste are obliged to present justified estimates every three years of the future cost of managing their existing nuclear waste, including spent nuclear fuel disposal and decommissioning of nuclear facilities. The MEAE annually confirms the assessed liability and the fund target. The waste generators annually pay the difference between the fund target and the amount already existing in the Fund. The payments can also be reimbursed if the funded amount exceeds the targets. The waste generators must provide collateral securities to MEAE for the portion of assessed liability that is not yet secured by the Fund. The VYR Fund store and reliably invest the funds. The tasks of the VYR Fund are described in detail in the Government Decree on the State Nuclear Waste Management Fund (161/2004).

In 2012, the VTT, which operates the research reactor (FiR 1), decided to shut down the reactor and the planning of the decommissioning phase started. VTT is responsible for observing the same requirements for funding as described above. As the decommissioning proceeds, VTT will be reimbursed.

The current estimates, including costs from the management of existing waste quantities and from the decommissioning of current NPPs and the research reactor, amounted to about 2723 million Euros at the end of 2019. The Fund has enough assets to secure the costs of all nuclear waste management measures that still have to be carried out for the currently existing waste, if needed.

The Radiation Act (Section 54, 55) provides that responsible party must lodge a financial security to ensure that the costs of radioactive waste management and any environmental decontamination measures can be paid for. For example, a security must be lodged if the operator´s safety license is for a high-activity sealed source or several sources with total activity corresponding to a high-activity sealed source, or if the action generates or may generate radioactive waste with considerable management costs. Decision on lodging a security as well as on the amount and verification of the security are made by STUK.

Financial provisions for post-closure

One of the main principles of radioactive waste disposal is that it shall be passively safe and active measures are not needed. In principle post-closure monitoring or other similar measures are not needed from safety perspective. According to the Nuclear Energy Act (Section 32), a condition for the expiry of the obligation for waste management of a nuclear waste generator is that the waste has been permanently disposed of in an approved manner and a lump sum to the State for the further control of the waste has been paid. Thereafter, the State is responsible for the necessary waste management measures and the incurred costs.

According to the Radiation Act (Section 80), the responsible party and others who have taken part in producing or handling the radioactive materials or waste must compensate the State for the costs incurred by the measures taken to render the waste harmless and to decontaminate the environment.

Article 23 Quality assurance

Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

Regulatory requirements regarding management systems

According to Section 38 of STUK Regulation (STUK Y/4/2018), organisations participating in the design, construction, operation and decommissioning of a nuclear facility or in closing of a repository shall employ a management system for ensuring safety and the management of quality. The objective of such a management system shall be to ensure that safety is prioritized without exception, and that quality management requirements correspond to the safety significance of the activity and function. The management system shall be systematically assessed and further developed. The quality management system must cover all functions that influence to safety of a nuclear facility. Further on, licensees are required to ensure that all their suppliers, sub-suppliers and other partners participating in functions that affect nuclear and radiation safety adhere to the quality management system. Along with the management system, the STUK Regulation sets requirements for documentation of the roles and responsibilities of management and monitoring of the operations.

Guide YVL A.3 sets general requirements for management systems regarding quality and safety management. Guide YVL A.3 refers to the ISO 9000:2015 definition of quality management according to which quality management consists of quality planning, quality control, quality assurance and quality improvement. Guide YVL A.3 adheres to IAEA Safety Requirements GSR Part 2 Leadership and management for safety. Requirements for quality management of system design are established in the Guide YVL B.1. Further requirements related to specific technical areas are presented in the corresponding technical guides.

STUK also has a dedicated YVL guide concerning nuclear facility construction and modifications, i.e., Guide YVL A.5. In this guide, there are requirements on construction and modification phases in addition to requirements concerning for example project and risk management. The management systems of the licensees and applicants are subject to approval by STUK.

According to the Guide YVL A.3, any safety-significant revisions to the management system must be submitted for approval to STUK, but minor revisions are only submitted for information prior to their use. STUK has during the period 2016–2018 revised the YVL requirements concerning management systems and quality management taking into account experiences, feedback and development of quality standards (e.g. ISO 19443).

According to the Radiation Act (859/2018), organizations that need a safety license for use of radiation sources are also subject to management system requirements. The Radiation Act stipulates that these organisations need to have e.g: 1) documented management system, 2) means to verify identified personell qualifications, education and induction, 3) adequate knowledge on safety and security critical duties with defined responsibilities, 4) measures to keep and develop good safety culture measures, and 5) availablility to utilize the expertises of a radiation safety and a medical physics expert. Some further details regarding radiation safety management systems are presented in the radiation safety regulation S/6/2019.

Measures taken by license holders

Holders of nuclear and radiation safety licences are plenty. Holders do have different approaches how management systems are documented and implemented. In a broad sense, management systems are agreements how organisations are managed (strategies), developed (visions), and how organisation activities are supported (processes). Usually ISO standards have been used as guidelines with consideration of e.g. resources, quality assurance, environmental, worker healthy, safety, security, and ethical aspects. A management system needs to be fit for license holders' purpose, and STUK's interest is to verify that management system meets the nuclear and radiation safety and security needs relevant for the company. The following gives an introductory example on Posiva's management system.

Posiva's management system documentation consists of a Management Manual, Organisation Manual and other manuals, and instructions related to all these. The Management Manual presents Posiva's vision, mission and values, company policies, organisation and areas of responsibility, general operational principles, quality assurance principles for functional processes, and general descriptions of resources. The Organisation Manual comprises more detailed descriptions of the functional processes, prinsiples and responsabilities. Posiva's management System complies to the requirements of the Guide YVL A.3 and ISO 9001:2015.

The functions and responsibilities of Posiva's organisations and personnel are described in detail in the Posiva's Administrative Rules, in the Organisational Manual and in the manuals and instructions of individual organisational units.

Posiva is actively developing the management system due to preparing for operating license. Current management system is valid until the end of the construction phase. For operating license, the updated management system shall be implemented completely early enough before operations. Organizational changes at Posiva are safety evaluated by management.

The Posiva integrated Management System ensures that nuclear safety significance is recognised and considered when making decisions and determining procedures.

Posiva aims at ensuring the supply chain quality management using a document specifying the requirements set for the quality management systems of the subcontractors and by auditing suppliers and manufacturers.

Management system of the regulatory body

STUK's management system documents include safety and quality policy, description of the management system, organisation and management, roles and responsibilities, personnel policy as well as description of processes and procedures. The results of management reviews, internal audits, self-assessments and international evaluations are used as lessons learned and inputs for the continuous improvement of the management system at STUK. STUK´s management system encompasses core processes and procedures that are specified and applied for regulation and oversight of nuclear facilities. The departments within STUK organisation regulating nuclear facilities are Nuclear Reactor Regulation and Nuclear Waste and Materials Regulation.

STUK has recently developed an internal procedure and a supporting tool further to improve regulatory processes and functions based on regulatory experience gathered from various sources. These have been applied since the beginning of 2019 and the experiences seem promising. In the future, the established procedure will developed be further e.g. including practices for sharing the lessons learnt with interested parties.

In accordance with the IRRS 2015 follow-up suggestions STUK's management decided, at the end of 2018, that an in-depth evaluation of STUK's management system will be performed. After the evaluation a development plan for a management system with more integrated approach will be prepared and implemented.

In conclusion, Finnish regulations and practices comply with Article 23.

Article 24 Operational radiation protection

Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

(a) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

(b) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and

(c) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

(a) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

(b) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

Basic radiation protection requirements

The principles of justification, optimisation and dose limitation are included in the Radiation Act (859/2018) (Sections 5 to 7). Occupational dose limits and dose limits for the general public are set forth in the Government Decree on Ionising Radiation (1034/2018) (Sections 13 to 15). These limits conform to the ICRP 103 Recommendation (2007), ICRP 119 Recommendation (2012) and the Council Directive 2013/59/EURATOM. The implementation of the Council Directive 2013/59/EURATOM (replacing the Council Directive 96/29/EURATOM) in Finnish legislation was completed in 2018. The principle requirements for the safe use of nuclear energy are given in the Nuclear Energy Act (990/1987) and decree (161/1988).

According to the Government Decree on Ionising Radiation (Section 13), the effective dose from occupational exposure must not exceed 20 mSv per year. Medical surveillance of employees of NPPs and other working places, where employees are engaged in radiation work, is performed following the Radiation Act and subsequent legislation implementing the related provisions of the Council Directive 2013/59/EURATOM.

The Radiation Act (Section 10) states that for radiation practices and radiation sources in generally used the detailed regulations on the dose constraints and potential exposure restrictions and their use, as well as on demonstration of the justification and the optimization of radiation protection shall be issued by STUK. According to the Government Decree on Ionising Radiation (Section 14), the limit for the general public is 1 mSv/a. There are individual cases that dose constraints are set lower than the maximum values, if such constraints are needed to take account of the radiation exposure originating from different sources and to keep the exposure as low as reasonably achievable. In addition, Nuclear Energy Decree (Sections 22 b and 22 d) sets annual dose constraints for the member of the public of nuclear power plants and facilities.

Dose limits

The maximum values for radiation exposure caused to the population in the vicinity of a NPP and a nuclear waste facility, including spent fuel storage, spent fuel encapsulation, operation of the disposal facility, anticipated operational occurrences or accidents, as well the maximum values of long-term radiation exposure caused by the disposal of nuclear waste are given in the Nuclear Energy Decree (161/1988). The annual dose of the most exposed individual among the population arising from the normal operation of a nuclear waste facility must be insignificantly low (more specific in the guides YVL D.4 and YVL D.5). According to Section 22 d of the Nuclear Energy Decree, the normal operation of a waste facility and the decommissioning of a waste facility shall be so designed that the annual dose for the member of the public may not exceed the 0.01 mSv constraint. The annual dose limit from the normal operation of an NPP is higher and that is 0.1 mSv. Other annual dose limits for anticipated operational occurrences and accidents are the same for both NPPs and nuclear waste facilities. The limit for an anticipated operation occurrence is 0.1 mSv, while the limit for a Class 1 postulated accident is 1 mSv, and the limit for a Class 2 postulated accident is 5 mSv and the limit for a design extension condition is 20 mSv per year. The dose limits are defined for the entire nuclear facility, including all nuclear facilities on the site.

The STUK Regulation (STUK Y/4/2018) provides more specific requirements for the disposal of spent nuclear fuel and facilities for handling and storage of spent nuclear fuel and other nuclear waste that are not part of a nuclear power plant. For example, the amount of spent nuclear fuel stored at any one time at a nuclear waste facility intended for the handling of spent nuclear fuel must be limited in a manner that involves no extensive measures to protect the public or which would impose long-term restrictions on the use of extensive land and water areas as a result of an accident situation.

STUK has issued several YVL Guides dealing with radiation protection regarding the design and operation of NPPs (Guides YVL C.1, C.2, C.3, D.3 and D.4). These also cover spent fuel storage, on-site waste management facilities and other nuclear waste facilities, including the operational period of disposal facilities for both LILW and spent fuel. The Guides define the level of safety required and form the basis for the regulatory review of the license application as well as for review and inspection during commissioning and operation.

Nuclear facilities must have a written programme (the ALARA action programme) to keep doses low. Based on the principle of continuous development, the programme must include both short-term and long-term plans and measures to limit the doses of occupationally exposed workers. From the overall viewpoint of radiation protection, the action programme must take into account the facility's operation, water chemistry, plant modifications, materials, decontamination, waste management, testing and inspections etc. The programme must include target limits for the highest individual annual and collective dose (for an NPP: manSv/GW net electric power) that must not be exceeded, and this limit must be continuously developed. The ALARA action programme must be kept up-to-date and submitted to STUK for information.

A licensee of a nuclear facility must present an analysis of the radioactive releases and radiation exposure to the population arising from the normal operation and from anticipated operational occurrences of the plant and for potential accidents. The reports must also demonstrate that the radiation exposure arising from the operation of the plant is as low as reasonably achievable (ALARA) and that radioactive releases to the environment are limited by employing the best available techniques (BAT).

In the YVL Guides, reporting requirements concerning exceptional situations including exceptional releases are given. Release rate limits are also given in the Guides, ensuring actions to be taken already before a release limit is reached. The Guides also stipulates requirements concerning the monitoring of release pathways and monitoring the environment of a nuclear facility.

Operational experiences

Experience gained from the operation of Finnish nuclear facilities shows that the dose constraints have not been exceeded, and that the ALARA principle has been followed. The results of environmental radiological monitoring programmes show that the amount of radioactive materials in the environment at the NPP sites, originating from the Finnish nuclear facilities, has been very low. The calculated radiation exposures to a representative person in the environment at the NPPs are currently less than one per cent of the dose constraint (Figure 12). The new NPP unit, OL3, will have advanced liquid and gaseous effluent treatment systems and it is expected that the discharges from the entire Olkiluoto NPP will remain at the current low level after the commissioning of the new unit. It should also be noted that the dose constraints and actual doses discussed above apply to the entire operation of the NPP and the contributions due to long-term spent fuel storage and waste management are insignificant fractions of the total exposure: the occupational collective doses resulting from waste management, decontamination and spent fuel management activities at the both NPPs maximum some hundredths of manSv per year.

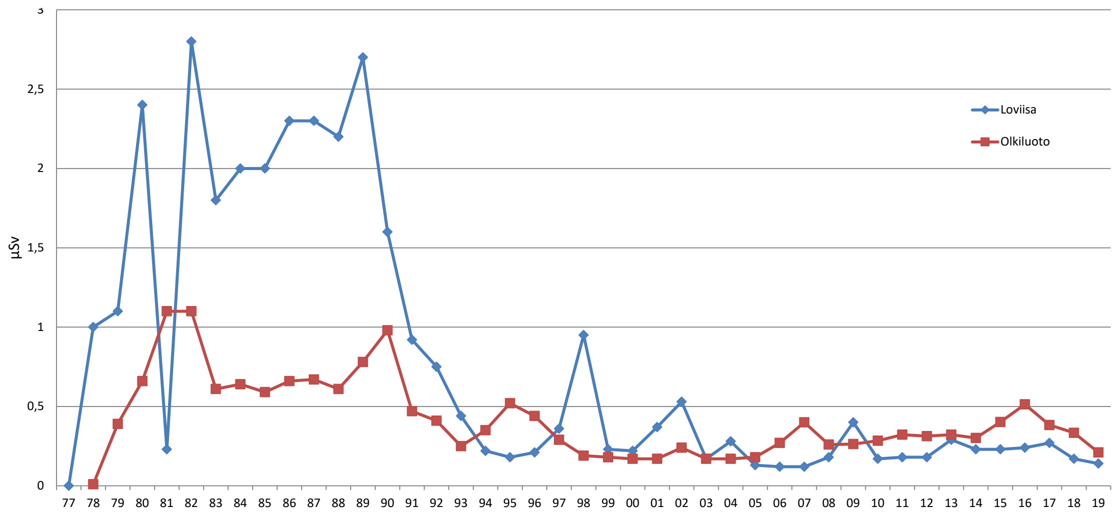


FIGURE 12. Committed doses (mSv/a) to a representative person in the vicinity of Finnish NPPs due to annual discharges of radioactive substances. The constraint for the annual dose is 0.1 mSv/a.

Article 25 Emergency preparedness

Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.

Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

On-site emergency preparedness

The emergency preparedness plans for spent nuclear fuel storages and existing radioactive waste management facilities are included in the plans and arrangement for NPPs. The preliminary plans for emergency preparedness for disposal facilities for spent nuclear fuel were presented as part of Posiva's construction license application as required by the Nuclear Energy Decree (Section 35). In the preliminary emergency plan Posiva has described the planning of emergency arrangements, preparedness and actions in emergency situations and so on. STUK has approved Posiva's preliminary emergency plan in April 2014. According to the Nuclear Energy Act (Section 20), adequate on-site emergency preparedness arrangements are required before starting the operation of a nuclear facility. The basic regulations for on-site emergency preparedness for nuclear installations are given in STUK's Regulation on Emergency Arrangements at Nuclear Power Plants (STUK Y/2/2018) and the detailed requirements by STUK in Guide YVL C.5. The regulation (STUK Y/2/2018) and YVL Guide C.5 also apply to other nuclear facilities and transportations as required by the danger they pose.

The licensee is responsible for the on-site emergency response arrangements. STUK's Regulation states e.g. that emergency planning must be based on an analysis of a nuclear facility's behavior in emergencies and on the analysis of the consequences of emergencies. Action in an emergency must be planned to take into account the controllability of events as well as the severity of their consequences. Therefore, emergencies are classified and described briefly in the emergency plan of a nuclear facility. In the Regulation (STUK Y/2/2018), the design basis for emergency planning is a simultaneous accident at the site's nuclear facilities and the Regulation also requires that appropriate training and exercises are arranged to maintain operational preparedness. Training exercises must be arranged in co-operation with the authorities concerned.

Emergency training and exercises are arranged annually for the emergency response organization of the nuclear facilities. The emergency training includes classroom and group-specific practical training, as well as special training, such as first aid, fire and radiation protection training. In addition to severe accidents, emergencies covered by the emergency response exercises must also include conditions classified as alerts. The content and scope of the training as well as feedback obtained from the training are assessed in the inspections of the STUK's periodic inspection programme.

On-site emergency exercises are conducted at the NPPs annually so that at least the licensee personnel, local off-site emergency management group and STUK participate in them. There are always observers from STUK and several other organizations to assess the performance of the exercising teams. The scenarios have varied from severe reactor accidents to alert-status events, which involve alerting the nuclear power plant emergency organization to the extent necessary to ensure the safety level of the plant. Additionally, exercises for other situations, such as security-related incidents are regularly conducted. STUK verifies the preparedness of the organizations operating nuclear power plants in yearly on-site inspections, as well as by supervising the licensee's emergency training and exercises. Emergency preparedness at the Loviisa and Olkiluoto power plants meet the regulatory requirements. Posiva must deliver the emergency plan in its operating license application, and during the commissioning of Posiva's nuclear waste facilities the emergency arrangements must comply with the emergency plan. Furthermore, an emergency exercise must take place before spent fuel is transferred or transported into the site area of the encapsulation plant.

Concerning the small users of radiation sources, the Radiation Act (Section 130) stipulates that STUK has to be notified immediately in case of any abnormal occurrence connected to the use of radiation and substantially detrimental to safety at the place where the radiation is used or in its environment. In addition, STUK shall be promptly informed of the disappearance, unauthorized use and possession of a radiation source requiring a safety license.

Off-site emergency preparedness

In addition to the on-site emergency plans established by the licensees, off-site emergency plans required by the rescue legislation (379/2011) are prepared by the regional authorities. The requirements for off-site plans and activities in a radiation emergency are provided in the Decree of the Ministry of Interior (612/2015). STUK acts as an expert body who supports and provides recommendations to authorities responsible for making decisions and implementing protective actions in case of nuclear or radiological emergency.

STUK publishes VAL Guides for emergency responses. The recent Guide update (2020) VAL 1 "Protective Measures in a Nuclear or Radiological Emergency" has been accepted for usage and it provides detailed guidance. In the case of an accident the local authorities are alerted by the operating organization of the plant.

The Ministry of Interior has published a guide “Nuclear or Radiological Emergencies” (MI publication 10/2016), which contains detailed information on the arrangements in Finnish society in the case of a nuclear or radiological emergency.

STUK has an Emergency Preparedness Manual for its own activities in case of a nuclear or radiological emergency. STUK has an expert on duty on a 24/7 basis. Notifications of an exceptional event (alarm) may be received from the operating organisations of the facilities, or from the automatic radiation monitoring network that covers the whole country (approx. 250 measuring stations), or from foreign authorities.

The off-site emergency plans include provisions to inform the population in the case of an accident. Written instructions on radiological emergencies, emergency planning and response arrangements have been provided to the population living within a 20 km Emergency Planning Zone. These instructions are regularly updated and distributed.

The regulations and guides are tested in full-scale off-site emergency exercises conducted every third year at both operating Finnish NPPs with the participation of all organizations with a role in the emergency response. In addition, the NPPs run smaller-scale exercises with the Rescue Service and STUK at least once every year.

The rescue planning is enhanced by the co-operation between the nuclear power plant, regional rescue services, regional police departments and STUK. There are permanent coordination groups for both Loviisa and Olkiluoto NPPs to ensure coordinated and consistent emergency plans, as well as to improve and develop emergency planning and arrangements and to share lessons from the exercises, regulations and other information. Furthermore, extensive training is arranged by these groups.

Early notification and communication

The on-site and off-site plans include provisions to inform the population in case of an accident. In addition, written information on radiation emergencies, emergency planning and response arrangements have been provided to the population. Such information can also be found on the internet pages of regional rescue services. Citizens living near nuclear facilities are regularly provided with more detailed written information on nuclear accidents and protective measures needed during emergencies.

STUK is the National Warning Point and the National Competent Authority in Finland for any kind of situation which might result in actual or potential deterioration of radiation safety of the population, environment or society. STUK is able to give advice to local, regional and governmental authorities on any required emergency response actions 24 hours a day.

Finland is a Contracting Party to the International Convention on Early Notification of a Nuclear Accident, as well as to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, both signed in Vienna in 1986. Furthermore, as a Member State of the European Union, the Council Directives and Regulations and Decisions concerning accident situations apply in Finland. In addition, Finland has respective bilateral agreements with Denmark, Germany, Norway, Russia, Sweden and Ukraine. Accordingly, arrangements have been agreed on to directly inform the competent authorities of these countries in the case of an accident. Similar arrangements ensure direct notification to the authorities of Estonia. The bilateral agreements also cover the exchange of relevant information on nuclear facilities.

The Nordic countries have published two joint documents that detail the co-operation arrangements in case of a radiological emergency. The Nordic Manual (updated 2015) describes practical arrangements regarding communication and information exchange to fulfil the stated obligations in bilateral agreements between the Nordic countries. The arrangements described in this document include all phases of events, including intermediate and recovery phases. The second document, the Nordic Flag Book (published 2014), describes joint guidelines, including operational intervention levels, for protective measures concerning the population and functions of society in case of nuclear or radiological emergencies. These guidelines agreed by radiation and nuclear safety authorities in Denmark, Iceland, Finland, Norway and Sweden form a unique document as it includes harmonised and practical criteria for early protective measures, as well as recovery actions after contamination. The Nordic Manual and Nordic Flag Book ensure that the response to any nuclear or radiological emergency in the Nordic countries is harmonised and consistent between the countries.

In addition to the domestic nuclear emergency exercises held annually on each nuclear power plant sites, STUK has taken part in international emergency exercises. STUK has also participated as a co-player in emergency exercises arranged by the Swedish and Russian nuclear power plant operators and authorities. Neighbouring countries have been actively invited to take part in the Finnish exercises.

Article 26 Decommissioning

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that:

(a) qualified staff and adequate financial resources are available;

(b) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;

(c) the provisions of Article 25 with respect to emergency preparedness are applied; and

(d) records of information important to decommissioning are kept.

Regulatory requirements

The Nuclear Energy Act (Section 7 g) states that the design of a nuclear facility must provide for the facility's decommissioning and that the related decommissioning plan should be presented. The decommissioning plan for a nuclear facility must be sent to STUK for approval as part of construction, operating and decommissioning license application for the facility (Sections 35, 36 and 36 a in the Nuclear Energy Decree). During operation, the licensee is obligated to prepare decommissioning plans for regulatory review every six years (Section 7 g in the Nuclear Energy Act). These plans aim at ensuring that decommissioning can be appropriately performed when needed and estimates for decommissioning costs are provided. According to the Nuclear Energy Act (Section 7 g), when the operation of a nuclear facility has been terminated, the facility must be decommissioned in accordance with a plan approved by

STUK. The dismantling of the facility and other measures taken for the decommissioning of the facility may not be postponed without due cause.

Guide YVL D.4 includes specific requirements for decommissioning. It requires that provision for the decommissioning of the nuclear facilities must already be made during the design phase. During the design phase, the license applicant must establish the decommissioning strategy. This strategy must be regularly evaluated and if necessary, updated during the operation of the facility. The limitation of radioactive waste generation and of the radiation exposure of workers and the environment arising from decommissioning must be considered.

The licensees are responsible for the implementation and costs of decommissioning. As described in Section F, Article 22, assets are collected in the VYR Fund. The State has the secondary responsibility in case the licensee is incapable of implementing its responsibilities. In this case the costs are secured by assets collected in the Fund and by the securities provided by the licensees.

Also, in the case of using radioactive sources subject to the Radiation Act, the licensee is responsible for decommissioning. The licensee must provide evidence that all disused sources have been transferred from the site appropriately, and, where appropriate, that there is no remaining contamination. Sections 54 and 55 of the Radiation Act prescribe practices subject to a financial provision in the licensing phase to ensure the availability of sufficient funds to secure the decommissioning costs.

Decommissioning plans

The four nuclear power plant units in Finland have been in operation for 37 to 41 years at the end of 2019. These units are planned to operate up to an overall operation period of 50 (LO1 and LO2) and 60 years (OL1 and OL2). The first Loviisa NPP unit has an effective operating license until 2027 (LO1). If FPH will not apply a license for extended operation, then the first commercial NPP decommissioning project is about to start at the end of this decade.

The most recent update of the NPP decommissioning plan made by FPH was issued at the end of 2018. The next revision of the decommissioning plan for the OL1 and OL2 will be sent for review by the end of 2020. The decommissioning plan for OL3 was submitted to STUK as a part of the operation license application of the plant in 2016. Fennovoima has also submitted the preliminary decommissioning plan for STUK's approval as part of a construction license application of Hanhikivi 1 unit in 2015. Decommissioning plans for OL3 and Hanhikivi 1 are approved by STUK as part of the licencing processes. The decommissioning plan of FiR 1 research reactor was approved by STUK as part of the decommissioning license application review in 2018.

The decommissioning plans include assessments of the occupational and off-site radiological safety of the operations. The plans include detailed descriptions of the required dismantling and waste management operations, including estimates of the workforce and other resources needed. The plans are based on the actual designs of the facilities and take into account the facility activity inventories. The contamination levels in the facilities are followed by means of specific monitoring and recording programmes.

The first nuclear facility decommissioning project in Finland is the decommissioning of VTT's research reactor FiR 1. The research reactor went in extended shutdown stage in June 2015. The EIA process for decommissioning was conducted in 2013–2015. VTT submitted the license application for the decommissioning in June 2017. STUK gave its statement of the license application to the MEAE in spring 2019. STUK's safety assessment was finalised at the same time. The main conclusion was that the license for the decommissioning can be granted and detailed safety requirements can be fulfilled, but there are issues that needs to be solved until the actual dismantling of the research reactor can start:

- The plans for the decommissioning phase are still partly unfinished and the fulfilment of the detailed safety requirements shall be evaluated before the dismantling works can be started. VTT shall provide the finalised FSAR with detailed decommissioning plans for approval to STUK. The actual dismantling works cannot be started until STUK has approved the FSAR.
- The current plan for managing radioactive waste is not detailed enough to ensure safe and smooth handling, storage and disposal of radioactive wastes. The overall evaluation of the radioactive waste management plans is on the responsibility of the MEAE. STUK has proposed for setting up a license condition for the waste management planning to ensure the adequate development of the waste management solutions for the decommissioning phase.

Currently the license application for the decommissioning of FiR 1 research reactor is waiting for approval from the Government. The license application process was interrupted due to unresolved issues on VTT's nuclear waste management plans. VTT initiated a two-phase procurement procedure for dismantling works and nuclear waste management solution in spring 2019. The contract was signed with FPH at the end of March 2020. In addition to planning and implementing of dismantling works, the contract contains the handling, storage and disposal of the radioactive waste at the Loviisa NPP site both from the operation and dismantling of the FiR 1 reseach reactor and VTT's old hot cell laboratory. It also contains an option to store the spent fuel at the Loviisa NPP site until it can be shipped back to USA according to the existing return programme (see more details Section D, Article 32). As the unclear issues related to nuclear waste management are now resolved, the license application process for decommissioning of FiR 1 can continue at the government level. According to the current estimate, the Goverment handling of the license application for decommissioning could be possible in autumn 2020.

SECTION G
Safety of Spent Fuel Management

Article 4 General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management individuals, society and the environment are adequately protected against radiological hazards. In so doing, each Contracting Party shall take the appropriate steps to:

(a) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

(b) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

(c) take into account interdependencies among the different steps in spent fuel management;

(d) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(e) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

(f) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

(g) aim to avoid imposing undue burdens on future generations.

Scope and principal regulations

Finland has adopted the once-through strategy for spent nuclear fuel management as described in Section B. Spent fuel is currently stored at the NPPs' spent fuel interim storage facilities and at the FiR 1 research reactor. The discussion in this Section is limited to the interim storage of spent fuel whereas the encapsulation and disposal plans for spent fuel are discussed in Section H, Safety of radioactive waste management.

The general regulations for the safety of spent fuel storage are included in the STUK Regulation (STUK Y/1/2018). More specific technical requirements are given in YVL Guides such as YVL D.3.

Criticality and removal of residual heat

According to the STUK Regulation (STUK Y/1/2018), the handling and storage of spent nuclear fuel, maintenance of subcritical conditions, integrity of fuel cladding, adequate heat removal and radiation shielding shall be ensured with a high degree of certainty. The Nuclear Energy Act, Guides YVL A.1 and YVL D.3 require that NPPs shall have enough space and adequate systems for the safe handling, treatment, storage and inspection of fresh and spent fuel.

Sub-criticality requirements are given in Guide YVL B.4. Sub-criticality of the spent fuel during interim storage must be ensured primarily through structural design solutions. The requirements concerning handling and storing spent fuel are given in Guide YVL D.3. Fuel damage in fuel storages and in fuel transfers are to be minimized by design solutions.

Spent fuel cooling shall satisfy the single failure criterion. This requirement is given in Guide YVL B.1.

At the Loviisa NPP site, the latest enlargement of the storage facility was commissioned in 2001. The installation of high-density fuel racks was started in 2007, and it will continue in the future according to necessity. The total allowable amount of spent fuel, according to the renewed operating license issued in 2007, is 1100 tU and the storage capacity with additional high-density racks will be adequate until the end of the planned 50 years of operational life.

At the Olkiluoto NPP site, after cooling in pools within the reactor buildings, the spent fuel is transferred to an on-site facility, commissioned in 1987, with an initial capacity of about 1200 tU. The enlargement of interim spent fuel storage was started in 2009 and finalized in 2015. The extension of the storage capacity included the construction of three new storage pools considering also the commissioning of OL3. The capacity of the interim spent fuel storage after this extension is 1800 tU. The extension has been included as part of the OL1 and OL2 operating license and was authorized as a plant modification. The safety of the spent fuel storage sites (both at Loviisa and at Olkiluoto) was analysed as part of the EU stress tests in relation to the Fukushima Dai-ichi accident.

The sub-criticality of the spent fuel in existing interim storage facility pools in Olkiluoto and Loviisa is ensured through the structural design of the racks and by choosing the boron containing rack material. In the Olkiluoto spent fuel storage, ion exchanged water is used in the pools, while the Loviisa spent fuel storage has boron containing cooling water in storage pools.

The cooling of the spent fuel in the storage pools is implemented with cooling water systems. Both spent fuel storages have two redundant cooling water circuits. If the cooling circuits are disabled in accidental conditions, cooling water can be fed from other sources to maintain the water level in the storage pools. At Loviisa NPP small cooling towers, which can be used for decay heat removal in case of loss of sea water cooling, can also be used for heat removal from the interim spent fuel storage pools, if the heat sink used in normal condition conditions is lost (see also Articles 5 and 7).

Waste minimization

Minimizing the amount of nuclear waste arising in spent fuel storage is related to minimizing the corrosion of the fuel assemblies and storage equipment and limiting the leakage from damaged fuel bundles. The requirements concerning these issues are stated in Guide YVL D.3. The coolant of spent fuel pools shall be kept clear and clean to facilitate the fuel identification.

The operating Finnish NPPs have performed measures to minimize the radioactive waste produced in spent fuel storage. In the Olkiluoto NPP, leaking fuel assemblies are closed in hermetically sealed capsules to minimize the Cs activity in the fuel pool cooling water clean-up system.

In Loviisa NPP, leaking fuel assemblies are stored in spent fuel pools without specified capsules. Pool water samples are taken regularly and no significant activity originating from leaking fuel rods has been identified. In Loviisa, the cobalt content of the shielding elements has been decreased to minimize the amount of activation products in the cooling water and in the decommissioning waste.

Interdependencies

The Finnish once-through spent fuel management strategy provides that the spent fuel is stored in interim storage facilities and is then planned to be disposed of in deep bedrock. The spent fuel of TVO and FPH is planned to be disposed in Olkiluoto, in vicinity of the TVO interim storage. The disposal plans, including spent fuel transfer and transport, encapsulation and disposal, have been adapted to all the fuel types in use in Olkiluoto reactor units 1 to 3 and in Loviisa units 1 and 2.

Posiva, the implementing organization for the spent fuel disposal of TVO and FPH, is co-owned as a joint company by these NPP utilities. Even though Posiva is the implementer of the final disposal, the waste management obligations remain with the NPP utilities. NPP utilities make sure that the interdepencies between the different steps in spent fuel management are considered in their waste management plans. Fennovoima Oy is responsible for the disposal of its own future spent fuel. Fennovoima started the EIA process for its own disposal site in June 2016 as required as a condition of the DiP. The choice of a site for the disposal of spent fuel will become relevant later, approximately in the 2040's.

Protection of individuals, the society and the environment

The operational radiation protection requirements for spent fuel storage are discussed in Article 24. The operating experience, as discussed in Article 9, indicate that spent fuel storage has led to practically no releases and occupational radiation exposures have been very low.

Biological, chemical and other hazards

The biological, chemical and other non-radiological hazards posed by the spent fuel storage are comparable with conventional industry hazards. Such hazards are regulated by legislation related to general occupational safety and to the management of hazardous substances.

Protection of future generations and avoidance of undue burdens on future generations

The interim storage of spent fuel is envisaged to last several decades. The current high level of safety can be maintained during that time by means of appropriate operational, maintenance and surveillance procedures. The nuclear power plant licensee is responsible for the storage safety, operations and costs. The assets collected in the VYR Fund secure the future costs of storage in case the licensee is no more able to take care of its responsibilities. Thus, the future generations are adequately protected, and any other undue burdens will not be imposed on them.

Article 5 Existing facilities

Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.

Safety reviews

The latest comprehensive safety assessments of the Loviisa and the Olkiluoto NPPs, including the spent fuel storages, have been carried out recently. For the Loviisa NPP it was performed in connection with the periodic safety review in 2014–2016 and for the Olkiluoto NPP in 2017–2018. The periodic safety review for the Olkiluoto NPP was carried out in connection with the renewal of operating licences for the Olkiluoto NPP reactor units.

In 2015, STUK finalised the safety assessment of the enlargement of the spent fuel storage facility at Olkiluoto and approved TVO's application to increase the capacity of the spent fuel storage facility (see Article 4).

Following the accident at the Fukushima Dai-ichi nuclear power plant, national safety assessments as well as EU level stress tests were initiated in Finland in 2011 and 2012. The safety of spent fuel storage facilities was assessed as part of NPP safety assessments. STUK has reviewed the results and made licensee specific decisions in July 2012. Based on the results, it was concluded that no such hazards or deficiencies were found that would have required immediate action in Finnish NPPs. However, areas where safety can be further enhanced were identified (e.g. decreasing the dependency on the plant's normal electricity supply and distribution systems, as well as on sea water cooled systems for residual heat removal of the reactor, containment and spent fuel storage pools, protection against external flooding, seismic resistance of spent fuel pools and fire-fighting systems). There were plans on how to address these areas and most of the improvements have already been implemented by the end of 2019. As an example, Loviisa NPP has completed modifications to ensure long-term decay heat removal in case of the loss of seawater by implementing an alternative ultimate heat sink, two air-cooled cooling units. Additionally, the availability of extra feed water into the storage pools has been improved. TVO has improved the seismic resistance of the fire water systems, improved the storage pool water level and temperature systems, and provided additional feed water sources into the spent fuel pools.

The comprehensive safety assessments for applications for the renewal of licences include updating the following safety relevant documents (among others):

- Final safety analysis reports (FSARs)
- Quality assurance programmes for operation
- Technical specifications
- Programmes for periodic inspections
- Plans for nuclear waste management, including decommissioning and disposal
- Timetables for nuclear waste management and estimated costs
- Plans for physical security and emergency preparedness
- Administrative rules for the facilities
- Programmes for radiation monitoring in the environment of the facilities

- Licensee assessments of compliance with the regulations, including assessment of the fulfilment of YVL Guides' requirements
- Licensee assessments of how an adequate safety level has been maintained

The periodic safety review report must include the same above listed updated information, as appropriate.

The re-licensing safety reviews and statements of STUK given to the MEAE concluded, regarding radiation and nuclear safety, that the conditions at the Loviisa and the Olkiluoto NPPs comply with the national nuclear energy legislation and regulations. In addition to the review of the above-mentioned documents, STUK has also made independent safety assessments and has annually performed several regular and topical inspections of the facilities.

Need for safety enhancement

The continuous safety assessment and enhancement approach applied in Finland is based on the Nuclear Energy Act (Section 7 a) stating that the safety of the use of nuclear energy shall be as high as reasonably achievable. To further enhance safety, all actions justified by operational experience, safety research and the progress in science and technology shall be taken.

Safety improvements have been annually implemented at the Loviisa and Olkiluoto NPPs including the facilities for spent nuclear fuel handling and interim storage since the commissioning of the reactor units. At the Olkiluoto spent fuel storage facility, recent safety improvements have been carried out in connection with the enlargement of the spent fuel storage facility. There exists no urgent need for additional improvements to upgrade the safety of these storage facilities. The recent safety improvements were implemented as a result of safety assessment due to the Fukushima-Daichi accident and the EU stress test mention earlier in this article under the title "Safety reviews".

Article 6 Siting of proposed facilities

Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:

(a) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;

(b) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

(c) to make information on the safety of such a facility available to members of the public;

(d) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

Siting process and site-related factors

The spent fuel management facilities are nuclear facilities, either as an integrated part of a nuclear power plant or as separate facilities. All the present spent fuel management facilities in Finland are located on the NPP sites. According to the Nuclear Energy Act and the Nuclear Energy Decree the application for a Decision-in-Principle shall include (among other things):

- An outline of the ownership and occupation of the site
- A description of settlement and other activities and town planning arrangements at the site and in its vicinity
- An evaluation of the suitability of the site and the restrictions caused by the planned nuclear facility on the use of surrounding areas
- An assessment report in accordance with the Act on the Environmental Impact Assessment Procedure (252/2017), as well as a description of the design criteria the applicant will observe in order to avoid environmental damage and to restrict the burden to the environment. More detailed requirements on the Environmental Impact Assessment are provided in the Decree (277/2017) on the Environmental Impact Assessment Procedure.

In the design of a nuclear power plant, including spent fuel management facilities on site, site-related external events shall be considered. The STUK Regulation (STUK Y/1/2018) provides as follows: *"The impact of local conditions on safety and on the implementation of the security and emergency arrangements shall be considered when selecting the site of a nuclear facility. The site shall be such that the impediments and threats posed by the plant to its surroundings remain extremely small and heat removal from the plant to the environment can be reliably implemented.*" In addition, Guide YVL A.2, "Site for nuclear facility", generally describes all the requirements concerning the site and surroundings of a nuclear facility. It also provides requirements on safety factors affecting the site selection and covers regulatory control. Specific provisions against earthquakes are provided in Guide YVL B.7.

Deterministic analyses are made to assess the impact of various natural phenomena and other external events. A probabilistic risk analysis (PRA) is required as part of the safety review for construction and operating licences. The PRA also and provides information on the estimated frequency of releases of radioactive substances and radiation exposures brought about by internal and external events. The requirements of the PRA are given in Guide YVL A.7, "Probabilistic risk assessment and risk management of a nuclear power plant". Restrictions for the type and amount of human activity in the vicinity of the nuclear facility site are described in Guide YVL A.2.

Assessment of new nuclear power plants and candidate sites

The DiP for Fennovoima NPP was originally ratified by the Parliament in 2010. In 2015, Fennovoima Oy changed its NPP plans and applied construction license for the AES-2006 type power plant. Since then the license application has been supplemented with several data and documentation deliveries. These deliveries have also complemented the site related documentation of Pyhäjoki, Hanhikivi. They are being evaluated and reviewed in connection with the construction license procedure. Deliveries have been reviewed by STUK and other expert organizations in their respective fields. In addition to the Finnish regulations, IAEA

Safety Requirements and Safety Guides, and WENRA requirements were considered in the review.

Safety impact

The safety impacts of a spent fuel management facility are analysed either in the safety analysis reports presented as part of the construction or in the operating license applications of NPPs regarding spent fuel storage. The operating licences for nuclear facilities are granted for a limited period. For the license renewal and the Periodic Safety Review, a comprehensive re-assessment of safety, including the environmental safety of the nuclear facility and the effects of external events on the safety of the facility, shall be performed. STUK reviews the license applications, including all site-specific safety reports.

Availability of information

The availability of information related to the siting process for a major nuclear facility is based on Finnish legislation on the openness of information, notably the Act on the Openness of Government Activities (621/1999). Further requirements are based on the Act and Decree on the Environmental Impact Assessment Procedure and the Nuclear Energy Act. The first step of consultation with the general public is the EIA procedure. Public hearings are arranged both in the programme phase of the EIA and during the actual impact assessment. The responsible contact authority for that procedure is the MEAE. The EIA report and the statement of the MEAE must be attached to the application for the Decision-in Principle.

The Nuclear Energy Act (Section 13) states that, before the DiP is made, the applicant shall make an overall description of the facility, the environmental effects it is expected to have and of its safety available to the public. The MEAE shall provide a chance for residents and municipalities in the immediate vicinity of the nuclear facility, as well as local authorities, to present their opinions in writing before the DiP is made. Furthermore, the Ministry shall arrange a public hearing in the municipality where the planned site of the facility is located and during this hearing the public must have the opportunity to give their opinions either orally or in writing. The presented opinions shall be made known to the Government. The Act (Section 14) further provides that a prerequisite for the DiP is that the planned host municipality for the nuclear facility is in favour of siting the facility in that municipality.

Consulting of contracting parties

Finland is a party to the Convention on Environmental Impact Assessment in a Transboundary Context, signed in Espoo in 1991. The Finnish policy is (Act 252/2017) to provide full participation to all neighbouring countries which may be affected by the nuclear facilities in question.

During 2017–2019 no Environmental Impact Assessments have been done in Finland. In 2018, MEAE made an individual case decision that the continuation of operating licenses of two Olkiluoto rector units did not require an EIA process and Sweden was informed on this. Fennovoima submitted the EIA report concerning Hanhikivi NPP to MEAE in February 2014 and later same year MEAE gave a statement about it. The statement on the Fennovoima spent fuel disposal EIA program was given by MEAE in December 2016. In the assessment procedure with respect to cross-border environmental impact, based on the Espoo Convention, the Ministry of the Environment notified the authorities of Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia, Russia and Austria about the EIA Programme. Austria, Sweden, Denmark, Norway, Germany, Estonia, Latvia, Russia and Poland participated in the international hearing on the EIA programme. Lithuania did not participate at this stage, but they requested to be involved in the EIA reporting and the construction licensing stages.

In June 2016 Fennovoima submitted an EIA programme concerning the disposal of spent nuclear fuel to the MEAE. The hearing process was conducted by the MEAE in autumn 2016 in Finland and abroad according to the Espoo Convention. The MEAE's statement was submitted to Fennovoima in December 2016. According to programme, the EIA outcome report will be scheduled so that the selection of spent fuel disposal site will be possible during 2040s.

Article 7 Design and construction of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(b) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;

(c) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

Regulatory requirements

According to the Nuclear Energy Act (Section 19) the prerequisite for granting a construction license is that the location of a nuclear facility is appropriate with respect to the safety of the planned operations and that environmental protection has been considered appropriately. The site related prerequisite for granting an operating license (Section 20) is that the environmental protection has been considered appropriately. The Nuclear Energy Decree (Section 32) requires that the construction license application shall include a description of the effects of the nuclear facility on the environment and a description of the design criteria that will be observed by the applicant in order to avoid environmental damage and to restrict the burden on the environment. In operating license application (Section 34) there should be a description of the measures to restrict the burden caused by the nuclear facility on the environment.

The guiding requirements for spent nuclear fuel storage design and construction are described in the STUK Regulation (STUK Y/1/2018) on the Safety of Nuclear Power Plants. More detailed requirements for the design and construction of nuclear facilities are given in the Guides YVL A.2, YVL A.5, YVL B.1, YVL B.3 and YVL D.3. The general design of the nuclear facility and the technology used are first assessed by STUK for when reviewing the application for a DiP and performing a preliminary safety assessment of the facility. More detailed safety assessments are carried out by STUK when reviewing applications for construction licences and for the operating license, as well as in connection with possible plant modifications. In the operating license renewals and in the periodic safety reviews the facility design is reassessed against safety requirements and advancements in science and technology.

The limitation of radiological impact is discussed in Section F in the context of Article 24.

Provisions for decommissioning

The Nuclear Energy Act (Section 7 g) states that provisions for decommissioning shall be included in the design of a nuclear facility. In the context of the licensing requirements, the STUK Regulation (STUK Y/1/2018) states that the design of an NPP shall consider decommissioning to limit waste volumes and radiation exposure both to workers and to the environment. The Nuclear Energy Decree (Section 32) requires that the application for a construction license must include a description of the applicant's plans and available methods for arranging nuclear waste management, including the decommissioning of the nuclear facility and the disposal of nuclear waste, and a description of the timetable for nuclear waste management and its estimated costs. More detailed requirements are given in Guides YVL A.1 and YVL D.4. The requirements regarding decommissioning plans are discussed in Section F.

Proven technology

The requirement to use high quality, carefully examined and well-tested technologies that are proven by experience are stated in the design requirements provided in the STUK Regulation (STUK Y/1/2018). Detailed requirements on the design of spent fuel handling systems are given in Guides YVL B.1, YVL D.3 and YVL E.11. Spent fuel storage at the Finnish NPPs is based on water pool technology, for which extensive experience exists worldwide.

Implementation during the review period

An assessment of the design of the facility and related technologies is made by STUK for the first time when assessing the application for a Decision-in Principle. Later on, the evaluation is continued, when the Construction License application is reviewed. Finally, a detailed evaluation of systems, structures and components is carried out through the design approval process during construction or facility modification phase.

The design of the Olkiluoto spent fuel storage facility and its extension was reviewed by STUK when assessing the construction of the extension part of the storage facility. The review included a preliminary safety analysis report and other safety related documents. Protection against an airplane crash was included in the design of the extension and it was also been improved for the existing part of the facility. Additionally, the cooling water systems for the spent fuel pools were improved to enable to feed water from outside the facility. The monitoring of the storage pool water level and temperature were improved to consider earthquake resistance and loss of the facility power supply to address lessons learned from the Fukushima Dai-ichi accident. The enlargement of the spent fuel storage facility at Olkiluoto was completed when STUK finalised the safety assessment on commissioning the extension and approved TVO's application to increase the capacity of the spent fuel storage facility in summer 2015. The final review included a Final Safety Analysis Report and the other safety related documents.

Additionally, the Loviisa spent fuel storage facility has been improved since the Fukushima Dai-ichi accident. The main changes were aimed at reducing the dependency on the plant's normal electricity supply and distribution system, as well as on the seawater cooled systems for residual heat removal from the reactor, containment and spent fuel pools. Two air-cooled cooling units were constructed and commissioned in 2014–2015 to ensure long-term decay heat removal in case of the loss of seawater. The design plans for the installation of a diverse water supply to the spent fuel pools were approved by STUK in 2015. The installation was implemented in 2019. Flood protection for NPPs was already improved in 2012 from +2.1 m to +2.45 m. After that flood protection design water level was increased to +2.95 m in 2018.

Article 8 Assessment of safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

(b) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (a).

Regulatory approach

The license applications for a new license or for the renewal of an existing license include the documents required by the Nuclear Energy Decree: Preliminary or Final Safety Analysis Reports; Probabilistic Risk Analysis Reports; Quality Assurance Programmes for Construction and Operation; Safety Classification Document, Operational Limits and Conditions Document (Technical Specifications); Programmes for Periodic Inspections; Plans for Physical Protection and Emergency Preparedness; Plans for Accounting and Control of Nuclear Materials; Administrative Rules for the Facilities; Programmes for the radiological baseline survey or the results of the radiological baseline survey; Programmes for Radiation Monitoring in the Environment of the Facilities; and Decommissioning plans.

The design of the facility is described in PSAR and in FSAR. These reports are submitted to STUK for approval in connection respectively with the applications for construction and the operating licences. According to the Nuclear Energy Decree, the FSAR shall be kept continuously up to date.

The requirements for performing the initial safety assessment and environmental impact assessment for nuclear facilities are discussed in the context of Article 6. A description of the safety principles that will be observed needs to be included in the DiP application.

The STUK Regulation (Y/1/2018) requires that the nuclear power plant safety and the technical solutions of its safety systems, including systems for spent fuel interim storage, shall be assessed and substantiated analytically and, if necessary, experimentally. Analyses should be maintained and revised if necessary, considering operating experience, the results of experimental research, plant modifications and the advancement of computational methods.

The safety assessments are reviewed by STUK with support of independent safety analyses and/or by external experts. The licences and related safety documents of the on-site spent fuel storages are attached to those of the respective NPPs and the renewal review processes take place simultaneously.

Implementation

As discussed under Article 7, an assessment of the design of the facility and related technologies is made by STUK for the first time when assessing the application for a Decision-in Principle. Later, the evaluation is continued when the Construction License application is reviewed. Finally, the detailed evaluation of systems, structures and components is carried out through their design approval process. The design of the Loviisa plant units was reassessed by STUK in connection with the Periodic Safety Review of the plant in 2014–2016. The Periodic Safety Review for the Olkiluoto NPP was carried out in connection with the renewal of operating licences for the Olkiluoto NPP reactor units in 2017-2018.

The preliminary safety analysis report and the other safety related documents for the extension of the Olkiluoto spent fuel interim storage facility were reviewed in 2010 before the construction work. The Final safety analysis report and the other safety related documents were reviewed in 2015 when STUK finalised the safety assessment on commissioning of the extension. The extension has been designed to withstand an aeroplane crash and the design of the existing part of storage has been updated.

Article 9 Operation of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) the license to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(b) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;

(c) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;

(d) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility;

(e) incidents significant to safety are reported in a timely manner by the holder of the license to the regulatory body;

(f) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(g) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

Initial authorisation

According to the Nuclear Energy Decree (Section 36), several documents, including the Final Safety Analysis Report shall be submitted to STUK when applying for an operating license. More detailed requirements are given in Guides YVL A.1 and B.1. The requirements for safety assessment are discussed in detail under Article 8.

Requirements for the commissioning programme for the NPPs and the associated spent fuel storage facilities are set out in Guide YVL A.5. According to the Guide, the purpose of the commissioning programme is to give evidence that the plant has been constructed and will function according to the design requirements. Through the programme potential deficiencies in design and construction can also be identified. The commissioning programme is described in the preliminary and final safety analysis reports, which are submitted to STUK for review and approval.

Operational limits and conditions

According to the Nuclear Energy Decree (Section 36), the applicant for an operating license shall provide STUK with the operational limits and conditions. These should set out the technical and administrative requirements for ensuring the plant's operation in compliance with the design bases and safety analyses. The operational limits and conditions include the requirements for ensuring the operability of systems, structures and components important to safety; and the limitations that must be observed in the event of component failure.

The STUK Regulation (STUK Y/1/2018) requires that systems, structures and components important to the safety of a nuclear facility shall be available as detailed in the design basis requirements. Operability and the effects of the operating environment shall be monitored by means of inspections, tests, measurements and analyses. Operability shall be checked in advance by regular maintenance, and provisions shall be made for maintenance and repairs in the event of any deterioration in operability. Condition monitoring and maintenance shall be planned, supervised and implemented so that the integrity and operability of systems, structures and components are reliably preserved throughout their service life. More detailed requirements for condition monitoring and maintenance programmes are given in the guide YVL A.8.

The operational limits and conditions are subject to the approval of STUK prior to the commissioning of the facility. Strict observance of the operational limits and conditions is verified by STUK through a regular inspection programme. Operational limits and conditions are updated based on operational experience, tests, analyses and plant modifications.

Established procedures

According to Guide YVL A.3 on management systems for nuclear facilities, document management shall cover all procedures required in the operation of the facility. The document management procedures shall be described as a part of the licensee's management system. These include, among other things, the specification, preparation, drawing up, review, approval, implementation, revision, dissemination, archiving and disposal of documents. The responsibilities and administrative procedures indicating how to take care of these actions shall be described in the licensee's management system. The procedures for operation shall be approved by the licensee itself, and procedures important for safety are required to be submitted to STUK for review. Detailed requirements are presented in the appropriate YVL Guides. STUK verifies that the approved procedures are in use and are followed in the operation of the facility by means of resident inspectors, inspections and reviews.

Engineering and technical support

The staffing, training and qualifications of the personnel are discussed in general in Section F, Article 22. STUK Regulation (STUK Y/1/2018) Section 25 requires that the organization shall have access to professional expertise and technical knowledge required for the safe operation of the plant, the maintenance of equipment important to safety and the management of accidents. The licensee of a nuclear facility has the primary responsibility for ensuring that the employees of the facility are qualified and authorised to their jobs and that the continuity of expertise is secured for the operational lifetime of the facility. Guide YVL A.4 specifies the expertise requirements for the positions which are important for safety. The requirements in Guide YVL A.4 also cover technical support.

TVO and FPH have both longstanding expertise in nuclear operations. TVO and Posiva uses external expertise regularly when needed in various design and modification activities. FPH has under corporate structure own unit for technical support to the Loviisa NPP among other projects. There are also on-site experts at the Loviisa NPP for various engineering and technical support functions.

Fennovoima has presented its latest organisation development plans with competences to cover all engineering tasks during the lifecycle of the plant including nuclear waste management in the construction license application submitted to MEAE in June 2015.

The competence of the engineering and technical support is supervised by the licensee. In addition, STUK carries out inspections by which the competence of the support staff is also evaluated.

Operating experiences, incident reports and evaluation

The STUK Regulation (STUK Y/1/2018) requires that feedback on operational experience is collected and safety research results are monitored, and both shall be assessed for the purpose of enhancing safety. Safety-significant operational events must be investigated for the purpose of identifying the root causes as well as defining and implementing the corrective measures. Improvements in technical safety, resulting from safety research, shall be considered to the extent justified based on the safety principles stated in the Nuclear Energy Act section 7 a.

According to Guide YVL D.3, a spent fuel condition surveillance programme, subject to STUK's approval, must be drawn up to monitor the effects of long-term storage on spent fuel.

Guides YVL A.9 and A.10 provide the reporting requirements in detail on incidents, operational disturbances, and events which must be reported to STUK. They also define requirements for the contents of the reports and the administrative procedures for reporting, including time limits for submitting various reports.

STUK's Annual Report on nuclear safety summarizes the operational events from the whole year and is available to the general public in Finnish and in English.

Operational events in spent fuel interim storage facilities have been rare in recent years. Some minor events have been reported by the licensee to the regulatory body. These events have, for example, been events that took place in the construction site of the enlargement for interim spent fuel storage in Olkiluoto. Other types of events have been those related to complying with administrative instructions.

Decommissioning plans

The Nuclear Energy Act (Section 7 g) describes the requirements for the preparation and updating of the decommissioning plans. Decommissioning issues are discussed in Section F, Article 26.

Article 10 Disposal of spent fuel

If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Article 3 relating to the disposal of radioactive waste.

According to the Finnish waste management policy, spent fuel is regarded as waste and shall be permanently disposed of in Finland. The encapsulation and disposal of spent fuel are discussed in the next Section H, in the context of the safety of radioactive waste management. Pre-disposal storage of spent fuel was handled in this Section G.

SECTION H
Safety of Radioactive Waste Management

Article 11. General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management, individuals, society and the environment are adequately protected against radiological and other hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

(a) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;

(b) ensure that the generation of radioactive waste is kept to the minimum practicable;

(c) take into account interdependencies among the different steps in radioactive waste management

(d) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(e) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;

(f) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

(g) aim to avoid imposing undue burdens on future generations.

Scope and general regulations

In this Section, the management of LILW from the nuclear facilities and from the research reactor, including disposal, the management of non-nuclear radioactive waste and management for spent fuel disposal are discussed. The relevant general regulations are, the Nuclear Energy Act (990/1987) and Decree (161/1988), STUK Regulation (Y/4/2018) on the Safety of the Disposal of Nuclear Waste including the disposal of low and intermediate level operational and decommissioning waste and spent nuclear fuel. The STUK regulation Y/1/2018 regulates the safe handling and storage of spent nuclear fuel in spent nuclear fuel storage facilities and nuclear waste handling in nuclear facilities attached to a nuclear power plant. More detailed technical requirements on the management and safety, including disposal, of LILW and spent fuel are given in the Guides YVL D.3, D.4 and D.5. Radioactive waste subject to the Radiation Act are regulated by STUK regulations S/2/2019 and S/5/2019.

Criticality and removal of residual heat

Regulatory requirements

STUK Regulation (Y/4/2018) requires that during the handling and storage of spent nuclear fuel, the possibility of criticality shall be very low and that the disposal package containing spent nuclear fuel shall be designed so that no self-sustaining chain reaction of fissions can occur, even in the disposal conditions.

Guide YVL D.3 Handling and storage of nuclear fuel further specifies that subcriticality of spent nuclear fuel shall be ensured by means of structural design solutions. The transfer casks, storage racks and handling equipment as well as the disposal canisters shall be designed to ensure criticality safety (exclusion of a chain reaction sustained by neutrons) in planned operational conditions and in the event of an anticipated operational occurrence or postulated accident. These requirements are stated in Guide YVL D.3 which also refers to the Guide YVL B.4.

In addition, Guide YVL D.5 requires that the design of the spent fuel disposal canisters shall also accommodate potential criticality conditions where the leak-tightness of the container has been lost and the container has sustained mechanical or corrosion-induced deformations. Also, the long-term criticality safety analyses of the disposal canister shall consider the possibility of a self-sustaining chain reaction of fissions and analyse the consequences of such an event as far as practicable.

The residual heat generation of spent fuel must be considered in the design of the encapsulation and disposal facilities. The requirements for the cooling of spent fuel during the encapsulation are presented in Guide YVL D.3.

Criticality and removal of residual heat in encapsulation and disposal facility of spent nuclear fuel

Criticality safety

Criticality safety analyses have been performed by Posiva in the construction license application. Posiva has confirmed in analyses that the spent fuel will remain subcritical when handled, stored or disposed of in a disposal canister. Subcriticality of spent fuel is ensured by the structural design of the fuel drying station and the disposal canister. To ensure the subcriticality the design of encapsulation facility prevents water entering the structures containing spent fuel. The analyses proved that even if structures containing spent fuel were filled with water, subcriticality was ensured by taking the burnup credit into account.

Posiva has analysed the criticality safety of copper/iron canisters and the analyses were provided to STUK for review in the construction license application. To prove the subcriticality of the spent fuel disposed in canisters, burnup credit has been applied in the criticality safety analyses.

In the post-closure criticality safety analyses the criticality of the disposal canister must be ruled out with very high certainty over the long term. In this respect, however, the analyses contain extremely conservative assumptions regarding the long-term evolution of the disposal canister geometry, indicating that re-criticality of the disposed fuel is highly unlikely.

Residual heat removal

Heat transfer analyses for spent fuel in encapsulation was performed by Posiva and the analyses were sent to STUK for review in the construction license application. The analyses showed that spent fuel and the surrounding rooms will remain at their design basis temperature even without active cooling using a ventilation system. The spent nuclear fuel transported to the encapsulation plant from the spent fuel interim storages will have been cooled in storage pools for a minimum of 20 years.

In the encapsulation plant, the cooling of spent fuel is provided by the ventilation system. If the ventilation system is not available, passive cooling can be run by natural circulation by opening the ventilation dampers. In a natural circulation mode, the filtering of the ventilated air from the encapsulation plant can be provided.

The Olkiluoto spent fuel disposal facility will have an underground buffer storage for encapsulated spent fuel. It is estimated that several tonnes of uranium (spent fuel) within copper-iron canisters may stay at a time within the buffer storage. The heat removal from the storage will be dimensioned conservatively.

The residual heat of the disposed spent fuel is also considered in the design of disposal canister and surrounding bentonite buffer in the disposal facility. The temperature of the canister-bentonite clay interface has been analysed and an appropriate safety margin has been used in the disposal facility dimensioning calculations. The maximum temperature of the disposal canister surface should be reached within 10 to 15 years after the disposal.

Thermal dimensioning including the detailed heat transfer phenomena in the near field of the deposition holes and optimisation of the disposal facility has been analysed. To ensure the functionality of engineered barriers, the minimum distances between deposition holes and deposition tunnels have been defined.

Waste minimization

Regulatory requirements

According to the Nuclear Energy Act (Section 27 a), the waste produced as a result of the use of nuclear energy must be kept as low as reasonable by practical means both in terms of its activity and the amount of waste. The requirements for waste minimization are presented in YVL guide D.4. This guideline emphasizes that the generation of waste must be decreased, i.e. by proper planning of repair and maintenance work and by means of decontamination, clearance and volume reduction practices. The Guide YVL D.4 also refers to sound working methods for waste minimization, e.g. volume reduction of waste, avoiding the transfer of unnecessary objects and materials in the controlled areas and by adoption of working processes which either create only small amounts of waste or in which the created waste is easily manageable.

The release of waste from regulatory control (clearance) is regulated by Guide YVL D.4. Both conditional and unconditional clearances are effectively used for waste minimization by the NPPs. Clearance criteria, levels and procedures are discussed in Section B, Article 32, Paragraph 1.

According to the Radiation Act 859/2018 (Section 78), the radioactive waste produced in the use of radiation or in non-nuclear radioactive instances shall be kept as low as reasonably possible by practical means. However, these practical means shall not compromise the principles of justification, optimization and individual radiation protection.

Waste minimization of LILW in NPP's

The accumulation of LILW in the Loviisa and the Olkiluoto NPPs is depicted in Figure 13. The average accumulation of low and intermediate level waste at the Olkiluoto NPP (OL1 and OL2) has been about 120 m³ and at the Loviisa NPP (LO1 and LO2) 24 m³ per year during 2017–2019. The accumulation of waste has in some years even been reduced by effective waste minimization and volume reduction measures, such as the radiochemical treatment of liquid waste, campaigns for removal of very low-level waste from regulatory control, and compaction of maintenance waste. Large metallic waste components have been transported for treatment at the Studsvik facility in Sweden which reduces the volume of radioactive waste to be disposed significantly. Activation products or parts containing external contamination or components that have been separated from the metal are transported back to Finland for disposal.

Loviisa NPP has continued the use of ion exchange methods for the purification of liquid waste (removal of Cs). The use of the method decreases the amount of liquid waste and the doses to the representative person in the vicinity of the NPPs as shown in Figure 12. Loviisa NPP has also developed the free release practises for the metal wastes during the reporting period and sent some big metal components to Sweden for melting in 2019.

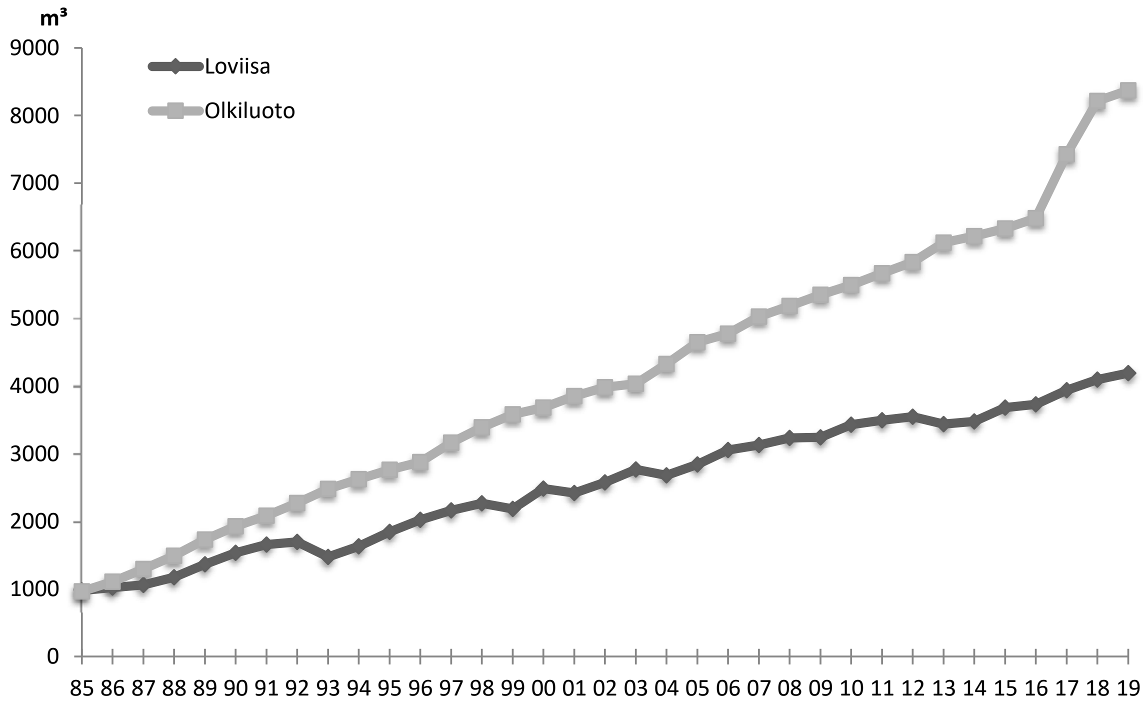


FIGURE 13. Accumalation of LILW in Loviisa and Olkiluoto NPP's

TVO has made a modification in both power plant units in the condensate polishing system to reduce the temperature and thus increase the lifetime of pre-coat resins. Consequently, the generation of spent ion exchange resins has decreased considerably. Surface contaminated metal scrap is decontaminated in a new facility by blasting with glass marbles. Decontaminated metals are released from regulatory control, if activity levels below those for clearance are reached. Part of the metal waste (removed large components e.g. heat exchangers and liquid coolers) has been transported for treatment in Sweden in 2018 and 2019. The removal of these large components from NPPs is also shown in Figure 13 as unusually high amounts of LILW waste accumulation in 2018 and 2019.

Waste minimization in the decommissioning of research reactor

The nuclear waste (in total 6 m^3) produced during the operation of reaserch reactor is packed and currently stored in Otaniemi. VTT has estimated that the amount of decommissioning waste will be about 75 tons. The waste management procedures are currently under development for the decommissioning phase. Waste minimization will be taken into account by careful planning and implementing efficient waste sorting and packaging methods and also by decontamination and clearance.

Waste minimization of non-nuclear radioactive wastes

The laboratories using radioactive sources in medical and research applications usually store their short-lived radioactive waste on their premises until it has decayed below the limits set for discharges in STUK S/2/2019. Only small amounts of waste need to be conditioned for disposal.

Interdependencies

Regulatory requirements

Guide YVL D.4 on the treatment and storage of LILW from NPPs requires that waste is treated, e.g. segregated, categorised and conditioned, in an appropriate way regarding its further management. The Guide YVL D.4 also provides for the consideration of the requirements of waste packages related to their disposal. These requirements may concern, e.g., the structure of the waste packages, their physical and chemical compositions, their resistance to external and internal loads and the amount and structural and chemical stability of radioactive substances in the waste packages.

Interdependencies in encapsulation and the disposal of spent nuclear fuel

Interdependencies in the context of spent fuel management are discussed in Section G.

Interdependencies in nuclear waste management activities in NPP's

Both operating nuclear power plants have their own LILW disposal facilities, thus the premises for considering interdependencies in the waste management chain are excellent. Interdependencies of the various steps in waste management are considered in the NPPs' Operational Manuals. At the Loviisa NPP all the waste treatment, conditioning, handling, storing, transport and disposal operations are carried out at the NPP site by the personnel of the Loviisa NPP. Only the spent nuclear fuel will be transported for disposal from the Loviisa NPP site to Posiva's disposal facility at Olkiluoto. In case of the Olkiluoto NPP, all the waste management steps take place at Olkiluoto. The Decision in Principle concerning Fennovoima also includes an LILW disposal facility on the NPP site. Fennovoima has performed preliminary site characterizations for proposed locations of disposal facility at the NPP site and STUK has reviewed these results.

Interdependencies in nuclear waste management activities in the decommissioning of the research reactor

The spent fuel of research reactor will be removed from the reactor before the dismantling is started. The spent fuel will likely be sent back to the USA according to the existing returning agreement. The agreement is valid until 2029.

The waste produced during the decommissioning of the research reactor is planned to be packed at the reactor site in a way that it could be later stored and disposed in Loviisa LILW repository.

Interdependencies in non-nuclear radioactive waste management

Non-nuclear radioactive waste is packed into barrels to enable it to be stored in a similar way as the operational waste from the nuclear power plants are stored. The non-nuclear wastes are currently stored on the premises of Suomen Nukliditekniikka in Orimattila and in the Government's storage facility inside the Olkiluoto LILW disposal facility. There is also an agreement to dispose of these wastes in the Olkiluoto LILW disposal facility and the disposal started in 2016.

Protection of individuals, the society and the environment

Regulatory requirements

Requirements for protection of workers are set in the Radiation Act 859/2018 and for protection of the population in the vicinity of nuclear waste facilities in Nuclear Energy Decree Section 22 d.

The Nuclear Energy Decree (161/1988) requires (section 22 d) that the post-closure safety of disposal of nuclear waste shall be designed and implemented in a manner where the radiation exposure caused by nuclear waste as a result of its expected evolution will not exceed the constraints set in the Nuclear Energy Decree. This requires that the annual effective dose to the most exposed members of the public remains below 0.1 mSv for a period of the first several thousand years. The average annual effective doses to other members of the public must remain insignificantly low.

Beyond that period, the average quantities of radioactive substances over long time periods, released from the disposed waste and migrating further into the environment, must remain below the nuclide specific constraints defined by STUK. These constraints are given in Guide YVL D.5 as limits for annual activity releases into the environment. They are defined so that, at their maximum, the radiation impacts arising from disposal are comparable to those arising from natural radioactive substances and on a large scale; the radiation impacts remain insignificantly low.

STUK Regulation Y/4/2018 states that the radiation exposure caused by rare events impairing long-term safety shall be assessed whenever possible. The probability of events causing significant radiation exposure shall be very low, and the widespread impacts of the release of radioactive substances caused by them must also be low.

In addition, Guide YVL D.5 pays attention to the protection of living nature requiring that the disposal of nuclear waste shall not detrimentally affect any species of fauna or flora. This must be demonstrated in the safety assessment by considering typical radiation exposures of terrestrial and aquatic populations in the disposal site environment, assuming the present time kinds of living populations. These exposures must remain clearly below the levels which, on the basis of the best available scientific knowledge, would cause a decline in biodiversity or other significant detriment to any living population of fauna or flora.

Protection of individuals, the society and the environment in spent fuel management
Dose limits and constraints that are applied to operational encapsulation and disposal facilities were already introduced in Section F, Article 24.

The design of Posiva's nuclear waste facilities takes account of limiting the radiation doses received by the personnel, population and the environment by all practical means. Fuel handling is designed so that the releases of radioactive substances in the facilities and their spread to the environment is limited as far as possible. The radiation exposure of the personnel is reduced by implementing the handling of spent fuel and the disposal canisters via remote control.

The radioactive releases and potential radiation doses to humans, plants and animals during the operation of the encapsulation plant and disposal facility have been analysed in PSAR. The PSAR was a part of the construction license application documentation. The radioactive releases and possible radiation doses have been analysed for normal operations, operational occurrences and for accident conditions.

The handling of fuel bundles that contain a leaking fuel rod has been considered in the design of the encapsulation plant. The handling of fuel bundles is performed in a hot cell, which is designed to limit the release of radioactive substances inside the encapsulation plant and further into the environment. The limitation of radiation is based on the structures and leak tightness of the hot cell. Additionally, the air conditioning of the hot cell is provided with filtering for radioactive substances.

The limiting operational occurrences that may occur include the mishandling of a fuel bundle followed by a possible radioactive release from broken fuel rods. These releases are assumed to occur in the hot cell or in controlled area of the encapsulation plant. Both are equipped with filtered air-conditioning.

The limiting accident conditions include the dropping of a fuel bundle in the hot cell or the dropping of a disposal canister in the canister lift shaft. In both conditions, the filtration of the hot cell air-conditioning or the filtration of the controlled area air conditioning would limit possible radioactive releases.

The analysed radiation dose for the operational occurrence is $2 \cdot 10^{-5}$ mSv, which is the equivalent of a dose from normal ingestion for one year. This dose is far below the limit of 0,1 millisievert specified in the regulations. For the worst-case accident condition, the radiation dose was analysed to be 0,01 millisievert, which is below the limit of 1 millisievert specified in the regulations.

Protection of individuals, the society and the environment in LILW management

According to the Nuclear Energy Decree section 22 d the average annual dose to the most exposed individuals of the population arising from the normal use of the LILW facility shall be below 0,01 millisievert (cf. also Section F, Article 24).

The radioactive releases and possible radiation doses to humans, plants and animals during the operation of LILW repositories are analysed in the Final Safety Analysis Reports (FSAR). The FSAR is a part of the original operation license application documentation and the report has been kept up to date since. The radioactive releases and possible radiation doses are analysed for normal operation, operational occurrences and in accident conditions. The analysed operational occurrences included, e.g., failures during the lifting of waste packages, failures in the groundwater pumping system or ventilation and power supply failures. The analysed accidents included, e.g., fires, earthquakes, flooding, intentional damage and traffic accidents during transportation.

During normal operation, the doses of workers are clearly below the limits set in the regulations. The possibility of operational occurrences and accidents that might affect radiation safety were deemed to be very unlikely in LILW repositories after analyses. The doses to the most exposed individuals were analysed for operational occurrences and accidents and with a high degree of certainty the exposures would be below the annual dose limits set for individuals. Under accident conditions, the annual doses of the workers would also remain below the annual dose limits set in the regulations with the proper education and instructions for workers and protective clothing and equipment.

The total discharges from Finnish NPPs have been very low and the total annual calculated radiation doses of the most exposed individual in the vicinity of both NPPs was less than 0.1% of the limit of 100 micro Sieverts that is established in the Nuclear Energy Decree. The discharges from waste management activities are very small compared to the total releases from NPPs and so are the annual doses to the most exposed individuals of the population.

Protection of individuals, the society and the environment in decommissioning of the research reactor

According to the operational limits and conditions of the research reactor FiR 1, the radioactive discharges into the air and water during operation will not be more than one tenth of the limits set for NPPs. In 2014 radioactive releases from the research reactor into the air were 0.22 TBq (Ar-41). The research reactor was permanently shut down in June 2015. Since then there has not been any radioactive releases to the air. Yearly releases into the air have at maximum been 17% of the release limit (3.7 TBq Ar-41 per year) set by STUK for the operation of the research reactor.

During the dismantling of the reactor and concrete structures, small amounts of radioactive substances (e.g. Co-60) may be released into the reactor building. The spread of the radioactivity will be prevented by choosing methods that prevent dust and particle formation. Additionally, some radioactivity (e.g. gaseous xenon and krypton) may be released into the reactor building during the handling of the damaged fuel assemblies. During dismantling, the reactor building will be kept under-pressurized, which efficiently prevents releases from the building. The ventilation system will be equipped with continuous radioactivity monitoring, and if needed, the air can be filtered before releasing it from the reactor building. All water produced during decommissioning will be collected into tanks and will not be released until it has been measured and found to be clean from radioactivity.

Protection of individuals, the society and the environment in non-nuclear radioactive waste management

According to Section 78 of the Radiation Act (859/2018), the amount of radioactive waste generated using of radiation and other radiation practices shall be kept as low as reasonably achievable without endangering the implementation of the general provisions (justification, optimization, limitation).

The radiation doses received from non-nuclear radioactive waste are very low. The dose received from the air emission of radioactive substances shall be under 10 μSv per year for a representative person. The dose limits and activity limits for discharges are given in the Regulation S/2/2019. Disused radioactive sources are stored in the Government waste facility in connection to the Olkiluoto LILW disposal facility and are disposed of in the same way as nuclear waste according to the operating license of the Olkiluoto LILW disposal facility.

Biological, chemical and other hazards

Regulatory requirements

According the Act on the EIA procedure (252/2017), the environmental impacts must already be evaluated in the planning and decision-making phase of a project. Another important aim of the EIA procedure is to increase the information available about the project to citizens and provide the opportunity to participate in the project planning phase. During the EIA-procedure, all types of environmental impacts (e.g. noise, dust, traffic, releases to air and water etc.) of the project are investigated and evaluated. In nuclear facility projects, other hazards than those posed by radiation are also considered during the EIA procedure.

Biological, chemical and other hazards in spent fuel management

During the construction and operation of the encapsulation plant and disposal facility for spent nuclear fuel small amounts of hazardous waste, such as waste oil, solvents and batteries will be generated. Hazardous waste is collected and sent to a hazardous waste treatment plant.

The encapsulation and disposal concept for spent nuclear fuel does not include any hazardous or harmful materials except nuclear waste. The outer shell of the disposal container is made from copper, but the release of copper from the disposal facility is limited by the slow corrosion rate of copper.

Biological, chemical and other hazards in LILW management in NPPs

Disposed LILW consists of the NPP's trash waste, scrap metal, filter elements and liquids and sludge. These materials and their immobilisation matrices are not harmful to the environment as such, but may contain harmful residues, such as heavy metals.

Some studies on radioactive nickel releases from the disposal facility have been carried out in Finland. The results show that the potential annual releases are small. In the same way, it can be argued that the release rate of chromium and poorly soluble lead and cadmium will also be small. The chemical effects of the Swedish LILW disposal facility (SFR) in Forsmark have been studied more thoroughly. SFR and the Finnish LILW facilities are similar regarding the structure and the type and the content of the disposed waste. The Swedish studies indicate that the increase of heavy metal concentrations in seawater would be negligible, mostly owing to the release barriers at the disposal facility.

When the waste is isolated properly, the discharges to the environment are small, when compared to other forms of industry or other sources of hazardous waste. As long as the engineered barriers isolate the radioactive waste, also other harmful substances are effectively isolated from the environment. Furthermore, the LILW repositories are located in areas which do not contain exploitable groundwater reserves for present day communities. This condition is expected to be valid in future as well.

Biological, chemical and other hazards in decommissioning of research reactor

The reactor building of FiR 1 reasearch reactor was constructed in 1950s when it was quite common to use asbestos, e.g. in fire shielding, pipe insulation, tiles and in mortar. In addition to asbestos, many other materials hazardous to health were used until the 1980s. In the 1990s the reactor building was renovated and materials containing asbestos, for example, were removed. There may still be some old plastic tiles and tile glue left in the building, which will be investigated for asbestos and other harmful materials before dismantling. If asbestos or other harmfully materials are found, they will be handled and disposed of according to current legislation before dismantling the reactor is started.

The research reactor still contains some chemicals used in the research. These are planned to be packed and disposed of duly before dismantling starts.

Biological, chemical and other hazards in non-nuclear radioactive waste management

Biological, chemical and other hazards may be related to some waste arising from medical and research applications. The requirements of the relevant non-radiation related regulations, including those related to general occupational health, are applied in these cases as appropriate.

Protection of future generations and avoidance of undue burdens on future generations

Regulatory requirements

Section 7 h of the Nuclear Energy Act states that nuclear waste shall be managed so that no radiation exposure is caused after disposal which would exceed the level considered acceptable at the time the disposal is implemented.

The Nuclear Energy Act (Section 7 h) requires that the disposal of nuclear waste in a manner intended as permanent is planned with due regard to safety and that ensuring long-term safety does not depend on the surveillance of the disposal site. In Section 8 of STUK Regulation Y/4/2018 it is required further that planning of the construction, operation and closure of a disposal facility must account for the reduction of the activity of nuclear waste through interim storage, the utilisation of high-quality technology and research data, and the need to develop an understanding of the performance of the barriers and long-term safety through investigations and monitoring.

Section 30 of STUK Regulation Y/4/2018 states that the long-term disposal safety shall be based on long-term safety functions achieved through mutually complementary barriers so that the degradation of one or more long-term safety functions or a foreseeable change in the bedrock or climate would not jeopardise the long-term safety.

The Nuclear Energy Act (Section 9) requires that a licensee whose operations generate or have generated nuclear waste must be responsible for all nuclear waste management measures and their appropriate preparation, as well as for their costs (See Section B, Article 32: Costs and funding). The principle of securing the future disposal of nuclear wastes applies to every nuclear waste producer.

Spent nuclear fuel

Until the mid-1990s, Finnish power companies had different arrangements for the management of spent fuel. Export was the primary option for the both operating companies, and FPH also implemented export. To fulfil its license conditions and the content of the Government Decision in 1983, TVO also initiated in 1983 its R&D work for spent fuel disposal within Finnish territory. The amendment of the Nuclear Energy Act in 1994, prohibited the imports and exports of nuclear waste and, after a transition period, since 1996 the disposal within Finnish territory has been the only disposal option.

Radiation protection of the public is discussed earlier in “Protection of individuals, the society and the environment”. The same principles protect future generations from the unwanted consequences of nuclear waste disposal.

The costs of the disposal of spent fuel are secured with assets collected in the VYR Fund. The obligation for financial provision starts when a MEAE licenced nuclear facility begins to produce nuclear (operational and spent fuel) waste.

LILW and VLLW

The Finnish nuclear waste management policy is based on the ethical principle of avoiding transferring undue burdens to future generations. Disposal facilities for LILW are operational at the both existing NPP sites and are planned to also host decommissioning waste. At Olkiluoto preparations for licensing VLLW disposal in a near-surface facility were started by the end of 2018.

The costs of the disposal of LILW are secured by assets collected in the VYR Fund (See Section B, Article 32: Costs and funding).

Decommissioning of the research reactor

The research reactor will be dismantled as soon as VTT has the technical and organizational readiness for the work and the required license for decommissioning is granted by the Government. The decommissioning will be performed under the supervision of the personnel who have been operating the reactor and who have the best knowledge of the facility.

The future waste management and disposal costs of the FiR 1 research reactor are secured by assets collected in the VYR Fund (See Section B, Article 32: Costs and funding).

Non-nuclear radioactive waste

Government owned non-nuclear radioactive waste are disposed in the Olkiluoto LILW disposal facility. Active institutional controls are not needed to ensure the safety of these disposal facilities during the post-closure period.

Article 12 Existing facilities and past practices

Each Contracting Party shall in due course take the appropriate steps to review:

(a) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;

(b) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

Existing facilities

Regulatory requirements

According to the Nuclear Energy Act (Section 7 a), the safety regarding the use of nuclear energy must be maintained at as high a level as practically possible. For the further development of safety, measures must be implemented that can be considered justified considering operating experience, safety research and advances in science and technology. In practice, this means that the existing facilities need to be improved based on the latest operational experience from Finland and abroad, and the latest technical developments should also be considered.

Existing facilities for spent fuel management

There are not yet any existing facilities aiming at final spent fuel disposal. The construction license for the spent fuel disposal facility was granted to Posiva at the end of November 2015 and the construction of the facility started in December 2016.

Existing facilities for LILW management

The predisposal management facilities for low and intermediate level radioactive waste at the Loviisa and the Olkiluoto NPPs are covered by the respective operating licences for the reactors. The LILW disposal facilities have separate operating licences both in Olkiluoto and in Loviisa. The requirements for their safety review are described in Section G and the conclusions drawn are valid for LILW management as well.

Thorough assessments of the safety of the facilities were carried out by the licensees and reviewed by STUK in connection with the construction and operating license applications.

A periodic safety review of the LILW disposal facilities is made with 15-year intervals. The Olkiluoto LILW disposal facility started operation in 1992 and consequently its safety assessment was reviewed by STUK in 2007. The operating license of Olkiluoto LILW disposal facility covers operational waste from OL1, OL2 and OL3 and state owned non-nuclear radioactive waste.

The LLW disposal halls of the Loviisa LILW disposal facility started operation in 1998. The construction of the ILW disposal cavern was completed in 2007 and started operation in 2019. The periodic safety review of the LILW facility was conducted in 2013–2014.

In conclusion, the safety reviews regarding the waste management of LILW at NPPs required by Article 12 were carried out at the time of licensing. The safety analysis reports are continuously up to date. In addition, periodical safety reviews are made regularly. Safety improvements have been continuously implemented at the Loviisa and the Olkiluoto plants, including the facilities for waste management, since their commissioning.

Existing facilities for decommissioning the research reactor

The predisposal management facilities for low and intermediate level radioactive waste from operation are covered by the existing operating license of FiR 1 research reactor valid until the end of 2023.

Existing facilities for non-nuclear radioactive waste management

Non-nuclear radioactive waste, e.g. from research, industry and hospitals is stored at existing facilities in the Suomen Nukliditekniikka storage facility and in the Olkiluoto LILW disposal facility.

Outokumpu Stainless is a steel manufacturer in northern Finland. The company receives scrap metal as a raw material for its production. On average once a year the company accidentally melts an Am-241-source. The nuclide is almost impossible to detect with radiation ports due to its low gamma energy. The company has radiation monitors for its product and slag, as well and this is how Am-241 is detected. The low-level contaminated slag is sited at an industrial dumping ground for disposal approved by STUK. The company also stores other low-level waste originating from smeltings at the industrial dumping ground before it is sited.

Terrafame Oy (formerly Talvivaara Sotkamo Oy) operates a nickel and zinc mine in Sotkamo. The ore in the mine contains small amounts of uranium which is extracted from the ore in the mine’s bioheap leaching process. Uranium is not currently recovered in the metal extraction process but is recirculated until finally mostly precipitated in waste rock piles and waste gypsum ponds. Terrafame applied for a license to extract uranium in 2017, and a license was granted in February 2020 by the Government. At the end of 2019 the amount of uranium in the gypsum ponds was estimated to be around 550 tonnes. The mine had wastewater leakages from a gypsum pond in 2012 and 2013, resulting in contamination of small nearby lakes with sulphate and heavy metals. The amount of released uranium outside the mining area was estimated to be relatively small and amounting to about 500–1000 kg. Environmental remediation of the lakes is being planned. As this waste does not originate from the nuclear fuel cycle and it contains only NORM, this convention does not apply to it.

Article 13 Siting of proposed facilities

Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:

(a) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;

(b) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;

(c) to make information on the safety of such a facility available to members of the public;

(d) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

Regulatory requirements

The description of siting procedures, provided under Article 6 for siting of spent fuel management facilities (including spent fuel storage facilities), is also applicable for facilities intended for the predisposal management of LILW at the NPPs and for the disposal of LILW or spent fuel, and is not repeated here.

Concerning the siting of a nuclear facility, STUK Regulation Y/4/2018 Section 12 includes the statement: *The impact of local conditions on operational safety and the feasibility to implement the arrangements for security and emergency arrangements shall be considered when selecting the site of a nuclear facility. The site shall be such that the detriments and threats posed by the operation of the facility to its vicinity remain very low.* Section 31 states that *"The characteristics of the rock at the disposal site shall, as a whole, be favourable to the isolation of the radioactive substances from the living environment. Any area with a feature that is substantially adverse to long-term safety shall not be selected as the disposal site."*

Guide YVL D.5 specifies the generic site suitability criteria.

Siting of nuclear and non-nuclear radioactive waste management facilities

Disposal facility for spent nuclear fuel

Spent fuel disposal facility site investigations at the Olkiluoto site have been going on since the 1980s. These have included many types of investigations airborne, surface and bedrock, and finally they included in situ investigations in the bedrock at the disposal depth at the ONKALO URCF to confirm the suitability of the bedrock for high level waste disposal.

In the context of the DiP process in 1999–2001 for TVO's and FPH's spent nuclear fuel disposal, Olkiluoto was selected by Posiva and proposed as the site for a spent nuclear fuel disposal facility. Based on the DiP, the project received permission to proceed with the construction of the underground rock characterisation facility and the more detailed site-specific studies. Knowledge of the site has increased significantly since the DiP stage. At the end of 2012 Posiva submitted a construction license application for a spent fuel encapsulation and disposal facility. The license application documentation also addresses the site related analysis concerning, for example, the design of facilities and the suitability of the disposal facility host rock. The studies of the disposal site and the analyses of the evolution scenarios of the site reaching far into the future are adequate for the construction license, and they have not introduced any matters which would not be favourable for the post-closure safety of the selected disposal site. Based on the studies and analyses, the conclusion can be drawn that the bedrock's characteristics are suitable for implementing the disposal as proposed.

Concerning the siting, design, construction and assessment of safety, the details of the regulatory approach to Posiva's spent fuel disposal project in Olkiluoto are described in Annex L.2.

The condition of the DiP on the NPP for Fennovoima required that it shall have either a co-operation agreement with shareholders of Posiva for spent fuel disposal in the Olkiluoto disposal facility or alternatively an EIA programme for a separate disposal facility shall be submitted within six years from the date of the DiP ratification (2010) by Parliament. In the absence of the agreement with Posiva's owners, Fennovoima submitted an EIA programme for the disposal facility to the MEAE in June 2016. The EIA programme contains both environmental studies and geological investigations to confirm the suitability of candidate sites for spent fuel disposal. The investigation phase will last about 20 years, based on current estimates. Fennovoima is aiming to select the site for final disposal in the 2040s at the earliest. In 2016, Fennovoima presented a co-operation agreement with Posiva Solutions Oy about the use of Posiva's competence in developing a spent fuel disposal solution for Fennovoima.

LILW disposal facilities

In Finland, the siting decisions for the LILW repositories at the NPP sites were strongly encouraged with short NPP operating licences during the early days of operations. Site investigations on FPH and TVO plant sites were started late 1970's and early 1980's, respectively. The DiP for Fennovoima's NPP in 2010 also includes an LILW disposal facility at the NPP site.

Waste management facilities for decommissioning waste from the research reactor

VTT has signed a contract at the end of March 2020 with FPH about dismantling FiR1 research reactor. The contract includes an option to store and dispose the operational and decommissioning waste of FiR 1 research reactor in Loviisa NPP site. The storage or disposal of VTT's waste can be done at Loviisa site only after updating the licenses of the existing facilities at Loviisa NPP site according Nuclear Energy Act.

Waste management facilities for non-nuclear radioactive waste

At present, non-nuclear radioactive waste is stored in Orimattila at the Suomen Nukliditekniikka storage facility, and in Olkiluoto. Additionally, the disposal of State owned non-nuclear waste has continued in Olkiluoto. Therefore, siting is currently not an issue.

Article 14 Design and construction of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(b) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;

(c) at the design stage, technical provisions for the closure of a disposal facility are prepared; the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

Regulatory requirements

The discussion under Article 7 (Section G) is relevant for the predisposal management facilities for LILW, which are covered by the operating licences of the NPPs and STUK Regulation Y/1/2018.

Safety requirements for the spent fuel encapsulation facility, which is planned to be situated in connection with the spent fuel disposal facility, are described in STUK Regulation Y/4/2016. Guides YVL A.5, YVL B.1 and YVL D.3 provide detailed safety requirements for the encapsulation facility design and construction.

The design requirements for LILW and spent fuel disposal facilities and the measures to limit radiological impacts from these facilities are discussed in Section G. An illustration for the disposal facility of spent fuel at Olkiluoto is shown in Figure 6. The design of Loviisa and Olkiluoto LILW disposal facilities are illustrated in Figures 7 and 8, respectively.

According to Section 8 of STUK Regulation Y/4/2018, disposal must be implemented in stages, with attention paid to aspects affecting long-term safety. The planning of the construction, operation and closure of a disposal facility shall account for the reduction of the activity of nuclear waste through interim storage, the utilisation of high-quality technology and research data, and the need to develop an understanding of the performance of the barriers and long-term safety through investigations and monitoring.

More detailed requirements on the design principles are given in Guide YVL D.5.

Design and construction of disposal facility for spent nuclear fuel

In connection with the construction license application, Posiva delivered a PSAR, which described the design bases of the disposal facility detailed enough. Based on the design documentation, it can be stated that the facility can be implemented to fulfil the safety requirements that were originally laid down in Government Decree 736/2008, which has been replaced by STUK Requirement Y/4/2018.

Posiva has submitted a description of the decommissioning of the encapsulation plant for the construction license and has taken decommissioning into account in the facility's design requirements. In the construction license application documentation, Posiva has presented the principles of closure in a way that is detailed enough for the construction license and has planned the closure to be implemented in a way that the bedrock maintains the characteristics important to post-closure safety as effectively as possible.

Conceptual plans for the closure of the disposal facilities have been included in their initial designs (e.g. the PSAR designs of the LILW repositories and the construction license application documentation of the spent fuel disposal facility in Olkiluoto). These closure plans will be reconsidered in the context of later licensing stages or periodic safety assessments.

Concerning siting, design, construction and assessment of safety, a more detailed description of the regulatory approach to Posiva's spent fuel disposal project in Olkiluoto is presented in Annex L.2.

Article 15 Assessment of safety of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

(b) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;

(c) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (a).

Regulatory requirements

Regarding the disposal of spent fuel and LILW, compliance with long-term radiation protection objectives as well as the suitability of the disposal concept and site must, according to STUK Regulation (STUK Y/4/2018), be justified by means of compliance with the long-term radiation protection objectives. Equally the suitability of the disposal concept and site must be justified through a safety case that addresses both the expected evolutions and unlikely disruptive events possibly impairing part of the multi-barrier long-term safety features. The requirements and analysis related to the operational safety of the waste management facilities are presented in Article 11.

According to Guide YVL D.5 a safety analysis must include:

- a description of the disposal system and the definition of barriers and safety functions;
- the specification of performance targets for the safety functions;
- a definition of the scenarios (scenario analysis);
- a functional description of the disposal system and a description of the conditions prevailing at the disposal site by means of conceptual and mathematical modelling, and the determination of necessary model parameters;
- an analysis of the quantities of radioactive substances that could be released from the disposed waste, penetrate the barriers and enter the biosphere, and an analysis of the resulting radiation doses;

- whenever possible, an estimation of the probabilities for activity releases and radiation doses arising from unlikely events impairing long-term safety;
- uncertainty and sensitivity analyses and complementary qualitative considerations; and
- a comparison of the outcome of the analyses against the safety requirements.

The licensee shall carry out a periodic safety review for the disposal of nuclear waste at least once every 15 years, unless otherwise stated in the conditions of the operating license. The periodic safety review must be conducted in compliance with the requirements of Guide YVL A.1, Regulatory control of the use of nuclear energy, where applicable.

Detailed requirements for the contents of the post-closure safety case are provided in Guide YVL D.5 Annex A. The post-closure safety case must include a description of the disposal system: quantities of radioactive substances; waste packages; buffer materials; backfill materials; structures for isolation and closure; excavated rooms; the geological, hydrogeological, hydrochemical, thermal and rock mechanical characteristics of the host rock; and the natural environment at the disposal site. The post-closure safety case shall define the safety concept, barriers and safety functions together with their performance targets.

The discussion under Article 8 on the safety assessment of spent fuel interim storage is valid for the predisposal management of LILW because both activities are covered by the operating licences of the reactor units at the present NPPs and by STUK's Regulation (Y/1/2018).

The predisposal management of waste subject to the Radiation Act generally involves operations which may not cause any extensive hazards: handling of sealed sources, segregation and packaging of small amounts of LLW. Thus, no comprehensive safety or Environmental Impact Assessments are needed, but the safety of the required operations needs to be evaluated in the context of the licensing process.

Implementation

Safety assessments performed for disposal of spent nuclear fuel

A R&D programme for spent fuel disposal was started in 1978 with a foundation of Nuclear Waste Commission of Power Companies (YJT). The coordinated research was run by the commission until the end of 1995. Thereafter, disposal R&D work has been run by TVO's and FPH's joint company Posiva. The early R&D programme mainly aimed at planning and implementing a spent fuel disposal project but also included a programme for LILW management.

Concerning post-closure safety, Posiva updated the safety assessment work presented in the DiP for the construction license application for the Olkiluoto encapsulation plant and disposal facility in 2012. A framework for the development of the post-closure safety case was first reported in 2005 and updated in 2008. Posiva developed the safety case portfolio to meet the regulatory requirements and to show the safety assessment methodology. Posiva submitted the construction license application at the end of 2012.

Together with the license application Posiva delivered the post-closure Safety Case (TURVA 2012). STUK reviewed the post-closure documentation during 2013-2015. Based on STUK's review of the safety case documentation, the post-closure safety assessment of the facility was found to be adequte for the purposes of the construction license. The results demonstrated that, after the closure, the facility would be safe to people and other living nature in the surroundings as was required by the Government Decree (736/2008) on the safety of disposal of nuclear waste. Furthermore, Posiva has indicated the suitability of the disposal method and disposal site in a manner for the purposes of the construction license stage. The review showed, however, that there is a need to further improve the post-closure safety case by clarifying the safety arguments and the related methods and by reducing the uncertainties concerning the performance of barriers. Posiva has prepared a plan to produce a post-closure Safety Case (TURVA 2020) in support of the operating license application. The present post-closure safety case plan is based on the following:

- Follow-up of further developments of STUK's regulations on the safe use of nuclear energy and safety of nuclear waste management and disposal
- Feedback from STUK on the post-closure safety case presented in 2012
- Lessons learned from the post-closure safety case work
- Recommendations and guidelines on the methodology for the development of post-closure safety by international bodies.

STUK has implemented a regulatory inspection programme for the oversight of the construction of the encapsulation plant and disposal facility, feasibility of the disposal concept and post-closure safety case development. These activities are described in more detail in Annex L.2.

Safety assessments performed for LILW repositories

The operating license of the Olkiluoto LILW disposal facility was renewed based on TVO's application in 2012 by the decision of the Goverment. The new license conditions enabled the disposal of operational waste from OL1, OL2 and OL3 units and State-owned radioactive waste in to Olkiluoto LILW disposal facility. In connection to this licensing process STUK prepared a safety assessment of the TVO's application.

The Government granted FPH a permission to use the LILW disposal facility in 1998. FPH submitted the first periodic safety review of the LILW disposal facility to STUK for approval in 2013. The update of the safety review must be submitted to STUK for approval after every 15 years.

STUK's safety review and decision in 2014 stated that the safety level of the Loviisa low- and intermediate-level operational waste disposal facility is good in terms of operational safety and long-term safety, and that the licensee has implemented the procedures needed to continue safe operation. STUK approved the periodic safety review of the Loviisa low- and intermediate level operational waste disposal facility carried out by FPH.

In 2018, FPH delivered to STUK Loviisa NPP decommissioning plan update. In accordance with this plan FPH provided to STUK the updated post-closure safety case in 2019. In the safety case both the constructed parts of the repository and planned parts for the decommissioning waste disposal are addressed. The safety case also considered the updated regulation and guidance.

STUK reviewed the safety case and reached conclusions on the adequacy of FPH's submission. The focus of STUK's review has been to ensure that the safety case for the repository follows the structure and intent of the regulatory requirements and is sufficiently developed and convincing to address the post-closure safety of the repository.

Based on its review STUK concluded that FPH has provided, overall, a clear and credible safety case to demonstrate that the existing repository for the operational waste fulfils and the planned repository for the decommissioning waste can be implemented to fulfil the regulatory requirements considering the post-closure safety. FPH makes clear presentation of the safety concept and the technical data and the analyses are, in general, state-of-the-art.

However, there remains a need to develop safety argumentation and methodologies further, and there is also a need to reduce some uncertainties regarding performance of the barriers. FPH will continue to develop the safety case, with an update to be presented in connection of the construction and operating licences for the enlargement of the repository for the disposal of the decommissioning waste, and in the connection of the periodic safety reviews.

Safety assessment performed for decommissioning of research reactor

The safety of the research reactor FiR 1 was reviewed focusing specifically on the safety of the decommissioning during 2017–2019. STUK's safety assessment concerning decommissioning was published in spring 2019.

Article 16 Operation of facilities

Each Contracting Party shall take the appropriate steps to ensure that:

(a) the license to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(b) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;

(c) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility, the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;

(d) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;

(e) procedures for characterization and segregation of radioactive waste are applied; and incidents which are significant to safety are reported in a timely manner by the holder of the license to the regulatory body;

(f) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(g) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;

(h) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

The legislative and regulatory requirements discussed under Article 9 are also valid for the predisposal management of LILW from the NPPs for the operational period of an LILW disposal facility, spent fuel encapsulation plant and spent fuel disposal facility. Therefore, only some specific features related to the disposal of LILW or spent fuel, as well as those related to radioactive waste from small operators, are presented here.

Initial authorization

The Nuclear Energy Decree (Section 36) requires that several documents, including the Final Safety Analysis Report (FSAR), are submitted to STUK when applying for an operating license for a nuclear facility. More detailed requirements are given in Guide YVL A.1, including STUK's review and inspection of the commissioning of a nuclear facility. The requirements for the safety assessment are discussed in detail above under Article 15.

In the context of the commissioning of a nuclear waste facility, the licensee must ensure that the systems, structures and components, as well as the entire facility function as planned. The licensee must ensure that an appropriate organization, adequately skilled workforce and applicable instructions exist for the future safe operation of the facility.

Operational limits and conditions

The requirements concerning operational limits and conditions are discussed in Article 9 and they are also valid for LILW facilities, including disposal, management of non-nuclear radioactive waste and for spent fuel encapsulation plant and disposal facilities.

Established procedures

According to the STUK Regulation on the Safety of Disposal of Nuclear Waste (STUK Y/4/2018) appropriate instructions must exist for the operation, maintenance, regular in-service inspections and periodic tests, as well as for transient and accident conditions. The reliable functioning of systems and components must be ensured by adequate maintenance and by regular in-service inspections and periodic tests. Detailed requirements are given in YVL A.3. This topic is also discussed in Section G.

Updated assessment for post-closure period

For the LILW disposal facilities, both in Loviisa and Olkiluoto, the operating license conditions require a periodic update of the safety assessment. The STUK Regulation (STUK Y/4/2018), concerning nuclear waste disposal, requires that a safety case must be presented when applying for a construction license and operating license for the disposal facility and when making substantial plant modifications. The safety case must be updated at regular intervals unless otherwise required in the license conditions. The need for updating the safety case must be assessed before making modifications that concern the disposal system. Furthermore, the safety case must be updated prior to the closure of the disposal facility.

Engineering and technical support

The STUK Regulation (Y/4/2018) requires that the licensee will employ adequate and competent personnel for ensuring the safety of the nuclear waste facility. The licensee must have access to the professional expertise and technical knowledge required for the safe construction and operation of the facility, the maintenance of equipment important to safety, the management of accidents and the long-term safety of disposal. The LILW repositories operate under the NPP organizations but the same regulations are applied. More detailed guidance for adequate engineering and technical support is presented in Guide YVL A.4 applies.

Posiva has expertise on planning for the safe disposal operation of SNF. Posiva's own expertise is supported by the technical expertise of Posiva's owners, TVO and FPH, and also by external experts. TVO and FPH have expertise on operating the LILW disposal facilities and their own expertise is supported by external experts.

Characterization and segregation of waste, incident reports

The guidance and requirements for LILW characterization and segregation is provided in Guide YVL D.4. STUK reviews plant procedures, the FSAR, and performs inspections on waste management at the NPPs and the disposal facilities to ensure compliance with all requirements.

Guide YVL D.3 provides requirements concerning the characterization of spent fuel to be disposed of and the characterization of the spent fuel disposal canisters. The properties that have a bearing on operational or long-term safety of disposal must be defined and characterized.

Incident reporting requirements are given in Guide YVL A.10.

Decommissioning plans

The Nuclear Energy Act (Section 7 g) states that the design of a nuclear facility must provide for the facility's decommissioning. The related decommissioning plan should already be presented in the construction license phase and the updated version of it in the operation license phase. During operation, the licensee is obligated to update decommissioning plans for regulatory review every six years (Section 7 g in Nuclear Energy Act). Guide YVL D.4 requires that provisions for the decommissioning of the nuclear facilities should be made already during the design phase.

The plans for the decommissioning of the facilities for LILW and spent fuel management, other than repositories, are part of the decommissioning plans of the NPPs.

The decommissioning plan of the spent nuclear fuel encapsulation plant was presented in the construction license application of spent fuel repository in 2012. The encapsulation plant will be decommissioned according to immediate dismantling strategy. The decommissioning plan for the encapsulation plant contains a preparation phase for decommissioning. The length of the preparation phase is about one year. The actual dismantling of the encapsulation plant and disposal of decommissioning waste is estimated to take about two years. The decommissioning plan for encapsulation plant will be updated for the operating license application of spent fuel reposiroty and regularly during operation.

Decommissioning is discussed in more detail under Article 26.

Closure plans

According to STUK Y/4/2018 the design of the disposal facility must consider the safety of the closure of the facility after its operation has ended. The disposal facility must be designed, constructed and operated in a manner that allows it to be closed without jeopardizing long-term safety. In addition, the siting, excavation, construction and closure of underground rooms must be implemented so that the characteristics of the rock deemed important in terms of long-term safety are retained, as far as possible.

The closure plans of the LILW repositories are presented in the Final Safety Assessment Reports of the facilities.

The closure plan for the spent nuclear fuel disposal facility was presented in the construction license application and in its technical appendices in 2012. The main closure principles, preliminary design requirements, implementation plan and materials to be used were presented. The main aim is that the closure of the disposal facility is planned and implemented so that the favourable bedrock conditions for disposal are maintained. After closure of the disposal facility the conditions in the bedrock should be as close to the natural bedrock conditions as possible. Posiva will continue the detailed closure planning over the forthcoming years.

Article 17 Institutional measures after closure

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility:

(a) records of the location, design and inventory of that facility required by the regulatory body are preserved;

(b) active or passive institutional controls such as monitoring or access restrictions are carried out, if required; and

(c) if, during any period of active institutional control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.

Regulatory requirements

According to STUK's Regulation on the Safety of the Disposal of Nuclear Waste (Y/4/2018), records must be kept of the disposed waste, which includes waste package specific information about the waste type, radioactive substances, location in the waste emplacement rooms and other necessary data. STUK maintains a database, where the nuclear waste data reported annually by the operators of the NPPs are stored. Guide YVL A.9 provides general requirements for reporting to STUK and includes provisions for waste management reporting. More detailed requirements for waste management records are given in Regulatory Guides YVL D.4 and YVL D.5. During the operational period, the records referred to above must be annually complemented and submitted to STUK. STUK will organise the long-term archiving of the information about the disposal facility and the disposed waste (STUK Y/4/2018, Section 29).

Institutional control

Two types of institutional control can be implemented: restrictions on land use (passive control) and technical surveillance of closed facility surroundings (active control).

According to the Nuclear Energy Act, Section 63, STUK's regulatory oversight rights include issuing land use restrictions after the closure of the disposal facility when deemed necessary. STUK's Regulation (Y/4/2018) on nuclear waste disposal further stipulates that an adequate protection zone should be reserved around the disposal facility as a provision for the prohibitions of measures referred to in Section 63 of the Nuclear Energy Act.

According to Guide YVL D.5, it can be assumed that human activities affecting the disposal facility, or the nearby host rock are precluded for 200 years at the most by means of land use restrictions and other passive controls. YVL D.5 also requires that before closure the facility operator shall submit for approval a closure plan to STUK including a plan for possible institutional control measures and a proposal for a protection zone. It should also be noted that the Finnish repositories for LILW are located at a depth of 60–100 m in the bedrock and the spent fuel disposal facility is planned to be located at least 400 m below the surface.

Potential intervention measures

After approval of the final closure of a disposal facility, the State bears the responsibility for the waste facility and of all intervention measures that may be needed (the Nuclear Energy Act, Section 34). Such measures are unlikely, because the disposal concepts are based on passive safety; multiple engineered barriers ensuring effective long-term containment of the disposed waste.

SECTION I
Transboundary Movement

Article 27 Transboundary movement

Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In so doing:

(a) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;

(b) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized;

(c) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

(d) a Contracting Party which is a State of origin shall authorize a accordance with the consent of the State of destination that the requirements of subparagraph (c) are met prior to transboundary movement;

(e) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

A Contracting Party shall not license the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees south for storage or disposal.

Nothing in this Convention prejudices or affects:

(a) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

(b) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;

(c) the right of a Contracting Party to export its spent fuel for reprocessing;

(d) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

Regulatory requirements

Regulations on transport of dangerous goods are laid down in Act on the Transport of Dangerous Goods (719/1994). In addition, several Decrees define more detailed requirements on the transport of dangerous goods. As far as radioactive material is of concern, additional requirements are given also in the Radiation Act (859/2018), as well as in the Nuclear Energy

Act (990/1987) and Decree (161/1988). Further guidance is given in Regulatory Guides YVL D.2 and ST 5.7 by STUK.

Concerning the transboundary movement of radioactive material, the Regulation 93/1493/ Euratom on shipments of radioactive substances between Member States must be applied. The requirements are also in accordance with the European Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel.

State border control concerning nuclear and non-nuclear radioactive materials

With respect to illicit trafficking, regulatory and detection measures were taken in the mid of 1990s to address and prevent the illicit trafficking of nuclear and non-nuclear radioactive materials across Finland's borders. The measures included installing fixed monitors for vehicles and railway traffic at all major crossing points along the Finnish–Russian border and at Helsinki harbour, and portable monitors at all crossing points. All measuring systems at the Finnish border crossing points were upgraded during 2008–2015 (the RADAR project), including upgrading all systems with neutron detection capability, allowing better detection of special nuclear materials. From 2016 onwards the Customs is the main operator of the radiation control measuring systems at the border crossing points. STUK owns the measuring equipment and is responsible for its maintenance. In addition, STUK arranges the trainings for the Customs personnel responsible for radiation protection on an annual basis. In 2019, the systematic radiation monitoring at the State borders led to 298 documented investigations. Of these cases, 38 were investigated in more detail with STUK assistance. None of these were associated to illicit trafficking.

Shipments of spent fuel and radioactive waste in 2017–2019

The shipments of spent fuel and radioactive waste abroad were denied by the Nuclear Energy Act approved by Finnish parliament in 1994 and the amendment regarding this change came into force in 1996 as part of the national nuclear waste management policy. Since then only shipments for reaseach purposes or waste processing (e.g. melting of metals) are allowed by Finnish legislation (Nuclear energy act Section 6 a).

Transboundary movements take place very seldom in Finland. During 2017–2019 spent fuel rods were shipped out of Finland to Sweden for research (2 shipments) and some large metal components were shipped also to Sweden for scrapping (3 shipments). Radioactive waste will be shipped back to Finland after the treatment. In addition, radioactive source inside steel scrap pale was returned from Finland back to Estonia. The authorization of these shipments was done according Directive 2006/117/Euratom.

SECTION J
DISUSED SEALED SOURCES

Article 28 Disused sealed sources

Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.

A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

Regulatory requirements

Regulatory control of radioactive sources is based on the Radiation Act and regulations issued pursuant thereto, into which the provisions of the European Union radiation protection directive (Council Directive /2013/57/ Euratom) have been implemented. Other EU regulations are applicable as well, e.g. the Council Regulation 1494/93/Euratom on shipments of radioactive substances between Member States.

According to the Radiation Act (Section 48) prior authorization is required for all activities involving radioactive sources, e.g. for the use, manufacture, trade in, holding and disposal of such sources. A safety license is granted by STUK upon written application. The general conditions for granting a license are laid down in the Radiation Act and the licensing procedure is prescribed in more detail in the Government Decree on Ionizing Radiation Annex 5. All premises where radioactive sources are employed are inspected by STUK regularly, every 2–8 years, depending on the type and extent of the practice. For sealed sources, the inspection frequency has normally been once every 3, 5 or 8 years depending on the activity and number of sources. The main objective of an inspection is to validate that the radioactive sources are used and stored safely, and other conditions set in the safety license are preserved. The inspector must identify each sealed source. However, the premises where several tens or more sources are employed (such as a large industrial facility) the licensee must provide written evidence of its own quality control on all the sources and then the inspector will randomly select about 10–20% of the sources for identification. Any discrepancies with the licensing information concerning the placing of the sources, new sources and sources taken out of use are recorded for amending the license accordingly. STUK is currently reviewing its inspection practices, and inspection frequencies will be considered more risk-informed in the future and other monitoring means will also be used.

The Radiation Decree (Section 130) provides that STUK has to be notified immediately, if a radiation source has disappeared, been stolen, lost or otherwise ceased to be in the licensee's possession. Licensing information is stored in a database maintained by STUK, also including source-specific information on each sealed source in the licensee's possession. Source-specific information is updated continuously according to the licensees' notifications and observations made during the inspections. Some low-activity radioactive sources, such as calibration sources employed in laboratories, as well as sources in the storages of dealers (e.g. importers of radioactive sources) are not individually registered in STUK's database. However, records of transfers of sources maintained by dealers are reported to STUK annually and they are also subject to inspection by STUK at any time.

Finland has pledged to the apply the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and its supplementary Guidance on the Import and Export of Radioactive Sources as well as Guidance on the Management of the Disused Radioactive Sources. The Code and the Guidance have been implemented into national requirements. Major parts of the Guidance on Disused Sources have been implemented into national requirements. However, some details are pending an update to the Radiation Act. Finland also actively participates on IAEA activities regarding this subject. However, as a member of the European Union and bound by its law, Finland only applies the Code with import or export from or to outside the EU. Source transfers within the EU are only regulated according to Council Regulation 1493/93/Euratom. Each import or export (as opposed to intra-EU transfer) of a high-activity sealed source requires a separate authorization by STUK. Procedures of the Guidance are followed for IAEA category 1 and 2 sealed sources.

Handling of disused sealed sources

Radiation Act (Section 83) states that it is not appropriate to store unnecessarily sealed sources no longer in use. In practice, however, it is sometimes difficult to define whether a stored source might have some use in the future. The annual fee for holding a license depends on the number of sources in the licensee's possession and, therefore, there is some financial incentive to transfer disused sources back to the provider (and therefrom to the manufacturer) or to a facility authorised for the handling, long-term-storage and disposal of disused sources. The number of devices containing unused sealed sources stored in the premises of various licensees is currently (2.3.2020) 404, i.e. about 6% of the total number of such devices in use (the total number is about 6680).

TVO has leased a storage cavern to the State in the LILW disposal facility at Olkiluoto for the interim storage of non-nuclear radioactive waste. The safety of the operations at the Olkiluoto storage is independently regulated by STUK's Department of Nuclear Waste Regulation and Safeguards. The most of this waste, including sealed sources, will be disposed of in the disposal facility. The disposal started at the end of 2016 based on revised operation conditions in 2012. A few high activity sealed sources will need a different disposal route, which is not yet determined. Finding solution to this issue is part of national cooperation described further in Annex L.4.

Disused sources have been collected by a private entrepreneur (Suomen Nukliditekniikka), by whom they are repacked, as necessary, and then transferred to state´s storage at Olkiluoto. Handling of radioactive disused sources from other companies requires also prior authorization. Suomen Nukliditekniikka is currently the only company authorised for this and has been the main operator in collecting and repacking disused sealed sources.

When new sources are authorized for use, STUK requires the applicant to present a plan on measures to be taken when it becomes a disused source. Essentially there are two main options;

either to have an agreement with the provider on returning the source or to transfer the source to the central storage facility at the cost of the licensee.

During recent years Finnish companies have exported annually some 500–1000 (2019: 518 items; 2019: 1235 items) sealed sources to foreign providers. Sealed sources that have not been manufactured in Finland cannot be imported to Finland as radioactive waste. Currently there is no on-going manufacturing of sources in Finland.

Orphan sources

According to the Radiation Act (Section 79), the licensee is required to take all measures needed to render radioactive waste arising from its operations harmless. If the origin of the waste is unknown, as in the case of orphan sources, the State has the obligation to render the radioactive waste harmless (Section 80). In such cases, responsible party – if identified later – must compensate the State for the costs incurred in such an action. With respect to orphan sources and border controls, see Section I.

All important users of scrap metal have fixed radiation monitors installed at the entrances to their facilities. Two largest scrap metal companies and one metal steel factory have been authorised to handle orphan sources according Radiation Act (Section 86). The procedures for orphan source handling have been presented to STUK before authorization. STUK co-operates with the Finnish Customs office and the metal industry in questions such as measurement arrangements and personnel training. STUK also provides expert help in cases where exceptional radiation is detected.

On an average, about 2–3 sealed radioactive sources have been found annually in scrap metal. Orphan sources, whose owners cannot be identified, are delivered to the State interim storage at Olkiluoto.

SECTION K
General Efforts to Improve Safety

The 6th Review Meeting in 2018 identified challenges and recorded some planned measures to improve the safety of radioactive waste management in Finland. The status of the overarching issues and challenges identified in the 6th review meeting is summarized in the beginning of this Section. The major developments in the nuclear and non-nuclear radioactive waste management in Finland since the 6th Review Meeting are the following:

- Spent nuclear fuel disposal project progressed in construction of the disposal facility and the encapsulation plant
- Licensing for decommissioning of Finland's first nuclear reactor commenced
- Progress in the low and intermediate waste management
- Strategy to enhance regulatory oversight
- The legislative and regulatory system was enhanced
- Improvement of the national plan for radioactive waste management
- The management of non-nuclear radioactive waste has progressed.

Aspects of nuclear and non-nuclear radioactive waste management have been developing well in Finland, but there are still challenges which Finland faces in the forthcoming years. These future challenges will be summarized in this Section as well. Finally, the 6th review meeting summarized good practices among the convention countries. In the end of this section, these are shortly reflected against the current status of Finnish radioactive waste management.

Overarching Issues identified by the 6th Review Meeting

The 6th review meeting identified issues which were common across the country groups and were deemed to be important to be addressed by the national reports for 7th review meeting. These overarching issues are listed in below and following a short consideration of each issue against the Finnish context.

1) Implementation of national strategies for spent fuel and radioactive waste management
The general objectives and timeline for the Finnish spent fuel management was essentially outlined with the Government Decision of 1983. The early-day disposal plans and arrangements are dealt in more detail in Section B, Article 32 and Section H, Article 11. The 1983 decision defined that the siting and evaluation work by licensees for the geological disposal option shall aim to the site selection by the end of year 2000. This Decision of 1983 also defined that construction license application for the spent fuel disposal facility should be applied by the end of year 2010 (this was delayed in 2003 with two years) and disposal operations should start around 2020 (current plan is the year 2024).

The construction license for the spent fuel disposal facility was granted at the end of 2015 (for more details see Section H, Articles 12 and 13). After the license, the extension of the underground research facility begun in 2016 towards the licensed underground rooms. Operating license application is expected to be delivered to the ministry at the end of 2021. Disposal is not possible until the granted operating license.

The operating NPP (Loviisa and Olkiluoto) have operating disposal facilities for LILW for power plant waste (see Secton H). Furthermore, extensions of these facilities are planned for decommissioning phase of power plants.

For the major part of the non-nuclear radioctive wastes there are defined responsibilities and waste-streams for conditioning, storage and disposal. However, certain highly active sealed sources do not have yet complete route for disposal as indicated in Section J (see also Annex L.4).

The infrequent discovery of orphan sources remains an issue. On an average, about 2–3 sealed radioactive sources have been found annually in scrap metal. Orphan sources, whose owners cannot be identified, are delivered to the State interim storage at Olkiluoto. To strengthen the responsibility of larger operators, Radiation Act was amended to include a safety license for operators that frequently come across orphan sources. To date, three such licences have been issued.

Overall, Finland considers that it is implementing, or it has realistic plans how to solve its waste management and disposal.

2) Safety implications of long-term management of spent fuel

Finland implements its overall policies described in Section B and national disposal strategies (described above) aiming for spent fuel disposal in geological repositoritory. The disposal plans and related licensing activities of long-term management of spent nuclear fuel from currently operating NPP's are at a mature stage in Finland (see Section G).

According to the plans, spent fuel is stored minimum 20–30 years at Olkiluoto and at Loviisa in interim storages before disposal. The Olkiluoto spent fuel interim storage facility has undergone many improvements during its extension, which commenced operations in summer 2015. Furthermore, the safety of both Olkiluoto and Loviisa spent fuel storage facilities has been improved since the Fukushima Dai-ichi accident. The capacity of both interim storage facilities has been evaluated to be adequate until the nuclear power plant operational lifetime, in case spent fuel disposal progresses as planned. Finland does not see any significant safety implications related to long-term management of spent fuel.

3) Linking long-term management and disposal of disused sealed radioactive sources

For the major part of the non-nuclear radioctive wastes there are defined responsibilities and waste-streams for conditioning, storage and disposal. As indicated in Section J and in the challenges below, there is a lacking disposal route for a minor set of highly active disused sealed sources. The predisposal management (treatment and conditioning) of these sources has been arragned, but licensed disposal is currently not available. This issue is also futher considered in Annex L.4.

4) Remediation of legacy sites and facilities
Currently, there are no unsolved legacies in Finland that would require remediation. During years 1958–1961 a uranium pilot mine operated in Paukkajanvaara, Eastern Finland. The pilot mine produced some 30 tU until the activity was found uneconomical. The pilot resulted some radioactive tailings and the legacy remained unsolved over three decades. As a result of STUK's initiative, the remadiation of the mine area finally started in 1993. The mine tailings were covered with a 2-metre thick soil cover and the mine pit was closed. STUK accepted the results of remediation in 2001.

There has been couple even smaller initiatives of uranium prospects. Imatran Voima (predecessor of FPH) studied Askola rapakivigranite (southern Finland) in late 1950s and Geological Survey of Finland continued later these studies (during late 1970s). In mid 1960s in Paltamo, NE Finland was discovered uranium from apatite contining drill cores. These prospects, as well, included some on-site extraction experiments. However, the tailings caused have been judged to be insignificant.

The status of the challenges from the 6th Review Meeting

The challenges to be addressed are listed in the following and status of them are shortly described.

1) Improvement of national waste management system to cover all possible waste streams (non-nuclear clean-up waste, FiR 1, HASS)
Because of the contamination event in the premises of Suomen Nukliditekniikka in 2016, a clean-up of Cs-137 contaminant had to be arranged. This clean-up created a moderate amount (20 m³) of non-nuclear radioactive waste. The items that were able to be decontaminated have been treated accordingly and disposed appropriately. The remaining waste (10 m³) has been treated and is currently stored in an interim storage. It's estimated that about half of this waste (5 m³) will need underground disposal and the rest of the waste can be classified as VLLW. The whole incident revealed a deficiency in the Finnish national waste management system for handling this type of non-nuclear radioactive waste. However, also deficiencies in the company safety culture and activities have been identified as well as a deviation in regulatory control.

Recent operating license updates (2018 and 2019) for Olkiluoto NPP units enable now the treatment and conditioning of non-nuclear LILW wastes, and the 2012 license update for Olkiluoto LILW repository enables disposal of these wastes. Therefore, deficiency for handling non-nuclear LILW waste in Finland has been addressed.

The High Activity Sealed Sources (HASS) that are not suitable for disposal in existing LILW repositories are remaining in the interim storage for non-nuclear wastes at Olkiluoto. Disposal route for these type of HASS sources will be addressed as a part of the Finnish national waste management plan but currently there is no operating facility that could dispose of these sources. MEAE steers a national coordination group that is engaged to find solutions to these problems (see further details below and Annex L.4). On a general level, the disposal of highly active non-nuclear radioactive waste is a national challenge for Finland and will remain so until practical options for disposal become available.

The decommissioning of the research reactor (FiR 1) is the first nuclear decommissioning project in Finland. It is still in the licensing phase. According to the current estimate the Government will consider the license application in autumn 2020. The primary option for spent fuel management is to repatriate it to the USA according to the existing return programme, which is valid until 2029. In March 2020, VTT signed a contract with FPH on dismantling FiR1 research reactor and waste management, as well as possible storage and disposal of decommissioning wastes to Loviisa NPP site. The storage and disposal would require changes to the existing operating license of Loviisa repository and Loviisa NPP. The secondary option for the FiR 1 spent fuel is the future disposal in the Olkiluoto spent fuel disposal facility. This would also require new agreements and licenses as indicated in Section B, Article 32.

As a summary Finland has addressed the challenge raised in the 6th review meeting. National system has been enhanced and plans for further enhancement exist. However, implementation of disposal routes for waste identified above will require some time.

2) Developing competences, regulatory framework, and regulatory oversight for decommissioning of nuclear facilities

Decommissioning license step was added into the Nuclear Energy Act and Nuclear Energy Decree from the beginning of 2018. This clarified the terms for the decommissioning of the nuclear facilities. Also, the Guide YVL D.4, which sets more detailed requirements for the decommissioning phase, was slightly updated in 2019. Anyhow, STUK and MEAE have already recognized the need to develop the requirements related to decommissioning for the future decommissiong projects. The decommissioning of the research reactor will be very important learning process for the regulatory body as the experiences gained will be used in updating the regulations and guides and later in planning the regulatory oversight for the decommissioning of NPPs. In addition, STUK is following the international development on the decommissioning and implementing in the forthcoming years the good practises into its regulations, guides and regulatory oversight actions.

STUK has established a regulatory oversight project which aims to ensure competent resources during the whole decommissioning phase of the research reactor. The project is supported by a range of STUK experts with varying areas of required competence. As a result of recently reached agreement between VTT and FPH, the practical regulatory oversight of the decommissioning is becoming topical and is to be planned, applying graded approach.

Developing competences, regulatory framework, and regulatory oversight for decommissioning of nuclear facilities will remain as continuing challenge even if Finland has clear plans how to manage the situation.

3) Regulatory communication to improve the general public´s understanding of disposal safety

STUK aims to communicate proactively, openly, promptly and clearly (see also Section E, Article 20). STUK is well-known to the public and the media. The communication strategy is based on the most trustworthy information available and responds to the expectations of the public. STUK communicates on its own web site and on social media platforms.

Communication with the public and other interested parties remains highly important for STUK. The objective is to share understandable and reliable information promptly as it arises. This will remain as continuing challenge in the future in the changing communications environment. General public interviews done during the years indicate that on its behalf STUK has succeeded in the past (cf. Section A, Figure 2). However, the proactive communication will be especially important during the coming years as licensing the spent fuel disposal facility operation becomes topical.

4) Independent research and maintenance of competent oversight

Currently the nuclear field in Finland is very active. Maintaining nationally both competent regulatory resources and qualified regulatory oversight, while older generations are reaching retirement age, forms a continuous challenge to the regulatory body. Also, the independent safety research within the regulatory body has been under pressure during the second decade of the new millennium.

Buiding-up competence of new resources and employees in the field of radioactive waste management is a shared concern of many interested parties (government, regulators, licensees, research institutes, universities). As an answer to this, a joint effort of introductory training has been taken. Courses on nuclear safety (YK course) and nuclear waste management (YJH course) have been arranged on annual basis since 2003 and 2010, respectively. For the season 2017–2018 these two courses were for the first time merged as a new nuclear and waste management safety (YJK) course. In all, YJK covers six separate training sessions and extends to 23 working days. Great interest for the courses confirms the need (over 1000 participants since 2003) and justifies the annual or every other year arrangements. Interest has also been shown to a tailor-made, common course for directors and board members of the nuclear power industry.

Publicly funded nuclear waste research has been going on since 1989 in Finland. Currently, the national research programme (KYT research programme) is in central role in the development of new competent human resources and higher educational degrees in the field of radioactive waste management. The 2012–2015 initiative (YTERA- Doctoral programme for Nuclear Engineering and Radiochemistry) ceased because of the financial difficulties.

The research institute VTT is the only hot cell service provider in Finland in the field of nuclear laboratory research. In 2016, VTT nuclear energy and nuclear safety researchers moved to a new CNS building that received STUK's safety license in 2017. VTT Nuclear Safety research employs 150 researchers and has six hot cells. VTT CNS offers its services nationally and intermationally to licensees but is also available for regulatory support.

The governmental budget cuts resulted in significant decrease of STUK's own radiation safety research during the recent years. Budget cuts did not impact STUK's oversight activities (charged from the licensees) or nuclear and waste safety research (funded via the waste management fund). To re-establish radiation safety research in Finland STUK actively pushed establishment of a national radiation safety research consortium in co-operation with universities in Finland. STUK has also been able to fund more its own radiation safety research with the incomes from expert services. Ensuring continued and stable funding of the radiation safety reseach in Finland remains a challenge (see Section E, Article 20).

The major developments in Finland since the 6th Review Meeting

Since the 6th review meeting certain major developments have been achieved in Finland. The successful activities during years 2017-2019 that earn separate references are listed in the following.

1) Spent nuclear fuel disposal project progressed in construction of the disposal facility and the encapsulation plant

Posiva submitted the construction license application and its supporting safety documentation to the authorities at the end of 2012. STUK's safety review and assessment of the application was submitted to the MEAE in February 2015. The construction license was granted by the Government to Posiva in November 2015. The construction of the disposal facility started in December 2016. The disposal project and granted license covers spent fuel from five reactors: LO1 and LO2, and OL1, OL2 and OL3. The construction of the disposal facility has proceeded as planned. The construction of the encapsulation plant began in June 2019 (Planned Measures to Improve Safety: Construction and oversight of the spent fuel disposal facility). Detailed description of the Posiva disposal facility project and the oversight are given in Annexes L2 and L3.

Posiva is also preparing to the commissioning phase and the operation license phase with planning the schedules and procedures. The prereview process of operation license documentation is agreed with the regulator and it is implemented within next years.

2) Licensing for decommissioning of Finland's first nuclear reactor commenced

VTT applied from the Government for a license for decommissioning of the FiR 1 research reactor in June 2017. STUK gave its statement and safety assessment of the license application to the MEAE in spring 2019. The main conclusion was, that the license for the decommissioning can be granted, but the detailed planning for the decommissioning phase and for the nuclear waste management shall be developed further before the actual dismantling can start. The waste management plans have been developed further as VTT signed a contract with FPH in March 2020, which agrees on the handling, storage and disposal of decommissioning waste in Loviisa NPP site. Future activities still need changes to the exisisting operating license of Loviisa disposal facility and Loviisa NPP. The dismantling will be regulated by STUK concerning radiation and nuclear safety aspects. The preliminary planning of the regulatory oversight activities for dismantling is on-going at STUK.

As the dismantling activities of the research reactor have not started during the reporting period, the identified measures to improve safety concerning decommissioning are still underway and remains future tasks. (Planned Measures to Improve Safety: Licensing of research reactor decommissioning and start of dismantling activities.)

3) Progress in the low and intermediate waste management

FPH delivered to STUK the updated post-closure safety case in 2019. In the safety case both the constructed parts of the repository and planned parts for the decommissioning waste disposal are addressed. The safety case also considered the updated regulation and guidance.

STUK reviewed the safety case and reached conclusions on the adequacy of FPH's submission. The focus of STUK's review has been to ensure that the safety case for the repository follows the structure and intent of the regulatory requirements and is sufficiently developed and convincing to address the post-closure safety of the repository. The Loviisa LILW repository post-closure safety case is dealt more in Section H (Article 15).

FPH will continue to develop the safety case, with an update to be presented in connection of the construction and operating licences for the enlargement of the repository for the disposal of the decommissioning waste, and in the connection of the periodic safety reviews.

In 2019 STUK also approved the commissioning of the solidified waste hall in the FPH's low and intermediate waste repository. In the end of 2019, FPH promptly started the disposal in the hall (cf. Figure 7).

At the end of 2018, TVO started its plannings for a VLLW near-surface disposal facility to be located at the Olkiluoto island. The licensing preparations of the facility are active and during the 2020 the EIA studies to be annexed with the application were going on.

4) Strategy to enhance regulatory oversight

STUK published a new strategy in 2018 covering the period of 2018–2022. The strategy is comprised of nine targets categorizied in three groups and supported by four core values as presented in Figure 14. The implementation of the strategy is underway. As part of the implementation STUK has started to evaluate its approach to spent fuel disposal oversight. STUK implemented project using service design where Posiva was involved as a customer for the regulator. Service design project outlined aspects related to roles of experts, clarity of organisations formal standpoint and interaction between STUK and Posiva that require further improvement actions.

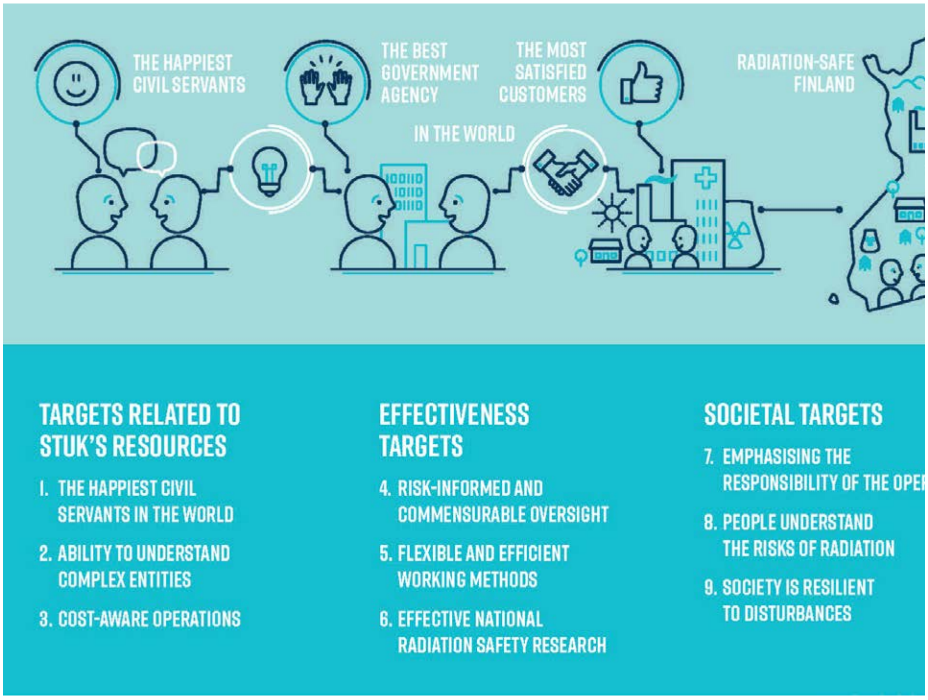


FIGURE 14. STUK strategy: vision, targets and values.

5) The legislative and regulatory system was enhanced

The Nuclear Energy Act was revised due to the Basic Safety Standards directive and because of the amended Nuclear Safety Directive in 2018. The revision of the Nuclear Energy Act included also amendments related to changes in the Pressure Equipment Act and licensing of nuclear facilities. The new Nuclear Energy Act and Decree introduced a decommissioning license step. The decommissioning license is granted by the Government. The Nuclear Energy Act is being updated in 2020 to renew legislation related to nuclear security arrangements.

In 2015, a revision to the Nuclear Energy Act enabled STUK to issue legally binding regulations. STUK has updated three of its regulations from 2016:

- Radiation and Nuclear Safety Authority Regulation on the Safety of Nuclear Power Plants (Y/1/2018)
- Radiation and Nuclear Safety Authority Regulation on the Security in the Use of Nuclear Energy (Y/2/2018)
- Radiation and Nuclear Safety Authority Regulation on the Safety of Disposal of Nuclear Waste (Y/4/2018).

Other regulations are currently being updated. In addition to the updated regulations, STUK issued one new Guide YVL D.7 Release barriers of spent nuclear fuel disposal facility in 2018.

A new Radiation Act proposal was submitted to Parliament on 28 March 2018. Parliament adopted the new Radiation Act on 29 September 2018. The act entered into force on 15 December 2018.

The new Radiation Act (859/2018) and secondary legislation issued under it implement the European Union's new Basic Safety Standards Directive concerning radiation protection (2013/59/Euratom). The implementation of the Directive required Finland to make many structural and terminological changes to its radiation legislation. Therefore, an overall reform of radiation legislation was justified in connection with the implementation of the Directive.

Government Decree on the Ionizing Radiation (1034/2018) issued on 22 November 2018 by the virtue of the new Radiation Act (859/2018) replaced the previous Radiation Decree (1512/1991).

The new Radiation Act authorizes STUK to issue legally binding regulations. One regulation was issued by the virtue of the Nuclear Energy Act and the Radiation Act:

- Radiation and Nuclear Safety Authority Regulation on the Exemption and Clearance Levels (STUK SY/1/2018)

As a result of overall reform of the radiation legislation, the status of ST Guides has been changed as recommendations.

Furthermore, it is regocnized that the current nuclear legislation has been amended several times. Therefore, MEAE has begun to evaluate the need of a comprehensive reform of the nuclear legislation.

6) Improvement of the national plan for radioactive waste management
Finland has a well-functioning system and technical solutions for the management of nuclear waste arising from NPPs and for the major part of non-nuclear radioactive waste. However, as a consequence of the sealed source incident in 2016 and its related clean-up work, as well the planning strorage and disposal of the research reactor decommissioning waste, and the continuing challenge of disposal of a few HASS sources, it has been identified that our national radioactive waste management plan and licensing system needs to be evaluated and improved to address all possible waste streams.

To improve the national plan, MEAE appointed in 2017 a National Cooperation Group on nuclear waste management (YETI) to examine the objectives, development measures and possible solutions for safe and cost-effective management of nuclear waste and other radioactive waste. Based on its deliberations, the group issued 15 recommendations and 7 suggestions to achieve these objectives. Currently the group follows up how its recommendations are being addressed. The group also addressed recommendations made by the Finnish Safety Investigation Authority about the sealed source incident in autumn 2016. The YETI group is described in more detail in Annex L.4.

In April 2018, MEAE appointed a working group tasked with assessing and proposing amendments to the legal standards that regulate the investment activities of the VYR Fund and its product selection. The working group concluded that regulation and administration of the investment of assets under the Fund's management can be amended in a way that provides opportunities for better long-term fund performance while at the same time ensuring that there are enough assets available to cover the costs of nuclear waste management. Ministry is currently preparing the amendments based on working group's opinion.

7) The management of non-nuclear radioactive waste has progressed
TVO has leased a cavern in the LILW disposal facility at Olkiluoto to the State for the interim storage of non-nuclear radioactive waste. The revised (in 2012) license conditions of the Olkiluoto LILW disposal facility enabled the disposal of non-nuclear waste, including sealed sources at the Olkiluoto LILW disposal facility. This activity started at the end of 2016 and has continued since then. Sealed sources containing nuclides causing the highest doses (C-14, Ra-226 and Am-241) are packed separately and are still stored in the interim storage.

In 2018 Government renewed the operating license of OL1 and OL2 units. The new operating license allows TVO to transfer nuclear wastes freely between the different NPP units (OL1, OL2 and OL3) and nuclear waste management facilities. It also enables TVO to receive radioactive waste from the other radiation users to its waste management facilities for handling, packaging and storage. This enables companies to agree on co-operation in radioactive waste management based on commercial contracts. Due to earlier operating license conditions this was not possible and was thought to be a major challenge for the co-operation in this field. The aim is also in the future to enable the flexible use of existing nuclear waste management facilities for the handling, packaging and storage of the radioactive wastes from the small users of radiation.

Challenges for future work in spent nuclear fuel and radioactive waste management

Finland has identified three main challenges for the future work, and these are summarized below.

1) Implementation of STUK's stategy

Implementation of STUK's strategic objective related to enhancing risk-informed and performance-based regulation and oversight, and highlighting licensee's responsibility for safety, including

- Changes needed to the nuclear energy regulations and regulatory guides, e.g. to be more be goal setting and enabling and emphasising the licensees' responsibility for safety.
- Developing the oversight activities to be more risk-informed and performance-based and emphasing licensees' responsibility, e.g. by crediting licensees' own oversight activities and good safety performance.
- Development of oversight practices and tools to take into account the possibilities offered by digitalisation and ensuring that the personnel has the necessary related skills.
- Ensuring resources on the implementation of the strategic objectives as well as on the oversight of many ongoing activities in different life-cycle phases of nuclear facilities.
- Especially a continuing regulatory challenge is to evaluate and to adapt oversight of Posiva's activities as new information and experience is gathered during the spent fuel disposal progress.

2) Developing competences and the regulatory framework for decommissioning

As the decommissioing of research reactor FiR 1 is Finland's first decommissioning project, Finland has limited experience in this area. The decommissioning project of the research reactor is an important learning process for STUK as the experiences gained will be used in updating regulations and YVL guides, and later also for planning the regulatory oversight for decommissioning NPPs. The first experiences are already gained during the review of the license application. STUK has identified needs to develop further the detailed guidance on the content of the required licensing documentation. There is also a need to consider, which documents shall be kept updated during the decommissioning phase, when the conditions change very often as the dismantling proceeds. The internal reporting of the experiences from the licensing phase is underway at STUK. The planning of the regulatory oversight for the actual dismantling phase is underway. As there is currently only one small decommissioning project on going in Finland, the maintaining and developing competences for the decommissioning remains a challenge in Finland both for the regulator and for the licensees.

3) Continuous challenges

Continuous challenges remain to maintain progress in spent nuclear fuel disposal and to implement improvements for national radioactive waste system identified in YETI group. In these challenges Finland has existing plans and implementation is ongoing. Therefore, no new actions are needed, but challenge still exists.

Areas of good Good Practices identified by the 6th Review Meeting

The 6th Review meeting identified six good practices during the Country Group Sessions held in May 2018. Those six good practices are listed in the following and are shortly refrected with short national responses.

1) Significant progress in the establishment of a final disposal facility for spent fuel: a construction license has been granted and construction has commenced. All stakeholders have been involved in the process of site selection. The decision has been taken with the consent of the local municipality.

From the Finnish viewpoint, its clear that our national efforts of many years are the reason for this good practice. As indicated in the beginning of this Section, Finland is approaching the operational stage of spent fuel disposal.

2) Completion of a holistic, graded approach to waste management of all waste types, culminating with the recent development of a dedicated VLLW disposal facility as a complement to the overall implementation of the programme.

Graded approach itself has been implemented in several locations of the national legislation as indicated in the Section E, Article 19 resposes. Finland has minor ambiguities in terms of some waste disposal routes (see e.g. Section H; Section F, Article 26). The recent updates of legislation identify VLLW disposal. Accordingly, both TVO and Fennovoima are planning near-surface disposal (Section B, Article 32). Currently VLLW is disposed together with LLW (Section D).

3) A robust approach to implementing waste management hierarchy has delivered significant benefits for the national programme, particularly regarding the management of LLW which has resulted in major reductions in the volumes of LLW requiring disposal at the LLW repository, thereby extending the lifetime for the facility by a hundred years.

As noted above, there has been some inefficiency in the Finnish VLLW management. Waste that has not been exempted for oversight goes at minimum to LLW disposal. Safety is not compromised but the legislation updates now enable the benefits for licensees.

4) A centralized storage facility for treatment and long-term storage of disused sealed radioactive sources.

For sealed sources that cannot be returned to manufacturer (Section B, Article 32), Finland has a centre for treating, conditioning and temporal storage (Section J) for the sources, and a separate centre for longer term storage (Section H, Article 11). Suomen Nukliditekniikka in Orimattila takes care of the former, while the latter is in the possession of STUK and located within the LILW repository owned by TVO at Olkiluoto.

5) Openness and transparency – public involvement in a national regulatory oversight process through reporting on an annual basis independently from any licensing process.

STUK compiles annual reports on its oversight activities. STUK also serves residents of facility sites by arranging meetings where dialogue about topics concerning local people is possible. During preparatory phase of a new regulation, interested parties are invited to comment and propose improvements to draft regulation.

Decisions of the regulatory body with all the background information used for the decision are public (availale on request) as soon as they are declared. On separate identified grounds (safety arrangements, commercial interests, etc.) parts of the decisions can be kept back from the publicity. On important or publically interesting decisions, as well as, all topical radiation safety related issues STUK publishes press releases on regular basis. The titles of active oversight cases are available from STUK website and website is also used for broader communication with the public (cf. Section E, Article 20)

6) Establishment of a consultative forum at each licensed site composed of regulator, regulatory expert organization, residents, experts recommended by the local residents and governments.

Licensing of the site contains public involvement processes this has been described while considering Section B, Article 32. Specifically, at the stage of considering a site suitability the ministry (MEAE) is responsible of arraning public hearings of interested parties (Section G, Article 6). On the public service basis, STUK is obliged to answer any questions assigned for its attention. STUK has not established permanent groups in licensed sites. Some of the licensees have a consultation group composing of local residents and licensee representatives.

SECTION L ANNEXES

L.1 National regulations and regulatory guides

Legislation

- Nuclear Energy Act (990/1987)
- Nuclear Energy Decree (161/1988)
- Decree on State Nuclear Waste Management Fund (161/2004)
- Act on Third-Party Liability (484/1972)
- Decree on Implementation of Third-Party Liability (486/1972)
- Radiation Act (859/2018)
- Decree on Ionizing Radiation (1034/2018)
- Act on Radiation and Nuclear Safety Authority (1069/1983)
- Decree on Radiation and Nuclear Safety Authority (618/1997)
- Decree on Advisory Commission on Nuclear Safety (1015/2016)
- Act on Environmental Impact Assessment Procedure (252/2017)
- Decree on Environmental Impact Assessment Procedure (277/2017)
- Act on Openness of Government Activities (621/1999)
- Decree on Financial Provision for the Costs of Nuclear Waste Management (991/2017)

STUK Regulations

- STUK Regulation on the Safety of a Nuclear Power Plant (STUK Y/1/2018)
- STUK Regulation on the Emergency Arrangements of a Nuclear Power Plant (STUK Y/2/2018)
- STUK Regulation on the Security in the Use of Nuclear Energy (STUK Y/3/2016)
- STUK Regulation on the Safety of Disposal of Nuclear Waste (STUK Y/4/2018)
- STUK Regulation on the Safety of Mining and Milling Operations Aimed at Producing Uranium or Thorium (STUK Y/5/2016)
- STUK Regulation on the Exemption and Clearance Levels (STUK SY/1/2018 – English translation pending)
- STUK Regulation on plans for radiation safety deviations and actions during and after radiation safety deviations (STUK S/1/2018 – English translation pending)
- STUK Regulation on security of radiation sources subject to authorization (STUK S/3/2018 – English translation pending)
- STUK Regulation on radiation measurements (STUK S/6/2018 – English translation pending)
- STUK Regulation on radioactive waste and releases in the use of unsealed sources (STUK S/2/2019 – English translation pending)
- STUK Regulation on practices involving exposure to natural radiation (STUK S/3/2019 – English translation pending)
- STUK Regulation on radiation safety of radiation sources during use and decommissioning of radiation sources and facilities (STUK S/5/2019 – English translation pending)

- STUK Regulation on practices subject to authorization (STUK S/6/2019 – English translation pending)

The Regulations are available at: https://www.stuklex.fi/en/maarays

Regulatory Guides on nuclear safety (YVL Guides)

(only Guides relevant to this report are included)

Group A: Safety management of a nuclear facility

- Guide YVL A.1 Regulatory control of safety in the use of nuclear energy, 17 March 2020
- Guide YVL A.2 Site for a nuclear facility, 15 February 2019
- Guide YVL A.3 Leadership and management for safety, 15 March 2019
- Guide YVL A.4 Organisation and personnel of a nuclear facility, 15 December 2019
- Guide YVL A.5 Construction and commissioning of a nuclear facility, 15 March 2019
- Guide YVL A.8 Ageing management of a nuclear facility, 15 February 2019
- Guide YVL A.9 Regular reporting on the operation of a nuclear facility, 15 February 2019
- Guide YVL A.10 Operating experience feedback of a nuclear facility, 15 February 2019
- Guide YVL A.11 Security of a nuclear facility, 15 November 2013
- Guide YVL A.12 Information security management of a nuclear facility, 22 November 2013

Group B: Plant and System Design

- Guide YVL B.1 Safety design of a nuclear power plant, 15 June 2019
- Guide YVL B.2 Classification of systems, structures and components of a nuclear facility, 15 June 2019
- Guide YVL B.3 Deterministic safety analyses for a nuclear power plant, 2 September 2019
- Guide YVL B.4 Nuclear fuel and reactor, 15 March 2019
- Guide YVL B.7 Provisions for internal and external hazards at a nuclear facility, 15 December 2019
- Guide YVL B.8 Fire protection at a nuclear facility, 15 December 2019

Group C: Radiation safety of a nuclear facility and environment

- Guide YVL C.1 Structural radiation safety at a nuclear facility, 15 March 2019
- Guide YVL C.2 Radiation protection and exposure monitoring of nuclear facility workers, 1 November 2019
- Guide YVL C.3 Limitation and monitoring of radioactive releases from a nuclear facility, 15 March 2019
- Guide YVL C.4 Assessment of radiation doses to the public in the vicinity of a nuclear facility, 15 March 2019
- Guide YVL C.5 Emergency arrangements of a nuclear power plant, 20 January 2020
- Guide YVL C.6 Radiation monitoring at a nuclear facility, 15 March 2019
- Guide YVL C.7 Radiological monitoring of the environment of a nuclear facility, 19.12.2016

Group D: Nuclear materials and waste

- Guide YVL D.1 Regulatory control of nuclear safeguards, 24 May 2019
- Guide YVL D.2 Transport of nuclear material and nuclear waste, 15 May 2019
- Guide YVL D.3 Handling and storage of nuclear fuel, 17 March 2020
- Guide YVL D.4 Predisposal management of low and intermediate level waste and decommissioning of a nuclear facility, 15 December 2019
- Guide YVL D.5 Disposal of nuclear waste, 13 February 2018
- Guide YVL D.7 Release barriers of spent nuclear fuel disposal facility, 13 February 2018

ST Guides for non-nuclear radioactive waste

As a result of overall reform of the radiation legislation, the status of ST Guides has been changed as recommendations.

- Guide ST 1.1 Safety in radiation practices, 23 May 2013
- Guide ST 1.4 Radiation user's organization, 2 November 2011
- Guide ST 1.5 Exemption of radiation use from safety licensing, 12 September 2013
- Guide ST 1.8. Qualifications and radiation protection training of persons working in a radiation user's organization, 25 January 2016
- Guide ST 5.1 Radiation safety of sealed sources and equipment containing them, 13 September 2016
- Guide ST 5.7 Shipments of radioactive waste and spent fuel, 6 June 2011
- Guide ST 6.2 Radioactive waste and discharges from unsealed sources, 9 January 2017
- Guide ST 12.2 Radioactivity of building materials and ash, 17 December 2010

Summary of national programme

National programme on the management of spent fuel and radioactive waste in Finland – summarising documentation in accordance with Article 12 of the European Council Directive 2011/70/Euratom: https://www.stuk.fi/documents/12547/554501/National+Programme+072015docx+14072015+English+translation+21082015.pdf

L.2 Regulatory control of the Olkiluoto spent fuel disposal project

From a regulatory viewpoint, the Olkiluoto spent fuel disposal project can be divided into the following main phases (approximate years):

1. Research phase from the late 1970s to the DiP licensing phase, 1978–2001
2. Design, research and development phase including construction of an underground rock characterization facility (from DiP to Construction license (CL)), 2001–2014
3. Construction and commissioning phase (from CL to operating license (OL)), 2015–2023
4. Operating phase (2024–2120, if no new NPPs)
5. Decommissioning and closure phase (2120–2125, assuming no new NPPs).

The first step in the licensing process was reached by mid-year 1999, when Posiva submitted the application for a DiP for an SNF disposal facility at Olkiluoto for the spent fuel from the four operating reactors. The DiP was granted by the Finnish Government in late 2000 and was accepted by the host municipality (veto right holder), Eurajoki, and ratified by the Finnish Parliament in early 2001. Later, the DiP was expanded with a separate DiPs to also cover the spent fuel from reactor units OL3

The initial DiP also made possible Posiva to start the construction of an underground rock characterization facility (ONKALO URCF) at the Olkiluoto site to the depth of the planned underground disposal facility. The DiP also requested the continuation of the research, development and design work to further elaborate the safety justifications in the disposal project for the purposes of the construction licensing stage.

Posiva has followed the time schedule set out in the Government decision in 1983 and accordingly submitted a construction license application and its supporting documentation to the authorities at the end of 2012. The Government granted Posiva the construction license at the end of 2015. This was the start of the construction phase.

Regulatory approach to the construction of ONKALO

Nuclear waste regulations require that the rock at the disposal site shall be characterized at the disposal depth. This requirement is further elaborated in the present STUK safety regulation (Guide YVL D.5), which states that the characterization may involve construction of a research or characterization facility on the site. The target of ONKALO URCF has been to ensure the suitability of the Olkiluoto site for a disposal facility and has been proposed from the beginning of the construction project also to be access route to the actual disposal facility in the future. Following the ratification of the Govermental DiP, STUK decided in 2001, based on its safety authority, that the ONKALO access route together with its auxiliary and other underground rooms shall be oversighted as if the URCF would be part of a licenced facility. Consequently, STUK implemented regulatory control to the ONKALO URCF construction project as a juvenile part of the whole repository project. However, a construction license was needed before starting the construction of the disposal rooms and other underground rooms outside the scope of the URCF.

Regulatory approach for Posiva's Research, Development and Technical Design (RD&D) activities

Every three years Posiva compiles a waste management program (YJH) for nuclear waste on behalf of TVO and FPH, who are liable for the nuclear waste generated at their nuclear power plants. TVO and FPH submit the program to the MEAE for regulatory review. STUK reviews the program and provides its own statement of its plans to the MEAE. The most recent program was submitted to the MEAE in September 2018 and it covers the period 2019-2021. STUK is responsible for regulating the safety related implementation of the RD&D work. During the period in concern, after Posiva had submitted the construction license application, STUK's regulatory control of Posiva's RD&D activities has focussed on demonstrating the feasibility and performance of the disposal concept.

The focus of STUK's regulatory control has changed from the overall safety case development to the demonstration of the disposal system processes and the emplacements of the disposal canisters. The experiences from the review and assessment of Posiva's safety case supporting the construction license application will also steer the future focus of the RD&D supervision. In addition to issues which Posiva has raised in the safety case, STUK's review has identified some other areas, where further RD&D work is needed to reduce existing uncertainties.

Regulatory review and assessment of the construction license application for Olkiluoto spent nuclear fuel encapsulation plant and disposal facility

In 2003, Posiva applied additional two years time for submitting the construction license application (initially scheduled by the end of 2010). When granting the license application postponement to 2012, the MEAE required in return a description of the status of the CLA by the end of 2009 to make sure the progress of the work. The reasoning was to conduct a regulatory review of the status and maturity of the development of the construction license application. STUK reviewed the draft safety case and the process was used as an exercise for the actual license application review.

STUK established an internal project for the license application review. The assessment of the fulfilment of the safety requirements and of the implementing organization's preparedness for construction were supported by STUK's inspection programme for the pre-construction phase. The inspection programme continued later as a construction inspection programme (CIP) for construction control of the disposal facility.

Posiva submitted the construction license application and its supporting documentation to the authorities at the end of 2012. STUK performed a review and assessed the fulfilment of all the applicable radiation and nuclear safety requirements. STUK prepared a statement and a safety evaluation report and submitted them to the Government in February 2015. In its assessment, STUK highlighted issues that needed further attention. The Government granted the construction license in November 2015.

Regulatory control for the construction of the disposal facility

After the construction license phase, STUK has continued comprehensive regulatory control over the subsequent detailed design, construction, manufacturing and pre-operational testing, which will then be followed by the review and assessment of the forthcoming operating license application.

STUK controls the implementation of the facility project in detail. The purpose of the control is to ensure that the conditions of the construction license and the approved plans required in Section 35 of the Nuclear Energy Decree are complied with and that the nuclear facility is also in other respects constructed in accordance with regulations issued on the basis of the Nuclear Energy Act. The following chapters provide an overall view of the implementation of the regulatory control in Posiva's case.

Verification of the readiness to start the construction

According to Section 108 of the Nuclear Energy Decree, various phases in the construction of a nuclear facility cannot be commenced until STUK has ascertained for each phase that all safety-related factors and safety regulations have been given enough consideration.

STUK performed inspections related to Posiva's readiness during October and November 2016 and stated in its decision given at the end of November 2016 that Posiva had achieved readiness for the construction project. Posiva started the construction of the first part of disposal facility which was outside the scope of the URFC part of ONKALO project on 1st of December 2016.

The next main phase of the project was starting the construction of the encapsulation plant and as stated in the Section 108 of the Nuclear Energy Decree, STUK ascertained Posiva's readiness also for this phase of construction. The inspection was performed in May 2019. As a result of the inspection STUK stated that Posiva had fulfilled the requirements concerning this phase of the facility construction project, and that Posiva is organizationally prepared to begin the construction of th encapsulation plant.

Oversight of the construction of the encapsulation plant and disposal facility

The Guide YVL A.5, Construction and Commissioning of a Nuclear Facility gives detailed guidance for the licensee and describes STUK's procedures for regulatory oversight. It includes oversight of the design, manufacturing, construction, installation, commissioning and reporting during the construction.

Overall, the regulatory oversight of the encapsulation plant will follow the same procedures as for the other nuclear facilities, considering a graded approach which focuses the oversight based on safety relevance. These procedures will be applied for the oversight of the construction of the encapsulation plant, because this is similar to the other nuclear waste processing facilities.

The Guide YVL A.5 cannot be directly applied for the regulatory oversight of the construction of the underground disposal facility. Excavating and drilling safety classified underground rooms with post-closure safety functions are specific to this facility and regulatory oversight procedures need to be adjusted for this purpose. The Guide YVL D.7 Engineered and natural barriers in a spent nuclear fuel disposal facility, describes the oversight of the underground disposal facility. This guide was published 2018.

In the disposal facility oversight concept, STUK has gathered the experience from the oversight of the underground rock characterization facility (ONKALO URCF). The disposal facility design documentation will be reviewed and approved by STUK according to the document type and safety classification of the rooms to be excavated.

After approval of the design documentation, STUK performs an inspection concerning the readiness to commence the excavations of safety classified underground rooms. During the construction, STUK performs inspections of the rock surface based on mapping documentation before the surfaces are covered by shotcrete and also similar inspections for the technical documentation of the excavated rooms.

During the construction, the commissioning inspection will be the final regulatory oversight procedure for the excavated rooms. It will conclude all the previous findings from earlier reviews, inspections, handling of non-conformances during the construction as well as quality control documentation.

Posiva is carrying out a comprehensive monitoring program which was started before the construction of the URCF started, to monitor the effects of construction activities on the site properties, such as maintaining the favourable properties of the site hydrology, hydrogeology and rock mechanics during both construction and operation of the disposal facility. A baseline study for the area was also made before the construction URCF started for the planned area. STUK is closely following the results of the monitoring programme during the construction.

Oversight of feasibility of the disposal concept

Based on the construction license review, Posiva has not yet fully demonstrated the feasibility of the emplacement of disposal components according to the latest design and some of the requirements for STUK's decision on the PSAR concern this issue. These include demonstrating among other things:

- Posiva's capability to excavate underground disposal rooms that fulfil the specifications
- the manufacture of engineered barrier components
- the installation of engineered barrier components.

The engineered barrier system (EBS) includes copper canister, bentonite buffer, backfilling of the tunnels and isolation and closure structures. STUK's oversight covers the design, manufacturing and installation of the EBS components. During the construction period, the EBS oversight focuses mainly on Posiva's R&D projects that aim to demonstrate the manufacture of EBS components fulfilling the requirement specifications set for them in the design documentation.

Oversight of post-closure safety case development during construction

The post-closure safety case has a clear interface with the construction of the disposal facility and the feasibility of the disposal concept. Changes in the post-closure safety case may influence the construction of the disposal facility and the feasibility of the disposal concept and vice versa.

To monitor the development work performed for the post-closure safety case requirements, STUK and Posiva have agreed to have regular discussions on the development work. The first step was to reach common understanding on the targets for the development work for each requirement set during the construction license application review. Secondly, Posiva developed project plans to address the requirements and delivered the plans to STUK for review. To have a clear overall view of Posiva's development work, STUK required Posiva to include all the project plans in the existing disposal concept development plan or in some other similar plans. The discussion will continue in the future as needed and at least when Posiva achieves the milestones set in the development projects.

Regulatory approach for nuclear safeguards

As ONKALO was foreseen to become a part of the disposal facility for spent nuclear fuel, STUK started implementation of the safeguards for ONKALO in 2003. Subsequently, Posiva was obliged to implement safeguards from the beginning of ONKALO excavation up to the closure of the disposal facility. In accordance with STUK's regulations, Posiva prepared and documented the necessary safeguard procedures and measures in a quality manual called "Nuclear Materials Handbook" which was approved by STUK in 2005. Since then Posiva has regularly updated the handbook and submitted the new versions to STUK for approval.

In 2013 Posiva submitted the preliminary Basic Technical Characteristics (BTC) of the geological disposal facility and the encapsulation plant to the European Commission (EC) as requested from new nuclear facility operators. The Commission has the assigned Material Balance Area (MBA) codes, WOLF, for the geological disposal facility and, WOLE, for the encapsulation plant. The two material balance areas constitute a site according to the Additional Protocol. The Posiva site (SSFPOS1) covers the fenced area around the buildings supporting the construction of the facilities. Based on the declarations, the IAEA and the EC perform regular inspections of the Posiva site and facilities.

STUK's safeguarding activities consist of inspecting and assessing Posiva's implementation of safeguards, reviewing Posiva's reports, and verification through on-site inspections that the disposal facility is in full compliance with Posiva's as-built documentation, also presented in the BTCs. STUK also verifies that the information in Posiva's declaration on the site is correct before the declaration is submitted to IAEA and the EC.

STUK approved the *"plan for arranging the safeguards control necessary to prevent the proliferation of nuclear weapons"* which was included in Posiva's construction license application. In the approval of the plan STUK highlighted to Posiva the need to plan and construct the facilities in a way that enables efficient implementation of safeguards by STUK, the European Commission and the IAEA. The safeguards long-term challenge is a good example of ongoing coordination with the IAEA and the EC in developing the concepts for new types of facilities, and to carry out the required safeguard activities for a period of hundred years. The task of accommodating the safeguards measures to be implemented at the encapsulation plant and geological disposal facility in the design of the facility is ongoing. Spent nuclear fuel, which has been emplaced in the disposal facility, cannot be re-verified later. A non-destructive assay instrument for verifying spent nuclear fuel at the single pin level is under development and currently the instrument is tested rigorously in nuclear power plants. The plan is to verify all spent fuel before packing into the spent fuel disposal canisters.

STUK's safeguard activities and findings are published annually in the safeguards report *"Implementing nuclear non-proliferation in Finland. Regulatory control, international co-operation and the Comprehensive Nuclear-Test-Ban Treaty"*.

L.3 Posiva's programme for spent fuel disposal

Introduction

In Finland, each producer of nuclear power generated electricity is fully responsible for its own nuclear waste management and its costs. Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (FPH) have been managing their own nuclear waste since their nuclear power plants began operating in the late 1970s and early 1980s. Regarded as high-level waste, the spent fuel is currently kept in interim water pool storage facilities at the plant sites. Later, it will be disposed of in the Olkiluoto bedrock. In 1995, TVO and FPH established a joint company, Posiva, to implement and manage the disposal of spent nuclear fuel produced in their nuclear power plants in Finland and to perform the associated research and development work. The disposal of spent nuclear fuel is scheduled to begin in the early 2020s.

Summary of spent fuel geological disposal history

The first study of the disposal of spent nuclear fuel appeared in a series of reports published by the Nuclear Waste Commission of Finnish Power Companies (YJT) in 1982. The study examined the safety and technical feasibility of the disposal in Finnish conditions under the multi-barrier principle. The existing information on the Finnish bedrock was compiled in respect to the long-term safety of disposal and the suitability of the rock for underground construction. In 1983 TVO launched an R&D programme to develop the disposal solution for spent nuclear fuel. The programme contained geological screening of the possible final disposal sites in 1983–1985. Preliminary site characterization started in 1987 at five sites. The site characterization programme included deep drilling, geological mapping, hydrogeological,

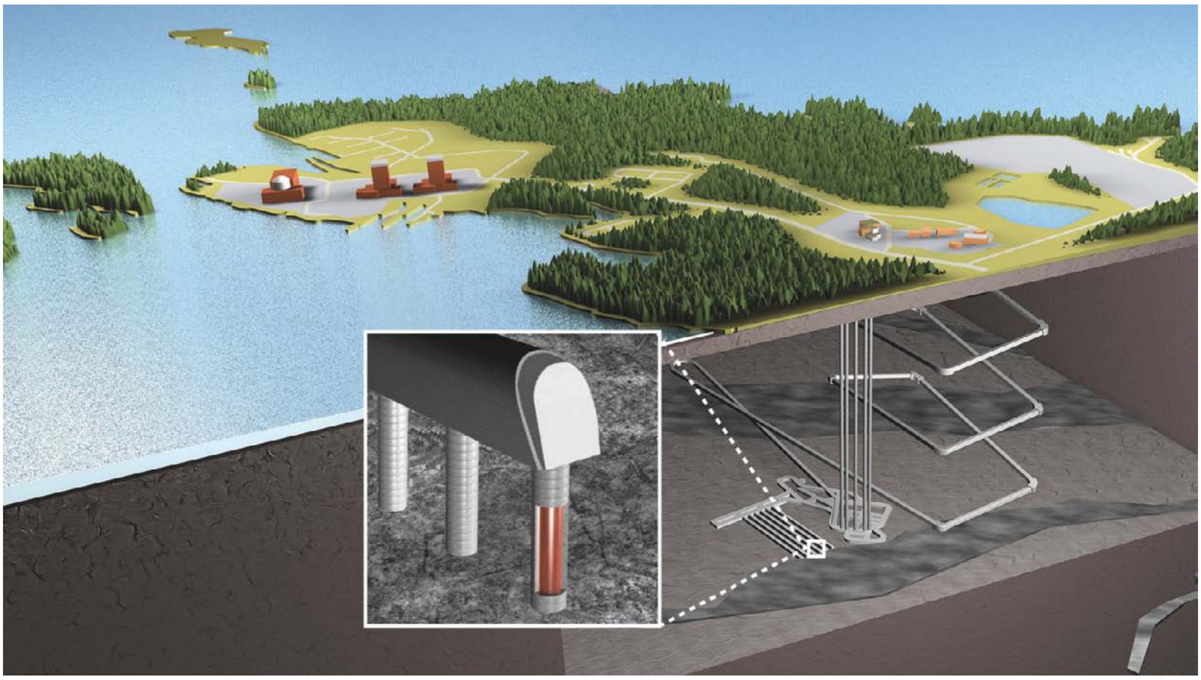


FIGURE L3-1. General layout of the constructed ONKALO facility, Posiva's disposal project and KBS-3V concept of disposal.

hydrogeochemical and rock mechanical studies. After summarizing the results of the preliminary site investigations, a detailed site characterization programme was conducted at four sites, Eurajoki, Loviisa, Äänekoski and Kivetty in 1992–1999. At the same time, the disposal concept was developed further in parallel to the site characterization. In 1999 Posiva applied for a DiP for a spent nuclear fuel disposal facility at Olkiluoto in Eurajoki. The Finnish Government made a favourable DiP in December 2000 and the Parliament ratified the decision in May 2001.

After the DiP was ratified in 2001, Posiva continued detailed site confirmation studies at the Olkiluoto site and the development of the disposal concept. The excavation of the ONKALO URCF was started in 2004. As URFC is constructed at the repository site and will be used as an access route to the disposal facility, the construction of ONKALO has been subject to the requirements applicable to nuclear facilities in general, and, in particular, to those addressing the construction of nuclear waste facilities. An extensive programme of site-specific characterization, testing and experiments was launched for ONKALO during URCF construction phase. The excavation of URCF was completed in 2016. The experience gained from the URCF part of ONKALO project will be used in the construction of the disposal facility.

General layout of ONKALO and the KBS-3V concept of disposal is presented in the Figure L3-1.

Construction license granted and construction started

According to the Government's DiP the spent fuel from the Loviisa and Olkiluoto NPPs will be disposed of in a KBS-3™ type geological repository on the Olkiluoto island in the municipality of Eurajoki. At the end of 2012 Posiva submitted a construction license application for an encapsulation plant and disposal facility to the Government.

The Finnish Nuclear Safety Authority (STUK) gave a positive safety statement supported with a safety evaluation concerning the construction license application on February 2015. In addition, STUK made a separate decision about the key safety documents, which were submitted to STUK for review together with the license application. In these decisions STUK set requirements for Posiva that must be met during construction or in the operating license application documentation. These requirements concern further work in safety demonstration for reducing some of the uncertainties related to the project. The Finnish Government granted the construction license to Posiva on November 12, 2015 for the disposal of 6500 tU from NPP units OL1–OL3 and LO1 and LO2. Posiva has continued research and detailed technical design of the nuclear waste facilities to fulfil the requirements set by STUK as a result of its safety evaluation.

The construction of the disposal facility transportation and connecting tunnels was started in December 2016 after STUK had confirmed Posiva's readiness to start the construction of the underground disposal facility. The scope of the first excavation phase also includes the first central tunnel into the disposal area. The construction of the disposal facility will be conducted in phases to limit disturbances caused by open spaces and to enable continuous improvement of the disposal technology during operation.

Posiva is planning to apply for the operating license by the end of 2021 and start operation of the encapsulation and disposal facilities in the first half of 2024. The time schedule depends

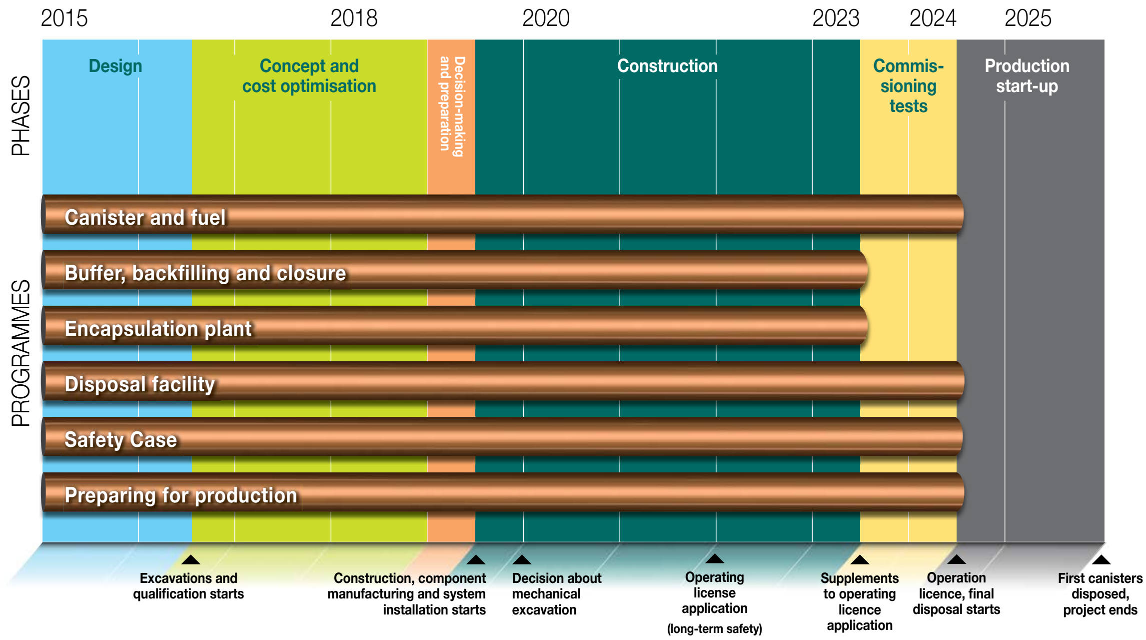


FIGURE L3-2. Current programmes and schedule.

on the duration of the operating license application review. The project plan and the schedule are presented in Figure L3-2.

Programme to address the open requirements

Posiva has established several development projects to address the requirements raised by STUK during the evaluation of the post-closure safety case for the construction license. These projects have been included into Posiva's programme schedule (Figure L3-2) and their progress is tracked to assess the readiness of the disposal concept and the safety case before moving on to the next phase of the programme. Posiva and STUK engage in frequent dialogue to evaluate Posiva's plans related to addressing the remaining STUK requirements.

The development projects on site confirmation and rock characterization deal with the compliance of various site models and respective site research data. They also deal with the reliability of the discrete fracture network modelling method, and address the interconnection between the safety functions, performance targets and design requirements of the host rock, and the reliability of Posiva's rock suitability classification (RSC) method. The aim of the work is to increase the reliability of the future safety case (TURVA-2020) by producing an integrated site model and by verifying its compliance with the data gathered from the site during the site investigations and during the construction of the ONKALO URCF facility according to Posiva's monitoring programme as reported in Posiva's 2012-01 report. Further information will be produced in several different projects under the site programme that include all site description projects for the evaluation of the long-term evolution of the site properties and in some specific projects. The specific projects include studies into issues such as the salinity of the groundwater (Merireikä project), the penetration depth and evolution of the composition of glacial melt waters (Saimaa project), sulphide flux on canister surfaces (Sulfidi project), and the evolution of mechanical properties of the host rock (POSE and Kalliomekaniikan paikankuvaus projects).

The integrated site model and the monitoring programme are in connection to the rock suitability classification (RSC), which is a method developed by Posiva during the construction of the ONKALO URCF facility for locating suitable rock volumes for various rooms and which will be used for the same purpose in the construction of the disposal facility. The reliability of the RSC method will be addressed, and the method will be evaluated and further developed during the detailed design and construction of the tunnels for the commissioning test. Detailed scale modelling of the site for the exact location of the rooms will be further developed in this connection.

Alternatives to the current model are being studied and modelling work is being carried out to evaluate the consequences of earthquakes and secondary movements on the disposal facilities (Seismologia project).

The post-closure evolution of the disposal system is affected by the evolution of the climate both from the short- and long-term perspective. Posiva has extended the studies to include extreme lines of evolution, such as extremely thick glaciation and an extended temperate climate by modelling the evolution of CO_2 contents for a period of 1 million years (Ilmastokehitys project). The results have been integrated into the safety case.

The projects regarding the disposal canisters concentrate on the industrialization of canister manufacturing methods, as well as evaluating and reducing the uncertainties of the long-term performance of the canisters. Manufacturing processes for canister components are being developed to produce components that fulfil their requirements and can be produced in a cost-effective way. Grain size has been one focus of the development work for copper components and the effects of the casting process on mechanical properties are another focus area for the cast-iron inserts.

The long-term integrity of the canisters requires copper to resist corrosion. Various forms of corrosion have been studied for a few decades and according to current knowledge it has been stated that there are no forms of corrosion that can threaten the required lifetime of the canisters. To reduce the uncertainties related to assumptions made in the assessments, some further corrosion tests have been performed. To support the statement and the tests, modelling has been carried out (copper sulphide modelling) in co-operation with the Swedish waste management organisation SKB.

Studies on the creep properties of the copper have been extended to include larger temperature and stress fields (lid weld) and to include the effects of sulphur and phosphorus (base material).

The clay components of the disposal concept include a buffer surrounding the canisters in the deposition holes and the backfill material of the deposition tunnels. The buffer consists of blocks and pellets and the backfill of granules, according to the current reference design. When bentonite clay comes into contact with water, it swells and limits the transport of water and other substances that might be harmful to the canister; the buffer also protects the canister mechanically in case of small rock shear movements. The development work addresses some remaining open issues for evaluating the evolution of the clay components, such as homogenization, mechanical and chemical erosion, alteration of the clay minerals, interaction between the clay and cement used in the underground construction. To study these processes, several projects have been established and are ongoing. Changing of the reference backfilling method to granular bentonite has been taken into consideration in these projects and it has caused some delays in concluding them. The wetting behaviour of buffer and backfill components has been tested on various scales (1:6, 1:2) and modelled to support current knowledge (DoSub, DOST, FISST projects). The interaction of the various clay components is also being studied (HDD project) and the wetting behaviour and mass loss during the saturation of the components has been further studied and modelled (mechE project) to reduce the uncertainties related to early evolution until the full saturation of the disposal system. Posiva is also participating in a Euratom Horizon 2020 project BEACON where homogenization of bentonite is further studied.

In the long term, mass loss of the buffer and backfill components could also occur due to chemical erosion of the clay. The rate of chemical erosion depends on the ground water composition, fractures conducting the ground water to the deposition tunnels and holes as well as on properties of the clay. To reduce the uncertainties related to the mass loss of buffer and backfill due to chemical erosion, data on fractures has been gathered, further tests on clay performance are being done and modelling is being carried out.

Performance of the bentonite buffer in the long-term is also affected by its mineralogical composition. Further knowledge to support the assumptions made about the buffer performance is being gathered via long-term laboratory tests (MAB project) performed in elevated temperatures and in selected ground water compositions. In EURATOM, in EURAD project a work package called HITEC has been started to study properties of bentonite in elevated temperatures; Posiva is participating in the project.

The long-term interaction of the clay components with the cement used in the construction of the disposal facility has been studied with help of laboratory experiments, computer simulations and discrete fracture network modelling (CBI and DFN projects). The aim of the work has been to set safe limits for the use of cement, under which the effect on the performance of the clay components can be disregarded.

Two large Euratom Horizon 2020 projects, MODERN2020 (monitoring strategies of disposal facility), and, MIND (microbial activity in disposal, where Posiva has been participating, have been completed. Currently, Posiva is participating in Horizon 2020 project BEACON (bentonite homogenisation) and in EURAD project HITEC (bentonite in higher temperatures) as mentioned above and is following the EURAD projects FUTuRE (Fundamental understanding of radionuclide retention) and SFC (Spent Fuel Characterization and Evolution Until Disposal). Posiva cooperating on the IGD-TP (Implementing Geological Disposal Technology Platform) platform in the KINA (Natural analogues) project.

The programme to address the open requirements has been performed mainly according to plans with some minor adjustments due to changes in the reference designs for industrialization and optimization purposes. Number of single tasks in various projects to close the open requirements have been raised from the original 155 to 179 tasks. In the beginning of 2020 two third of the tasks have been finished and the work to finish the remaining ones is ongoing. The results of the finished tasks have been directed to the ongoing safety case work; they have reduced its uncertainties and hence imporved its realiability. The aim is to finish all of the task and close the requirements by the end of 2021.

The integrated site model has been developed and the first full draft of Olkiluoto site description report has been finished and the review of the report is ongoing. The report includes results from all site description projects for the evaluation of the long-term evolution of the site properties. Reliability of the RSC method has been evaluated and further developed. Evolution of the climate including extreme lines of evolution both from the short- and long-term (up yto 1 M years) perspective has been modelled and the results have been directed to the safety case.

Manufacturing methods of canister components have been further studied and developed, copper corrosion and creep studies have been concluded to the main parts. Various scales of bentonite tests have been performed and long-term properties of bentonite has been further studied. Some tests and modelling work is still ongoing.

Safety case methodology and transparency of describing and selecting scenarios has been further developed and the safety case work is proceeding.

Full scale in-situ system test (FISST)

Full scale in-situ system test, FISST is a part of Posiva's strategy for the gradual implementation of tests and demonstrations (Posiva WR 2009-24 report). Posiva has moved from laboratory scale and full-scale installation tests of individual components to a phase of testing the installation of the entire final disposal system in ONKALO. The FISST consists of a disposal concept test in accordance with Posiva's reference plan (KBS-3V) using materials largely in line with the reference plans. In the demonstration area of ONKALO, demonstration tunnel #2 and two its test deposition holes, which have been excavated and bored in the demonstration area in ONKALO has been used for the test.

Objectives of the test have been set as:

- demonstrating the installation and logistics of the various components with Posiva's prototype machinery
- provide a platform to test and develop the functionality of Posiva's organisation
- demonstrating the evolution of the KBS-3 system in the early phase.

The FISST project and test has been designed in 2016–2017, extensive preparations for the test, including rock excavations, manufacture of components and installation of instrumentation have been made in 2017–2018. Readiness to start the installations of the FISST was achieved in 2018.

The test involved installation of two heated copper canisters, two set of deposition hole buffer, and approximately 50 m of deposition tunnel backfill as well as a deposition tunnel end plug. In deviation from the reference plans, a buffer made up of block segments instead of ringshaped and cheese shaped blocks and was installed in the second test deposition hole.

In FISST prototype installation equipment has been used and the achievement of the initial state after the installations has been studied (Figure L3-3). To study the early evolution of the system, in addition to the manufacturing and installation of components, the FISST also involves instrumentation and monitoring of the performance of EBS components as well as monitoring the environment in the FISST tunnel and in demonstration area.

FIGURE L3-3. EBS components installed with prototype machines in FISST.

Reporting of the FISST is ongoing and the test monitoring is continued for as long as it produces appropriate data.

Evaluation of Posiva's preparedness for nuclear construction

According to Section 108 of the Nuclear Energy Decree, the various phases in the construction of a nuclear facility cannot be commenced until STUK has ascertained for each phase that all safety-related factors and safety regulations have been given sufficient consideration on the basis of the documents mentioned in Section 35 of Nuclear Energy Decree and other detailed plans and documents.

In order to ensure Posiva's preparedness to continue to the nuclear construction phase, Posiva established and implemented a verification programme. The programme included verifications of several levels of documentation, requirements and activities. In addition to the documentation and review of requirements, Posiva conducted one independent review and carried out one self-evaluation related to organizational preparedness, safety culture and management of nuclear facilities.

Posiva's verification was conducted during April–September 2016 and the evaluation report was sent to STUK. STUK conducted three inspections during October–November 2016 to verify Posiva's readiness to commence the nuclear construction. No significant open issues were observed which would restrain underground nuclear construction activities, and on 25th November Posiva's preparedness for nuclear construction was confirmed by STUK. The MEAE was informed of the commencement of the nuclear construction on the 9th of December 2016.

Entering into the construction phase

In the beginning of the year 2019 Posiva made a comprehensive evaluation of its readiness, and thereafter also a decision, to enter to the next construction phase. Posiva compiled an extensive documentation for its owners as a basis for making the decision on the large investment including the following: the construction of the encapsulation plant, the second contract of the final disposal facility and its systems, detailed design and purchase of final disposal machinery and starting the final disposal in the first deposition tunnel.

Posiva made a scientific–technical and organizational evaluation of readiness and feasibility taking into consideration the following perspectives:

- Disposal concept
- Production processes and logistics
- Operational nuclear safety
- Production process and provisions for disturbances in the fuel handling cell
- Production personnel and organization
- Status of actions for optimization and industrialization
- Economical provisions for final disposal
- Encapsulation plant programme
- Disposal facility programme
- Disposal machinery programme
- Strategy for licencing and qualifications
- Organizational readiness
- Organizational management during construction.

Posiva's whole organization was heavily involved in the documentation and the evaluation work. The documentation was reviewed by committees working for Posiva's Board of Directors and by an internal inspector before it was submitted to Posiva's Board of Directors. Based on the documentation and statements made on it, Posiva's Board of Directors made in June 2019 the investment decision and the decision to enter into the construction phase. The foundation stone for Posiva's encapsulation plant (Figure L3-4) was laid in a festive ceremony in the presence of the Prime Minister of Finland Mr. Antti Rinne on the 23rd of September 2019 in Olkiluoto.

FIGURE L3-4. Illustration of the encapsulation plant.

Final disposal facility and encapsulation plant construction status and progress

Construction of the encapsulation plant started in June 2019. The underground excavation work package LTU1 (Final disposal facility, tunnel excavation contract no. 1) that started the nuclear construction phase in December 2016, was finished with excavations in December 2019. The total amount of LTU1 excavation is around 117 000 m³. The underground excavation work package LTU2 (Final disposal facility, tunnel excavation contract no. 2) is planned to be started in Q2/2020.

The construction status in February 2020 is as follows:

- The LTU1 work package excavations have been finished with the total amount of excavation at around 117 000 m³
- Canister shaft is fully excavated Raise boring of the shaft was finished in March 2019.
- The air outlet shaft has been in operation since 2017
- Canister reception station excavation at −437 m was finished in 2018
- Vehicle connectionshave been fully excavated by 2019
- Excavation of the first part of the central tunnel 5 and 6 has been started
- Pilot hole drillings of the first five deposition tunnels have been started
- Construction and installation of heating, ventilation, air-conditioning (HVAC) and electricity works in the technical rooms have been started
- Construction of the encapsulation plant is ongoing and progressing according to the planned schedule.

Preparations to start the LTU2 work package are ongoing and it is aimed to be started in 2020. The first part of the central tunnels 5 and 6 are aimed to be excavated and reinforced by 2022. Excavation of the tunnel for the integrated system test is included in the LTU2 and is aimed to be finished in 2020.

Personnel shaft reinforcement work entered into challenges in 2018 and the work was interrupted. A new solution was found, and the work was re-started in the end of 2019 with the aim to finish the reinforcement work in 2020. The manufacture of the steel structures is ongoing, and the aim is to install them by the end of 2020. The personnel hoist is planned to be installed by mid 2023.

The canister shaft reinforcement work is planned to be commenced and finished in 2020. The canister lift manufacture is planned to be ready in 2021, installation by the end of 2022 and commissioning of the canister lift is planned to be done by the end of 2023.

The construction work for the supporting structures of the technical area at −437 m has been finished in 2019. Canister reception station construction and system installation works are planned to be started in 2020 and finished in 2022.

Installation of the HVAC systems and construction works of in the vehicle connections and central tunnels is planned to be finished in 2022.

Encapsulation plant construction work is progressing according to the planned schedule (Figure L3-5). Aim is to finish the construction works by mid 2022. Manufacture of the systems of the encapsulation plant has been started. Installation of systems is aimed to start in 2021 and commission of the encapsulation facility systems is planned to be started in 2022 and finished in 2023.

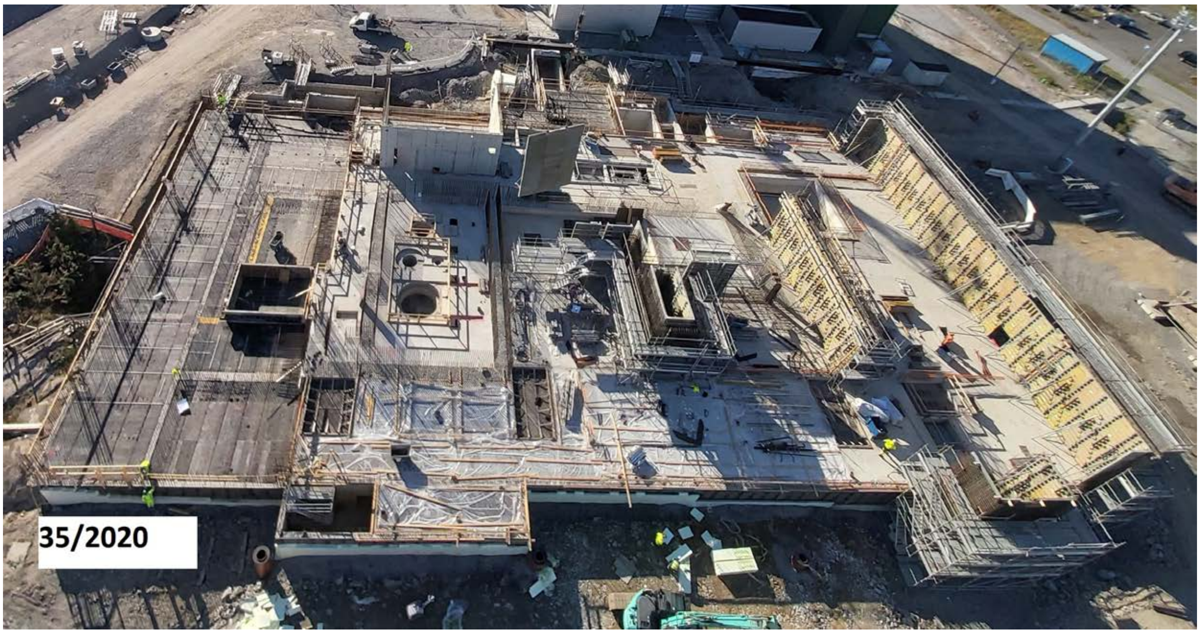


FIGURE L3-5. Construction site of the encapsulation plant.

Programme milestones 2020–2024 to reach the operational phase

Posiva's programme is divided into several phases. The main schedule of the programme contains all the relevant activities and time critical links between separate works. The main milestones reached already are:

- Design and cost optimization phase (2018)
- Readiness for full scale in-situ system test – FISST (2018)
- Completion of the full scale in-situ system test installations – FISST (2019)
- Start of the construction phase (2019)
- Start of construction of encapsulation plant (2019).

The main forthcoming milestones are:

- Qualification of canister components (2020)
- Qualification of buffer and backfill designs, and manufacturing and installation methods (2021)
- Submission of operating license application (2021)
- Excavation of final disposal tunnels 1–5 finished (2021)
- Encapsulation plant ready for commissioning tests (2023)
- Supplementing of operating license application with as-built documentation on the facilities (2023)
- Commissioning tests (2023–2024)
- Operation license and start of nuclear operation (2024).

Design and cost optimization phase

The basic concept and general technical design of the disposal facility were approved, when a positive safety statement concerning the construction license was granted by STUK and the construction license was granted by the Government. According to the construction license decision from the Government, technical modifications and improvements to the design and concepts can be authorized by STUK, if they are within the terms of the construction license.

In 2017 Posiva started a programme sub-phase to optimize the design and costs of disposal. The main objective is to become more cost effective in the implementation without reducing the level of safety and to establish an industrialized concept for the disposal operation. In practice, this means detailed investigations into making the disposal processes simpler and more robust, developing the technical design so that standard industrial processes, systems, equipment and structures can be utilized, and bringing overlapping design criteria into line. The concept and cost optimization phase was focusing on design completion, operation concept modelling, and supply chains for the backfill and canister components.

Based on studies and evaluations, decisions on the following changes were made during the design and cost optimization phase according to Posiva's change management process:

- central tunnel backfilling was changed from bentonite blocks to in-situ backfilling with a mixture of crushed rock and bentonite
- a criterion in rock suitability classification
- deposition tunnel and deposition hole distance optimization
- buffer manufacture of segmented blocks
- canister purchase chain optimization
- deposition tunnel in-situ backfilling with granules
- bentonite supply chain optimization
- deposition tunnel profile optimization.

Studies on heat conductivity of the rock are ongoing and aimed to be finished by the end of 2021. The study aims at producing further knowledge on the heat conductivity of the host rock for optimizing the layout of the final disposal facility, the distance of deposition tunnels and the deposition holes.

Posiva has also been studying different alternatives to scheduling the emplacement priority disposal order of the owners' spent fuel and to optimize the concept for simultaneous activities for both the disposal of spent fuel and the excavation work at the disposal facility (Figure L3-6). Every significant design or conceptual change has been reviewed and approved according to the graded approach by its significance to nuclear or long-term safety.

Preparation for operations

The operational activities are organised into a "preparation for operations" programme (TUVA), which incorporates the following activities organised as separate projects:

- Development of excavation and excavation related methods,
- Further development of prototype machinery for engineering barrier system installation such that they can be used effectively in operations,

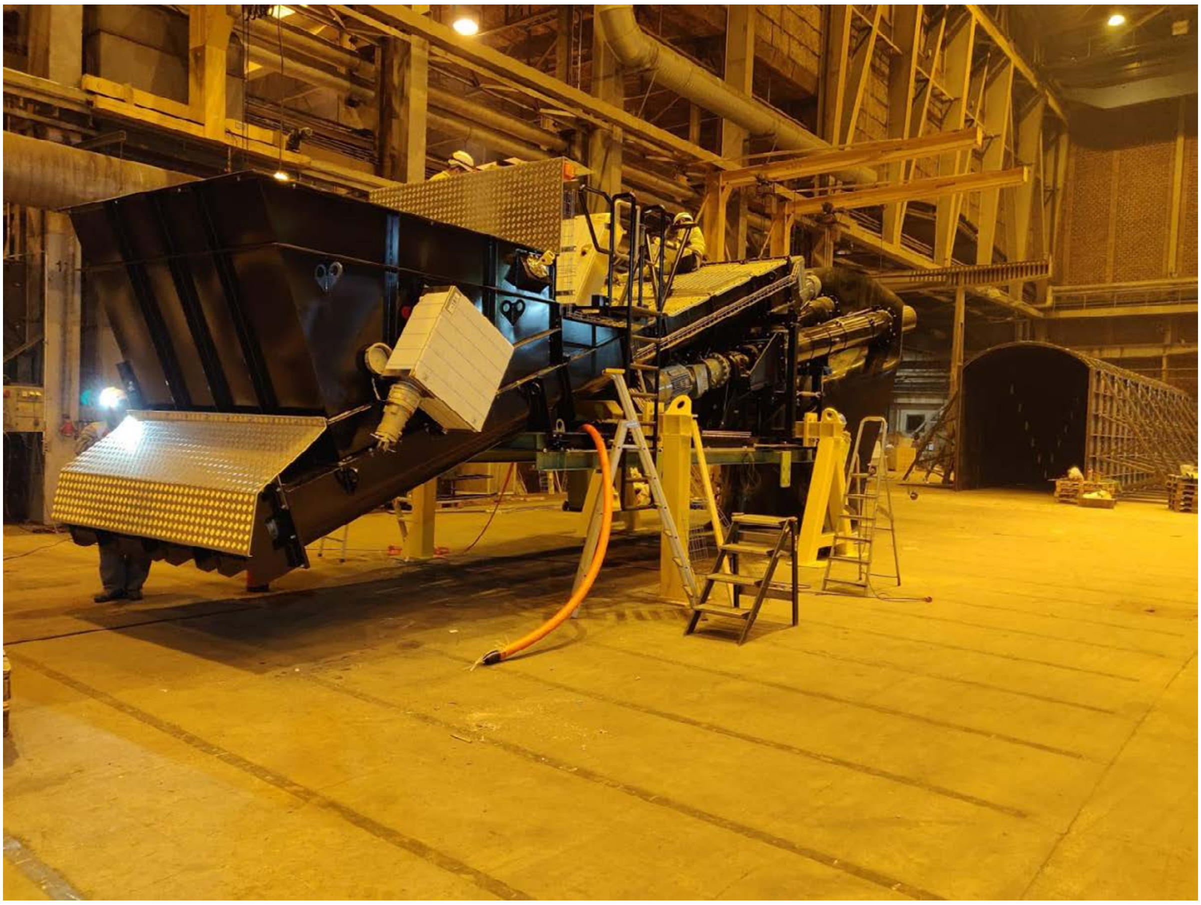


FIGURE L3-6. Granule backfilling test.

- Planning and optimisation of operations,
- Planning and optimisation of maintenance, and
- Commissioning of facilities.

Each activity produces outcomes that prepare the operational organisation for effective operations. Currently to date the outcomes produced include feasibility studies for excavation and excavation related methods, further development and detailed design of the installation machinery for the engineered barrier system, plans and guidance for the operation processes and optimized production plan.

During the years preceding the Overall Commissioning Test without spent fuel (OCTw/o) the operational and maintenance procedures and systems, will be developed to achieve targeted operational schedules efficiently. Moreover, activities to achieve organisational readiness for operations are in progress. It is scheduled that the final readiness will be demonstrated in the OCTw/o in 2023–2024.

A new programme "Production equipment of disposal facility" has been established in 2019 for further development, design, manufacture and commissioning of the machinery for the

installation of the engineered barrier system (EBS) and for excavating the deposition holes in the deposition tunnels. The programme includes also a project to develop an integrated automation for the machines. The following machines are included in the programme:
- Canister transfer and installation machine
- Buffer installation machine
- Backfill installation machine
- Deposition hole boring machine
- Deposition hole bottom levelling machine.

Design of the EBS-installation machinery has been updated in 2019 taking into consideration experiences gathered in the FISST test. Design freeze of the canister transfer and installation machine has been made and backfill installation machine has been tested in 2019.

Manufacture of the machines is planned to start in 2021 and they are aimed to be ready and tested to be ready for the commissioning test in 2023.

Post-closure safety case

The post-closure safety case will be a portfolio of several reports described later in this document section. Long-term safety requirements and disposal design requirements have been improved in line with the safety concept for clarifying the connections between long-term safety and design solutions. Posiva has been studying the materials of the components for the engineered barrier system to address factors affecting their long-term properties as described before. Posiva will also clarify the selection process for the relevant scenarios to be used in the safety case.

For the purpose of the operating license application, a safety case showing that the repository will satisfy the requirements for long-term safety is being produced. The main components of the safety case consist of a description of the design basis and initial state, an assessment of the performance of the disposal system in different future scenarios and an analysis of the likelihood and consequences of any potential releases of radioactive substances from the repository. The assessment starts from the initial state of the repository and then goes on to study the possible lines of evolution that the disposal system could be subject to in the future. The assessment of the lines of evolution is based on the best available scientific knowledge and data gathered both from Olkiluoto and from different laboratory experiments and technical tests conducted over 30 years. The safety case consists of a portfolio of reports as shown in Figure L3-4.

The main changes since the safety case for the construction license application (TURVA-2012) reflect the integration of the LILW-repository for encapsulation process waste; a more transparent link between the long-term evolution, scenario formulation, and analysis of radiological consequences; as well as enhancements in the production, management and communication of the safety case contents.

The status of the main safety case reports is following:

- Design Basis (DB) – The connections between the safety functions and performance targets have been checked. The first final draft of the report was submitted to STUK for a preliminary review in 2018, has been reviewed and updated by Posiva in 2019 according to STUK's comments.
- Initial State (IS) – Initial state of the EBS and the spent fuel and the description of the initial state of the biosphere, the host rock and the final diposal facility are presented in the IS report. The report also describes their deviations for the safety case. Design freeze for the IS was made in 2018, however some changes in the reference designs made after that have been considered in the report. Hydrogeochemical and hydrogeological modelling results are being included in the report. The first final draft of the report will be submitted to STUK for a preliminary review in Q3/2020.
- Low and Intermediate Level Waste Repository Assessment (LILW-RA) – the first final draft of the report has been internally reviewed and updating of the report for submitting to STUK for a preliminary review is ongoing, the report will be submitted to STUK for a preliminary review in Q2/2020.
- Performance Assessment and Formulation of Scenarios (PAFOS) – Method to define scenarios has been finished including an improved recognition of main uncertainties in future evolution, especially canister evolution. Writing of the report is ongoing, the first final draft of the report is planned to be submitted to STUK for a preliminary review in mid 2020
- Future Human Actions (FHA) are described based on a systematic formulation of scenarios. The report has been writeen and will be cross-checked with the AOR in 2021.
- Analysis of Releases (AOR) – release scenarios of radionuclides have been further developed by grouping the scenarios according to canister failure mechanisms, all calculation cases have been drafted, an approach for simulation of radionuclide release and transport has been futher developed with an improved handling of uncertainties. Input information for the analyses has been chosen, evaluated, reviewed and stored in the Safety Assesment Database. Writing of the report is ongoing, the first final draft of the report is planned to be submitted to STUK for a preliminary review in the beginning of 2021.
- Models and Data (MD) : Work with modelling flow charts and their interconnections is ongoing. A source term report has been compiled and is being reviewed. The first final draft of the report is planned to be submitted to STUK for a preliminary review in the beginning of 2021.
- Complimentary Considerations (CC) – The report presents supplementary, qualitative information to the safety case. The first final draft of the report was submitted to STUK for a preliminary review in the beginning of 2020.
- Synthesis - writing of the report is ongoing, the first final draft of the report is planned to be reviewed in mid 2021; the report will not be submitted to STUK for a preliminary review.

All above reports are planned to be submitted to STUK in the end of 2021.

Project for operating license application

The Finnish Government granted the construction license to Posiva on November 2015. Since then Posiva has started a project which aims to achieve a granted operating license so that the operation of the disposal facility would be able to start around the first half of year 2024. The project aims to submit the operating license application (Nuclear Energy Decree, section 20) by the end of 2021. The current plan is to apply for a 45-year operating license with a periodic safety review every 15 years. The plan is also to supplement the application with the results of an "overall commissioning test without spent fuel" (OCTw/o) and with an as-built analysis in the summer of 2023. STUK will conduct a safety review of the operating license application to be used as the basis for the Government's decision on the license application. The operating license can be granted by the Government, if Posiva fulfils the requirements set out in the Nuclear Energy Act.

The operating license project includes collecting the information that Chapter 5 of the Finnish Nuclear Energy Decree under "Licensing" requires to be submitted with the operating license application to the Government and to STUK for its safety review. Additionally, the Regulatory Guides on nuclear safety (YVL) define information requirements that must be included in the documentation submitted to STUK. Specifically, Guide YVL A.1 "Regulatory oversight of safety in the use of nuclear energy" defines many of these, but also other regulatory guides include complementary requirements. Producing and or assembling all the required documentation is included in the licensing project. The licensing project acts as an interface with the MEAE and STUK.

During the construction phase, before the submittal of the operating license application, the licensing of the engineering solutions and building of the facilities will be reviewed and approved step by step by STUK. The safety assessments of the built facilities, operations, accident analyses, as well as post-closure safety analysis of the spent nuclear fuel disposal will be submitted along with the operating license application for STUK's safety review.

Organizational activities

Posiva has established and maintained the necessary management processes for the disposal project and modified its organization to meet current and future needs. The disposal project has been divided into several development and design programmes, which are further divided into several projects. A steering group has been established and working to support and control each programme and projects under them. The role of Posiva's programmes has been enforced in the matrix format organization. Furthermore, a dedicated project steering and follow-up group for project progress and resourcing control has been set up.

Safety culture of the organization has been studied and actions based on the study have been defined and performed. The actions are followed by Posiva's steering group.

In the design phase of Posiva's programme, nuclear and radiation safety is ensured in the design of facilities, systems, structures and equipment for safe operation of the encapsulation plant and the final disposal facility. Posiva complies with an established configuration management procedure which includes an assessment of effects on nuclear and radiation safety for each proposed change.

Reviews and reports describing the status of the disposal project are provided on a monthly basis to the steering group, where programme and line organization managers form a consensus on the status of the activities and forward their draft resolutions for decision making and approval. The status and follow-up of the main objectives, in addition to open requirements and actions required to close them are permanent topics on the steering group's agenda.

Specific groups and processes to monitor design modifications (design authority function) and provide safety oversight, configuration management, assessments of long-term safety, nuclear safety and safety culture have all been established and are in active use. STUK has carried out its annual programme of nuclear construction inspections (CIP). STUK's programme covers all major and safety significant processes related to nuclear facility construction. During the evaluation of Posiva's preparedness for nuclear construction and during the on-going construction time no significant observations have been raised. A report on the status of construction activities is submitted to STUK monthly.

L.4 National cooperation group on nuclear waste management (YETI)

In June 2017, the Ministry of Economic Affairs and Employment appointed a National Cooperation Group on Nuclear Waste Management (YETI) to examine the objectives, development measures and possible solutions for safe and cost-effective management of nuclear waste and other radioactive waste for the period extending from the present well into the future. The cooperation group had members from the MEAE, the Ministry of Social Affairs and Health, the Ministry of the Environment, the Ministry for Foreign Affairs, STUK, FPH, TVO, Fennovoima, VTT, Posiva, LUT, and the University of Helsinki. The group worked for 1.5 years.

The cooperation group found that the requirements contained in the Nuclear Energy Act and the Radiation Act concerning the management of nuclear waste and other radioactive waste should be more harmonised and be independent of the manner in which the wastes are generated. It is also important that all radioactive waste existing and to be generated in Finland will be managed appropriately, regardless of its origin, producer or the method in which it was produced. Finland must have procedures covering the processing, storage and disposal of all nuclear wastes and other radioactive wastes generated in the country. It would be appropriate to have the capability to carry out the processing and disposal of wastes mainly relying on the existing infrastructure.

The licensing of nuclear facilities has mainly worked well in Finland. However, there is a need to develop the licensing procedures for nuclear facilities, as making even a minor amendment to license terms are slow and expensive. This hampers the licensee's efforts to develop their activities and, in the worst case, prevents cooperation with other licensees in waste management issues. It has also been necessary to complement the operating licences with licences for operations granted by STUK, which may have made it more difficult to manage or control the whole. The nuclear facility licensees could include managing small operators' wastes in their actions if this does not affect electricity production or the sociological acceptability of the operation.

Cooperation should also be developed on the interface of the Nuclear Energy Act, Radiation Act and Waste Act in the future. Waste released from supervision under the Nuclear Energy Act and the Radiation Act has been found harmless with respect to its radiation properties, which places it under supervision pursuant to the Waste Act. However, prejudices continue to be associated with such wastes which hamper and, in the worst case, prevent their appropriate processing. The authorities should work together to dispel prejudices by disseminating the required information adequately and at the right time.

The working group also proposes to the Safety Investigation Authority that the safety recommendation issued to the Ministry of Economic Affairs and Employment and the Ministry of Social Affairs and Health could be closed. The recommendation said that the ministries should jointly establish procedures for granting licences for and managing radioactive waste in order to ensure that all radioactive waste generated in Finland can be handled, stored and disposed of safely in our country in the event that returning it to the manufacturing country via the importers proves inappropriate or impossible. The recommendation was discussed in the cooperation group and taken into account when MEAE prepared the new operating license to OL1 and OL2 units enabling also management of other radioactive wastes at Olkiluoto. Futhermore, the recommendation was taken into account in cooperation group´s recommendations for the future licencing.

The working group issued 15 recommendations and 7 suggestions aiming to achieve above mentioned objectives (http://urn.fi/URN:ISBN:978-952-327-441-9). The recommendations were measures either addressed to the authorities or they were of major national importance and strongly supported by the working group. The suggestions were measures addressed either directly to licensees or they supported national activities. One of the working group recommendations concerned establishing a monitoring group to oversee the handling of the recommendations and suggestions. The monitoring group started its work in autumn 2019 and the group will meet one to three times a year. The recommentations and suggestions can be found in more detail in cooperation group's final report.

L.5 Spent fuel and radioactive waste inventory at the end of 2019

IAEA - SRIS

REVIEW AND SUBMISSION

Member State	**FINLAND**		
Reporting Period	**2019**	**Submission Status**	**DRAFT**

REPORT DESCRIPTION / COMMENTS
data freeze 31.12.2019

Waste Classes

Classification Scheme

Class	VLLW %	LLW %	ILW %	HLW %	Note
VLLW	100	0	0	0	
LLW	0	100	0	0	
ILW	0	0	100	0	
HLW	0	0	0	100	

Sites and Facilities

Loviisa NPP

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
Radioactive Waste	Storage	Shielded building	Solid waste storage (RCA)	805 m3		0	1977	2065	
Radioactive Waste	Storage	Unshielded building	Solid waste storage (on site)	900 m3		0	1977	2065	
Radioactive Waste	Storage	Above ground silo	Liquid waste storage (TW)	2400 m3		0	1977	2065	
Radioactive Waste	Storage	Shielded building	Solid waste storage (silos, RCA)	74 m3		0	1977	2033	
Radioactive Waste	Disposal	Geological silos or caverns	Maintenance waste hall 1	1270 m3	Crystalline Rock (Granite)	100	1997	2068	
Radioactive Waste	Disposal	Geological silos or caverns	Maintenance waste hall 2	1270 m3	Crystalline Rock (Granite)	100	2005	2068	
Radioactive Waste	Storage	Other	Maintenance waste hall 3	2000 m3		0	2012	2068	Geological silos or caverns
Radioactive Waste	Disposal	Geological silos or caverns	Solidified waste hall 1	24500 m3	Crystalline Rock (Granite)	120	2019	2068	
Spent Fuel	Storage	Wet at Reactor, SNF pool	Loviisa 1 reactor building	60 tHM		0	1977	2030	
Spent Fuel	Storage	Wet at Reactor, SNF pool	Loviisa 2 reactor building	60 tHM		0	1980	2033	
Spent Fuel	Storage	Wet away from Reactor, Storage Pool	Spent fuel storage 1	60 tHM		0	1980	2050	
Spent Fuel	Storage	Wet away from Reactor, Storage Pool	Spent fuel storage 2	827 tHM		0	1983	2060	

Otaniemi FiR 1

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
Spent Fuel	Storage	Wet at Reactor, SNF pool	FiR 1 reactor pool	0 tHM		0	1962	2023	
Radioactive Waste	Storage	Unshielded building	FiR 1 site	10 m3		0	1962	2023	
Spent Fuel	Storage	Dry at Reactor, Storage room	FiR 1 reactor building	0 tHM		0	1962	2023	
DSRS	Storage		FiR 1 DSRS	2 m3		0	1962	2023	

Olkiluoto NPP

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
Spent Fuel	Storage	Wet at Reactor, SNF pool	Olkiluoto 1 reactor building	260 tHM		0	1978	2038	
Spent Fuel	Storage	Wet at Reactor, SNF pool	Olkiluoto 2 reactor building	266 tHM		0	1980	2038	
Spent Fuel	Storage	Wet away from Reactor, Storage Pool	Spent fuel storage (KPA)	1666 tHM		0	1989	2080	
Radioactive Waste	Storage	Shielded building	Solid waste storage(KAJ)	14000 m3		0	1985	2038	
Radioactive Waste	Storage	Shielded building	Solid waste storage(MAJ)	11000 m3		0	1985	2038	
Radioactive Waste	Storage	Shielded building	Liquid waste storage(OL1 and OL2)	380 m3		0	1978	2038	
Radioactive Waste	Disposal	Geological silos or caverns	Solid waste storage LLW(silos, MAJ)	8060 m3	Crystalline Rock (Granite)	90	1992	2080	
Radioactive Waste	Disposal	Geological silos or caverns	Solid waste storage ILW(silos,KAJ)	5642 m3	Crystalline Rock (Granite)	90	1992	2080	
Radioactive Waste	Storage	Shielded building	Solid waste drum storage(OL1 and 0L2)	410 m3		0	1978	2038	
Radioactive Waste	Storage	Shielded building	Liquid waste storage OL3 (KPE,KPK)	122 m3		0	2020	2060	
Radioactive Waste	Storage	Shielded building	Solid waste storage OL3 (KPA)	156 m3		0	2020	2060	
Spent Fuel	Storage	Wet at Reactor, SNF pool	Olkiluoto 3 reactor building	485 tHM		0	2020	2060	

		pool	building						

Interim Storage of State Owned Waste

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
DSRS	Storage		Interim Storage of State Owned Waste	60 m3		0	1999	2038	

Hanhikivi NPP

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
Radioactive Waste	Disposal	Near surface - earthen trenches	VLLW	0 m3	Unknown (Site not Selected)	0	2035	2140	Planned facility
Radioactive Waste	Disposal	Geological silos or caverns	LLW/ILW	0 m3	Crystalline Rock (Other)	0	2037	2139	Planned facility
Spent Fuel	Storage	Wet at Reactor, SNF pool	Reactor	0 tHM		0	2029	2089	Planned facility
Spent Fuel	Storage	Wet away from Reactor, Storage Pool	ISFS	0 tHM		0	2034	2135	Planned facility
Spent Fuel	Disposal	Deep geological repository	Final disposal	0 tHM	Unknown (Site not Selected)	0	2124	2135	Planned facility
Radioactive Waste	Storage	Shielded building	Waste Storage building	0 m3		0	2029	2089	Planned facility

Final Repository for spent fuel

Materials Managed	Usage	Type of Facility	Facility Name	Total Cap.	Host Rock	Nominal Depth (meters)	Operation from	Operation to	Note
Spent Fuel	Disposal	Deep geological repository	Final Repository for spent fuel	0 tHM	Crystalline Rock (Gneiss)	420	2025	2120	Final disposal facility for spent fuel is under construction. The operation will start in 2020's.

Radioactive Waste Inventory

Disposal of Radioactive Waste

Waste Class	Location	Facility	Total activity	Main Radionuclides	Waste Origin Distribution (RO, FFE, RP, NA, DF, DC, RE, ND - Total 100%)	Volume Disposed(m3)	Note
LLW	Loviisa NPP	Maintenance waste hall 1	128.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	1276.00	
LLW	Loviisa NPP	Maintenance waste hall 2	182.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	775.00	
ILW	Loviisa NPP	Solidified waste hall 1	25.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	12.00	
LLW	Olkiluoto NPP	Solid waste storage LLW(silos, MAJ)	28.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	4490.00	
ILW	Olkiluoto NPP	Solid waste storage ILW(silos,KAJ)	69.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	2105.00	

Storage of Conditioned Waste

Waste Class	Location	Facility	Current Volume Stored(m3)	Total activity	Main Radionuclides	Waste Origin Distribution (RO, FFE, RP, NA, DF, DC, RE, ND - Total 100%)	Currently Planned Management Route	Note
VLLW	Loviisa NPP	Solid waste storage (on site)	135.00	212.00 MBq	Ni-63, Co-60, Ag-110m	100, 0, 0, 0, 0, 0, 0, 0	Other	Clearance
LLW	Loviisa NPP	Solid waste storage (RCA)	171.00	42.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	
ILW	Loviisa NPP	Maintenance waste hall 3	318.00	947.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	
ILW	Loviisa NPP	Solid waste storage (RCA)	138.00	944.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	
LLW	Olkiluoto NPP	Solid waste storage(KAJ)	1462.00	16.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	
VLLW	Olkiluoto NPP	Solid waste storage(MAJ)	69.00	0.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Near Surface	
ILW	Olkiluoto NPP	Solid waste drum storage(OL1 and 0L2)	81.00	0.00 GBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	
LLW	Olkiluoto NPP	Solid waste drum storage(OL1 and 0L2)	58.00	0.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	Geological	

Storage of Unconditioned Radioactive Waste

Waste Class	Location	Facility	Total activity	Main Radionuclides	Waste Origin Distribution (RO, FFE, RP, NA, DF, DC, RE, ND - Total 100%)	Current Stored Quantity	Estimated Disposal Volume(m3)	Physical Form	Current Planned Management Route	Note
ILW	Loviisa NPP	Liquid waste storage (TW)	13.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	1318.00 m3	5400.00	Liquid	Geological	
ILW	Loviisa NPP	Solid waste storage (silos, RCA)	0.00 TBq		100, 0, 0, 0, 0, 0, 0, 0	49.00 m3	203.00	Liquid	Geological	
ILW	Otaniemi FiR 1	FiR 1 site	0.16 TBq	Eu-152, Eu-154, Co-60, H-3, C-14, Cl-36	100, 0, 0, 0, 0, 0, 0, 0	4.00 m3	0.00	Solid	Geological	Thermal column graphite, activity inventory is based on calculations in year 2016. Main nuclides are chosen based on activity importancy in final disposal
LLW	Otaniemi FiR 1	FiR 1 site	13.00 MBq	Cs-137, Co-60, Eu-152, Eu-154	100, 0, 0, 0, 0, 0, 0, 0	2.00 m3	0.00	Solid	Geological	
ILW	Olkiluoto NPP	Liquid waste storage(OL1 and OL2)	0.00 TBq	Co-60, Ni-63, Cs-137	100, 0, 0, 0, 0, 0, 0, 0	60.00 m3	0.00	Liquid	Geological	

Disused Sealed Radioactive Sources

Location	Facility	Total activity	Number of Sources	Main Radionuclides	Currently Planned Management Route	Note
Otaniemi FiR 1	FiR 1 DSRS	0.00 MBq	2.00	Sb-124, Po-210	Geological	Neutron source, PoBe, ID R30, inside of triga element Neutron source, SbBe, ID R33, in reactor core position F23
Interim Storage of State Owned Waste	Interim Storage of State Owned Waste	11.70 TBq	12100.00	Am-241, Cs-137, Pu-238, Kr-85, H-3	Geological	The number of sealed sources is rough estimate. The exact number of sealed sources in the storage is not known as they have been packed in the past. At that time only total activity of radionuclides and dose rate at package surface was saved in the database. The bookkeeping is developed and currently also the number of sealed sources is stored into database.

Spent Fuel Inventory

Storage of Power Reactor Spent Fuel

Reactor Type	Origin	Location	Facility	Country	Current Inventory(tHM)	Currently Planned Management Route	Note
PWR	Own SF in MS	Loviisa NPP	Loviisa 1 reactor building		31.00	Direct Disposal	
PWR	Own SF in MS	Loviisa NPP	Loviisa 2 reactor building		31.00	Direct Disposal	
PWR	Own SF in MS	Loviisa NPP	Spent fuel storage 1		29.00	Direct Disposal	
PWR	Own SF in MS	Loviisa NPP	Spent fuel storage 2		591.00	Direct Disposal	
BWR	Own SF in MS	Olkiluoto NPP	Olkiluoto 1 reactor building		97.00	Direct Disposal	
BWR	Own SF in MS	Olkiluoto NPP	Olkiluoto 2 reactor building		118.00	Direct Disposal	
BWR	Own SF in MS	Olkiluoto NPP	Spent fuel storage (KPA)		1364.00	Direct Disposal	

Disposal of Power Reactor Spent Fuel

Reactor Type	Location	Facility	Current Inventory(tHM)	Note

Storage of Spent Fuel from Other Sources (Non-Power)

Reactor Type	Origin	Facility	Location Facility	Country	Current Inventory(kgHM)	Currently Planned Management Route	Note
LEU	Own SF in MS	Otaniemi FiR 1	FiR 1 reactor pool		15.70	Subject to supplier return agreement	
LEU	Own SF in MS	Otaniemi FiR 1	FiR 1 reactor building		5.60	Subject to supplier return agreement	

Disposal of Spent Fuel from Other Sources (Non-Power)

Reactor Type	Location	Facility	Current Inventory(tHM)	Note

Total Inventory

Total Radioactive Inventory

Waste Class	Total Amount (Stored / Disposed) (m3)	Decommissioning Amount (m3)	Total Activity	Note
VLLW	204.00	0.00	TBq	
LLW	8234.00	0.00	28.40 TBq	
ILW	4085.00	0.00	71.00 TBq	
HLW	0.00	0.00	TBq	

Total Spent Fuel Inventory

Spent Fuel	Total Amount (Stored / Disposed)(m3)	Total Activity	Note
Spent Fuel	2261.00	TBq	

Outlook Facilities

Planned Capacity for Facilities

Facility	Materials Managed	Current Capacity	Capacity in 2030	Capacity in 2050	Other year	Capacity	Note
Solid waste storage (RCA) [1977 - 2065]	Radioactive Waste / Storage	805.00 m3	805.00 m3	805.00 m3		m3	
Solid waste storage (on site) [1977 - 2065]	Radioactive Waste / Storage	900.00 m3	1700.00 m3	1700.00 m3	2022	1700.00 m3	
Liquid waste storage (TW) [1977 - 2065]	Radioactive Waste / Storage	2400.00 m3	2400.00 m3	2400.00 m3		m3	
Solid waste storage (silos, RCA) [1977 - 2033]	Radioactive Waste / Storage	74.00 m3	74.00 m3	0.00 m3		m3	
Maintenance waste hall 1 [1997 - 2068]	Radioactive Waste / Disposal	1270.00 m3	1270.00 m3	1270.00 m3		m3	
Maintenance waste hall 2 [2005 - 2068]	Radioactive Waste / Disposal	1270.00 m3	1270.00 m3	1270.00 m3		m3	
Maintenance waste hall 3 [2012 - 2068]	Radioactive Waste / Storage	2000.00 m3	2000.00 m3	2000.00 m3		m3	
Solidified waste hall 1 [2019 - 2068]	Radioactive Waste / Disposal	24500.00 m3	8650.00 m3	8650.00 m3		m3	
Loviisa 1 reactor building [1977 - 2030]	Spent Fuel / Storage	60.00 tHM	60.00 tHM	0.00 tHM		tHM	
Loviisa 2 reactor building [1980 - 2033]	Spent Fuel / Storage	60.00 tHM	60.00 tHM	0.00 tHM		tHM	
Spent fuel storage 1 [1980 - 2050]	Spent Fuel / Storage	60.00 tHM	60.00 tHM	60.00 tHM		tHM	
Spent fuel storage 2 [1983 - 2060]	Spent Fuel / Storage	827.00 tHM	tHM	tHM		tHM	
							According current time

FiR 1 reactor pool [1962 - 2023]	Spent Fuel / Storage	0.00 tHM	tHM	tHM	2023	0.00 tHM	schedule FiR 1 research reactor will be decommissioned in 2023. Spent fuel will be shipped to USA or stored in Loviisa NPP site.
FiR 1 site [1962 - 2023]	Radioactive Waste / Storage	10.00 m3	0.00 m3	m3	2023	0.00 m3	According current time schedule FiR 1 research reactor will be decommissioned in 2023. Radioactive waste will be transported to Loviisa NPP site for storage and disposal.
FiR 1 reactor building [1962 - 2023]	Spent Fuel / Storage	0.00 tHM	0.00 tHM	tHM	2023	0.00 tHM	According current time schedule FiR 1 research reactor will be decommissioned in 2023. Spent fuel will be shipped to USA or stored in Loviisa NPP site.
FiR 1 DSRS [1962 - 2023]	DSRS / Storage	2.00 m3	0.00 m3	m3	2023	0.00 m3	
Olkiluoto 1 reactor building [1978 - 2038]	Spent Fuel / Storage	260.00 tHM	260.00 tHM	0.00 tHM		tHM	
Olkiluoto 2 reactor building [1980 - 2038]	Spent Fuel / Storage	266.00 tHM	260.00 tHM	0.00 tHM		tHM	
Spent fuel storage (KPA) [1989 - 2080]	Spent Fuel / Storage	1666.00 tHM	1666.00 tHM	1666.00 tHM		tHM	
Solid waste storage(KAJ) [1985 - 2038]	Radioactive Waste / Storage	14000.00 tHM	14000.00 tHM	14000.00 tHM		tHM	
Solid waste storage(MAJ) [1985 - 2038]	Radioactive Waste / Storage	11000.00 m3	11000.00 m3	11000.00 m3		m3	
Liquid waste storage(OL1 and OL2) [1978 - 2038]	Radioactive Waste / Storage	380.00 m3	380.00 m3	380.00 m3		m3	
Solid waste storage LLW(silos, MAJ) [1992 - 2080]	Radioactive Waste / Disposal	8060.00 m3	8060.00 m3	8060.00 m3		m3	
Solid waste storage ILW(silos,KAJ) [1992 - 2080]	Radioactive Waste / Disposal	5642.00 m3	5642.00 m3	5642.00 m3		m3	
Solid waste drum storage(OL1 and 0L2) [1978 - 2038]	Radioactive Waste / Storage	410.00 m3	410.00 m3	410.00 m3		m3	
Liquid waste storage OL3 (KPE,KPK) [2020 - 2060]	Radioactive Waste / Storage	122.00 m3	122.00 m3	122.00 m3		m3	
Solid waste storage OL3 (KPA) [2020 - 2060]	Radioactive Waste / Storage	156.00 m3	156.00 m3	156.00 m3		m3	
Olkiluoto 3 reactor building [2020 - 2060]	Spent Fuel / Storage	485.00 tHM	485.00 tHM	485.00 tHM		tHM	
Interim Storage of State Owned Waste [1999 - 2038]	DSRS / Storage	60.00 m3	60.00 m3	60.00 m3		m3	
VLLW [2035 - 2140]	Radioactive Waste / Disposal	0.00 m3	0.00 m3	500.00 m3	2130	14000.00 m3	Capacity and operation times are estimates based on current plans.
LLW/ILW [2037 - 2139]	Radioactive Waste / Disposal	0.00 m3	0.00 m3	5100.00 m3	2090	21000.00 m3	Capacity and operation times are estimates based on current plans.
Reactor [2029 - 2089]	Spent Fuel / Storage	0.00 tHM	250.00 tHM	250.00 tHM		tHM	Operation times are estimates based on current plans.
ISFS [2034 - 2135]	Spent Fuel / Storage	0.00 tHM	0.00 tHM	750.00 tHM	2060	1500.00 tHM	Estimated amount of fuel produced is expected to be around 1 200 - 1 800 tons. Capacity and operation times are estimates based on current plans.
Final disposal [2124 - 2135]	Spent Fuel / Disposal	0.00 tHM	0.00 tHM	0.00 tHM	2124	1500.00 tHM	Estimated amount of fuel produced is expected to be around 1 200 - 1 800 tons. Capacity and operation times are estimates based on current plans.
Waste Storage building [2029 - 2089]	Radioactive Waste / Storage	0.00 m3	500.00 m3	500.00 m3		m3	Operation times are estimates based on current plans.
Final Repository for spent fuel [2025 - 2120]	Spent Fuel / Disposal	0.00 tHM	tHM	tHM	2120	6500.00 tHM	Final disposal facility for spent fuel is under construction. The operation will start in 2020's.

Outlook Radioactive Waste

Planned Disposal of Radioactive Waste

Waste Class	Currently Disposed Volume(m3)	Total volume disposed by 2030 2030(m3)	Volume of Decommissioning Waste disposed by 2030(m3)	Total volume disposed by 2050(m3)	Volume of Decommissioning Waste disposed by 2050(m3)	Other year	Total volume disposed (m3)	Volume of Decommissioning Waste disposed (m3)	Note
VLLW	0.00	2300.00		6900.00					
									Decommissioning waste in 2030 is from research reactor. Decommissioning waste in 2050 is from LO1 and LO2 units. Year 2100 contain decommissioning wastes from OL1,

LLW	6541.00	8761.00	35.00	10661.00	15373.00	2100		41500.00	OL2 and OL3. According current time schedule OL1 and OL2 will be decommissioned and wastes disposed by 2070 and OL3 by 2100. This estimate contains all for now waste types (VLLV, LLW, ILW and HLW) as more detailed information is not yet available.
ILW	2117.00	8278.00	9.00	9078.00	2266.00				
HLW	0								

Planned Storage of Conditioned Radioactive Waste

Waste Class	Currently Stored Volume(m3)	Total volume of stored waste in 2030(m3)	Volume of Stored Decommissioning Waste in 2030(m3)	Total volume of stored waste in 2050(m3)	Volume of Stored Decommissioning Waste in 2050(m3)	Other year	Total volume of stored waste(m3)	Volume of Stored Decommissioning Waste (m3)	Note
VLLW	204.00								
LLW	1691.00								
ILW	537.00								
HLW	0								

Planned Storage of Unconditioned Radioactive Waste

Waste Class	Currently Stored Volume(m3)	Total volume of stored waste in 2030(m3)	Volume of Stored Decommissioning Waste in 2030(m3)	Total volume of stored waste in 2050(m3)	Volume of Stored Decommissioning Waste in 2050(m3)	Total volume of stored waste (m3)	Other year	Volume of Stored Decommissioning Waste (m3)	Note
VLLW	0.00								
LLW	0.00								
ILW	5603.00								
HLW	0								

Planned Storage of Disuses Sealed Radioactive Sources

Site	Currently Stored Nr. of Sources	Total stored in 2030	Total stored in 2050	Other year	Total stored	Note
Loviisa NPP	0					
Otaniemi FiR 1	2.00					Sources are transported to Interim Storage of State Owned Waste during decommissioning of FiR 1 at latest in 2023 or to Storage in Loviisa NPP.
Olkiluoto NPP	0					
Interim Storage of State Owned Waste	12100.00	13000.00	155000.00			These are only very rough estimates. The radiation legislation from 2018 requires that sealed sources should be sent back to the manufacturer in country of origin. This estimate do not take it into account.
Hanhikivi NPP	0					
Final Repository for spent fuel	0					

Outlook Spent Fuel

Planned Storage of Spent Fuel

Origin	The amount of currently spent fuel(tHM)	The planned inventory in 2030(tHM)	The planned inventory in 2050(tHM)	The planned inventory in Year (tHM)	Mass(tHM)	Note
Own SF in MS	2261.00	3154.00	4169.00			The whole inventory of spent fuel is still reported as stored. The final disposal of spent fuel is planned to start in 2020's. This has not yet been taken into account in this reporting as the disposal rate is not known exactly.
SF outside MS	0					
Foreign SF in MS	0					

Planned Storage of Spent Fuel (Non-Power)

Origin	The amount of currently spent fuel(kgHM)	The planned inventory in 2030(kgHM)	The planned inventory in 2050(kgHM)	The planned inventory in Year(kgHM)	Mass(kgHM)	Note
Own SF in MS	21.30					The spent fuel of Research reactor is planned to be shipped back to USA. The timing of the shipment is not known. The current returning agreement is valid until 2029.
SF outside MS	0					
Foreign SF in MS	0					

Planned Disposal of Spent Fuel

Fuel Type	The amount of currently spent fuel(tHM)	The planned inventory in (tHM)	The planned inventory in (tHM)	The planned inventory in Year(tHM)	Mass(tHM)	Note

Planned Disposal of Spent Fuel (Non-Power)

Fuel Type	The amount of currently spent fuel(tHM)	The planned inventory in (tHM)	The planned inventory in (tHM)	The planned inventory in Year (tHM)	Mass(tHM)	Note

L.6 Overview matrix of Finland

Type of Liability	Long-term management policy	Funding of Liabilities	Current practice / Facilities	Planned facilities
Spent fuel	Disposal of SF in bedrock	Licensees have full financial liability.	Interim storage at the NPP sites and in the FiR1 research reactor. Construction License for an encapsulation plant and a disposal facility for SF from existing NPPs was granted in 2015.	Construction of the encapsulation plant and the disposal facility started in 2016. Future NPP operators negotiate cooperation agreement with the owners of existing facilities or build their own facilities.
Nuclear fuel cycle wastes	Disposal of LILW in intermediate depth bedrock (Loviisa & Olkiluoto)		Operating LILW disposal facilities at the both NPP sites. (Loviisa & Olkiluoto)	Future NPP operators build own disposal facilities at NPP site
Non-nuclear radioactive wastes	Disposal for most of the waste and storage for a small quantity of waste (Olkiluoto)		Handling, repacking and transport to storage by authorized private entrepreneur. Storage at Olkiluoto. Disposal to LILW silos started in 2016 in Olkiluoto.	Disposal in LILW silos
Decommissioning liabilities	Preliminary plans required in construction license phase		Decommissioning of FiR 1 research reactor is in a licensing phase	Decommissioning of FiR 1 research reactor Decommissioning plans of NPPs updated every six years
Disused Sealed Sources	Return to manufacturer or disposal	Licensees and state for orphan sources	See non-nuclear radioactive waste section	Disposal in LILW silos

B

stuk

ISBN 978-952-309-488-8
ISSN 2243-1896

STUK
Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority
Laippatie 4, 00880 Helsinki
Tel. +358 9 759 881
www.stuk.fi