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

5th Finnish National Report as referred to in Article 32 of the Convention

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

STUK

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5th Finnish National Report as referred to in Article 32 of the Convention

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

# Executive summary

This is the Finnish National Report, in accordance with the provisions of Article 32 of the Joint Convention, for the Fifth Review Meeting of the Contracting Parties in May 2015. The fulfilment of the obligations of the Convention and the developments of waste management after the Fourth Review Meeting, during the reporting period 2011–2013, are assessed in this report. It presents the recent developments and describes the waste management facilities and practices in Finland, to be reviewed and discussed by the contracting parties.

As spent nuclear fuel is defined in the Finnish legislation as radioactive waste, the nuclear power plants at Loviisa and Olkiluoto are the main generators of radioactive waste. Fortum Power and Heat Oy operates two VVER units at the Loviisa site and Teollisuuden Voima Oyj two BWR units at Olkiluoto. The Loviisa units 1 and 2 were commissioned in 1977 and 1981, and the Olkiluoto units 1 and 2 in 1978 and 1980, respectively. In addition, a new nuclear power plant unit is being constructed at the Olkiluoto site. As to the future, the Decision-in-Principle, the first step in the licensing process, was made by the Government for two new reactors in 2010, one for Teollisuuden Voima Oyj at the Olkiluoto site and one for Fennovoima Oy, for which Pyhäjoki was chosen as the site in 2011. At the Olkiluoto and Loviisa sites there are interim storages for spent fuel as well as repositories for low and intermediate level radioactive wastes. Furthermore, a Triga Mark II research reactor is operated in Espoo by VTT Technical Research Centre of Finland. However, in 2012 VTT decided to start planning of the decommissioning and eventual shut-down of the research reactor, due to economical reasons.

The four Finnish NPP units operated during the reporting period safely with high capacity factors and generated spent fuel accordingly. The generation of low and intermediate level radioactive waste was kept low. Activities and programmes related to waste management continued in accordance with the national strategy, milestones and timetable. The licensees and Posiva Oy, the spent fuel disposal implementer, showed good safety performance and safety management practices in carrying out their responsibilities in spent fuel and radioactive waste management.

The main focus of activities during the reporting period was the spent nuclear fuel disposal project. The construction licence application including the safety documentation for the spent nuclear fuel encapsulation and disposal facilities was submitted to the authorities at the end of 2012. Posiva Oy is aiming to start disposal operations around 2022. During the reporting period, the highlights in Finland were as follows:

### Spent nuclear fuel disposal project progressed as planned

- The disposal project reached the construction licence application stage. At the end of 2012 Posiva submitted the construction licence application and its supporting safety documentation to the authorities. MEE started the licensing process and STUK the safety review and assessment in the beginning of 2013. The preparation of the application has required an extensive effort, from both the regulator and the implementer, in research, technical development and competence development of organisations. The safety review and assessment is currently going on and some preliminary results are elaborated in this report. The licence application review and STUK's regulatory approach are described in Annex L.1. Posiva's programme for spent fuel disposal is presented in Annex L.2.
- The construction of the underground rock characterization facility, ONKALO, which started in July 2004, progressed to disposal depth. Most of the excavation work was completed by early 2013. The access tunnel reached the length (chainage) of 4987 m and the depth of 455 m. The main characterisation level is located at the depth of 420 m, but some of the auxiliary rooms are deeper down at the depth of 437 m. Regulatory control procedures for ONKALO were established during the previous reporting period and continued to be implemented with the depth and detail that would allow the use of the facility as a part of the disposal facility. The procedures are described in Annex L.1.

### Progress was made in spent fuel management

- In the Loviisa NPP spent fuel storage, the installation of dense fuel racks was started in 2007 and is continuing. The allowable total amount of spent fuel, according to the renewed operating licence issued in 2007, with additional high density racks, is evaluated by FPH as adequate up to the end of the planned 50 years of operational life of the NPP.
- At the Olkiluoto plant TVO started the construction work for enlarging the interim storage in autumn 2010 and construction and installation work was completed in early 2014. The extension is carried out according to the updated safety requirements which require among other things that the design has to withstand a large airplane impact. The extension is scheduled to be commissioned during 2014.
- The safety of the spent fuel storages (at both the Loviisa and the Olkiluoto site) was analyzed as part of the EU stress tests in relation to the Fukushima accident, and the results were reported within the Convention on Nuclear Safety.
- Spent fuel of the research reactor FiR 1 is stored on site. VTT has decided to decommission FiR 1 due to insufficient funding for continued operation. VTT will prepare the EIA report during 2014 and after that VTT can apply for a licence amendment for the research reactor decommissioning. The first option for spent fuel management is to return the fuel to the United States as defined in the current contract. The second option is interim storage and later disposal to the Olkiluoto spent fuel disposal facility, which would require a new licensing process for the disposal facility.

### Management of LILW from nuclear facilities was improved

- Improved facilities for LILW operations at the Loviisa NPP were commissioned in 2010. The LILW repository was enlarged with a new room for waste handling and a tunnel facilitating disposal operations.
- A modified licence to operate the Olkiluoto LILW repository, granted in 2012, allows the disposal of Olkiluoto 3 low and intermediate level operational waste as well as most of the radioactive waste that the government is responsible to take care of. The application contained an updated safety assessment of the facility.
- During the reporting period, no spent fuel or radioactive waste incidents in the Finnish NPPs were reported.

### The regulatory system was strengthened

STUK continued to increase its resources and activities in response to the expanding operations of Posiva in preparing and implementing the review of the disposal facility (encapsulation facility and repository) construction licence application.

- The Finnish nuclear and radiation safety legislation and regulatory guidance were developed further. Legally binding EU directives as well as international guidance, such as IAEA safety standards and WENRA recommendations were taken into account in this work.
  - The Nuclear Energy Act was revised and amended in 2011 (Council Directive 2009/71/Euratom), in 2012 (inspection organizations included), and in 2013 (Council Directive 2011/70/Euratom).
  - The Radiation Act and Decree were revised in 2013 (Council Directive 2011/70/Euratom and for conformance with the European Community Radiation Protection Legislation).
  - The Council Directive 2013/39/Euratom of 5 December 2013 will be implemented into the Finnish legislation during the next four years.
  - Detailed safety requirements on the management of spent nuclear fuel and radioactive waste resulting from the production of nuclear energy are provided in STUK's regulatory guides, the YVL Guides. After amending the nuclear energy legislation in 2008, also the revision of the existing YVL guide system was commenced. Forty new YVL guides were issued on December first 2013.
  - Detailed safety requirements on the management of radioactive waste, subject to the Radiation Act, are provided in STUK's ST Guides. They have been updated in accordance with the changes in the respective legislation.
- 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 need to be considered for the legislation mainly concerning the independence of STUK. The amendments to the Nuclear Energy Act and the Radiation Act were under preparation in 2013. The follow-up IRRS review is in June 2015.

### Technical support and competence were developed

- VTT Technical Research Centre of Finland continued to support effectively the regulatory body in safety assessment work, providing safety analysis capabilities and tools e.g. via the regulatory research programmes, and performing reviews of safety analyses. In addition, several international experts have supported STUK's review work of spent fuel encapsulation and disposal safety during pre-licence phase and in construction licence review.
- Competence management, especially taking into account the retirement of large post-war age groups, is a concern also in Finland. During 2010–2012, the Ministry of Employment and the Economy set up a committee to report on the availability of competence and resources in the nuclear energy sector. STUK was a participant in the committee. One of the recommendations was that the future needs and focus areas of the Finnish nuclear energy sector research must be accurately defined and a long-term strategy drawn up for research activities. One of the conclusions was also that there is a challenge in maintaining continuity of knowledge and also in attracting new competent personnel. Investments in research and the availability of high-standard education and training are crucial. At the end of January 2013 the Ministry of Employment and the Economy set up a working group to prepare a research and development strategy (see Article 22).
- International cooperation and transparency belong to the cornerstones of the development of the national solutions for spent fuel and waste safety in Finland. In addition to active participation in international and bilateral forums (IAEA, EU, WENRA, OECD/NEA), foreign consultants continued to participate both in regulatory reviews and Posiva's development work.

## Challenges for future work

- The main challenges are related to the spent fuel disposal project. Finalizing the construction licence application review for the Olkiluoto spent fuel encapsulation and disposal facility is a challenging task, as are both for Posiva and STUK the planning and preparation for the construction and for the commissioning phase. Posiva and STUK invest in their processes and resources to ensure that all safety related regulatory and implementation tasks can be performed with high quality and without undue delay.
- The planned Olkiluoto disposal facility currently covers spent fuel from the four reactors in operation, from the one under construction (Olkiluoto 3) and from the one under planning (Olkiluoto 4). As Fennovoima Oy is not an owner of Posiva, the plans of Posiva do not cover disposal of spent fuel from Fennovoima's future NPP unit. According to the Decision-in-Principle Fennovoima must supplement its plan for the disposal of spent nuclear fuel by 2016 by submitting to the Ministry of Employment and the Economy either an agreement with Posiva's owners, i.e. TVO and FPH, on nuclear waste management in cooperation with Posiva as outlined in the application for a Decision-in-Principle, or an environmental impact assessment programme for a spent fuel disposal facility of its own.
- LILW generated from the operation of the research reactor FiR 1 is stored at the reactor facility until decommissioning. VTT is negotiating with the Finnish NPP licensees (TVO and FPH) for possible interim storage and future disposal of decommissioning waste. The dismantling of the reactor is planned to start in late 2015 and to last about two years.
- The European Commission promotes worldwide co-operation to further develop nuclear, radiation and waste safety through its INSC program and its predecessors. Finland has been and will be a supporter of this European development and involvement. The insufficiency of competent personnel for this work may adversely affect the co-operation.
- Communication will become an increasingly important success factor for STUK, Posiva, and the power companies. The interest in radiation and nuclear safety topics will continue to increase. The media, including the social media, plays an important role in communication.
- While most radioactive waste streams have a disposal solution, a small quantity of the small user waste – consisting of nuclear material and a few high activity sources – cannot be disposed of in the Olkiluoto LILW disposal facility due to inventory restrictions. An alternative disposal route for these wastes is currently being negotiated.

## From the 4th Review Meeting

The 4th Review Meeting in 2012 identified challenges and items for follow-up, and recorded some planned measures to improve safety of nuclear waste management in Finland. On request of the Review Meeting these issues are included and responded in this 5th National Report of Finland. The issues are listed here, with the related Articles given in brackets.

## Finland – Challenges

- Maintain timely progress of SNF disposal project. (Articles 13–15, Annexes L.1 and L.2)
- New NPP (Fennovoima): further define plans for disposal of spent nuclear fuel, by 2016 (Article 32)
- Human resources (Regulator & Operators) (Article 20, Article 22, Section K):
  - High rate of retirement
  - Simultaneous implementation: SNF project + new NPPs
  - Maintaining know-how and human resources in a changing funding environment

- Communication is an increasing success factor (Article 20)
- Safety related improvements as a response to the Fukushima accident (BDB accidents) (Article 32, Article 19, Section K)

### Finland – Planned Measures to Improve Safety

- Extension and upgrade (Article 32, Section K):
  - Loviisa LILW repository
  - Loviisa & Olkiluoto spent fuel storage
- ONKALO underground laboratory completed in 2012 (Annex L.2)
- IAEA Peer Review (IRRS) planned for 2012 (Article 19, Article 20, Section K)
- Enhanced safety features and expansion of Olkiluoto SF storage facility to be completed by 2014 (Article 32)
- Extraction of Uranium from waste solutions at Ni and Zn mining company (Section A, Article 12, Section K)
- Recruitment, education & training: to take into account retirements (Article 20, Article 22, Section K)

### 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 are recognized, regularly reviewed and addressed. The required effort for continuous improvement is made.

# Contents



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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 |
| 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 (company for spent fuel disposal) |
| 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 |
| 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.

# SECTION A 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 in 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 Finnish National Report for the Fifth Review Meeting in May 2015.

The fulfilment of the obligations of the Convention and the developments after the fourth Review Meeting during 2011–2013 are assessed in this report. The self-assessment is mainly based on the Finnish legislation and regulations, on the status of existing and projected spent fuel as well as other nuclear and radioactive waste management facilities, and on the activities to develop and improve operational and long-term safety of the facilities. The plans for the decommissioning of nuclear facilities and the regulation and management of radioactive waste generated outside the nuclear fuel cycle are discussed as appropriate.

The main regulations in the field of spent nuclear fuel management as well as nuclear and other radioactive waste management are the Nuclear Energy Act and Decree, the Radiation Act and Decree, the Government Decrees on nuclear safety and on the safety of disposal of nuclear waste and the regulatory guides (YVL Guides and ST Guides) issued by the Radiation and Nuclear Safety Authority (STUK). The most essential safety regulations are listed in Annex L.5.

Chapter 2a of the Nuclear Energy Act gives general nuclear safety and security principles, including some principles to be followed in nuclear waste management. Nuclear waste shall be managed so that after the disposal of the waste no radiation exposure is caused which would exceed the level considered acceptable at the time the disposal is implemented. The disposal of nuclear waste in a manner intended as permanent shall be planned giving priority to safety and so that ensuring long-term safety does not require surveillance of the disposal site.

The Nuclear Energy Act (Section 5) requires that the use of nuclear energy, taking into account its various impacts, has to be in line with the overall good of the society. It provides (Section 6) that the use of nuclear energy must be safe; it shall not cause harmful effects to humans or damage to the environment or property. Section 7 further requires that sufficient physical protection and emergency planning as well as other arrangements for limiting nuclear damage and for protecting nuclear energy against illegal activities shall be the prerequisite for the use of nuclear energy.

The Radiation Act (Section 2) provides that the benefits accruing from the use of radiation and practices involving exposure to radiation shall exceed the detriment it causes; that the practice shall be organized in such a way that the resulting exposure to radiation hazardous to health is kept as low as reasonably achievable and that no person's exposure shall exceed the maximum values prescribed in the Radiation Decree.

These general safety principles, included in the Nuclear Energy Act and the Radiation Act, apply to the management of spent nuclear fuel and of other nuclear waste arising from the use of nuclear energy and the associated nuclear fuel cycle. Radioactive waste produced in other activities is regulated solely by the Radiation Act.

Finland is a member state of the European Union and thus EU legislation is in force in Finland. EU decrees are directly applicable as such whereas EU directives have been implemented by national legislation. The most important EU legislation related to the management of spent fuel and radioactive waste is the Council Directive 2011/70/ Euratom (Nuclear Waste Directive).

There are two nuclear power plants operating in Finland: the Loviisa and the 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). In addition, a third PWR (pressurized water reactor) unit is under construction at the Olkiluoto site.

In 2010, the Finnish Parliament endorsed the Government's Decision-in-Principle (DiP) to build two more NPP units, one by TVO at the Olkiluoto site and the other by Fennovoima Oy at a new site, Pyhäjoki (Figure 1). In 2013 Fennovoima Oy submitted a new EIA programme since the chosen reactor type for the Pyhäjoki plant does not correspond the reactor type given in the DiP. The updated EIA report was completed in February 2014. The EIA report considers nuclear waste management as a whole and describes the progress made since 2008.

Both NPPs in operation have storage facilities for fresh and spent nuclear fuel and facilities for treatment and storage of low and intermediate level radioactive waste (LILW). The disposal facility for LILW was taken into operation at the Olkiluoto site in 1992 and for LLW at the Loviisa site in 1998. The Loviisa NPP has continued the commissioning of the liquid waste (ILW) solidification facility. Due to modifications needed in plant equipment the project schedule has been updated. The disposal facility for the solidified liquid waste is under commissioning. According to the licensee's plan the commissioning will be completed in 2015.

All spent fuel generated at the Olkiluoto plant is stored on-site. Previously the spent fuel of the Loviisa plant was transported to the Mayak facilities in the Russian Federation, after interim storage of a few years. An amendment to the Nuclear Energy Act was passed in 1994, stating that spent fuel and all other nuclear wastes generated by the Finnish NPPs have to be treated, stored and disposed of in Finland. Spent fuel shipments to Russia were terminated at the end of 1996, and since then the spent fuel generated at the Loviisa plant has been stored at the plant site. In 1995, a joint waste management company Posiva Oy was established by FPH and TVO for taking care of the disposal of the spent fuel of the nuclear power plants they operate.

The Finnish fuel cycle policy is based on the once-through option. In 1999 Posiva proposed, in a Decision-in-Principle (DiP) application, to site a

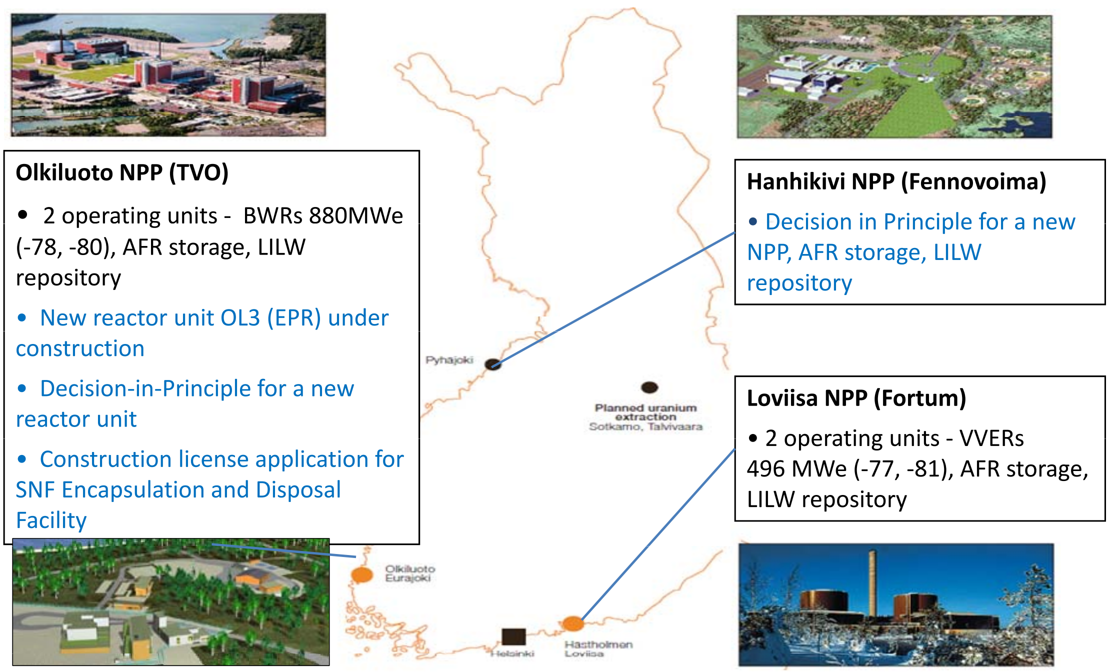



**Figure 1.** The nuclear power plants in Finland.

disposal facility for spent nuclear fuel (Figure 2) at Olkiluoto in Eurajoki, a couple of kilometres from the Olkiluoto NPP. This application was reviewed and approved from safety viewpoint by STUK and approved by the municipality of Eurajoki in January 2000. The Finnish Government made the DiP in December 2000 and the Parliament endorsed it in May 2001.

Later, the Parliament has ratified two Decisions-in-Principle on the extension of the disposal facility to provide capacity for the spent fuel from the new NPP units at Olkiluoto. The first ratification took place in 2002 and it concerned the Olkiluoto 3 unit, and the second one concerning the Olkiluoto 4 unit was made in 2010. Fennovoima Oy is not a co-owner of Posiva and consequently the extension plans do not cover spent fuel from Fennovoima Oy's future NPP unit.

According to the Decision-in-Principle Fennovoima Oy must amend its plan for the disposal of spent nuclear fuel by the end of June 2016 by submitting to the Ministry of Employment and the Economy either an agreement on nuclear waste management cooperation as outlined in the application for a Decision-in Principle, or an environmental impact assessment programme for a spent fuel disposal facility operated by Fennovoima Oy itself. In March 2012 the MEE appointed a committee to explore the disposal possibilities in view of a national solution by the end of year. The key recommendation was that the most expedient and cost-efficient method is to aim for an optimised solution in disposal, making use of the competence and experience accumulated during Posiva's project.

The DiP of 2001 authorized Posiva to construct a rock characterization facility "ONKALO" down to the actual disposal depth. ONKALO is intended to be used as part of the repository and it is constructed under pertinent regulatory control. The application for the construction licence for the main parts of the repository and for the spent fuel encapsulation plant was submitted to the authorities at the end of 2012. The safety review and assessment is currently going on and some preliminary results are elaborated in this report. The Government decision of the Construction Licence is expected in early 2015.

A research reactor FiR 1 (TRIGA Mark II, 250 kW) has been operated by VTT Technical Research Centre of Finland in Espoo and it has been in use since 1962. In 2012, VTT decided to

**Figure 2.** The access tunnel to the disposal facility of spent fuel under construction at Olkiluoto (POSIVA).

shut it down and therefore the environmental impact assessment (EIA) process for the decommissioning was started in 2013 and the EIA programme was submitted to the contact authority (MEE) at the end of 2013. The EIA report is planned to be completed by the end of 2014. VTT also has radiochemical laboratories and a hot-cell for studies of pressure vessel materials and other radioactive materials. In addition, radiochemical and particle accelerator laboratories are located at the universities of Helsinki, Turku and Jyväskylä.

In 2010, Talvivaara Sotkamo Oy submitted an application for the recovery of uranium with a volume of around 350–500 tonnes per year as a by-product in nickel and zinc mining. The Government made a positive decision in 2012. It was appealed to the Supreme Administrative Court which overruled the decision in 2013. The application will be reassessed when the Government has updated information on the company's financial situation. During the production processes uranium follows the other metals. Since uranium has not yet been recovered, it ends up in the gypsum waste water pond. In 2012, water from a gypsum waste water pond began to leak into the environment at the Talvivaara mine site after the bottom of a pond gave way. The leaking waste water caused uranium contamination to the surroundings. This is described in more detail in Chapter H.12., as well as some past practices and disposal of waste due to accidental melting of radioactive sources in the Outokumpu Stainless Oy's steel foundry in Tornio, Finland, 2010.

### Structure of Report

This report has been structured in accordance with the Guidelines Regarding the Form and Structure of National Reports (INFCIRC 604/Rev 2). Emphasis has been put on Section K to reflect the revision of INFCIRC 604/Rev 3 (updated in May 2014). This 5th National Report is aimed to be a stand-alone document and does not require familiarity with the earlier reports. The fulfilment of the obligations of the Convention and the latest development during 2011–2013 are described in the following chapters. In Section B and Annex L.8, policies and practices of waste management in Finland are summarised as stipulated in Article 32, paragraph 1. In section C, the scope of application, taking into account the Finnish circumstances is explained, as stipulated in Article 3. Section D provides information on spent fuel and waste management facilities in Finland and on the inventories of spent fuel and radioactive waste, as stipulated in Article 32, paragraph 2. The implementation of each of the Articles from 4 to 28 of the Convention is separately evaluated in Sections E to J. Section K summarises general efforts to improve safety. Section L contains the annexes:

- Regulatory approach to the Olkiluoto spent fuel disposal project (L.1),
- Programme for spent fuel disposal (L.2),
- List of spent fuel storages and inventory of spent fuel (L.3),
- List of radioactive waste management facilities and inventory of radioactive waste (L.4),
- List of laws, regulations, safety guides and other relevant documents (L.5),
- References to official national and international reports related to radiation and nuclear safety (L.6),
- References to reports of international review missions performed at the request of a Contracting Party (L.7), and
- Spent fuel and radioactive waste management policy (L.8).

# 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.*

### Criteria used to define and categorize radioactive waste

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, and 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.

Other radioactive waste than nuclear waste is regulated in the framework of the Radiation Act. According to the Act (Section 10), the term radioactive waste denotes radioactive substances, and various items that have no use any more and have 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 shall also be regarded as radioactive waste in case the owner of the substances or the appliances cannot be found.

The main sources of radioactive waste in Finland are nuclear wastes generated from the operation of the four power reactors and one small research reactor. Other radioactive wastes arise from a number of facilities using radioisotopes in medical, research and industrial applications. Consequently, the Finnish 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. Waste classification according to disposal route is illustrated in Figure 3.

#### Spent fuel from nuclear facilities

The Nuclear Energy Act defines spent fuel from the operation of nuclear reactors as nuclear waste, destined for disposal in a permanent manner. Due to its high activity and heat generation, spent fuel is regarded as high-level waste.

#### 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 Guide YVL D.4. Solid and liquid wastes arising from the controlled area of a NPP contain almost exclusively short-lived beta and gamma emitters and are grouped into the following activity categories:

- **Low level waste** contains so little radioactivity that it can be treated without any special radiation protection arrangements. The activity concentration in waste is then not more than 1 MBq/kg, as a rule.
- **Intermediate level waste** contains radioactivity to the extent that effective radiation protection arrangements are needed when they

are processed. The activity concentration in the waste is then from 1 MBq/kg to 10 GBq/kg, as a rule.

The classification for the disposal purpose is given in Government Decree 736/2008. It distinguishes short-lived and long-lived waste accordingly:

- **Short-lived waste** shall refer to nuclear waste the activity concentration of which after 500 years is 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** shall refer to nuclear waste, the activity concentration of which after 500 years is 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 general and case-specific clearance of nuclear waste. Both clearance options are founded upon the criteria of 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, shall not exceed 10 µSv and that also otherwise the radiation exposure arising from the cleared material is as low as reasonably achievable.

Mass and surface concentration based activity constraints for general clearance are given in YVL D.4. One set of constraints is for unlimited amounts of material and the constraints are taken from IAEA Safety Guide RS-G-1.7. Another set of constraints are applied for limited waste quantities not exceeding 100 tonnes per year for one NPP or other nuclear installation. In case-specific clearance the activity concentrations are determined on a case-by-case basis but care has to be taken that they do not exceed the exemption limits given e.g. in the Council Directive 96/29/Euratom and Guide ST 1.5.

Guide YVL D.4 also covers clearance of regulated buildings and sites in the context of decommissioning of nuclear facilities. The radiation protection requirement for such clearances is that the annual individual dose shall not exceed a constraint

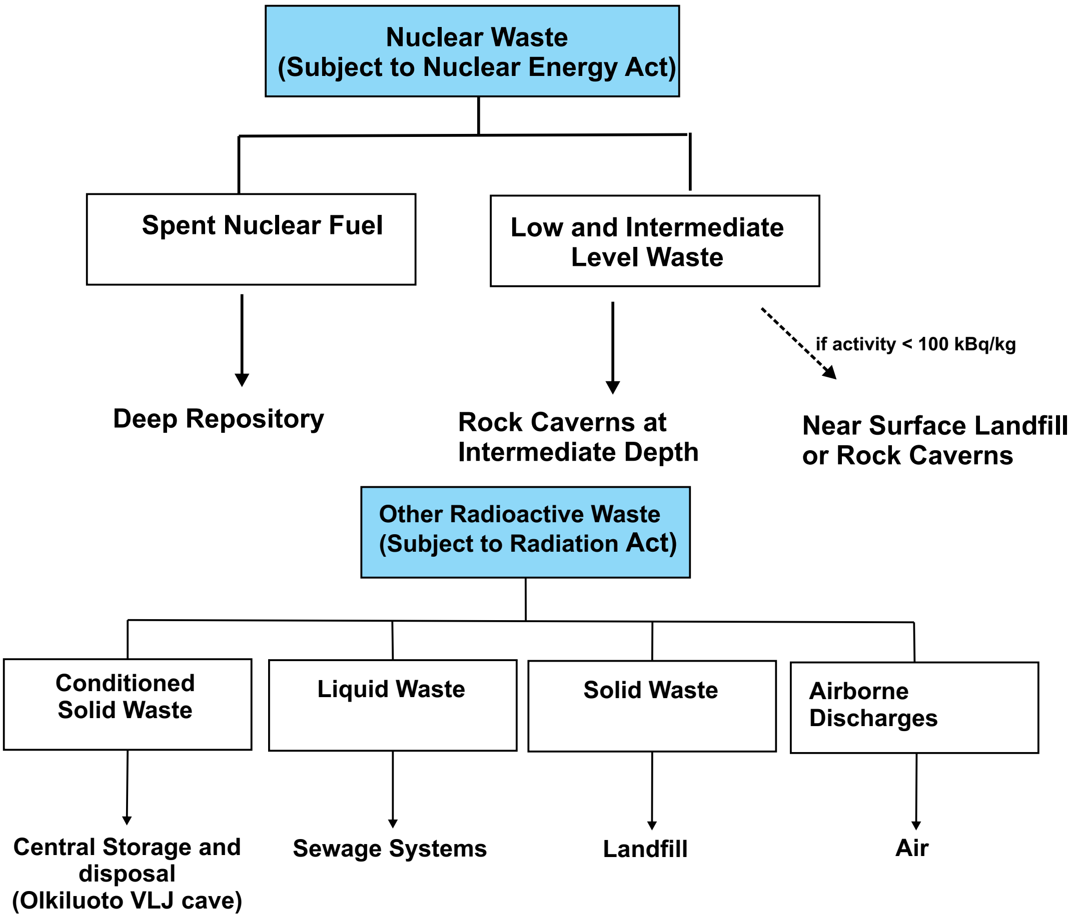



**Figure 3.** Classification of radioactive waste for disposal purposes.

between 10 µSv and 100 µSv, 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 are in conformity with the annual dose constraint to the most exposed individual of the population. The dose constraint for NPPs is 0.1 mSv per year (Government Decree 717/2013) and 0.01 mSv per year for nuclear waste facilities (Government Decree 736/2008, YVL D.3 and YVL D.5).

### Radioactive waste from medical use, research and industry

For small user waste, constraints for disposal in landfill or sewage system are provided in Guide ST 6.2. The criteria are based on the trivial dose as above in the case of clearance of nuclear waste.

According to Guide ST 6.2, liquid waste can be disposed of into a sewage system and solid waste can be delivered to a landfill site or an incineration plant, if the activities are below the nuclide specific limits based on the Annual Limit on Intake values. The upper level of radioactivity is 100 kBq for a sealed source eligible to be considered as solid waste and within these activity limits. Sealed sources with higher radionuclide content and other radioactive waste not eligible for disposal to landfill have to be delivered to a site approved by STUK for storage and disposal.

### Spent fuel and radioactive waste management policy

The main regulations in the field of nuclear energy are the Nuclear Energy Act and Decree, the Radiation Act and Decree, the Government Decrees and the Decisions of the Government, as well as the Regulatory Guides (YVL Guides) issued by the Radiation and Nuclear Safety Authority (STUK). Besides that, the long-term objectives for spent fuel and nuclear waste management have been given in the earlier decisions by the Ministry of Trade an Industry. The most essential safety regulations and guides are listed in Annex L.5. The legislative and regulatory measures to fulfil the obligations of the Convention were discussed in detail in the previous national reports by Finland related to the Joint Convention. It was concluded that the Finnish regulatory framework fulfils the obligations of the Convention, and also the objectives of the Convention are complied with. Finland has implemented the requirements of the European Council directive (2011/70/Euratom), which also implies requirements for waste management policy and strategy. However no change in the Finnish policy and strategy were needed and the spent fuel and radioactive waste management policy hasn't been changed during 2011–2013.

A summary of the spent fuel and radioactive waste management policies are given in Text Box 1 and a more detailed text is reproduced in Annex L.8.

### Spent fuel and radioactive waste management practices and plans

The management practices for nuclear waste and other radioactive waste are described in detail below. A concise overview of the management strategies is given in Text Box 2.

The main producers of nuclear waste are the NPP utilities Teollisuuden Voima Oyj (TVO) and Fortum Power and Heat Oy (FPH). They take care of interim storage of spent fuel, of conditioning and disposal of low and intermediate level waste and of planning and execution of future decommissioning of the NPPs, including also the disposal of the decommissioning waste of the NPPs.

TVO and FPH have formed a joint company, Posiva Oy, which is responsible for the preparations for and later implementation of their spent fuel disposal. The disposal project currently covers spent fuel from the four reactors in operation, from the one under construction (Olkiluoto 3) and from the one under planning (Olkiluoto 4).

The operator of the research reactor, VTT Technical Research Centre of Finland, has facilities for storage of its spent fuel and radioactive waste. Producers of other radioactive waste perform some waste management operations, such as initial storage, clearance and disposal into landfill type sites. Small user waste that cannot be cleared, or, in the case of sealed sources, returned to the manufacturer, must be handed over to Suomen Nukliditekniikka against a fee that covers the interim storage and later disposal of the waste.

## *Text Box 1: Nuclear and other radioactive waste management policy*

### *Legislative basis*

*Nuclear waste is regulated by the Nuclear Energy Act and is defined as radioactive waste, including spent fuel, arising from the use of nuclear energy. Other radioactive waste is subject to the Radiation Act.*

### *Political decision-making and public consultation*

*Construction of a major nuclear waste facility shall be in line with the overall good of the society, as judged by the Government and the Parliament. Consent of the proposed host municipality is required for the construction of such a facility. An environmental impact assessment procedure shall be conducted prior to the first authorization step of a major nuclear waste facility.*

### *Responsibilities*

*Licensee of a nuclear waste management facility shall ensure its safe use including physical protection and emergency preparedness. Producer of nuclear waste is responsible for the implementation and expenses of the pertinent waste management and decommissioning activities, including the related planning, research and development work. The State is responsible for nuclear waste after its approved disposal and has the secondary responsibility in case the producer of nuclear waste is incapable to fulfil his management obligation.*

*User of radioactive substances shall render harmless the radioactive waste arising from operations in question, including those involved with natural radioactive substances. A financial security shall be furnished for a sealed source or other radioactive waste with substantial liability. The State has the secondary responsibility in case the producer of radioactive waste is not capable to fulfil his management obligation.*

### *Waste management and decommissioning principles*

*The Nuclear Energy Act states that nuclear waste generated in Finland with some exceptions shall be treated, stored and permanently disposed of in Finland. Nuclear waste generated elsewhere, shall not be handled, stored or permanently disposed of in Finland. A long-term overall schedule for the implementation of nuclear waste disposal in Finland was contained in the Policy Decision of the Government in 1983. Subsequently the Ministry of Trade and Industry and later the Ministry of Employment and the Economy (MEE) have issued decisions re-establishing and amending the schedule.*

*The preferable management option for disused sealed sources is to return them to the supplier/manufacturer. If this is not feasible, a disused sealed source or other small user waste can be delivered to an installation licensed to receive condition and transfer radioactive waste to a central storage operated by the Radiation and Nuclear Safety Authority (STUK).*

*Means to reduce the amounts of nuclear waste arising from the decommissioning shall be considered already in the design of a nuclear facility. Decommissioning plans shall be regularly updated during the operation of the facility. Implementation of decommissioning shall not be unjustifiably postponed.*

### *Safety principles and control*

*Safety of nuclear waste management facilities shall be kept as high as reasonably achievable and all actions justified by safety research and the progress in science and technology shall be taken into account to enhance safety. Nuclear waste shall be disposed of so that no radiation impact exceeding the currently acceptable level will occur in the future and so that ensuring long-term safety is based on passive safety functions.*

*MEE determines the principles on the basis of which the nuclear waste management obligation is to be implemented. STUK is responsible for the required safety assessment in authorization processes and for the control of the safe management of nuclear and other radioactive waste. The construction and operating licences for waste management facilities are prepared by MEE and granted by the Government*

### Spent fuel management

Spent nuclear fuel from NPPs is stored at the power plant sites until it will be disposed of. Initially, the fuel is cooled for one to five years in the storage pools inside the reactor buildings. The Loviisa NPP has, in addition to the storage pools in the reactor

## *Text Box 2: Nuclear and other radioactive waste management strategy*

### *Responsibilities*

*Current and future producers of nuclear waste (the NPP utilities TVO, FPH and FV) take care of interim storage of spent fuel, of conditioning and disposal of low and intermediate level waste and of planning for and implementation of the decommissioning of the NPPs. A company, Posiva Oy, jointly owned by FPH and TVO, is responsible for the preparations for and later implementation of 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 is responsible for its own spent fuel disposal as well as for other nuclear waste management and decommissioning activities.*

*Producers of other radioactive waste manage their waste within the limits of their technical capability while ensuring safety and security. Small user 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, condition and transfer radioactive waste to a central storage operated by STUK.*

### *Waste management and decommissioning objectives*

*Such low and intermediate level nuclear waste that meets the acceptance criteria for the repositories at the NPP sites will be disposed of without unnecessary delays. Waste that cannot yet be disposed of is stored safely. Also other low and intermediate level waste, such as decommissioning waste and small user waste, is envisaged to be disposed of in the rock cavern repositories 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. The goal for starting the disposal operations is approximately the year 2020. The spent fuel disposal programme is subject to continuous regulatory review and is now in the construction licence application review phase. The prospective nuclear utility Fennovoima Oy must by the end of June 2016, either reach an agreement on co-operation on disposal of its spent fuel with the owners of Posiva Oy or present an Environmental Impact Programme for a spent nuclear fuel disposal facility of its own.*

*The implementation of decommissioning of the NPPs will be optimized taking into account the technical aspects, radiological impact, future use of the site, availability of 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 liability system*

*A financing system for the costs of future waste management and decommissioning exists to ensure that the producers of nuclear waste bear their full financial liability on the coverage of those costs and that the costs can be covered even in case of insolvency of the waste generator. The pertinent licence-holders submit the technical plans and cost calculations, on which the liability estimates are based, for regulatory review at three year intervals. After confirmation of the financial liabilities, the licensees pay fees to a State controlled fund and provide securities for the liability not yet covered by the funded money.*

buildings, a separate integrated pool type storage facility. The latest enlargement of the storage facility was commissioned in 2001. The installation of dense fuel racks was started in 2007 and will continue in the future. The allowable total amount arising of spent fuel, according to the renewed operating licence issued in 2007, is 1100 tU and the storage capacity with additional high density racks should be adequate until the end of the planned 50 years of operational life.

At the Olkiluoto plant the spent fuel is, after cooling in the pools at the reactor buildings, transferred to an on-site interim storage facility, commissioned in 1987, with a capacity of about 1200 tU. The current capacity is estimated to be used up in 2014. TVO started the construction works for enlarging the Olkiluoto interim storage in autumn 2010 and construction and installation works have been finalized in early 2014. The extension of the storage capacity includes the construction of three

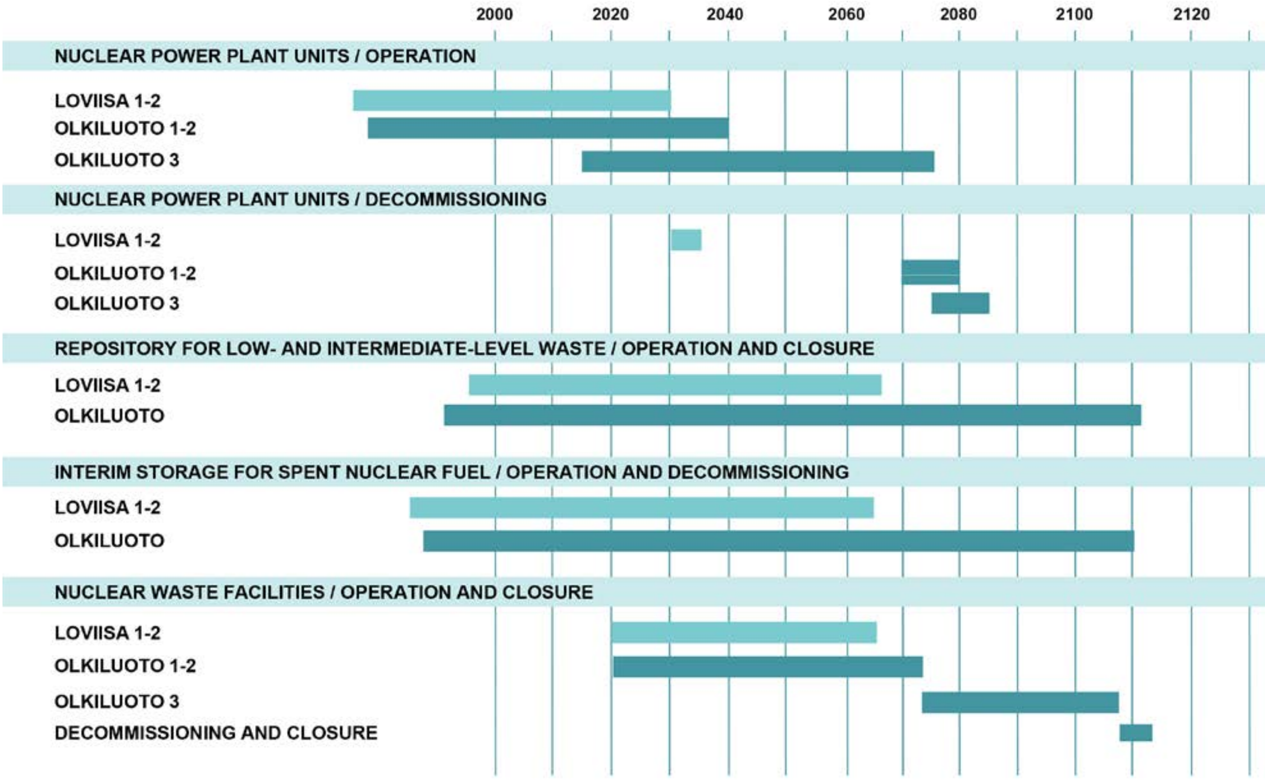



**Figure 4.** Timetable for the management of spent fuel from the nuclear power plants at Loviisa and Olkiluoto.

new storage pools and the extension has been carried out according to the updated safety requirements (Government Decree 717/2013), which requires among other things that the design has to withstand a large airplane impact. The extension has been included as part of the Olkiluoto NPP 1&2 operating licence and has been authorized as a plant modification. The extension is scheduled to be commissioned during 2014. The storage of spent fuel from the Olkiluoto 3 unit has been taken into account in the design of the extension of the interim storage. The safety of the spent fuel storages (at both Loviisa and Olkiluoto site) was analyzed as part of the EU stress tests in relation to the Fukushima accident.

The nuclear energy legislation provides for disposal of nuclear waste into the Finnish bedrock. Posiva is implementing the spent fuel disposal programme on behalf of its owners in line with the Government Policy Decision of 1983 and a further decision by the Ministry of Trade and Industry in 2003:

- Disposal site selection in 2000.
- Start of construction of an underground rock characterization facility (ONKALO) in Olkiluoto in 2004;
- A description in 2009 of the preparedness for the application of the Construction Licence in 2012;
- Preparedness for the application of the Construction Licence in 2012, which Posiva fulfilled by submitting the construction licence application for Olkiluoto Encapsulation and Disposal Facility by the end of 2012;
- Readiness for starting the disposal operations in the early 2020's.

The various steps from siting until closure scheduled for the Olkiluoto disposal facility are illustrated in Figure 4. The construction of the underground rock characterization facility (ONKALO) started in July 2004. Posiva completed the excavation works for access tunnel and technical rooms in 2012. The length (chainage) of tunnels reached 4987 m in length and 455 m in depth. Posiva has excavated four short demonstration tunnels, which are used for testing the emplacement technology. Posiva's programme for spent fuel disposal is described in Annex L.2., and STUK's regulatory control of the spent fuel disposal project in Annex L.1.

The current total amount of spent fuel having Decisions-in-Principle for disposal in Olkiluoto is 9000 tonnes of uranium, which is further divided in estimated reservations: 1050 tU from Loviisa 1 and 2, 2950 tU from Olkiluoto 1 and 2, 5000 tU from Olkiluoto 3 and 4. The estimates are based on the expectation that the units Loviisa 1 and 2 have total operational lifetimes of 50 years (until 2027 and 2030), respectively, Olkiluoto 1 and 2 lifetimes of 60 years (until 2038 and 2040), and Olkiluoto 3 and 4 lifetimes of 60 years (Figure 4).

Before disposal, spent fuel of TVO and FPH will be stored in water pools in practice for 30 to 50 years and thereafter transferred to the encapsulation and disposal facilities which will be located at Olkiluoto. The minimum cooling time before encapsulation is set for 20 years. 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 of copper to provide a shield against corrosion. The canisters will be emplaced in an underground facility that consists of technical rooms and a network of tunnels, which will be constructed at the depth of 400 to 455 m in crystalline bedrock.

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

The preliminary designs of the encapsulation and disposal facilities, operational and post-closure safety assessments and summaries of site characterization were included in Posiva's Decision-in-Principle application and in the supporting documents. STUK's preliminary safety assessment of the application was published in January 2000 and the Parliament ratified the Decision-in-principle in 2001. A further DiP regarding the expansion of the encapsulation and disposal facility for the needs of the Olkiluoto 3 reactor was ratified by the Parliament in May 2002. The Decision-in-Principle to extend the capacity of the disposal facility to include the spent fuel from one further reactor

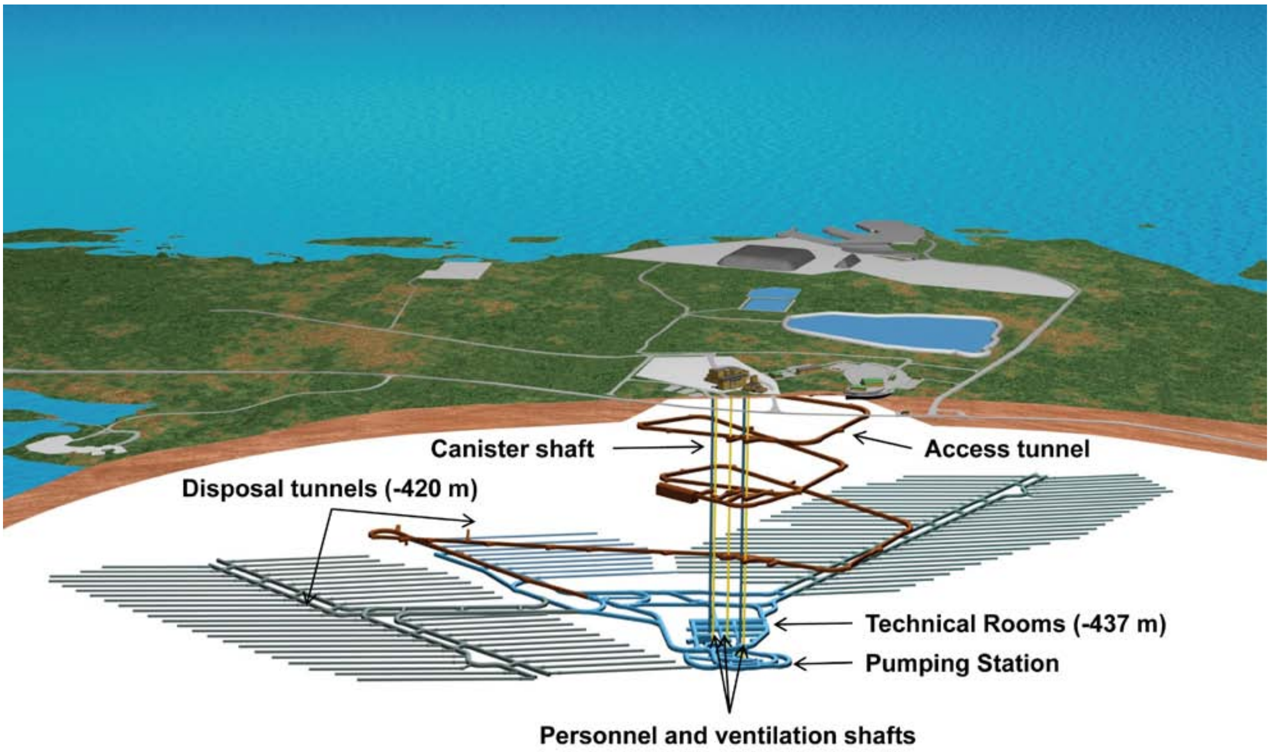



**Figure 5.** A schematic presentation of the layout of the underground rock characterization facility and the network of disposal tunnels (KBS3-V option).

unit, Olkiluoto 4, was ratified by the Parliament in July 2010. Posiva submitted a description of its preparedness for the construction licence application, along with the current drafts of construction licence application documentation, in 2009. STUK reviewed this preliminary licence application material and gave a statement to MEE on Posiva's preparedness in September 2010 and a more detailed safety review to Posiva in June 2011. Posiva submitted the construction licence application and its supporting safety documentation to the authorities at the end of 2012. MEE started the licensing process and STUK the safety review and assessment in the beginning of 2013. The licence application review and STUK's regulatory approach is described in Annex L.1. Posiva's programme for spent fuel disposal is presented in Annex L.2.

Posiva Oy, Teollisuuden Voima Oyj and Fortum Power and Heat Oy published in September 2012 the triennial overview of the status and plans for R&D and technical design in the field of nuclear waste management required in Sections 74 and 75 of the Nuclear Energy Decree. The programme is focused on the years 2013–2015 and describes the years 2016-2018 in a more general manner. STUK reviewed the programme and submitted a statement to MEE in January 2013. MEE submitted its statement to the licensees in April 2013.

Spent fuel of the research reactor FiR 1 is stored on site. VTT has decided to decommission FiR 1 due to insufficient funding for continued operation. VTT submitted the EIA programme for decommissioning and dismantling in autumn 2013 to MEE, which gave a statement of the EIA programme adequacy in February 2014. VTT will prepare the EIA report during 2014 and after that VTT can apply for a licence for the research reactor decommissioning. The first option for spent fuel management is to return the fuel to the United States. Another option is interim storage and later disposal into the Olkiluoto spent fuel disposal facility, but this would require a new Decision-in-Principle and licensing of the Olkiluoto disposal facility for research reactor spent fuel. The total amount of spent nuclear fuel is about 340 kg (ca. 25 kgU). The shipment of the research reactor fuel could take place in early 2016. The current cost estimate for the decommissioning and the management of spent fuel and other wastes of the research reactor is 8.5 million €. The shipment of the spent fuel of FiR 1 to the USA has to be arranged so that the fuel needs to be removed from the reactor be-

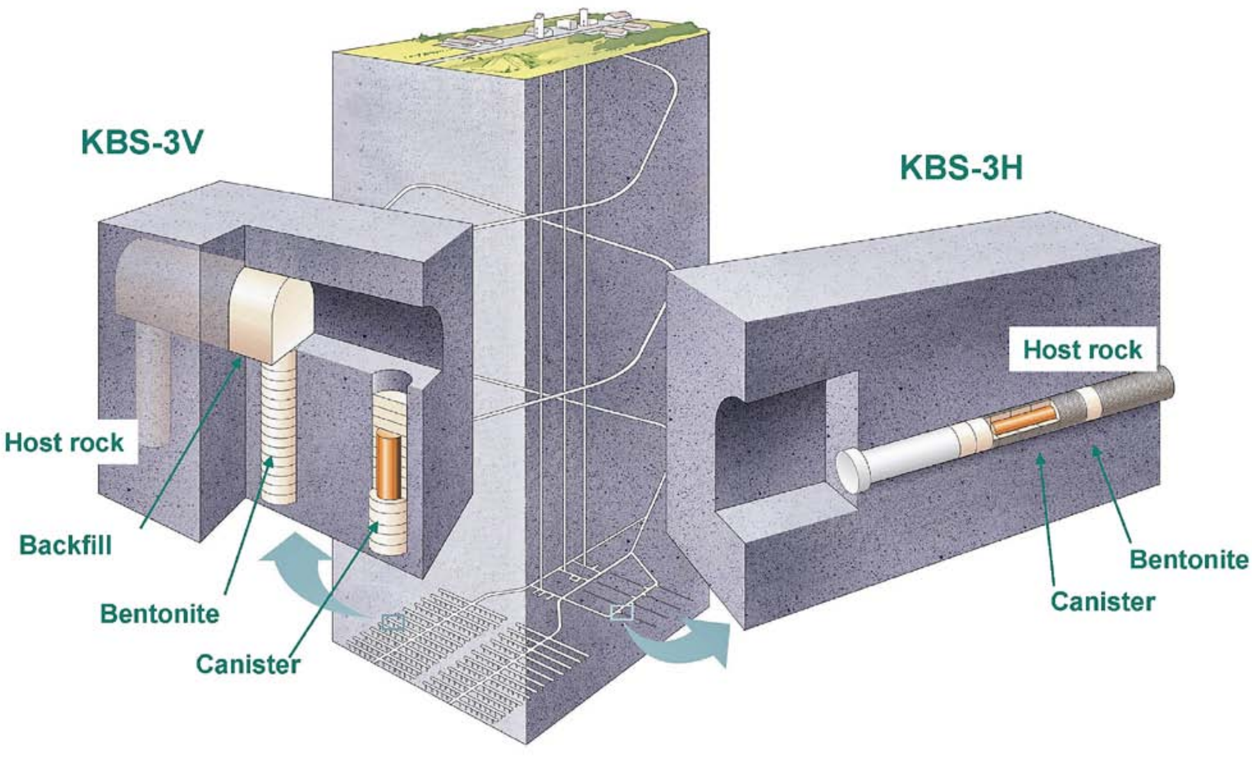
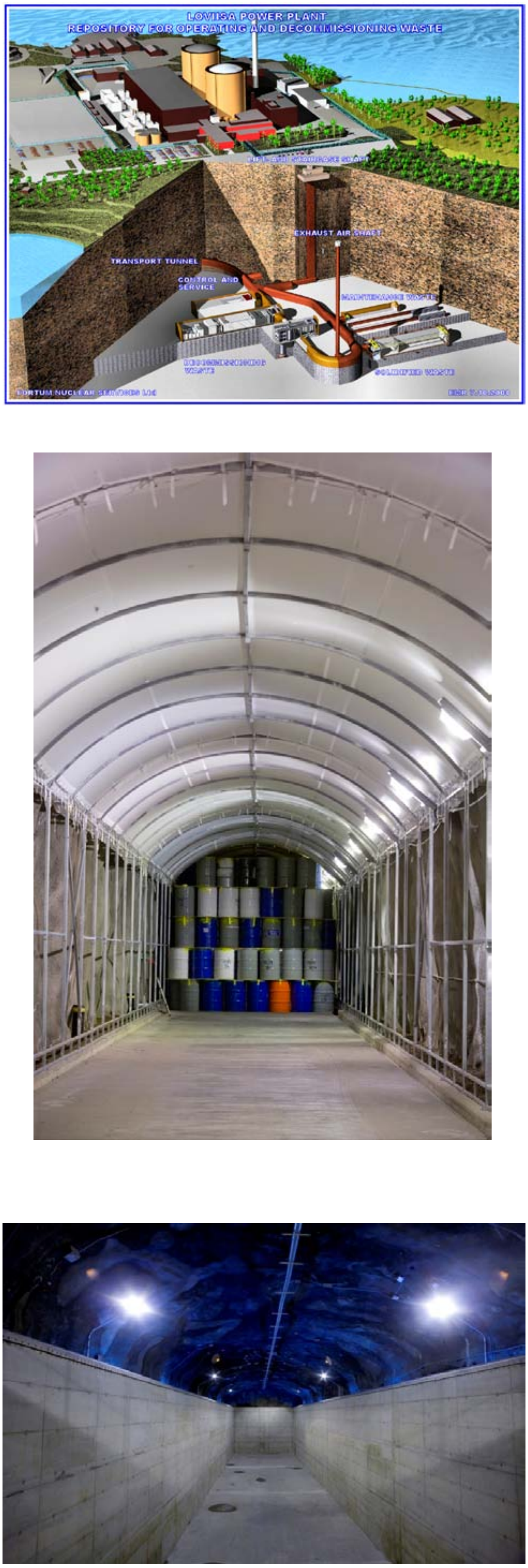



**Figure 6.** Disposal tunnel and canisters with both the vertical and horizontal disposal options depicted.




fore 12 May 2016 and the fuel has been received in the USA by 12 May 2019 at the latest.

## Management of LILW from nuclear facilities

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

At Loviisa, wet LILW (radioactive concentrates, such as spent ion exchange resins, evaporator deposits and corrosion sludge) is for the time being stored in tanks at the NPP. The plant uses an innovative selective ion exchange method to reduce the volume of liquid radioactive waste. The commissioning of a solidification facility was expected in early 2014, but is postponed due to problems encountered in waste packages used for pre-operational tests. The construction and system commissioning tests are otherwise finalised and STUK is expecting to receive an application for operation authorization after FPH has addressed the problems with the waste packages. At Olkiluoto, wet LILW is immobilized in bitumen before transfer to the disposal facility. Sludge, radioactive concentrates and spent ion exchange resins from liquid waste treatment in Olkiluoto 3 are planned to 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 at 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 of highly activated waste has not been conditioned

**Figure 7.** 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.

but is stored at the NPPs and is expected to be conditioned and disposed of together with decommissioning waste of similar type.

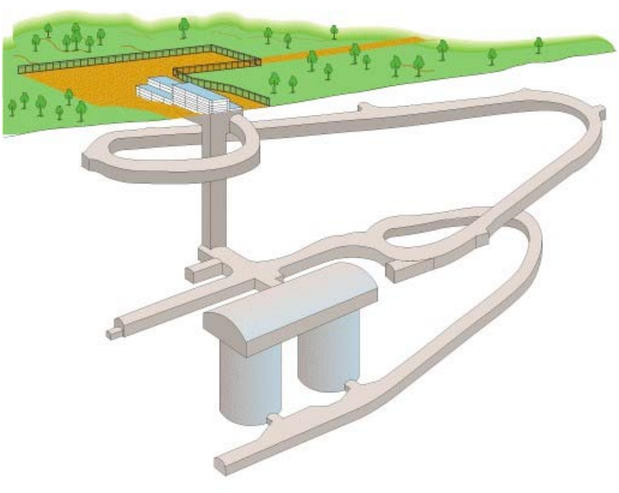
According to the strategy adopted by the Finnish nuclear operators, low and intermediate level wastes from reactor operations are disposed of in the bedrock at the power plant sites. The construction of the repository at the Olkiluoto site began in 1988 and the operation in 1992. At Loviisa, the construction of the repository was started in 1993 and the operation of the first phase of the disposal facility was started in 1998. The disposal facilities are operated by the nuclear power plant operators, FPH at Loviisa and TVO at Olkiluoto.

The Loviisa repository is located at the depth of approximately 110 m in granite bedrock. The repository consists of two tunnels for solid LLW and a cavern for immobilised ILW (Figure 7). Inside the cavern for ILW, the waste packages are emplaced in a pool-shaped structure made of reinforced concrete. A new tunnel was constructed during 2010 to 2013 and it is initially licensed only for such storage that also facilitates the sorting of waste, allowing clearance from regulatory control of some of the waste. The tunnel is planned to be licensed later even for the disposal of operational or decommissioning waste.

The Olkiluoto repository consists of two silos at the depth of 60 to 95 m in tonalite bedrock, one for solid LLW and the other for bituminized ILW (Figure 8). The silo for solid LLW is a shotcreted 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 in. The LILW from Olkiluoto 3 will be disposed of in the same repository. The repository will be extended in the future, to be able to receive all the LILW from Olkiluoto 1, 2 and 3 reactor units during the planned 60 years of operation of the units.

LILW generated from the operation of the research reactor FiR 1 is stored at the reactor facility until decommissioning. VTT is negotiating with the Finnish NPP licensees (TVO and FPH) for possible interim storage and future disposal of decommissioning waste. The estimated total amount of decommissioning waste is 28 tons with an activity of 30 TBq. The dismantling of the reactor is planned to be started in late 2015 and to last about two years.

Based on Fennovoima Oy's plans LILW will be collected, stored, handled and disposed of at the power plant site. Fennovoima Oy has made an early estimate on 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 facility which will be constructed at a depth of several tens of meters in the bedrock. Fennovoima Oy also considers a surface based facility as an option for



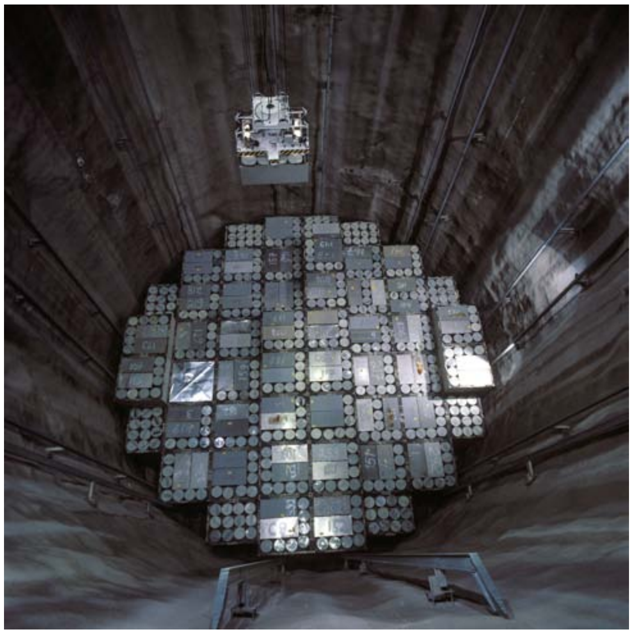


**Figure 8.** The Olkiluoto LILW repository. LLW drums in the disposal silo (left) and cross-sectional view of the repository lay-out (right).

the disposal of very low level waste (VLLW). All the LILW and VLLW management plans are currently presented only on a principal level and they will be developed further within the next licensing phases.

### Management of other 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 return to the supplier/manufacturer of the source or delivery to the national long-term storage operated by STUK's Department of Environmental Radiation Surveillance. This role in operating the storage is defined in Radiation Decree, Section 24 b. A private entrepreneur, Suomen Nukliditekniikka, takes care of the conditioning, packaging and transfer of the spent sealed sources and other small user radioactive waste and they are stored in an interim storage cavern attached to the LILW repository at Olkiluoto, under the regulatory control of STUK's Department of Nuclear Waste and Material Regulation. 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 the uses of radiation. The disposal of sealed sources and other small user radioactive waste is included in the renewed operating licence for Olkiluoto LILW repository, which was granted by the Government in 2012. The disposal operations for these radioactive wastes have not been started and the more detailed planning for sorting, packaging and emplacement operations is ongoing.

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, nature of the work and the nature and amount of radioactive substances in use. In addition to being below the limits, all discharges to the environment shall be as low as reasonably achievable.

In practice, most of the wastes 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 e.g. for the sealed sources. A common practice is that radionuclide laboratories store their short lived radioactive wastes at their premises until they have decayed below the limits set for discharges in Guide ST 6.2. However, some wastes resulting from radiochemical research at VTT have been sent to STUK for storage in Olkiluoto. In addition, the waste resulting from studies conducted by VTT e.g. on the reactor pressure vessel material behaviour for the Loviisa NPP are returned back for disposal in the Loviisa LILW repository.

All radionuclide laboratories 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

No nuclear power plants are currently being decommissioned and neither are such decommissioning projects foreseen in the near future. VTT Technical Research Centre of Finland has decided to decommission its research reactor (FiR 1) due to insufficient funding for continued operation. VTT submitted the EIA programme for decommissioning and dismantling to MEE in autumn 2013. MEE gave a statement of the EIA programme adequacy in February 2014. VTT will prepare an EIA report during 2014 and after that VTT can apply for a change of the operating licence for the research reactor decommissioning. Decommissioning is licensed as a change of the operating licence and granted by the Government. VTT has planned to apply for a renewed licence at the end of 2014. The dismantling is scheduled to start at the end of 2015 and to last about two years. The dismantling will be regulated by STUK concerning the radiation and nuclear safety aspects. VTT updated its plan for the research reactor nuclear waste management and submitted the plan for MEE in June 2013 as required. MEE requested statements from stakeholders, including STUK, and based on these statements required that VTT further develops and clarifies options and methods for waste management and also includes these adjustments in the cost estimates. MEE required VTT to submit a cost estimate to MEE in July 2014 and an updated waste management plan in September 2014.

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 latest plan for the Olkiluoto NPP decommissioning was submitted in 2008. By the end of 2014 TVO will submit an updated decommissioning plan for the review by the authorities. The decommissioning plan for the Loviisa NPP is based on immediate dismantling, within eight years from shutdown while for the Olkiluoto NPP, a safe storage period of about 30 years prior to dismantling is envisaged. The postponed dismantling is based on a main circuit activity decrease and 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 wastes from the decommissioning of the NPPs are based on the extension of the 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 decommissioning plans is the emplacement of large components, such as pressure vessels and steam generators, in the disposal rooms as whole entities, without cutting them in pieces.

# 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.*

Finland has adopted the once-through nuclear fuel cycle. Thus, all spent nuclear fuel, after it has been permanently removed from the reactor, is in the scope of the Convention.

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

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

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: | 620 tHM [1] (effective[2]) |
| Inventory (end of 2013): | 560 tHM (4657 assemblies, maximum burnup 55 MWd/kgU) |
| Essential features: | Pool storages inside both reactor buildings<br>Basket type pool storage in the NPP auxiliary building<br>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: | 15762 tHM[1] (effective[2]) |
| Inventory (end of 2013): | 1374 tHM (8096 assemblies, maximum burnup 53 MWd/kgU) |
| Essential features: | Pool storages inside both reactor buildings<br>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 2013): | 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 2013): | 1613 m³ |
| Essential features: | Pretreatment, compaction and packaging of solid LLW<br>Pretreatment of liquid LILW<br>Eight tanks, 300 m³ each, for storage of liquid LILW<br>Solidification plant for liquid LILW<br>Two storage rooms inside the NPP for packed LLW<br>(Dry) storage well and pool storage for unconditioned activated waste<br>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 2013): | 437 m³ |
| Essential features: | Pretreatment, compaction and packaging of solid LLW<br>Pretreatment and bituminisation of liquid LILW<br>Four buffer storage rooms for conditioned LILW<br>Pools storage of unconditioned activated waste<br>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 2010): | 6 m³ |
| Essential features: | Storage room in the basement of a laboratory building |
| **Storage for state owned waste (recognised installation)** | |
| Owner: | Suomen Nukliditekniikka |
| Location: | Roihupelto, city of Helsinki, Southern Finland |
| Purpose: | Buffer interim storage of radioactive waste for example from industry and hospitals |
| Inventory (end of 2013): | 2 m³ (3.8 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 2013): | HEU: 0.8 g, LEU: 536 g, UNat: 574 g, DU: 369 kg, Th: 199 g |
| 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 2013): | 56 m³ (50.14 TBq, prominent nuclides: $^{3}$H, $^{137}$Cs, $^{85}$Kr, $^{241}$Am, $^{238}$Pu, not including Th-232 (2.5 kg) and depleted uranium (1270 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.

## Small user 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 licensees' notifications and to observations made during the inspections. Small users of radioisotopes have in their premises some radiation sources 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 store unnecessarily sources for which no use is foreseen.

## Waste from past practices

There are no significant amounts of waste from past practices requiring further management (see also Section H).

**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 m³ (0.45 TBq, dominant nuclides Co-60, Ni-63, Cs-137) |
| Essential features: | Rock tunnels for LLW<br>Vault for solidifed ILW |
| **Olkiluoto disposal facility** | |
| Owner: | TVO |
| Location: | Olkiluoto island, Municipality of Eurajoki, South-Western Finland |
| Purpose: | Disposal of LILW |
| Inventory (end of 2013): | 5681 m³ (52.0 TBq, dominant nuclides Co-60, Ni-63, Cs-137, Sr-90, C-14) |
| Essential features: | Rock silo for conditioned packed ILW<br>Rock silo for conditioned/packed LLW |

## Decommissioning

No significant facilities subject to nuclear energy or radiation protection legislation are being decommissioned. In 2002, the decommissioning of a sterilisation plant was completed in Ilomantsi, Eastern Finland. The highly active Co-60 source was transported abroad for reuse. There was no contamination in the facility.

# 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.*

### Safety requirements and regulations

In Finland, the legislation for the use of nuclear energy and for radiation protection was established in 1957. Since then, several amendments and new regulations have been issued.

#### Nuclear legislation and regulations

The current Finnish nuclear energy 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 and operation 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 wastes;
- 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 above provisions shall 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 the citizens shall be given on the level of Acts.

In 2011 two revisions were made in the Nuclear Energy Act. The first one 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 safe use of nuclear energy was already stipulated in the Act, but by the first amendment the requirement that the obligation cannot be delegated or transferred to another party was included. The licensee's obligation to arrange necessary training for nuclear safety personnel and the responsibility of Ministry of Employment and the Economy to arrange the 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 use 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 the Directive 2011/70/Euratom of 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 graded approach and to keep the generation of radioactive waste to the minimum which is reasonably practicable were included in both Acts. In the Nuclear Energy Act the provisions of self-assessment and peer review were updated to cover also 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 need to be considered for the legislation mainly concerning the independence of STUK. The amendments to the Nuclear Energy Act and the Radiation Act were under preparation in 2013.

A new proposal for the Nuclear Safety Directive is in the preparation process in the EU Atomic Question Group and will most probably be implemented in the Finnish legislation during the next reporting period.

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 sets forth the specific requirements on nuclear waste management (Sections 27a-34) and for the financial provisions of nuclear waste management (Sections 35-53). These provisions also address spent fuel management.

Based on the Nuclear Energy Act, the Government issued in 2008 and 2013 the following regulations:

- Government Decree on the Safety of Nuclear Power Plants (733/2008), updated by a new Decree 717/2013
- Government Decree on the Security in the Use of Nuclear Energy (734/2008), revised in 2013
- Government Decree on Emergency Response Arrangements at Nuclear Power Plants (735/2008), updated by a new Decree 716/2013
- Government Decree on the Safety of Disposal of Nuclear Waste (736/2008).

The Decrees 717/2013 and 716/2013 are applied to a nuclear power plant which is defined to be a nuclear facility equipped with a nuclear reactor and other related nuclear facilities located on the same plant site. The regulations are also applied to other nuclear facilities to the extent applicable. Decree 734/2008 is applied to all use of nuclear energy, i.e., it covers all nuclear facilities and activities.

The Decree on the Security in the Use of Nuclear Energy was updated on 1 May 2012. The Decrees on the Safety of Nuclear Power Plant (733/2008) and on Emergency Response Arrangements at Nuclear Power Plants (735/2008) were amended in 2013 mainly due to tightening of safety requirements after the TEPCO Fukushima Dai-ichi accident and new WENRA Safety Objectives. The new Decrees 717/2013 and 716/2013 came into force on 25 October 2013. A new Government Decree on the safety of mining and milling operations aimed at producing uranium or thorium was under preparation in 2013 and will be finalized in the future.

Some other minor amendments were also made in nuclear and radiation legislation to reflect changes of other legislation (labor safety, criminal code). Amendments in other national legislation have not caused essential changes to the regulatory control of waste management nor to the safety requirements set for them.

As described above, the nuclear legislation has been amended several times.The Ministry of Employment and the Economy 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 shall comply with, unless some other acceptable procedure or solution has been presented to STUK by which the level of safety stipulated in the Nuclear Energy Act, the Nuclear Energy Decree and the YVL Guides is achieved.

The procedure to apply new guides to existing nuclear facilities is such that the publication of an 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 the research reactor. To new nuclear facilities, however, the guides apply as such.

Nowadays the most important references considered in rulemaking are the IAEA safety standards and WENRA (Western European Nuclear Regulators' Association) reference levels as well as WENRA's recommendations on storage and decommissioning of waste and WENRA's latest statement on Safety Objectives of New NPPs. Other sources of safety information are worldwide co-operation with other countries using nuclear energy, e.g. with the member countries of OECD/NEA. The Finnish policy is to participate in the international discussion on developing safety standards and to adopt or adapt the new safety requirements into national regulations.

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, also the revision of the existing YVL guide system was 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 to the same guide making it easier to use by the licensees and other stakeholders; also they will be coupled to the stage of licensing process
- to rewrite the separate requirements in such a way that each requirement will have its own number, be short and clearly stating who-what-when shall be doing something; requirements are expressed in shall-format, descriptive text is provided only when necessary
- to limit unnecessary prescriptiveness when considering the requirements.

Considering the WENRA Safety Reference Levels published in 2007 and 2008, the Finnish policy is to include all of them in the revised regulatory guide system. This was confirmed already during the updating work of regulatory guides through a systematic approach to record all the Reference Levels in certain guides.

After the TEPCO Fukushima Dai-ichi accident it was decided to include lessons learnt from the accident into the revised guides, which has delayed the completion of the new guides. The most important changes included in the new YVL Guides due to the accident deal with the design of NPPs and spent fuel storages, with the consideration of severe external hazards and with the requirements concerning on-site emergency preparedness including multi-unit accidents.

Director General of STUK approved 40 new YVL guides and they were issued on 1 December 2013.

The re-structured system of YVL Guides is presented in Figure 9. In the area of waste management the most important changes are that the requirements concerning spent fuel storages were updated to take account of the lessons from the Fukushima accident, and that the requirements concerning the decommissioning of nuclear facilities were included in the YVL guidance. Four guides will be issued later because some more changes are needed in the legislation prior to the publication of these guides.

### Legislation and regulations for the use of radiation sources

The Radiation Act and Decree were revised in 1991 to take into account the 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 be in conformance 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.

**Structure of the new YVL-guides**

| A Safety management of a nuclear facility | B Plant and system design | C Radiation safety of a nuclear facility and environment | D Nuclear materials and waste | E Structures and equipment of a nuclear facility |
|---|---|---|---|---|
| A.1 Regulatory oversight of safety in the use of nuclear energy | B.1 Safety design of a nuclear power plant | C.1 Structural radiation safety at a nuclear facility | D.1 Regulatory control of nuclear safeguards | E.1 Authorised inspection body and the licensee's in-house inspection organisation |
| A.2 Site for a nuclear facility | B.2 Classification of systems, structures and components of a nuclear facility | C.2 Radiation protection and exposure monitoring of nuclear facility workers | D.2 Transport of nuclear materials and nuclear waste | E.2 Procurement and operation of nuclear fuel |
| A.3 Management system for a nuclear facility | B.3 Deterministic safety analyses for a nuclear power plant | C.3 Limitation and monitoring of radioactive releases from a nuclear facility | D.3 Handling and storage of nuclear fuel | E.3 Pressure vessels and piping of a nuclear facility |
| A.4 Organisation and personnel of a nuclear facility | B.4 Nuclear fuel and reactor | C.4 Assessment of radiation doses to the public in the vicinity of a nuclear facility | D.4 Predisposal management of low and intermediate level nuclear waste and decommissioning of a nuclear facility | E.4 Strength analyses of nuclear power plant pressure equipment |
| A.5 Construction and commissioning of a nuclear facility | B.5 Reactor coolant circuit of a nuclear power plant | C.5 Emergency arrangements of a nuclear power plant | D.5 Disposal of nuclear waste | E.5 In-service inspection of nuclear facility pressure equipment with non-destructive testing methods |
| A.6 Conduct of operations at a nuclear power plant | B.6 Containment of a nuclear power plant | C.6 Radiation monitoring at a nuclear facility | D.6 Production of uranium and thorium | E.6 Buildings and structures of a nuclear facility |
| A.7 Probabilistic risk assessment and risk management of a nuclear power plant | B.7 Provisions for internal and external hazards at a nuclear facility | C.7 Radiological monitoring of the environment of a nuclear facility | | E.7 Electrical and I&C equipment of a nuclear facility |
| A.8 Ageing management of a nuclear facility | B.8 Fire protection at a nuclear facility | | | E.8 Valves of a nuclear facility |
| A.9 Regular reporting on the operation of a nuclear facility | | | | E.9 Pumps of a nuclear facility |
| A.10 Operating experience feedback of a nuclear facility | | | | E.10 Emergency power supplies of a nuclear facility |
| A.11 Security of a nuclear facility | | | | E.11 Hoisting and transfer equipment of a nuclear facility |
| A.12 Information security management of a nuclear facility | | | | E.12 Testing organisations for mechanical components and structures of a nuclear facility |

**Collected definitions of YVL-guides:** same data is shown both as the collection and within the guides.

**Figure 9.** The re-structured system of the YVL Guides.

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, will be implemented into the Finnish legislation during the next four years.

## Licensing

The licensing process is defined in the legislation. The construction and operation of a nuclear facility is not allowed without a licence. The licences are prepared by the Ministry of Employment and the Economy and granted by the Government. For a NPP, a spent nuclear fuel storage, a nuclear waste disposal facility or another significant nuclear facility the process consists of three steps:

- Decision-in-Principle – made by the Government and ratified by the 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 limited period of time, 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 NPP, 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 the Parliament are required. An Environmental Impact Assessment (EIA) procedure has to be conducted prior to the application of the DiP and the EIA report has to be annexed to the DiP application. A condition for granting the Decision-in-Principle is that the construction of the facility in question is in line with the overall good of the society. Further conditions are as follows:

- The municipality of the intended site of the nuclear facility is in favour of constructing the facility;
- No factors have appeared which indicate that the proposed facility could not be constructed and operated in a safe manner.

The entry into force of the Government's Decision-in-Principle further requires ratification by the Parliament. The Parliament cannot make any changes to the Decision; it can only approve or reject it as such. The authorization process of a nuclear facility is described in Figure 10. In the construction and operating licence phases the acceptance of the Parliament and the host municipality are no more needed.

To a nuclear waste management facility the authorization procedure was implemented for the first time during the period November 1999 – May 2001 when Posiva Oy applied for a Decision-in-Principle for the disposal facility for spent nuclear fuel originating from the Loviisa and Olkiluoto nuclear power plants. The Government made the DiP in December 2000 and the 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 the spent fuel from the new reactor units Olkiluoto 3 and Olkiluoto 4.

The Nuclear Energy Decree (Section 112) requires that if the licensee intends to carry out such modifications to the nuclear facility systems, structures, nuclear fuel or the way the facility is operated, which influence safety and involve changes in the plans or documents approved by the Radiation and Nuclear Safety Authority (STUK), the licensee shall obtain approval from STUK for such modifications before they are carried out. Correspondingly, STUK shall approve measures related to the decommissioning of a nuclear facility. The licensee shall ensure that the documents mentioned in Sections 35 and 36 are revised accordingly.

The licensing system was assessed in the IRRS 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 authorities in the authorization process for safety. In particular, the amendments should ensure that STUK has the legal authority to specify any licence conditions necessary for safety.

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 licence 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, the cases not requiring a licence are identified, e.g. when the use of radiation or a device is exempted.

## Prohibition of operation without licence

The use of nuclear energy without a licence provided by the Nuclear Energy Act is prohibited.

## Control and enforcement

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 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), technical specifications, the operational manual and for disposal facilities also the post-closure Safety Case documentation in support of PSAR and FSAR. STUK's onsite inspections aim at e.g. verifying that the actual operations at the nuclear facilities comply with the regulations and the documents of the licensee.

The Radiation Act (Section 6) provides that adherence to the Act and regulations issued in accordance with it shall be regulated by STUK. The supervisory 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.

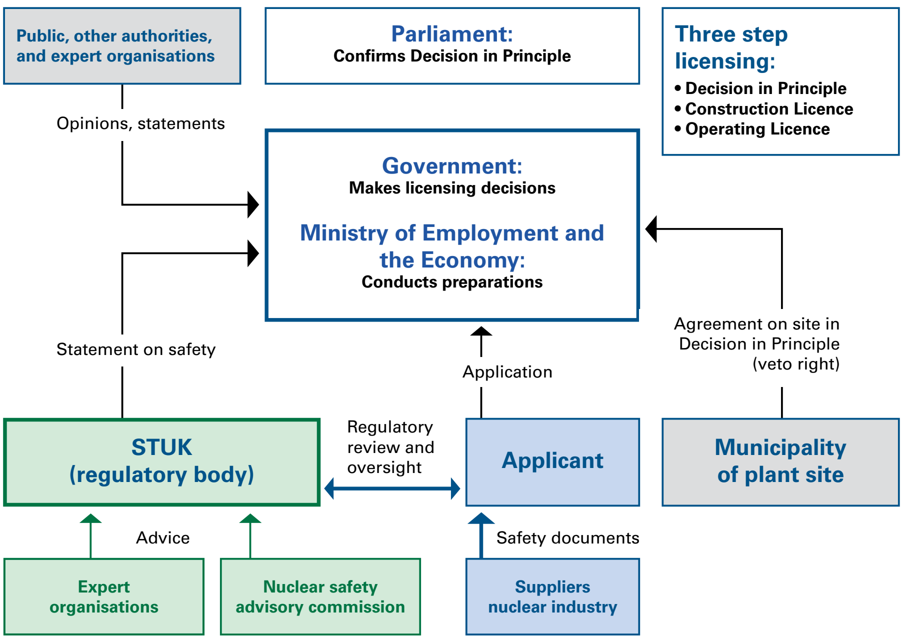



**Figure 10.** Authorization of nuclear facilities in Finland.

### Clear allocation of responsibilities

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, and the utilities are also responsible for the arising expenses. This obligation cannot be delegated or transferred to another party.

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, is taking care of the preparation for and later implementation of spent fuel encapsulation and disposal. The DiP of a NPP granted to Fennovoima Oy requires the presentation of waste management plans for spent fuel by the end of 2016 at the latest.

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 case where the practice produces or may produce radioactive waste that cannot be rendered harmless without considerable expenses, 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 other radioactive waste (the Radiation Act, Section 51) is incapable of fulfilling its management obligation. STUK operates an interim storage of radioactive waste, where limited amounts of spent sealed sources and other radioactive waste are received upon compensation covering their further management costs.

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.*

### Supreme authorities

According to the Nuclear Energy Act (Section 54), the overall authority in the field of nuclear energy is the Ministry of Employment and the Economy which has the responsibility of formulating the national energy policy. The Act (Section 28) states that the Ministry shall decide, having consulted, when necessary, the Ministry of the Environment in the matter, the principles on the basis of which the waste management obligation is to be implemented. The Ministry prepares matters concerning nuclear energy, including the nuclear waste management, for the Government for decision-making.

As stipulated in the Radiation Act (Section 5), which covers radioactive, non-nuclear waste management, the Ministry of Social Affairs and Health (MSAH) is the supreme authority on the supervision of practices involving exposure to radiation.

### Regulatory authority for radiation and nuclear safety

STUK is an independent governmental organisation for the regulatory control of radiation and nuclear safety. The mission of STUK is “to protect people, society, environment, and future generations from harmful effects of radiation”. The current Act on STUK was given in 1983 and the Decree in 1997. The Decree has been revised several times due to the organizational changes, but the basic duties of STUK are still the following:

- Regulatory control of safety of the use of nuclear energy, emergency preparedness, physical protection and nuclear safeguards,
- Regulatory control of the use of radiation and other radiation practices,
- Monitoring the radiation situation in Finland, and maintaining preparedness for abnormal radiation situations,
- Maintaining national metrological standards for radiological measurements,
- Research and development work for enhancing radiation and nuclear safety,
- Providing information and publishing reports on radiation and nuclear safety issues, and participating in training activities in the field,
- Producing expert services in the field,
- Making proposals for developing the legislation and preparing the decrees and decisions of the Government in the radiation and nuclear safety fields, and issuing general guides in these fields, and
- Participating in international co-operation and taking care of international control, contact or reporting activities as enacted or defined.

STUK is administratively under the Ministry of Social Affairs and Health. Connections to various ministries and governmental organisations are described in Figure 11.

It is emphasised that the regulatory control of the safe use of nuclear energy and radiation is independently carried out by STUK and other governmental bodies cannot take for their decision a matter that has been delegated by law to STUK. STUK has no responsibilities or duties which would be in conflict with regulatory control.

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

### STUK's regulatory rights, competence and resources

STUK has the legal authority to carry out regulatory activities. The responsibilities and rights of STUK, as regards the regulation of the use of nuclear energy and the respective waste management, are provided in the Nuclear Energy 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 guides, national registers and inventories, information and public communication. STUK's responsibilities include nuclear safety, nuclear safeguards and nu-

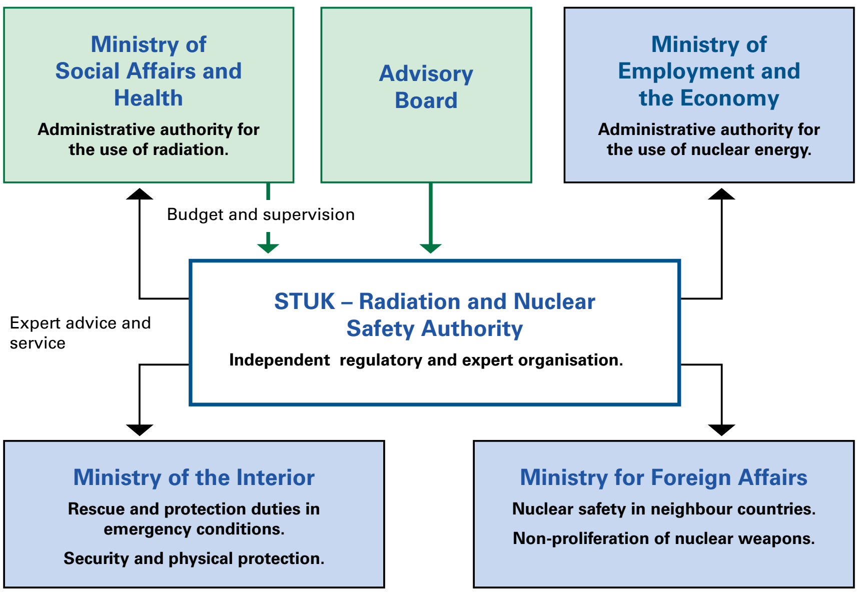



**Figure 11.** Co-operation between STUK and Ministries and other governmental organisations.

clear security. The regulatory control is described in detail in Guide YVL A.1.

STUK does not grant construction or operating licences for nuclear facilities. However, no such licence can de facto be issued without STUK's safety review and decision on the fulfilment of the safety regulations.

According to the Radiation Act (Section 16), STUK grants safety licences for the use of radiation. The regulatory rights of STUK are described in the Act (Sections 53–58).

STUK has adequate resources to fulfil its responsibilities. The total number of the personnel (at the end of 2013) was 347, of which 137 are directly involved with radiation and nuclear safety as well as nuclear safeguards and security related regulatory activities. In recent years the number of experts in the area of nuclear waste management has been about 20 persons. In addition, STUK has its own R&D programme (see Section E) supporting its regulatory needs related to nuclear waste safety, and has organized international expert support groups for the safety issues of the disposal site, technology and safety assessment. During 2013 the main emphasis of the expert groups has been supporting the regulatory review of the construction licence application for spent nuclear fuel encapsulation and disposal facility.

The organizational structure of STUK was slightly modified in 2013. The structure and the responsibilities within STUK are provided in the Quality Manuals of STUK. Also procedures for regulatory control and other activities of STUK are presented in the manuals. The new organization of STUK is described in Figure 12.

In order to ensure quality of its programme, to improve safety and to promote international co-operation and transparency, STUK organised an international peer review on its regulatory approach and activities related to the spent fuel disposal project in 2009 (http://www.stuk.fi/stuk/en_GB/palveluksessasi/ -->link International evaluations).

In October 2012, an IRRS mission (IAEA's Integrated Regulatory Review Team) was carried out. The main conclusion based on the IRRS results was that there exists no urgent need for additional improvements to upgrade the safety of the Finnish radioactive waste and nuclear waste management. The scope of the mission was nuclear facilities, except the research reactor FiR 1 (preparations for environmental impact assessment for the decommissioning of this reactor were commenced earlier in 2012), radiation sources and transport. In its preparations to this mission, STUK carried out a comprehensive self-assessment and developed a preliminary action plan for improvement.

As a result of the IRRS mission, the review team recognised several strengths and good practices such as effective safety assessment of new nuclear power plants, STUK's organisation and conduction of emergency exercises and STUK's active contribution to the global improvement of radiation and nuclear safety. They also identified areas for improvement, such as a need to strengthen the legislative framework by embedding in the law the separation of STUK from entities having responsibilities or interests that could unduly influence STUK's decisions, enhancing the effectiveness of STUK's inspection activities and implementing of an independent monitoring programme for the environment of NPPs. The Nuclear Energy Act is currently under revision, and therein STUK's position in the governmental system is addressed, as well as STUK's mandate to give binding safety regulations corresponding to current governmental decrees and its mandate to define licence conditions.

The results as well as the action plan with timetable for each suggestion and recommendation based on the IRRS mission results and the self-assessment are published on STUK's website (http://www.stuk.fi/stuk/en_GB/irrs-2012). These actions have been incorporated in the operating programmes and annual plans. A follow-up mission is planned to take place in 2015.

STUK's public communication is proactive, open, timely and understandable. Communication is a privilege and duty of all employees. Good cooperation with the media is emphasized in all communication. A prerequisite for successful communication is that STUK is known among media and general public and the information given by STUK is regarded as truthful. Communication is always based on the best available information. Even sensitive matters are openly communicated.

STUK's own web site is a very important tool in communication. STUK is also active in using channels of social media and is able to adapt to the changes in the field. Currently STUK is active in using Twitter, Facebook, Youtube and Flikr.

STUK publishes printed information materials and has published for example a series of books on radiation and nuclear safety. The books are intended to be used as handbooks for those who work in the field and for students.

STUK participates actively in European and international co-operation in the field of nuclear waste and radiation safety. STUK's experts participate in the OECD/NEA, IAEA, IRPA, ICRP and European Commission expert groups. STUK is also involved in the work of European Commission through European Nuclear Safety Regulators Group (ENSREG) and its waste management subgroup, Atomic Questions Group, as well as through Western European Nuclear Regulators Association WENRA. In addition, there is regulatory co-operation with neighbouring Nordic countries and Russia. Regarding Russia, cooperation is conducted both bilaterally and through the multinational Contact Expert Group (CEG) under IAEA auspices.

In the area of regulatory control of waste management, STUK receives about 10% of its financial resources through the Government budget. Per legislation, the licence holders pay the regulatory expenses to STUK. In 2013 the costs of the regulatory control of nuclear safety were 18.3 million €. The total costs of nuclear safety regulation were 19.7 million €. Thus the share of activities subject to a charge was 92.9%.

## Regulatory support organisations and technical and scientific programmes

STUK uses technical support organisations and independent experts to support its decision making process for the spent fuel and radioactive waste management and disposal. The expert work in spent fuel disposal is categorized into three areas: Site evaluation, engineered barrier system and safety assessment. STUK has established 15 framework contracts to cover these three areas. The main national technical support organisation of STUK in the field of nuclear energy is VTT Technical Research Centre of Finland. In VTT and other Governmental or University institutes, tens of experts are working in the area of safety of nuclear power plants as well as spent nuclear fuel and radioactive waste management.

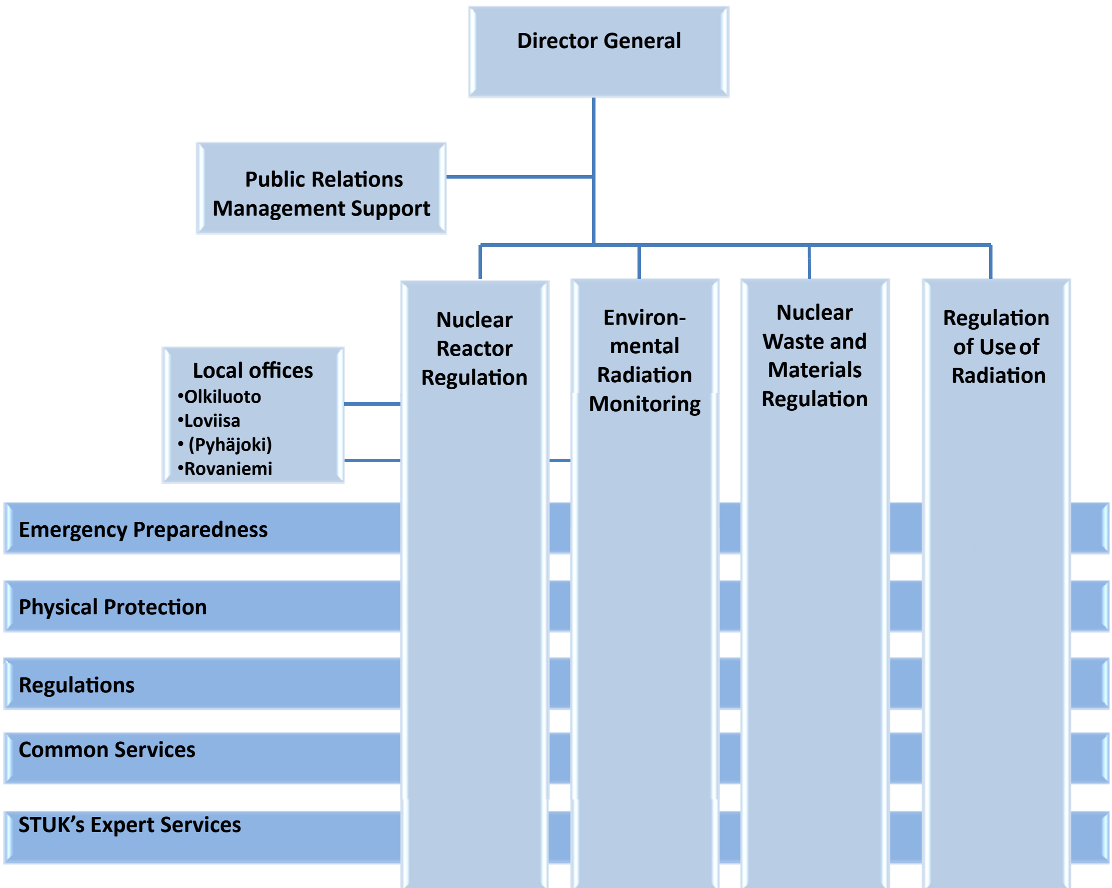



**Figure 12.** The organisation of STUK at the end of 2013.

The main R&D programmes on nuclear waste management in Finland are the following:

- The programme of Posiva Oy; the programme is mainly aimed at planning and implementing the disposal of spent nuclear fuel from TVO and FPH;
- The programme of STUK; aimed at supporting the regulatory decision making of STUK when regulating Posiva and the power companies;
- The KYT programme (KYT 2014, http://kyt2014.vtt.fi/eng/index.htm), administrated by the MEE; is aimed at supporting the further development and maintenance of the overall national competence and the sufficient and comprehensive expertise needed for regulatory purposes, and at assessing alternative solutions for the long-term management of spent fuel.
- The NPP utilities FPH and TVO have their own R&D programmes for low and intermediate level wastes (treatment, conditioning/solidification, storage, and disposal) and decommissioning of nuclear power plants.

The framework programme (in Finnish and in English) for KYT2014 can be found at the website http://www.tem.fi/files/28692/TEM_72_2010_netti.pdf. An international peer review of the KYT Programme was organised by the MEE in 2012. The results of the peer review are published at website http://kyt2014.vtt.fi/eng/index.htm

Reports on the regulatory control of nuclear and radiation safety, including radioactive waste management, are published annually.

STUK's Advisory Commission on Nuclear Safety has been established by a separate Decree (164/1988). This Commission gives advice to STUK on important safety issues and regulations. The Commission also gives its statements on licence applications. It has two international Committees, one for nuclear waste safety (NWSC) and one for reactor safety (RSC). In addition, an Advisory Commission on Radiation Safety has been established for advising the Ministry for Health and Social Affairs. The members of the Advisory Commission on Nuclear Safety and the Advisory Commission on Radiation Safety are nominated by the Government.

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

# 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. According to the Act (Section 9) each licensee, whose operations generate or have generated nuclear waste is responsible for all nuclear waste management measures and their appropriate preparation, and is responsible for their costs. If the licence holder is found not to be capable for 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 physical protection and emergency preparedness arrangements and other necessary arrangements for limitation of nuclear damages. The authorities regulate these arrangements, but the responsibilities belong to the licensees. To ensure that the financial liability for the future management and disposal of nuclear wastes and for the decommissioning of nuclear facilities is covered, the licensees under a waste management obligation shall fulfil the financial provision obligation by payments into the National Nuclear Waste Management Fund, and shall furnish the State with securities as a precaution against insolvency. The Nuclear Waste Management Fund is independent of the State budget, but it is controlled and administered by the Ministry of Employment and the Economy.

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 shall organize the practice so that it meets all radiation safety requirements prescribed in the Act and shall take all the measures needed to render radioactive waste arising from its operation harmless. The Act also provides for the responsibility of decontamination of the environment, if the radioactive material is released in such an extent that the resulting health or environmental hazards require action. According to the Act (Section 50), in utilization of natural resources containing radioactive materials, the responsible party shall ensure that radioactive wastes do not pose any health or environmental hazards during the operations, including measures taken while 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 its employees are qualified and authorised for their jobs. According to the Nuclear Energy Act (Section 19), a necessary condition for granting a construction licence of 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. Furthermore, a nuclear facility must have a responsible manager and his/her deputy approved by STUK (Section 7k § of the Nuclear Energy Act).

According to the Government Decree 717/2013 the NPP personnel shall be well suited for its duties, competent and well trained. Initial, complementary and refresher training programmes shall be established for the personnel. For ensuring safety in all situations, competent personnel shall be available in a sufficient number. The Government Decree 736/2008 on the safety of the disposal of nuclear waste includes similar requirements. Accordingly, 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 and company-level plans which are updated annually.

In addition, Posiva is co-operating with other European waste management organizations in the framework of the Technology Platform for Implementing Geological Disposal of Radioactive Waste (IGD-TP). In addition, Posiva has bilateral agreements or understandings on international cooperation with several research and implementing organizations acting in the area of nuclear waste management. Posiva also participates in the 7th Framework programme of the European Commission and in various projects of the Nuclear Energy Agency of the OECD.

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 in safety related matters of the operations the expertise is available, taking into account the nature and the risks posed by the operation. The responsible party shall appoint a radiation safety officer. In a licence application the applicant shall provide information on the competence of the persons working with radiation.

STUK shall lay down the qualifications of the radiation safety officer and other persons, as applicable, and investigate that these qualification requirements are met (Section 18 of the Radiation Act). The licensee shall provide appropriate training for the 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 detailed requirements on radiation protection training for the radiation safety officers and qualified experts. The competence that has to be demonstrated by an exam includes a general part covering the basics of radiation protection and the appropriate legislation. Special requirements are attributed to different fields of applications of radiation.

According to the Nuclear Energy Act (Section 55), STUK is responsible for controlling the necessary qualifications of the persons engaged in activities important to safety. Guide YVL A.4 sets more specific requirements for safety critical positions, e.g. for the responsible manager and persons responsible for safeguards, emergency preparedness and security. The Guide has also specific requirements on management and leadership competence.

Accordingly, personnel and human resources related issues are included in STUK's inspection programmes for Posiva and for the nuclear power plants. During the years 2011–2013 STUK has paid attention especially to assessing the organization and personnel planning of Posiva. Currently, STUK is reviewing Posiva's organization, human resources and competence as part of the construction licence application for the spent nuclear fuel encapsulation and disposal facility.

The long time scales associated with the spent fuel disposal underline the importance of the availability of qualified domestic experts in the field also in the future. However, changes in energy markets and the fast development of technology will bring new challenges to the knowledge base, and this requires special effort by all the parties. Also a considerable share of Finnish nuclear experts, within the regulator, the operators as well as within research institutes and universities, is currently retiring and at the same time additional human resources are needed owing to the spent fuel disposal project and the new NPP projects. The challenges are tackled by training young experts in the nuclear safety field in two specific training related co-operation programmes of Finnish organizations active in the nuclear energy field.

In 2010 the first course covering comprehensively nuclear waste management ("National YJH course") was launched. The impetus for the course development resulted from an evaluation of the KYT2010 programme (Finnish Research Programme on Nuclear Waste Management) pointing out the need to address competence maintenance also by the means of training, not only in research projects. The National YJH course curriculum was designed based on earlier Finnish experiences in teaching the nuclear waste management subjects. 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 80 participants altogether by the end of 2013. The training content is produced also jointly by the participating organizations, which form also the planning group that is chaired by the Ministry of Economy and the Employment. The practical course coordination has been carried out by Aalto University. (More information can be found at http://www.euronuclear.org/events/nestet/nestet2013/transactions/nestet2013-needs.pdf).

In 2012, the three Universities Aalto, Helsinki University and Lappeenranta University of Technology set up a Doctoral programme YTERA (YTERA – Doctoral Programme for Nuclear Engineering and Radiochemistry), which is funded by the Academy of Finland, the universities and the industry (the NPP utilities and Posiva). The Doctoral Programme covers all fields of nuclear engineering and radiochemistry including nuclear waste management. The Programme has seven full-time doctoral students and around 25 associated doctoral students. The current programme period runs until the end of 2015 (http://physics.aalto.fi/studies/ytera/).

In addition, during 2003–2013 several hundreds of experts have been trained during the 5–6 weeks training courses ("YK course") emphasizing the safety of NPPs and including some basic features of nuclear waste management. The 11th training course is organized in 2013–2014 and the 12th course for 2014–2015 is started in autumn 2014.

The intention is to continue with the training courses on an annual basis as long as there are enough participants who need the training. Training materials have been developed so that they can be used by the organizations in their internal training programmes as appropriate.

During 2010–2012 a committee set up by the Ministry of Employment and the Economy worked on a report aiming at giving recommendations and steps to be taken until the 2020's for ensuring competence and resources needed for the nuclear energy sector. The participants of the committee represented different organisations involved in the activities related to nuclear energy. 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 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 Report of the Committee for Nuclear Energy Competence in Finland (in English) can be found on (http://www.tem.fi/files/33099/TEMjul_14_2012_web.pdf). The report has been published both in Finnish and English.

At the end of January 2013 the Ministry of Employment and the Economy set up a working group to prepare a research and development strategy. The objectives of the working group included the following tasks:

(1) definition of main development lines for the Finnish research activities in the area of nuclear energy (vision until 2030, road maps, nuclear energy research in general, nuclear safety research, research on advanced nuclear reactor concepts, research on nuclear fusion technology),

(2) identification of priority areas for nuclear energy research taking into account future research needs and the required knowledge base,

(3) definition of the needs for the development of research infrastructure covering the needs of different actors in the nuclear energy sector,

(4) optimization of the management of national research programmes as well as the provision of funding to the research programmes and

(5) enable Finland to participate in the international research activities in the nuclear energy sector in a more significant manner than presently.

The working group was chaired by a representative of the Ministry of Employment and the Economy who also provided secretariat to the working group. The nominated members of the working group included experts from STUK, VTT, Finnish Academy, Aalto University, Technical University of Lappeenranta, University of Helsinki, FPH, TVO and Posiva. The divisions of the working group were the following: 1) Nuclear safety, 2) Nuclear waste management, 3) Researcher training in the nuclear energy field, 4) Future nuclear energy technologies and basic physics, 5) Nuclear energy research in social sciences and 6) From research to business in nuclear energy field. Results of the research and development strategy work have been published (in Finnish) at the end of April 2014.

The recommendations of the working group are 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 on 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 into the development of innovations. The growth of business operations and internationalisation are supported by bringing the players together under Team Finland. 7) It is proposed that an advisory committee be set up in connection with the Ministry of Employment and the Economy (MEE) linked with nuclear energy research and co-operation as a permanent expert body to support decision-making in national questions related to the nuclear energy.

Implementation of these recommendations will require concrete actions concerning funding of the national nuclear safety R&D programmes, including nuclear waste safety.

## Financial resources

The Nuclear Energy Act (Sections 35 to 53) provides detailed regulations for the financial arrangements for nuclear waste management and the Decree on the State Nuclear Waste Management Fund further specifies the financing system. The financial provisions are described in greater detail in the Decision of the Government on Financial Provisions for the Cost of Nuclear Waste Management (168/1988). The producers of nuclear waste are obliged to present every three years justified estimates of the future cost of managing their existing waste, including spent nuclear fuel disposal and decommissioning of facilities. The Ministry of Employment and the Economy (MEE) confirms annually 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 pay annually 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 shall provide securities to MEE for the portion of financial liability that is not yet covered by the Fund.

In 2012, VTT Technical Research Centre of Finland which operates the research reactor (FiR 1) decided to shut down the reactor and the planning of the decommissioning phase started. VTT is responsible for following almost similar practices 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, arise to about 2385 million Euros with no discounting (Figure 13). The total cost was increased by about 12 % in the period 2010–2013 from the last period 2007–2010. The increase is justified mainly with the increase of the general price level and modifications of the decommissioning and disposal plans.

### Financial provisions for post-closure

According to the Nuclear Energy Act (Section 32), a condition for the expiry of waste management obligation 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 shall 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) and Guide YVL A.3 require that a survey of quality assurance for the construction phase as well as a quality management system manual of the applicant shall be submitted to STUK for approval when applying for a construction licence for a nuclear facility. The applicant shall assess how organizations participating in the construction satisfy the Finnish safety and quality requirements. The assessment shall be included in the preliminary safety analysis report which shall 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 as a part of the operating licence application.

According to the Government Decrees 717/2013 and 736/2008, the organisations participating in the design, construction, operation, nuclear waste management and decommissioning of a nuclear facility are required to employ a management system. The management system shall aim at ensuring that priority will always be given to safety and that the requirements for quality management are commensurate to the importance to safety

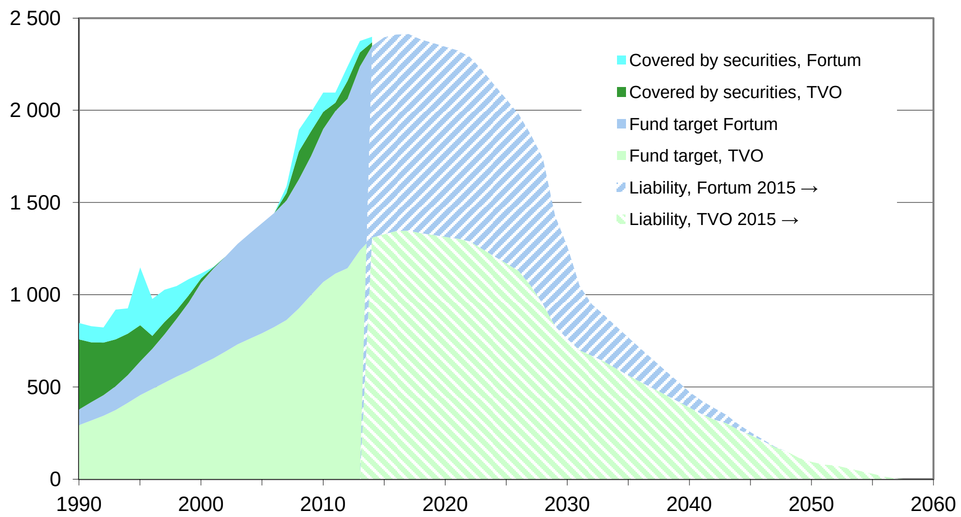



**Figure 13.** The fund targets (for the operating reactors) in the Nuclear Waste Management Fund and liabilities covered by securities. After 2014 the data are illustrative and take into account both the use of the funds for the implementation and additional inputs until the closing of the reactors.

of the action. The management system shall be systematically assessed and developed. The quality management system requirements concerning nuclear facilities are provided in Guide YVL A.3 reflecting the updating of the IAEA guidelines and the recent development in the quality management in industry.

The quality management system of the licensee/applicant is subject to approval by STUK. The licensee/applicant has to send also the quality management manuals of its main suppliers to STUK for review. Furthermore, quality assurance programmes have to be established by all other organisations participating in activities important to the safety of the use of nuclear energy. STUK verifies the implementation of quality management systems and quality assurance programmes through reviews and inspections.

The licensees (FPH and TVO) and the nuclear waste management company Posiva have adopted certified quality management systems consistent with the ISO 9001 standard. TVO has developed and implemented a project specific ISO 9001 certified quality management system for the construction phase of the Olkiluoto 3 unit. The quality management system of VTT Technical Research Centre of Finland is also based on the quality standard ISO 9001. The management systems of the aforementioned organisations fulfil also the requirement set in Guide YVL A.3. Moreover, FPH, TVO and Posiva have adopted an environmental management system according to ISO 14001.

Posiva's contractors supplying products important to safety shall have a quality management system fulfilling the requirements of Guide YVL A.3. These organisations also have to prepare a supply specific quality assurance programme. STUK verifies with graded approach the implementation of the quality management systems and the quality assurance programmes through reviews and inspections. Posiva submitted its quality management manual to STUK for approval in connection with the construction licence application. STUK approved Posiva's manual with conditions in 2013 and continues verifying the implementation of the management system with quality assurance related inspections.

STUK itself has a Quality Management System which consists of the quality policy, quality manuals on different levels, evaluation and assessment procedures and follow-up of development projects. The quality manuals contain the quality policy, description of the quality system, organization and management, main and supporting working processes and the personnel policy. The results of systematic internal audits, self-assessments and external evaluations, including international evaluations (such as IRRS in 2012) as well as feedback from licensees, customers and other stakeholders, are used as inputs for the development and continuous improvement projects of STUK's Quality Management System.

STUK also evaluates the service providers in the procurement process. STUK only uses audited or otherwise accepted service providers. Important issues in the evaluations are the service provider's professional skills, independence, and impartiality.

STUK's quality policy is under revision based on the updated STUK's strategy for the years 2013–17.

## 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 are in conformity with the ICRP 103 Recommendation (2007), ICRP 60 Recommendation (1990) and the Council Directive 96/29/Euratom.

According to the Radiation Decree (Section 3) the effective dose from occupational exposure shall 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

Government Decree 717/2013 includes regulations for limiting the radiation exposure of the general public and the releases of radioactive substances into the environment, arising from the normal operation of a NPP (including spent fuel storage and LILW treatment and storage facilities), as well as from anticipated operational transients and accidents. The constraint for the annual dose of the most exposed individual among the population, arising from the normal operation or an anticipated operational transient of a NPP, is 0.1 mSv. The annual dose refers to the sum of the effective dose arising from external radiation within the period of one year, and of the committed effective dose from the intake of radioactive substances within the same period of time. The individual annual dose constraint as a result of postulated accidents is 1 mSv, 5 mSv or 20 mSv depending on the type and likelihood of the accident. The dose constraints are defined to include all nuclear facilities on one site. Thus the future operation of Olkiluoto 3 will not increase the applied dose constraints at the site.

STUK has issued several new YVL Guides dealing with radiation protection as regards the design and operation of NPPs (Guides YVL C.1, C.2, C.3 and D.3). They cover also spent fuel storages and on-site waste management facilities, including the operational period of on-site disposal facilities for LILW. The Guides define the level of safety required and are the basis for regulatory review of the licence application as well as for review and inspection during commissioning and operation.

According to Government Decree 736/2008, a spent fuel encapsulation and disposal facility and its operation shall be designed so that as a consequence of undisturbed operation of the facility, discharges of radioactive substances to the environment remain insignificantly low. The radiological consequence of an anticipated operational transient as the annual dose to the most exposed members of the public shall remain below 0.1 mSv. The annual dose caused by postulated accidents shall remain below 1 mSv or 5 mSv depending on the type and likelihood of the accident.

The NPPs shall have a written programme (the ALARA action programme) to keep doses low. Based on the principle of continuous development, the programme shall include target limits for the highest individual annual dose and collective dose (manSv/GW net electric power) that shall not be exceeded. If the collective occupational dose at one NPP unit exceeds the collective dose limit as an average of two consecutive years, a report of the causes and the measures to improve radiation safety shall be drawn up and submitted to STUK for information. For the design of a new NPP a target of 0.5 manSv per 1000 MWe as an average over the whole lifetime of the plant is set in Guide YVL C.1.

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 would be reached. The Guides also give requirements concerning monitoring release pathways and environmental surveillance during the operation of nuclear facilities.

### Operational experiences

Experience gained from 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 of the NPP sites, originating from the Finnish nuclear facilities, has been very low. Calculated radiation exposures to the most exposed persons in the environment of the NPPs are currently less than one per cent of the dose constraint (Figure 14). 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 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.

## 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 radioactive waste management facilities are included in the plans and arrangement for NPPs. 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 the Government Decree 716/2013 and the detailed requirements by STUK in Guide YVL C.5.

The licensee is responsible for the on-site emergency response arrangements. The Government Decree states e.g. that emergency planning shall

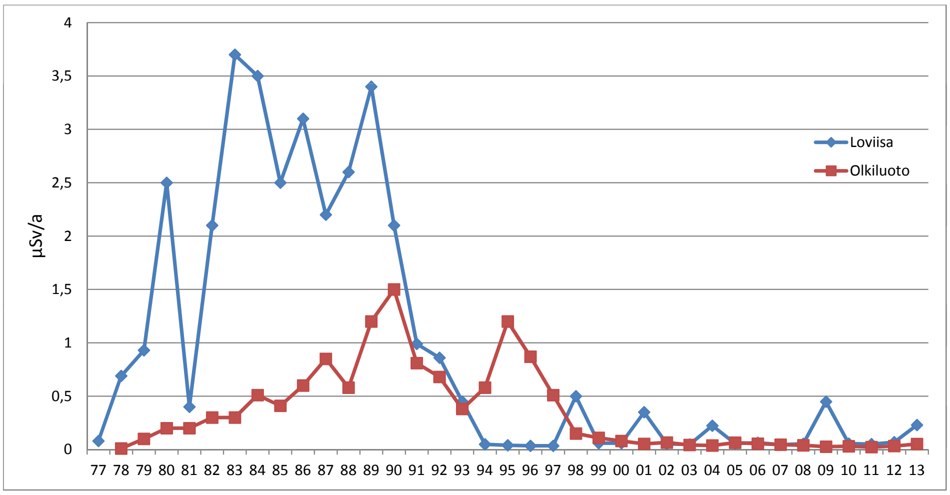



**Figure 14.** Committed doses (µSv/a) calculated by STUK to members of critical groups in the vicinity of the Finnish NPPs due to annual discharges of radioactive substances. The dose constraint is 100 µSv/a.

be based on the analysis of NPP behaviour in emergencies and on the analysis of the consequences of emergencies. Actions in an emergency shall be planned taking into account controllability of events as well as severity of their consequences. Therefore, different categories of emergency situations are considered. The Decree also requires that appropriate training and exercises shall be arranged to maintain operational preparedness. Exercises shall be arranged in co-operation with the authorities concerned.

On-site emergency exercises are conducted 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 organisations assessing the performance of the exercising teams. The scenarios have varied from severe reactor accidents to alert-status events, which involve alerting nuclear power plant emergency organization to the extent necessary to ensure the safety level of the plant. Also exercises for other situations, such as security-related incidents are regularly conducted.

Concerning the small users, the Radiation Decree (Section 17) stipulates that STUK has to be notified immediately in case of any abnormal occurrence, connected with the use of radiation and substantially detrimental to safety, at the place where the radiation is used or in its environment. In addition, STUK has to 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 are prepared by local authorities. The requirements for off-site plans and activities in a radiation emergency are provided in the Rescue Act and the Rescue Decree (2011) and in the Decree on Emergency Planning and Public Information issued by the Ministry of the Interior (2011). Full scale off-site emergency exercises are conducted every third year at both Finnish NPPs. Smaller scale exercises are held annually at each site with participation of the staff of NPP, local authorities and STUK. In addition to exercises held with licensees, exercises with local, regional and national authorities are regularly organised.

During the recent years, three important documents concerning emergency preparedness and response have been updated in Finland. Two of them are VAL Guides 1 and 2, which define the strategy, criteria, and operational intervention levels for different protective actions in early and intermediate phases. The guidelines form a unique set of documents that includes criteria for early protective measures, actions after contamination and lifting measures. They take into account both domestic nuclear or radiological emergencies and emergencies in more distant locations, and cover both accidents and intentional acts. The guidelines are also a practical implementation of the new international radiation protection concept established for emergencies (ICRP 103). The VAL Guides were an essential basis to the "Nordic Flag Book", which is a recently updated version of the document containing the strategies and operational intervention levels for protective actions commonly agreed-upon by all Nordic countries (Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency; Nordic Guidelines and Recommendations; 2014).

### 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 in the telephone directories of Finland. 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 has established an Emergency Preparedness Manual for its own activities in the case of a nuclear accident or radiological emergency. STUK has an expert on duty for 24 hours a day, in order to be able to immediately give advice to local, regional and governmental authorities on needed emergency response actions. The expert on duty receives notifications on an exceptional event directly from the operating organisations of the facilities, or automatically from the environmental radiation monitoring network covering the whole country, or from foreign authorities.

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 done 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.

## 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 provisions for decommissioning

The Nuclear Energy Act (Section 19) states that sufficient and appropriate methods for arranging the decommissioning of a nuclear facility have to be identified before the construction licence is granted. Guide YVL D.4 requires that provisions for the decommissioning of the nuclear facilities shall be made already during the design phase. During the design phase the licence applicant has to establish the decommissioning strategy. This strategy shall 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 shall be considered.

The general provision for licensing and the waste management obligation is included in the current nuclear energy legislation. The first decommissioning project in Finland will be the decommissioning and dismantling of the research reactor FiR 1. The decommissioning is planned to take place during the next reporting period. Guide YVL D.4 has been published in December 2013. This Guide replaces the earlier Guide YVL 8.2 and includes more specific requirements for decommissioning.

The licensees are responsible for the implementation of decommissioning. As described in Chapter “Financial resources”, assets are collected into the Nuclear Waste Management Fund. The Fund ensures that financial resources are available for the licensee to implement decommissioning. The state has the secondary responsibility if 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. The financing of the decommissioning and waste management actions for the research reactor (FiR 1) are also covered by assets in the Nuclear Waste Management Fund.

Also in cases of uses of radioactive sources subject to the Radiation Act, the licensee is responsible for decommissioning. The licensee shall 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 at the licensing phase to ensure the availability of sufficient funds to cover decommissioning costs.

### Decommissioning plans

The four reactor units in Finland have been operated for 33 to 37 years. These units are planned to be operated further up to the total operation period of 50 yrs (Lo 1 & 2) and 60 yrs (OL 1 & 2). No nuclear power plants are currently being decommissioned and the first project of this kind will be the decommissioning of the research reactor which will take place in the near future. The current licence of the research reactor FiR 1 is valid until 2023. Nevertheless, in July 2012 the operator VTT Technical Research Centre of Finland made the decision for the shutdown of the reactor and started a more detailed planning of the reactor decommissioning and dismantling. The first step in the decommissioning phase was the Environmental Impact Assessment (EIA) process which started in the autumn 2013. The EIA is going on and when the report has been prepared VTT will update the decommissioning plan for the reactor in more detail.

According to the Nuclear Energy Act (Section 28) the licensees are obliged to prepare decommissioning plans for regulatory review and to update them every six years. These plans aim at ensuring that decommissioning can be appropriately performed when needed and the estimates for decommissioning costs are realistic. The latest update of the NPP decommissioning plan was issued at the end of 2012 by Fortum Power and Heat. The next update for Teollisuuden Voima Oyj's (TVO) decommissioning plan will be submitted to the authorities by the end of 2014, since the latest plan was issued at the end of 2008.

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

# 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 direct disposal strategy for spent nuclear fuel management as described in Section B. Spent fuel is currently stored at the NPPs' spent fuel storages. The operation of the disposal facility for the spent fuel of TVO and FPH is scheduled to commence in the beginning of the 2020's. 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. Fennovoima Oy will become a licensee under a waste management obligation after the approval of the operating licence for the NPP unit.

The general regulations for the safety of spent fuel storage are included in Government Decree (717/2013). More specific technical requirements are given in various YVL Guides such as YVL D.3.

### Criticality and removal of residual heat

According to Government Decree 717/2013 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 high certainty. The Nuclear Energy Act, Guides YVL A.1 and YVL D.3 require that a NPP shall have sufficient space and systems for the safe handling, treatment, storage and inspection of fresh and spent fuel. Subcriticality requirements are given in Guide YVL B.4. Subcriticality of the spent fuel during interim storage shall be ensured primarily by the structural design solutions. The requirements concerning the handling and storing the spent fuel are given in Guide YVL D.3. The fuel damages 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.

### Waste minimization

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

The Finnish NPPs have performed some measures to minimize the radioactive waste produced in spent fuel storages. 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 leaking fuel assemblies are stored in the spent fuel pools without specified capsules. Pool water samples are taken regularly and no significant activity originating from the leaking fuel rods has been indentified. In Loviisa, the cobalt content of the shielding elements has been decreased to minimize the amount of activation products in the cooling water.

### Interdependencies

The Finnish direct disposal spent fuel management scheme provides that the fuel is stored in spent fuel storage pools at power plant sites and is planned to be disposed of in deep bedrock. The spent fuel of TVO and FPH is planned to be disposed of in Olkiluoto, in the vicinity of the largest present interim storage. The disposal plans including spent fuel transport, encapsulation and disposal have been adapted to all the fuel types in use in Olkiluoto reactor units 1 to 3 and in both Loviisa reactor units. Also the possible needs for modifications to take into account spent fuel from the Olkiluoto 4 unit have been identified.

Posiva, the implementing organisation for the spent fuel disposal of TVO and FPH is co-owned by these NPP utilities. Thus, the interdependencies between different steps are taken into account in practice. Fennovoima Oy is responsible for the disposal of its own future spent fuel and is required to submit a more detailed plan for a disposal programme within six years from the NPP DiP ratification, i.e. by the year 2016.

Though the current policy is based on the direct disposal option, reprocessing of spent fuel would be technically feasible later on due to the long interim storage period. The selected disposal concept would, to a great extent, be applicable to disposal of high level reprocessing waste as well. However, the present legislation requires that all management of high level waste from the NPPs, such as spent fuel, needs to take place in Finland.

### Protection of individuals, society and the environment

The operational radiation protection requirements for spent fuel storage are discussed under Article 24. Operating experiences as discussed under Article 9 indicate that spent fuel storage has caused 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 storage safety, operations and costs. The assets collected in the State Nuclear Waste Management Fund cover future costs of storage, waste disposal and decommissioning in case the licensee is no more able to take care of its responsibilities. Thus the future generations are adequately protected and they will not be imposed to any other undue burdens.

## 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 re-licensing of the operation of the plant in 2006–2007 and for the Olkiluoto NPP in connection of the periodic safety review in 2009. A comprehensive safety assessment for the Olkiluoto spent fuel storage was carried out in 2009 and reviewed by STUK 2010 in connection with licensing the construction of the storage extension.

Following the accident at the Fukushima Daichi nuclear power plant, national safety assessments as well as EU level stress tests were initiated in Finland during 2011 and 2012. The safety of spent fuel storages 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 is concluded that no such hazards or deficiencies have been found that would require immediate actions at the Finnish NPPs. However, areas where safety can be further enhanced have been identified and there are plans on how to address these areas.

The comprehensive safety assessments for applications for the renewal of licences are required to include the updates of e.g. the following safety relevant documents:

- Final safety analysis reports
- Quality assurance programmes for operation
- Technical specifications
- Programmes for periodic inspections
- Plans for nuclear waste management, including decommissioning and disposal
- Timetable of 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 shall include the same information, updated as appropriate.

The re-licensing safety reviews and statements of STUK given to the Ministry of Employment and the Economy concluded that, as regards radiation and nuclear safety, the conditions at the Loviisa and the Olkiluoto NPPs comply with the Finnish nuclear energy legislation and regulations. In addition to the review of the above mentioned documents, STUK has also performed independent safety assessments and has annually made a number of regular and topical inspections to the facilities.

The safety of the FiR 1 research reactor was reviewed in the context of the renewal of the operating licence in 2011. The present licence is valid until the end of 2023. However, in the summer of 2012 VTT made the decision to end the operation. During the decommissioning phase the safety will be reviewed focused on the safety of the decommissioning in particular. The first step in this phase has been the preparation of the programme for the environmental impact assessment (EIA) during 2013. The decommissioning of the research reactor is discussed in Section F.

### 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 reasonable achievable. To further enhance safety, all actions justified by operational experiences, safety research and the progress in science and technology shall be taken.

In conclusion, the safety review required by Article 5 of the Convention has already been carried out. Safety improvements have been annually implemented at the Loviisa and the Olkiluoto plants including the facilities for spent nuclear fuel handling and interim storage since the commissioning. At the Olkiluoto spent fuel storage recent safety improvements have been carried out in connection with the enlargement of the spent fuel storage. There exists no urgent need for additional improvements to upgrade the safety of these 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 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 for a new nuclear facility has to include e.g.:

- 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 its vicinity,
- An evaluation of the suitability of the site and the restrictions caused by the nuclear facility on the use of surrounding areas,
- An assessment report in accordance with the Act on the Environmental Impact Assessment Procedure (468/1994) 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 (713/2006) on the Environmental Impact Assessment Procedure.

In the design of a nuclear plant, including spent fuel management facilities on site, site-related external events have to be taken into account. Government Decree 717/2013 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 describes generally all the requirements concerning the site and surroundings of a nuclear facility, gives requirements on safety factors affecting the site selection as well as covers the 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. The probabilistic risk assessment (PRA) required as part of the safety review for construction and operating licences provides information on the estimated frequency of and consequences brought about by internal and external events. The requirements on 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 activities 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. The construction is in progress. Site-related factors were evaluated and reviewed in connection with the Construction Licence procedure. Further clarifications have been submitted by the licensee during construction.

During 2007–2010 new EIAs were carried out for the three NPP units planned. Two of these EIAs were carried out by the existing NPP operators TVO and FPH on their NPP sites. The third one was carried out by a new nuclear power company Fennovoima Oy. In the beginning of the EIA process they had four optional sites for the NPP but one of the sites was excluded during the EIA process. The EIA procedure did not reveal any major nuclear or radiation safety issues as regards the proposed new NPP sites or new units on the existing sites.

Separate applications for the Government's Decision-in-Principle for new NPP units were submitted in 2008 and 2009 by TVO, FPH and Fennovoima Oy. The relevant site-related factors potentially affecting the safety of the planned new NPP units and the related nuclear facilities during their projected lifetime were again evaluated for the existing Loviisa and Olkiluoto sites and for the alternative new sites at Pyhäjoki, Simo and Ruotsinpyhtää proposed by Fennovoima Oy. In late 2009, Fennovoima Oy removed the Ruotsinpyhtää site from its application for a Decision-in Principle. The evaluations were reviewed by STUK and other expert organisations in their respective fields. In addition to the Finnish regulations, IAEA Safety Requirements and Safety Guides and WENRA requirements were considered in the review.

The Government granted positive DiPs for TVO and Fennovoima Oy in May 2010. Those were ratified by the Parliament in July 2010. The DiP granted for Fennovoima Oy included two optional sites for the NPP. Fennovoima Oy announced in October 2011 that they had selected Pyhäjoki on the coast of the Gulf of Bothnia to be the site for the new nuclear power plant.

In December 2013 Fennovoima Oy signed a plant supply contract with Rosatom Overseas. Fennovoima Oy also started a new EIA process for the site since the Rosatom reactor type (AES-2006) was not included in the previous EIA. They submitted the updated EIA programme for MEE in September 2013 and MEE gave its statement on the EIA report in early June 2014.

## Safety impact

The safety impact of a spent fuel management facility is analysed either in the safety analysis reports presented as part of the construction and operating licence applications of NPPs regarding spent fuel storage or separately for the planned encapsulation and disposal facility for spent fuel. 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, shall 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 the Finnish legislation on the openness of information, notably on 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 assessment. The responsible contact authority for that procedure is the Ministry of Employment and the Economy. The EIA report 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 shall make available to the public an overall description of the facility, of the environmental effects it is expected to have and of its safety. The Ministry of Employment and the Economy shall provide residents and municipalities in the immediate vicinity of the nuclear facility as well as local authorities a chance to present their opinions in writing before the Decision-in-Principle is made. Furthermore, the Ministry shall arrange a public hearing in the municipality where the planned site of the facility is located and during this hearing the public shall have the opportunity to give their opinions either orally or in writing. The presented opinions have to 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, done in Espoo in 1991. The Finnish policy is (Act 468/1994) to provide full participation to all neighbouring countries which can be affected by the nuclear facilities in question.

Notable events during the review period 2011–2013 are described below. Spent fuel management facilities (storages) are part of the nuclear reactor projects. However, the encapsulation and disposal facility for spent fuel is licensed separately.

An Environmental Impact Assessment (EIA) procedure for the Rosatom AES-2006 nuclear power plant unit was started by Fennovoima Oy in September 2013. Public hearing on the Environmental Impact Assessment Programmes was organised by the MEE as the liaison authority specified in the EIA Decree. Several organisations made statements on the EIA Programme. STUK gave its statement on the new EIA programme in October 2013. MEE issued a statement on the EIA programme in December 2013.

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 program. Lithuania did not participate at this stage but they requested to be involved in the EIA reporting and the construction licensing stages.

## 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

The guiding requirements for spent nuclear fuel storage design and construction are described in Government Decree 717/2013 on Nuclear power plants. The general design of the nuclear facility and the technology used is assessed by STUK for the first time in the context of reviewing the application for a Decision-in-Principle and performing a preliminary safety assessment of the facility (Ruokola, 2000). More detailed safety assessments are carried out by STUK when reviewing the applications for the construction licence and the operating licence. 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.

### Limitation of radiological impacts

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 safety of the planned operations and that environmental protection has been taken into account appropriately. The Nuclear Energy Decree (Section 32) requires that the construction licence application shall include a description of the effects of the nuclear facility on the environment and a description of the design criteria that will be observed by the applicant in order to avoid environmental damage and to restrict the burden on the environment. More detailed requirements are given in Government Decree 717/2013 and, regarding design and construction of nuclear facilities, in Guides YVL A.2, YVL A.5, YVL B.1, YVL B.3 and YVL D.3.

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

### Provisions for decommissioning

The Nuclear Energy Act (Section 7g) states that provisions for decommissioning shall be included in the design of a nuclear facility. In the context of the licensing requirements, the Government Decree 717/2013 states that the design of an NPP shall 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) lays down that the application for a construction licence has to 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 wastes, and a description of the timetable of nuclear waste management and its estimated costs. More detailed requirements are given in Guides YVL A.1 and YVL D.4. The requirements regarding decommissioning plans are discussed in Section F.

### Tested technology

The requirement to use carefully examined and tested high quality technologies that are proved by experience is stated in the design requirements provided in the Government Decree 717/2013. 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, of 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 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 the other safety related documents. Protection against 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. Also the cooling water systems for the spent fuel pool have been improved to enable water feed from outside. 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 accident.

## 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; Manuals 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; Decommissioning plans.

The design of the facility is described in the Preliminary Safety Analysis Report (PSAR) and in the Final Safety Analysis Report (FSAR). The reports are submitted to STUK for approval in connection with, respectively, the applications for Construction and Operating Licences. According to the Nuclear Energy Decree, the FSAR has to be continuously updated.

The requirements of 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.

Government Decree (717/2013) requires that the nuclear power plant safety and the technical solutions of its safety systems including systems for spent fuel interim storage shall be assessed and substantiated analytically and, if necessary, experimentally. These include analyses of operational occurrences and accidents, strength analyses, failure mode and effect analyses, and probabilistic risk assessments. Analyses shall 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 also 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 re-licensing of the operation of the plant in 2006–2007. The design of the Olkiluoto plant units was reassessed by STUK in 2008–2009 in connection with the Periodic Safety Review.

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. The extension is designed and the design of the existing part of storage is updated to withstand a large aeroplane crash.

## 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 is required to 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 storages are set forth 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 possible deficiencies in design and construction can also be observed. 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. They shall 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.

Government Decree (717/2013) requires the nuclear power plant to have a condition monitoring and maintenance programme for ensuring the integrity and reliable operation of systems, structures and components. This programme shall 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 a 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 experiences, tests, analyses and plant modifications.

### Established procedures

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

### Engineering and technical support

The staffing, training and qualifications of the personnel are discussed in general in Chapter "Human resources" of Section F. 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 the expertise is secured for the operational lifetime of the facility. Guide YVL A.4 specifies the expertise requirements for the positions important to safety.

Nuclear Competence Center/Technical Support of Fortum Power and Heat Oy is working as a technical support organization for the Loviisa NPP personnel also in waste management and nuclear fuel questions. TVO utilizes sections of Nuclear Engineering and Power Plant Engineering as its technical support. Fennovoima Oy has presented preliminary plans during the Decision-in-Principle process to form competence to cover all engineering tasks during the life-cycle of the plant including nuclear waste management.

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

### Operating experiences, incident reports and evaluation

Government Decree 717/2013 requires that operational experience feedback shall be collected and safety research results monitored, and both assessed for the purpose of enhancing safety. Safety-significant operational events shall 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 program, subject to STUK's approval, shall be drawn up in order to monitor the effects of long-term storage on spent fuel.

Guides YVL A.9 (under translation) and A.10 provide in detail the reporting requirements on incidents, operational disturbances, and events which have to 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 publishes the operational events in its quarterly reports on nuclear safety that are also available to the general public in Finnish. STUK's Annual Report on nuclear safety summarizes events from the whole year and is available to the general public in Finnish and in English.

Operational events in spent fuel interim storages have been rare in recent years. Some minor events are being reported by the licensee to the regulatory body. These events have been for example events that took place in the construction site of the enlargement of spent fuel interim storage. Other types of events have been those related to complying with the 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 "Decommission" of Section F.

## 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 shall be permanently disposed of in Finland. Therefore, 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 nuclear facilities, including disposal, management of other radioactive waste and the plans for spent fuel encapsulation and disposal are discussed. The relevant general regulations are, besides the Nuclear Energy Act and Decree, the Government Decree (717/2013) on the general regulations for the safe handling and storage of spent nuclear fuel and other nuclear waste in a nuclear facility attached to a nuclear power plant, and the Government Decree (736/2008) on the safety of the disposal of nuclear waste including the disposal of low and intermediate level operational and decommissioning waste and of spent nuclear fuel. More detailed technical requirements on management, including disposal, of LILW and spent fuel are given in the YVL Guides. Radioactive waste subject to the Radiation Act is regulated by Guide ST 6.2.

### Criticality and removal of residual heat

Government Decree (736/2008) requires that in the handling of spent nuclear fuel, the occurrence of a self-sustaining chain reaction of fissions shall be prevented to a high degree of certainty and that the disposal package containing spent nuclear fuel shall be designed so that no self-sustaining chain reaction of fissions can occur, even in the disposal conditions.

Guide YVL D.3 further specifies that transport casks, storage rooms and handling equipment as well as the waste canisters shall be designed so that no critical fuel concentrations may be formed in any operational situations, including anticipated operational occurrences and postulated accidents. In addition, Guide YVL D.5 requires that the canisters emplaced in the geological repository shall retain their subcriticality in the long term, when the internal structures of the canisters may have corroded and the canisters may be partly filled with groundwater.

The criticality safety of the copper/iron canisters has been studied by Posiva since 1995 and the latest results are presented in the Construction Licence Application. Several combinations of enrichment, burnup and cooling time have been studied in order to determine the reactivity maxima between 5 years and 1 million years. The methodology used takes into account the reduction of the reactivity as a function of burnup (burnup credit).

The residual heat generation of spent fuel is also required to be taken into account in the design of the encapsulation and disposal facilities. Guide YVL D.5 prescribes that spent fuel disposal shall be implemented with due regard to long-term safety, and in doing so, one aspect to be considered is the reduction of the activity and decay heat prior to disposal. The requirements for the heat removal during the encapsulation are presented in Guide YVL D.3.

As for Posiva's disposal canister, the canister-bentonite clay interface temperature is required to be at maximum 100 °C. This temperature, with a safety margin of 10 °C, is used in the repository dimensioning calculations. The maximum temperature of the disposal canister surface is reached within 10 to 15 years after the disposal.

Thermal dimensioning including the detailed heat transfer phenomena in the near field and optimisation of the repository has been studied. The canisters are planned to be emplaced in disposal holes in tunnels with a minimum separation between 7.5 and 10.5 metres depending on the fuel type inside the disposal canisters. The distance between parallel disposal tunnels is 25 m in the planned reference case.

## Waste minimization

Waste minimization is in the interest of the nuclear power companies, as less waste to be disposed of implies smaller disposal costs. Guide YVL D.4 underlines that generation of waste shall be decreased i.a. by proper planning of repair and maintenance and by means of decontamination, clearance and volume reduction practices. The Guide also refers to sound working methods for waste minimization, e.g. by volume reduction of waste, by avoiding transfer of unnecessary objects and materials in the controlled areas and by adoption of working processes that either create only small amounts of waste or the created waste is easily manageable.

The release of very low level waste from regulatory control (clearance) is regulated by virtue of 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 chapter "Criteria used to define and categorize radioactive waste" of Section B.

The accumulation of LILW in the Loviisa and the Olkiluoto NPPs is depicted in Figure 15. The average annual accumulation of LILW to be disposed of has been fairly low: about 85 m$^3$ per plant (each having two operational reactor units). The accumulation of waste has in some years even turned to decline by effective waste minimization and volume reduction measures, such as radiochemical treatment of liquid waste, campaigns for removal of very low level waste from control, and compaction of maintenance waste. Some large metal components of NPP origin have been transported for treatment to Studsvik facility in Sweden. Activation products or external contamination containing parts or components that have been separated from the metal are transported back to Finland for disposal.

In the 1990's FPH developed, together with the Laboratory of Radiochemistry of the University of Helsinki, sophisticated selective ion exchange methods for 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 15 and also in the decrease of the doses to the most exposed persons in the vicinity of the Finnish NPPs shown in Figure 14.

TVO has made a modification in both plant units in the condensate polishing system in order to decrease the temperature and thus increase the lifetime of precoat resins. Consequently, the generation of spent ion exchange resins has decreased considerably. Low and intermediate level waste subject to long-term storage at the Olkiluoto plant mostly includes components removed from inside the reactor pressure vessels. These components are stored in the fuel pools.

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 medium level waste at the Olkiluoto NPP has been about 85 m$^3$ per reactor year.

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

The laboratories using radioactive sources in medical and research applications usually store their short-lived radioactive waste at 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

Guide YVL D.4 on 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 composition, their resistance to external and internal loads and the amount and structural and chemical stability of radioactive substances in the waste packages.

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 the disposal facility at Olkiluoto. In case of the Olkiluoto NPP, all the steps of waste management take place at the site. The Decision in Principle concerning Fennovoima Oy includes also a LILW disposal facility on the NPP site. Fennovoima Oy has performed preliminary site characterizations for proposed sites and STUK has reviewed these results.

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

## Protection of individuals, society and the environment

The operational radiation protection of radioactive waste management facilities is discussed under Article 24.

The Government Decree (736/2008) requires that a disposal facility for nuclear waste shall be designed so that as a consequence of normal operation of the facility, discharges of radioactive

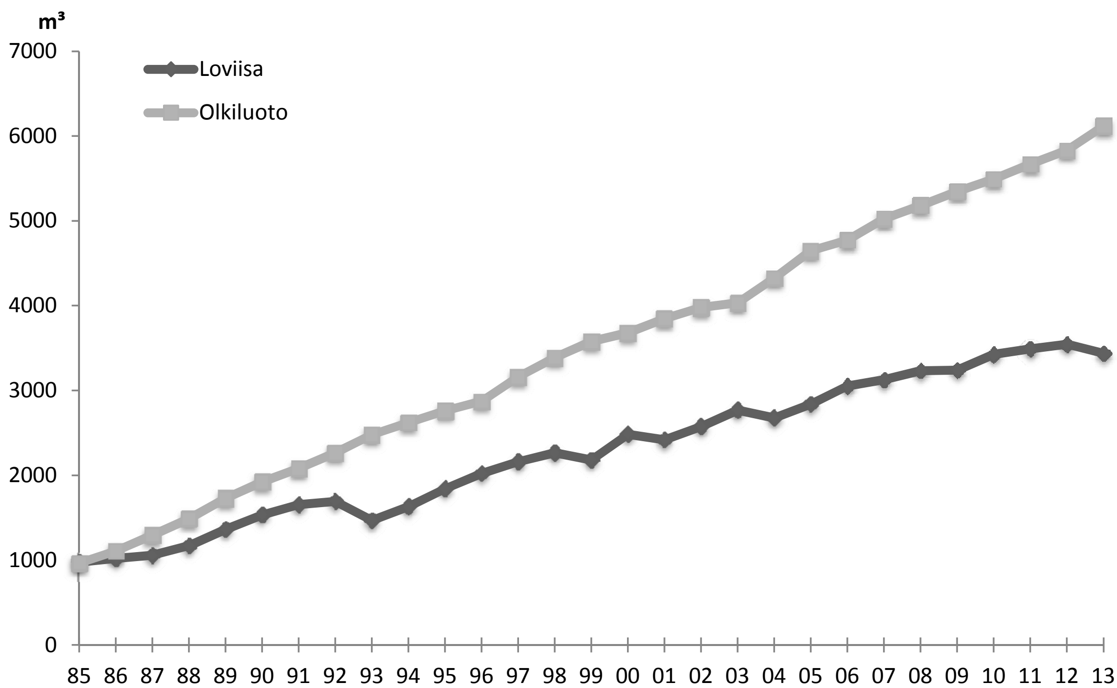



**Figure 15.** Accumulation of LILW in Loviisa and Olkiluoto NPPs.

substances to the environment would remain insignificantly low, so that the annual effective dose to the most exposed members of the public as a consequence of anticipated operational occurrences remains below 0.1 mSv. As a consequence of a postulated accident, the annual dose to the most exposed members of the public, other than workers of the facility, remains below the value of 1 mSv when the postulated accident can be assumed to occur with a frequency exceeding or equal to $10^{-3}$ per year. The annual dose to the most exposed members of the public has to remain below the value of 5 mSv when the postulated accident can be assumed to occur with a frequency of less than $10^{-3}$ per year.

Regarding the long-term radiation protection requirements for nuclear waste disposal, Government Decree (736/2008) requires that in the period of the first several thousands of years the annual effective dose to the most exposed members of the public shall remain below 0.1 mSv and the average annual effective doses to other members of the public shall remain insignificantly low. Beyond that period the average quantities of radioactive substances over long time periods, released from the disposed waste and migrating further to the environment, shall remain below the nuclide specific constraints defined by STUK. These constraints are given in Guide YVL D.5 as limits for annual activity releases to 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.

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

### Biological, chemical and other hazards

Other hazards than those posed by radiation are considered in the EIA reports in the same way as in the connection with other industrial activities but are not especially dealt with in the safety analysis of LILW repositories.

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 like heavy metals.

Some studies on radioactive nickel releases from the repository have been carried out in Finland. The results show that the potential annual release is small. In the same way it can be argued that also the release rate of chromium and poorly soluble lead and cadmium will 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 content of disposed waste. Swedish studies indicate that the increase of heavy metal concentration in seawater would be negligible, mostly owing to the release barriers in the repository.

In case the waste is isolated properly, the discharges to the environment are small, when compared with other forms of industry or other sources of hazardous wastes. At least as long as the engineered barriers are isolating the radioactive waste also the 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 may be related to some wastes arising from medical and research applications. The requirements of the relevant non-radiation related regulations, including those related to general occupational health, are applied as appropriate.

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

The limitation of the potential hazard to future generations posed by the disposal of LILW or spent fuel is discussed under Sections G and H. Section 7 h of the Nuclear Energy Act states that nuclear waste shall be managed so that no radiation exposure will occur after disposal that would exceed the levels considered acceptable during the implementation of disposal.

The Finnish nuclear waste management policy is based on the ethical principle to avoid transferring undue burdens to future generations. Disposal facilities for LILW are operational at both NPP sites and are planned to host also decommissioning waste. In 2012 TVO was granted a renewed operating licence for the LILW repository. The licence includes also the disposal of radioactive wastes from small users of radiation in Finland. Active institutional controls are not needed to ensure the safety of these disposal facilities in the post-closure period. Preparations for spent fuel disposal have progressed in accordance with the objectives set by the Government Decision in 1983. The costs of the disposal of LILW and spent fuel, as well as of the decommissioning of the NPPs and the FiR 1 research reactor, are covered by assets collected in the Nuclear Waste Management Fund. The obligation for financial provision starts when MEE or STUK grants a licence for operations that produce nuclear waste. For new NPPs the obligation to set assets in the Fund starts when the NPP has an operating licence and fuel is loaded in the reactor.

The Nuclear Energy Act (Section 7 h) requires that the disposal of nuclear waste in a permanent manner shall be planned with due regard to safety and that ensuring long-term safety does not depend on the surveillance of the disposal site. Section 10 of Government Decree (736/2008) adds that the planning of the disposal of nuclear waste shall take account of the decrease of the activity by interim storage, and the utilisation of high quality technology and scientific knowledge. Furthermore, Section 9 of the Decree requires that the long-term performance of barriers shall be confirmed by establishing an investigation and monitoring programme, to be implemented during the operational period of the disposal facility. However, the implementation of the disposal shall not be unnecessarily postponed.

## Article 12 Existing facilities and past practices

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

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

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

### Existing facilities

The predisposal management facilities for low and intermediate level radioactive waste in the Loviisa and the Olkiluoto NPPs and the FiR 1 research reactor are covered by the respective operating licences of the reactors. The LILW disposal facilities have separate licences. The requirements for safety review are described in Section G and the conclusions drawn are valid for LILW management as well.

Thorough assessments of the safety of the facilities were carried out by the licensees and reviewed by STUK in connection with the construction and operating licence applications. A periodic safety review of the LILW disposal facilities is made at 15 year intervals. The Olkiluoto LILW disposal facility was taken into 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 new Olkiluoto 3 NPP unit for disposal in the facility was evaluated. The operating licence admitted in 1992 covered the disposal of operational waste from Olkiluoto 1 and 2. TVO submitted an application to the Government in September 2011 for an amendment of the operating licence of the VLJ repository to allow the disposal of the low and intermediate level nuclear waste from the Olkiluoto 3 plant unit, and also of some radioactive wastes originating from the use of radiation in non-nuclear industry. The Government made a decision on the modification of the operating licence conditions of the Olkiluoto

VLJ repository in November 2012. The small user wastes are currently stored in underground facilities either in the connection of the VLJ repository in Olkiluoto or in Roihupelto in Helsinki (see Table 2 in Section D).

The first stage of the Loviisa LILW disposal facility, the LLW disposal tunnel, was taken into operation in 1998. The construction of the second stage of the facility, 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 third stage of the disposal facility, the connecting tunnel and the third LLW disposal cavern, was reviewed by STUK in 2010. The third cavern will be used in the first place as LLW storage and will be licensed for disposal operations in the future. FPH submitted its periodic safety review of the LILW facility to STUK in 2013.

In conclusion, the safety reviews regarding the predisposal management of LILW at NPPs and the research reactor required by Article 12 are carried out at the time of licensing, the safety analysis reports being continuously updated. 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 the commissioning of the NPPs.

Talvivaara Sotkamo Oy is a mine which produces nickel and zinc. During the production processes uranium follows the other metals. Since uranium has not yet been recovered, it ends up to the gypsum waste water pond. Now, the amount of uranium in the gypsum pond is estimated to be 300–600 tonnes.

On November 4, 2012, water from a gypsum waste water pond began to leak at the Talvivaara mine after the bottom of pond gave way. The leaking waste water was acidic and contained high concentrations of heavy metals. Normally, the uranium concentration in the gypsum pond water is low, i.e., less than 50 microgram per liter. But due to a rainy autumn, extra water containing additional highly acidic substances had been conducted from the mining area to the gypsum ponds. For this reason, the pH of the water fell so low that the uranium started to dissolve from the gypsum into the water. The highest measured uranium concentration in the leakage water was about 6000 micrograms per liter. Most of the leaking waste water was prevented from leaking outside the mining area but some of it had to be led to downstream waters. According to current estimates, about 0.1–0.6 ton of uranium was released into the environment. In the mining area, there are about 30–40 tonnes uranium in different kinds of waters. Uranium has been removed from contaminated

**Figure 16.** Uranium containing precipitation stored in geotubes in Talvivaara mine.

water by lime precipitation (neutralization). This precipitation containing uranium is temporarily stored in different basins in the mining area and in large geotubes (Figure 16).

### Past practices

In 1958–1961, a company established by the Finnish industry carried out uranium mining and milling activities in a pilot scale facility in Paukkajavaara in the municipality of Eno in the Eastern part of Finland. About 31 000 tonnes of uranium ore was excavated from small open mines and an underground mine. After the termination of the activities the mines were left open and the mine and mill tailings were left at the site.

The restoration of the site was carried out in 1992–1994 by the current owner of the area. The mine and mill tailings were covered with layers of clay and gravel and a soil layer on the top. Finally, trees were planted on top of the disposal site. Furthermore, the bottom sediment of a nearby lake was covered by an additional layer of soil and other material. STUK inspected the work and carried out environmental surveillance in the area. Five years after the completion of the restoration, STUK, having carried out further environmental studies, concluded that no radiation risk is posed to the human health by the disposed mining and milling waste and confirmed the waste to be permanently disposed of in accordance to the requirements of the Nuclear Energy Act (Sections 32–34). However, as an extra precaution restrictions for utilization of the site were imposed: any permanent occupancy, construction work or earthmoving is not allowed in the area.

Very small scale uranium mining and milling activities were carried out in 1956–1959 in Askola, Southern Finland; only about 1000 tonnes of ore was treated. The owner of the site did some restoration work in the area in late 1980's and reported to STUK in 1991. STUK's inspection and later investigations made by STUK in 2007 concluded that the restoration was not yet satisfactory and the case is still open. Even so, the area does not pose any immediate hazard to the nearby population or the environment.

Some wastes from non-uranium mining and ore processing contain elevated levels of uranium and thorium. In 1961–1972 lead was mined and processed in Korsnäs, on the West Coast of Finland. The amount of waste is 760000 tons. The average uranium and thorium concentrations of the waste are both estimated at 60 ppm. Currently there is no foreseen use for the area and the area is surrounded with a fence. Possible remedial action is considered when the current owner (Municipality of Korsnäs) decides on the possible future use of the area. Also about 36000 tons of milled ore remained at the mining area. It contains 120–360 ppm of uranium and 250–370 ppm of thorium. In 1997, the heaps of ore were remedied by covering them with a one-meter thick layer of soil.

At the Vihanti Zinc mine, where mining activities ended in 1992, the wastes contain uranium 400 Bq/kg (30 ppm) on an average. The area has been covered with a thin layer of soil which, together with the increasing vegetation, prevents dusting and reduces slightly external gamma radiation.

Several radioactive sources containing Am-241 were accidentally melted in Outokumpu Stainless Oy's steel foundry in Tornio, Finland during 2006–2010. Radioactive waste due to this melt was disposed in the vicinity of the foundry and covered in accordance with the approved plan in autumn 2010.

## 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*

**Table 4.** Siting of the spent fuel disposal facility in Olkiluoto.

| | |
|---|---|
| | **Site characterisation phase** |
| **1983–1999** | Site investigations and regulatory reviews<br>• Countrywide site screening 1983–85<br>• Preliminary site investigations at five areas 1987–1992<br>• Detailed site investigations at four areas 1993–1999<br>• Regulatory reviews in 1986 and 1993 |
| | **Environmental impact assessment procedure** |
| **1997**<br><br><br><br><br>**1998** | EIA Programme<br>• 20 scoping workshops organised by Posiva in four municipalities<br>• EIA programme report, February 1998<br>• Public hearings in four municipalities<br>• Statements and written opinions to MTI*<br>• Judgement by MTI, November 1998 |
| **1999** | EIA Report<br>• Report, May 1999<br>• Public hearings in four municipalities<br>• Statements and written opinions to MTI<br>• Judgement by MTI, November 1999 |
| **2008** | EIA Programme on expanding the capacity of spent nuclear fuel repository<br>• EIA Programme, May 2008<br>• Public hearing in Eurajoki municipality<br>• Statements and written opinions to MEE<br>• Judgement by MEE, August 2008<br><br>EIA Report<br>• Report, October 2008<br>• Public hearing in Eurajoki municipality<br>• Statements and written opinions to MEE<br>• Judgement by MEE, March 2009 |

* During the EIA procedure and the DiP processes for disposal of the spent fuel from the operating reactors and separately for the spent fuel from OL3, during 1997 to 2001 the statements were issued by the predecessor of MEE, i.e. the Ministry of Trade and Industry, MTI.

*not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.*

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 includes also an LILW repository at the NPP site. In the context of the Decision-in-Principle process in 1999–2001 for TVO's and FPH's spent fuel disposal, Olkiluoto was selected as the site for a spent nuclear fuel disposal facility. Posiva submitted at the end of 2012 a construction licence application for a spent fuel encapsulation and disposal facility. The licence application documentation addresses also the site related analysis concerning for example the design of facilities and the suitability of the disposal facility host rock. Concerning siting, design, construction and assessment of safety, details of the regulatory approach to the Olkiluoto spent fuel disposal project are described in Annex L.1.

The DiP for Fennovoima Oy required that it should have an co-operation agreement with shareholders of Posiva Oy for spent fuel disposal in the Olkiluoto disposal facility or alternatively an EIA programme for a separate repository within six years from the date of the DiP ratification (2010)

**Table 4.** (continues)

| | **Decision-in-Principle process** |
|---|---|
| **1999** | Application for DiP<br>• DiP application submitted to the Government, May 1999<br>• EIA report annexed to the application<br><br>Handling of application<br>• Public hearing in Eurajoki municipality<br>• Statements and written opinions to MTI |
| **2000** | • Preliminary safety appraisal by STUK, January 2000<br>• Consent statement by Eurajoki municipality, January 2000<br>• DiP by the Government, December 2000 |
| **2001** | • Ratification of the DiP by the Parliament, May 2001 |
| **2002** | Ratification of the DiP to expand the capacity of the repository to include the spent fuel from the 5th reactor unit (Olkiluoto 3 reactor unit) |
| **2004** | Start of construction of the underground rock characterisation facility, ONKALO, with the aim of final confirmation licence of the site suitability |
| **2008** | Application for DiP on spent fuel from the Olkiluoto 4 unit<br>• DiP application submitted to the Government, April 2008<br>• EIA report 1999 annexed to the application |
| **2009** | Handling of application of Olkiluoto 4<br>• Public hearing in Eurajoki municipality, October 2008<br>• Statements and written opinions to MEE<br>• Preliminary safety appraisal by STUK, May 2009<br>• Consent statement by Eurajoki municipality, December 2008<br>• DiP by the Government, May 2010<br>• Ratification of the DiP by the Parliament, July 2010<br><br>Application for DiP on spent fuel from the Loviisa 3 unit<br>• DiP application submitted to the Government, March 2009<br>• EIA report 2008 annexed to the application<br><br>Handling of application of Loviisa 3<br>• Public hearing in Eurajoki municipality, June 2009<br>• Statements and written opinions to MEE<br>• Preliminary safety appraisal by STUK, October 2009<br>• Consent statement by Eurajoki municipality, August 2009<br>• Unfavourable DiP by the Government, May 2010 |
| **2010** | Ratification of the DiP to expand the capacity of the repository to include the spent fuel from the 6th reactor unit (Olkiluoto 4 reactor unit) |
| **2012** | Submission of application for the construction licence of the spent fuel encapsulation and disposal facility 28th December 2012 |

by the Parliament. The first possible step for siting a separate disposal facility for the spent fuel of Fennovoima Oy will be the EIA programme.

The description of siting procedures, provided under Article 6 (Section G.) for the NPPs (including the spent fuel storages), 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, Government Decree (736/2008) states that the geological characteristics of the disposal site, as a whole, shall be favourable for the isolation of the disposed radioactive substances from the environment. An area having a feature that is substantially adverse to long-term safety shall not be selected as the disposal site. Guide YVL D.5 specifies the generic site suitability criteria. The siting requirements for waste and spent fuel management facilities are described in Guides YVL A.2, YVL D.3 and YVL D.4. Spent fuel disposal facility site investigations at the Olkiluoto site have been going on since the early 1980's. These have included many kinds of investigations from the air and surface, boreholes at different depths, and finally they will include direct investigations at the disposal depth at the ONKALO facility to confirm the suitability of the site.

The various steps of the siting process concerning the disposal of spent fuel in Olkiluoto are detailed in Table 4.

## Article 14 Design and construction of facilities

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

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

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

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

The discussion under Article 7 (Section G) is valid for predisposal management facilities for LILW, which are covered by the operating licences of the NPPs and Government Decree (717/2013).

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 Government Decree for nuclear waste disposal (736/2008). Guides YVL A.5, YVL B.1 and YVL D.3 give detailed safety requirements for the encapsulation facility design and construction.

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

According to Government Decree (736/2008), the design, excavation, other construction works and closure of the underground facility shall be implemented in a manner that retains the characteristics of the host rock important to long-term safety as far as possible. The depth of the waste emplacement rooms shall be selected appropriately with regard to the waste to be disposed of and the local geological features. The objective shall be that the impacts of above-ground events, actions and environmental changes on long-term safety will remain minor and inadvertent human intrusion to the repository will be difficult. More detailed requirements on the design principles are given in Guide YVL D.5.

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 repository in Olkiluoto). These closure plans will be reconsidered in the context of later licensing stages or the periodic safety assessments.

Concerning siting, design, construction and assessment of safety, a more detailed description of the regulatory approach to the Olkiluoto spent fuel disposal project is presented in Annex L.1.

## 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 approach

The discussion under Article 8 on the safety assessment of spent fuel storage is valid for the predisposal management of LILW from NPPs because both activities are covered by the operating licences of the reactor units at the present NPPs and by the Government Decree (717/2013).

The predisposal management of radioactive wastes subject to the Radiation Act involves generally 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 is evaluated in the context of the licensing processes.

Regarding the disposal of spent fuel, compliance with long-term radiation protection objectives as well as the suitability of the disposal concept and site shall, according to Government Decree (736/2008), be justified by means of compliance with the long-term radiation protection objectives, equally the suitability of the disposal concept and site shall be justified through a safety case that addresses both the expected evolutions and unlikely disruptive events impairing long-term safety.

According to Guide YVL D.5 a safety analysis, or a safety case as in the Government Decree, shall include:

- a description of the disposal system and the definition of barriers and safety functions;
- a 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 in 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 are 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 in every 15 years, unless otherwise provided in the conditions of the operating licence. The periodic safety review shall include assessments of the disposal facility's safety status and the long-term safety of the disposal as well as potential development targets in order to maintain and enhance safety. The safety analysis report and the safety case shall be updated to reflect the results of the safety review. The periodic safety review shall 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 Annex A of Guide YVL D.5. The post-closure safety case shall 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 with their performance targets.

The scenarios shall be systematically composed to cover any events and factors that may be of relevance to long-term safety and that may arise from:

- external factors, such as climate changes, geological processes and events or human actions;
- radiological, mechanical, thermal, hydrological, chemical, biological and radiation-related factors internal to the disposal system;
- quality non-conformances in the barriers; and
- the combined effects of all the aforementioned factors.

The base scenario shall assume that the performance targets defined for each safety function are met. The influence of declining performance of one or several safety functions shall be analysed by means of variant scenarios. Disturbance scenarios shall be constructed for the analysis of unlikely events impairing long-term safety referred to in Guide YVL D.5. The argumentation for the assumed extent of the declining performance of a safety function shall be presented.

In order to analyse the release and migration of disposed radioactive substances, conceptual models shall be drawn up to describe the underlying events and processes. In addition to the models constructed to describe such release and migration processes, conceptual models shall also be constructed to describe the safety functions and the factors affecting them. The respective mathematical models are derived from the conceptual models, normally by way of simplification. The simplification of the models and the determination of the required input data shall be based on the principle that the performance of a safety function will be neither overestimated nor overly underestimated.

The modelling and the determination of input data shall be based on high-quality scientific knowledge and expert judgement obtained through empirical studies, such as laboratory analyses, site investigations and evidence from natural analogues. The models and the input data shall be consistent with the scenario, the assessment period and the disposal system. Whenever the input data used in modelling involve random variations due to, for example, the heterogeneity of the bedrock, models that accommodate random variation shall be employed.

The selection of computational methods, performance targets and input data shall be based on the principle that the actual radiation exposure and the actual quantities of released radioactive substances shall, with a high degree of certainty, be lower than those obtained through safety analyses.

The significance of the uncertainties involved in the safety case shall be assessed by means of appropriate methods. The safety case shall include an assessment of the confidence level with regard to compliance with the safety requirements and of the uncertainties with the greatest impact on the confidence level.

In the event that a scenario cannot be comprehensively and reasonably assessed by means of quantitative safety analyses, its significance shall be examined by means of complementary considerations, such as calculations by simplified methods, comparisons with natural analogues, or observations of the geological history of the disposal site. The significance of such considerations grows as the assessment period increases, and safety evaluations extending beyond the time horizon of one million years can mainly be based on complementary considerations. Complementary considerations shall also be made parallel to the actual safety assessment to enhance the confidence in the results of the analysis or certain parts of it.

The safety case shall be carefully documented. The basic assumptions that underlie each part of the safety case along with the methods employed, the results obtained and the relation of the part to the case as a whole shall be easy to ascertain (clarity), and the rationale for the assumptions, input data and the models adopted shall be easy to find in the documentation (transparency and traceability).

The quality of the safety case shall be ascertained through the management system related to the design, construction and operation of the disposal facility. The party implementing the project shall have an expedient organisation, adequate competence and an appropriate information management system in place. The various stages of the preparation of the safety case shall be systematically planned, and the reliability of the results of crucial studies and analyses shall be ascertained by means of independent expert reviews or analyses, for example.

### Implementation

Concerning safety after closure, Posiva continued the safety assessment work after the Decision-in-Principle with the goal to be ready to submit the construction licence application for the Olkiluoto encapsulation and disposal facilities in 2012. A framework for the development of the post-closure safety case was first reported in 2005 and updated in 2008. Posiva has 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. The TURVA-2012 Safety Case portfolio consists of the following main reports (references to these reports are given in Annex L.2):

- The **Synthesis** report describes the overall methodology of analysis, bringing together all the lines of arguments for safety, and the statement of confidence and the evaluation of compliance with long-term safety constraints
- The **Design Basis** report explains the performance targets and target properties for the repository system
- The **Description of Disposal System** report summarizes the initial state of the repository system and present state of the surface environment
- The **Features, Events and Processes** report describes the features, events and processes affecting the disposal system
- The **Performance Assessment** analyses the performance of the repository system and evaluates the fulfilment of performance targets and target properties
- The **Formulation of Radionuclide Release Scenarios** report describes the climate evolution and defines release scenarios
- The **Models and Data for the Repository System** report presents models and data used in the performance assessment and in the analysis of the radionuclide release scenarios
- The **Biosphere Data Basis** presents data used in the biosphere assessment and summary of models
- The **Assessment of Radionuclide Release Scenarios** and **Biosphere Assessment** reports describes the analysis of releases and calculation of doses and activity fluxes
- The **Complementary Considerations** provides supporting evidence including natural and anthropogenic analogues

The safety case will rely heavily on a number of supporting reports, especially

- The **Site Description**
- The **Biosphere Description**
- **The Biosphere Assessment: Modelling reports**
- The **Design** and **Production Line** reports, which describe the design and the initial state of the repository after emplacement of the canisters.

In 2013 STUK carried out an overall assessment of the post-closure Safety Case submitted to STUK in connection with the filing of 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. STUK's regulatory review of the construction licence application is on-going and to support the more detailed review STUK also uses outside experts. The regulatory review process is described in more detail in Annex L.1.

An essential part of Posiva's spent fuel disposal programme is the investigations that are carried out in the underground rock characterisation facility (ONKALO). The excavation of ONKALO has reached its final depth of 420 metres. Investigations aim at confirming the suitability of the bedrock for disposal and acquiring data on site characteristics for the design of the disposal facility and for its safety evaluation.

STUK has implemented a regulatory inspection programme for reviewing the development of the construction licence application and the supporting long-term safety case and for the ONKALO project. These activities are described in more detail in Annex L.1.

## Article 16 Operation of facilities

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

*(a) 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;*

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

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

(d) *engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;*
(e) *procedures for characterization and segregation of radioactive waste are applied; 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 discussion on and references to nuclear energy legislation, general safety regulations and STUK's guidance discussed under Article 9 are also valid for the predisposal management of LILW from the NPPs, for the operational period of a LILW disposal facility, spent fuel encapsulation and spent fuel disposal. 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, shall be submitted to STUK when applying for an operating licence. 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 shall ensure that the systems, structures and components as well as the entire facility function as planned. The licensee shall ensure that an appropriate organization, adequately skilled workforce and applicable instructions exist for the future operation of the facility.

### Operational limits and conditions

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

### Established procedures

According to Government Decree (736/2008) appropriate instructions shall 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 shall 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 discussed also in Section G.

### Updated assessment for post closure period

For the LILW repositories, both in Loviisa and in Olkiluoto, there is an operating licence condition requiring a periodic update of the safety assessment. Government Decree (736/2008), concerning nuclear waste disposal, requires that the safety case shall be updated every 15 years, if not otherwise prescribed in the licence conditions. The safety case shall be updated prior to the final closure of the disposal facility.

### Engineering and technical support

Government Decree (736/2008) requires that the licensee's organisation shall have access to the professional expertise and technical knowledge required for the safe operation of the nuclear waste facility and for the long-term safety of the nuclear waste disposal. The LILW repositories operate under the NPP organizations and the requirement for adequate engineering and technical support in Guide YVL A.4 applies.

Posiva's expertise on safe operation is based on the resources of its Department for Development and the Safety Unit. The owners of Posiva, i.e. TVO and FPH, share their technical support for Posiva. Technical support resources are also provided 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 repositories to ensure compliance with the 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 canister. The properties that have a bearing on operational or long-term safety of disposal have to be defined and characterized.

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

### Decommissioning plans

The plans for the decommissioning of the facilities for LILW and spent fuel management, others than repositories, are part of the decommissioning plans of the NPPs. Decommissioning is discussed in more detail under Article 26.

### Closure plans

In accordance with Government Decree (736/2008), a safety case for a disposal facility shall be included in the application for a construction licence and for the operating licence. The safety case shall be updated every 15 years, if not otherwise prescribed in the licence conditions. The safety case shall be updated prior to the final closure of the disposal facility. An investigation and monitoring programme shall be implemented during the operational period of the disposal facility to obtain confirming information on the long-term performance of the barriers.

## 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.*

### Records

According to Government Decree (736/2008), records shall be kept of the disposed waste which includes waste package specific information on 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 1.5 gives general requirements for reporting to STUK and includes provisions for waste management reporting. More detailed requirements for waste management records are given in Guides YVL D.4 and YVL D.5. During the operational period the records referred to above shall be annually complemented and submitted to STUK. STUK shall organise the storing of the information on the disposal facility and the disposed waste in a permanent manner. At the time of the closure of the repository, the records of the disposed waste and the relevant information in the FSAR will be converted into a form for long-term deposition approved by the national archive.

### Institutional control

Two types of institutional control can be implemented: restrictions in land use (passive control) and technical post-closure surveillance (active control).

According to the Nuclear Energy Act, Section 63, STUK's supervisory rights include issuing land use restrictions after the closure of the disposal facility when deemed necessary. Government Decree (736/2008) on nuclear waste disposal further stipulates that an adequate protection zone shall 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 repository or the nearby host rock, are precluded for 200 years at the most by means of land use restrictions and other passive controls. YVL D.5 also requires that before closure the facility operator submits to STUK a closure plan 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 60–100 m depth in the bedrock and the spent fuel repository is planned to be located at least 400 m below the surface.

### Potential intervention measures

After approval of the closure of a LILW or of a spent fuel repository, the State bears the responsibility of the waste repository and all intervention measures that may be needed (the Nuclear Energy Act, Section 34). Such measures are unlikely because the repository 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 destination south of latitude 60 degrees South for storage or disposal.*

*Nothing in this Convention prejudices or affects:*

- *(a) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;*
- *(b) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;*
- *(c) the right of a Contracting Party to export its spent fuel for reprocessing;*
- *(d) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.*

### Regulatory approach

Regulations on transport of all kinds of dangerous goods are laid down in Act and modal Decrees on Transport of Dangerous Goods. As far as radioactive material is of concern, additional requirements are given in the Radiation Act and Decree as well as in the Nuclear Energy Act and Decree. Concerning the transboundary movement of radioactive material, the Regulation 93/1493/Euratom on shipments of radioactive substances between Member States shall 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. Further guidance is given in regulatory guides YVL D.2 and ST 5.7 of STUK.

With respect to illicit trafficking, regulatory and detection measures were taken in mid 1990's to address and prevent illicit trafficking of nuclear and other radioactive materials across Finland's borders. It included installing fixed monitors for vehicles and railway traffic to all major crossing points along the Finnish–Russian border and at Helsinki harbor, and portable monitors at all crossing points. In 2008 the Customs and STUK launched a joint project for revising radiation control at the borders, which will be implemented in 2009-2014. The project includes equipment procurements and upgrades at the Finnish border crossing points, including upgrading all systems with neutron detection capability, allowing better detection of special nuclear materials. Also, integrating the capability of expert reach-back support is one key part of the project. As part of the improved expert support, an update of common operational methods and instructions is included in project. To ensure that the new methods are efficiently implemented at the border crossing points, a training plan and provision of training together with the Customs School are included the project.

## Experiences

According to an agreement between Finland and the Soviet Union spent fuel was to be shipped from the VVER type Loviisa power plant to the Soviet Union/Russian Federation. Subsequent to the amendment of the Nuclear Energy Act approved by the Finnish Parliament in 1994, the transportation was ceased in 1996. During the years 1981–1996 altogether about a total amount of 330 tU of spent fuel was returned to Russia. The spent fuel was transported by a special train in TK-6 transport casks under special safety arrangements.

Besides the shipments of spent fuel discussed above, there have been few cases of transboundary movements. In 2008–2013 two spent fuel rods were shipped out of Finland for research purposes and some large metal components for scrapping. Radioactive waste was shipped back to Finland after the treatment.

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 cooperation with Russian counterparts, the number of cases has fallen drastically and altogether only three cases of illicit radioactive material were detected at the Finnish border control between 2001 and 2013. Radioactive alarms at the border are nowadays mostly caused by persons coming from therapy treatment or by raw material having naturally occurring radioactive materials.

# 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 control of sealed sources

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 the Member States.

According to the Radiation Act (Section 16) prior authorization is required for all activities with radioactive sources, e.g. for the use, manufacture, trade in, holding and disposal of sources. A safety licence is granted by STUK upon written application. 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 1–8 years, depending on the type and extent of the practice. For sealed sources the inspection frequency is normally once in 5 years. The main objective of an inspection is to validate that radioactive sources are used and stored safely and other conditions set in the safety licence preserve. The inspector shall identify each sealed source. However, in premises where several tens or more sources are employed (such as a large industrial facility) the licensee shall provide written evidence on its own regular checks on all the sources and then the inspector shall randomly select about 10–20% of the sources for identification. Any discrepancies to licensing information concerning placing of 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, including also 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 into STUK's database. However, records of transfers of sources maintained by dealers are reported to STUK annually and they are also subject to inspection by STUK at any time.

### 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 shall 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 (24.4.2014) 285, i.e. less than 5% of the total number of such devices in use (total number is about 6330).

TVO has leased to the State a cavern in the LILW disposal facility at Olkiluoto for interim storage of non-nuclear radioactive waste. The amount of stored waste cannot be more than 100 m$^3$. 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. A few high activity sealed sources will need a different disposal route, which is not yet determined.

Disused sources are collected by a private entrepreneur, 'Suomen Nukliditekniikka', by whom they are repacked, as necessary, and then transferred to the storage at Olkiluoto. STUK's Radiation Practices Regulation Department has issued an authorisation based on the Radiation Act to Suomen Nukliditekniikka for its operations as a recognised installation. The safety of the operations at the Olkiluoto storage is independently supervised by STUK's Department of Nuclear Waste and Materials Regulation.

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 shall be required for all sources.

Sources manufactured in Finland can be returned to Finland once they have become disused sources.

## Orphan sources

According to the Radiation Act (Section 50) the licensee is required to take all the measures needed to render harmless radioactive wastes arising from its operations. If the origin of the waste is unknown, like in the case of orphan sources, the State has the obligation to render the radioactive waste harmless (Section 51). In such case, the licensee – if identified later – shall compensate the State for the costs incurred in such an action.

With respect to the orphan sources and border controls, see Section I.

All important users of scrap metal have installed fixed radiation monitors at the gates of their installations. STUK co-operates with the Customs and the metal industry in questions such as measurement arrangements and training of personnel. 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 among imported scrap metal. Orphan sources, whose owner cannot be identified, are delivered to the State interim storage at Olkiluoto.

# SECTION K Planned activities to improve safety

## Spent fuel disposal

The project to construct an encapsulation and disposal facility for spent nuclear fuel in Olkiluoto can be seen as the most important activity for improvement of nuclear waste safety in Finland. The project has progressed as planned during the reporting period. The construction licence application for the facility was submitted at the end of 2012, and STUK started the review of the application with the aim of being able to finalize the safety evaluation by late 2014.

Both Posiva and STUK continue to develop their processes and resources to ensure that they are ready for the next steps in the program: implementation and oversight of the construction as well as the further development of equipment and the updating and completion of safety case during the review process.

STUK finalised the complete revision of the system of safety guides (YVL-guides) during the reporting period. After the construction licence review STUK will incorporate the experience gained in developing the guidance further.

The disposal project requires continued research and development programmes. As stipulated by the Nuclear Energy Act (990/1987), the producers of the waste are solely responsible for the safe handling, management and disposal of their wastes. This responsibility includes the planning and implementation of required research and development efforts as well as bearing all costs thereof. For regulating the safe management of nuclear wastes, independent R&D is necessary for MEE and STUK. The three main R&D-programmes concerning spent nuclear fuel disposal are:

- The R&D-programme of Posiva; the programme is mainly aimed at planning and implementing the spent fuel disposal project;
- The R&D-programme of STUK; the regulatory R&D-programme aims at supporting the regulatory decision making of STUK;
- The KYT2014-programme, and its planned follow-up programme KYT2018 for the years 2015 2018, administrated by MEE; the program aims at supporting the creation and maintenance of the overall competence and the basic abilities needed regarding management and disposal of mainly spent fuel, and in addition at assessing alternative solutions for long-term management of spent fuel.

Posiva's R&D-programme is obviously the largest and has had the major challenge to produce the results, which are related to the Olkiluoto-site, the engineered barrier system and the safety case and which were needed to justify the construction licence application submitted at the end of 2012. Further R&D is still needed for the next licensing phase (operating licence) e.g. in decreasing uncertainties in safety assessment.

## Spent fuel storage

The extension of the spent fuel interim storage facility at Olkiluoto started in 2010 and the facility is expected to be operational in 2014. Protection against large airplane crash is included in the design of the extension and the protection of the existing part of the facility will also be improved. Enhancement in safety is also achieved through improved spent fuel pool cooling water systems that will enable water feed from outside and modifications in instrumentation that will enable reading of spent fuel pool water level gauges and temperature gauges outside the pool area also under an accident situation.

## LILW disposal

In Loviisa, the LILW repository was enlarged with a new room for waste handling and a tunnel facilitating disposal operations.

A modified licence to operate the Olkiluoto LILW repository, granted in 2012 allows disposal of Olkiluoto 3 low and intermediate operational waste and such waste from the centralized storage of small user's waste that can be disposed in the facility. The application contained an updated safety analysis of the facility.

A small quantity of small user waste consisting of nuclear material and a few high activity sources cannot be disposed of in the Olkiluoto facility. Actions have been started to find an alternative disposal route for these wastes.

## Uranium mining

Talvivaara Sotkamo Ldt, a subsidiary of Talvivaara Mining Company Plc producing primarily nickel and zinc by bioheapleaching method, submitted an application to recover uranium from the leaching solution in 2010. The process decreases the (small) concentration of uranium in the waste of the metal recovery facility and the company aims to produce about 350 to 500 tonnes or uranium per year. The environmental impact assessment procedure was completed in March 2011. On March 1, 2012, the Government granted licence to extract uranium from Talvivaara ore at the Sotkamo mine, as referred to in the Nuclear Energy Act. However, the Supreme Administrative Court (KHO) revoked in early December 2013 this license. The court ruled that so many changes had occurred within Talvivaara since then that the licence was no longer valid. Re-organisation of the company is ongoing, so the court sent the licence back to the MEE for reconsideration. The company is also having financial, technical and environmental problems and it is not clear when uranium production could start.

STUK has developed its capabilities and internal guidance on safety related to uranium mining and milling. Before the uranium recovery could start STUK shall ascertain that the operation meets all the safety requirements laid down in Nuclear Energy Act.

## Peer reviews

MEE requested an IAEA Integrated Regulatory Review Service (IRRS) review. The review, preceded by a self assessment, took place in late 2012 and covered also waste management. The review complemented the 2009 peer review by EU member state regulators arranged by STUK. The IRRS follow-up mission is scheduled for June 2015.

## Education and training

An important factor in achieving a high level of safety in waste management is competent personnel in the pertinent organizations. A pilot project for enhanced education and training concerning spent fuel disposal was launched in 2010, with a short course arranged in December 2010 for new staff in several organisations. Subsequently, a continuing programme similar to that for the nuclear reactor safety was set up and is ongoing.

# SECTION L Annexes

## L.1 Regulatory approach to 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 1970's 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 (2022–2120, 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 covering spent fuel arising from the four operating reactors. The DiP was given by the Finnish Government in late 2000, approved by the host municipality, Eurajoki, and ratified by the Finnish Parliament in early 2001. Later on the DiP was expanded in separate DiPs to cover also the spent fuel from reactor unit OL3 (approved in 2002) and respectively from the planned reactor unit OL4 (approved in 2010). The initial DiP also authorized Posiva to start the construction of an underground rock characterization facility (URCF) ONKALO, at the Olkiluoto site down to the depth of the planned underground disposal, as required by the regulation. STUK has developed a specific regulatory programme for ONKALO construction, which is described in more detail in the following section.

The DiP also called for the continuation of the research, development and design work to elaborate further the safety justifications in the disposal project for the purposes of the construction licensing stage. Posiva has followed the Government strategy and submitted the construction licence application and its supporting documentation to the authorities at the end of 2012.

### Regulatory review and assessment of Construction Licence application for Olkiluoto spent nuclear fuel encapsulation and disposal facility

Posiva submitted the construction licence application and its supporting documentation to the authorities at the end of 2012. STUK started the related review and assessment in early 2013. At the end of 2013 STUK was performing a thorough review and assessment against safety requirements and the outcome will be documented in STUK's safety evaluation report. The planned duration for STUK's review process is 1.5 to 2 years. After the construction licence step STUK will continue to have 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.

### Planning for the review and assessment of construction licence application

The review process, organization, schedule and resources are described in STUK's internal project plan for the licence application review. The main element of the project is the review of the extensive safety documentation. The assessment of the fulfilment of the safety requirements and of the implementing organization's readiness for construction activities is supported by STUK's inspection programme for the pre-construction phase. The inspection programme is expanded later to include the construction inspection programme for the construction control of the encapsulation and disposal facilities.

The Ministry of Employment and the Economy required Posiva to submit preliminary (draft) licence documentation by the end of 2009. The reasoning was to have a regulatory review of the status and maturity of construction licence application development. STUK reviewed the draft safety case and the process was used as an exercise for the actual licence application review. STUK used this experience in developing the plan for the actual construction licence application review.

The regulatory assessment of safety is done against the regulatory safety requirements. STUK's approach was previously a more safety issue oriented and from bottom to top assessment. In order to have a more regulatory requirement oriented and safety related review basis for the detailed review and assessment, STUK construed a review plan as a part of process development. This review plan contains a collection of earlier regulatory observations and expectations for the construction licence application that were derived from and linked to regulatory safety requirements. The review plan is used as guidance for all experts participating in STUK's review. It is also intended to be used as the structure for STUK's safety evaluation report.

As regards project resources, STUK has allocated the necessary amount of its in-house waste management and nuclear facility expertise to the project. Important parts of the safety case focus on the post-closure safety and the related safety assessments are wide and need to be carefully assessed in a timely manner. For this reason STUK has signed agreements with both VTT Technical Research Centre of Finland and several international experts to support its review and to conduct independent modeling. The total number of experts involved in STUK's review work during 2013 ranged between 60 to 70 persons and the total volume of work by external experts was of the order of 13 person-years.

### Regulatory review of construction licence application

According to the Nuclear Energy Act and Decree, when applying for a construction licence, the applicant shall submit the following to STUK:

- The preliminary safety analysis report, which shall include the general design and safety principles of the nuclear facility, a detailed description of the site and the nuclear facility, a description of the operation of the facility, a description of the behaviour of the facility during accidents, a detailed description of the effects that the operation of the facility has on the environment, and any other information considered necessary by the authorities.
- A probabilistic risk assessment of the design stage.
- A proposal for a classification document, which shows the classification of structures, systems and components important to the safety of the nuclear facility on the basis of their significance with respect to safety.
- A description of quality management during the construction of the nuclear facility, showing the systematic measures applied by the organizations that take part in the design and construction of the nuclear facility in their operations affecting quality.
- Preliminary plans for the arrangements for security and emergencies.
- A plan for arranging the safeguards control that is necessary to prevent the proliferation of nuclear weapons.

In addition to the documentation concentrating mostly on operational safety, the regulation for nuclear waste disposal requires the licensee to submit a safety case concentrating on post-closure safety. This is in practice the most extensive part of the construction licence application documents. STUK's YVL Guides give more details for the required content of these documents.

STUK's task in the construction licence application process is to review and assess the fulfillment of all the applicable radiation and nuclear safety requirements. STUK shall also prepare a statement and a safety evaluation report for the Government. In the appraisal STUK has the possibility to highlight issues that need further attention or to propose licence conditions.

During the first quarter of 2013 STUK performed the first initial review phase. The aim of the initial phase, sometimes compared to docketing, was to check that the licence application contained all the main elements requested in

STUK's regulations (YVL Guides). The first STUK decision concentrated on the completeness of the operational safety documents. Based on the initial review, for most parts the review progressed to the detailed review phase. However, some application documents were not accepted for detailed review in the initial stage. The most important exceptions were related to safety classification where the basis of safety relevance were required to be re-evaluated and when needed also the encapsulation system descriptions updated. The initial review for post-closure safety documentation was finalized in autumn 2013 and STUK accepted Posiva's TURVA-2012 safety case to provide the basis for detailed review.

The assessment of the fulfilment of the safety requirements and of the implementing organization's readiness for construction activities is supported by STUK's inspection programme for the pre-construction phase. The inspection programme is expanded later to include the construction inspection programme for the encapsulation and disposal facility construction control.

After passing the construction licence step, STUK will have comprehensive regulatory control for the detailed design, construction, manufacturing and pre-operational testing, which will then be followed by the review and assessment of the pending operating licence application.

The objective of the inspections performed by STUK during the pre-construction phase is to support the review and decision making process by verifying the licence applicant's processes and procedures and also technical issues described in the licence application documentation. Through these inspections STUK will have a realistic view of the status of the applicant's activities and progress of its development work. STUK focuses the inspections on the licence applicant and the organizations responsible for the nuclear facility's design, and also on any organizations involved in the project whose work can be deemed to have major implications on safety. The main topics for these inspections are the management system of the organization concerned, in particular the organization of operations and the management of resources, competence management, management system processes and procedures, the management of non-conformances, interface management and reporting, and supply chain management as well as data security. STUK's inspections will cover all the main processes and major parts of sub- processes defined in the licence applicant's management system.

### Regulatory approach to the construction of ONKALO

The Finnish regulation requires that the bedrock in the disposal site shall be characterized at the disposal depth before submitting the construction licence application. This requirement was further developed in the STUK safety regulation (Guide YVL D.5), which defined that the characterization involves 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 repository purposes and has been proposed to be an access route to the actual repository. STUK has implemented regulatory control of the ONKALO construction and regulates it like it would be an access route to a nuclear facility. However, a construction licence is needed before starting construction of the encapsulation facility and the first disposal tunnels and disposal holes.

The construction of ONKALO to the planned disposal depth disturbs the geological environment and conditions in a variety of ways, as described below. The purpose of STUK's regulatory control of the Onkalo construction is primarily to ensure that the design, location, orientation and construction are carried out in such a manner that the geo-environment retains its favourable characteristics and conditions needed for the safety functions. In particular, this implies the minimization of:

- Host rock responses to excavation, excavation disturbed areas and zones,
- Groundwater leakages to the ONKALO tunnels and shafts, and
- Introduction of foreign, potentially harmful substances to ONKALO during construction (cement and other grouting materials, reinforcement materials, explosives etc.).
- Pathways from surface to disposal rooms.

The main elements of STUK's regulatory control are:

- Review and assessment of design, construction and as-built documents. The document submittal is based on an approved document delivery plan and construction communication plan.

- Inspection activities can be divided into three areas that are the Construction Inspection Programme (CIP), inspections concerning the readiness to begin excavation and other work phases and inspection concerning construction works on site.
- Review of as-built documentation related to the future commissioning of the facility.

### Regulatory approach for Posiva's RD&D activities

Posiva publishes an RD&D plan for nuclear waste management every three years and submits it to MEE for regulatory review. STUK reviews the report and gives a statement to the Ministry. The most recent report was submitted to the Ministry in September 2012. STUK is responsible for regulating the safety related implementation of the RD&D work. During the period after the DiP and before the construction licence application, STUK's regulatory control of Posiva's RD&D activities was mainly directed to the evolving safety case material.

The regulatory approach taken by STUK has been to closely follow Posiva's safety case development and to perform reviews of draft safety case documents. Another area of regulatory control has been to follow Posiva's RD&D activities which are described in the programmes submitted to regulatory review every three years. In practice this has been implemented through regular visits to research laboratories, factories and workshops where safety related studies or demonstrations have been performed.

The focus of STUK's regulatory control is changing from the overall safety case development to the demonstrations of the disposal system process and the emplacements. The review and assessment of Posiva's safety case supporting the construction licence application will steer the future focus of the RD&D regulation. In addition to issues which Posiva has raised in the safety case STUK's review will most likely reveal areas where further RD&D work is needed to decrease existing uncertainties.

### Regulatory approach for Nuclear Safeguards

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

In 2013 Posiva submitted the preliminary Basic Technical Characteristics (BTC) of the geological repository and the encapsulation plant to the European Commission (EC) as requested from new nuclear facility operators. The Commission has assigned Material Balance Area (MBA) codes W0LF for the geological repository and W0LE for the encapsulation plant. The facility constitutes 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 to the Posiva site and facilities.

STUK's safeguards activities consist of inspecting and assessing Posiva's safeguards implementation, reviewing Posiva's reports and verifying by on-site inspections that ONKALO is in compliance with Posiva's as-built documentation presented also in the BTC. STUK also verifies that the information in Posiva's declaration on the site is correct before the declaration will be submitted to IAEA and the EC.

Presently STUK is reviewing Posiva's construction licence application submitted to the Government at the end of 2012. The plan for arranging the safeguards control is necessary to prevent the proliferation of nuclear weapons. In the review of the licence application STUK has to pay attention to the international agreements and also to the European Commission regulations. The safeguards long-term challenge is a good coordination with the IAEA and the EC to develop the concepts for the new types of facilities, and to carry out the needed safeguards activities in an efficient way for a period of a hundred years. The current task is to accommodate the safeguards measures to be implemented at the encapsulation plant in the design of the facility.

STUK's safeguards activities and findings are published annually in the safeguards report "Implementing nuclear non-proliferation in Finland. Regulatory control, international cooperation and the Comprehensive Nuclear-Test-Ban Treaty".

## L.2 Programme for spent fuel disposal

### General

According to the Government Decision-in-Principle, ratified by the Parliament in 2001, the spent fuel from the Loviisa and Olkiluoto nuclear power plants will be disposed of in a KBS-3 type geological repository on the Olkiluoto island in the municipality of Eurajoki. At the end of 2012 Posiva Oy, the company responsible for the implementation of the disposal, submitted an application to the Government for a licence to construct the facilities needed for that purpose. The facilities consist of an encapsulation plant for packaging the spent fuel elements and the actual geological repository, both on the same site. A full safety case "TURVA-2012" was produced to support the licence application.

The reference repository design is based on the idea of emplacing the spent fuel canisters in vertical position in floors of the repository tunnels ("KBS-3V"), but work has also continued on the alternative of horizontal deposition of the canisters in tunnels ("KBS-3H"). The focus of the technical development work is now shifting to the underground rock characterization facility, ONKALO, in which an extensive program of testing and demonstrations has been started. An important part of the work carried out in ONKALO is the testing of the rock classification methodology for identifying the suitable locations for the deposition tunnels and holes.

### ONKALO Rock Characterization Facility

The first overall site characterization programme for a nuclear spent fuel repository in Finland was launched in 1982. This programme already suggested that the final stage of site investigations, called the site confirmation stage according to the IAEA vocabulary then, should include characterization of the bedrock performed in an underground rock characterization facility. International opinions have also emphasised the importance of underground rock characterization before the decision to construct the repository is taken. Generic underground laboratories are operating in several countries (Stripa, Grimsel, URL, Äspö, Bure). The development and full-scale testing of the disposal concept conducted at these laboratories have shown the significance of site-specific properties in the design of the disposal systems.

The excavation of the underground rock char-

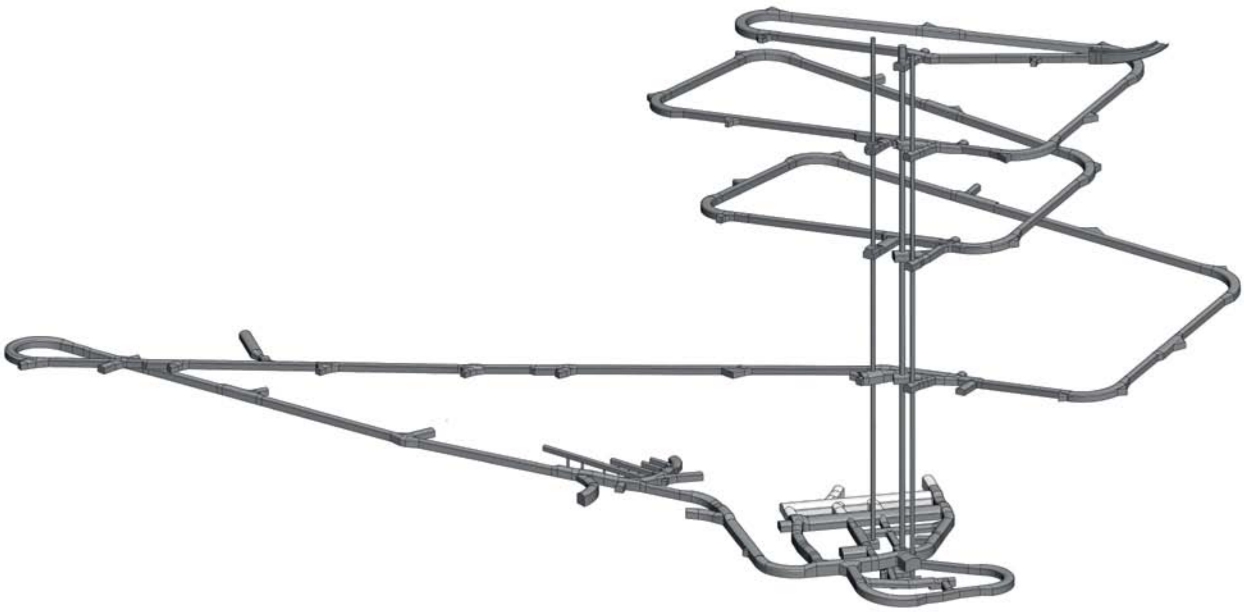


**Figure A.** ONKALO layout in 2011 Figure by Esa Parviainen/Saanio & Riekkola Oy.

acterization facility, ONKALO, is now nearing completion at Olkiluoto. Unlike the generic rock laboratories, ONKALO has been constructed at the actual repository site and it should be possible to use ONKALO in the future as an access route to the repository. For these reasons the construction of the facility has been subject to the rules and requirements applicable to nuclear facilities in general, and, in particular, to those addressing the construction of nuclear waste repositories. It is also regulated by STUK and international safeguards.

The original design and plans for the underground facility were reported at the level of detail needed for a conventional construction permit granted by the municipality of Eurajoki in 2003. Since then a number of changes have been made in the layout of ONKALO access tunnel, and the number of access shafts has been increased from one to three. Also the layout and the depth of the auxiliary rooms at the main characterization level have been updated to match with the current needs. The ONKALO layout, as realized, is shown in Figure A.

The main characterization level is located at the depth of –420 metres, but some of the auxiliary rooms are deeper down at the depth of –437 metres. Most of the excavation work was completed by early 2013 and the rest of the construction work should be ready during 2015 - 2016. The total underground volume of ONKALO will be approximately 365 000 $m^3$, the combined length of tunnels and shafts being 9.8 km. The access tunnel from the surface to the repository level consists of approximately 5 km of tunnelling with an inclination of 1:10. The shafts are excavated to the level of the auxiliary rooms and in addition the personnel shaft and one of the ventilation shafts to the maintenance level of –455 metres. The personnel shaft will be equipped with a man-cage for personnel transport and some maintenance purposes. The connecting tunnels from the access tunnel to the personnel shaft at every 1 to 1.5 km will make it easier to ventilate and evacuate the ONKALO facility. Furthermore, for testing and demonstration purposes Posiva has designed and constructed two additional demonstration tunnels (lengths of 35 and 21 metres) in 2013.

An extensive programme of testing and experimentation has been launched in ONKALO, including various studies into the geochemical and transport properties of the bedrock, and various tests of the technology to be used in the disposal operations (Figure B). Once the construction licence has been granted the construction work will continue to the first panels and deposition tunnels of the repository.

### Site investigations

During the last years, the site investigation activities at Olkiluoto have been concentrated on confirmation of the site suitability, increase in the overall understanding of the site, and demonstrating a practicable methodology for selecting suitable rock volumes for the repository panels, tunnels and deposition holes. Multidisciplinary studies have been carried out both in the ONKALO facility and on surface. The main data sources were the 57 deep cored drillholes with lengths varying from 300 to 1200 meters, and the approximately 5 km long ONKALO access tunnel and the other underground facilities. The Olkiluoto Site Description

Figure B. Testing the equipment for boring of the deposition holes in ONKALO.

(Posiva 2011) is one of the supporting reports for the construction licence application

Two deep surface-based drillholes, OL-KR57 being the deepest in Olkiluoto with the length of 1200 m, were drilled in 2011. The latest investigation trench OL-TK19 was excavated in 2012. However, the data collection from previous data sources has continued, e.g., with ground water sampling, hydraulic measurements mainly for monitoring purposes, an extensive charge potential measurement campaign and a large interference test in drillholes of the eastern area of Olkiluoto. All the available data was used for the Olkiluoto Site Description 2011, but the models will still be updated in the future with new observations.

In ONKALO, data acquisition has continued by detailed and systematic geological mapping and other studies of the tunnel surfaces, by drilling and measurements of pilot holes, characterization holes and other holes, and by specific projects in the investigation and demonstration facilities. During the construction of ONKALO in 2003–2013, a total of 25 pilot holes (with an average length of 125 m) have been drilled, as well as characterization holes and groundwater stations and other shallow holes. Pilot holes were drilled mainly for checking the rock quality and the exact location of modelled faults and hydrological zones in advance of the excavation. Pilot hole drillings and related studies are important also for testing and demonstration of rock suitability classification (RSC). In all drillholes, extensive geophysical, geological and hydrological loggings were carried out.

Recent geophysical surveys have been concentrated on pilot holes in the vicinity of demonstration tunnels and in investigation niche 3 excavated for rock mechanics and excavation damage (EDZ) studies. In the investigation niche 3, also specific charge potential, GPR and tomographic measurement campaigns were carried out in 2013 for purposes of Posiva Spalling Experiment (POSE). In the demonstration area, an extensive tunnel seismic experiment (Figure C) was done mainly for the needs of the local detailed scale 3D fault and fracture modelling and for rock suitability classification.

The interpretation of the POSE experiment will continue for several years. The last phase of POSE, carried out during 2013, involved heating of one of the three test canister holes in the niche

**Figure C.** Tunnel seismics (geophone installation) in the demonstration facilities on the level ca. 420 m.b.s.l.

in order to cause a symmetrical thermal stress increase around the hole due to the thermal expansion of rock. The results of the test were inconclusive: spalling type damage may not be a factor in Olkiluoto because of the heterogeneous and anisotropic nature of the Olkiluoto rock, and further studies are needed.

A detailed hydrogeological investigation project (HYDCO) started in 2010 and has continued in the investigation niche 4. The aim of the project is to obtain better understanding of the detailed hydraulic characteristics of the bedrock. Interesting issues are, for instance, the connections between water conductive fractures. The last phase of the project included a detailed hydraulic interference test.

New flow log equipment (PFL Lite) has been tested in the pilot holes drilled in planned locations of test canister holes in demonstration tunnel 2. The new device is better than the traditional PFL DIFF equipment for measuring this type of pilot holes. New hydraulic data was collected also by flow log measurements in pilot holes, grouting holes and other holes around the facilities. Inflow mapping and measurements of the tunnel surfaces are carried out systematically.

In the REPRO project (investigation niche 5) rock matrix retention properties are investigated under in-situ conditions. The first experiment in 2012 included the injection of tracers (I-125, Na-22, HTO and Cl-36) and related modelling work. The preliminary results were used in the second retention experiment. The second experiment was started in 2013 in the same fracture but with smaller flow rate and different combination of tracers (Na-22, Sr-85, Cl-36, HTO and Ba-133). Both of these experiments were single-hole measurements, but in the future, REPRO will continue with a three-year cross-hole experiment. Drill core samples from the REPRO niche have been analysed in the laboratory to test diffusion properties, permeability, sorption, porosity, pore structure and density. Breakthrough curves based on two first REPRO experiment results are shown in Figure D.

The microbial reduction of sulphate and energy sources for the microbes are studied in the Sulphate Reduction Experiment (SURE). The first phase, SURE 1, was reported in 2013. The experiment was carried out in SO4 rich groundwater conditions, activating the microbes with $CH_4$ and $H_2$ gases. SURE 2, which was carried out in CH4 rich conditions, and SURE 3 phases will be reported during 2014.

The INEX experiment was established to investigate the potential changes in pH and redox conditions, and in the buffering capacity and hydrogeochemical processes related to groundwater infiltration. The first phase of the experiment was started in 2008 and completed in summer 2012, and it will be reported in 2014. The buffering capacity was so high in the INEX area that the redox conditions remained anaerobic and no hydrogeochemical changes were observed during Phase I. In Phase II the experimental set up will be more “aggressive” and oxygenated water will be injected to bedrock with a conservative tracer to observe the processes effected.

After the publication of the Olkiluoto Site Description 2011 (Posiva 2011), the modelling tasks have aimed at the production of updated discipline-specific reports and an integrated site description update for the purpose of the application for the operating licence. A new version of the geological model, including conceptual submodels of deformation, petrology and alteration, has been prepared and will be published in 2014. The new version will show improved understanding of the deformation history and migmatite structures of the Olkiluoto bedrock. Detailed scale modeling, developed mainly for rock suitability classification purposes, integrates the geological, geophysical and hydrogeological interpretations of the ONKALO demonstration area (Figure E).

The updating of the hydrogeological structure model started in 2013 with collecting, preparing and reporting the background data. The hydraulic and geophysical investigation campaigns in deep drillholes in the eastern area of Olkiluoto during 2013–2014 are important data sources for the hydrogeological interpretation. The modeling report will be published in 2014. One goal for the recent geological and hydrogeological model updates has been to extend the site understanding to cover the eastern area of Olkiluoto.

New versions of the geological and hydrogeological discrete fracture network (DFN) model were developed for background information of the flow and transport modeling. The DFN models were summarized in the Olkiluoto Site Description 2011. One of the most important tasks in the future will be the preparation of a new database for DFN purposes including a large set of new geological and hydrogeological data especially from the repository level. The new modeling work is planned to integrate the hydrogeological and geological modeling.

After the Olkiluoto Site Description 2011, the rock mechanics modeling work has concentrated on predictions and back-calculations for the POSE experiments and the further updates of the site scale model. Currently the model is being updated with new investigation data, modeling methods and visualizations. One purpose of the rock mechanics model is to observe the effect of brittle fault zones on the local stress field.

The Olkiluoto Monitoring Programme was originally launched in 2004 when the construction of ONKALO started. The programme was updated in 2012 for the purpose of the construction licence application. It includes rock mechanics, hydrological, hydrogeochemical, and surface environment studies to monitor natural changes within the geosphere and biosphere of Olkiluoto as well as changes caused by the ONKALO construction and other human activities. In addition, controlling the use of foreign materials in the construction of ONKALO has been a part of the programme. A particular objective of the monitoring programme

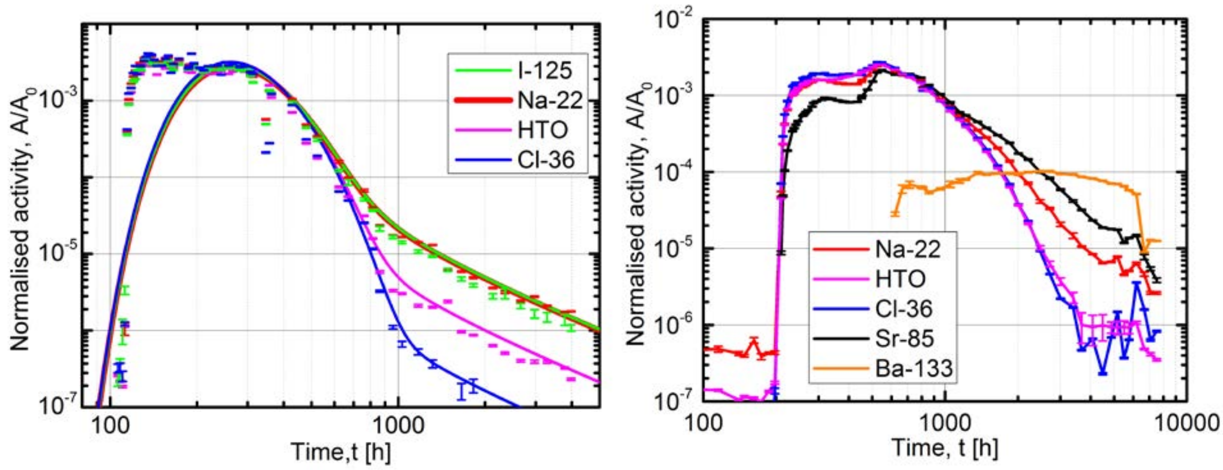



**Figure D.** Breakthrough curves for different flow rates and tracers from REPRO experiments

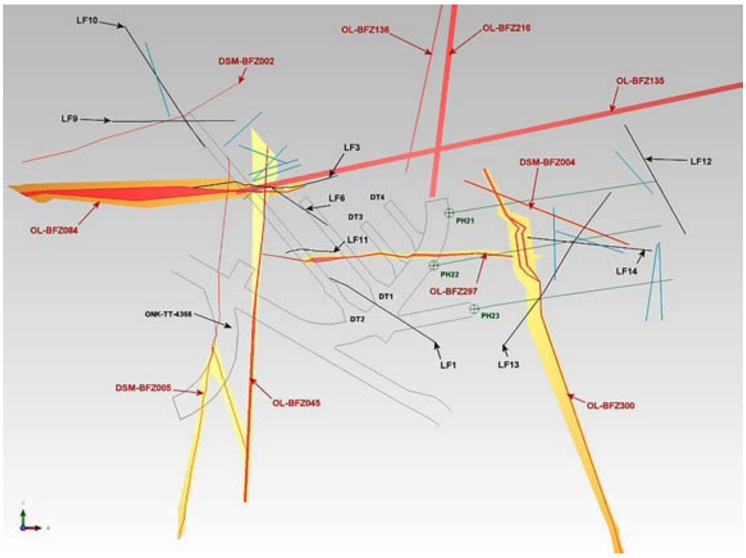



**Figure E.** Horizontal intersection of the detailed scale model in the demonstration facilities: modelled large fractures (black), brittle deformation zones (red), their influence zones (yellow), transmissive fractures measured in pilot holes (blue) and pilot holes ONK-PH21 – 23 (green).

is to observe such possible changes in the host rock and surface environment that may affect the long-term safety of the disposal of spent nuclear fuel. The next update of the programme is planned to be published in 2018 and will describe the monitoring during the operational phase.

The Rock Suitability Classification (RSC) programme produced its main report in 2012 as part of the reporting for the construction licence. The main purpose of the RSC methodology is to locate suitable volumes for disposal facilities in four stages: repository, deposition panel, single deposition tunnel, and canister hole stage. The classification is based on a set of observable criteria connected to the long-term safety based target properties for the host rock.

### Development of the engineered barrier system

At the moment the spent fuel is being stored in water pools in interim storage facilities at Loviisa and Olkiluoto. After a few decades of cooling it will be transferred to the encapsulation facility at Olkiluoto where it will be encapsulated in copper-iron canisters each containing 12 BWR or PWR fuel assemblies from currently operating power plants or 4 PWR fuel assemblies from the Olkiluoto 3 unit, which is currently under construction. The canister design consists of a cast iron insert as a load-bearing element and an outer container of oxygen-free copper to provide a shield against corrosion. The canisters will be emplaced in a network of tunnels, which will be constructed at the depth of 420 to 450 m in crystalline bedrock. The annulus between the canister and the rock wall will be filled with compacted bentonite. A schematic picture of canisters in deposition tunnels is shown in Figure F.

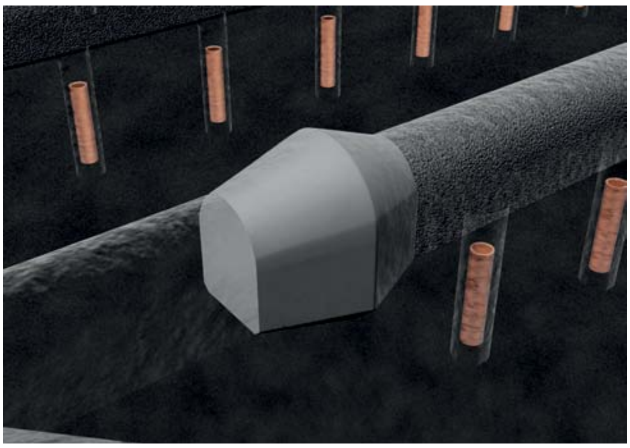


**Figure F.** A disposal tunnel with canisters surrounded by the bentonite buffer.

The work on canister development includes the design, canister manufacturing, canister sealing and canister inspection. The canister design work has been focused on gathering up all factors affecting the design, the design requirements and the studies addressing the fulfilment of the design requirements. The design has been described in the report Design of Disposal Canister (Raiko 2012a). The report compiles studies on natural phenomena, theoretical models and analyses, measurements, practical tests, manufacturing trials and material studies that have been done for several years. The “canister production line” report (Raiko 2012b) describes the production and installation chain of the canister from the design requirements until the time it has been installed in the deposition hole. The description is used as the starting point (initial state) for the long-term safety assessment.

The copper overpack of the canister, which varies for different fuel types only in length, can be manufactured with several methods. The present methods under development are extrusion and pierce & draw. With these methods Posiva, together with SKB, has during the past three years manufactured seven full-size copper canisters. The properties of the manufactured canisters have been studied by non-destructive tests and it has been shown that canisters meeting the requirements can be manufactured by these methods. Similarly, eight nodular cast iron inserts for the disposal canisters have been cast in foundries in Finland and Germany, three of which were made for Posiva and SKB jointly. The manufacturing methods, requirements for manufacturing and results of manufacturing trials are described in the Canister Production Line 2012 report (Raiko 2012b).

The reference sealing method for the Posiva canister has been the high-power electron beam welding. The method is an industrial welding method for steel and copper components but the wall thickness of the disposal canister creates an extra challenge. As an alternative method for sealing the friction stir welding (FSW) method has been studied. The method is based on hot forming, for which the required temperature is achieved through friction of a tool rotating with high speed in the material to be welded. In 2013, Posiva made an evaluation of the two methods and announced in March 2014 its decision to select the FSW as the welding method for the encapsulation plant, which will be built in Olkiluoto. The advantages of the FSW are the smaller and more even grain size, isotropic grain structure and good mechanical properties. In other words, the properties of FSW weld are closer to the mechanical properties and grain structure of the copper components. In very aggressive conditions, the FSW weld has proven to have better properties compared to EBW. The same applies for stress corrosion and creep properties of the welds, on which better results have been gained with FSW.

To prove that the canister to be disposed is initially intact, non-destructive testing of the canister components and the lid weld has been developed focusing mainly on the radiography for volumetric inspection, and on phased-array ultrasonic method for more detailed detection and sizing of possible defects. In addition, eddy current has been developed to detect surface or near-surface defects and visual testing for surface defects. The reliability of the NDT methods has been studied jointly with SKB by verifying them with metallographic examinations. The non-destructive testing methods, their requirements and experience gained with them are described in three reports (Pitkänen 2010, 2013, Kanzler 2013).

The bentonite buffer that surrounds the canister is emplaced in the deposition hole in form of compacted blocks. The buffer design has been published in 2012 (Juvankoski 2012)). The gap between the buffer and the host rock will be filled with bentonite pellets. A small scale buffer test has been performed in ONKALO focusing on the test set-up to gain experience on building a buffer test.

For the buffer block manufacturing the isostatic compaction technique has been developed. The focus of the work has been on the production of blocks with the target density out of MX-80 type sodium bentonite. The results of this work will be applied for manufacturing of full scale blocks. Part of the work consists of modelling the pressing process.

As a part of the 7th Framework Programme of the European Commission a project named "LUCOEX" has been started by a consortium between SKB, Posiva, ANDRA and NAGRA. The project includes a work package led by Posiva that focuses on developing solutions to the buffer emplacement issues.

After all the canisters and buffer components within a deposition tunnel have been emplaced, the deposition tunnel will be backfilled and sealed with a plug. Posiva's plan is to backfill the tunnels with pre-compacted clay blocks using bentonite pellets for the voids between the blocks and the host rock. The tunnels will be sealed with a concrete plug at the mouth of the tunnel. During the last years several laboratory and field tests have been performed to study geotechnical properties such as hydraulic conductivity and swelling pressure of various backfill materials. For assessing the mechanical interaction between the buffer and the backfill, a mechanical model is being developed. The main conclusions of testing and laboratory work are described in the backfill design report (Autio 2012) and the backfill production line report (Keto 2012).

The manufacturing of backfill blocks by uniaxial pressing has been developed and blocks with required properties have been produced. The plug is now being constructed for testing in ONKALO as part of the European Commission 7th Framework Programme project named "DOPAS".

The closure of the access tunnels and shafts is based on a compartment solution: the access routes are divided into parts according to depth and prevailing hydraulic conditions, and different plugs and backfill materials are used for each part according to its characteristics. The design of underground disposal facility closure design is described in the closure design report (Dixon 2012).

### Facility design

The design work for the encapsulation plant and disposal facility continues (Palomäki & Ristimäki 2012). Main drawings for both facilities have been produced and sent to STUK as part of other licensing documentation in the construction licence application. All main process systems have also been pre-designed in order to produce the PSAR system descriptions. In the encapsulation plant (Figure G) the spent fuel elements are transferred from the transport containers to disposal canisters, a lid is friction-stir welded to the canister body and the weld is machined and inspected, after which the canisters are ready for disposal. The encapsulation facility is located at the repository site, and, therefore, the disposal canisters can be transferred by lift to the disposal facility.

The layout designs of the disposal facility are based on the outcome of the rock suitability and classification work that indicates the suitable rock volumes for the deposition tunnels in the Olkiluoto area. However, the final decisions on the locations of tunnels and deposition holes will be made on the basis of detailed geological and geophysical information that will become available only after the central tunnels have been excavated. A schematic picture of how the repository could look like is shown in Figure H.

**Figure G.** Cross section of Encapsulation plant.

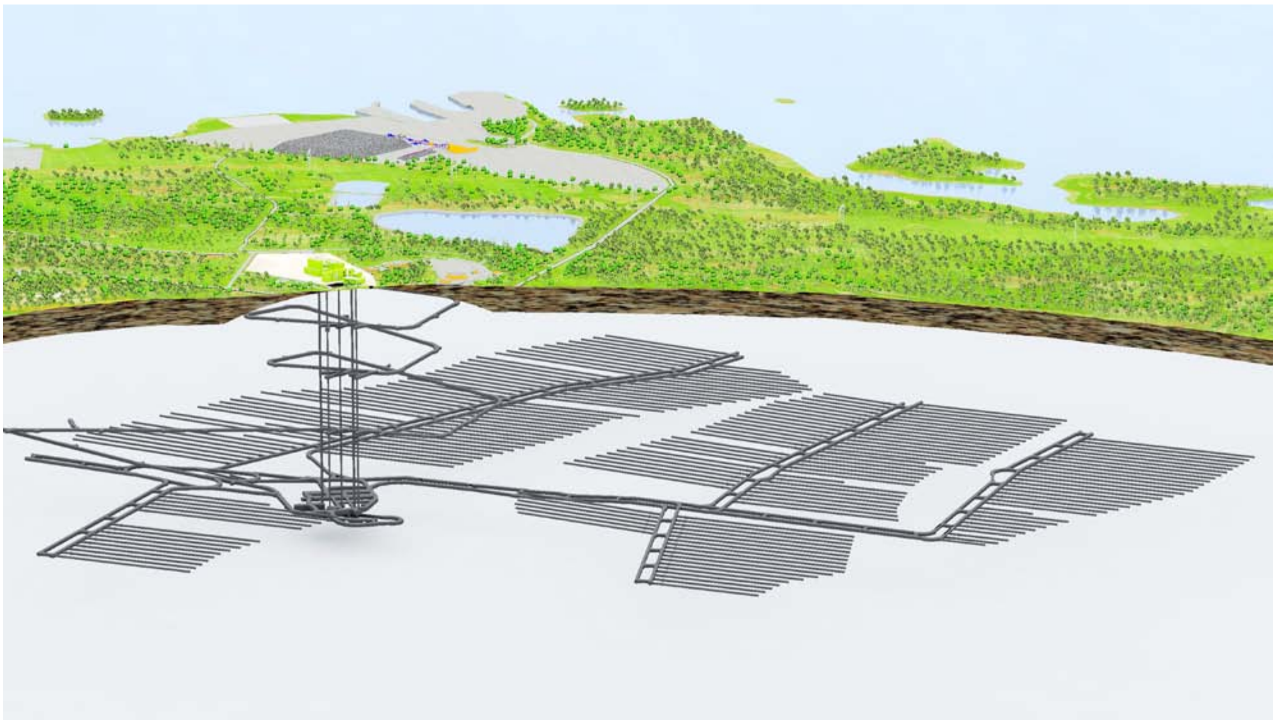


**Figure H.** A schematic presentation of the layout of the Disposal facility.

In parallel with the technical design work and the planning of the operational practices of the facility, work has been done to assess the operational safety of the facilities. The safety analyses (Rossi & Suolanen 2013) have been reported in the context of the application for the construction licence.

As part of the work on encapsulation and disposal processes prototype systems of a few essential systems have been developed. These systems are the canister transfer trolley and canister mover in the encapsulation process and the buffer, canister and backfill material installation machines for the repository. The designs of these prototype systems have been completed and the manufacturing is ongoing. Prototype testing will start in spring 2014 and continue to the end of 2015. The prototype of the canister installation machine is presented in Figure I.

## Assessment of long-term safety

For the purpose of the construction licence application a safety case has been produced showing that the repository will satisfy the requirements for long-term safety. The main components of the safety case consist of an assessment of the performance of the repository system in different future scenarios and an analysis of the probability and consequences of any releases of radioactive substances from the repository. The assessment starts from the initial state of the repository as described in the "production line reports" of the engineered barrier system and the near-field host rock, and then goes on to studying the possible courses of development that the repository system can be subject to in the future. The assessment of the future evolution is based on scientific knowledge and data gathered both from Olkiluoto and from different laboratory experiments and technical tests through more than 25 years. For the quantitative assessment, models based on scientific theories are used.

The safety case consists of a portfolio of reports as shown in Figure J. Its main components can be described as follows:

The initial state of the geosphere and biosphere, as well as ongoing evolutionary processes, such as land uplift, groundwater flow and mixing of groundwater types, are determined by site investigations and compiled in the site descriptive models of the geosphere and the biosphere. These have been presented in the Olkiluoto Site Description (Posiva 2011) and in the Olkiluoto Biosphere Description (Posiva 2012b).

**Figure I.** Prototype of the canister installation machine.

The Description of the Disposal System Report (Posiva 2012c) summarises the information on the waste form, the engineered barrier system and the Olkiluoto site. More detailed descriptions are given in technical and scientific reports on various components of the disposal system, including the site descriptive model of Olkiluoto and the description of biosphere conditions. Background analyses related to future climatic conditions are also performed and reported (Pimenoff et al. 2011a,b, Pimenoff 2012).

In the new safety case portfolio, the earlier Biosphere Assessment Portfolio has been fully integrated. However, the expression Biosphere assessment will be retained. It (Posiva. 2012d) refers to the description of the current biosphere and its evolution, landscape modelling, and the assessment of radiological consequences.

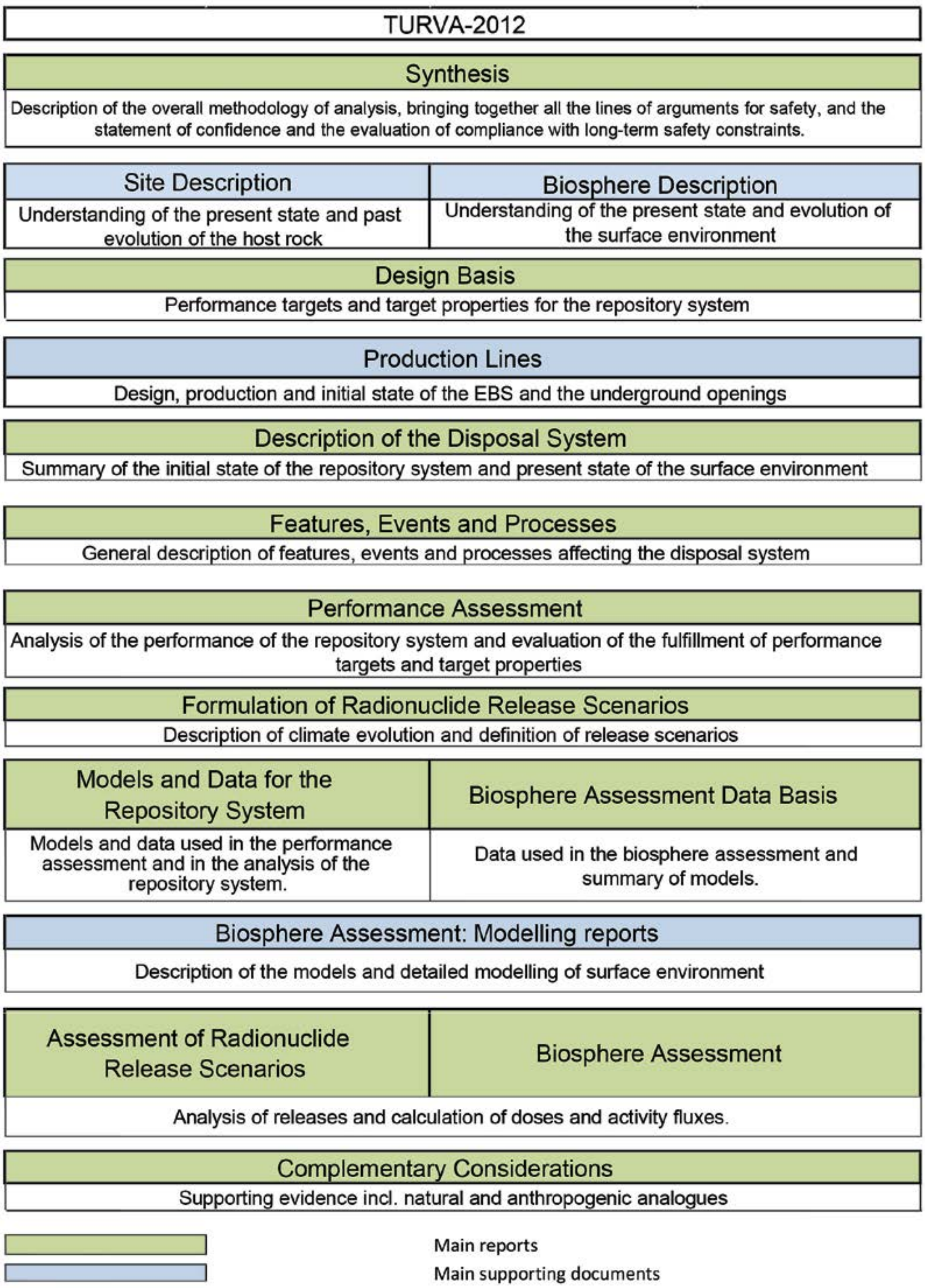



**Figure J.** Posiva's Safety Case Portfolio in 2012 (Posiva 2012a).

The Design Basis Report (Posiva 2012e) focuses on the long-term safety aspects of the design, leaving the plant design basis to be discussed elsewhere. The aim of this report is to gather all relevant loads and interactions which the disposal plant designers need to take into account when designing the disposal systems and layouts for the construction and operating licence applications. The fulfilment of the requirements, the performance assessment, is analyzed in the Performance Assessment Report (Posiva 2012f) for each engineered barrier system (EBS) component. The design basis in the context of this report concerns the specification of the loads that the barriers must withstand, material restrictions and acceptance criteria which are relevant in the Base Scenario and its extensions (corresponding to the most likely lines of future development of the repository) in the Posiva Safety Case. The design basis presented in this report represents a data-freeze of Posiva's requirements management system VAHA.

The features, events and processes affecting the evolution of the repository are described in the Feature, Events and Processes Report (Posiva 2012g). The evolution of the repository and the scenarios, for analysis in the safety assessment, is described in the Formulations of Scenarios Report (Posiva 2012h).

The Models and Data Report (Posiva 2012i) documenting the data and their interpretation (including modeling) in the context of the safety case has a key role for ensuring the overall quality of the assessment. The Models and Data Report is the main link between the safety case and the EBS design and development as well as between the safety case and the Olkiluoto site investigations. The report explains the most significant data used in the actual assessment. It consists of a discussion of those parameters, data and underlying assumptions that are considered important for the results of the safety assessment calculations and the conclusions of the safety case as a whole. The data used in the biosphere assessment and the summary of biosphere models are described in Data Basis for the Biosphere Assessment report (Posiva 2012j).

The scenarios analyzed quantitatively address both the expected evolution of the repository and disruptive events, as required by YVL D.5. The assessment of the releases of radionuclides and the radiological consequences of these releases are presented in the Analysis of Radionuclide Release Scenarios Report (Posiva 2012k).

The Complementary Considerations Report (Posiva 2012l) provides additional evidence for the long-term safety of disposal according to the KBS-3 method at the Olkiluoto site. Finally, the whole safety case, including the main results, is described in the Synthesis Report (Posiva 2012c).

The engineered barriers constitute an important factor in ensuring the long-term safety in Posiva’s safety concept. Posiva's safety concept states that long-term safety is primarily based on the long-term containment of radionuclides by the engineered barrier system consisting of a canister and a buffer designed to protect the canister. The performance studies have therefore been focused on establishing the behaviour of the copper canister and its protective bentonite buffer and on examining the harmful processes.

Many of these studies have been conducted as international joint projects and bilateral studies with SKB. Studies on the clay barriers include LOT (Long-Term Test of Buffer Material), ABM (Alternative Buffer Materials), FEBEX (Full-scale Engineered Barriers Experiment) LASGIT (Large Scale Gas Injection Test), EBS Task Force, FORGE (Fate Of Repository GasEs), BELBAR (Bentonite Erosion: effects on the Long term performance of the engineered Barrier and Radionuclide transport), and CFM (Colloid Formation and Migration). Studies on UO2 dissolution and solubility have continued in the 7th Framework Programme of the European Commission in the projects named REDUPP (Reducing Uncertainty in Performance Prediction) and FIRST Nuclides (Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel).

Studies into migration phenomena have continued in both domestic and international projects, such as in the Task Force for Groundwater Flow and Solute Transport arranged by Äspö Hard Rock Laboratory. Posiva has also taken part in the work of the NEA’s “Sorption Forum” project and in the TDB (Thermodynamic Data Base) project. A new code (“MARFA”) has been developed for the radionuclide transport in far-field together with SKB. The aim is to obtain the state-of-the-art computer code for use in the safety assessment projects. The work is carried out at the

Southwest Research Institute. Posiva has also participated in the 7th Framework Programme of the European Commission in a project called CROCK (Crystalline rock retention processes), in which the main objective was to improve the safety statement for the crystalline rock far-field as a radionuclide migration barrier. The effects of permafrost and glaciation on the long-term safety of the disposal system have been studied in cooperation with SKB and NWMO in the GAP project (Greenland Analogue Project). The project will last until 2014, but some preliminary results have been published as Posiva working reports (Harper et al. 2012).

### Development of the horizontal disposal solution

In parallel with the vertical disposal design (KBS-3V) now constituting the reference solution for Posiva and SKB, the development work for the horizontal disposal design (KBS-3H) has continued with SKB, concentrating on the specific characteristics of the horizontal design. A joint project entitled "KBS-3H System Design 2011–2016" was established in 2011 for further development work on the horizontal solution. Alongside the joint project, Posiva has taken into account even the space needs and requirements set by the 3H solution in its plant design work.

The main objective of the joint project is to develop the technical engineering of the 3H alternative and the understanding of its systems to a level where a Preliminary Safety Assessment Report (PSAR) can be produced for the 3H alternative and used for a comparison between the 3V and 3H alternatives. The comparison of the two alternatives also includes environmental issues, costs and safety issues (long-term, operational and occupational safety). The objective regarding long-term safety is to demonstrate that 3H is at least as safe an alternative as 3V. The DAWE (Drainage, Artificial Watering and air Evacuation) design solution chosen as the reference design for the horizontal solution is presented in more details in Posiva 2012m, Posiva 2012n and Posiva 2013.

A full-scale demonstration of the DAWE design solution chosen as the reference design in 2010, entitled the Multipurpose Test (MPT), is being carried out in the Äspö Hard Rock Laboratory (Figure K). The MPT is part of the four-year international LUCOEX project, initiated in 2011 and scheduled to end at the end of 2014. The purpose of the MPT is to test the manufacture, transport and installation of main components, as well as the techniques compliant with the DAWE design solution, such as artificial wetting of the clay material. The installation work for the MPT was finalized at the end of 2013 and the monitoring phase initiated. The duration of the field phase is under evaluation since it will continue beyond the LUCOEX project. The joint performance of the components and the behaviour of clay material will be tested; samples will be taken for the latter purpose after the dismantling at the end of the test.

Close to the earlier excavated KBS-3H deposition niche at Äspö HRL at level -420 m, test drilling using the directional core drilling technique has been initiated. A 300 m long artificial test hole "Borehole Deviation Facility" has been constructed on the surface for testing and calibrating the inclination and deviation tools. The work aims at developing readiness for the pilot hole drilling/boring from the deposition niche into the eventual KBS-3H demonstration drift. The first 100 m of the pilot hole is planned to be reamed to the full drift size of 1850 mm.

Big Bertha tests BB2 & BB3 have been finalized and the documentation will be concluded early 2014. The objective of the BB2 test was to study the swelling pressure development of the buffer through the perforated shell, the protective cylinder around the Super container. The bentonite blocks and the gap between the perforated shell and the "drift wall" were compliant with the concept design. Consequently the early evolution of the swelling pressure corresponds to the real swelling evolution in MPT. The objective of the BB3 test was to study the swelling development within the distance block during the 6 month long test duration. The gap and the bentonite block were also compliant with the concept design.

In both tests the artificial water filling was performed in accordance with the DAWE design solution. The objective was to fill the gap with water. The test results indicated a slower swelling pressure development in both tests than expected.

The two production line reports entitled "Design, Construction and Initial State of the KBS-3H Underground Openings and "Buffer bentonite and filling components" are currently being produced. In addition to these, other production line reports to be initiated in 2014, describing the specific characteristics of the 3H design, include “Super container” and “Plugs”.

An updated description of the repository layout and stepwise implementation of the KBS-3H concept in the Olkiluoto bedrock for the amount of 9000 tU of spent nuclear fuel, using the same basis as for the 3V layout, will be made in 2014.

Currently scoping analyses regarding the Olkiluoto site are being performed related to the canister failure models of several canisters due to the erosion of bentonite caused by dilute glacial water after an ice age and followed by enhanced canister corrosion, as well as to canister failures due to shear movements in the bedrock. These are the key areas for investigation identified in the preliminary KBS-3H safety analysis (Posiva 2007). The work will be performed using the chosen DAWE reference solution.

A study on the long-term interaction between buffer bentonite and titanium, the material selected for the Super container shell, i.e. a protective cylinder, and for the plugs was continued. The study is scheduled to end in 2014. The work is based on earlier research regarding the interaction between titanium and bentonite. The study focuses on chemical processes which may have a deteriorating effect on the safety performance of the buffer.

The Design Basis – KBS-3H memorandum has been compiled in compliance with the structure of the Design Basis report for KBS-3V (Posiva 2012e). The Design Basis report for KBS-3H is scheduled to be compiled at the end of 2014.

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**Figure K.** Illustration of the Multipurpose test (MPT) drift components (distance blocks on both sides of the Super container and the transition block).The cables from the sensors are lead through the pipes in the plug collar. Short water filling pipes (3 pcs.) and one long air evacuation pipe are also seen at the bottom part of the collar.

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## L.3 List of spent fuel storages and inventory of spent fuel

| Loviisa NPP | | |
|---|---|---|
| | Inventory (end of 2013)/ storage capacity | |
| **Storage** | **Mass* (tHM)** | **Fuel assemblies** |
| Pool storage in Loviisa 1 reactor building | 30.3/57 | 252/481 |
| Pool storage in Loviisa 2 reactor building | 10.7/58 | 89/485 |
| Basket type pool storage at the NPP | 57.7/57 | 480/480 |
| Rack type pool storage at the NPP | 461.5/582 | 3836/4842 |
| Total inventory/storage capacity (gross) | 560/756 | 4657/6288 |
| Total effective** storage capacity | 620 | 5157 |

| Olkiluoto NPP | | |
|---|---|---|
| | Inventory (end of 2013)/ storage capacity | |
| **Storage** | **Mass* (tHM)** | **Fuel assemblies** |
| Pool storage in, Olkiluoto 1 reactor building | 86.4/267 | 524/1520 |
| Pool storage in Olkiluoto 2 reactor building | 94.6/274 | 568/1560 |
| Separate storage facility at the NPP site | 960.8/1257 | 5658/7146 |
| Total inventory/storage capacity (gross) | 1187.3/1799 | 6750/10226 |
| Total effective** storage capacity | 1623 | 9226 |

| FiR 1 research reactor | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Mass (kgU)** | **Fuel elements** |
| Wet storage | 2.04 | 11 |
| Dry storage | 2.41 | 13 |
| Total inventory | 4.45 | 24 |

* tHM means that the spent fuel inventory is presented in tonnes of heavy metals.
** 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.4 List of radioactive waste management facilities and inventory of radioactive waste

| Loviisa NPP | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Volume (m³)** | **Activity (TBq)** |
| Storage room for LLW inside the NPP | 209.0 | 0.18 |
| Storage room for ILW inside the NPP | 38.13 | 0,16 |
| Tank storage for wet LILW*** | 1230 | 16.7 |
| Storages for activated metal waste | 39.5 | high (not measured) |
| On-site storage hall for VLLW | 96.0 | low |

| Olkiluoto NPP | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Volume (m³)** | **Activity (TBq)** |
| Buffer storage rooms inside the NPP | 194 | 22.1 |
| On-site storages for operational waste | 176 | low |
| Storages for activated metal waste | 53 | high |
| Spent oil candidate for clearance | 11 | low |
| Interim storage for state owned waste | 56 | 51.4 |

| FiR 1 research reactor | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Volume (m³)** | **Activity (TBq)** |
| Waste storage in the laboratory building | 6 | 0.001 |

| STUK's waste storage | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Volume (m³)** | **Activity (TBq)** |
| Storage room in STUK's building | 2 | 3.8 |

| Storage for small user waste containing nuclear material | |
|---|---|
| **Storage** | **Inventory (end of 2013) Volume (m³)** |
| 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 | | |
|---|---|---|
| | Inventory (end of 2013) | |
| **Storage** | **Volume (m³)** | **Activity (TBq)** |
| Rock cavern attached to the Olkiluoto disposal facility | 56 | 50.14 |

*** Tank storage for wet LILW includes sediment matter on the bottom of the tanks estimated to be about 60 m³.

## L.5 List of main regulations

Most of the regulations can be found in English at http://plus.edilex.fi/stuklex/en/.

### Legislation (as of 30.7.2014)

- 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 (468/1994)
- Government Decree on Environmental Impact Assessment Procedure (713/2006)
- Act on the Openness of Government Activities (621/1999)
- Policy Decision of 10th November 1983 by the Government on the Objectives to be Observed in Carrying out Research, Surveys and Planning in the Field of Nuclear Waste Management, Nuclear Law Bulletin, No 33 (1984) pp.42-44
- Decision of the Government on Financial Provision for the Costs of Nuclear Waste Management (165/1988)
- Government Decree on the Safety of Nuclear Power Plants (717/2013) (replacing earlier Government Decree 733/2008)
- Government Decree on the Security in the Use of Nuclear Energy (734/2008) (revised in 2012)
- Government Decree on Emergency Response Arrangements at Nuclear Power Plants (716/2013) (replacing earlier Government Decree 735/2008)
- Government Decree on the Safety of Disposal of Nuclear Waste (736/2008) (replacing earlier Decisions of the Government 398/1991 and 478/1999)

### Relevant EU Directives, Regulations and Decisions

- Council Regulation 93/1493/EURATOM of 8 June 1993 on shipments of radioactive substances between Member States
- 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
- Council Directive 97/43/EURATOM of 30 June 1997 on health protection of individuals against dangers of ionizing radiation in relation of medical exposure, and repealing Directive 84/466EURATOM
- Council Directive 2003/122/EURATOM of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources
- Council Directive 2006/117/EURATOM of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel
- Commission Decision of 5 march 2008 establishing the standard document for the supervision and control of shipments of radioactive waste and spent fuel referred to in the Council Directive 2006/117/Euratom
- Council Directive 2009/71/EURATOM of 25 June 2009 on the nuclear safety of nuclear installations
- Council Directive 2011/70EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste
- Council Decision 87/600/EURATOM of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency

### Guides issued by STUK (as of 30.7.2014, only Guides relevant to this report included)

- Guide YVL A.1 Regulatory control of safety in the use of nuclear energy, 22 November 2013
- Guide YVL A.2 Site for 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 1.5 Reporting nuclear power plant operation to the Radiation and Nuclear Safety Authority, 8 September 2003 (replaced by YVL A.9)
- 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
- 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 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 (in publication process)
- 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 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
- 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 radiation user's organization, 17 February 2012
- Guide ST 5.1 Radiation safety of sealed sources and equipment containing them, 7 November 2007
- 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
- Guide VAL 1 Protective measures in Early Phase of a Nuclear or Radiological Emergency
- Guide VAL 2 Protective measures in Intermediate Phase of a Nuclear or Radiological Emergency

## L.6 References to official national and international reports related to safety

- The Final Disposal Facility for Spent Nuclear Fuel, Environmental Impact Assessment Report, Posiva Oy, 1999
- Vieno, T., Nordman, H., Safety Assessment of Spent Fuel Disposal in Hästholmen, Kivetty, Olkiluoto and Romuvaara, TILA-99, POSIVA 99-07, March 1999
- Ruokola E (ed.). Posiva's Application for a Decision-in-Principle Concerning a Disposal Facility for Spent Nuclear Fuel. STUK's Statement and Preliminary Safety Appraisal, STUK-B-YTO 198, March 2000.
- Environmental Impact Assessment Report on Expanding the Capacity of Spent Nuclear Fuel Repository, Posiva Oy, 2008.
- Posiva's Application for a Decision in Principle on Spent Fuel from the Olkiluoto 4 Unit, STUK's Statement and Preliminary Safety Appraisal, May 2009.

- Posiva's Application for a Decision in Principle on Spent Fuel from the Loviisa 3 Unit, STUK's Statement and Preliminary Safety Appraisal, October 2009.
- Finnish Report on the Safety of Spent Fuel and Radioactive Waste Management, Finnish national Report as Referred to in Article 32 of the Joint Convention on the Safety of Spent Fuel and Radioactive Waste Management, STUK-B-YTO 223, Helsinki 2003.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. 2nd Finnish National Report as referred to in Article 32 of the Convention. STUK-B-YTO 243. STUK, Helsinki 2005.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. 3rd Finnish National Report as referred to in Article 32 of the Convention. STUK-B 96. Helsinki: Radiation and Nuclear Safety Authority; 2008
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. 4th Finnish National Report as referred to in Article 32 of the Convention. STUK-B 138. Helsinki: Radiation and Nuclear Safety Authority; 2011
- Finnish report on nuclear safety. Finnish 6th national report as referred to in Article 5 of the Convention on Nuclear Safety. STUK-B 164. Helsinki: Radiation and Nuclear Safety Authority; 2013
- Erja Kainulainen (Ed.). Regulatory oversight of nuclear safety in Finland. Annual report 2013. STUK-B 176. Helsinki: Radiation and Nuclear Safety Authority; 2014
- The Government Resolution and Safety Strategy for Society 2010
- European Stress Tests for Nuclear Power Plants, National Action Plan FINLAND, December 2012 (http://www.stuk.fi/ydinturvallisuus/fi_FI/fukushima-selvitykset/_files/88946073696944417/default/European_Stress_Test_-_National_Action_Plan_-_Finland.pdf)
- Report of the Committee for Nuclear Energy Competence in Finland, 2012 (http://www.tem.fi/files/33099/TEMjul_14_2012_web.pdf)
- Nuclear Energy Research Strategy Group (YES) Ydinenergia-alan tutkimusstrategia, Energia ja ilmasto 16/2014 (in Finnish)
- Fennovoima's Application for a Supplement to Government Decision-In-Principle M 4/2010 vp pursuant toSection 11 of the Nuclear Energy Act (990/1987), granted on May 6, 2010 http://www.fennovoima.fi/userData/fennovoima/doc/pap/PAP2014_EN_DIGI_LOW.pdf
- Environmental Impact Assessment Report for a Nuclear Power Plant, February 2014, by Fennovoima http://www.fennovoima.fi/userData/fennovoima/doc/yva/yva2013/EIAreport2014.pdf; STUK's assessment of it only in Finnish http://www.stuk.fi/ajankohtaista/tiedotteet/fi_FI/news_903/_files/91805571943118302/default/4_J42211_2014Saatekirje-alustava-turvallisuusarvio-fennovoima.pdf
- TVO's Application for a Decision-in-Principle concerning the Construction of a Nuclear Power Plant Unit – Olkiluoto 4 https://www.tem.fi/files/23613/OL4_PAP_en_lukittu.pdf
- TVO's Environmental Impact Assessment Report, Extension of the Olkiluoto Nuclear Power Plant by a Fourth Unit, http://www.tvo.fi/uploads/files/YVA_selostusraportti_EN_Secured_pien.pdf

## L.7 References to reports of international review missions performed at the request of the Contracting Party

- STUK's Action Plan based on STUK's self-assessment and IRRS findings, 2013 (http://www.stuk.fi/ydinturvallisuus/fi_FI/fukushima-selvitykset/_files/88946073696944417/default/European_Stress_Test_-_National_Action_Plan_-_Finland.pdf)
- Integrated Regulatory Review Service (IRRS) mission to Finland, Helsinki, 15–26 October 2012.
- EU Waste Peer Review 2009 to STUK's Waste Management (http://www.stuk.fi/stuk/fi_FI/kansainvaliset-arviot/_files/89760656094724105/default/stuk-action-plan-eu-27-peer-plan.pdf)
- Operational Safety of Nuclear Power Plant, Finland (Loviisa), OSART Mission (Operational Safety Review Team), IAEA-NSNI/OSART/07/139, 5-21 March 2007.
- Regulatory Review Team (IRRT), Follow-Up Mission to Finland, 31 August– 9 September 2003, IAEA/NSNI/IRRT/03/03, IAEA, Vienna, 2003

- Technical Notes of the International Regulatory Review Team (IRRT) Mission to Finland, 12–13 March 2000, IAEA, Vienna, 2000
- Integrated Safety Assessment of Research Reactors (INSARR), Report to the Government of Finland, NSNI/INSARR/1999-2, IAEA, Vienna, August 1999
- Evaluation of the Finnish Nuclear Waste Management Programme, Report of the WATRP Review Team / International Atomic Energy Agency, Waste Management Assessment and Review Programme, Ministry of Employment and the Economy, Helsinki, 1994
- Operational Safety of Nuclear Installations, Finland (Loviisa), OSART Mission (Operational Safety Review Team) 5-23. November 1990
- Operational Safety of Nuclear Installations, Finland (Olkiluoto), OSART Mission (Operational Safety Review Team), IAEA-NENS-86/2, IAEA, Vienna, September 1986

## L.8 Spent fuel and radioactive waste management policy

### General

The principles of the nuclear waste management were originally set in the Finnish Government's policy decision of 1983 and later in the decisions by the MEE. These decisions also set a long-term schedule for the implementation of nuclear waste management including the site selection and start of the operation of the spent fuel disposal facility.

### 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 (the Nuclear Energy Act, Sections 31 and 32). When the licensee's waste management obligation has ceased because the disposal of nuclear waste has been carried out in an approved manner, the ownership right to the nuclear 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. Also, the responsible party utilizing natural resources containing radioactive substances shall ensure that radioactive waste poses no hazard to health or to the environment, both during the operations and at their conclusion. The state has the secondary responsibility in case a producer of radioactive waste is incapable of fulfilling its management obligation (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 considerable general significance shall require a Government's Decision-in-Principle (DiP) on that the construction project is in accordance with the overall good of the society. Such facilities include major nuclear waste management facilities. Before making the DiP referred to in Section 11, the Government shall 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 Government DiP shall be forwarded, without delay, to the Parliament for perusal. The Parliament may reverse the DiP as such or may decide that it remains in force as such (Section 15 of the Nuclear Energy Act).

The Nuclear Energy Decree (Section 24) provides that an application for a DiP shall be appended by an assessment report drawn up according to the Act on the Environmental Impact Assessment Procedure and a statement from the coordinating authority (Ministry of Employment and the Economy, MEE) as well as a description on 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 process facilitating public involvement and information transfer to the people affected. It considers a wide scope of potential impacts, such as human health and comfort, natural environment and biodiversity, municipal structures and the use of natural resources.

### Spent fuel and nuclear waste management principles

According to the Nuclear Energy Act (Section 27a) the amount of nuclear waste generated in the use of nuclear energy must be kept as small as is reasonably possible with practical measures, both regarding 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 shall 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 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 can be handled, stored and disposed of outside Finland, if justified on grounds of safety or due to a significant economic or other weighty reason.

### Principles for decommissioning of nuclear facilities

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

### Management principles for other radioactive waste

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 of rendering harmless of any disused sources, 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 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.

### Safety principles and control

The Nuclear Energy Act (Section 7a) prescribes that the safety of the use of nuclear energy (including waste management activities) shall be as high as reasonable achievable. To further enhance safety, all actions justified by operational experiences, safety research and the progress in science and technology shall be taken. Additionally, nuclear waste shall 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 shall be planned giving priority to safety and so that ensuring long-term safety does not require the monitoring 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 assessment of safety in authorization processes, issuance of detailed safety requirements and 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. The basic goal of the financing system for radioactive waste management and decommissioning is to ensure that funds for future waste management are collected so that assets are available even in case of insolvency of the waste generator. The NPP operators include the costs of waste management, even those arising from the decommissioning of the NPPs, in the price of nuclear electricity. Initially, the nuclear power companies had internal funds for that purpose, but by virtue of 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 Ministry of Employment and the Economy) in 1988. To ensure that the financial liability is covered, every third year the nuclear power companies and the operator of the research reactor are obliged to present cost estimates for the future management of nuclear wastes and take care that the required amount of money is set aside to the State Nuclear Waste Management Fund. In order to provide for the insolvency of the nuclear utilities, they shall provide securities to the State for that part of financial liability which is not covered by the Fund. Also in case of the research reactor, the operator is responsible for the planning and implementation for spent nuclear fuel and nuclear waste management. In the case of the research reactor the State initially funded the necessary provision to the State Fund.

The Radiation Act (Section 19) provides for furnishing the financial security of radioactive waste management for non-nuclear practices as follows: to ensure that the licensee meets the costs incurred in rendering radioactive waste harmless and in carrying out any decontamination measures that may be needed in the environment, the licensee shall furnish securities if the operations produce or are liable to produce radioactive waste that cannot be rendered harmless without substantial cost.

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