

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

6th Finnish National Report as referred to
in Article 32 of the Convention

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Executive 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 6th Finnish National Report under the Joint Convention in accordance with the provisions of Article 32. It will be subject to review in May 2018 in the sixth Review Meeting of the contracting parties in Vienna. The fulfilment of the obligations of the Convention and the development of waste management after the Fifth Review Meeting, during the reporting period 2014–2016, are assessed in this report.

There are currently two nuclear power plants operating in Finland: Loviisa and Olkiluoto plants. The Loviisa plant comprises two VVER-440 units (Russian type pressurised water reactors), operated by Fortum Power and Heat Oy (FPH). The Olkiluoto plant comprises two BWR units (boiling water reactors); operated by Teollisuuden Voima Oyj (TVO) and a third PWR (pressurized water reactor) unit is under construction. In addition, Fennovoima Oy (Fennovoima) has applied for a construction licence 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 licence 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. 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 in Olkiluoto. 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 5th Review Meeting are as follows: there has been real progress in spent nuclear fuel disposal, as well as the enhancement of spent fuel interim storage safety, in addition improvements have been made in NPP's LILW management and non-nuclear radioactive waste disposal, and there has been significant progress in the planning of the research reactor decommissioning. Furthermore, the legislative and regulatory framework has been enhanced, national competences for future needs have been evaluated and developed, and the IRRS follow-up mission (IAEA's Integrated Regulatory Review Service) was carried out in Finland. Only the main achievements are presented in this summary section. 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 also presents Finland's future challenges in nuclear and radioactive waste management.

Since the 5th Review Meeting

The 5th Review Meeting in 2015 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 6th National Report of Finland. The issues are listed here, 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, Annex L.5)
- 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

- Licensing of the encapsulation plant and the disposal facility for encapsulated spent fuel (Section H, Annexes L.2 and L.3)
- Implementation of recommendations from the IRRS review (Article 20)
- Licensing of research reactor decommissioning and start of dismantling activities (Article 9, Article 26, Annex L.5).

The legislative and regulatory system has been enhanced

The current Finnish nuclear legislation is based on the Nuclear Energy Act from 1987, together with a supporting Nuclear Energy Decree from 1988. The Nuclear Energy Act has been revised several times over the years. The revision of the Nuclear Energy Act in 2015 enabled STUK to issue legally binding regulations. Based on the Nuclear Energy Act, STUK issued four regulations in 2016 to replace the earlier Government Decrees

on nuclear safety for nuclear power plants, the security in the use of nuclear energy, the emergency response arrangements at nuclear power plants, and the disposal of nuclear waste. In addition, one new regulation for the safety of uranium and thorium production was issued.

Development of national competences for future needs

STUK's role and responsibilities were assessed in a peer review, as part of the IRRS mission (IAEA's Integrated Regulatory Review Service), in October 2012. In the follow-up mission in June 2015 the regulatory activities in Finland were reviewed based on the IAEA Safety Standards and international best practices. The main conclusion of the IRRS follow up mission was that STUK had made significant progress in most areas and many improvements had been implemented in accordance with the action plan.

The implementation of the recommendations from the *“Nuclear Energy Research Strategy”*-report from 2013 is on-going by the Ministry of Economic Affairs and Employment (MEAE). The main aim is to ensure the availability of the competent resources for the safe use of nuclear energy. As an example of the on-going implementation of the recommendations, the Nuclear Energy Act was updated in 2015 to ensure the financing of the enhancement of the nuclear safety research infrastructure.

In addition to the basic training given for the nuclear sciences in universities in Espoo, Helsinki, and Lappeenranta, the availability of competent human resources has also been improved by the additional training of young experts in the nuclear safety field in different ways, e.g. through a networked doctoral programme (YTERA – Doctoral programme for Nuclear Engineering and Radiochemistry in 2012–2015) and through separately arranged national courses focusing on nuclear and waste management safety (YK and YJH Courses).

Due to the rearrangement of research funding instruments in Finland and additional budget cuts by the Government, STUK has partly terminated and also significantly reduced its radiation safety research. Instead of its own research programme, STUK has established a national radiation safety research programme in co-operation with all universities in Finland to ensure that radiation safety research will continue in Finland.

The spent nuclear fuel disposal project has progressed to the construction phase

The Finnish nuclear fuel cycle policy is based on the once-through principle. After removal from the reactor spent fuel is stored in interim pool type storages at the power plant sites. After a storage period lasting tens of years, the spent fuel will be disposed of deep in the Finnish bedrock.

Posiva submitted construction licence application and supporting safety documentation to the authorities at the end of 2012. STUK's safety review and assessment was submitted to the Ministry of Economic Affairs and Employment (MEAE) in February 2015. The construction licence was granted by the Government to Posiva in November 2015. The construction of the disposal facility started in December 2016. Posiva is responsible for the preparations for and later on for the implementation of the disposal of spent fuel of its owners TVO and FPH. The disposal project and the granted licence cover spent fuel from five reactors: Loviisa 1 and 2, in addition to Olkiluoto 1, 2 and 3.

In the Decision-in-Principle for Fennovoima's new reactor unit, Fennovoima was required to define its plans for future spent nuclear fuel management and disposal by the end of June 2016. As required, in June 2016 Fennovoima submitted an Environmental Impact Assessment programme for its planned spent fuel disposal activities to the MEAE. Fennovoima and Posiva Solutions Oy (Posiva's subsidiary that focuses on supplying services) have signed a co-operation agreement to ensure that the expertise of Posiva is available for Fennovoima's spent nuclear fuel management activities. The co-operation started in 2016.

Spent fuel interim storage safety has been enhanced

The safety of the spent fuel storages was analysed as a part of the EU stress tests in relation to the Fukushima Dai-ichi accident. Hazards or deficiencies that would have required immediate action were not found, but areas where safety could be further enhanced were identified (e.g. reducing the dependency on nuclear power plant's normal electricity supply and distribution systems as well as on the 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 firefighting systems).

The spent fuel interim storage facility in Olkiluoto undergone numerous improvements during its capacity extension, which became operational in summer 2015. These included, e.g. protection against large airplane crashes and enabling a cooling water feed from outside the storage area. Based on the evaluation in relation to the Fukushima Dai-ichi accident, water level and temperature monitoring functions have been improved for earthquake resistance and for the potential loss of the facility power supply.

Additionally, the Loviisa spent fuel storage has been improved after the Fukushima Dai-ichi accident. The main changes are aimed at reducing the dependency on the plant's normal electricity supply and distribution system, as well as on seawater cooled systems for residual heat removal from the reactor, containment and spent fuel pools. Furthermore, the flood protection of the NPP has been improved.

Operation in low and intermediate level waste management proceeded

The predisposal management of LILW was developed in Loviisa NPP during the reporting period as the solidification plant was authorized for full operation in 2016. Loviisa NPP has now been able to start the solidification of historical liquid wastes, which had been stored in tanks from the start of NPP's operation in the late 1970s. The aim is to solidify and dispose of all existing liquid waste in the forthcoming years.

The disposal of non-nuclear radioactive waste has commenced

Non-nuclear radioactive wastes originating, e.g. from research, industry and hospitals has been stored in a cavern in the LILW disposal facility at Olkiluoto. The licence conditions of the Olkiluoto LILW disposal facility were revised in 2012. The revised license enabled the disposal of non-nuclear radioactive waste in the Olkiluoto LILW disposal facility. The disposal of non-nuclear radioactive waste started in 2016 and currently most waste accumulated over the years have been disposed of.

Planning for decommissioning Finland's first nuclear reactor has started

The research reactor FiR 1 (TRIGA Mark II, 250 kW) has been in operation since 1962. The operation of FiR 1 has been carried out by VTT Technical Research Centre of Finland Ltd. in Espoo since 1971. In 2012, VTT decided to shut down the research reactor due to insufficient funding for its continued operation. The Environmental Impact Assessment procedure for the decommissioning was conducted in 2013-2015. FiR 1 will be the first nuclear reactor to be decommissioned in Finland. VTT submitted an application to the Government for a decommissioning licence on June 20, 2017 (formally this is a new operating licence as the present Finnish legislation does not define a decommissioning licence). The dismantling is scheduled to start in early 2019 and to last about two years. The dismantling will be regulated by STUK concerning the radiation and nuclear safety aspects.

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

Finland has identified for itself challenges for the future work in spent nuclear fuel and radioactive waste management and these are summarized below. Progress in spent nuclear fuel disposal programme has been identified as a continuous challenge because the proceeding project requires the development of regulatory requirements. Moreover, regulatory oversight needs to be developed and adjusted for the different project phases. STUK has procedures in place to review and update plans and regulations as the disposal project proceeds to each new phase and the needs for development are identified. Furthermore, Posiva is well prepared for the construction phase of the disposal project and preparations are ongoing for the forthcoming operation phase.

In addition, the development of national competences and a regulatory framework are identified as a continuous challenge because the nuclear field in Finland is very active at the moment and competent resources are required both for regulatory oversight as well as for licensees and license applicants.

Finland has identified following three main challenges for the future work:

- **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 also for major part of non-nuclear radioactive wastes. However, as a consequence of 1) an incident at a sealed radioactive source in the storage facilities in Suomen Nukliditeknikka and its related clean-up work (for more detail information see Section J, article 28), 2) planning of the research reactor decommissioning waste storage and disposal and 3) unresolved challenges of disposal for a few HASS sources, it has been identified that the national radioactive waste management plan and licensing system needs to be evaluated and improved to ensure a national system with capabilities for all possible waste streams. MEAE has invited an ad-hoc expert group to address these issues. The group will also address recommendations made by the Finnish Safety Investigation Authority about the sealed source incident. This group will start its work in autumn 2017.
- **Developing competences and a regulatory framework for decommissioning**
The research reactor, FiR 1, will be the first nuclear reactor to be decommissioned in Finland. As this is the first decommissioning project, Finland has limited experience in this area. VTT and STUK are both co-operating internationally gathering knowledge and experience about the implementation and regulation of decommissioning. The decommissioning project of the research reactor is also a very important learning process

for STUK as the experiences gained will be used in updating regulations and YVL guides and also later on in planning the regulatory oversight for the decommissioning of NPPs.

- **Communication to improve general public's understanding of disposal safety**

The Finnish public has a high degree of trust in the radiation and nuclear safety regulator, STUK, and there is a good degree of trust towards the safety of nuclear waste management and disposal. However, the interest of the general public towards disposal seems to be declining. Additionally, the latest poll results (conducted by e.g. Finnish Energy in 2016) show indications of a slight decrease in trust towards the safety of nuclear waste disposal. Developments of these trends need to be followed in forthcoming polls. The regulatory work and decisions made by the regulator have to be clear and understandable to the general public. The general public should also have the correct understanding of disposal safety and related risks. Due to these challenges, STUK, for its part, initiated a strategic communication development project in spring 2016 to address both the changing communication environment and the use of modern communication tools.

Candidate for good practice

Finland has identified that the granting of the construction licence for a spent fuel disposal facility is a candidate for good practice. Finland is the first country that has granted a construction licence for a final repository for spent fuel. Construction of the facility is on-going. The development and evaluation of safe disposal has been a long-lasting systematic process involving conducted in good co-operation with the Government, ministries, regulators, Posiva, nuclear power companies as well as research organisations while acknowledging the roles and responsibilities of the different parties. The approach taken in Finland has enabled timely progress of the disposal project with political and public support and resulted in approval of the construction licence application in 2015. This is a concrete step towards improving safety in a unique and proven manner.

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.

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List of acronyms

| | |
|-----------|---|
| AFR | Away from reactor |
| BWR | Boiling water reactor |
| DiP | Decision-in-Principle by the Government |
| EIA | Environmental impact assessment |
| EPR | European pressurized water reactor |
| ETCS | European Credit Transfer and Accumulation System |
| FPH | Fortum Power and Heat Oy (NPP utility) |
| FSAR | Final Safety Analysis Report |
| ILW | Intermediate level waste |
| LILW | Low and intermediate level waste |
| LLW | Low level waste |
| MEAE* | Ministry of Economic Affairs and Employment |
| MEE* | Ministry of Employment and the Economy |
| MTI* | Ministry of Trade and Industry |
| NORM | Naturally occurring radioactive materials |
| NPP | Nuclear power plant |
| ONKALO | Underground rock characterization facility for spent fuel disposal at Olkiluoto |
| Posiva | Posiva Oy (joint company for spent fuel disposal of TVO and FPH) |
| PSAR | Preliminary Safety Analysis Report |
| PWR | Pressurized water reactor |
| SNF | Spent Nuclear Fuel |
| ST Guide | Safety regulation issued by STUK subject to radiation legislation |
| STUK | Radiation and Nuclear Safety Authority |
| TVO | Teollisuuden Voima Oyj (NPP utility) |
| URCF | Underground Rock Characterization Facility |
| VAL Guide | National Protective Actions Guidelines in Case of Radiological or Nuclear Emergency |
| VLLW | Very low level waste |
| VTT | VTT Technical Research Centre of Finland |
| VYR | State Nuclear Waste Management Fund |
| YVL Guide | Safety regulation issued by STUK subject to nuclear energy legislation |

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

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 6th 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 2018 in the sixth Review Meeting of the contracting parties in Vienna.

The fulfilment of the obligations of the Joint Convention and the developments during 2014–2016 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 nuclear waste management activities in Finland. The plans for the decommissioning of nuclear facilities and also the regulation and management of radioactive waste generated outside the nuclear fuel cycle are discussed when required.

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 5th 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.

The main developments during the reporting period 2014–2016 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 low and intermediate level 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 5th review meeting. The identified future challenges and planned improvements are also presented in Section K.

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 |

More detailed information about currently ongoing projects is included in the appendices. Firstly, the legal background to nuclear waste management and radioactive waste management is described in Appendix L.1. Appendices L.2 and L.3 describe the 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. Nuclear waste management plans for the new NPP project Hanhikivi 1 are described in Appendix L.4. The current status of the decommissioning of research reactor FİR 1 is summarized in Appendix L.5.

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 VVER-440 units (Russian type pressurised water reactors), operated by Fortum Power and Heat Oy (FPH). The Olkiluoto plant comprises two BWR units (boiling water reactors) operated by Teollisuuden Voima Oyj (TVO) and a third PWR (pressurized water reactor) unit is planned to be commissioned at the end of 2018 at the Olkiluoto site. In addition, Fennovoima has applied for a construction licence for one pressurized water reactor (AES-2006) in Pyhäjoki (Figure 1). Finland also has a research reactor FİR 1 in Otaniemi, which is currently in an

extended shutdown state and according to current plans it will be decommissioned in 2019–2021.

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 Pyhäjoki in the 2030s.

The construction licence 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 Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (FPH). The disposal project and granted construction licence covers spent fuel from five reactor units: Loviisa 1 and 2, Olkiluoto 1, 2 and 3. In June 2016, Fennovoima submitted an Environmental Impact Assessment programme for a spent fuel disposal facility to the MEAE. At the same time, a co-operation agreement with Posiva Solutions Oy (Posiva's subsidiary that focuses on supplying services) was signed to ensure that the expertise of Posiva is available for Fennovoima's spent nuclear fuel management activities. Co-operation started in 2016.

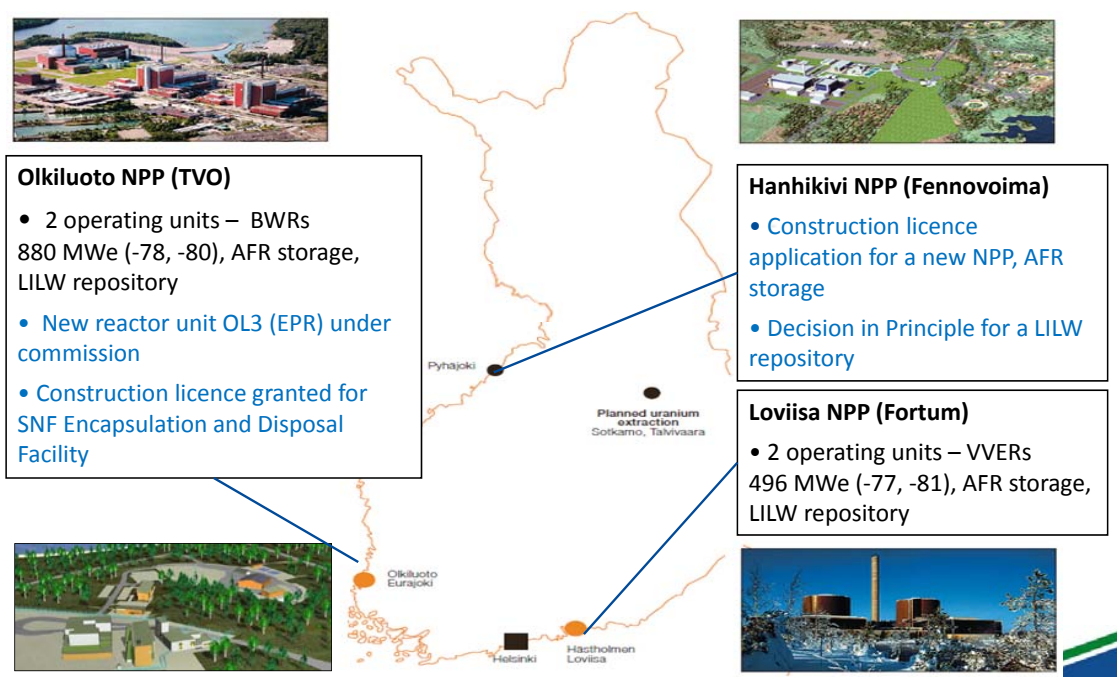


Figure 1. The nuclear power plants in Finland.

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 first principles for nuclear waste management were originally set out in the Finnish Government's policy decision of 1978. This first decision defined the overall responsibilities for waste management, as well as financial responsibilities and the Finnish Government's role in the oversight of the R&D work needed to implement the policy. The policy and strategy were further elaborated in a government decision in 1983 for TVO and later on in the decisions by the predecessors to MEAE. These decisions also set a long-term schedule for the implementation of nuclear waste management including site selection and the start of the operation of the spent fuel disposal facility. 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.

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 because 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 50) 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 or 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 51).

Political decision-making and public consultation

According to the Nuclear Energy Act (Section 11), the construction of a nuclear facility of consider-

able general significance requires 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). The DiP approved by the Government must be forwarded, without delay, for handling by 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 (the Ministry of Economic Affairs and Employment, 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).

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 27a) the amount of nuclear waste generated in the use of nuclear energy must be kept as low as is rea-

sonably 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 6a), 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 6a of the Nuclear Energy Act). As stipulated in Section 7b 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 10), 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 31b), when requesting a safety licence for the use of a high-activity sealed source, the request must include a plan for rendering any disused sources harmless, including the arrangements for their return to the manufacturer or supplier, or their surrender to a recognised installation. The Radiation Decree (Section 24b) specifies that STUK shall discharge the function of rendering radioactive waste harmless where there is no recognised facility of the kind referred to in the Radiation Act. STUK may agree with the custodian of the waste that custody of the waste will be permanently assigned to the Government in return for a non-recurrent compensation charge.

Principles for decommissioning of nuclear facilities

The Nuclear Energy Act (Section 7g) requires that provisions for the decommissioning of a nuclear facility must be taken into account 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 7a) 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 7h 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 licence conditions. Respectively, the Radiation Act (Section 6) states that compliance with the Act and with the provisions and regulations issued pursuant thereto shall be supervised by STUK. The Act (Section 16) 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 (Article 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. A State Nuclear Waste Management Fund has been set up and funds are collected in advance annually as a provision to fulfil any pending nuclear waste management and decommissioning obligations and to ensure that funds are available in case any licence holder is unable to fulfil its obligations. The NPP operators include the costs of waste management, even those arising from the decommissioning of the NPPs, into the price of the electricity produced by the NPPs. Initially, the nuclear power companies had internal funds for that purpose, but by virtue of the entry into force of the Nuclear Energy Act, the State Nuclear Waste Management Fund was established under the former Ministry of Trade and Industry (now MEAE) in 1988. To ensure that financial liability is fully covered, 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 nuclear waste and decommissioning of facilities and must take care that the required amount of money is set aside in the State Nuclear Waste Management Fund. In addition, they shall provide securities to the State for that part of their financial liability, which is not yet covered by the Fund (Article 45). 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 State Fund.

The Radiation Act (Section 19) 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 2.

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 (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 7b of the Nuclear Energy Decree, the spent fuel from the research reactor in Finland can be handled, stored, and disposed of outside Finland.

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/4/2016. 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

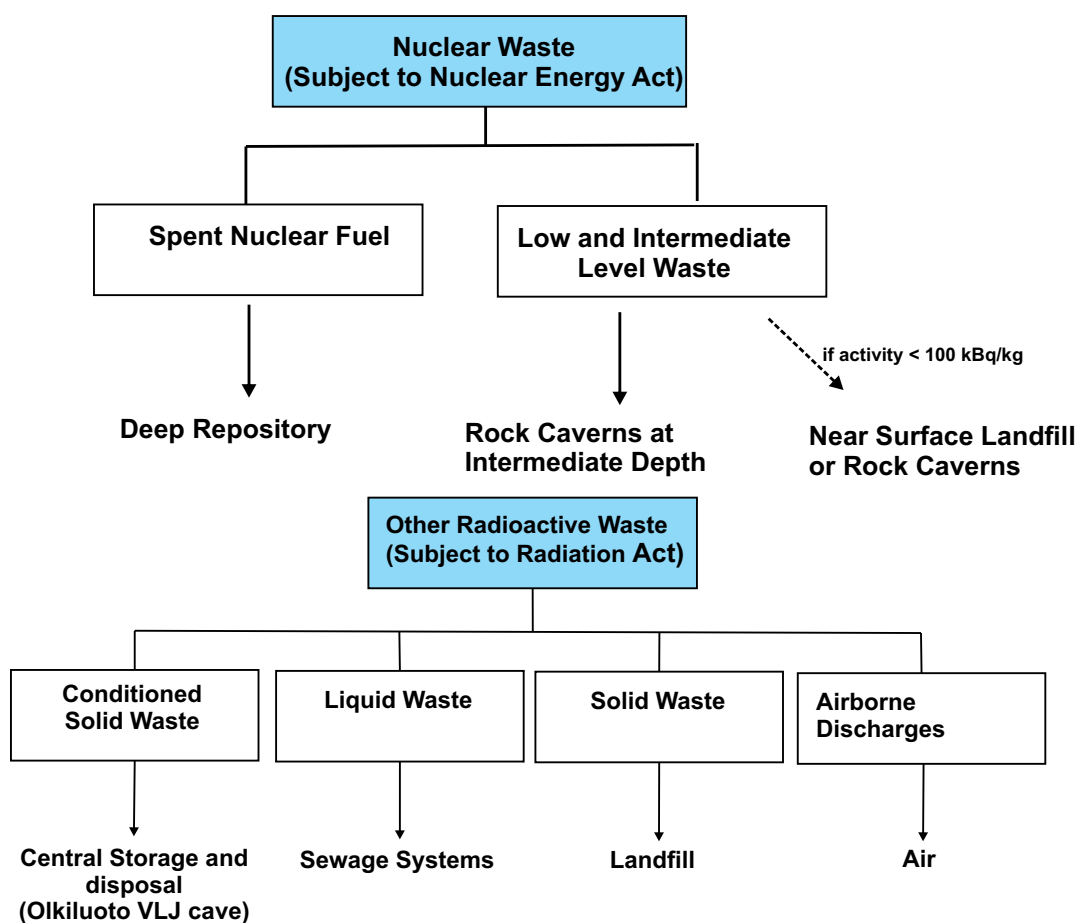


Figure 2. Classification of radioactive waste for disposal purposes.

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 < 1 TBq, 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/4/2016. 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;

Guide YVL D.4 provides for the general and case-specific clearance of nuclear waste. 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 μ Sv 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 in 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. Another set of values 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 but care must be taken that they do not exceed the exemption values given, e.g. in the Council Directive 96/29/Euratom and Guide ST 1.5.

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 μ Sv and 100 μ Sv, to be determined on the basis of 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 for disposal in landfill sites or sewage systems are provided in Guide ST 6.2. The criteria are based on the trivial dose as specified above for the clearance of nuclear waste.

According to Guide ST 6.2 *Radioactive waste and emissions from the use of unsealed sources*, liquid waste may be disposed of into a sewage system and solid waste may be delivered to a landfill site or an incineration plant, as long as the activity levels are below the nuclide specific limits based on the exemption limit. Sealed sources with activity levels below the exemption limit may be disposed of as non-radioactive waste. If the activity of a sealed source is above the exemption limit, the source needs to be disposed of as radioactive waste through a recognized facility.

Spent fuel and radioactive waste management practices and plans

The 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 a number of facilities using radioisotopes for medical, research and industrial applications. The management practices for nuclear waste and non-nuclear radioactive waste are described in detail below. A concise overview of the management strategies is provided on the next page.

The NPP utilities Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (FPH) each take care of the interim storage of spent fuel, the conditioning and disposal of low and intermediate level waste, and the planning and execution of future decommissioning of the NPPs, including also the disposal of the decommissioning waste of the NPPs. Additionally, Fennovoima, when it becomes a licensee, will be responsible for nuclear waste management and decommissioning activities as well as for the interim storage and disposal of spent fuel.

TVO and FPH have formed a joint company, Posiva, which is responsible for the preparation and implementation of the disposal their spent fuel. The disposal project currently covers spent fuel from the four reactors in operation and from the one under construction (Olkiluoto 3).

The operator of the research reactor, VTT Technical Research Centre of Finland Ltd, has facilities for the interim storage of its spent fuel, as well as low, intermediate level and non-nuclear radioactive waste. 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 (592/1991), a recognized installation may receive radioactive wastes and sealed sources if it has a safety licence approved by STUK for its operations. If there are not any recognized installations, STUK will be responsible 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 latest enlargement of the storage facility was commissioned in 2001. The installation of high density fuel racks was started in 2007 and will continue in the future according to necessity. The total allowable amount of spent fuel, according to the renewed operating licence 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 in 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 finalized in 2015. The extension of the storage capacity included the construction of three new storage pools taking into account also the commissioning of Olkiluoto 3. The capacity of the interim spent fuel storage after this extension is 1800 tU. The extension has been included as part of the Olkiluoto 1 and 2 operating licence and was authorized as a plant modification. The safety of the spent fuel storage sites (at both Loviisa and Olkiluoto site) was analysed as part of the EU stress tests in relation to the Fukushima Dai-ichi accident.

In practice, before disposal, the spent fuel will be stored in water pools for 30 to 50 years and thereafter transported or transferred to the encapsulation and disposal facilities in Olkiluoto. Posiva is implementing the spent fuel disposal programme on behalf of its owners, TVO and FPH, in line with the Government Policy Decision of 1983 and a further decision by the Ministry of Trade and Industry in 2003. The major past and future milestones of the spent fuel disposal programme are the following:

- Site selection for the spent fuel disposal facility in 2000
- Start of construction of an underground rock characterization facility (ONKALO) in Olkiluoto in 2004
- A description in 2009 of the preparedness of the Construction Licence application preparation

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 principles

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 geological 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 MAEA). The disposal operations are expected to begin in the 2020s. The spent fuel disposal programme is subject to a continuous regulatory review. The construction licence was granted in 2015. The operation licence application is expected to be submitted to the Government in 2020.

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 taking into account 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 producers of nuclear waste bear the full financial responsibility for their waste management costs. A funding system for the provisions of future costs arising from waste management and disposal as well as decommissioning exists to ensure that the costs can be covered even in case of the waste generators' inability to fulfil their obligations in the future. The pertinent licence-holders submit technical plans and cost calculations for regulatory review at three-year intervals and these estimates are used as a basis for calculating liability estimates. After the annual confirmation of the financial liabilities, the licensees pay fees into a State controlled Nuclear Waste Management Fund and provide securities for the liability not yet covered by the Fund.

- Submittal of the construction licence application for the Olkiluoto Encapsulation and Disposal Facility at the end of 2012
- Construction licence for the Encapsulation and Disposal Facility granted by Government in November 2015
- Construction of the disposal facility started in December 2016
- Readiness for starting disposal operations planned to be achieved in the early 2020s.

The construction of the Underground Rock Characterization Facility (URCF ONKALO) was conducted in 2004–2012. The length (chainage) of the tunnels is 4987 m and the tunnel reached a depth of 455 m. Posiva has excavated four short demonstration tunnels for testing the emplacement technology. STUK's regulatory control of the spent fuel disposal project is described in Annex L.2 and the current status of Posiva's programme for spent fuel disposal is described in Annex L.3.

The construction licence granted by the Government in November 2015 enabled the disposal of in total 6500 tonnes of uranium (spent fuel) in Olkiluoto. The estimate is based on the following expectations of operational lifetimes: Loviisa 1

and 2: 50 years and Olkiluoto 1, 2 and 3 60 years (Figure 3).

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.

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 4 and an individual deposition tunnel with two canister emplacement variants are illustrated in Figure 5.

Spent fuel from the research reactor 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

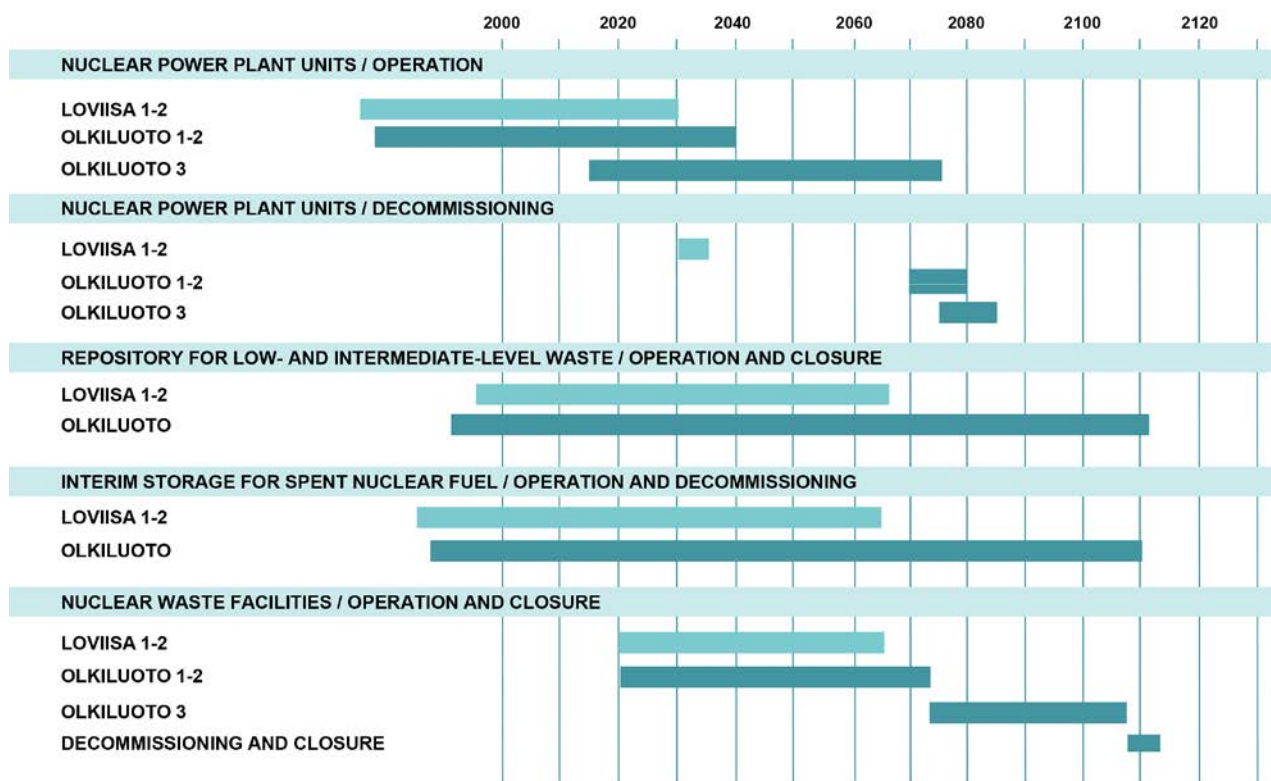


Figure 3. Timetable for the management of spent fuel from the nuclear power plants at Loviisa and Olkiluoto.

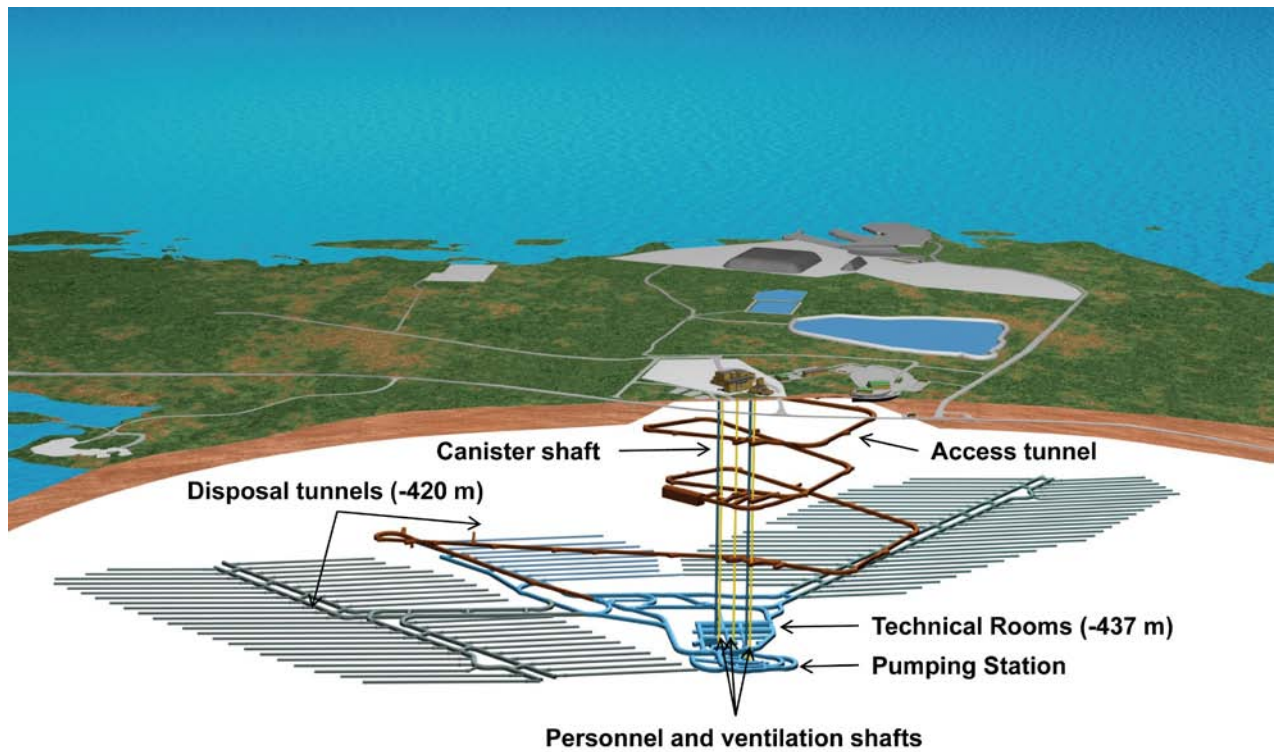


Figure 4. A schematic presentation of the layout of the underground rock characterization facility and the network of disposal tunnels (KBS3-V option).

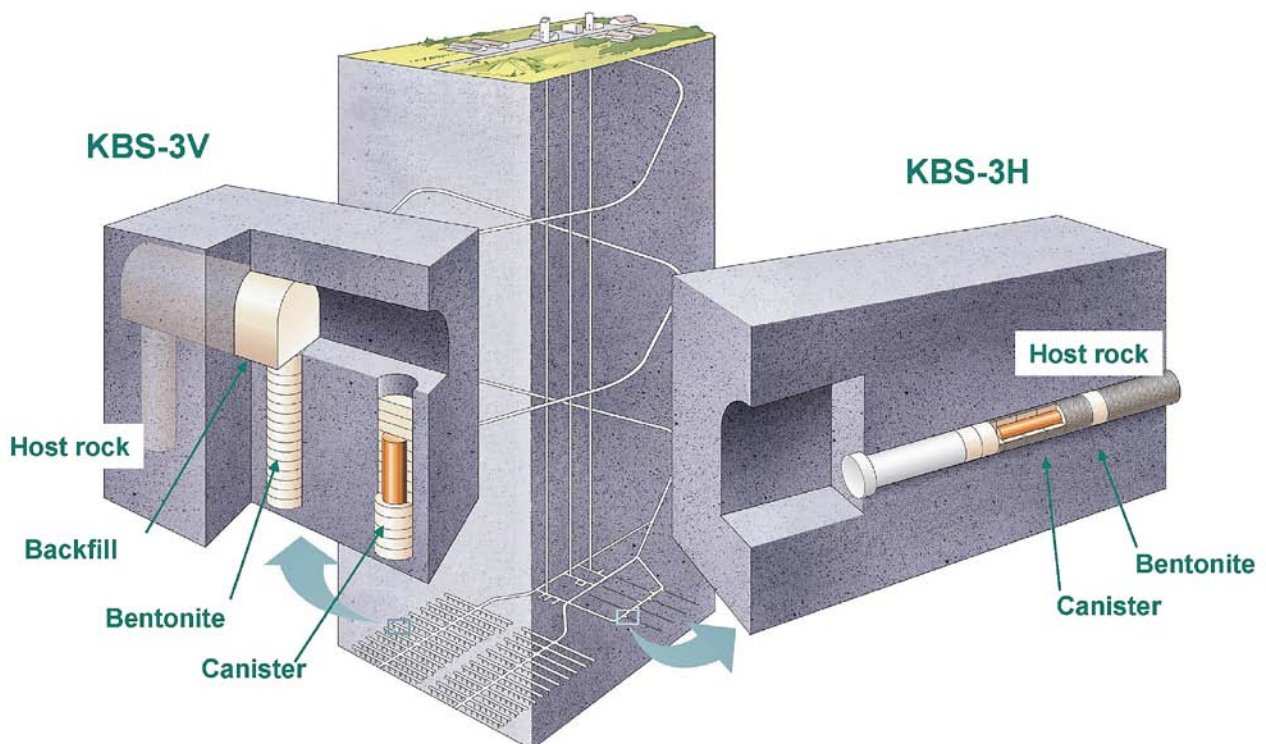
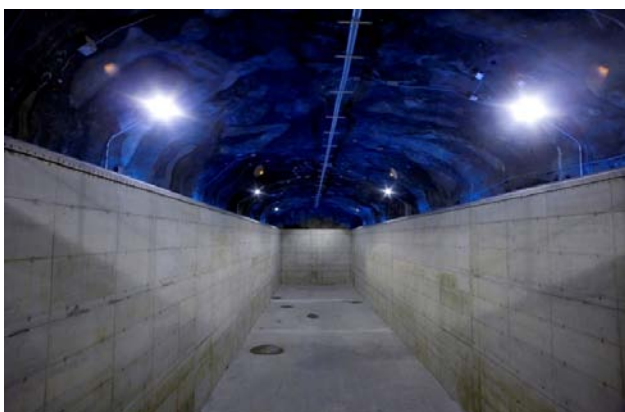


Figure 5. Disposal tunnel and canisters with both the vertical and horizontal disposal options depicted.



Program of U.S. Department of Energy (DoE). Another option is interim storage and later disposal in the Olkiluoto spent fuel disposal facility. This would require an agreement between the companies and the licensing of the Olkiluoto disposal facility also for the research reactor's spent fuel. 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 Fortum's innovative selective ion exchange method to reduce the volume of liquid radioactive waste. Fortum 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 will be dried in drums.

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.

Activated metal waste consists of irradiated components and devices that have been removed from inside of the reactor vessel. So far, this kind

Figure 6. The Loviisa repository. a) Cross-sectional view of the repository for LILW and the planned extension for decommissioning waste, b) Drums of LLW from reactor operation waste in the repository tunnel and c) An empty repository tunnel for solidified waste.

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 operators, FPH at Loviisa and TVO at Olkiluoto.

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 6). Inside the cavern for ILW, the waste packages are emplaced in a pool-shaped structure made of reinforced concrete. A new hall (HJT3) was constructed during 2010–2013 and it has initially 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 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 7). 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. The disposal facility will be extended in the 2030s, to be able to receive all the LILW from Olkiluoto 1, 2 and 3 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.

LILW generated from the operation of the research reactor FiR 1 is stored at the reactor facility in Otaniemi until decommissioning. VTT is negotiating with the Finnish NPP licensees (TVO and FPH) for possible interim storage and will continue negotiations later on for future disposal of decommissioning waste. 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 facil-

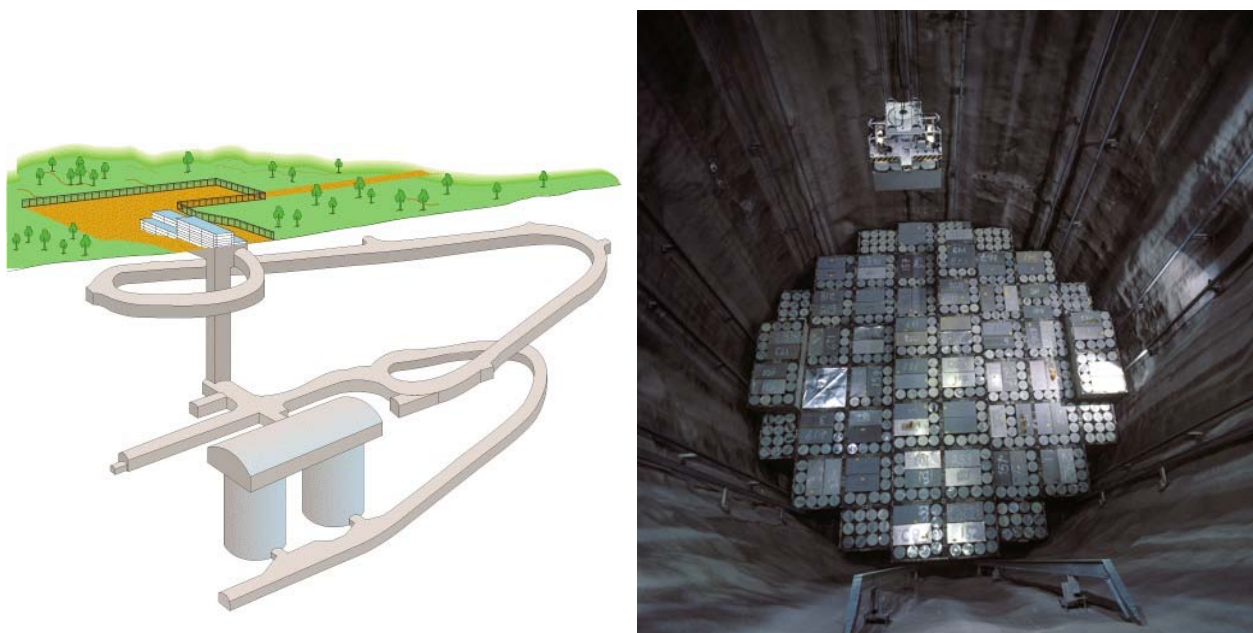


Figure 7. The Olkiluoto LILW repository. LLW drums in the disposal silo (left) and cross-sectional view of the repository lay-out (right).

ity 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 very low-level waste (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 licence 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 Radiation Decree, Section 24 b (for more information see Section J Disused Sealed Sources).

Radioactive waste is stored under the regulatory control of STUK's Department of Nuclear Waste and Material Regulation in an interim storage cavern attached to the LILW disposal facility at Olkiluoto. The Department of Environmental Radiation Surveillance of STUK takes care of the waste containing nuclear material and stores it at STUK. The organisational structure of STUK clearly separates 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 renewed operating licence for the Olkiluoto LILW disposal facility. The licence 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 activity limits regarding gaseous or liquid discharges or solid-waste disposal, established in Guide ST 6.2, are not exceeded. 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 limits set for discharge in Guide ST 6.2. 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.

All radionuclide laboratories in Finland are inspected by STUK regularly, every 1–5 years, depending on the type and size of the practice, with storage and other activities related to waste management as a standard item in the inspection agenda.

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 the Radiation and Nuclear Safety Authority (STUK).

Decommissioning plans for nuclear facilities

The decommissioning of the Finnish operating nuclear power plants is not foreseen in the near future. The utilities have updated the decommissioning plans of NPPs for regulatory review every six years (the Nuclear Energy Act, Sections 7g and 28). FPH submitted an updated plan for the decommissioning of the Loviisa NPP for regulatory review in 2012 and TVO's last plan for the Olkiluoto NPP decommissioning was submitted in

2014. 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 Olkiluoto 3 unit will be operational while the Olkiluoto 1 and 2 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 could 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 decommission-

ing 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 has decided to decommission its research reactor (FiR 1) due to insufficient funding for continued operation in 2012. The licensing for the decommissioning started in autumn 2013 with the Environmental Impact Assessment (EIA) procedure. The EIA procedure ended in February 2015, when the MEAE gave its statement on the EIA report. VTT has applied for a licence for decommissioning the research reactor in June 2017. The dismantling is scheduled to be started in 2019 and to last about two years. 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.

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 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 materials (NORM-waste), except sealed radium sources, is not declared as radioactive waste for the purposes of the Convention. However, some experience with the current practice for managing NORM waste is reported in section H.

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.*

Spent fuel and radioactive waste management facilities

Table 1. Spent fuel storage in Finland.

| Loviisa nuclear power plant | |
|-------------------------------|---|
| Owner: | FPH |
| Location: | Hästholmen island, town of Loviisa, Southern Finland |
| Purpose: | Interim storage of spent fuel |
| Capacity: | 673 tHM ¹ (effective ²) |
| Inventory (end of 2016): | 626 tHM ¹ (5167 assemblies, maximum burnup 55 MWd/kgU) |
| Essential features: | Pool storages inside both reactor buildings Basket type pool storage in the NPP auxiliary building Rack type pool storage in the NPP auxiliary building |
| Olkiluoto nuclear power plant | |
| Owner: | TVO |
| Location: | Olkiluoto island, municipality of Eurajoki, South-Western Finland |
| Purpose: | Interim storage of spent fuel |
| Capacity: | 1770 tHM ¹ (effective ²) |
| Inventory (end of 2016): | 1469 tHM (8720 assemblies, maximum burnup 53 MWd/kgU) |
| Essential features: | Pool storages inside both reactor buildings Pool storage in a separate facility at the NPP site |
| FIR 1 research reactor | |
| Operator: | VTT |
| Location: | Otaniemi, town of Espoo, Southern Finland |
| Purpose: | Interim storage of spent fuel |
| Inventory (end of 2016): | 4.45 kgU (24 elements, maximum burnup 33 MWd/kgU) |
| Essential features: | Wet storage for cooling. After several years' cooling time the elements are transferred to the well type dry storage. |

¹ tHM means spent fuel inventory is presented in tonnes of heavy metals.

² The reserve capacity for exceptional unloading of the entire reactor core to storage pool, for storage pool repairs and space for dummy elements are excluded.

Table 2. Predisposal management of radioactive waste in Finland.

| | |
|---|--|
| Loviisa nuclear power plant | |
| Owner: | FPH |
| Location: | Hästholmen island, town of Loviisa, Southern Finland |
| Purpose: | Treatment, conditioning and interim storage of LILW |
| Inventory (end of 2016): | 1660 m ³ |
| Essential features: | Pretreatment, compaction and packaging of solid LLW Pretreatment of liquid LILW Eight tanks, 300 m ³ each, for storage of liquid LILW Solidification plant for liquid LILW Two storage rooms inside the NPP for packed LLW (Dry) storage well and pool storage for unconditioned activated waste On-site light built storage hall for waste candidate for clearance |
| Olkiluoto nuclear power plant | |
| Owner: | TVO |
| Location: | Olkiluoto island, municipality of Eurajoki, South-Western Finland |
| Purpose: | Interim storage of LILW |
| Inventory (end of 2016): | 310 m ³ |
| Essential features: | Pretreatment, compaction and packaging of solid LLW Pretreatment and bituminisation of liquid LILW Four buffer storage rooms for conditioned LILW Pools storage of unconditioned activated waste Treatment and storage buildings at the site for unconditioned LLW |
| FiR 1 research reactor | |
| Operator: | VTT |
| Location: | Otaniemi, town of Espoo, Southern Finland |
| Purpose: | Treatment, packaging and interim storage of LILW |
| Inventory (end of 2016): | 6 m ³ |
| Essential features: | Storage room in the basement of a laboratory building |
| Storage for state owned waste (recognised installation) | |
| Owner: | Suomen Nukliditeknikka |
| Location: | Roihupelto, city of Helsinki, Southern Finland |
| Purpose: | Buffer interim storage of radioactive waste for example from industry and hospitals |
| Inventory (end of 2016): | 2 m ³ (2.4 TBq) |
| Essential features: | Buffer interim storage is for packing and conditioning radioactive wastes from industry and hospitals (e.g. spent sources). The waste is packed in form suitable for disposal. This material does not contain nuclear material. |
| Storage for small user waste containing nuclear material | |
| Owner: | STUK – Radiation and Nuclear Safety Authority |
| Location: | Roihupelto, city of Helsinki, Southern Finland |
| Purpose: | Buffer interim storage of small user radioactive waste containing nuclear material |
| Inventory (end of 2016): | Pu: 10.5 g, HEU: 208 g, LEU: 27.4 g, UNat: 46.5 kg, DU: 395 kg, Th: 2.4 kg |
| Essential features: | Buffer interim storage is for packing and conditioning radioactive wastes from industry and hospitals. The waste is packed in form suitable for disposal. |
| Storage for state owned waste | |
| Owner: | TVO/Ministry of Social Affairs and Health ³ |
| Location: | Olkiluoto island, municipality of Eurajoki, South-Western Finland |
| Purpose: | Long-term interim storage of sealed sources and other small user waste |
| Inventory (end of 2016): | 35 m ³ (36 TBq, prominent nuclides: ³ H, ¹³⁷ Cs, ⁸⁵ Kr, ²⁴¹ Am, ²³⁸ Pu, not including Th-232 (2.5 kg) and depleted uranium (1284 kg) |
| Essential features: | Rock cavern attached to the Olkiluoto disposal facility |

³ By an agreement made in 1996 between TVO and the Ministry of Health and Social Affairs, the waste is stored in a separate rock cavern in TVO's Olkiluoto LILW disposal facility. The waste is owned by the State, with the Ministry of Social Affairs and Health as the responsible organisation.

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). Spent fuel is currently stored in pool storage facilities located at the plant sites. Low and intermediate level waste is also stored and disposed of at the NPP sites. Small amounts of spent fuel and radioactive waste has been produced during the operation of the FiR 1 re-

search reactor in Otaniemi. The spent fuel from the research reactor and radioactive waste is currently stored at Otaniemi.

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 licen-

Table 3. Disposal of radioactive waste in Finland.

| Loviisa disposal facility | |
|------------------------------------|---|
| Owner: | FPH |
| Location: | Hästholmen island, town of Loviisa, Southern Finland |
| Purpose: | Disposal of LILW |
| Inventory (end of 2013): | 1886 m ³ (0.45 TBq, dominant nuclides Co-60, Ni-63, Cs-137) |
| Essential features: | Rock tunnels for LLW Vault for solidified LLW |
| Olkiluoto disposal facility | |
| Owner: | TVO |
| Location: | Olkiluoto island, Municipality of Eurajoki, South-Western Finland |
| Purpose: | Disposal of LILW |
| Inventory (end of 2013): | 5681 m ³ (52.0 TBq, dominant nuclides Co-60, Ni-63, Cs-137, Sr-90, C-14) |
| Essential features: | Rock silo for conditioned packed LLW Rock silo for conditioned/packed LLW |

sees 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 according to Guide ST 5.1 it is prohibited to unnecessarily store sources for which no use is foreseen.

Waste from past practices

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

Decommissioning

VTT is currently planning the decommissioning of an old hot cell laboratory. The functions of the laboratory are being transferred step by step to a new VTT Centre for Nuclear Safety. The actual decommissioning means, for example, cleaning structures from contamination resulting from the use

of radiation, as well as arrangements concerning radioactive waste resulting from the cleanup and finally disposal of radioactive waste. The final state of the laboratory after decommissioning will be “brown field” meaning that the laboratory building will be released from regulatory control for another use. This can be done after the premises have been found to be clean from radioactivity and the radioactive waste has been properly handled and stored.

Detailed planning for the laboratory decommissioning was completed during spring 2017. VTT compiled a decommissioning plan, which includes 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.

The actual dismantling of the laboratory can start after STUK has approved the decommissioning plan.

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 licence;*
- (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 1991, respectively. Since then, several amendments to these acts and new detailed regulations have been issued.

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 6a) the provisions forbidding export of nuclear waste do not apply to nuclear waste that has been generated in connection with or as a result of the operation of a research reactor in Finland.

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. This was demanded by the new Constitution requiring that the general principles for the protection of citizens should be provided for in governmental 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 Ministry of Economic Affairs and Employment (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 IRRS (Integrated Regulatory Review Service) 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. Amendment of Radiation Act was begun in 2016 and is currently ongoing.

By definition, 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 27a to 34) and requirements for the financial provision for nuclear waste management are specified in Sections 35–53. Sections 35 to 53 describe the National Nuclear Waste Management Fund (VYR Fund) and its operating principles. Funds are collected from licensees under the waste management obligation and paid into the VYR Fund based on the estimated waste management costs for all operations, including disposal, of any nuclear waste a licensee has in a given year.

Based on the Nuclear Energy Act, in 2016 STUK issued the following regulations:

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

Regulations Y/1/2016 to Y/4/2016 replaced the previous Government Decrees regulating the same safety areas. Regulation Y/5/2016 on Uranium or

Thorium mining is new. The Regulations issued by STUK are legally binding according to Section 7q of Nuclear Energy Act.

The Regulations Y/1/2016 (Safety of a Nuclear Power Plant, Y/2/2016 (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/2/2016 and Y/3/2016 are also applied to other nuclear facilities to the extent applicable, based on the graded approach.

The Regulation on the Security in the Use of Nuclear Energy is a minor update of the previous Government Decree from 27 November 2008. The Regulations on the Safety of Nuclear Power Plants (Y/1/2016) and Emergency Response Arrangements at Nuclear Power Plants (Y/2/2016) were only slightly revised from the previous Government Decrees from 2013 and include changes to safety requirements arising from the Fukushima Dai-ichi accident and new WENRA (Western European Nuclear Regulators' Association; see also chapter *Nuclear Regulatory Guidance*) Safety Objectives. A new Regulation on the safety of mining and milling operations aimed at producing uranium or thorium (Y/5/2016) was prepared in 2015. The Regulation on the Safety of Disposal of Nuclear Waste (Y/4/2016) was a major revision of the previous Government Decree from 2008. Its structure was fully reorganized, and major changes were made based on experiences from regulatory oversight of the LILW disposal facilities as well as oversight and review of the licence application for Posiva's spent fuel disposal facility. The main changes were related to regulation of the design and construction of waste treatment facilities such as Posiva's encapsulation plant.

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.

At the end of 2016, revision to both the Nuclear Energy Act and the Radiation Act started due to the Basic Safety Standards directive and to the amended Nuclear Safety Directive. The revision of

the Nuclear Energy Act will also include amendments related to e.g. changes in the Pressure Equipment Act and licensing for nuclear facilities. The proposed new Nuclear Energy Act and Decree will introduce a decommissioning licence step. The decommissioning licence will be granted by the Government if the changes in the law are approved by the end of 2017 as planned. This would clarify the terms for the decommissioning of the nuclear facilities in the future.

As described above, the nuclear legislation has been amended several times. The MEAE has 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 achieves the required level of safety stipulated in the Nuclear Energy Act, the Nuclear Energy Decree and STUK Regulations.

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 applies 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 mem-

ber 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. Considering the WENRA Safety Reference Levels published in 2007–2015, the Finnish policy is to include all of them in the revised regulatory guide system. This was confirmed already during the updating work for regulatory guides through a systematic approach to recording all the Safety Reference Levels in relevant YVL guides.

STUK used to have a set of about 70 YVL guides in force, which have been continuously re-evaluated for updating. After amending the nuclear energy legislation in 2008, the revision of the existing YVL guide system was also commenced. The main objectives of this effort were the following:

- to update the contents of the regulatory guides, especially with the IAEA and WENRA requirements and with the lessons learnt from the Olkiluoto Unit 3 project,
- to restructure the guide system better to reflect the various areas of safety; at the same time to limit the total number of guides and the need for cross-referencing between the guides
- to compile requirements concerning related safety issues in the same guide making it easier to use by the licensees and other stakeholders; also they will be coupled to the licensing process stages
- to rewrite the separate requirements in such a way that each requirement would have its own number, be short and clearly state who-what-when things are done; the requirements would be expressed in a shall-do format, and descriptive text would be provided only when necessary
- to limit unnecessary prescriptiveness when considering the requirements.

The Director General of STUK accepted 40 new YVL guides and they entered into force on December 1, 2013. 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.

Legislation and regulations for the use of radiation sources

The Radiation Act and Decree were revised in 1991 to take into account ICRP Publication 60 (1990 Recommendations of the International Commission on Radiological Protection). The Radiation Act and Decree were further amended in 1998, 2005, 2008 and 2013 to conform with the European Community Radiation Protection Legislation, including:

- the Council Directive 96/29/Euratom of 13 May 1996, on the Protection of the Health of Workers and General Public Against the Dangers Arising from Ionizing Radiation,
- the Council Directive 2003/122/Euratom of 22 December 2003, on the Control of High-Activity Sealed Radiation Sources and Orphan Sources, as well as,
- the Council Directive 2006/117/Euratom of 20 November 2006, on the supervision and control of shipments of radioactive waste and spent fuel, and
- the Council Directive 2011/70/Euratom of 19 July 2011, establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

Detailed safety requirements on the management of radioactive waste, subject to the Radiation Act, are provided in STUK's ST Guides. The responsible party running a radiation practice is obliged to ensure that the level of safety specified in the ST Guides is attained and maintained.

The Council Directive 2013/39/Euratom of 5 December 2013, laying down basic safety standards for protection against the danger arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, is currently being implemented into the Finnish legislation.

Licensing of spent fuel and radioactive waste management activities

The licensing process is defined in legislation. The construction and operation of a nuclear facility is not permitted without a licence and licences are prepared by the MEAE and granted by the Government. For any nuclear reactor unit, spent nuclear fuel storage, nuclear waste disposal facil-

ity, or another significant nuclear facility the process consists of three steps:

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

The conditions for granting a licence are prescribed in the Nuclear Energy Act (Sections 18–20). The operating licences of a nuclear facility are granted for a fixed term, generally for 10–20 years. In case the operating licence is granted for a longer period than 10 years, 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 Licence 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 Environmental Impact Assessment (EIA) procedure has to be conducted prior to the application for the DiP and 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 would not be constructed and operated in a safe manner.

The entry into force of the Government's Decision-in-Principle further requires ratification by Parliament. Parliament cannot make any changes to the Decision; it can only approve or reject it as such. The Decision-in-Principle is also granted for a fixed term, typically this is 5 years for nuclear power units. The authorization process for a nuclear facility is described in Figure 8. In the construction and operating licence application handling processes, the acceptance of Parliament and

of the hosting municipality are no longer required. However, the municipality's opinion is still taken into account during these licence application phases.

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 and 2010 for the extension of the capacity of the spent fuel disposal facility to include spent fuel from the new reactor units Olkiluoto 3 and Olkiluoto 4. TVO decided not to apply for a construction licence for Olkiluoto 4 unit in June 2015, and thus the DiP for the NPP unit as well as Posiva's DiP for final disposal of OL4 spent fuel expired. Therefore, Posiva has a DiP in force for the final 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 licence 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 licence, which is currently being implemented into the Nuclear Energy Act.

On the basis of the Nuclear Energy Act (Section 16), minor licences for spent fuel and nuclear waste management activities (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 Sections 16 and 17 of the Act. The use of radiation requires a safety licence, which can be granted by STUK upon application. A safety licence can be subject to extra

conditions needed to ensure safety. In addition, cases not requiring a licence are identified in the process, e.g. when the use of radiation or a device is exempted.

Prohibited operation without a licence

The use of nuclear energy without a licence provided by the Nuclear Energy 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 6) provides that adherence to the Act and regulations issued in accordance with it shall be regulated by STUK. The regulatory rights of STUK are described in the Act (Sections 53–58).

The Nuclear Energy Act and the Radiation Act define the enforcement system and rules for suspension, modification or revocation of a licence. 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 Ministry of Economic Affairs and Employment (MEAE). The Radiation and Nuclear Safety Authority (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 physical protection 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)

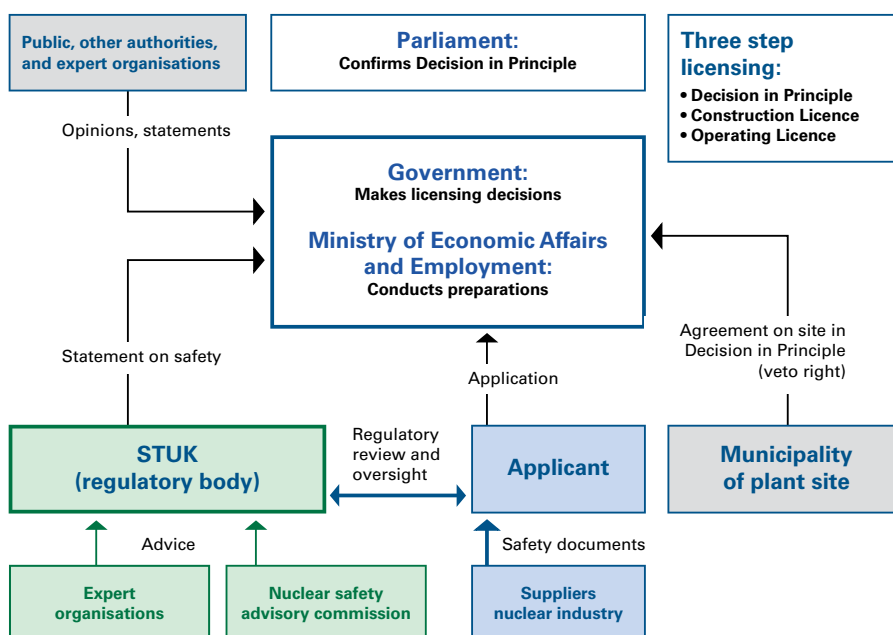


Figure 8. Authorization of nuclear facilities in Finland.

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 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 refined its waste management plans since the DiP from the NPP was granted to Fennovoima in 2014. The interim spent fuel storage and the management of LILW including its disposal are handled by Fennovoima in Pyhäjoki. Fennovoima also submitted its preliminary decommissioning strategy for the NPP to STUK for approval in 2015. Plans for the disposal of spent nuclear fuel were updated by the end of June 2016 as it was required as a condition of the DiP and Fennovoima has started actions to resolve the issue. VTT is responsible for radioactive waste produced during the operation of the research reactor and also during decommissioning. Currently all produced radioactive waste and spent fuel is stored at Otaniemi. The waste management strategy for the decommissioning phase is currently under development.

The Radiation Act (Section 50) 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 51) 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 Ministry of Economic Affairs and Employment (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 (1991/592, currently under revision) the Ministry of Social Affairs and Health is responsible for the general evaluation of the health hazards caused by radiation, evaluation of the need for measures to limit exposure to radiation, and the imposition of the requirements for such measures as well as requirements for monitoring the radiation exposure of workers and other persons exposed to radiation. STUK supervises compliance with the Radiation Act and with the provisions and regulations issued. Additionally, the medical uses of radiation are directed and supervised by STUK.

The mission of the Radiation and Nuclear Safety Authority (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 falls administratively under the Ministry of Social Affairs and Health. Interfaces with ministries and governmental organisations are described in Figure 9. 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 be in 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
- providing information 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 regarding the regulation of the use of nuclear energy and use of radiation are provided in the Nuclear Energy Act and Decree and also 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 licence would be issued without STUK's statement, where the fulfilment of the safety regulations is confirmed. The regulatory oversight is described in detail in Guide YVL A.1.

STUK's Advisory Committee was established in March 2008. The Advisory Committee helps STUK to develop its functions as a regulatory, research and expert organisation in such a manner 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 decree. This Committee gives advice to STUK on important safety issues and regulations. The Committee also gives its statements on licence applications. The Committee

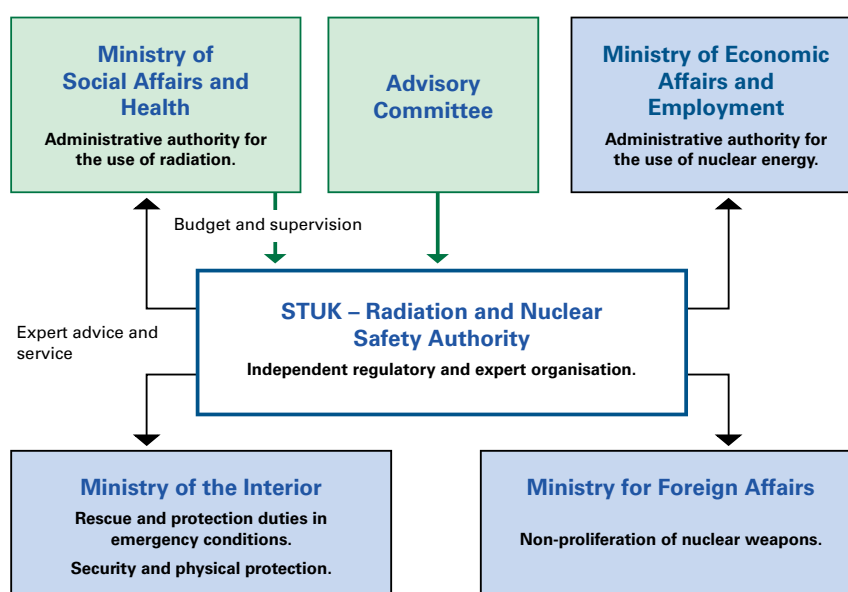


Figure 9. Co-operation between STUK and Ministries and other governmental organisations.

has two international sub-committees, one for reactor safety (RSC) and one for safety issues related to radioactive waste (NWSC). In addition, the Advisory Committee on Radiation Safety has been established for advising the Ministry for Social Affairs and Health. 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 providing consultation to STUK on important security issues. The committee also aims to follow and promote both international and domestic co-operation in the field of nuclear related security issues. The members of the Advisory Committee on Nuclear Security are nominated by the Government.

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

STUK's roles and responsibilities have been assessed by a peer review. A full-scope IRRT mission (IAEA's International Regulatory Review Team) was carried out in 2000 and a follow-up mission in 2003. An IRRS mission (IAEA's Integrated Regulatory Review Service) was carried out in October 2012 and a follow-up mission in June 2015.

In November 2009, a team of 11 European regulators carried out an EU 27 Peer Review of STUK's processes for regulating radioactive waste management activities in Finland. The review

focused on STUK's regulation of the spent fuel disposal facility and its associated underground rock characterisation facility, ONKALO. The team concluded that STUK has a well-established, effective and efficient basis for regulating nuclear waste management in Finland. Nevertheless, the team felt that STUK needs to review its guidelines and regulations, which are currently based on NPP to ensure that they are sufficiently clear for the purposes of regulating waste management and to ensure greater transparency to stakeholders.

In June 2015, the follow-up mission, 5 international experts and 4 IAEA staff members reviewed regulatory activities in Finland on the basis of IAEA Safety Standards, international best practices and experiences and lessons learned from the 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 FİR 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 taken into account 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. STUK's current position administratively under the Ministry of Social Affairs and Health continues to have the potential for STUK's decision-making to be unduly influenced by interests in medical applications of radiation. 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 licence amendment; and to address the arrangements for research in radiation safety. STUK has updated its action plan to take these into account in its future development actions.

One of the open suggestions is related to STUK's management system. Although a number of improvements were initiated by STUK to its management system, the IRRS team felt that there is still work that has to be undertaken for further enhancing STUK's management system. For example STUK will continue reviewing and revising existing Quality Manuals and guidance documents for consistency and improve overall descriptions of the processes including sub-processes and their independency, further develop self-assessments, internal and external audit programmes, develop more detailed procedures for use of a graded approach in the authorization systems, structures and components and in planning and conducting inspections.

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 the Figure 10.

STUK receives about 34 % of its financial resources through the State budget. However, the costs of regulatory oversight are charged in full to the licensees. The model for financing the regulatory work is called a net-budgeting model and it has been applied since 2000. In this model, the licensees pay the regulatory oversight fees directly to STUK. In 2016, the cost of the regulatory oversight

for nuclear safety was 19 million €. The regulatory oversight of the use of radiation and non-nuclear waste was about 3.4 million € in 2016.

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 end of 2016, the number of staff in the department of Nuclear Waste and Material Regulation came to 26. The regulatory oversight of waste management facilities is supported by the Nuclear Reactor Regulations department with more than 100 experts from different disciplines. At the end of 2016, the number of staff in the Radiation Practices Regulation Department was 52. Non-nuclear radioactive waste is mainly regulated by the Radiation in Industry section, which has a staff of 8. 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 own review and assessment work. The main technical support organisation of STUK is the VTT Technical Research Centre of Finland Ltd., but also Lappeenranta University of Technology (LUT) and Aalto University (former Helsinki University of Technology) are important. Furthermore, international technical support organisations and experts are used if needed.

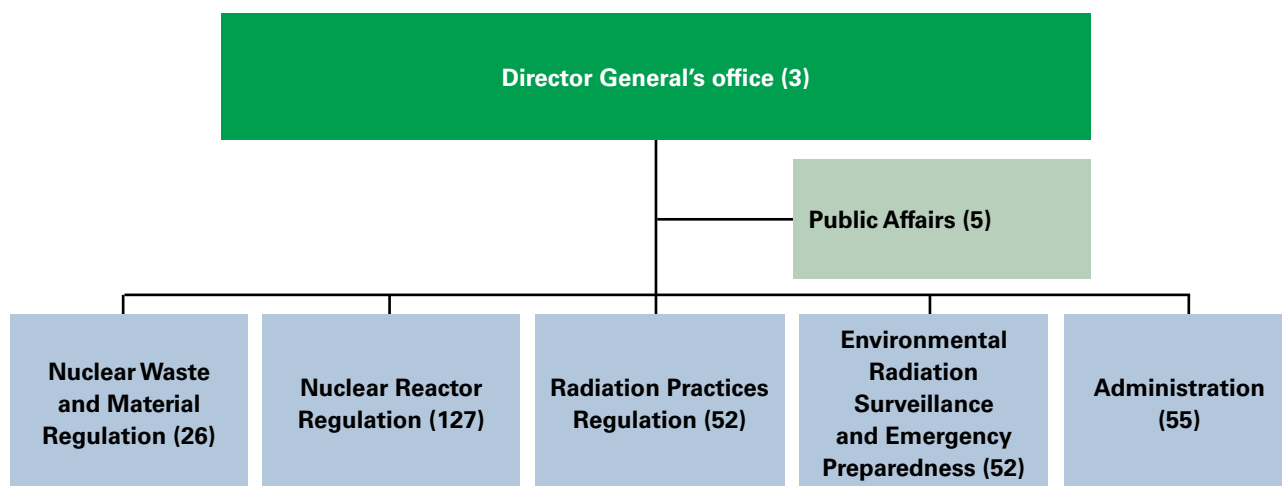


Figure 10. The organisation of STUK at the end of 2016 was 321.

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 53d and 53e) comes from the licence holders via the State Nuclear Waste Management Fund (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 safety assessments 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

In Finland, VTT Technical Research Centre of Finland Ltd is the largest research organisation in the field of nuclear energy. At VTT, about 200 experts work in the field of nuclear energy, about half of them full-time. Two thirds of the radioactive waste management research in Finland is focused on the disposal of spent fuel. The largest individual research organizations are VTT, LUT (Lappeenranta University of Technology), GTK (the Geological Survey of Finland), and Aalto University (formerly the Helsinki University of Technology, HUT).

The Nuclear Energy Act was amended in 2003 to ensure funding for nuclear waste management research in Finland. Funds are collected annually from the licence holders into a special fund under the State Nuclear Waste Management Fund (VYR). For the research into nuclear waste, the annual funding payments are proportional to the current fund holdings for future waste management activities. In 2016 the Nuclear Energy Act was amended and a temporary increase in the money collected for the fund was introduced. The purpose of the temporary increase of the research funding is to renew the ageing infrastructure of the nuclear energy related research. The increased funding will be collected between 2016 and 2025. During the first stage, the additional funding is allocated for the commissioning of the new VTT Centre for Nuclear Safety (CNS) building, and in the second stage, for a thermohydraulic laboratory at Lappeenranta University of Technology.

The research projects have been selected so that they support and develop the competence in nuclear safety and nuclear waste management and to create preparedness for the regulator to be able to respond to emerging and urgent safety issues. These national safety research programmes are called SAFIR and KYT. The objective of KYT2018 (the Finnish Research Programme on Nuclear Waste Management) is to ensure the sufficient and comprehensive availability of nuclear technological expertise and other capabilities required by the authorities when comparing different nuclear waste management approaches and implementation methods. Similarly to the previous pro-

gramme, KYT2018 is also divided into three main categories:

- new and alternative technologies in nuclear waste management
- long-term safety research in nuclear waste management and
- social science studies related to nuclear waste management.

The main emphasis in the KYT research programme will continue to be devoted to safety related research. The funding of the research programme is provided mainly by the State Nuclear Waste Management Fund (VYR) into which those responsible for nuclear waste management will annually pay 0.13 % from 2016 to 2020, and 0.10 % from 2021 to 2025 of their respective assessed liability. In 2016 the level of funding of the KYT research programme was 2.9 million €.

SECTION F Other general safety provisions

Article 21 Responsibility of the licence 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 licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

If there is no such licence 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 licence 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 covered, the licensees under a

waste management obligation must fulfil the financial provision obligation by making payments into the State Nuclear Waste Management Fund (VYR), and furnish the State with securities as a precaution against insolvency. The State Nuclear Waste Management Fund is independent of the State budget, but it is controlled and administered by the MEAE.

As a precondition for granting a safety licence for the use of radiation, the Radiation Act requires (Section 16) that the applicant presents valid proof on the safe management of any radioactive waste which may be generated. Further, the Radiation Act (Section 50) provides 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. According to the Act (section 50), 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 51) 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 is responsible for controlling the necessary qualifications of the persons engaged in activities important to nuclear safety. The regulatory requirements for human resources are stated in the Nuclear Energy Act (Sections 7, 19 and 20), STUK Regulations (STUK Y/1/2016 and STUK Y/4/2016) and Guide YVL A.4. The requirements for the licensees' personnel are set out in the Nuclear Energy Act Section 7, which stipulates that the personnel should be well suited for their duties, competent and well trained. Further according Nuclear Energy Act Section 7 a nuclear facility must have a responsible director for construction and operation of the nuclear facility and responsible persons for emergency preparedness, security and safeguards and their deputies – all approved by STUK. According to the Nuclear Energy Act (Section 19), a necessary condition for granting a construction licence for a nuclear facility is the availability of the necessary expertise. According to the Nuclear Energy Act (Section 20), an operating licence of a nuclear facility can be granted if the applicant has the necessary expertise available and, in particular, if the operating organisation and the competence of the operating staff are appropriate.

According to Section 25 of the STUK Regulation

STUK/Y1/2016 and Section 38 of the STUK Regulation STUK Y/4/2016, significant functions with respect to safety within nuclear power plants and disposal facilities must be designated, and training programmes must be prepared for developing and maintaining the professional qualifications of the personnel working in such positions.

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. 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 licence applicants. The overall functionality of Posiva's management system, organization structure, processes, and procedures are included in STUK's inspection programmes for the different phases of Posiva's nuclear facility project. During 2014–2016 STUK has paid especially attention through the inspection programmes to assessing Posiva's human resource strategy, development, and planning.

In activities related to the use of radiation other

than in nuclear facilities, the Radiation Act (Section 14) prescribes that the responsible party is required to ensure that sufficient expertise is available in safety related matters of operations, taking into account the nature and the risks posed by the operation. The responsible party must appoint a radiation safety officer. In a licence application the applicant must provide information on the competence of the personnel working with radiation.

STUK specifies the qualifications for the radiation safety officer and other personnel, as applicable, and carries out inspections to check that these qualification requirements are met (Section 18 of the Radiation Act). The licensee must provide appropriate training for employees. Guide ST 1.4 sets the requirements for the organisation for the use of radiation including the competences needed. Guide ST 1.8 further sets out detailed requirements on radiation protection training for radiation safety officers and qualified experts. Competence including a general part covering the basics of radiation protection and the appropriate legislation need to be demonstrated by an exam. Special requirements are attributed to different fields of applications of radiation.

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 Olkiluoto 3 project, the new reactor project Hanhikivi 1, and the spent nuclear fuel disposal project and decommissioning of the research reactor). The long time scales 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.

The basic training on nuclear area is provided by the Lappeenranta University of Technology and in the metropolitan area by Aalto and Helsinki universities. Lappeenranta University of Technology offers M.Sc. Major program in Nuclear

Engineering; Aalto University offers a Minor program in nuclear engineering, and Helsinki University offers degrees in radiochemistry.

During 2012–2015, three Universities Aalto, Helsinki University and Lappeenranta University of Technology run a doctoral programme called YTERA (YTERA – Doctoral Programme for Nuclear Engineering and Radiochemistry), which was funded by the Academy of Finland, the universities and industry (the NPP utilities and Posiva). The aim was to ensure the supply of high-level expertise in nuclear engineering and radiochemistry and to create a permanent network for nuclear post-graduate education. The programme covered all fields of nuclear engineering and radiochemistry including nuclear waste management and it involved close collaboration with Finnish research bodies, industry and authorities that deal with nuclear energy generation. In general, the YTERA doctoral programme has achieved its goals. During the programme 21 new doctors graduated.

The main organisations in the nuclear energy area in Finland develop and organize the basic professional training course on nuclear safety (“YK course”), which is an annually held approximately 6-week training programme for students and staff members of the participating organisations (STUK, the licensees, VTT, Aalto University, Lappeenranta University of Technology and the Ministry of Economic Affairs and Employment). The first course commenced in September 2003 and the 14th basic professional training course started in the autumn of 2016. At the moment, over 900 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 first national nuclear waste management course (“National YJH course”) commenced in 2010. The current course with a six-day curriculum has been running since 2011 for around 20-25 students at a time and equalling 2 ECTS credits (ECTS = European Credit Transfer and Accumulation System), with around 100 participants altogether by the end of 2016. The training content is produced and developed jointly by the participating organizations. The YJH and YK courses will be merged into one YJK-course starting from autumn 2017.

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 update of the competence review is planned to be carried out in 2017 to reflect the current changes in the operating environment.

At the end of January 2013, the MEAE set up a working group to prepare a research and development strategy (YES). The nominated members of the working group included experts from STUK, VTT, the Finnish Academy, Aalto University, the Lappeenranta University of Technology, the University of Helsinki, Fortum, TVO and Posiva. The results of the research and development strategy work were published at the end of April 2014. The report “Nuclear Energy Research Strategy” emphasizes the importance of the research in competence building. The recommendations of the working group were the following: 1) The areas of focus in nuclear energy research must be compiled into wide-ranging national programmes. 2) The scientific level of Finnish nuclear energy research needs to be raised. 3) Active participation is needed in international research that is important for Finland through broad-based national multidisciplinary collaboration. 4) To secure the quality and quantity of researcher education, a broad and comprehensive doctoral programme network needs to be established for the nuclear energy field. 5) Building, maintaining, and utilising infrastructure requires coordination at the national level. Financing needs to be considered strategically and the roles of national financiers need to be clarified. 6) In research activities, input is needed for innovation development. The growth of business operations and internationalisation should be supported by bringing the players together under Team Finland. 7) It is proposed that an advisory committee be set up in connection with the MEAE which would be linked to nuclear energy research and co-operation and that this would act as a permanent expert body to support decision-making in national questions re-

lated to the nuclear energy. The MEAE has started the implementation of the recommendation. In 2015 the Nuclear Energy Act was changed to ensure the financing for the enhancement of nuclear safety research infrastructure.

Financial resources

In Finland, each licensee is responsible for all ongoing costs caused by radioactive waste management and decommissioning of nuclear facilities. The rationale of the funding system, which collects financial provisions from the waste generators for radioactive waste management and decommissioning, is to ensure that the funds for the future waste management are collected that the assets are available even in the case where the waste generator is unable to fulfil its obligations.

The Nuclear Energy Act (Section 35 to 53) provides detailed regulations for the funding arrangements and provisions for nuclear waste management and the Decree on the State Nuclear Waste Management Fund further specifies the system for financial provisions. The financial provisions are described in greater detail in the Decision by the Government on Financial Provisions for the Cost of Nuclear Waste Management (165/1988). The Decision by the Government on Financial Provisions for the Cost of Nuclear Waste Management will be replaced by a Government decree in 2017. The producers of nuclear waste are obliged to present justified estimates every three years of the future cost of managing their existing waste, including spent nuclear fuel disposal and decommissioning of facilities. The MEAE annually confirms the assessed liability and the proportion of liability the Nuclear Waste Management Fund has to reach (the fund target). The tasks of the Nuclear Waste Management Fund are described in detail in the Government Decree on the State Nuclear Waste Management Fund (161/2004). The waste generators annually pay the difference between the fund target and the amount already existing in the Fund, but can also be reimbursed if the funded amount exceeds the liabilities. The waste generators must provide collateral securities to MEAE for the portion of financial liability that is not yet covered by the Fund.

In 2012, the VTT Technical Research Centre of Finland, which operates the research reactor (FiR-1), decided to shut down the reactor and the plan-

ning of the decommissioning phase started. VTT is responsible for observing similar requirements for funding as described above.

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 2497 million Euros at the end of 2016.

Financial provisions for post-closure

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 51), 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.

The Nuclear Energy Decree (Section 35) requires that a description of the applicant's quality management for the construction phase must be submitted to STUK for approval when applying for a construction licence for a nuclear facility. The applicant must assess how organizations participating in the construction satisfy the Finnish safety and quality requirements. The assessment needs to be included in the Preliminary Safety Analysis Report (PSAR) which must be sent to STUK for approval. When applying for the operating licence, the applicant has to send the management system manual to STUK for approval according to the Nuclear Energy Decree (Section 36).

According to the STUK's regulation on the Safety of Disposal of Nuclear Waste (Section 38),

organisations participating in the design, construction, operation, and decommissioning of a nuclear waste facility or closing of a disposal facility must employ a management system to ensure the management of nuclear safety, radiation safety and quality. The management system must ensure that priority is always be given to safety and that the requirements for quality management are commensurate to the importance of any actions regarding safety. The management system must further be systematically assessed and developed. The management system requirements concerning nuclear facilities are provided in the Guide YVL A.3 reflecting the updating of the IAEA requirements and guidelines.

Measures taken by licence holders

The licensees (FPH and TVO) have established and implemented integrated management systems (IMS) consistent with Guide YVL A.3. The licensees must maintain, develop and continuously improve their management systems according to the requirements set out in Guide YVL A.3.

Posiva has established and implemented its integrated management system (IMS). STUK has reviewed and approved the management system as part of the construction licence application documentation. The management system needs to be supplemented and updated before the commissioning and operating phases of the project.

The construction licence was granted to Posiva in November 2015. During 2016 STUK re-evaluated the readiness of Posiva's organization for the construction activities. As a part of this evaluation also the integrated management system and Posiva's most important functions were assessed through several inspections at the site. STUK's approval for the launching the construction activities of the disposal facility was given in late 2016 and Posiva started the construction of the facility in December 2016.

Posiva's contractors supplying products important to safety must also have a quality management system fulfilling the main requirements of Guide YVL A.3. These organisations also need to prepare a supply specific quality plan for the design, manufacturing and testing of the products. STUK verifies the implementation of the quality management systems and the quality plan with a graded approach through reviews and inspections.

As a part of this oversight STUK participates in the safety related contractor audits performed by Posiva.

Management system of the regulatory body

STUK itself has a Quality Management System, which consists of a safety and quality policy, quality manuals on different levels, evaluation and assessment procedures and follow-up on development projects. The policy statement was updated in 2015 based on the strategy plans. The quality manuals contain the safety and quality policy, descriptions of the quality system, organization and management, main and supporting working processes and the procedures related to them. The results of systematic internal audits, self-assessments and external evaluations, including international evaluations (such as IRRS follow up in 2015) as well as feedback from licensees, customers and other interested parties, are used as inputs for the development and continuous improvement of STUK's Quality Management System.

STUK also evaluates the contractors as part of the procurement process. STUK uses only approved contractors. The approval is based on audits or detailed evaluations performed through a review of tender documentation. Important issues in the evaluations include professional skills, independence, and impartiality of the contractor as well as their capacity to produce high quality services.

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:

- (d) 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;*
- (e) 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*
- (f) 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:

- (g) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and*
- (h) 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 basic requirements for the safe use of nuclear energy are given in the Nuclear Energy Act. The principles of justification, optimisation and dose limitation are included in the Radiation Act (Section 2). Occupational dose limits and dose limits for the general public are set forth in the Radiation Decree (Sections 3 to 6). These limits conform to the ICRP 103 Recommendation (2007), ICRP 60 Recommendation (1990) and the Council Directive 96/29/EURATOM. The implementation of the Council Directive 2013/59/EURATOM (replacing the Council Directive 96/29/EURATOM) in Finnish legislation is currently ongoing.

According to the Radiation Decree (Section 3), the effective dose from occupational exposure must not exceed 20 mSv per year as an average over five years, or 50 mSv in any single 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 96/29/EURATOM.

The Radiation Decree (Section 7) states that the detailed instructions on the application of the maximum values laid down for radiation exposure and on the calculation of radiation doses shall be issued by STUK. The decree further states that notwithstanding the dose limits given in the Decree (Sections 3 to 6), e.g. the 1 mSv/a limit for the general public, STUK may, in individual cases,

set constraints 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.

Dose constraints

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 guide YVL D.5). The annual dose limit from the normal operation of an NPP 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/4/2016) 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 and D.3). 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 licence application as well as for review and inspection during commissioning and operation.

In the Guide YVL D.5, STUK has specified that a disposal facility shall be so designed that the average annual dose to the most exposed individuals of the population, arising from normal operation of the facility, may not exceed the 0.01 mSv constraint. The constraint is stricter than the limit for an NPP.

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 surveillance 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 the most exposed persons in the environment at the NPPs are currently less than one per cent of the dose constraint (Figure 11). The new NPP unit, Olkiluoto 3, 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 are of the order of some hundredths of manSv per year.

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/2/2016) and the detailed requirements by STUK in Guide YVL C.5. The regulation (STUK Y/2/2016) and Guide YVL 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 consequenc-

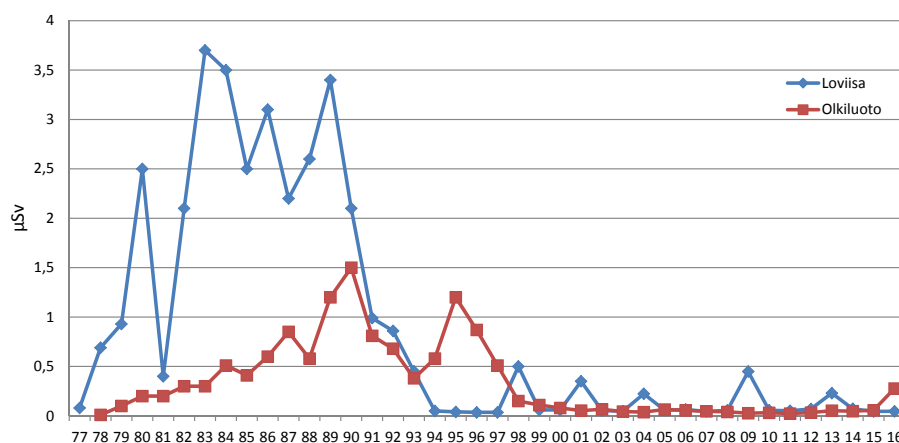


Figure 11. Committed doses ($\mu\text{Sv/a}$) calculated by STUK to members of critical groups in the vicinity of the Finnish NPPs due to annual discharges of radioactive substances. The dose constraint is $100 \mu\text{Sv/a}$.

es 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/2/2016), 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 licence 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.

Concerning the small users of radiation sources, the Radiation Decree (Section 17) 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 must be informed if a radiation source has disappeared, been stolen, lost or otherwise ceased to be in the licensee's possession.

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. Guide VAL 1 (2012) "Protective Measures in the Early Phase of a Nuclear or Radiological Emergency" and VAL 2 (2012) "Protective Measures in an Intermediate Phase of a Nuclear or Radiological Emergency" provide detailed guidance. In the case of an accident the local authorities are alerted by the operating organisation 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:

- (i) *qualified staff and adequate financial resources are available;*
- (j) *the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;*
- (k) *the provisions of Article 25 with respect to emergency preparedness are applied; and*
- (l) *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 and operating licence application for the facility (Sections 34 and 36 in the Nuclear Energy Decree). During operation, the licensee is obligated to prepare decommissioning plans for regulatory review every six years (Section 28 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 7g), 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 requires that provision for the decommissioning of the nuclear facilities must already be made during the design phase. During the design phase, the licence applicant must establish the decommissioning strategy. This strategy must be regularly evaluated and if necessary updated during the commissioning 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 general provision for licensing and the waste management obligation is included in the current nuclear energy legislation. Guide YVL D.4 was published in 2013 and it includes more specific requirements for decommissioning than the earlier Guide YVL 8.2. The guidance will be developed

further based on the experiences gained from FiR 1 decommissioning.

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

Also in cases of uses of 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 19 and 31f of the Radiation Act prescribe practices subject to a financial provision in the licensing phase to ensure the availability of sufficient funds to cover the decommissioning costs.

Decommissioning plans

The four nuclear power plant units in Finland had been in operation for 34 to 39 years at the end of 2016. These units are planned to operate up to an overall operation period of 50 (Lo1 & Lo2) and 60 years (OL1 & OL2). No nuclear power plants are currently being decommissioned or planned to be decommissioned in the near future.

The most recent update of the NPP decommissioning plan made by FPH was issued at the end of 2012. TVO updated its decommissioning plan for the OL1 and OL2 units at the end of 2014. The decommissioning plan for OL3 was submitted to STUK as a part of the operation licence application of the plant in 2016. Fennovoima has also submitted the preliminary decommissioning plan for STUK's approval as part of a construction licence application in 2015. VTT is currently updating the decommissioning plan for the research reactor for the decommissioning licence application. VTT is also preparing the decommissioning plan for the old hot cell laboratory located in Otaniemi, Espoo.

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 decommissioning project in Finland is the decommissioning of VTT's research reactor FiR 1 in 2018–2022. The decision to shut down the research reactor was made in 2012 by VTT (the operator). In June 2015, the research reactor was permanently shut down and VTT started detailed planning of the reactor decommissioning and dismantling. The Environmental Impact Assessment

(EIA) process for decommissioning was conducted in 2013–2015. The end point of the EIA process was MEAE's statement about the EIA report in February 2015. VTT has prepared an operating licence application for decommissioning since there is not yet a separate decommissioning licence stated in Finnish legislation. VTT submitted the application for the operating licence regarding the decommissioning in June 2017.

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 principle for spent nuclear fuel management as described in Section B. Spent fuel is currently stored at the NPPs' spent fuel interim storage facilities. The discussion in this Section is limited to the interim

storage of spent fuel whereas the 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/1/2016). 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/1/2016), 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 must have sufficient space and 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 must satisfy the single failure criterion. This requirement is given in Guide YVL B.1.

Existing interim storage facilities in Olkiluoto and Loviisa have ensured the sub-criticality of the spent fuel in the pools 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 a small cooling tower is connected to the interim spent fuel storage cooling system to ensure cooling 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 also 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 must also be kept sufficiently 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 for disposal in Olkiluoto, in close vicinity of the largest present 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 makes sure that the interdependencies between the different steps in spent fuel management are taken into account 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.

Protection of individuals, 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 low compared to the potential radiological 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 State Nuclear Waste Management Fund cover 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, were carried out for the Loviisa NPP in connection with the periodic safety review in 2014–2016 and for the Olkiluoto NPP in 2007–2009. The next periodic safety review will be carried out in 2016–2017 in connection with the renewal of operating licences for the Olkiluoto NPP reactor units which has been submitted to the regulator.

The enlargement of the spent fuel storage facility at Olkiluoto, which started in 2009, was completed in 2015, when STUK finalised the safety assessment on commissioning of the extension and approved TVO's application to increase the capacity of the spent fuel storage facility.

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 were 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) and there are plans on how to address these areas, some of which have already been implemented. As an example, Loviisa NPP has already 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 and also provided additional feed water sources into the spent fuel pools.

The comprehensive safety assessments for applications for the renewal of licences include up-

dating 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 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 made a number of 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 7a) 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.

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 has to 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 must be taken into account. The STUK Regulation (STUK Y/1/2016) provides as follows: *“The safety impact of local conditions, as well as the physical protection and emergency preparedness arrangements, shall be considered when selecting the site of a nuclear power plant. The site shall be such that the impediments and threats posed by the plant to its environment remain extremely minor and heat removal from the plant to the environment can be reliably implemented.”* In 2013 STUK issued Guide YVL A.2, “Site for nuclear facility”, which 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 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” which was issued by STUK in 2013. 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 construction Licence for the Olkiluoto 3 unit was granted by the Government in February 2005. Site-related factors were evaluated and reviewed in connection with the construction licence proce-

ture. Further clarifications have been submitted by the licensee during construction.

During 2008–2009 three applications for the Decision-in-Principle for new NPP units were submitted to the Government. The relevant site-related factors potentially affecting the safety of the new planned NPP units and the related nuclear facilities during their projected lifetimes were evaluated for the existing Loviisa and Olkiluoto sites and for the alternative new sites at Pyhäjoki, Simo and Ruotsinpyhtää. The evaluations were 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 licence applications of NPPs regarding spent fuel storage. The operating licences for nuclear facilities are granted for a limited period of time. For the licence 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, must be performed. STUK reviews the licence 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 Environmental Impact Assessment (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 Decision-in-Principle is made, the applicant must 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 must 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 Decision-in-Principle is made. Furthermore, the Ministry must 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 must be made known to the Government. The Act (Section 14) further provides that a necessary prerequisite for the Decision-in-Principle 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 2014–2016 there have been three Environmental Impact Assessments in Finland. Fennovoima submitted the EIA report concerning Hanhikivi NPP to MEAE in February 2014. The statement by the MEAE was given in June 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.

The Environmental Impact Assessment (EIA) process for the decommissioning of the research reactor FiR 1 was conducted in 2013–2015. The EIA report was submitted to the MEAE in October 2014 and the process ended in February 2015 with the MEAE's statement on the EIA programme. The

Espoo Convention was not followed in this case, because the environmental influence, if any exist, are local.

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.

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 approach

According to the Nuclear Energy Act (Section 19) the prerequisite for granting a construction licence 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 taken into account appropriately. The site related prerequisite for granting an operating licence (Section 20) is that the environmental protection has been taken into account appropriately. The Nuclear Energy Decree (Section 32) requires that the construction licence application must 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 licence 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/1/2016) 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 Decision-in-Principle 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 licence, as well as in connection with possible plant modifications. In the operating licence 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 7g) states that provisions for decommissioning must be included in the design of a nuclear facility. In the context of the licensing requirements, the STUK Regulation (STUK Y/1/2016) states that the design of an NPP must take into account decommissioning so as 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 licence 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 Chapter 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/1/2016). 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 Licence 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 licensing 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 a large airplane crash has been included in the design of the extension and it has also been improved for the existing part of the facility. Additionally, the cooling water systems for the spent fuel pools have been improved to enable a water feed from outside the plant. The monitoring of the storage pool water level and temperature has been improved to take into account 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 will be done in 2017. Flood protection for NPPs was already improved in 2012 from +2.1 m to + 2.45 m, but plans for further improvements were submitted to STUK in 2015. The aim is to implement the plans in 2018 to increase the design water level to +2.95 m.

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 licence applications for a new licence or for the renewal of an existing licence 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 the Preliminary Safety Analysis Report (PSAR) and in the Final Safety Analysis Report (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 must 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 Decision-in-Principle application.

The STUK Regulation (Y/1/2016) requires that the nuclear power plant safety and the technical solutions of its safety systems, including systems for spent fuel interim storage, must be assessed and substantiated analytically and, if necessary, experimentally. Analyses should be maintained and revised if necessary, taking into account 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 on, the evaluation is continued when the Construction Licence 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 and the design of the Olkiluoto plant units in 2008–2009.

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 a large aeroplane crash and the design of the existing part of storage has been updated likewise.

Article 9 Operation of facilities

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

- (a) the licence 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 licence 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), a number of documents, including the Final Safety Analysis Report must be submitted to STUK when applying for an operating licence. 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 licence has to provide STUK with the operational limits and conditions. According to the Nuclear Energy Decree (Section 36), the applicant for an operating licence has to 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 also the limitations that must be observed in the event of component failure.

The STUK Regulation (STUK Y/1/2016) requires a nuclear power plant to have a condition monitoring and maintenance programme for ensuring the integrity and reliable operation of all systems, structures and components. This programme must define inspections, testing, maintenance, replacements and other procedures for controlling operability and the impacts on the operating environment.

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 must cover all procedures required in the operation of the facility. The document management procedures must 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, dis-

semination, archiving and disposal of documents. The responsibilities and administrative procedures indicating how to take care of these actions must be described in the licensee's management system. The procedures for operation must 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/1/2016) 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 has 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 life-cycle of the plant including nuclear waste management in the construction licence 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/1/2016) requires that feedback on operational experience is collected and safety research results are monitored, and both must 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 taken into account to the extent justified on the basis of 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 28) describes the requirements for the preparation and updating of the decommissioning plans. Decommissioning issues are discussed in Chapter F.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 Chapter 3 relating to the disposal of radioactive waste.

According to the Finnish waste management policy, spent fuel is regarded as waste and must be permanently disposed of in Finland. Therefore, the encapsulation and disposal of spent fuel are discussed in Section H, in the context of the safety of radioactive waste management.

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 plans for spent fuel disposal are discussed. The relevant general regulations are, the Nuclear Energy Act (990/1987) and Decree

(161/1988), STUK's Regulation (Y/4/2016) 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/1/2016 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 YVL Guides D.3, D.4 and D.5. Radioactive waste subject to the Radiation Act is regulated by Guide ST 6.2.

Criticality and removal of residual heat

Regulatory requirements

STUK's Regulation (Y/4/2016) requires that in the handling of spent nuclear fuel, the occurrence of a self-sustaining chain reaction of fissions must be prevented to a high degree of certainty and that the disposal package containing spent nuclear fuel must be designed so that no self-sustaining chain reaction of fissions can occur, even in the disposal conditions.

Guide YVL D.3 further specifies that subcriticality of spent nuclear fuel must be ensured by means of structural design solutions. The transfer casks, storage racks and handling equipment as well as the disposal canisters must be designed so that subcriticality of the fuel is ensured in any planned operational conditions, including anticipated operational occurrences and postulated accidents. 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 canisters disposed of in the disposal facility must remain subcritical in the long term. The design of the spent fuel disposal canisters must also accommodate conditions where the leak-tightness of

the container has been lost and the container has sustained mechanical or corrosion-induced deformations.

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 licence 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.

The subcriticality of spent fuel during transportation will be analysed separately during fuel transport cask licensing in early 2020s.

Posiva has analysed the criticality safety of copper/iron canisters and the analyses were provided to STUK for review in the construction licence 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 licence 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 for long time, passive cooling is provided 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 residual heat of the 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 Guide YVL 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 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.32.1.

According to the Radiation Act (Section 49 a), the radioactive waste produced in the use of radiation or in non-nuclear radioactive instances must be kept as low as reasonable by practical means.

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 annual accumulation of LILW has been fairly low: about 100 m³ per plant (each having two operational reactor units) during 2014–2016. 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 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 treated waste significantly. Activation products or parts containing external contamination or components that have been

separated from the metal are transported back to Finland for disposal.

In the 1990s FPH, together with the Laboratory of Radiochemistry at the University of Helsinki, developed sophisticated selective ion exchange methods for the purification of liquid waste (especially the removal of Cs, Sr and Co). The benefits of these methods, now in use at the Loviisa NPP, can be seen in Figure 12 and also in the decrease of the doses to the most exposed persons in the vicinity of the Finnish NPPs shown in Figure 11.

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.

Disposal containers can be filled more effectively, when crushed metal is placed in the unused spaces of containers. 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. The average accumulation of low and intermediate level waste at the Olkiluoto NPP (OL1 and OL2) has been about 60 m³ per reactor year during the reporting period. Part of the metal waste (large components)

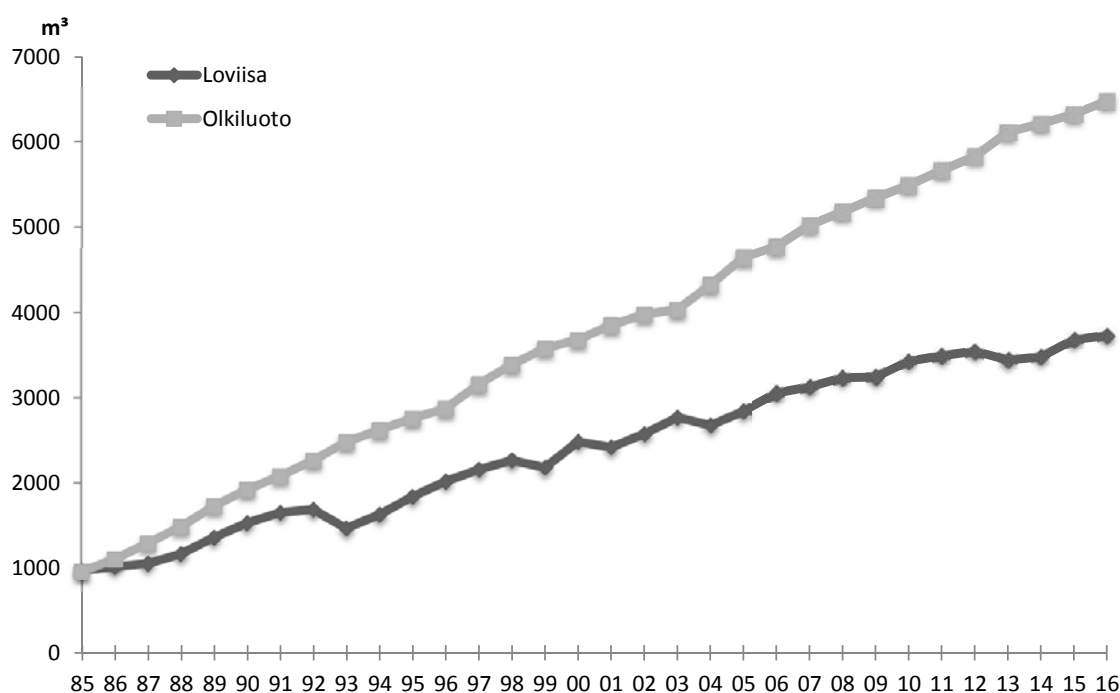


Figure 12. Accumulation of LILW in Loviisa and Olkiluoto NPPs.

has been transported for treatment in Sweden.

At the new NPP unit Olkiluoto 3 an in-drum drying facility is planned to be used for the conditioning of liquid wastes. The drying facility is expected to provide an effective volume reduction. This new waste type is planned to be stored in the interim at the site before disposal in the Olkiluoto LILW disposal facility. An extension of the disposal facility for the needs of Olkiluoto 3 reactor unit is expected in the 2030s.

Waste minimization in the decommissioning of research reactor

During the operation of the research reactor, the produced waste amounts have been small, only about 6 m³ have been produced since 1962. The waste is packed and currently stored in Otaniemi. VTT has evaluated that the amount of decommissioning waste will be about 75 m³. VTT is currently planning the decommissioning in detail and also waste management procedures are under development. 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 Guide ST 6.2. 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 with regard to its further management. The Guide 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 Chapter 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 taken into account 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 operators 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 sites and STUK has reviewed these results.

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

The time schedule for the decommissioning and waste management activities of the research reactor are planned so that the interdependencies between different steps are taken into account. The spent fuel will be removed from the reactor before the actual dismantling is started. The spent fuel will most likely be sent back to the USA according to the existing agreement. Decommissioning waste is packed at the reactor site and then stored for 20–30 years before disposal.

The waste produced during the decommissioning of the research reactor will be packed in a similar way to how the power plants have packed their operational waste to ensure that the storage and disposal at NPP sites are possible. VTT is currently negotiating the possibility to store radioactive wastes in Olkiluoto. The required storage time is a few tens of years before disposal. The possibility for the disposal of waste at the Olkiluoto LILW disposal facility has been very

preliminarily discussed with TVO, but there is not yet an agreement on this.

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 Nukliditeknikka in Helsinki 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 final disposal has started in 2016.

Protection of individuals, society and the environment

Regulatory requirements

STUK's Regulation (Y/4/2016) refers to Section 2 and Chapter 9 of the Radiation Act (592/1991) concerning the radiation exposure of workers and the population in the vicinity of a nuclear waste facility.

The disposal facility is a nuclear waste facility and Nuclear Energy Decree (161/1988) section 22 d is applied regarding this regarding the maximum values for radiation exposure caused to the population in the vicinity of a nuclear waste facility due to its operation as well as anticipated operational occurrences or accidents. The decree requires that as a consequence of the normal operation of the facility, the annual effective dose to the most exposed members of the public must remain insignificantly low. As a consequence of anticipated operational occurrences, the annual effective dose to the most exposed members of the public must remain below 0.1 mSv. As a consequence of a postulated accident, the annual effective dose must remain below 1 mSv. A postulated accident can be assumed to occur with a frequency of at least 10^{-3} per year. For a postulated accident assumed to occur with a frequency of less than 10^{-3} per year, the annual dose to the most exposed members of the public must remain below 5 mSv. Under the design extension conditions, the limit of the annual dose to the most exposed members of the public is 20 mSv.

The Nuclear Energy Decree (161/1988) requires (section 22 d) that the 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/4/2016 states that the radiation exposure caused by rare events impairing long-term safety must be assessed neverwhensoever possible. The probability of events causing significant radiation exposure must 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 must 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

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 the Preliminary Safety Analysis Report (PSAR). The PSAR was a part of the construction licence 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 pin 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 pins. These releases are assumed to occur in the hot cell or in controlled area of the encapsulation plant. Both of these 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 mSv specified in the regulations. For the worst-case accident condition, the radiation dose was analysed to be 0...01 mSv, which is below the limit of 1 mSv 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 must be insignificantly low.

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 licence 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 2012 radioactive releases from the research reactor into the air were 0...21 TBq. 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 49a of the Radiation Act (592/1991), the amount of radioactive waste generated by the use of radiation and other radiation practices must be kept as low as reasonably achievable without endangering the implementation of the general provisions of Section 2 (justification, optimization, limitation).

The radiation doses received from non-nuclear radioactive waste are very low. The dose received from the use of unsealed sources must be under 10 µSv per year for a representative person. The dose limits and activity limits for discharges are given in the guide ST 6.2 Radioactive waste and emissions from the use of unsealed sources.

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 licence of the Olkiluoto LILW disposal facility.

Biological, chemical and other hazards

Regulatory requirements

According to the Act on the Environmental Impact Assessment procedure (EIA) (252/2017), the environmental impacts must already be evaluated in the planning and decision-making phase of the project. The other 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 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 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 an-

nual 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. At least as long as the engineered barriers isolate the radioactive waste, other harmful substances are effectively isolated from the environment. Furthermore, the LILW repositories are located in areas which do not presently contain exploitable groundwater reserves for communities.

Biological, chemical and other hazards in decommissioning of research reactor

The reactor building 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 harmful 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 must be managed so that no radiation exposure will occur after disposal that would exceed the levels considered acceptable during the implementation of the disposal.

The Nuclear Energy Act (Section 7 h) requires that the disposal of nuclear waste in a permanent manner is planned with due regard to safety and that ensuring long-term safety does not depend on the surveillance of the disposal site. Section 8 of STUK Regulation Y/4/2016 adds 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/4/2016 states that the long-term disposal safety must 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).

Spent nuclear fuel

Preparations for spent fuel disposal have progressed in accordance with the objectives set by the Government Decision in 1983.

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 covered by assets collected in the Nuclear Waste

Management Fund. The obligation for financial provision starts when the MEAE grants a licence for operations that produce nuclear waste.

LILW

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 both existing NPP sites and are planned to also host decommissioning waste.

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

Decommissioning of the research reactor

The decommissioning planning of the research reactor started immediately after the decision to end its operation was made by VTT in spring 2012. The aim is to decommission the research reactor as soon as VTT has the technical and organizational readiness for the work and the required licence 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 covered by assets collected in the Nuclear Waste Management Fund (See Section B, Article 32: Costs and funding).

Non-nuclear radioactive waste

In 2012 TVO was granted a renewed operating licence for the Olkiluoto LILW disposal facility that also includes the disposal of Government owned non-nuclear radioactive waste. Active institutional controls are not needed to ensure the safety of these disposal facilities in 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 up-*

grade 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 taken into account.

Existing facilities for spent fuel management

There is not yet any existing facility for spent fuel management. The construction licence 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 Chapter 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 licence applications. A periodic safety review of the LILW disposal facilities is made at 15 year intervals. The Olkiluoto LILW disposal facility started operation in 1992 and consequently its safety assessment was submitted for review in

2007. In the same context, the suitability of the waste packages from the Olkiluoto 3 NPP unit for disposal in the facility were evaluated. The operating licence granted in 1992 covered the disposal of operational waste from Olkiluoto 1 and 2. The amendment of the operating licence of the Olkiluoto LILW disposal facility approved by the Government in November 2012 also covers OL3 and State owned non-nuclear radioactive waste stored in underground facilities in Olkiluoto.

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 the FSAR of the facility was accordingly updated and reviewed by STUK. Correspondingly, the safety related documentation for the construction of the connecting tunnel and the third LLW disposal hall, was reviewed by STUK in 2010. FPH submitted its periodic safety review of the LILW facility to STUK in 2013. STUK's safety review and decision dated 15 December 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 had implemented the procedures needed to continue its safe operation.

In conclusion, the safety reviews regarding the predisposal management of LILW at NPPs and the research reactor 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. 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 in the FiR 1 research reactor are covered by the operating licences of the respective NPP reactors. For the decommissioning, VTT has updated its radioactive waste management plan and submitted it to STUK for approval as part of the operating licence application for decommissioning submitted to the Government in June 2017.

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 Nukliditeknikka storage facility in Helsinki 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 end product and slag, as well and this is how Am-241 is detected. The low-level contaminated slag is stored by the company and finally the slag is sited at an industrial dumping ground for disposal according plans approved by STUK.

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 recovered in the metal production process of the mine, but is recirculated in the process and is finally precipitated in waste gypsum ponds. At the end of 2016 the amount of uranium in the gypsum pond is estimated to be 400–500 tonnes. The mine had gypsum waste pond leakages in 2012 and 2013, resulting in contamination of small nearby lakes with sulphide 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 naturally occurring radioactive materials (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 (Chapters G.6.1–G.6.4) for NPPs (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 disposal facility for spent nuclear fuel, STUK Regulation Y/4/2016 Section 12 includes the statement: *the effect of local conditions on operational safety and the feasibility to implement the arrangements for security and emergency preparedness shall be considered when selecting the site of a nuclear waste facility. The site shall be such that the detriments and threats posed by the facility to its vicinity remain very low.* Section 31 states that the host rock at the disposal site must, as a whole, be favourable to the isolation of radioactive substances from the living environment. Any area with a feature that is substantially adverse to long-term safety must 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 early 1980s. These have included many investigations of the air, surface and bedrock, and finally they included in situ investigations in the bedrock at the disposal depth at the ONKALO underground rock characterization facility to confirm the suitability of the bedrock for disposal.

In the context of the Decision-in-Principle process in 1999–2001 for TVO's and FPH's spent nuclear fuel disposal, Olkiluoto was selected as the site for a spent nuclear fuel disposal facility. Based on the Decision-in-Principle, 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 Decision-in-Principle stage. At the end of 2012 Posiva submitted a construction licence application for a spent fuel encapsulation and disposal facility. The licence 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 sufficient for the construction licence, 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 should have 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 should be submitted within six years from the date of the DiP ratification (2010) by Parliament. 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 the 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. At the same time, Fennovoima signed a contract 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 made in 1983. The Decision-in-Principle for Fennovoima Oy'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 is negotiating with TVO about the possibility to store their decommissioning waste in Olkiluoto for the next few tens of years. VTT also plans to negotiate a contract on the disposal of decommissioning waste with TVO. If these negotiations result in an agreement, a separate site for the storage or disposal facilities for the decommissioning wastes from the FjR 1 reactor will not be required, but licensing for the suitability of the existing facilities for the decommissioning waste of VTT is required.

Waste management facilities for non-nuclear radioactive waste

Currently, non-nuclear radioactive waste is stored in Helsinki at the Suomen Nukliditeknikka storage facility and in Olkiluoto. Additionally, the disposal of State owned non-nuclear waste has started in Olkiluoto. Therefore a siting is currently no longer an issue.

Article 14 Design and construction of facilities

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

- 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;*
- 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;*
- 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 (Chapter G) is relevant for the predisposal management facilities for LILW, which are covered by the operating licences of the NPPs and STUK Regulation Y/1/2016.

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 Chapter G. An illustration for the disposal facility of spent fuel at Olkiluoto is shown in Figure 5. The design of Loviisa and Olkiluoto LILW disposal facilities are illustrated in Figures 6 and 7, respectively.

According to section 8 of STUK Regulation Y/4/2016, disposal must be implemented in stages, with particular attention paid to aspects affecting long-term safety. The planning of the construc-

tion, 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.

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 licence application, Posiva delivered a Preliminary Safety Analysis Report (PSAR), which described the design bases of the disposal facility at a sufficient level. Based on the design documentation, it can be stated that the facility can be implemented in a way that makes it possible to fulfil the safety requirements that were originally laid down in Government Decree 736/2008, which has now been replaced by STUK Requirement Y/4/2016 in 2016.

Posiva has submitted a sufficient description of the decommissioning of the encapsulation plant for the construction licence and has taken decommissioning into account in the facility's design requirements. In the construction licence application documentation, Posiva has presented the principles of closure in a way that is sufficient for the construction licence and has planned the closure to be implemented in such 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 licence 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's Regulation (STUK Y/4/2016), 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 licence. 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/1/2016).

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

Concerning post-closure safety, Posiva updated the safety assessment work presented in the Decision-in-Principle for the construction licence 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 licence application at the end of 2012.

During 2013–2015 STUK carried out an overall assessment of the post-closure Safety Case (TURVA 2012) submitted to STUK in connection with filing the application for a construction licence, establishing the sufficiency and adequacy of the information provided, and issuing a decision on accepting the document for a more detailed review process. Based on STUK's review and assessment of the safety case documentation, the post-closure safety of the facility has been analysed sufficiently for the purposes of the construction licence. 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 sufficient manner for the purposes of the construction licence 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 licence 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
- STUK's official feedback 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

On 21 September 2011, TVO submitted an application to the Government for an amendment to the operating licence of the LILW disposal facility to allow the disposal of low and intermediate level nuclear waste also from the Olkiluoto 3 plant unit and the disposal of radioactive sources created by the use of radiation. According to the Radiation Act and the Radiation Decree, such waste is the responsibility of the State and the practical management of these wastes is carried out by STUK.

STUK prepared a safety assessment for the modification of the operating licence for the LILW disposal facility in Olkiluoto and used the assessment as the basis for a favourable statement issued to the MEAE on 28 June 2012 on the modification of the operating licence conditions of the Olkiluoto LILW disposal facility. The Government made a decision on the modification of the operating licence conditions of the Olkiluoto LILW disposal facility on 22 November 2012.

The operational waste (LILW) generated during the operation of the Loviisa NPP is disposed of into geological disposal facility located in the immediate vicinity of the NPP. The Government granted Fortum permission to use the LILW disposal facility until 31 December 2055 in April 1998. Fortum submitted the first periodic safety review of the LILW disposal facility to STUK for approval on December 2013. The update of the safety review must be submitted to STUK for approval after every 15 years.

STUK's safety review and decision dated 15 December 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 Fortum.

Safety assessment performed for decommissioning of research reactor

The safety of the FiR 1 research reactor was reviewed in the context of the renewal of its operating licence in 2011. The present licence is valid until the end of 2023. During the presently on-going licensing efforts for the decommissioning phase, the safety of the research reactor will be reviewed focusing on the safety of the decommissioning in particular.

Article 16 Operation of facilities

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

- the licence 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;*
- operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;*
- 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;*
- engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;*
- procedures for characterization and segregation of radioactive waste are applied; incidents significant to safety are reported in a timely manner by the holder of the licence 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 pre-disposal 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 a number of documents, including the Final Safety Analysis Report, are submitted to STUK when applying for an operating licence 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/4/2016) 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 Chapter G.

Updated assessment for post closure period

For the LILW disposal facilities, both in Loviisa and Olkiluoto, the operating licence conditions require a periodic update of the safety assessment. The STUK Regulation (STUK Y/4/2016), concerning nuclear waste disposal, requires that a safety case must be presented when applying for a construction licence and operating licence for the disposal facility and when making substantial plant modifications. The safety case must be updated at regular intervals unless otherwise required in the licence 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/4/2016) requires that the licensee 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 and the requirement for adequate engineering and technical support presented in Guide YVL A.4 applies.

Posiva has expertise on planning for the safe disposal operation. Posiva's own expertise is supported by the technical expertise of Posiva's owners, TVO and FPH, and also 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 and the related decommissioning plan should already be presented during licensing and operation phases. During operation, the licensee is obligated to prepare decommissioning plans for regulatory review every six years (Section 28 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 encapsulation plant was presented in the construction licence application in 2012. The encapsulation plant will be decommissioned according to its 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.

Decommissioning is discussed in more detail under Article 26.

Closure plans

According to STUK Y/4/2016 (Section 21) the design of the disposal facility must consider the safe-

ty 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 (Section 31).

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 licence 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/4/2016), 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 (Y/4/2016 29 §).

Institutional control

Two types of institutional control can be implemented: restrictions on land use (passive control) and technical post-closure surveillance (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/4/2016) 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 should be 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 should submit 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 licence the shipment of its spent fuel or radioactive waste to a destina-

tion 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 all kinds 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 (592/1991) and Decree (1512/1991), 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. The radiation control at the borders was revised in a co-operation project between the Finnish Customs office and STUK during 2008–2015 (the RADAR project). All measuring systems at the Finnish border crossing points were upgraded, including upgrading all systems with neutron detection capability, allowing better detection of special nuclear materials. STUK was responsible for the procurement of the equipment and also for radiation protection training of the Customs personnel in co-operation with the Customs school. The trainings of the Customs personnel responsible for radiation protection continues on an annual basis. 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.

Experiences

Spent fuel from the VVER type Loviisa NPP was shipped to the Soviet Union for the first time in 1981 according to an agreement between Finland and the Soviet Union and later on to Russia between 1992 and 1996. Altogether about a total amount of 330 tU of spent fuel was returned. The shipments 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.

Nowadays, transboundary movements take place very seldom in Finland. During 2008–2016 two spent fuel rods were shipped out of Finland for research purposes and some large metal components were shipped for scrapping. Radioactive waste was shipped back to Finland after the treatment. In addition, two shipments through Finland have been reported.

Regarding illicit trafficking, the systematic border control for monitoring radioactive materials has produced substantial results over the years. In 1997, the top year, 23 shipments were stopped at the border. After a number of turned-back shipments and enhanced co-operation with Russian counterparts, the number of cases has fallen drastically.

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 directives (Council Directive 96/42 Euratom, and Council Directive 97/43 EURATOM etc.) 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 16) 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 licence is granted by STUK upon written application. The general conditions for granting a licence are laid down in the Radiation Act and the licensing procedure is prescribed in more detail in the Radiation Decree (Sections 14–18). 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 is normally 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 condi-

tions set in the safety licence 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 regular checks 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 licence accordingly.

The Radiation Decree (Section 17) 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 monthly or 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. The Code and the Guidance have been implemented into national requirements. 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 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

The Radiation Act (Section 10) states that radioactive sources which have no further use must be rendered harmless. Guide ST 5.1 dealing with sealed sources specifies that disused sources may not be stored unnecessarily. 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 licence 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 recognised installation (a facility authorised for the handling, long-term-storage, or disposal of sources). The number of devices containing unused sealed sources stored in the premises of various licensees is currently (2.3.2017) 365, i.e. about 5% of the total number of such devices in use (the total number is about 6515).

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 and Materials Regulation. The most of this waste, including sealed sources, can also be disposed of in the disposal facility based on the revised (in 2012) operation conditions of the Olkiluoto LILW disposal facility. The disposal of non-nuclear radioactive waste in the Olkiluoto LILW disposal facility started at the end of 2016 after the approval of the changes in the Olkiluoto LILW disposal facility's operating licence conditions. A few high activity sealed sources will need a different disposal route, which is not yet determined.

Disused sources have been collected by a private entrepreneur (Suomen Nukliditeknikka), by whom they are repacked, as necessary, and then transferred to storage at Olkiluoto. STUK's Radiation Practices Regulation Department has issued an authorisation based on the Radiation Act to a private entrepreneur for its operations

as a recognised installation. Due to an incident with a broken source and resulting contamination in early 2016, STUK forbade the company to receive any new sources in March 2016. In June 2017 STUK approved the application by Suomen Nukliditeknikka for the continuation of its operation in new premises, which were inspected and approved by STUK as suitable for receiving, handling and storing non-nuclear radioactive waste.

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. The first option is preferred and it is foreseen that in the future an agreement on returning the source to the provider will be required for all sources.

Sources manufactured in Finland can be returned to Finland once they have become disused sources. Sealed sources that have not been manufactured in Finland cannot be imported to Finland as radioactive waste. Currently there is no ongoing manufacturing of sources in Finland.

Orphan sources

According to the Radiation Act (Section 50), 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 51). In such cases, the licensee – 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. 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 1–2 sealed radioactive sources have been found annually in imported scrap metal. Orphan sources, whose owners cannot be identified, are delivered to the State interim storage at Olkiluoto.

Incident with sealed source

According to the Radiation Act (592/1991), a recognized installation, which is licenced by STUK, can receive non-nuclear radioactive waste and sealed sources for handling and storage. The only recognized installation in Finland is Suomen Nukliditeknikka which has been operating since 2009. In March 2016, there was a contamination event on the premises of Suomen Nukliditeknikka. The contamination resulted from a leaking Cs-137 sealed source (original activity 925 MBq). Because STUK's radiochemistry laboratory operates in the same building with Suomen Nukliditeknikka, the event caused a significant risk to sensitive activity measurements as minute amounts of contamination could have spread in the building.

The cleaning of the facilities from the contamination started immediately. The cleaning work was finalised in spring 2017. The resulting waste includes water, cleaning material and contaminated goods. The handling and disposal of this waste is yet to be resolved and the case has revealed a deficiency in the Finnish system for handling non-nuclear radioactive waste. As a result, the Ministry of Social Affairs and Health as well as Ministry of Economic Affairs and Employment have set up a working group to further develop the national strategy for radioactive waste and to find a permanent national solution. One of the problems is that nuclear power plants have the equipment to treat the kind of waste produced (e.g. contaminated material) but their licence conditions forbid using it for non-nuclear radioactive waste.

After the incident STUK issued an order forbidding Suomen Nukliditeknikka to receive new disposed sources before it can meet the full safety requirements. Disused sources are currently stored by

the users or dealers/importers. STUK has a responsibility based on Section 24 b of the Radiation Decree 1512/1991 to act as a recognized installation if none exists. Suomen Nukliditeknikka applied for a license to continue its operation in new premises in spring 2017. STUK inspected the premises and the company itself and stated that it now fulfils safety requirements. STUK thus granted licence for the company to resume its operations again at the end of June 2017.

To capture all lessons learned from the incident, STUK requested the Finnish Safety Investigation Authority (<http://www.otkes.fi/en/>) to investigate the incident. The Authority concluded its investigation in early 2017 and published a report that included several safety recommendations such as:

- All parties involved with treatment of minor radioactive waste are to follow the established measures for ensuring the integrity of radiation sources as described in the radiation safety instructions for the reception, transport, treatment and packaging for final disposal of radiation sources.
- The Ministry of Social Affairs and Health and the Ministry of Economic Affairs and Employment 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.

After the incident STUK has also reviewed its own operating procedures and made improvements to regulatory control, communications and emergency preparedness processes.

SECTION K General efforts to improve safety

The 5th Review Meeting in 2015 identified challenges and recorded some planned measures to improve the safety of nuclear waste management in Finland. The status of the findings made in the 5th review meeting is summarized in this chapter. The major developments in the nuclear and non-nuclear radioactive waste management in Finland since the 5th Review Meeting are include the following:

- concrete progress in spent nuclear fuel disposal
- enhancement of spent fuel interim storage safety
- improvements in NPP LILW management and non-nuclear radioactive waste disposal
- planning of the research reactor decommissioning and dismantling started.

Furthermore, the legislative and regulatory framework was enhanced, national competences for future needs were evaluated and developed, and an IRRS follow-up mission (IAEA's Integrated Regulatory Review Service) was carried out in Finland. More detailed information on developments concerning the various topics of the Convention are described in connection with the relevant articles.

Aspects of nuclear and non-nuclear radioactive waste management have been developing well in Finland, but there are still challenges which Finland has to face in the forthcoming years. The challenges are related to the overall radioactive waste management framework, competences, and the regulatory framework for decommissioning and communication.

The status of the challenges from the 5th Review Meeting

The 5th Review Meeting in 2015 identified challenges concerning nuclear and non-nuclear radioactive waste management in Finland. On request

of the Review Meeting these issues are included and the responses are outlined in this 6th National Report of Finland. The status of the challenges are listed here with the related Articles given in brackets.

Construction and oversight of the SF disposal facility (Section H, Annexes L.2 and L.3)

During the reporting period STUK finalised the safety evaluation of Posiva's construction licence application for the encapsulation plant and disposal facility. In addition to a documentary review, the regulatory oversight contained several inspections in different areas (e.g. management systems, resource management, design, construction, research and monitoring activities). The statement and a safety evaluation report were submitted to the Government in February 2015. In the assessment STUK highlighted several issues that required further action. The Government granted the construction licence to Posiva in November 2015. At the end of November 2016, after several inspections, STUK approved Posiva's application to start the construction of the disposal facility. The construction commenced on the 1st of December 2016. At same time, the regulatory oversight of the construction of the encapsulation plant and disposal facility has been planned and the oversight of disposal facility construction has started. Finland has met the challenges identified for the reporting period in the 5th review meeting concerning the regulatory oversight of the disposal of spent nuclear fuel and the construction of the disposal facility. Progress in spent nuclear fuel disposal has been identified as a continuous challenge as the proceeding project leads to the need to further develop regulatory requirements. Additionally, regulatory oversight needs to be developed and adjusted to the different

project phases. STUK has procedures in place to review and update plans and regulations as the disposal project proceeds to each new phase and needs for development are identified. Further, Posiva is well prepared for the construction phase of the disposal project and preparations are ongoing for the forthcoming operation phase. The development of national competences and regulatory framework have also been identified as a continuous challenge as the nuclear field in Finland is currently very active and competent resources are required both for the regulatory oversight and for the licensees and license applicants. The procedures for the management of resource needs are addressed below.

Decommissioning and waste management of the FiR 1 research reactor (Article 9, Article 26, Annex L.5)

The first decommissioning project in Finland is the decommissioning of the research reactor (FiR 1), and this is in the licensing phase. STUK will start the review of the licence application in autumn 2017 aiming to finalise it in 2018. The Government will consider the licence application in early 2019. As the project is the first decommissioning project in Finland, STUK has identified following challenges during the preparation and licensing phase of the project: 1) The legislation and YVL guides concerning decommissioning need to be reviewed and updated. Renewal of the nuclear energy law is ongoing and during the update the decommissioning license, among other things, will be added to the legislation. YVL guides will be updated later based on the experience gained from the decommissioning project. 2) The regulatory oversight along with competent resources must be ensured for the decommissioning project. Project organization has been established for the regulatory oversight and will be supported by a range of experts with varying areas of required competence. The regulatory oversight of the project should still be planned separately for the decommissioning project so that it will be adequate but not exaggerated. 3) The waste management plans of the licensee must be developed further. Currently there are still several alternatives for the waste management of spent fuel and decommissioning wastes. The plans should be fixed before entering into the dismantling phase.

Ensuring adequate resources and competence (STUK, utilities, research organizations, waste management organizations and the Government) (Article 20, Article 22)

The Ministry of Economic Affairs and Employment, STUK, licensees, VTT and universities all share this challenge. To ensure sufficient induction training in the nuclear field, courses on nuclear safety (YK course) and nuclear waste management (YJH course) for new staff have been arranged yearly in co-operation with the above-mentioned organizations and with some consultancy companies. The plan is to continue these courses in one common or separate course yearly in the future to ensure that basic courses in the area exists for newcomers. Interest has also been emerged into a tailor-made, common course by directors and board members of the nuclear power industry. In addition, a doctoral programme (YTERA – Doctoral programme for Nuclear Engineering and Radiochemistry) was established as a collaborative effort between the universities and other stakeholders in nuclear energy going in 2012–2015 to educate people in the nuclear field. Furthermore, The programme was successful and educated 44 students in total of which 21 earned a doctoral degree. YTERA partners are currently planning a new DEN-NST-project (Doctoral Education Network in Nuclear Science and Technology) to continue to educate people in the field. Also the national research programme (KYT research programme) plays a very important role in the development of new competent human resources in the field of radioactive waste management. The Finnish VTT Technical Research Centre of Finland Ltd has built the new VTT Centre for Nuclear Safety Research to Otaniemi with 150 researchers and six hot cells. Ensuring adequate and competent resources remains a continuous challenge as Finland has an active nuclear energy sector. The Finnish national framework has procedures in place for addressing this challenge.

Communication with the public and stakeholders to maintain confidence in safe waste management and the regulatory framework (Article 20)

STUK aims to communicate proactively, openly, promptly and clearly. 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 stakeholders remains highly important for STUK to share understandable and reliable information promptly as it arises. This will be a challenge in the future in the changing communications environment.

Disposal of a few High-Activity Sealed Sources (HASS) which are not suitable for disposal in existing LILW repositories (Section J)

The disposal plans for HASS have not proceeded during the reporting period. The few HASS sources that do exist will be addressed as part of the Finnish national waste management plan and currently there is no operating facility that could dispose of these sources. On a more general level, the management of non-nuclear radioactive waste remains a national challenge for Finland and will remain so for the next reporting period and will be taken into account when developing Finland's national framework.

The major developments in Finland since the 5th Review Meeting

The legislative and regulatory system was enhanced

The current Finnish nuclear legislation is based on the Nuclear Energy Act from 1987, together with a supporting Nuclear Energy Decree from 1988. 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 import and export of nuclear waste, including spent fuel, is prohibited in the revised Act. Since 1994, the Nuclear Energy act has been revised several times, e.g. to implement the Nuclear Safety Directive (Council Directive 2009/71/EURATOM) and the European Council Directive on the management of spent fuel and radioactive waste (Council Directive 2011/70/EURATOM). In 2015, a revision to the Nuclear Energy Act enabled STUK to issue legally binding regulations. Based on the Nuclear Energy Act, STUK issued four regulations in 2016 to replace the earlier Government Decrees

and one new regulation on the safety of uranium and thorium production:

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

At the end of 2016, both the Nuclear Energy Act and the Radiation Act were being revised due to the Basic Safety Standards directive and because of the amended Nuclear Safety Directive. The revision of the Nuclear Energy Act will include also amendments related to changes in the Pressure Equipment Act and licensing of nuclear facilities. The proposed new Nuclear Energy Act and Decree will introduce a decommissioning licence step. The decommissioning licence will be granted by the Government if the changes in law are approved by the end of 2017 as planned. This would clarify the terms for the decommissioning of the nuclear facilities in the future.

STUK's role and responsibilities were assessed in a peer review, as part of the IRRS mission (IAEA's Integrated Regulatory Review Service), in October 2012. In the follow-up mission in June 2015 regulatory activities in Finland were reviewed on the basis of IAEA Safety Standards and international best practices. The results are that the recommendations and suggestions from the 2012 IRRS missions have been taken into account by STUK 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 in 2012 could be closed. The recommendation left open deals with STUK's position under the Ministry of

Social Affairs and Health, which will be discussed further in Finland. Two new recommendations were raised to amend legislation so that decommissioning a nuclear installation and the closure of a disposal facility would require a licence amendment; and to address arrangements for research in radiation safety. STUK has updated its action plan to take these recommendations into account in future development actions. One of the open suggestions is related to STUK's management system. Although STUK had initiated many improvements to its management system, the IRRS team felt that there is still work that needs to be undertaken for further enhancing STUK's management system. The implementation of the IRRS recommendations has proceeded as planned in the 5th review meeting (*Planned Measures to Improve Safety: Implementation of recommendations from the IRSS review*).

Development of national competences for future needs

Ensuring adequate and competent resources is a continuous challenge in a small country like Finland, where the nuclear energy sector is very active: four reactors (OL1, OL2, LO1 and LO2) are in operation, one nuclear power reactor (OL3) will soon be commissioned, one is in the construction licencing phase (Hanhikivi 1), a disposal project is ongoing and the decommissioning of the research reactor FiR 1 is going to start in the near future. Basic training in nuclear science is provided by the Lappeenranta University of Technology as well as Aalto and Helsinki universities. MEAE, STUK, licensees, VTT and the universities share the challenge of ensuring adequate and competent resources and have jointly arranged yearly nuclear safety (YK course) and nuclear waste management (YJH course) courses for new staff in several organizations. The plan is to continue these courses in the future. In addition, the availability of competent human resources has been ensured by training young experts in the nuclear safety field in different ways, e.g. on a doctoral programme (YTERA – Doctoral Programme for Nuclear Engineering and Radiochemistry and DEN-NST – Doctoral Education Network in Nuclear Science and Technology). Additionally, the national research programme (KYT-program) plays a very important role by providing education to guarantee

competent new human resources in the nuclear and radioactive waste management areas.

During 2010–2012 a committee set up by the Ministry of Economic Affairs and Employment (MEAE) worked on a report to provide recommendations and steps to be taken until the 2020s for ensuring the competence and resources needed for the nuclear sector. One of the recommendations of the committee was that the future needs and focus areas of the Finnish nuclear energy sector research must be accurately defined and a long-term strategy should be drawn up for further development of research activities. This calls for a joint project between research organisations and other stakeholders in the field. The update of the competence review is planned to be continued in 2017 to reflect the current changes in the operating environment.

At the end of January 2013, the MEAE set up a working group to prepare a research and development strategy. The report “Nuclear Energy Research Strategy”, published at the end of April 2014, emphasizes the importance of research in competence building with seven recommendations. The implementation of the recommendations is on-going by the MEAE. As an example of the on-going implementation, the Nuclear Energy Act was updated in 2015 to ensure the financing for the enhancement of the nuclear safety research infrastructure.

The two main ongoing R&D programs in Finland concerning nuclear waste and spent nuclear fuel management and disposal are:

- The joint R&D-programme between TVO and Fortum (compiled by Posiva); the programme is mainly aimed at planning and implementing a spent fuel disposal project but also includes an R&D-programme for LILW management;
- The national research programme (KYT-2018) for 2015–2018, administered by MEAE; the programme aims at supporting the creation and maintenance of overall competence and the basic skills needed regarding the management and disposal of nuclear waste (mainly spent fuel).

The Government reduced STUK's budget over the past years mostly due to reorganisation of funding and research in the governmental organisations. Oversight activities are charged in full from the licensees, and nuclear and waste safety research

programmes are funded via the waste management fund, so budget cuts have not impacted nuclear safety research or resources needed for regulated activities. However, due to budget cuts, STUK has partly terminated and significantly reduced its radiation safety research (e.g. research into the biological effects of radiation, or biodosimetry). Since radiation safety research activities contributed to the maintenance and development of expertise in Finland, STUK has established a national radiation safety research programme in co-operation with all universities in Finland to ensure that radiation safety research will be continued in Finland.

Spent nuclear fuel disposal project progressed to the construction phase

The Finnish nuclear fuel cycle policy is based on the once-through principle. After removal from reactors, spent fuel is stored in pool type interim storage facilities at the power plant sites. Two interim storages have been in operation in Loviisa and Olkiluoto already for over 30 years. Fennovoima is also planning to construct a pool type interim storage facility in Pyhäjoki. After a storage period of some tens of years, the spent fuel will be disposed of in the Finnish bedrock.

In 1999, in a Decision-in-Principle (DiP) application, Posiva proposed, to site a disposal facility for spent nuclear fuel at Olkiluoto in Eurajoki. The application was reviewed from a safety viewpoint by STUK and accepted by the municipality of Eurajoki in January 2000. The Finnish Government made the DiP in December 2000 and Parliament ratified it in May 2001. The DiP authorized Posiva to continue the planned disposal project and also to construct an underground rock characterization facility “ONKALO” at the actual disposal depth. ONKALO is intended to be used as part of the disposal facility and it was constructed under pertinent regulatory control. Posiva submitted the construction licence 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 licence was granted by the Government to Posiva in November 2015. The construction of the disposal facility started in December 2016. Posiva is responsible for the preparations and later implementation of spent fuel disposal for its owners TVO and

FPH. The disposal project and granted licence covers spent fuel from five reactors: Loviisa 1 and 2, Olkiluoto 1, 2 and 3. The licensing of the encapsulation plant and disposal facility has proceeded as planned and presented in the 5th review meeting. (*Planned Measures to Improve Safety: Licensing of encapsulation plant and disposal facility for encapsulated spent fuel*).

In the Decision-in-Principle for a new NPP, Fennovoima was required to define its plans for future spent nuclear fuel disposal. As required, Fennovoima submitted an environmental impact assessment programme for spent fuel disposal in June 2016 to the MEAE. Fennovoima and Posiva Solutions Oy, Posiva’s subsidiary that focuses on supplying services, have signed a co-operation agreement to ensure that Posiva’s expertise will be available for Fennovoima’s spent nuclear fuel management. Full co-operation started in 2016.

Spent fuel interim storage safety was enhanced

The Olkiluoto spent fuel interim storage facility has undergone many improvements during its extension, which commenced operations in summer 2015. Protection against a large airplane crash has been included in the design of the extension and the protection has also been improved for the original part of the facility. Additionally, the cooling water systems for the spent fuel storage pools have been improved to enable a water feed from outside the facility. The monitoring of the storage pool water level and temperature has been improved to take earthquake resistance and the potential loss of the facility power supply into account to address lessons learned from the Fukushima Dai-ichi accident.

Furthermore, the Loviisa spent fuel storage has been improved since the Fukushima Dai-ichi accident. The main changes are aimed at reducing the dependency on the plant’s normal electricity supply and distribution system, as well as on seawater cooled systems for residual heat removal from the reactor, as well as 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 for cooling. The design plans for the installation of a diverse water supply to the spent fuel pools have also been approved by STUK in

2015 and the installation is planned to be carried out during 2017. Finally, the flood protection of the NPP has been improved.

Operation in low and intermediate level waste management has proceeded as previously

The predisposal management of LILW takes place at the NPPs under their operating licences and other provisions and there have not been any major changes in the procedures during the reporting period. In the Loviisa NPP the solidification plant was authorized for full operation in 2016 and was the main development in the predisposal management of LILW. The Loviisa NPP has now been able to start the solidification of historical liquid radioactive waste, which has been stored in tanks from the start of NPP's operation from late 1970s. The aim is to solidify and dispose of all existing liquid waste during the forthcoming years.

At both operating NPPs, solid LLW is transferred after conditioning to the disposal facilities located on the power plant sites. At Olkiluoto the operation of the LILW disposal facility started in 1992 and in Loviisa in 1998. Fennovoima is planning to construct a similar LILW disposal facility on the Pyhäjoki site.

The disposal of non-nuclear radioactive waste has started

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) licence conditions of the Olkiluoto LILW disposal facility have enabled the disposal of non-nuclear waste, including sealed sources at the Olkiluoto LILW disposal facility. The started at the end of 2016. 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.

Planning for decommissioning of Finland's first nuclear reactor commenced

The research reactor FiR1 (TRIGA Mark II, 250 kW) has been in operation since 1962. The operation of the FiR1 reactor has been carried out by VTT Technical Research Centre of Finland Ltd. since 1971. In 2012, VTT decided to shut the reactor down due to insufficient funding for its contin-

ued operation. VTT submitted an EIA programme for decommissioning the FiR1 reactor to the MEAE in autumn 2013, followed by the submission of the EIA report in October 2014. The FiR1 reactor will be the first nuclear reactor to be decommissioned in Finland. VTT has submitted an application to the Government for a licence for decommissioning in June 2017 (formally a new operating licence, as the present Finnish legislation does not yet define a decommissioning licence, and a separate decommissioning licence will be included in a new act). The dismantling is scheduled to start in early 2019 and to last about two years. The dismantling will be regulated by STUK concerning radiation and nuclear safety aspects.

As the licensing and 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.)

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.

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 also for the major part of non-nuclear radioactive waste. However, as a consequence of the sealed source incident and its related clean-up work, as well the planning of the research reactor decommissioning waste storage and disposal, 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. The MEAE has invited an ad-hoc expert group to address these issues. The group will also address recommendations made by the Finnish Safety Investigation Authority about the sealed source incident in autumn 2016. This group will start its work in autumn 2017.

Developing competences and the regulatory framework for decommissioning

The research reactor, FiR 1, will be the first nuclear reactor to be decommissioned in Finland. As this is the country's first decommissioning project, Finland has limited experience in this area. VTT and STUK are both co-operating internationally with their peers, gathering knowledge and experience regarding decommissioning. 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 on also for planning the regulatory oversight for decommissioning NPPs.

Communication to improve the general public's understanding of disposal safety

The Finnish public has a high degree of trust in the radiation and nuclear safety regulator, STUK, and good level of trust towards the safety of nuclear waste disposal in the country. However, the interest of the general public towards disposal related information seems to be decreasing. Additionally, the latest results of polls (conducted by e.g. Finnish Energy in 2016) evaluating public opinion show an indication of a slight decrease in trust towards disposal safety. The development of this trend needs to be followed in the up-coming polls. The regulatory work and decisions made by the regulator

need to be clear and understandable to the public. The general public should also have the correct understanding of disposal safety and the related risks. Due to these challenges, STUK initiated a strategic communication development project in spring 2016 to address both the changing communication environment and the use of modern communication tools.

A candidate for good practice

Finland has identified granting the construction licence for a spent fuel disposal facility as a candidate for a good practice. Finland is the first country that has granted a construction licence for a final repository for spent fuel. Construction of the facility is on-going. The development and evaluation of safe disposal has been a long-lasting systematic process conducted in good co-operation between the Government, ministries the regulator, Posiva, nuclear power companies as well as research organisations while acknowledging the roles and universities responsibilities of the different parties. The approach taken in Finland has enabled the timely progress of the disposal project with political and public support and resulted in approval of the construction licence application in 2015. This is a concrete step towards improving safety in a unique and proven manner.

SECTION L Annexes

L.1 List of main national regulations

Legislation (as of 30.12.2016)

- Nuclear Energy Act (990/1987)
- Nuclear Energy Decree (161/1988)
- Government Decree on the State Nuclear Waste Management Fund (161/2004)
- Act on Third Party Liability (484/1972)
- Decree on the Implementation of Third Party Liability (486/1972)
- Radiation Act (592/1991)
- Radiation Decree (1512/1991)
- Act on the Finnish Centre for Radiation and Nuclear Safety (1069/1983)
- Decree on the Radiation and Nuclear Safety Authority (618/1997)
- Decree on Advisory Commission on Nuclear Safety (164/1988)
- Act on the Environmental Impact Assessment Procedure (252/2017)
- Government Decree on Environmental Impact Assessment Procedure (277/2017)
- Act on the Openness of Government Activities (621/1999)
- Decision of the Government on Financial Provision for the Costs of Nuclear Waste Management (165/1988) (to be replaced by a Government Decree in spring 2017)

STUK Regulations

- STUK Regulation on the Safety of Nuclear Power Plants (STUK Y/1/2016)
- STUK Regulation on Emergency Response Arrangements at Nuclear Power Plants (STUK Y/2/2016)
- STUK Regulation on Security in the Use of Nuclear Energy (STUK Y/3/2016)
- STUK Regulation on the Safety of the Disposal of Nuclear Waste (STUK Y/4/2016)

- STUK Regulation on the Safety of Mining and Milling Operations Aimed at Producing Uranium and Thorium (STUK Y/5/2016)

The Regulations are available on the Internet at: <http://www.finlex.fi/fi/viranomaiset/normi/555001> (in English).

Regulatory Guides on nuclear safety (YVL Guides) (as of 31.12.2016, 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, 22 November 2013
- Guide YVL A.2 Site for a nuclear facility, 15 November 2013
- Guide YVL A.3 Management systems of a nuclear facility, 15 November 2013
- Guide YVL A.4 Organisation and personnel of a nuclear facility, 15 November 2013
- Guide YVL A.5 Construction and commissioning of a nuclear facility, 15 November 2013
- Guide YVL A.8 Ageing management of a nuclear facility, 15 November 2013
- YVL A.9 Regular reporting on the operation of a nuclear facility, 15 August 2014
- Guide YVL A.10 Operating experience feedback of a nuclear facility, 15 November 2013
- Guide YVL A.11 Security of a nuclear facility, 15 November 2013
- Guide YVL A.12 Information security of a nuclear facility, 15 November 2013

Group B: Plant and System Design

- Guide YVL B.1 Safety design of a nuclear power plant, 15 November 2013

- Guide YVL B.2 Classification of systems, structures and components of a nuclear facility, 15 November 2013
- Guide YVL B.3 Deterministic safety analyses for a nuclear power plant, 15 November 2013
- Guide YVL B.4 Nuclear fuel and reactor, 15 November 2013
- Guide YVL B.7 Provisions for internal and external hazards at a nuclear facility, 15 November 2013
- Guide YVL B.8 Fire protection at a nuclear facility, 15 November 2013

Group C: Radiation safety of a nuclear facility and environment

- Guide YVL C.1 Structural radiation safety at a nuclear facility, 15 November 2013
- Guide YVL C.2 Radiation protection and exposure monitoring of nuclear power plant workers, 15 November 2013
- Guide YVL C.3 Limitation and monitoring of radioactive releases from a nuclear facility, 15 November 2013
- YVL C.4 Radiological monitoring of the environment of a nuclear facility (17 March 2015)
- Guide YVL C.5 Emergency preparedness of a nuclear power plant, 15 November 2013
- Guide YVL C.6 Radiation monitoring at a nuclear facility, 15 November 2013
- Guide YVL C.7 Radiological monitoring of the environment of a nuclear facility, 19 December 2016

Group D: Nuclear materials and waste

- Guide YVL D.1 Regulatory control of nuclear safeguards, 15 November 2013
- Guide YVL D.2 Transport of nuclear material and nuclear waste, 15 November 2013
- Guide YVL D.3 Handling and storage of nuclear fuel, 15 November 2013
- Guide YVL D.4 Predisposal management of low and intermediate level waste and decommissioning of a nuclear facility, 15 November 2013
- Guide YVL D.5 Disposal of nuclear waste, 15 November 2013

ST Guides for non-nuclear radioactive waste

- Guide ST 1.1 Safety fundamentals in radiation practices, 23 May 2013

- Guide ST 1.4 Radiation user's organization, 2 November 2011
- Guide ST 1.5 Exemption of the use of radiation from the safety licence, 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 wastes and discharges, 1 July 1999
- Guide ST 12.2 Radioactivity of building materials and ash, 17 December 2010

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 Decision-in-Principle licensing phase (DiP), 1978–2001
2. Design, research and development phase including construction of an underground rock characterization facility (from DiP to Construction licence (CL)), 2001–2014
3. Construction and commissioning phase (from CL to operating licence (OL)), 2015–2022
4. Operating phase (2023–2120, if no new NPPs)
5. Decommissioning and closure phase (2120–2125, assuming no new NPPs).

The first step in the licensing process was reached at the end of 1999, when Posiva Oy 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 given 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 on, the DiP was expanded with two separate DiPs to also cover the spent fuel from reactor units OL3 and OL4. The DiP for OL4 expired when TVO decided not to apply for a construction licence for the Olkiluoto 4 unit in June 2015.

The initial DiP also authorized Posiva to start the construction of an underground rock charac-

terization facility (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 Government strategy set out in 1983 and accordingly submitted a construction licence application and its supporting documentation to the authorities at the end of 2012. The Government granted Posiva the construction licence 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 must be characterized at the disposal depth. This requirement is further developed 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. ONKALO has functioned as an underground rock characterization facility to ensure the suitability of the Olkiluoto site for a disposal facility and has been proposed also to be access route to the actual disposal facility in the future. STUK has implemented regulatory control of the ONKALO construction project and regulated it as if it would be an access route to a nuclear facility. However, a construction licence was needed before starting the construction of the disposal rooms.

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

Every three years Posiva publishes an RD&D plan for nuclear waste management on behalf of TVO and FPH, who are liable for the nuclear waste generated at their nuclear power plants, and submits it to the Ministry of Economic Affairs and Employment (MEAE) for regulatory review. STUK reviews the plan and provides its own statement to the MEAE. The most recent plan was submitted to the MEAE in September 2015 and it covers the period 2016-2018. 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 licence application, STUK's regulatory control of Posiva's RD&D activities has focussed on demonstrating the feasibility and performance of the final 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 licence 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 licence application for Olkiluoto spent nuclear fuel encapsulation plant and disposal facility

The MEAE required Posiva to submit a preliminary (draft) of the licence documentation by the end of 2009. The reasoning was to conduct a regulatory review of the status and maturity of the development of the construction licence application. STUK reviewed the draft safety case and the process was used as an exercise for the actual licence application review.

STUK established an internal project for the licence 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 licence 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 the assessment, STUK highlighted issues that needed further attention.

Regulatory control for the construction of the disposal facility

After the construction licence 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 licence 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 licence 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 sufficient 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 Onkalo project (the underground rock characterization facility) on 1st of December 2016.

The next main phase of the project will be starting the construction of the encapsulation plant and as stated in the section 108 of the Nuclear Energy Decree, STUK will ascertain Posiva's readiness also for this phase of construction. Based on the present time schedule this will be carried out in 2018.

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 also 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, taking into account 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, will describe the oversight of the underground disposal facility. This guide will be published during 2017.

In the disposal facility oversight concept, STUK has taken the experience into account from the oversight of the underground rock characterization facility (Onkalo). 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 will perform an inspection concerning the readiness to commence the excavations. During the construction, STUK will perform inspections of the rock surface based on mapping documentation before the surfaces are covered by shotcrete and perform 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 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. STUK is closely following the results of the monitoring programme during the construction.

Oversight of feasibility of the disposal concept

Based on the construction licence 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 will cover the design, manufacturing and installation of the EBS components. During the construction period, the EBS oversight will focus 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. 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 set milestones 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 licence 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 under rigorous testing in nuclear power plants. The plans are to verify all spent fuel before packing into the spent fuel disposal casks.

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 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 Fortum established a joint company, Posiva Oy, 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 1993 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 1993-1995. Preliminary site characterization started in 1987 at five sites. The site characterization programme included deep drilling, geological mapping, hydrogeological, hydro geochemical 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 Decision-in-Principle (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 underground rock characterization facility (URFC) ONKALO was started in 2004. As ONKALO 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 construction phase. The excavation of ONKALO was completed in 2016. The experience gained from the 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 licence granted and construction started

According to the Government's Decision-in-Principle the spent fuel from the Loviisa and

Olkiluoto NPPs will be disposed of in a KBS-3TM type geological repository on the Olkiluoto island in the municipality of Eurajoki. At the end of 2012 Posiva submitted a construction licence 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 licence 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 licence application. In these decisions STUK set requirements for Posiva that must be met during construction or in the operating licence 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 licence to Posiva on November 12, 2015 for the disposal of 6500 tU from NPP units Olkiluoto 1–3 and Loviisa 1 and 2. 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 licence by the end of 2020 and start operation of the encapsulation and disposal facilities by the end of 2023. The time schedule depends on the duration of the operating licence 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 licence. 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.

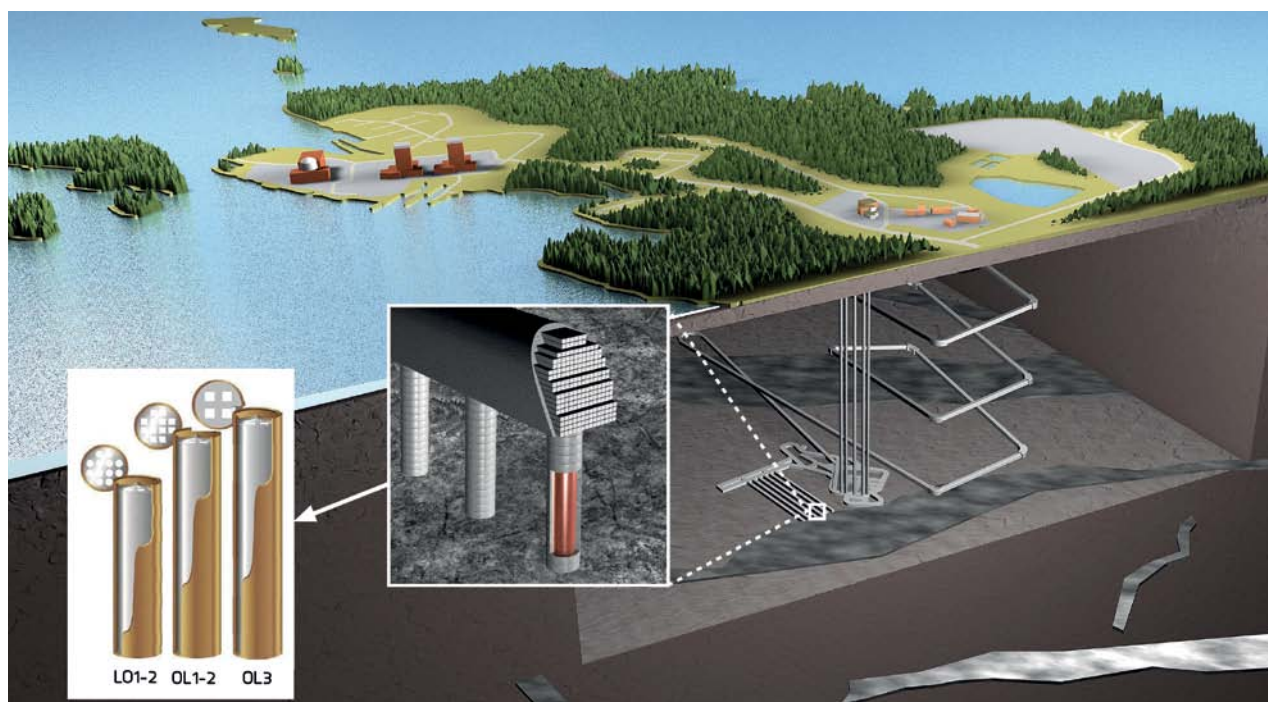


Figure L3-1. General layout of ONKALO research facility and KBS-3V concept of disposal.

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 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 facility for locating suitable rock volumes for various rooms and which will be used for the same purpose in the construction of the final 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 earth quakes and secondary movements on the final 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 is extending the studies to include extreme lines of evolution, such as extremely thick glaciation and an extended temperate climate by modelling the evolution of CO₂ contents for a period of 1 million years (Ilmastokehitys project). The results will be integrated into the safety case.

The projects regarding the disposal canisters

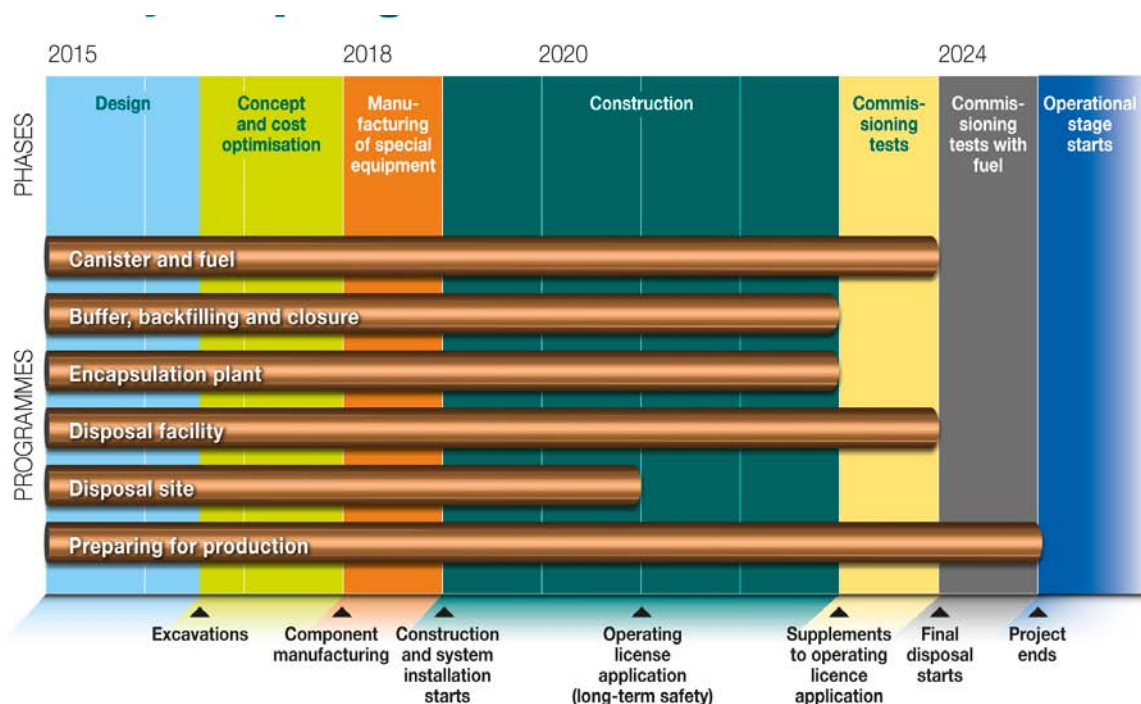


Figure L3-2. Project progress model and schedule.

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 is 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 will be performed. To support the statement and the tests, modelling is being carried out (copper sulphide modelling) in co-operation with the Swedish waste management organisation SKB.

Studies on the creep properties of the copper are being 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. Both the buffer and the backfill consist of blocks and pellets. The backfill also includes granules, according to the current design. When bentonite clay come 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. The wetting behaviour of buffer and backfill components is being 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 is being further studied and modelled (mechE project) to reduce the uncertainties related to early evolution until the full saturation of the disposal system.

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 is being 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.

The long-term interaction of the clay components with the cement used in the construction of the final disposal facility is being studied with help of laboratory experiments, computer simulations and discrete fracture network modelling (CBI and DFN projects). The aim of the work is to set safe limits for the use of cement, under which the effect on the performance of the clay components can be disregarded.

Posiva has completed work during 2016 in two large EURATOM co-funded demonstration projects for disposal technologies LUCOEX (emplacement technologies) and DOPAS (plugs and seals) among several other 7th research framework projects. Currently, Posiva is participating in the Euratom Horizon 2020 projects: BEACON (bentonite homogenisation), MODERN2020 (monitoring strategies of disposal facility), and, MIND (microbial activity in disposal), and is cooperating on the IGD-TP (Implementing Geological Disposal Technology Platform) platform in the CAST project dealing with the release ratio of C-14 in spent nuclear fuel, and the DISCO project studying the dissolution of spent nuclear fuel in disposal conditions. The criticality safety of the spent nuclear fuel in disposal conditions is also being further assessed.

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 the Radiation and Nuclear Safety Authority (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 Degree 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. The general contents of the programme structure are presented in Figure L3-3. 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.

Disposal facility construction status and progress

Excavation works for the encapsulation plant foundations started in June 2016. The underground excavation work package LTU1 (Final disposal facility, tunnel excavation contract no. 1) that started the nuclear construction phase in December 2016, is continuing as planned and according to the schedule. The total amount of LTU1 excavation will be around 100 000 m³ and the contract is estimated to be finished in June 2019.

The construction status in June 2017 is as follows:

- The LTU1 work package progress stands at around 25 000 m³
- Canister shaft works commenced with rock injection in February 2017. The aim is to start canister shaft raise boring in February 2018 and is planned to be ready in December 2018
- Canister shaft connections at -90 m and -180 m have been fully excavated. Canister shaft connection excavation at -290 m has started.
- Canister reception station excavation at -437 m has started
- Vehicle connections 9 and 22 have been excavated. Connections 1, 5, 15, 17 and 23 are ongoing.

The construction of the supporting structures of the personnel shaft has commenced and the work is planned for completion during June 2017 – March 2018. Manufacture and installation of the steel structure for the personnel elevator and building services are scheduled for February 2018 – May 2019. The air outlet shaft will be equipped and operational in June 2017. The construction work for the supporting structures of the technical area at -437 m are planned to start in June 2018. The construction work in general is progressing according to the planned schedule.

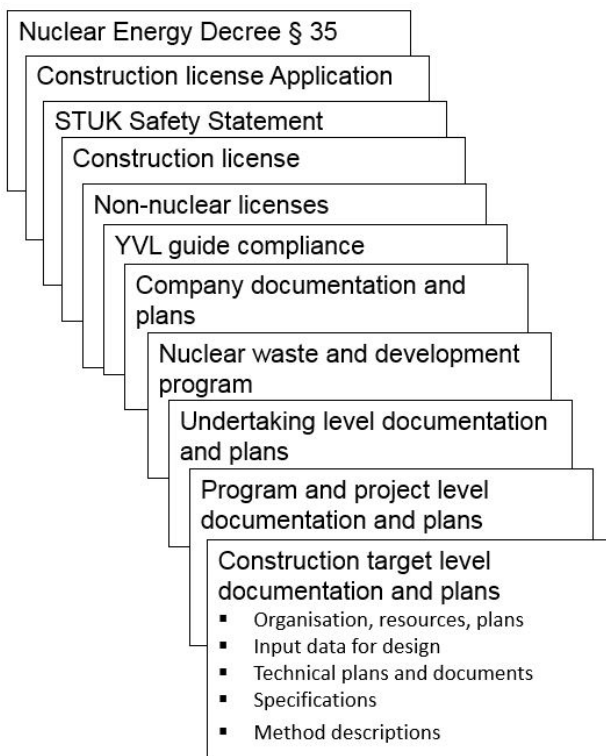


Figure 3-3. General structure of Posiva's preparedness program.

Programme milestones 2017–2023 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 are:

- Design and cost optimization phase (Q1/2017)
- Freezing of encapsulation plant lay-out; (Q2/2017)
- Readiness for full scale in-situ system test (FISST); (Q1/2018)
- Start of construction of encapsulation plant; (Q1/2019)
- Qualification of canister components; (Q4/2019)
- Qualification of manufacturing methods for backfilling materials, (Q1/2020)
- Submission of operating licence application; (Q4/2020)
- Excavation of final disposal tunnels 1-3 finished; (Q3/2021)
- Encapsulation plant ready for commissioning tests; (Q1/2023)
- Operation licence and start of nuclear operation (Q4/2023).

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 licence was granted by STUK and the construction licence was granted by the Government. According to the construction licence 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 licence.

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 more simple and 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 ongoing concept and cost optimization phase is focusing on design completion, closing open safety requirements, operation concept

modelling, and supply chains for the backfill and canister components.

Posiva is also 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. Every significant design or conceptual change will be reviewed and approved according to the graded approach by its significance to nuclear or long-term safety. Posiva's objective is to conclude this programme phase in late 2017 with the aim of being able to present a more reliable and detailed estimate of the total costs and of the overall disposal schedule to Posiva's owners for their next decision-making stage.

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,
- 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. Additional functionalities and the increased operational reliability of prototype machinery are being further developed. Plans for potential production schedules have been drawn up along with specifications for operational requirements with the maintenance requirements related to production schedules, and updates to the commissioning plan.

During the years preceding the Overall Commissioning Test without spent fuel (OCTw/o) the operational and maintenance procedures, systems, and machinery will be developed to achieve targeted operational schedules efficiently and will be commissioned. Moreover, activities to achieve organisational readiness for operations are in pro-

gress. It is scheduled that the final readiness will be demonstrated in the OCTw/o 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 operational licence 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 licence 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.

Project for operating licence application

The Finnish Government granted the construction licence to Posiva on November 2015. Since then Posiva has started a project which aims to achieve a granted operating licence so that the operation of the disposal facility would be able to start around the end of the year 2023. The project aims to submit the operating licence application (Nuclear Energy Decree, section 20) by the end of 2020. The current plan is to apply for a 30-year operating licence 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 2022. STUK will conduct a safety review of the operating licence application to be used as the basis for the Government’s decision on the licence application. The operating licence can be granted by the Government, if Posiva fulfils the requirements set out in the Nuclear Energy Act.

The operating licence project includes collecting the information that Chapter 5 of the Finnish Nuclear Energy Decree under “Licensing” requires to be submitted with the operating licence applica-

| Synthesis |
|---|
| Description of the overall methodology of analysis, bringing together all the lines of argument for safety, and the statement of confidence and the evaluation of compliance with long-term safety constraints |
| Design Basis (DB) |
| Safety functions, performance targets and design requirements, their basis and the links between them |
| Initial State (IS) |
| Initial state of the repository system and the present conditions of the surface environment |
| LILW Repository Assessment (LILW-RA) |
| Assessment of the long-term performance of the repository for LILW from the encapsulation plant and identification of interactions with the SNF repository |
| Performance Assessment and Formulation of Scenarios (PA-FOS) |
| Assessment of fulfilment of performance targets taking into account the expected and alternative climate and surface environment evolutions. Scenarios formulation based on uncertainties/deviations identified in the assessment |
| Models and Data (M&D) |
| Models and data used in the performance assessment and in the transport, release and dose calculations for the disposal system |
| Analysis of Releases (AOR) |
| Overview of the main results from the radionuclide release and transport modelling from the repository system to the surface environment and evaluation of radiological consequences |
| Complementary Considerations (CC) |
| Supporting evidence for safety including natural and anthropogenic analogues |

Figure L3-4. The present safety case portfolio (SNF, spent nuclear fuel; LILW, low and intermediate level waste).

tion 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” (22 November 2013) defines many of these, but also other regulatory guides include complementary requirements. Producing and or assembling all of 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 licence 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 licence application for STUK’s safety review.

Organizational activities

Posiva has established 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 to support and control the main programmes and projects under them. The previous organization has been adapted from a single line organization into a matrix format and from R&D into design and implementation. Furthermore, a dedicated project steering and follow-up group for project progress and resourcing control has been set up.

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 (RTO). 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.

L.4 Fennovoima’s nuclear waste management plans

Introduction

Fennovoima Oy plans to build the Hanhikivi 1 (FH1) nuclear power plant (NPP) to produce electricity for its owners at production cost price. Provided that a construction licence is granted by the Government, the plant will be built in Pyhäjoki in Northern Finland (Figure L4-1). The thermal power of the reactor unit will be 3220 MW and the



Figure L4-1. Hanhikivi 1 nuclear power plant will be built in Pyhäjoki in Northern Finland.

electrical power output will be 1 200 MW. On-site there will also be other nuclear facilities as stated in the Decision-in-Principle (2009, supplemented in 2014) required for the construction and operation of the power plant unit.

The unit's planned service life is 60 years (Figure L4-2). Fennovoima's nuclear power plant unit will be supplied by RAOS Project Oy (RAOS), which is a part of the Rosatom Group. The plant type will consist of a Rosatom AES-2006 pressurized water reactor.

Waste amount estimations

The waste inventory given in Table L4-1 is based on the estimates made by RAOS. The inventory is expected to be further elaborated when operation of the reactor unit FH1 starts.

In addition to the operational waste, the amount of decommissioning waste is estimated to be around 17.000 m³.

The estimated amount of spent fuel produced during 60 years' operation is expected to be around 1.200–1.800 tons, which according to Finnish legislation must be handled as waste and needs to be disposed of in Finland.

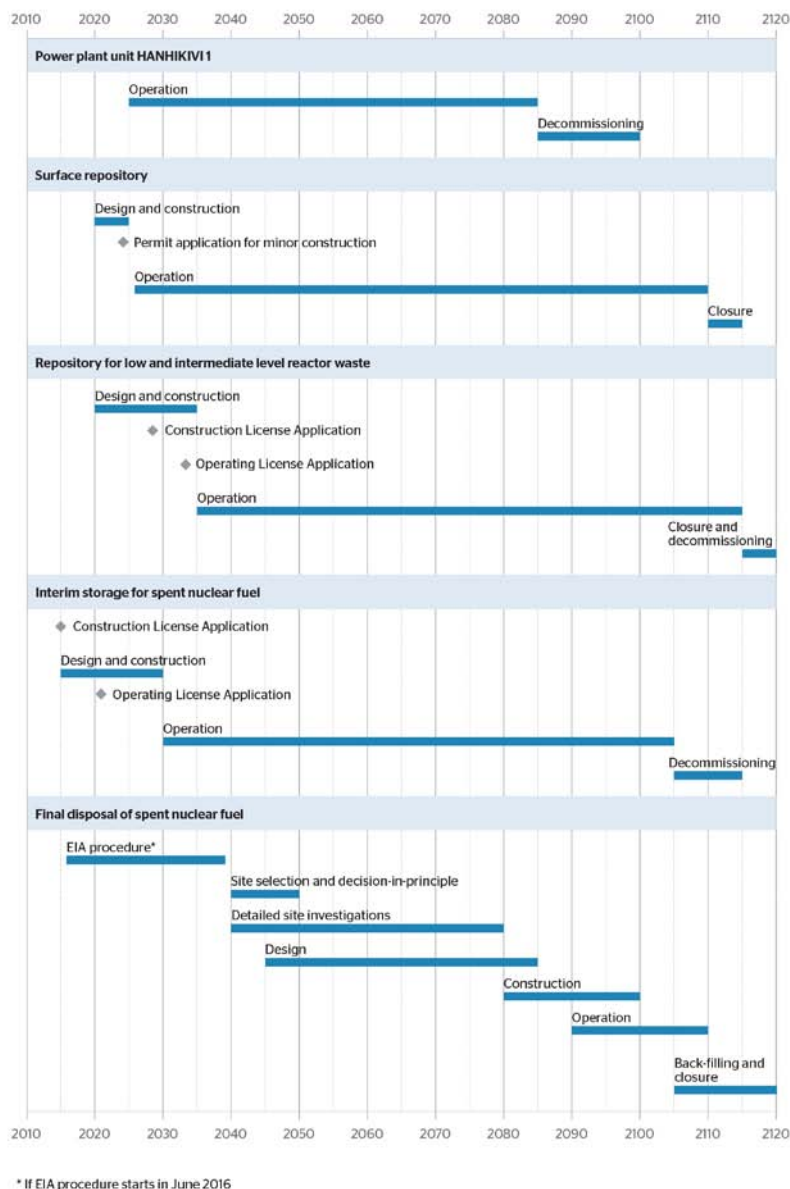


Figure 4-2. Overall nuclear waste management schedule of FH1.

Table L4-1. Estimated radioactive waste (packed for disposal) production from FH1 based on information provided by RAOS.

| | AES-2006 |
|------------------------------|-----------------------------|
| DRY WASTE | |
| Compactable | |
| VLLW | 4.9 m ³ /a |
| LLW | 8.4 m ³ /a |
| ILW | 4.0 m ³ /a |
| Non-compactable | |
| VLLW | 4.8 m ³ /a |
| LLW | 10.5 m ³ /a |
| ILW | 3.6 m ³ /a |
| Dry waste total: | 36 m³/a |
| WET WASTE¹ | |
| VLLW | – |
| LLW | 25.7 m ³ /a |
| ILW | 27.1 m ³ /a |
| Wet waste total: | 52.8 m³/a |
| ALL TOTAL: | 89 m³/a |
| TOTAL 60 a | 5 340 m³ |

1) Resins from the steam blowdown system (4 m³/a) are expected to be (conditionally) free-released.

Spent fuel management

Interim storage of spent fuel

Fennovoima applied for the construction licence for an interim spent fuel storage facility in June 2015 as part of the NPP construction licence application. Both dry cask storage and wet pool storage concepts were included as alternatives in the construction licence application. In summer 2016, Fennovoima chose a wet pool type storage solution for Hanhikivi 1. The differences between the dry and wet concepts in safety and economics were considered small thus making the comparison of the concepts very difficult. The decision was based on previous good experiences of operating pool storage facilities in Finland, as well as licensing challenges seen in the dry cask storage concept. Currently Fennovoima is preparing the technical description of the wet storage facility to be submitted to the nuclear safety authority in 2017.

Fennovoima's plan is to start the construction of the interim spent fuel storage facility around the time of the start of the commercial operation of the FH1 in 2024. The storage facility needs to be in operation about 7 years after the start of the com-

mercial operation of the nuclear power plant unit, thus giving Fennovoima plenty of time to construct the facility and to obtain an operating licence for it.

The interim storage is planned to operate until 2125, allowing the heat of the spent nuclear fuel to decrease to a sufficiently low level for its final disposal. The interim storage will be first constructed for the amount of spent nuclear fuel from 30 years of NPP operation. At least two extensions are planned for the storage facilities. In the first extension, the pool capacity will be increased to house spent fuel arising from 60 years of NPP operation. In the second extension, it is planned to make the storage independent from the FH1 reactor unit, thus enabling the immediate dismantling of the reactor unit after the commercial operation has ended in approximately 2085.

Spent fuel disposal

Spent nuclear fuel (around 1.200–1.800 tons during the sixty-year lifespan) from Fennovoima's nuclear power plant will be disposed in the Finnish crystalline bedrock. In disposal solutions based on the KBS-3 concept, the spent fuel will be inserted into copper canisters at an encapsulation plant, surrounded by bentonite clay, and placed in deposition holes drilled deep in the bedrock. The disposal schedule will be planned to allow the optimization of safety and the financial feasibility of the operations.

Fennovoima's primary objective has been to negotiate an agreement concerning the disposal of spent nuclear fuel with Posiva Oy's (responsible for the disposal of the spent nuclear fuel of its owners) owners, Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (Fortum). In its condition of the Decision-in-Principle granted in May, 2010 concerning the construction of Fennovoima's nuclear power plant and the amendment to the decision of 18 September 2014, the Government of Finland required Fennovoima to present the Ministry of Economic Affairs and Employment (MEAE) with either a co operation agreement with the current operators under a nuclear waste management obligation, i.e. TVO and Fortum, or an environmental impact assessment program (EIA programme) for its own disposal facility for spent nuclear fuel.

Fennovoima started co-operation with Posiva Oy by signing an agreement with Posiva Solutions

Oy, Posiva's subsidiary that focuses on supplying services, at the end of June 2016. The co-operation started in autumn 2016 and it concerns research and development activities, and the objective is to support Fennovoima to achieve readiness for submitting its own application for a Decision-in-Principle concerning the disposal of spent nuclear fuel. The co-operation agreement has been made for the next ten years. At the same time, Fennovoima submitted an environmental impact assessment programme (EIA program) to the MEAE. The programme suggests Eurajoki and Pyhäjoki as alternative locations for the spent fuel encapsulation plant and disposal facility. Eurajoki by the Gulf of Bothnia (Figure L4-1) is the municipality, where Posiva Oy's disposal facility is being constructed. On July 12, 2016, the Ministry considered that the assessment programme fulfilled the condition in the Decision-in-Principle and resumed processing the NPP construction licence application.

According to the current estimate, the disposal operations will begin no earlier than in the 2090s. The disposal of spent nuclear fuel from the Hanhikivi 1 nuclear power plant unit will be completed in the early 2100s, after which the disposal facility will be permanently closed. Fennovoima may carry out the disposal of spent nuclear fuel in co-operation with the parties currently under the nuclear waste management obligations, or independently by constructing its own final disposal facility, or as a combination of these two alternatives. The disposal schedule presented above shall be further specified after the disposal solution is established in more detail.

Operational waste management

Waste classification

The main waste management objective is to minimize the waste volume, while trying to keep the volumetric activity concentration of the waste as low as reasonably achievable. For this purpose, adequate waste sorting will already be organized at the point of waste generation.

The operational waste is divided into four categories based on its radioactivity concentration. These categories are: 1) Intermediate-level waste, 2) Low-level waste, 3) Very low-level waste, and 4) exempt waste. The activity limits for the categories are defined in the STUKguide (Regulatory Guide

YVL D.4) and STUK Regulation (STUK Y/4/2016). In addition to the radiological characterization, the chemical form must be taken into account in waste sorting and packing.

Solid waste management

According to the plans, the solid nuclear waste management process already starts before material is brought to the NPP, by limiting certain materials from ending up in the nuclear waste, based on the possible harmful long-term safety effects caused by these materials.

The second stage is to carry out preliminary waste sorting at the waste generation location. Due to limitations in the measuring equipment, as well as available expertise, this will be very crude initial sorting. The actual sorting by activity will be done in the waste management building, where the packed waste will be cut and compacted to minimize the waste volume and will be characterized based on its activity. For the activity measurements, certain special arrangements will be made to minimize the disturbance due to background radiation, thus increasing the measurement accuracy.

Liquid waste management

Liquid radioactive waste generated in various processes in the NPP will first be condensed by using filtering, ion exchange and evaporators. At the point when further condensing is no longer practical, the liquid as well as the filtering media will be solidified into a concrete matrix. The solidification plant will be in the NPP; thus, no transportation will be required for the liquid waste. Before solidification, the liquid waste can be aged in tanks for 1–2 years depending on the radiological properties of the waste.

The solidification process will be planned to take into account the chemical properties of the waste as well as the radiological classification. Based on worker radiation protection the surface dose rate will be limited to 2 mSv/h during the transportation.

Waste clearance

Fennovoima is planning to use waste clearance as defined in YVL D.4 as much as practical. Due to municipal waste management limitations, there might be some non-radiological limiting factors

(e.g. bans on landfill disposal of burnable waste) making the clearance financially unfeasible and technically difficult.

Low and intermediate level waste disposal

Predisposal storage

Before disposal the LILW will be stored in the NPP. The NPP will have storage facilities for 10 years of waste production. The storage space will have 20% additional capacity for unseen waste generation.

Near surface repository

The introduction of the VLLW waste category has made it possible to use a near surface repository. VLLW is waste that has an average activity lower than 0.1 MBq/kg (Nuclear Energy Decree), and can be handled without special radiation protection equipment. The near surface repository will be constructed during the first years of NPP operations, and it will be used throughout lifetime of the NPP. Decommissioning waste with activity less than 0.1 MBq/kg will be deposited in the same near surface repository as the operational VLLW. The total activity of the planned disposal amount is less than 1 TBq. The disposed waste will be isolated from the environment by preventing water reaching the waste with dense ground constructions and protective layers. Possible leakage waters will be collected and monitored.

LILW disposal facility

A low and intermediate level waste repository will be built at an intermediate depth in the bedrock (around a hundred meters deep) for operational and decommissioning waste. The LILW-disposal

facility is likely to be excavated around 2030, as it will need to be in operation for about ten years after the start of the NPP's commercial production. Additional disposal tunnels and other spaces required for decommissioning waste will be excavated later, in approximately the 2070s. As shown in Figure L4-3, the grey areas are preliminary reservations for the decommissioning waste. As the total activity of the planned disposed waste exceeds 1 TBq, the intermediate depth disposal site is considered a large-scale waste disposal facility. Thus, it is a separate nuclear facility, requiring its own construction and operating licence. In the bedrock disposal facility, the waste packaging, as well as the concrete injected between waste packages and the bedrock will isolate the waste from the environment. If needed, (mainly for ILW) steel reinforced concrete lining and waterproof elements, such as bentonite clay, can be used to ensure safe long-term waste disposal.

Decommissioning plan

The decommissioning has been taken into account in the plant design. A preliminary decommissioning plan has already been prepared and submitted to STUK for approval. For the operating licence application, the decommissioning plan will be updated and it will be made more detailed. During the operational phase, the decommissioning plan will be updated every six years, making it more detailed in every round.

L5 Decommissioning of the Finland's first nuclear reactor FiR1

VTT Technical Research Centre of Finland Ltd. shut down the Finnish Reactor 1 (FiR 1) in Otaniemi, Espoo, in June 2015 and started preparations for its decommissioning. FiR 1 is an open-tank Triga Mk II type reactor of 250 kW nominal thermal power. General Atomics (US) has supplied more than 60 of this type of reactors to institutions around the world.

Licensing and funding for decommissioning

FiR 1 is the first nuclear reactor to be decommissioned in Finland. VTT has submitted an application to the Government in June 20, 2017 to receive a licence for decommissioning (formally a new operating licence as the present Finnish legislation does not separately define a decommission-

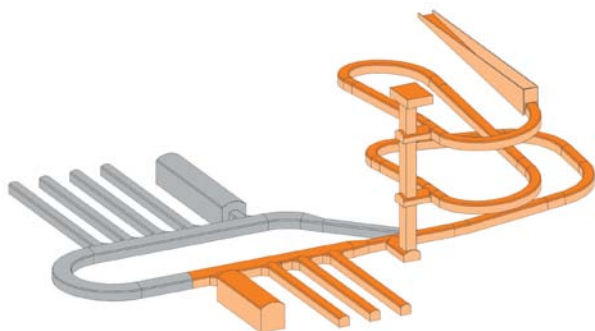


Figure 4-3. Bedrock repository for LLW and ILW with reservation for decommissioning waste (grey).

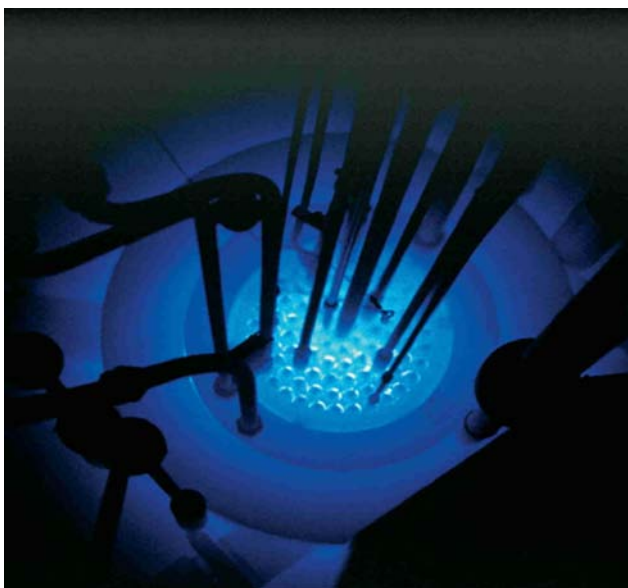


Figure L5-1. The core of FiR 1 in operation.

ing licence). To cover the costs, there is a deposit of approximately EUR 12 million in the Finnish Nuclear Waste Management Fund for the decommissioning and waste management of FiR 1. The fund reimburses costs gradually to the licensees according to the completion of their decommissioning duties.

Dismantling of the reactor

The dismantling of the reactor can commence once the spent nuclear fuel has been removed from the reactor core. In 2017, VTT (supported by a number of contractors) completed a detailed dismantling plan and work instructions, including waste handling and packaging in compliance with the requirements for transport and interim storage. Additionally, the dismantling work will be carried out by external contractors, under VTT's supervision. Dismantling the reactor is estimated to take 1–2 years, including decontamination and release of the facility. The building can then be used for some other purpose.

Nuclear waste management

Inventory estimates

has completed detailed activity inventory calculations and will complement them by taking samples before and during the dismantling operation. The estimated volumes and total radioactivity of the spent fuel and the waste generated by the decommissioning process are relatively small (estimates for spent fuel ~100 TBq / 15 kgU; for dismantling waste ~ a few TBq / less than 100 m³).



Figure L5-2. Plant engineer in the control room of the reactor during the last day of operation in June 2015.

Spent fuel

The fuel is subject to the return programme of the US DOE running until May 2019. The primary scenario for the management of the nuclear fuel is to send it back to its country of origin, specifically to Idaho National Laboratory in the USA, where batches of nuclear fuel from TRIGA research reactors have previously been returned from various countries. Presently the programme has however halted, as Idaho State has stopped all nuclear waste transports to Idaho National Laboratory (INL) due to breaches of the Idaho Settlement Agreement. VTT considers return to US as the primary option for the spent fuel, and is preparing licensing and contracts required for fuel's return and transport while waiting for the issue to be resolved. The secondary option would be disposal in Finland. However, this would require special additional licensing for the encapsulation and spent fuel disposal facilities currently under construction in Olkiluoto.

Low-level and intermediate-level nuclear waste resulting from the decommissioning project

The operating and dismantling waste will consist of low-level and intermediate-level nuclear waste.

The disposal of the waste will be negotiated with existing LILW disposal facility licensees and the disposal needs to be coordinated with the decommissioning and waste disposal schedules of the nuclear power plants. This means that the waste will be placed in an interim storage facility for a period of nearly 20 years. The interim storage and disposal can be arranged in co-operation with nuclear power utilities in Finland.

There are a few materials in FiR 1 (graphite, aluminium and the FludentTM moderator material) that require specific attention. The waste generated by dismantling the Finnish nuclear power plants contains no reactor graphite and only a small amount of aluminium. VTT has conducted a literature survey on the chemical behavior of irradiated graphite and aluminium, and their impact on the long-term safety of existing repositories. VTT has also studied international practices for the disposal of graphite.

The later stages of the disposal process will depend on decision by the nuclear power companies on whether to extend the current intermediate-level waste repositories, and on the decommissioning schedule of the nuclear power plants, and on the disposal of the resulting dismantling waste.

L.6 List of spent fuel storages and inventory of spent fuel

Loviisa NPP

| <i>Storage</i> | <i>Inventory (end of 2016)/ storage capacity</i> | |
|---|--|------------------------|
| | <i>Mass¹ (tHM)</i> | <i>Fuel assemblies</i> |
| Pool storage in Loviisa 1 reactor building | 17.8/57 | 148/481 |
| Pool storage in Loviisa 2 reactor building | 23.0/58 | 191/485 |
| Basket type pool storage at the NPP | 57.7/57 | 480/480 |
| Rack type pool storage at the NPP | 523.1/635 | 4348/5286 |
| Total inventory/storage capacity (gross) | 621/809 | 5167/6732 |
| Total effective ² storage capacity | 673 | 5601 |

Olkiluoto NPP

| <i>Storage</i> | <i>Inventory (end of 2016)/ storage capacity</i> | |
|---|--|------------------------|
| | <i>Mass¹ (tHM)</i> | <i>Fuel assemblies</i> |
| Pool storage in Olkiluoto 1 reactor building | 86.2/260 | 540/1520 |
| Pool storage in Olkiluoto 2 reactor building | 89.7/266 | 546/1560 |
| Separate storage facility at the NPP site | 1302.0/1666 | 7663/9756 |
| Total inventory/storage capacity (gross) | 1477.9/2192 | 8749/12836 |
| Total effective ¹ storage capacity | 2021 | 11836 |

FiR1 research reactor

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|-----------------|--------------------------------|----------------------|
| | <i>Mass (kgU)</i> | <i>Fuel elements</i> |
| Wet storage | 2.04 | 11 |
| Dry storage | 2.41 | 13 |
| Total inventory | 4.45 | 24 |

1 tHM means that the spent fuel inventory is presented in tonnes of heavy metals.

2 In the effective capacity the reserve capacity for exceptional unloading of the entire reactor core to storage pool, for storage pool repairs and space for dummy elements are excluded (cf. Table 1 in Section D).

L.7 List of radioactive waste management facilities and inventory of radioactive waste

Loviisa NPP

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|--|--------------------------------|--|
| | <i>Volume (m³)</i> | <i>Activity (TBq)</i> |
| Buffer storage rooms inside the NPP | 218.8 | <1 |
| On-site storages for operational waste | 108.8 | low for LLW 0.9 TBq for solidified resins |
| Tank storage for wet LILW | 1408 | 15.4 |
| Dry silos for ILW | 43.5 | high (not measured) |

Olkiluoto NPP

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|--|--------------------------------|-----------------------|
| | <i>Volume (m³)</i> | <i>Activity (TBq)</i> |
| Buffer storage rooms inside the NPP | 190 | 16.6 |
| On-site storages for operational waste | 49.3 | 0.09 |
| Pool storage for activated metal waste | 53 | high |
| Spent oil candidate for clearance | 16 | low |
| Interim storage for state owned waste | 35.2 (in on site storage) | not measured |

FiR 1 research reactor

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|--|--------------------------------|-----------------------|
| | <i>Volume (m³)</i> | <i>Activity (TBq)</i> |
| Waste storage in the laboratory building | 6 | 0.001 |

Storage of non-nuclear radioactive waste

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|---|--------------------------------|-----------------------|
| | <i>Volume (m³)</i> | <i>Activity (TBq)</i> |
| Roihupelto, Storage room in STUK's building | 2 | 3.8 |

Storage of non-nuclear radioactive waste

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|---|---|--|
| | <i>Volume</i> | |
| Roihupelto, Storage room in STUK's building | HEU 0.8 g LEU: 536 g UNat: 574 g DU: 369 kg Th: 199 g | |

Storage for state owned waste

| <i>Storage</i> | <i>Inventory (end of 2016)</i> | |
|---|--------------------------------|-----------------------|
| | <i>Volume (m³)</i> | <i>Activity (TBq)</i> |
| In on-site storage (KAJ-storage Olkiluoto) | 35.2 m ³ | Not measured |
| Disposed in the Olkiluoto disposal facility | 20.8 m ³ | Not measured |

L.8 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 at FiR1 research reactor. Construction Licence 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 built their own. |
| Nuclear fuel cycle wastes | Disposal of LILW in intermediate depth bedrock (Loviisa & Olkiluoto) | | Operating LILW disposal facilities at 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 authorised 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 licence phase | | Decommissioning of FiR research reactor is in a licensing phase. | Decommissioning of FiR 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. |