

Publications of the Ministry of Economic Affairs and Employment
TEM reports • Energy • 2019:45

Final Report of the National Cooperation Group on Nuclear Waste Management



Ministry of Economic Affairs
and Employment of Finland

Publications of the Ministry of Economic Affairs and Employment
reports 2019:45

Final Report of the National Cooperation Group on Nuclear Waste Management

Ministry of Economic Affairs and Employment

ISBN PDF: 978-952-327-441-9

Layout: Government Administration Unit, Publications

Helsinki 2019

Description sheet

Published by	Ministry of Economic Affairs and Employment	2019	
Authors	Linda Kumpula, Outi Slant		
Title of publication	Final Report of the National Cooperation Group on Nuclear Waste Management		
Series and publication number	Publications of the Ministry of Economic Affairs and Employment TEM reports 2019:45		
Register number		Subject	Energy
ISBN PDF	978-952-327-441-9	ISSN (PDF)	1797-3554
Website address (URN)	http://urn.fi/URN:ISBN:978-952-327-441-9		
Pages	85	Language	English
Keywords	nuclear energy, nuclear waste management, nuclear waste, radioactive substances, radioactivity, radiation, energy		
Abstract			
<p>In June 2017, the Ministry of Economic Affairs and Employment appointed a working group to explore the objectives, development measures and alternative solutions for safe and cost-efficient nuclear waste management and other radioactive waste management from today well into the future. It is the working group's opinion that it is important to ensure appropriate management of all existing and future radioactive waste regardless of its origin, producer or production method. Finland must have in place procedures that cover the processing, storage and disposal of all nuclear waste originating in Finland, as well as other radioactive waste.</p> <p>It is expedient to primarily use the existing infrastructure to implement waste processing and disposal. This will require cooperation and development of the nuclear facilities' licence procedures. From the licence holder's perspective, cooperation is feasible if it does not affect companies' electricity production or the sociological acceptability of operations. However, making changes to the licences of nuclear facilities is slow and expensive, and it will complicate cooperation with other licence holders. If licence procedures are to be developed by legislative means, every effort should be made to ensure flexibility while upholding the important principles of the Nuclear Energy Act such as risk-conscious approach to safety, the correct level of decision-making, the opportunity of local municipalities to influence, and society's participation.</p> <p>In the future, steps must be taken to develop cooperation in areas affected by the Nuclear Energy Act, Radiation Act and Waste Act. Waste exempted from supervision under the Nuclear Energy Act and Radiation Act is harmless with respect to its radiation properties, in which case it is supervised under the Waste Act. However, certain prejudices are still attached to such waste, which makes its appropriate management more complicated.</p>			
Publisher	Ministry of Economic Affairs and Employment		
Distributed by/ publication sales	Electronic version: julkaisut.valtioneuvosto.fi Publication sales: julkaisutilaukset.valtioneuvosto.fi		

Kuvailulehti

Julkaisija	Työ- ja elinkeinoministeriö	2019	
Tekijät	Linda Kumpula, Outi Slant		
Julkaisun nimi	Kansallisen ydinjätehuollon yhteistyöryhmän loppuraportti		
Julkaisusarjan nimi ja numero	Työ- ja elinkeinoministeriön julkaisu 2019:45		
Diaari/ hankenumero		Teema	Energia
ISBN PDF	978-952-327-441-9	ISSN PDF	1797-3554
URN-osoite	http://urn.fi/URN:ISBN:978-952-327-435-8		
Sivumäärä	85	Kieli	englanti
Asiasanat	ydinenergia, ydinjätehuolto, ydinjätteet, radioaktiiviset aineet, radioaktiivisuus, säteily, energia		
Tiivistelmä	<p>Työ- ja elinkeinoministeriö asetti kesäkuussa 2017 työryhmän selvittämään turvallisen ja kustannustehokkaan ydinjätehuollon ja muun radioaktiivisen jätteen huollon tavoitteita, kehitystoimenpiteitä ja ratkaisuvaihtoehtoja nykypäivästä pitkälle tulevaisuuteen. Työryhmän näkemyksen mukaan on tärkeää, että kaikesta Suomessa jo olevasta ja tulevasta radioaktiivisesta jätteestä huolehditaan asianmukaisesti riippumatta sen alkuperästä, tuottajasta tai tuotantotavasta. Suomella tulee olla menettelyt, jotka kattavat kaikki Suomessa syntyneiden ydinjätteiden ja muiden radioaktiivisten jätteiden käsittelyn, varastoinnin ja loppusijoittamisen. Tarkoituksenmukaista on, että jätteiden käsittely ja loppusijoittaminen toteutetaan pääasiassa olemassa olevalla infrastruktuurilla. Tämä vaatii yhteistyötä ja ydinlaitosten lupamenettelyjen kehittämistä. Luvanhaltijoiden näkökulmasta yhteistyö on mahdollista, jos sillä ei ole vaikutusta yhtiöiden sähköntuotantoon tai toiminnan yhteiskunnalliseen hyväksyttävyyteen. Ydinlaitosten lupien muuttaminen on kuitenkin hidasta ja kallista, ja se hankaloittaa yhteistyötä muiden luvanhaltijoiden kanssa. Lupamenettelyjen kehittämisessä tulee lainsäädännön keinoin tavoitella riittävää joustavuutta, säilyttäen kuitenkin ydinenergiain tärkeät periaatteet, kuten turvallisuuden riskitietoisuus, oikea päätöksenteon taso, sijoituspaikkakuntien vaikuttamismahdollisuudet ja yhteiskunnan osallistuminen.</p> <p>Yhteistyötä on jatkossa kehitettävä myös ydinenergiain, säteilylain ja jätelain rajapinnassa. Ydinenergiain ja säteilylain mukaisesta valvonnasta vapautettu jäte on säteilyominaisuuksiltaan vaaratonta, jolloin se siirtyy jätelain mukaiseen valvontaan. Jätteeseen liittyy kuitenkin edelleen ennakkoluuloja, jotka hankaloittavat niiden asianmukaista käsittelyä.</p>		
Kustantaja	Työ- ja elinkeinoministeriö		
Julkaisun jakaja/myynti	Sähköinen versio: julkaisut.valtioneuvosto.fi Julkaisumyynti: julkaisutilaukset.valtioneuvosto.fi		

Presentationsblad

Utgivare	Arbets- och näringsministeriet	2019
Författare	Linda Kumpulainen, Outi Slant	
Publikationens titel	Slutrapport från nationella samarbetsgruppen för kärnavfallshantering	
Publikationsseriens namn och nummer	Arbets- och näringsministeriets publikationer 2019:45	
Diarie-/ projektnummer		Tema Energi
ISBN PDF	978-952-327-441-9	ISSN PDF 1797-3554
URN-adress	http://urn.fi/URN:ISBN:978-952-327-441-9	
Sidantal	85	Språk engelska
Nyckelord	kärnenergi, kärnavfallshantering, kärnavfall, radioaktiva ämnen, radioaktivitet, strålning, energi	
Referat	<p>Arbets- och näringsministeriet tillsatte i juni 2017 en arbetsgrupp för att utreda målen med och åtgärderna för utveckling av en säker och kostnadseffektiv kärnavfallshantering och hantering av annat radioaktivt avfall och alternativa lösningar i samband därmed utgående från dagsläget och med sikte inställt långt in i framtiden. Arbetsgruppen anser att det är viktigt att allt radioaktivt avfall som redan finns och sådant som uppkommer i framtiden i Finland hanteras på tillbörligt sätt oberoende av dess ursprung, vem som producerat det eller det sätt på vilket det har producerats. Finland bör ha förfaranden som omfattar all hantering, lagring och slutförvaring av kärnavfall och annat radioaktivt avfall som uppkommit i Finland.</p> <p>Det är ändamålsenligt att avfallshanteringen och slutförvaringen av avfallet genomförs huvudsakligen med den existerande infrastrukturen. För detta krävs samarbete och utveckling av tillståndsförfaranden som gäller kärnanläggningar. Ur tillståndshavares synvinkel är samarbetet möjligt, om det inte inverkar på bolagens elproduktion och verksamhetens sociala acceptabilitet. Det går dock mycket långsamt och är mycket dyrt att ändra tillstånden för kärnanläggningar, och det försvårar samarbetet med andra tillståndshavare. När tillståndsförfaranden utvecklas bör målet vara att man med lagsstiftningsmedel eftersträvar tillräcklig flexibilitet, dock så att kärnenergilagens viktiga principer, såsom säkerhet som utgår från riskbedömning, den rätta nivån av beslutsfattande, förläggningssorternas påverkansmöjligheter och samhällets deltagande, bevaras.</p> <p>Samarbetet bör i fortsättningen utvecklas också i kontaktytan mellan kärnenergilagen, strålskyddslagen och avfallslagen. Det avfall som har undantagits från tillsynen enligt kärnenergilagen och strålskyddslagen är ofarligt i fråga om strålningsegenskaperna, och omfattas fortsättningsvis av tillsynen enligt avfallslagen. Avfallet är dock alltjämt förknippat med fördomar som försvårar den ändamålsenliga hanteringen av det.</p>	
Förläggare	Arbets- och näringsministeriet	
Distribution/ beställningar	Elektronisk version: julkaisut.valtioneuvosto.fi Beställningar: julkaisutilaukset.valtioneuvosto.fi	

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Foreword

In June 2017, the Ministry of Economic Affairs and Employment appointed a working group to look at possible solutions for managing nuclear wastes and other radioactive wastes over a period extending from the present well into the future. The working group examined legislation on nuclear wastes and other radioactive wastes, the licensing architecture, disposal of sealed sources, challenges related to waste released from supervision, and the first nuclear facility to be decommissioned in Finland, or VTT Technical Research Centre of Finland's FiR 1 research reactor and its nuclear waste management. The working group also expressed its views on the National Programme for the management of spent fuel and radioactive waste laid down in the European Council Directive (2011/70/EURATOM), international and national reporting as well as competence development and international cooperation. This final report contains the working group's recommendations.

The working group was also tasked to discuss the Safety Investigation Authority's (SIA) investigation report (Y2016-01) concerning an accident at Roihupelto. In this report, the Safety Investigation Authority issued a safety recommendation to the Ministry of Social Affairs and Health and the Ministry of Economic Affairs and Employment. The Safety Investigation Authority recommended that the two ministries work together to establish licensing and supervision procedures for radioactive waste, ensuring that all radioactive waste generated in Finland can be handled, stored and disposed of in Finland, in case returning it to the country of manufacture proves unfeasible or impossible.

In summer 2018, the working group's discussions and the solution models proposed by it also led to, with the support of Teollisuuden Voima Oyj, a new type of licence term being included by the Ministry of Employment and the Economy in the operating licences granted for nuclear power plant units Olkiluoto 1 and Olkiluoto 2 by the Government on 20 September 2018. These licences will additionally enable the

handling and interim storage of low and intermediate level waste and other radioactive waste in Olkiluoto. The ministry will also continue the new practice thus established in the preparation of future operating licences.

The working group was chaired by Liisa Heikinheimo from the Ministry of Economic Affairs and Employment, with Linda Kumpula from the Ministry of Economic Affairs and Employment serving as its Secretary-General. The secretaries drawing up the working group's records were Netta Skön (until 10 November 2017), Jaakko Louvanto and Outi Slant (from 15 January 2018) from the Ministry of Economic Affairs and Employment. The working group's members were Jorma Aurela and Jaakko Louvanto from the Ministry of Economic Affairs and Employment; Mikko Paunio and Jari Keinänen from the Ministry of Social Affairs and Health; Susanna Wähä (until 12 December 2017), Sami Rinne (from 26 February 2018) and Kati Vaajasaari (until 31 December 2018) from the Ministry of the Environment; Pia Nordberg (until 31 July 2017), Kirsi Lipponen (from 29 August 2017 till 7 January 2019), Veli Pekka Valtonen (from 9 January 2019) and Heikki Yrjölä from the Ministry for Foreign Affairs; Jussi Heinonen and Santtu Hellstén from the Finnish Radiation and Nuclear Safety Authority; Jari Tuunanen and Tapani Eurajoki from Fortum Power and Heat Oy; Kristiina Rusanen and Juha Poikola from Teollisuuden Voima Oy; Heikki Hinkkanen, Ville Koskinen (until 12 December 2017) and Hanna Virlander (from 9 March 2018 to 18 January 2019) from Fennovoima Oy; Petri Kotiluoto and Suvi Karvonen from VTT Technical Research Centre of Finland; Kari Kaukonen and Samu Myllymaa from Posiva Oy; Juhani Hyvärinen from Lappeenranta-Lahti University of Technology LUT; and Kerttuli Helariutta from the University of Helsinki.

The working group met 13 times during its term extending from 14 September 2017 to 31 January 2019. The group also organised a seminar on competence development and international cooperation in nuclear waste management on 14 February 2019.

At the completion of its task, the working group submitted its unanimous final report to the Ministry of Economic Affairs and Employment.

Helsinki, June 2019

Chair Liisa Heikinheimo

Deputy Director General

Ministry of Economic Affairs and Employment

1 Introduction

In June 2017, the Ministry of Economic Affairs and Employment appointed a National Cooperation Group on Nuclear Waste Management (YETI) to examine the objectives of and the development measures and possible solutions for safe and cost-effective management of nuclear waste and other radioactive waste for a period extending from the present well into the future.

The development of nuclear waste management in Finland has progressed according to a government resolution on the objectives and schedules of research, investigation and planning activities related to nuclear waste management adopted by the Government in 1983. The objectives set in the government resolution have up to this time been achieved well. The next significant objective will be the disposal of spent nuclear fuel which, according to the government resolution, should begin around 2020. We can thus say that licensees under a waste management obligation in Finland discharge their duties responsibly. The management of other radioactive wastes is also in many respects well planned and organised in Finland.

There may be major differences between legislative requirements applicable to radioactive waste management depending on how the waste was generated; provisions on nuclear wastes are laid down in the Nuclear Energy Act, while provisions on other radioactive wastes are laid down in the Radiation Act. The YETI working group found the consistence of these Acts and consequentially applying international statutes and drafting lower-level regulations important issues in which further development is needed. In the working group's view, it is important that all radioactive waste existing and to be generated in Finland will be managed appropriately, regardless of its origin, producer or the method in which it was produced. Finland must have procedures covering the handling, storage and disposal of all nuclear wastes and other radioactive wastes generated in the country. This objective has not yet been fully achieved.

The final report describes the topics discussed by the working group and sets out the recommendations and suggestions relevant to them. The working group also recommends that the national programme for spent fuel and radioactive waste management referred to in Council Directive 2011/70/EURATOM be updated to cover the wastes within the scope of both the Nuclear Energy Act and the Radiation Act as a whole.

The group started its work by preparing a Road Map for 2018–2030 to outline the objectives of waste management in concrete terms. A number of ad hoc reports were also produced to prepare the ground for the discussions. Finally, the working group's findings were summed up in the form of conclusions, recommendations and suggestions. At the beginning of its term, the working group was given the authority to specify the topics of the required ad hoc reports. Procedures related to the State Nuclear Waste Management Fund were excluded from the group's tasks at this time, as a dedicated working group was appointed for this purpose in April 2018. Disposal solutions for spent nuclear fuel were also excluded from the group's brief, apart from the fuel of VTT Technical Research Centre of Finland's FIR 1 research reactor and discussions related to spent nuclear fuel as part of nuclear waste management as a whole. Commercial agreements between companies were also excluded from the working group's tasks.

2 Current status and goal state for 2030 of nuclear waste and other radioactive waste management

2.1 Current status of nuclear waste and other radioactive waste management

There are currently three nuclear power companies in Finland. Two of them have operating power plants (Figures 1 and 2) and are licensees under a waste management obligation. Teollisuuden Voima Oyj's (TVO) nuclear power plant units Olkiluoto 1 and Olkiluoto 2 (OL1, OL2) and Fortum Power and Heat Oy's (FPH or Fortum) Loviisa 1 and Loviisa 2 units (LO1, LO2) have been operating for some forty years. Additionally, TVO's Olkiluoto 3 unit (OL3) will begin generating electricity in 2020. Fennovoima Oy (Fennovoima) has applied for a construction licence for nuclear power plant Hanhikivi 1 in Pyhäjoki as a newcomer in the industry.

A polluter pays principle has been adopted in Finland, according to which those who generate nuclear wastes are responsible for managing them. TVO and FPH manage the low and intermediate level wastes generated in connection with nuclear energy production and interim storage of spent nuclear fuel themselves on their plant sites. Fennovoima is planning to do the same on its site. The processing, interim storage and disposal of wastes are managed effectively at Olkiluoto and Loviisa. While space in the caverns intended for the geological disposal of low and intermediate level waste (VLJ caves) will suffice for several more years, their expansion will be necessary later, especially to dispose of decommissioning waste from nuclear power plants.

Some of the decommissioning waste will be very low level waste, and good experiences of its near surface disposal have been obtained in other countries. The Nuclear Energy Act also allows near surface disposal in Finland, and the power companies have expressed interest in it. New licensing procedures regulated under the Nuclear Energy Act will be needed for the expansion of the VLJ caves, the near surface disposal of very low-level waste and the decommissioning and dismantling of nuclear power plants.

Originally, FPH and TVO were planning to export their spent nuclear fuel. This plan was only followed by FPH, while TVO stored all of its spent fuel in an interim storage facility of spent fuel at Olkiluoto. However, exporting spent nuclear fuel was prohibited under an amendment to the Nuclear Energy Act in 1994, after which the companies established Posiva Oy in 1995 to prepare and implement the disposal of spent nuclear fuel in Finland. Posiva has made good progress in its plans; the company was granted a construction licence for its disposal facility in 2015 and is expected to have preparedness for the disposal of spent nuclear fuel in 2024. Low and intermediate level wastes which must be processed, stored and disposed of are also generated in connection with Posiva's operations. Should Posiva's operations be expanded, for example to include a new nuclear power plant unit belonging to its owners or the disposing of other spent nuclear fuel generated in Finland, Posiva would need to go through the licensing procedure referred to in the Nuclear Energy Act.

Similarly to TVO and FPH, Fennovoima will also take care of the management of its low and intermediate level waste on the plant site (Figure 3). The debate on the disposal of Fennovoima's spent nuclear fuel has been lively in recent years. Fennovoima's primary plan is based on nuclear waste management cooperation with Posiva's owners and the disposal of Fennovoima's spent fuel at Posiva's disposal facility. As an alternative, Fennovoima is planning to operate its own disposal facility for spent nuclear fuel either in Eurajoki or Sydänneva in Pyhäjoki. The alternatives for the disposal of Fennovoima's spent nuclear fuel were discussed by a previous Ministry of Economic Affairs and Employment working group¹ in 2012. The final report of this working group, which was published in 2013, remains up to date.



Figure 1. Olkiluoto nuclear power plant. Source: TVO

The decommissioning and dismantling of the first nuclear facility in Finland is about to start over the next few years. This facility is VTT Technical Research Centre of Finland's FiR 1 research reactor in Otaniemi. Before they start dismantling, spent nuclear fuel must be removed from the reactor's premises. VTT Technical Research Centre of Finland's primary option is returning the spent nuclear fuel to the United States, from where the fuel was originally obtained. It is likely that before the fuel can be returned, VTT will need interim storage for its spent nuclear fuel outside Otaniemi campus area. The other alternative for VTT is to dispose of the spent nuclear fuel in Finland. Under the valid legislation, other nuclear waste must be managed in Finland; in other words, the waste should be handled, stored and disposed of in Finland.

Some of the nuclear power plants' operating and decommissioning waste will be harmless enough regarding its radiation properties to be removed from the plants as ordinary waste. The procedure for release from supervision in question works mainly well. The prohibition of taking organic waste to landfills, which entered into force in 2016, has however hampered these activities. Taking organic waste released from supervision to an incinerator has proven difficult, which is why operators have been forced to take it to landfills under derogations.

Radioactive wastes have been and will be generated in Finland also in such fields as health care, industry and research. These wastes resulting from use of radiation typically include disused sealed sources, unsealed sources and radioactive wastes generated during the handling of the sources or related research activities. While waste batches generated from use of radiation are typically small, they are located around the country. The producers of these wastes are responsible for making them harmless. Most of these wastes are so harmless in their radiation properties that they can be removed directly as waste referred in Waste Actor after short-term storage. Some of the wastes contain organic materials, however, and similar challenges have emerged in having the wastes accepted by landfills and incinerators as in the case of wastes from nuclear power plants.

The sources with the most dangerous properties can be returned to importers and manufacturers abroad. Sometimes a receiver for the source can no longer be found, and it becomes necessary to manage it in Finland. The Ministry of Social Affairs and Health has in place an agreement concluded with TVO in 1996 on the interim storage and disposal of such state-owned waste in the VLJ cave at Olkiluoto. Some individual high-activity sealed sources are currently found in Finland, however, for which there is no suitable disposal facility at the moment. Building a dedicated disposal facility for these sealed sources is not appropriate, however, and a disposal solution in which the existing infrastructure can be used should be found for them.



Figure 2. Loviisa nuclear power plant. Source: Fortum Power and Heat Oy

2.2 Goal state of nuclear waste and other radioactive waste management for 2030

The working group has formulated a goal state for the management of nuclear waste and other radioactive waste: in 2030, Finland will have a well-functioning system for managing nuclear waste and other radioactive waste. This system will be comprehensive, flexible and enabling. Disposal routes will be available for all wastes, and ad hoc solutions will not be needed for the management of wastes whose generation was not anticipated. Sufficient preparedness will also exist for the management of radioactive wastes generated as a result of any incidents. Waste management procedures and supervision will have been arranged in proportion to the risks, regardless of the origin of the waste. All functions related to nuclear wastes and other radioactive wastes will be robust, they will be sufficient in proportion to the needs, and the actors will be viable and resilient.

The rules and licensing procedures of use of nuclear energy will enable rational operation. Operating and/or other licences will be sufficiently comprehensive to allow the licensees to also cope with exceptional situations under their valid licences. The lifecycle of the nuclear facility licensing process will be straightforward, as will be the procedures for amending the licences. For the part of nuclear waste management, the appropriateness of the decision-in-principle procedure will have been reconsidered, and if necessary, a new procedure type will have been introduced: the decision-in-principle procedure will have been lightened by limiting it to issues that are important for society in principle, rather than tying it stringently to the volume of nuclear waste to be disposed of or the organisation managing the waste. The necessity of the decision-in-principle procedure for the expansion of disposal facilities, for example to accommodate decommissioning waste, will also have been reconsidered. Other licensing procedures related to expanding disposal facilities as well as the procedures and responsibilities (licensee/government) for the (partial) closure of disposal facilities will also have been discussed and, if necessary, clarified and specified. In addition, coordination between the codes on nuclear waste and other radioactive waste will have been improved, resulting in an effective set of statutes. A documented operating model will be available for applying the environmental impact assessment procedure to nuclear waste management. Following this model, carrying out environmental impact assessments will be straightforward and appropriate.

The requirements applicable to decommissioning will have been specified based on the experiences obtained from the dismantling of Swedish plants and FIR 1 research reactor. The management of other radioactive wastes will have been solved either by expanding nuclear power plants' waste management solutions to radioactive waste management or by some other centralised and costeffective method. The management of waste released from supervision will have been arranged by creating attractive operating conditions for conventional waste management operator/s. The availability of waste management services will have been secured by means of a level playing field. The general objective will be reducing waste volumes, either by influencing production or by processing the waste and making it less harmful for the environment. One possibility is building a shared incinerator or issuing an existing facility with a licence for waste fractions suitable for incineration. Management of waste resulting from incidents will have been organised, and the relevant regulation will be applicable to the regulation of nuclear waste management.

National nuclear waste management cooperation will be primarily based on commercial activities. Large and small operators in the industry and the State will engage in effective cooperation. Developing collaboration between large operators will also be seen as a concrete opportunity. Importation of Finnish expertise to other countries will have been put on a permanent footing, which will contribute to ensuring that competence can be maintained in Finland (Team Finland). Business opportunities related to exporting and importing cross-border services will also have been investigated. The turnover of Posiva Solutions will have grown in line with its strategy, and the company will bring a significant cash flow for its owners. Fortum will be a major player in selected segments of waste management and decommissioning operations, and Posiva's current consultants will have increased their external sales and partnership with Posiva. Partnerships between universities, research institutes and the industry will support growing commercial business. The authorities will have clear-cut roles that enable smooth cooperation. Legislation will have been developed and streamlined, and it will enable collaboration between operators in the industry as well as the exportation of Finnish expertise and the sales of services abroad.

In order to develop and maintain competence in Finland, the current national research programmes for nuclear waste management (KYT)² and nuclear safety (SA-FIR)³ will have been amalgamated, the courses on nuclear waste management and nuclear safety will have been merged (YJK course), and the universities will have

developed a joint doctoral programme focusing on nuclear safety, nuclear waste management and radiochemistry. The challenges related to competence development and maintenance will have been defined, and effective practices will have been developed to respond to them. National and international research in nuclear waste will also have been coordinated optimally.

The following chapters discuss the situation of nuclear waste management and the management of other radioactive waste in greater detail, as well as the actions needed to achieve the goal state described here.



Figure 3. Fennovoima's nuclear power plant site at Hanhikivenniemi in autumn 2018.
Source: Fennovoima Oy.

3 Statutes on nuclear waste management, interfaces and change needs

3.1 Current regulatory environment, structure and interfaces

Nuclear Energy Act

Provisions on nuclear waste management are laid down in the Nuclear Energy Act. Nuclear waste management refers to all measures necessary to recover, store and handle nuclear waste and dispose of it (Figure 4). Nuclear waste management also includes measures pertaining to the decommissioning and dismantling of a nuclear facility.

The Nuclear Energy Act defines nuclear waste as radioactive waste generated in connection with or as a result of the use of nuclear energy. Spent nuclear fuel is also regarded as nuclear waste once it can no longer be used for energy production. Nuclear waste also includes 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.

Under the Nuclear Energy Act, nuclear waste management shall be in line with the overall good of society and safe, and it shall not cause injury to people, or damage to the environment or property. According to the leading principle of nuclear waste management, the amount and the activity of nuclear waste generated in connection with use of nuclear energy shall be kept as small as reasonably possible through practical measures. Nuclear waste may also be released from supervision referred to in the Nuclear Energy Act and placed under supervision compliant with the Waste Act

(646/2011) if the exposure caused by the waste to the population is minor and the waste does not exceed the threshold values set for it.

Under Chapter 2 of the Nuclear Energy Act, nuclear waste generated in Finland shall be handled, stored and disposed of in Finland. This provision does not apply to nuclear waste which is delivered abroad for research purposes or for treatment in an appropriate manner. Additionally, nuclear waste that has been generated in connection with or as a result of the operation of a research reactor in Finland may be delivered abroad permanently. On the other hand, nuclear waste generated elsewhere than in Finland shall not be handled, stored or disposed of in Finland.

Nuclear waste management operations are subject to a licence. A licensee whose operations generate or have generated nuclear waste (*licensee under a waste management obligation*) shall be responsible for all nuclear waste management measures and their appropriate preparation, as well as for their costs (*waste management obligation*). Cancellation of a licence or expiration of its validity shall not exempt the licensee from their obligations related to nuclear waste management.

Under the Nuclear Energy Act, the implementation of nuclear waste management may be examined as part of the licensing procedure of nuclear facilities, including nuclear power plants (decision-in-principle, construction licence, operating licence or decommissioning licence). This procedure shall include an assessment of whether the applicant's methods for arranging nuclear waste management are adequate and appropriate.

In other respects, the licensing procedure for nuclear waste management depends on the scale and significance of the operation. When a nuclear facility used for nuclear waste management is regarded as having *considerable general significance*, a decision-in-principle of the Government must be applied for, deeming that its construction is in line with the overall good of society. Such facilities of considerable general significance include facilities intended for use for disposal of amount of nuclear waste having radioactive substances with significant activity (e.g. total activity > 1 TBq). These facilities also include facilities where a volume of nuclear waste with a significant level of activity (e.g. total activity > 100,000 TBq) is handled or stored at once.

A construction and operating licence granted by the Government shall also be applied for a facility used for nuclear waste management, and a decommissioning licence shall be applied for a nuclear facility to be decommissioned, if its operation is large in scale.

This includes the aforementioned disposal facilities. These facilities also include facilities where a volume of nuclear waste with a significant level of activity (e.g. total activity > 1 TBq) is processed or stored at once. When calculating the activity levels, the activity caused by natural uranium, thorium or depleted uranium shall not be taken into account.

When the operation of a facility used for nuclear waste management is not large in scale (e.g. total activity < 1 TBq), or it focuses on the transfer, transport, import or export of nuclear waste, an operating licence granted by the Radiation and Nuclear Safety Authority as laid down in section 21 of the Nuclear Energy Act is required.

The licensee shall fulfil their obligation to manage their nuclear waste according to the decision of the Ministry of Economic Affairs and Employment, or the decision of the Radiation and Nuclear Safety Authority if the licence for operations that generate nuclear waste has been granted by this Authority, until the licensee's waste management obligation expires. While the waste management obligation is valid, the Ministry of Economic Affairs and Employment may, on request, completely or partially transfer the waste management obligation to another party if the transfer of the obligation does not endanger the implementation of the nuclear waste management. The Ministry of Economic Affairs and Employment may order various licensees under the waste management obligation to undertake waste management measures jointly, if by doing so safety can be increased or costs can be substantially reduced or if any other weighty reason so requires.

The State has a secondary waste management obligation; in other words, the State will manage the nuclear waste of a licensee under a waste management obligation if implementing nuclear waste management or some part of it is not possible by measures taken by the licensee. Additionally, responsibility for nuclear wastes after their processing and disposal is transferred to the State once the licensee's waste management obligation has expired.

The licensee under a waste management obligation shall also make financial provision for the costs of nuclear waste management as provided in Chapter 7 and for financing research related to nuclear waste management as provided in Chapter 7a.

Radiation Act

Provisions on the management of radioactive waste, excluding nuclear waste, are laid down in the Radiation Act (859/2018). Radioactive waste management refers to measures needed to treat, isolate and dispose of radioactive waste or to restrict its use, ensuring that the waste does not endanger human health or the environment (Figure 4).

Under the Radiation Act, radioactive waste means a radioactive substance or appliances, goods and materials contaminated by radioactive substances, that have no use or for which no owner can be found and which must be managed due to their radioactivity. In practice, this means disused sources containing radioactive substances and other radioactive wastes generated in connection with their use. Any facilities contaminated with radioactive substances must also be decontaminated or dismantled after their operation.

Under the Radiation Act, use of sources containing radioactive substances and management of radioactive waste must be safe and use of sources must be arranged to minimise the amount of radioactive waste generated as far as reasonably possible through practical measures. Sources containing radioactive substances are not regarded as radioactive waste as long as they are in use. Under the Radiation Act, the operator may transfer a source containing radioactive substances to its manufacturer or supplier or to another operator once the need to use it ceases.

The generation of radioactive waste can be influenced by reducing the use of sources containing radioactive substances and agreeing upon their return already in the purchasing phase. The use of high-activity sealed sources should be justified in comparison to equipment producing radiation by electrical means or other alternative technologies. In addition, sealed sources may only be imported to Finland from non-EU countries or shipped from another EU Member State if their manufacturer has undertaken in writing to receive the sealed source once it is no longer used. However, if the half-life of the radioactive substance contained in the sealed source is short enough, the sealed source may be, after storage, released from supervision under the Radiation Act and subjected to supervision under the Waste Act. Sealed sources must be removed from use at the latest 40 years after their conformity with the requirements has been proven.

Any sources containing radioactive substances for which no receiver be found abroad must be managed in Finland. On the other hand, a source containing

radioactive substances, which has been manufactured outside Finland, may not be imported from a non-EU country or shipped from another EU Member State to Finland as radioactive waste. Other radioactive waste may, however, be imported and shipped for processing and disposal if a valid agreement exists at the time of the transfer regarding the use of a suitable disposal facility. Exporting radioactive waste is prohibited, however, e.g. to States which are estimated not to have adequate technical, legislative and administrative capabilities for managing radioactive wastes.

Functions associated with sources containing radioactive substances and radioactive wastes are subject to a licence under the Radiation Act. A safety licence granted by the Radiation and Nuclear Safety Authority must be obtained for such purposes as possession, use, storage and safekeeping of sources containing radioactive substances and radioactive waste management. Importing sources containing radioactive substances and radioactive wastes from non-EU countries and exporting them to such countries are also subject to a licence.

An operator must see to the management of any radioactive waste generated in connection with their activities. When applying for a safety licence, an operator must describe the arrangements for managing radioactive wastes during the operation and when discontinuing it. The operator may hand over radioactive wastes to another operator active in the field of radioactive waste management. If exposure to the population caused by the waste is found to be minor, the waste may be released from supervision under the Radiation Act and removed following the provisions of the Waste Act.

According to the Radiation Act, the State has a subsidiary waste management obligation: the State will manage the radioactive wastes generated in connection with an operator's actions if the operator does not meet, or cannot be expected to meet, their waste management obligation within a reasonable period of time. The State will also see to the management of radioactive waste when the origin of such waste is unknown or an operator with a waste management obligation cannot be found. The State will also see to radioactive waste management if the operator cannot hand over a source containing radioactive substances or radioactive waste to the manufacturer or another operator.

The operator must also lodge a security to ensure that the costs of radioactive waste management and any environmental decontamination measures can be paid for.

For example, a security must be lodged if the operator’s licence is for high-activity sealed sources or several sources containing radioactive substances with total activity corresponding to a high-activity sealed source, or if the action generates or may generate radioactive waste with considerable management costs. Decisions on lodging a security as well as on the amount and verification of the security are made by the Radiation and Nuclear Safety Authority.

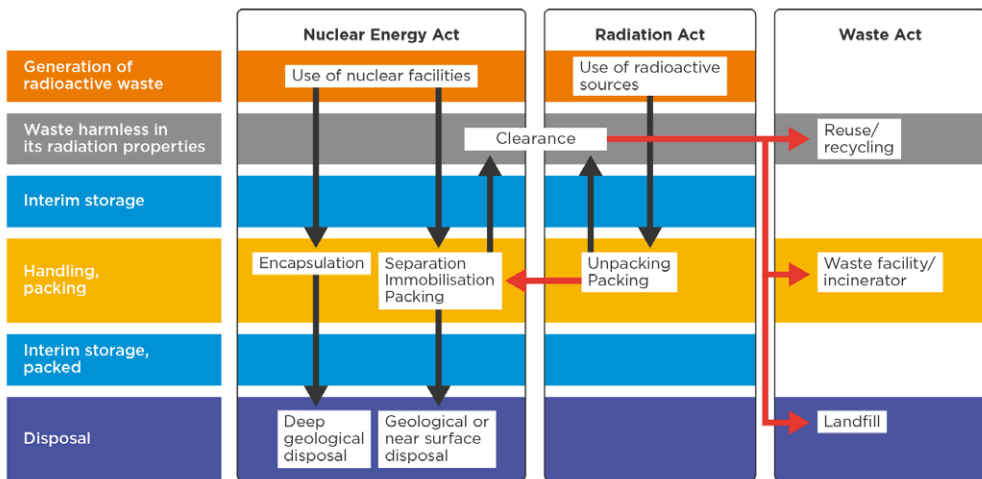


Figure 4. Radioactive waste is generated as the result of use of nuclear facilities and use of sources containing radioactive substances. Radioactive waste referred to in the Radiation Act does not have its own disposal facility in Finland, but the waste can be handled, stored and disposed of at the nuclear facilities according to the limits of their licences. Red arrows indicate the transfer of waste from the scope of one law to another. Source: Juhani Hyvärinen

Waste Act

The purpose of the Waste Act (646/2011) is to prevent the hazard and harm to human health and the environment posed by waste and waste management, to reduce the amount and harmfulness of waste, to promote the sustainable use of natural resources, to ensure functioning waste management and to prevent littering. The Act applies to waste, waste management, and littering as well as products and activities generating waste. The Act does not apply to, among other things, nuclear waste referred to in the Nuclear Energy Act or radioactive waste referred to in the Radiation Act.

In the Waste Act, waste means any substance or object which the holder discards or intends, or is required, to discard. Hazardous waste means any waste with properties that render it flammable or explosive, infectious, or hazardous to human health or the environment in other ways, or with other corresponding properties (hazard property). Waste management means such activities as the collection, transport, recovery and disposal of waste, including after-care of disposal sites (Figure 4).

Under the Waste Act, an order of priority shall be followed in waste management insofar possible: as a first priority, the amount and harmful properties of the generated waste should be reduced. Where waste is generated, however, the waste holder shall primarily prepare the waste for reuse or, secondarily, recycle it. If recycling the waste is not possible, the waste holder shall use the waste in other ways, including for energy. If using the waste is not possible, it shall be disposed of according to Waste Act. Waste disposal means in Waste Act, among other things, placing it in a landfill or incinerating it without energy recovery.

The polluter pays principles has been adopted in the Waste Act, according to which the original producer or the current or prior holder is liable for the waste management costs. The costs of disposal and the fee charged for it include the costs of the establishment, operation, decommissioning and after-care of the disposal facility or site and the security for the waste management back-end activities.

Arranging waste management is the responsibility of the waste holder. The waste holder's liability to organise waste management expires or is transferred to a new holder when the waste is handed over to a receiver who has a licence or other appropriate approval for receiving it.

Act on Environmental Impact Assessment Procedure

The objective of the Act on Environmental Impact Assessment Procedure (252/2017) is to promote the carrying out of environmental impact assessments and consistently taking the assessments into consideration in planning and decisionmaking while providing improved access to information and opportunities for participation for all. Environmental impact assessment (EIA) refers to assessing the direct and indirect impacts of the project under scrutiny in Finland and outside Finnish territory. The assessment should cover impacts on the population and human health, living conditions and comfort; the ground, soil, waters, air, climate,

vegetation as well as organisms and biodiversity; urban structure, material property, landscape, townscape and cultural heritage; natural resources use; and interactions between the factors listed above.

The responsibility for carrying out an environmental impact assessment rests with the operator whose project or activities the assessment concerns. In projects concerning nuclear facilities referred to in the Nuclear Energy Act, the authority responsible for ensuring that the environmental impact assessment procedure is carried through (as the contact authority) is the Ministry of Economic Affairs and Employment. General guidance and monitoring related to the Act as well as the overall development of the EIA procedure are within the remit of the Ministry of the Environment. The Ministry of the Environment also sees to tasks set out in the Convention on Environmental Impact Assessment in a Transboundary Context, to which Finland is a party.

The environmental impact assessment procedure is always applied to projects and project modifications that are likely to have significant environmental impacts. These projects and project modifications are listed in Annex 1 to the Act, or the so-called project list. In individual cases, the EIA procedure may also be applied to projects other than those cited on the project list and modifications to implemented projects other than those included in the modifications on the project list if they are likely to cause significant environmental impacts similar to the ones included on the list. Decisions on applying the assessment procedure to nuclear facilities referred to in the Nuclear Energy Act in individual cases are made by the Ministry of Economic Affairs and Employment.

Projects related to the Nuclear Energy Act and the Radiation Act on the project list include nuclear power plants and other nuclear reactors without a power limit; facilities intended for the reprocessing of spent nuclear fuel; and facilities designed for the production and isotopic enrichment of nuclear fuel, processing of spent nuclear fuel or high-level waste, disposal of spent nuclear fuel or radioactive waste, or storage of spent nuclear fuel or radioactive waste for more than 10 years at a location other than the site on which it was generated.

The results of environmental impact assessments must be taken into consideration in decisions-in-principle and licensing decisions compliant with the Nuclear Energy Act.

3.2 Development needs related to the regulatory environment

The Nuclear Energy Act and Decree need to be developed in a number of ways. Reconciling the Nuclear Energy Act and Decree is difficult in parts, and the definitions contained in them are dispersed. The Act was intended for large nuclear power plant projects of national significance implemented by an individual major company. Certain fundamental provisions, by virtue of which more detailed provisions could be issued, are absent in the Nuclear Energy Act. Additionally, the different operating licences granted by the Radiation and Nuclear Safety Authority are scattered around the various Chapters of the Act. The definitions of nuclear waste and a licensee under a waste management obligation need to be amended, while it may also be necessary to update the definition of a nuclear waste facility.

The definitions of nuclear waste in the Nuclear Energy Act and the Radiation Act are inconsistent. Nuclear waste is a definition created in the Nuclear Energy Act for radioactive waste generated in connection with or as a consequence of use of nuclear energy, which also covers spent fuel. The Radiation Act defines radioactive waste as waste generated as a result of use of radiation. In the international context, there is no separate definition for nuclear waste and radioactive waste; spent fuel is seen as a separate entity not covered by the definition of radioactive waste. While the national definition is not inconsistent with international definitions as such, in practice it may lead to difficulties of interpretation, which is why it is appropriate to evaluate the possibilities of introducing uniform definitions.

International definitions also leave some room for manoeuvre regarding the stage at which spent fuel, for example, is interpreted as waste. Spent fuel can be regarded as either reusable material or waste. In Finland, the latter interpretation has been adopted as a point of departure. The national definitions have been found awkward in practice, for example in the context of exporting research samples consisting of fuel rods. In the future, it may be necessary to examine the definition of nuclear waste in proportion to reusability and ensure consistency with the terminology used in the Radiation Act.

The point at which the waste management obligation begins is also not accurately specified in the Act. In practice, however, the obligation is considered to begin on a sliding scale somewhere between the construction licence stage and operating licence stage. This may be justified by the fact that, even if the action generating waste only begins once the operating licence has been granted, preparations for waste management

measures must be launched before that time. In the most concrete terms, this means confirming compliance with the principles of the waste management obligation referred to in section 28 of the Nuclear Energy Act, based on which the operator has the duty to submit a waste management scheme at the latest together with the operating licence application.

In order to avoid ambiguities of interpretation, however, the time at which the waste management obligation begins should be specified to avoid situations involving unclear interpretations for new operators (Posiva and later Fennovoima). In addition, the procedures associated with the licensee's waste management obligation, including possibilities of transferring the obligation and the expiry of the obligation at the practical level, need to be examined when developing the regulation in the future.

Transferring the waste management obligation may be appropriate when the licensee of a disposal facility accepts the nuclear waste of another licensee for disposal. Also when the period between the decommissioning of a nuclear power plant and the disposal of spent nuclear fuel, including the closure of a disposal facility, is significantly long, transferring the waste management obligation regarding nuclear waste already disposed may be considered. An alternative to this is examining the expiry of the waste management obligation related to a partly closed disposal facility, in which case the arrangements for supervision and monitoring carried out by the State should also be considered.

Ultimately, sufficiently detailed provisions on the expiry of the waste management obligation have not been issued. Under the valid Act, when the responsibility for nuclear waste is transferred to the State, the licensee responsible for waste management has to pay the State a one-off fee for monitoring and supervising the wastes. The amount of this one-off fee should be specified, as the current legislation fails to do so.

Recommendation 1. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority together with the licensees investigate and, if necessary, develop the definition of nuclear waste and clarify definition of licensee under a waste management obligation in the Nuclear Energy Act. Aim of the recommendation is enabling the appropriate processing of the waste or product generated in different actions. The objectives also include harmonising national and international definitions. This recommendation should be accounted for in developing legislation.

Recommendation 2. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority prepare a document on the licensees' waste management obligation. This document would address the alternative solutions of waste management obligation and also take into consideration the procedures and responsibilities related to the partial and full closure of disposal facilities. Any shortcomings and ambiguities associated with the waste management obligation in the legislation should be addressed when developing the Nuclear Energy Act. The deadline for implementing the recommendation is 31 December 2020 regarding the document, and the recommendation should be accounted for in developing legislation.

Interface between the Nuclear Energy Act and the Radiation Act

In terms of procedures related to nuclear wastes and other radioactive wastes, it is vital that the interface between the Nuclear Energy Act and the Radiation Act is clearcut and that provisions on similar issues follow the same principles and procedures in both Acts, taking scaling and targeting proportionate to the risk into account. In particular, these issues include licensing, reusability of waste, releasing wastes from supervision, waste management and financial provision obligations as well as enabling the processing, interim storage and disposal of wastes subject to the Radiation Act in facilities subject to the Nuclear Energy Act.

Interface between the Nuclear Energy Act, the Radiation Act and the Waste Act

The Nuclear Energy Act, the Radiation Act and the Waste Act have an interface regarding waste released from supervision. The Waste Act is not applied to nuclear waste referred to in the Nuclear Energy Act or radioactive waste referred to in the Radiation Act, but wastes released from supervision pursuant to both Acts are within the scope of the Waste Act. Under the Nuclear Energy Act and the Radiation Act, wastes released from supervision have been declared harmless regarding their radiation properties, and on these grounds these wastes should not be determined to have a hazard property referred to in the Waste Act. However, they may be dangerous due to some other property of the waste. No immediate needs for improvements were found in the regulation on waste released from supervision.

4 Developing the licensing architecture

4.1 Current state of licensing architecture of nuclear facilities

The licensing of nuclear facilities has mainly worked well in Finland, and the implementation of nuclear waste management has progressed further in Finland than in other countries. The licensing procedures of nuclear facilities follow an architecture defined in the Nuclear Energy Act, or a chain of licensing stages often beginning from a government's decision-in-principle and continuing with a construction and operating licence granted by the Government. Following the operating licence, or several fixed-term licences, the nuclear facility is decommissioned subject to a decommissioning licence. The licensing stages also include an environmental impact assessment which, at minimum, must be carried out before applying for a decision-in-principle and decommissioning licence. In other situations, the need for an environmental impact assessment is considered on a case-by-case basis.

The duties and responsibilities related to applying for licences are well defined in the Nuclear Energy Act. The operator applies for a decision-in-principle and licences for a nuclear facility. The decisions-in-principle and licensing decisions are prepared by the Ministry of Economic Affairs and Employment and made by the Government. A precondition for granting a licence is that the Radiation and Nuclear Safety Authority is in favour of the project in its safety assessment. Additionally, the decision-in-principle is approved or rejected by Parliament. The Radiation and Nuclear Safety Authority also serves as a licensing authority and issues so-called licences for operations to companies on application. The licences for operations are associated with such operations as the processing, storage and disposal of nuclear wastes when their total activity is low. The Radiation and Nuclear Safety Authority also issues transport licences (Figure 5) and safety licences referred to in the Radiation Act.

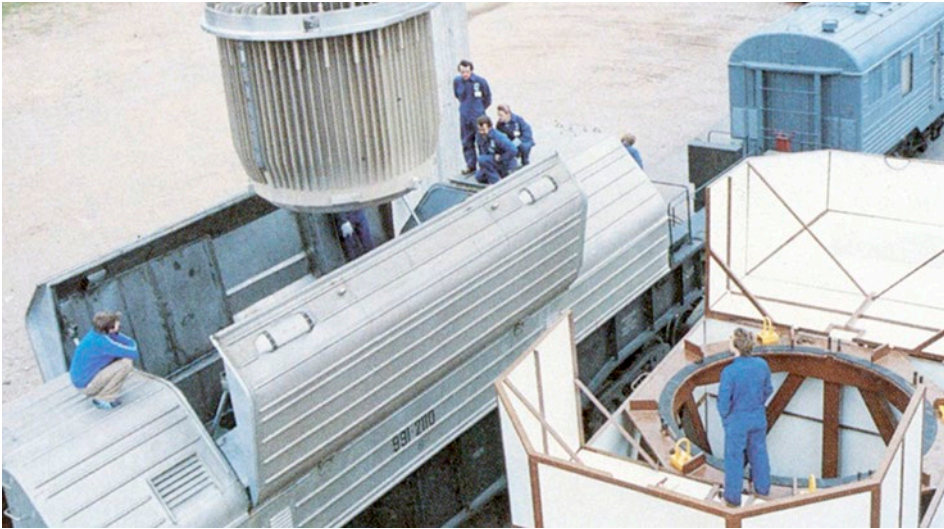


Figure 5. In the early years of the use of Loviisa nuclear power plant, the spent nuclear fuel was returned after short interim storage period to the Soviet Union (later to Russian). After Posiva starts operation, fuel will be transported from Loviisa to the Olkiluoto in Eurajoki.
Source: Fortum Power and Heat Oy

The Nuclear Energy Act is an old statute, and its provisions have been amended frequently over the decades. The Act was passed at a time when operations in this industry had recently been put on a permanent footing in Finland, and it may not have been possible to anticipate the situations related to the final stage of the facilities' life cycle. The amendments have also partly eroded the uniformity of the statutes, and the legislation may sometimes create situations difficult to interpret regarding licensing and the licensing architecture. It is vital for the operators to have a clear idea of what is expected of them in different situations. This would also facilitate their long-term planning.

It is important for the operators to be able to conclude commercial agreements on nuclear waste management cooperation. The Act allows such agreements, and agreements have also been concluded in recent years. However, nuclear facilities' valid licences set limitations to the cooperation, and attention should also be paid to the licences from this perspective.

4.2 Developing the licensing architecture of nuclear facilities

Practical cooperation and also the development of nuclear power companies' in-house operations are hampered by the fact that amending the valid licences of nuclear facilities is a slow and expensive process, even if the changes are relatively minor. Consequently, licences for nuclear facilities could be developed by legislative means to provide better coverage for the entire life cycle of the facility, with more detailed requirements provided in lower-level decisions. Alternatively, the licences should be made more flexible in other ways. Practices adopted for applying licences and for preparing decisions concerning them may also be more restrictive than legislation itself. Currently, the operating licences of nuclear facilities limit the activities, for example regarding the area in which the waste subject to the licence was generated and where the waste may be stored and disposed of within the nuclear facility site. This has led to situations where functions required for the normal operation of a nuclear facility have been enabled by licences for operations granted by the Radiation and Nuclear Safety Authority outside the scope of the operating licences for the nuclear facilities granted by the Government. In the future, the smooth running of such functions should be promoted by putting together clearer licence packages.

Accounting for wastes regulated under the Radiation Act as part of developing the licensing architecture

The challenges related to licences for nuclear facilities in relation to other radioactive waste generated in Finland emerged concretely as an accident caused by the rupture of a disused sealed source took place in the premises of Suomen Nuklitekniikka at Roihupelto in 2016. In this situation, radioactive substance contained by the sealed source spread on the company's own premises and in the nearby premises of the Radiation and Nuclear Safety Authority. The wastes generated while decontaminating the premises could not be taken to nuclear power plants for processing, even if the plants had the equipment needed to process this waste, as their operating licences only permitted them to process nuclear waste generated at the plant in question. Applying for a separate licence for processing the waste was also found an ineffective solution at that time.

The Safety Investigation Authority (SIA) decided to investigate the accident and, in its investigation report⁴, issued a recommendation according to which *the Ministry of Social Affairs and Health and the Ministry of Employment and Economic Affairs [should]*

jointly establish procedures for granting licences for and managing radioactive waste in order to ensure that all radioactive waste generated in Finland can be handled, stored and disposed of safely in our country in the event that returning it to the manufacturing country via the importers proves inappropriate or impossible [2017-S12].

The licensing procedures under the Nuclear Energy Act and the Radiation Act are separate processes in Finland, whereas there is an essential need to account for wastes subject to the Radiation Act in nuclear facilities' licences. In the Finnish context, rather than the location where the waste was generated and whether it is subject to the provisions of the Nuclear Energy Act or the Radiation Act, the essential point is that the waste can be processed, stored and disposed of safely and cost-effectively. Whereas there are nuclear facilities in Finland where all radioactive waste generated in the country could at least be processed and stored and potentially also disposed of, the licences and procedures need to be developed. Attention should thus be paid to this matter in connection with future licensing processes. The disposal solution for wastes subject to the Radiation Act partly remains undecided, and it has thus been impossible to lay down provisions on their disposal in Radiation Act.

While the nuclear facility licensees could incorporate the waste management of small operators in their operations, their priority is electricity production, which cannot be allowed to be affected negatively by solutions related to other operators' waste management. The licensees wish to avoid risks associated with licensing procedures and the local acceptability of the actions, and for this reason, they will not apply for new licences or amendments to the existing ones without careful consideration. In the current model of licensing procedures, the process of making amendments to and expanding the licences slows down and even prevents the emergence of new solutions in radioactive waste management.

Addressing safety risks as part of developing the licensing architecture

Additionally, the licensing structure related to radioactive wastes should be developed as a whole on the basis of the safety risk posed by the wastes. This awareness is not realised at the moment: as the licensing authority under the Radiation Act, the Radiation and Nuclear Safety Authority may issue a safety licence for using very high-activity sources, whereas the processing, storage and disposal of the low and intermediate-level wastes from the decommissioning of VTT's research reactor, for

example, are discussed by the Government, even if the activity level of these wastes is about one hundredth of the most active sources.

For the part of nuclear wastes, the licensing authority is determined by the threshold value for total activity laid down in the Nuclear Energy Decree, or 1 TBq. When this threshold value is exceeded, the facility responsible for the processing, storage and disposal of nuclear waste is regarded as a nuclear facility, in which case decisions on its licences are made by the Government. The threshold value is low considering the nature of the industry, and no justifications for it can be found any more. From the licensees' perspective, however, a clear-cut limit may be considered justified. Any increase in the threshold value based on safety aspects and the type of licences on which it is appropriate for the Government to make decisions remain to be considered. The threshold value is not related to safety assessment, as the Radiation and Nuclear Safety Authority evaluates the safety regardless of the licensing procedure.

Accounting for new facility types in licensing architecture development

The possibility of new types of facilities being built in Finland should be accounted for in the developing of licensing architecture. There currently are no disposal facilities in Finland below the threshold value of 1 TBq. Very low-level waste is disposed of in near surface disposal facilities in many other countries, however, and there is also interest in doing so in Finland. The concept of disposal would be different, as the waste could be placed in the ground rather than in the bedrock. A disposal facility for very low-level waste could be described as a supervised industrial landfill according to the Nuclear Energy Act, with the Radiation and Nuclear Safety Authority serving as its licence authority. The applicability of the provisions under the Nuclear Energy Act will only be proven at the practical level if and when such facilities are built in Finland.

The potential of Small Modular Reactors (SMRs) becoming part of the nuclear power scene in Finland may also have an impact on the licensing architecture of nuclear facilities and the principles of nuclear waste management. Currently, the most highly advanced small modular reactors in commercial terms are pressurised light-water reactors; the nuclear fuel in them is similar to the fuel used in large operating nuclear power plants, however with fuel elements which are only half the conventional length. Other technologies in this size range are also being developed.

Low and intermediate level waste generated in connection with small modular reactors is similar to the waste generated in large nuclear power plants. As a rule, the amount of the nuclear waste generated is proportionate to reactor power. The management of nuclear waste from small modular light-water reactors would not be technically different from the practices at large nuclear power plants. Potentially, they could rely fully on outsourced services for their waste management if nuclear waste management service providers were available. The constructor of small modular reactors may also be a company which already has a licensed nuclear facility at another location. However, several modules built on the same site would be a challenge to the licensing architecture if some of them were constructed and commissioned later than others.

Political and societal perspectives should also be addressed in the development of the licensing architecture for nuclear facilities. Interesting topics in recent years have included issues related to spent nuclear fuel and potential new nuclear facility sites, in particular. In licensing procedures, it is furthermore important to address societal participation and providing possibilities for exerting influence to the municipalities in which the plants would be located and their neighbours. The municipalities in which the plants are located, in particular, have a heavy involvement in the daily issues related to the plants and, among other things, they issue the conventional construction permits to the nuclear facilities.

Recommendation 3. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority develop the licensing procedures under the Nuclear Energy Act and the Radiation Act to ensure that the requirements for and supervision of waste management procedures have been organised in proportion to the risks, regardless of the origin of the waste. This recommendation should be accounted for in developing legislation.

Recommendation 4. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority develop the licensing procedures and supervision measures under the Nuclear Energy Act and the Radiation Act to ensure that the licences enable cooperation in the management of all nuclear waste and other radioactive waste generated in Finland. The cooperation in waste management would take place as part of the licensees' business, ensuring that

development efforts will not put the safety of waste management at risk. This recommendation should be accounted for in developing legislation.

4.3 More detailed reviews and development goals of the licensing architecture of nuclear facilities

Environmental impact assessment

The objective of environmental impact assessment is taking environmental impacts into account when planning and making decisions on projects and providing better access to information and opportunities for participation for local residents. The environmental impact assessment covers the entire life cycle of the nuclear facility from construction to decommissioning or closure.

The environmental impacts of facilities must be assessed before applying for a decision-in-principle. The projects for which an environmental impact assessment must be carried out are listed in Annex 1 to the Act on Environmental Impact Assessment Procedure. On a discretionary basis, an environmental impact assessment may also be required in individual cases for projects that are of different type or similar but smaller than the projects included on this list. An environmental impact assessment must also be carried out for nuclear power plants and other nuclear reactors before their decommissioning. The Act on Environmental Impact Assessment Procedure does not provide a definition for the term nuclear power plant, which may leave room for interpretation regarding the scope and timeliness of environmental impact assessments carried out in the decommissioning stage of nuclear power plants.

An environmental impact assessment must also be carried out before significant modifications are made to projects. An environmental impact assessment is required if the modification corresponds to the projects referred to in the project list regarding its size, and also in other individual cases on a discretionary basis. The consideration of need for an environmental impact assessment is hampered by challenges related to the definition of a project referred to in the Act on Environmental Impact Assessment Procedure and, on the other hand, determining the significance of modifications. The criteria for consideration of need are also expressed at a very general level, which adds to its challenges. The Act on Environmental

Impact Assessment Procedure does not set a limit indicating where the consideration of need itself could be regarded as unnecessary, and basically it should be carried out before even the smallest modifications.

The Act is also challenging in the sense that it only recognises a single operator as the party responsible for the project, even if a project could involve large-scale cooperation in nuclear waste management with another operator. Implementing major projects may also result in situations where the contact authority can no longer be unambiguously defined. The contact authority in projects related to nuclear facilities referred to in the Nuclear Energy Act is the Ministry of Economic Affairs and Employment. The ministry also is the contact authority in the disposal projects of very low-level wastes, even if such disposal facilities are not nuclear facilities. However, the wastes disposed of at the facility originate from nuclear facilities referred to in the Nuclear Energy Act. Developing this legislation and procedure are within the Ministry of the Environment's remit.

Suggestion 1. The working group proposes that the Ministry of Economic Affairs and Employment and the Ministry of the Environment prepare a document on the environmental impact assessment procedure (EIA procedure), which describes the implementation of this procedure in the management of nuclear wastes and other radioactive wastes, and develop the EIA procedure in use of nuclear energy. The deadline for implementing this suggestion is 31 December 2020 regarding the document, and the suggestion should be taken into consideration in developing legislation, accounting for the jurisdictions of the different authorities.

Decision-in-principle

The particular purpose of a decision-in-principle is to assess if building a so-called *nuclear facility of considerable general significance* in the country is in line with the overall good of society. Nuclear power plants have always been regarded as such nuclear facilities. A decision-in-principle should also be obtained for disposal facilities where the total activity of the nuclear waste, within the limits of certain additional conditions, is greater than 1 terabecquerels (TBq). A decision-in-principle should also be obtained for a facility which will, for example, be used to process or interim storage a volume of nuclear waste whose total activity is greater than 100,000 TBq. In practice, the threshold value for disposal is so low that a decision-in-principle must be obtained for all disposal facilities, excluding a facility for very low-level

wastes. On the other hand, the threshold value applicable to other nuclear facilities for waste management is so high that interim storage facilities for low and intermediate level waste are excluded from the decision-in-principle procedure.

When a decision-in-principle is granted for a nuclear power plant, it also takes a stand on the management of nuclear waste generated in connection with the plant's operation and decommissioning, including spent fuel. The established practice in Finland is that an application for a decision-in-principle concerning nuclear waste facilities built on nuclear power plant sites is included in the application for a decision-in-principle for the nuclear power plant. Decisions-in-principle concerning encapsulation and disposal facilities for spent nuclear fuel have, however, become differentiated from those on nuclear power plant units. A decision-in-principle is, however, possible to be applied separately for a nuclear waste facility co-located with the nuclear power plant.

In the case of nuclear waste facilities, the overall good of society might mean the need for a nuclear waste facility and the suitability of its intended site, for example. With respect to a disposal facility, the need for a decision-in-principle has been justified particularly by the high radiation levels and long-term radioactive properties of nuclear wastes as well as the potential limitations nuclear wastes could set for land use. Additionally, such technical issues as the safety of the planned nuclear facility, including an evaluation of its site, are considered when granting a decision-in-principle. There may be several options for the plant's site, however. If the Radiation and Nuclear Safety Authority finds that the nuclear waste facility cannot be built to be safe, it is in everyone's interest to stop the progress of the project at the decision-in-principle stage. While the Radiation and Nuclear Safety Authority also evaluates the safety of the site at this stage, adding to the legislation a provision on a site licence, which would be applied for separately from but in connection with the decision-in-principle stage, might prove practical. In the decision-in-principle phase, the most appropriate solution is to stop the project also if the municipality in which the nuclear waste facility would be built opposes it. The decision-in-principle is granted by the Government, after which Parliament either approves it as such or rejects it.

Modifications unavoidably come up in nuclear facility projects after the decision-in-principle procedure. The Nuclear Energy Act does not take a clear stand on whether a new decision-in-principle should be applied for a nuclear facility that has

already been built or is under construction if significant modifications are made to the project. However, this practice has been adopted for facilities in the planning stage, and as a point of departure, it should also be followed in the future while the current legislation remains valid. Decisions-in-principle for nuclear power plant projects have been regranted if a planned nuclear facility has been modified, for example as a new plant supplier is brought in. Since the first decision-in-principle granted for Posiva's encapsulation and disposal facility (Figure 6) in 2000, two decisions-in-principle in favour of a project have been made, in both of which spent nuclear fuel of a new nuclear power plant unit have been added to the project. The waste volumes and technical details of nuclear waste management set out in the decisions-in-principle are currently followed strictly, even if the volumes of low and intermediate level wastes, in particular, are difficult to estimate at the decision-in-principle phase due to such factors as the extended operational lifetimes of nuclear power plants. The most appropriate practice is also allowing the nuclear waste management methods to evolve during the project's lifetime.

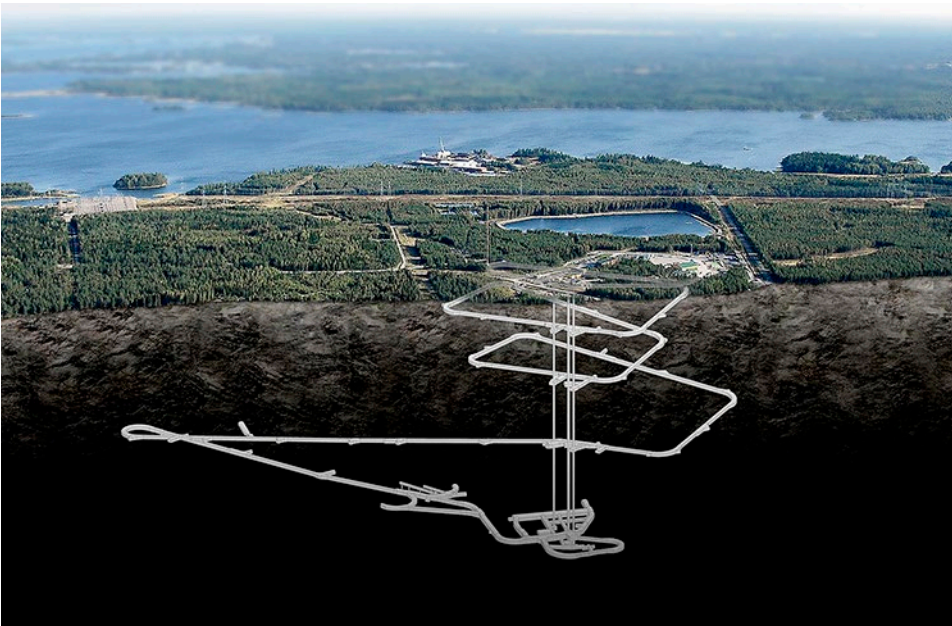


Figure 6. The disposal facility for spent nuclear fuel will be located at the depth of several hundred metres in Olkiluoto bedrock in Eurajoki. Disposal tunnels will be built at the disposal facility gradually as disposal progresses. Source: Posiva Oy.

The need for a new decision-in-principle will have to be considered in the future if spent nuclear fuel from new nuclear power plant or other radioactive waste are added to the planned activities of Posiva's encapsulation and disposal facility currently under construction. When considering the need for a decision-in-principle, the increase in amount of waste should be evaluated in proportion to the amount of waste generated by a new nuclear power plant unit and the changes in the activities in comparison to the original plans. The increase in amount of waste could, for example, be compared to the increased power of nuclear power plants, which would require an amendment to the terms of the operating licence but not a new decision-in-principle procedure.

The need for a decision-in-principle may also have to be considered in connection with the expansion of TVO's and Fortum's VLJ caves. So far, the operating licence of TVO's VLJ cave have been amended to dispose also nuclear waste generated in operation of OL3 nuclear power plant unit and other radioactive waste referred in Radiation Act (Figure 7). However, this amendment did not require an expansion of the VLJ cave, and a new decision-in-principle procedure did not go ahead. Even if the cave had been expanded, this would not have been a new nuclear facility site in Finland, a new licensee, or waste or a waste management method of a significantly new type, and the benefits of a decision-in-principle would be questionable in this respect. Expanding the disposal facility also cannot be the only criterion for launching a decision-in-principle procedure, as the expansion of the disposal facility of spent nuclear fuel will be part of the Posiva's normal operation under operation licence.

When considering the need for a new decision-in-principle, as an important viewpoint emerges the suitability of the site in terms of the overall good of society and preserving the municipality's possibilities for exerting influence. Nevertheless, the decision-in-principle is a cumbersome process and should not be launched without weighty reasons.

Recommendation 5. The working group recommends that the Ministry of Economic Affairs and Employment prepare a document on the application of the current decision-in-principle procedure to nuclear facilities used for nuclear waste management, which have a construction licence or an operating licence. The further development of the decision-in-principle procedure should be taken into account when developing the Nuclear Energy Act if necessary. The objective of this document is to clarify when a nuclear facility project is modified to the extent that

requiring a new decision-in-principle is justified. The deadline for implementing the recommendation is 31 December 2020 regarding the document, and the recommendation should be accounted for in developing legislation.

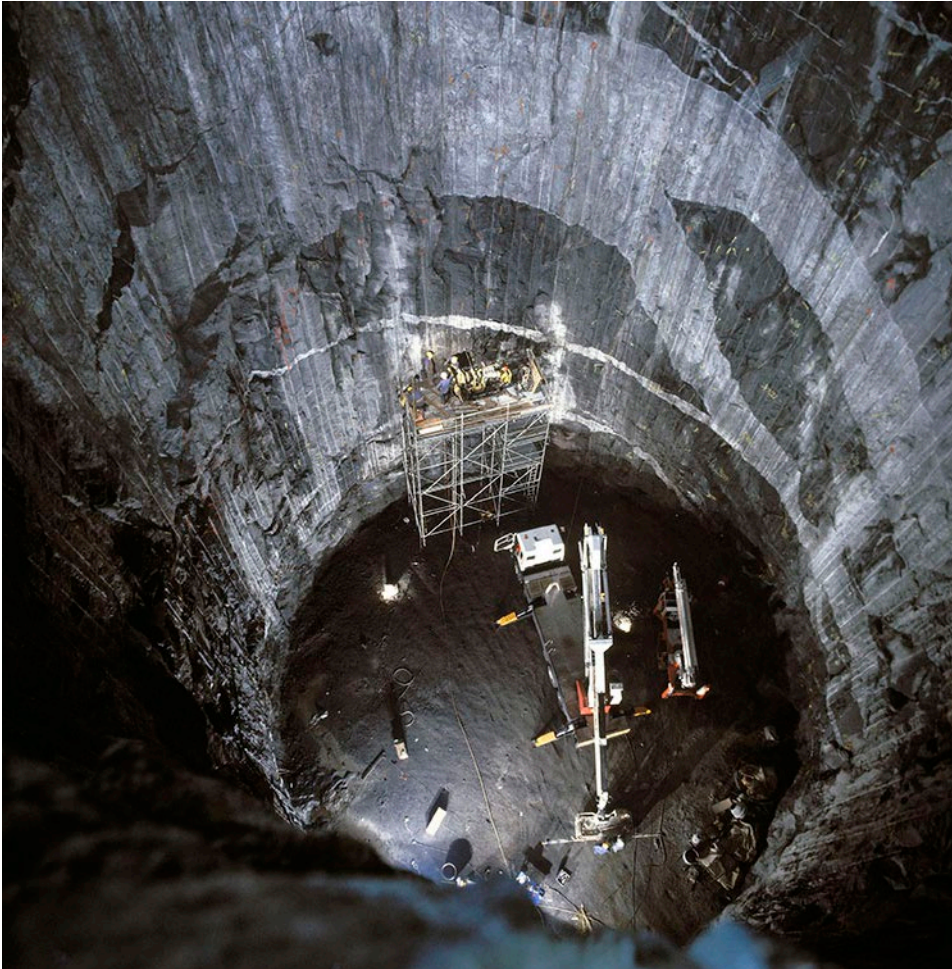


Figure 7. Operating and decommissioning waste from Olkiluoto nuclear power plant will be disposed of in the VLJ cave on the plant site. Source: TVO/Korpi-Hallila.

Construction licence

A construction licence must be obtained for building a nuclear facility. A construction licence must be obtained for a disposal facility where the total activity of the nuclear waste, within the limits of certain additional conditions, is greater than 1 TBq.

A construction licence must also be obtained for a facility which will, for example, be used to process or interim storage a amount of nuclear waste with a total activity greater than 1 TBq. In practice, this threshold value is so low that a construction licence must be obtained for all disposal facilities, excluding a facility for very low-level wastes. A decision-in-principle concerning a nuclear facility of considerable general significance must be valid in order for a construction licence to be granted.

The construction licence is granted by the Government, and it is valid until further notice. A precondition for granting a construction licence is that the Radiation and Nuclear Safety Authority has found in its safety assessment that the nuclear facility can be built to be safe. The suitability of the nuclear facility site and having control of the site required for the operation are additionally stressed in the preconditions for granting a construction licence. Otherwise the preconditions for granting a construction licence and an operating licence are the same in practice; however, the idea is that the construction licence phase plans are specified to produce the final plans for the operating licence application.

The need for a new construction licence should be considered when significant new construction takes place at a nuclear waste facility, which was not taken into consideration in the original construction licence. The need for a licence has to be considered when, for instance, a disposal facility for low and intermediate level wastes is to be expanded. However, this could result in a situation where the same nuclear facility has several Government-granted licences valid at the same time, which would be unpractical in terms of supervision and, in the worst case, result in conflicting licence terms. When nuclear power plant structures are modified and interim storage facilities for spent nuclear fuel are expanded, the established practice is to make these changes as so-called plant modifications without a construction licence granted by the Government, and this could be a viable option also for modifications to other nuclear waste facilities. It should additionally be noted that the generation of nuclear waste is the unavoidable consequence of a nuclear power plant's operation, and consequently, it would be unreasonable to unnecessarily hamper the carrying out of waste management measures appropriately, responsibly and safely.

Operating licence and licence for other use of nuclear energy

Under section 20 of the Nuclear Energy Act, a licence to operate a nuclear facility may be granted after a licence has been granted for the construction of the facility

and the preconditions for granting the licence are met. However, if the operation involves only processing and interim storage of nuclear waste where the total activity of the waste at the facility at any one time is less than 1 TBq, or disposal where the total activity of the waste is less than 1 TBq, the licence should be applied for pursuant to section 21 of the Act. A licence for operation referred to in section 20 of the Act is granted by the Government, and for operation referred to in section 21 by the Radiation and Nuclear Safety Authority. A precondition for granting an operating licence for a nuclear facility is that the Radiation and Nuclear Safety Authority has found in its safety assessment that the safety requirements will be met.

The operating licence entitles the licensee to operate the constructed nuclear facility for a fixed term in compliance with the licence conditions/terms included in the licence. However, the operation may only start after an inspection. When the length of the term is considered, particular attention shall be paid to ensuring safety and to the estimated duration of operations. Special terms complementing the provisions of the Nuclear Energy Act may be included in the licence, but only to the extent that the issue in question is not adequately regulated under Radiation and Nuclear Safety Authority regulations. For example, the licence terms may concern ensuring the safe use of nuclear energy, securing nuclear waste management, implementing security or emergency arrangements, fulfilling international agreements in the nuclear energy sector to which Finland is a contracting party, or preventing the proliferation of nuclear weapons.

The licence terms may be amended in order to maintain the general principles for the use of nuclear energy and the preconditions for the granting of a licence. When amending the licence terms, the same procedure shall be complied with, where applicable, as when granting a licence. According to the established practice, this means submitting a licence application, the handling of the application, and the making of a licence decision.

Amending the operating licence terms following the current practice is slow, cumbersome and expensive, and even the best long-term plans are unable to prepare for unanticipated situations. Neither does the practice facilitate cooperation with other operators, even if the waste volumes were small and the properties of the wastes similar.

Operating licences should be drawn up at a more general level, particularly without imposing excessively stringent limits on the waste volumes. An amendment to the

Nuclear Energy Act should be considered, under which modifying the licence terms would be easier at least when it comes to the processing and storage of wastes, or some other procedure could be used to modify the waste volumes, for example a decision of the Ministry of Economic Affairs and Employment or the Radiation and Nuclear Safety Authority, if the modification has no bearing on safety. The operating licences should also enable several optional methods for nuclear waste management, especially for new nuclear facilities.

Additionally, the time spans of disposal facilities are very long, even compared to nuclear power plants. This may necessitate special features in the lengths of disposal facilities' operating licence terms and the licence conditions. The operating licences of disposal facilities for low and intermediate level wastes at Olkiluoto and Loviisa will be valid until the 2050s. The planned operating lifetime of Posiva's disposal facility (Figure 8) is over 100 years.



Figure 8. The demonstration tunnels at Posiva's disposal facility have an important role in research and development carried out before disposal operations begin. Source: Posiva Oy.

Decommissioning licence and potential closure licence

The decision on the time at which using a nuclear facility will be discontinued is made by the licensee. Once the nuclear facility is no longer used, the licensee has the duty to initiate measures aiming for its decommissioning. A licence for decommissioning a nuclear facility should be applied for well in advance before the operating licence expires. The decommissioning licence, which is valid until further notice, is granted by the Government.

The decommissioning licence entitles the holder of the nuclear facility to decommission the facility in a manner intended to be permanent. Under the Nuclear Energy Act, decommissioning means the dismantling of a finally closed nuclear facility so that no special measures are required on the plant site due to radioactive materials originating in the dismantled nuclear facility. Thus, the remaining buildings and the site can be released from regulatory control under Nuclear Energy Act. A nuclear facility being decommissioned shall be a facility referred to in the Act until it has been confirmed as decommissioned by the Radiation and Nuclear Safety Authority. Once a nuclear facility has been decommissioned, the requirements set for a nuclear facility no longer apply to it.

If the licensee chooses immediate dismantling as the decommissioning strategy of a nuclear facility, it is appropriate that the transition from operation to decommissioning takes place seamlessly and without undue delays. Additionally, co-located nuclear facilities may reach the decommissioning stage at different times, which may require reconciliation between operating and decommissioning licences. While the decommissioning of a nuclear facility may not be started before the licence has been granted, the licensee may carry out preparatory work under the operating licence and under the Radiation and Nuclear Safety Authority's supervision. Consequently, transition phase procedures should be developed and streamlined further.

Rather than being decommissioned, disposal facilities are closed once they are no longer in use. Under the Nuclear Energy Act, the disposal of nuclear wastes is considered implemented when the Radiation and Nuclear Safety Authority has confirmed the nuclear waste to be disposed of in a manner it has approved. So far, the legislation contains no provisions on a specific licence for closing disposal facilities, and the closure of such facilities takes place under the disposal facility's operating licence. The need to add a closure licence to the legislation should be considered. From the government's viewpoint, factors in favour of adding a closure licence to

the legislation include clarifying how responsibility of the disposed waste is transferred from the licensee to the State after closure of the facility and recommendations made in international evaluations.

Adding procedures associated with the expiry of licences for nuclear facilities to the legislation should also be considered. A decommissioning licence valid until further notice should expire once the nuclear facility has been acceptably decommissioned. The final licence of a disposal facility, especially if it is a closure licence valid until further notice, should expire once the disposal facility has been closed down.

Recommendation 6. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority develop further the transition phase provisions related to operating licences and decommissioning licences as well as the procedures associated with licence expiry. This recommendation should be accounted for in developing legislation.

Suggestion 2. The working group proposes that Fortum submit to the Ministry of Economic Affairs and Employment a report on experiences from the decommissioning of nuclear facilities in Sweden. This report could also contain clear proposals for developing the regulations subordinate to the Nuclear Energy Act in Finland. The deadline for this suggestion is 31 December 2021.

Suggestion 3. The working group proposes that VTT submit to the Ministry of Economic Affairs and Employment a report on experiences from the decommissioning of the research reactor. This report could also contain clear proposals for developing the regulations subordinate to the Nuclear Energy Act in Finland. The report is to be delivered together with the report on experiences submitted to the Radiation and Nuclear Safety Authority as required in the Regulatory Guides on nuclear safety and security.

Recommendation 7. The working group recommends that the Radiation and Nuclear Safety Authority submit to the Ministry of Economic Affairs and Employment a report on the Swedish authorities' experiences from decommissioning of nuclear power plants. The deadline for this recommendation is 31 December 2021.

5 Decommissioning of the research reactor and other measures of nuclear waste management

VTT Technical Research Centre of Finland has a FiR 1 research reactor in Otaniemi, Espoo, which the Finnish Government purchased from the United States for Helsinki University of Technology for training and research purposes in 1960 (Figure 9). VTT took over the reactor in 1971. Since 1962, the reactor has been used for research, teaching, isotope production and other service activities. In 1999–2012, it was also used for providing radiotherapy. VTT closed down the reactor permanently in summer 2015 and applied to the Government for an operating licence for decommissioning and dismantling the reactor in summer 2017. The decommissioning is planned to begin no later than 2023, and the premises are to be handed over to Aalto University by 2025. The research reactor is the first nuclear facility to be decommissioned in Finland. Useful expertise and experience for the decommissioning of other nuclear facilities may be obtained from its decommissioning and dismantling.

Small quantities of nuclear waste were generated while the research reactor was in use and will be produced at the time of its decommissioning (approx. 100 fuel elements and 100 m³ of low and intermediate level waste). The activity levels of the nuclear wastes are approx. 300 TBq (spent fuel) and less than 5 TBq (dismantling waste), or less than 1/10,000 compared to the levels of spent fuel and dismantling waste from a nuclear power plants.

VTT also has a material research facilities at Otakaari 3, which it intends to decommission in the next few years. This facility has been in use for some 40 years, and during that time, it has accumulated approx. 10,000 material research samples, a significant share of which came from Fortum's Loviisa nuclear power plant. Additionally, approx.

50 m³ of radioactive waste, for which interim storage and disposal must be arranged, will be generated in the decommissioning of the facility.

Due to the small quantity of these wastes, it is not feasible for VTT to build a dedicated disposal facility for them. On the other hand, this means that VTT depends on cooperation with other licensees under a waste management obligation.

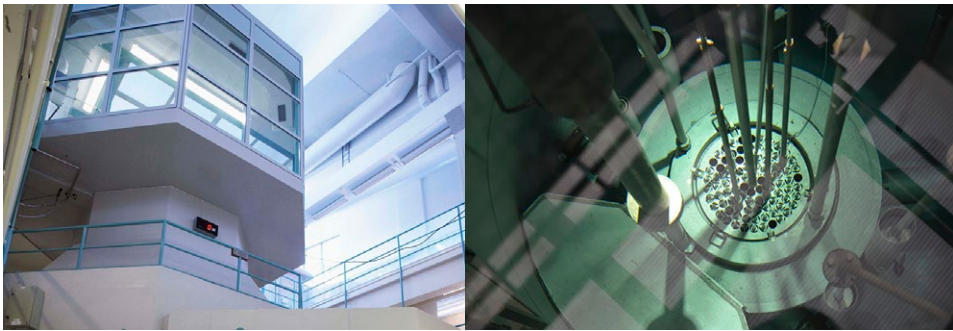


Figure 9. VTT's FIR 1 research reactor (on the left) and the research reactor's pool and core (to the right) are no longer in use. The spent nuclear fuel must be removed from the reactor before its dismantling can begin. Source: VTT

5.1 Disposal solutions for spent fuel from the research reactor

The nuclear fuel used in the research reactor came from the United States. The nuclear fuel is covered by the global Foreign Research Reactor Spent Nuclear Fuel Acceptance Program of the US Department of Energy, under which the United States receives spent nuclear fuel and sees to its interim storage and disposal. According to this program, the nuclear fuel from the research reactor must be returned to the United States by 12 May 2019. However, returning spent nuclear fuel has not been possible for several years due to the political situation in the United States. The US Department of Energy has been preparing the partial extension of the program, and it is likely that spent nuclear fuel from the VTT's research reactor can also be returned after the deadline cited above.

VTT has an agreement in principle concluded with Posiva in 1990 concerning a domestic disposal solution for the spent nuclear fuel from the research reactor. The

agreement covers a situation where transporting spent nuclear fuel abroad from the research reactor turns out to be impossible. In this case, the spent nuclear fuel would, after suitable interim storage, be transported to Olkiluoto for disposal. However, significant research and planning as well as a detailed agreement between the companies would be required to implement a domestic solution. The current agreement in principle remains valid until 30 June 2020.

Both waste management solutions for spent nuclear fuel may require interim storage. The spent fuel is currently placed in the reactor pool and in a dry storage in the reactor's premises. Due to their location, however, VTT's premises in Otaniemi are poorly suited for longer storage of spent nuclear fuel, and storing the fuel in the reactor premises delays the dismantling of the research reactor. However, the valid operating licences of operating nuclear power plants in Olkiluoto and in Loviisa do not enable the storage of the spent fuel from the research reactor on their sites.

Recommendation 8. The working group recommends that VTT and the Ministry of Economic Affairs and Employment actively promote the return of spent nuclear fuel to the United States. If it cannot be returned to the United States, VTT should ensure that a national disposal solution can be found. VTT should prepare a progress plan for the interim storage and disposal of spent nuclear fuel in Finland together with Posiva and/or Posiva's owners. Under the existing agreement in principle, the negotiations should be initiated no later than 30 June 2020. The deadline for implementing the recommendation is 31 December 2022.

5.2 Disposal solutions for low and intermediate level wastes from the research reactor and the material research facilities

Under the Nuclear Energy Act, the operating and decommissioning wastes of the research reactor must be managed in Finland. TVO's and Fortum's VLJ caves, which are already in use in Finland, could be suitable for the disposal of nuclear waste from the research reactor and also for radioactive wastes from VTT's material research facilities (Figure 10). While these caves have Government-granted operating licences valid until the 2050s, neither licence allows the disposal of the low and intermediate level wastes from the research reactor and the material research facilities.

Before their disposal, the low and intermediate level wastes must also be possible to process, package and store. While VTT is planning to process and package the wastes in the reactor premises, the company has limited space for storing the wastes, in particular. Consequently, it may become necessary to store and, if needed, also repackage the wastes at one of the operating nuclear power plants. Under the operating licences granted by the Government in 2018, the processing and storage of wastes are currently possible at TVO's Olkiluoto nuclear power plant but not at Fortum's Loviisa nuclear power plant.

Suggestion 4. The working group proposes that VTT work together with TVO or Fortum, striving to find a sustainable solution on commercial terms and prepare a progress plan for the management of VTT's low and intermediate level wastes and other radioactive wastes. The indicative deadline for carrying out the suggestion is 1 June 2020.

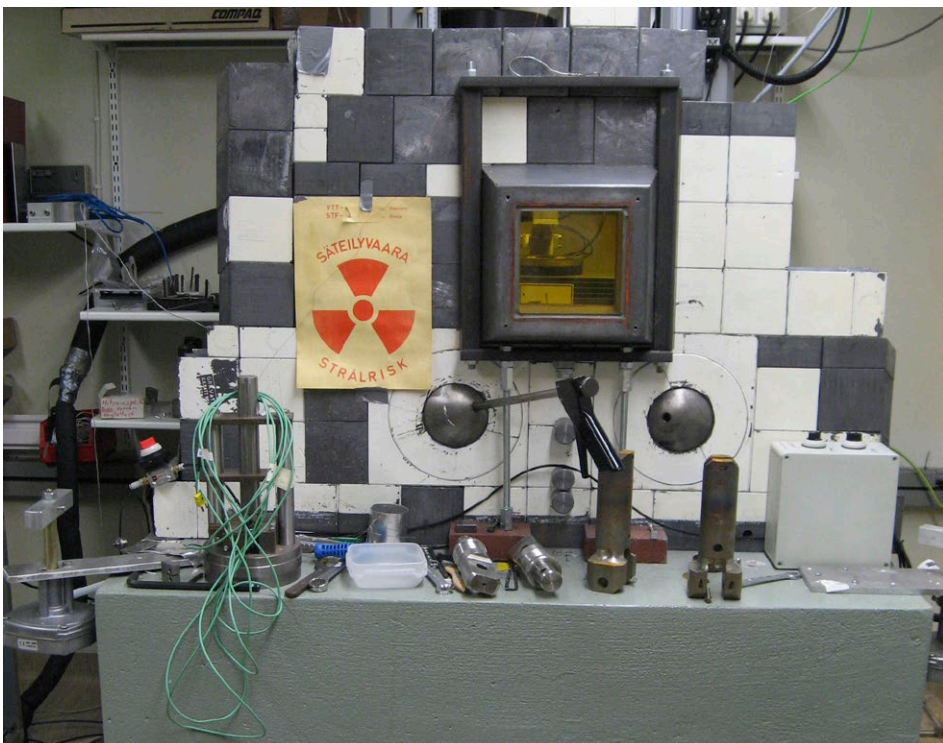


Figure 10. Contaminated workstations at VTT's old material research facilities (Otakaari 3, Espoo). Low and intermediate level waste will be produced as the facilities are dismantled. Source: VTT

5.3 VTT Centre for Nuclear Safety's waste management solutions

The operations of VTT's material research facilities located at Otakaari 3 have mainly moved to VTT Centre for Nuclear Safety (Figure 11). The waste management plan for VTT Centre for Nuclear Safety was prepared by VTT, and the building has licences granted by the Radiation and Nuclear Safety Authority under the Radiation Act. The arrangements for customer research activities which generate radioactive waste at VTT Centre for Nuclear Safety involve returning used samples and high and intermediate level wastes generated in the research activities and, where appropriate, also low level radioactive wastes produced to the customer. Wastes that are harmless regarding their radiation properties are released from supervision effectively.

Nevertheless, VTT Centre for Nuclear Safety will need to work together with Finnish nuclear power companies to organise its waste management. In the course of its operation, the Centre will produce radioactive wastes for which no individual customer can be readily identified to whom the wastes could be returned. Additionally, returning wastes abroad is relatively expensive and labour-intensive, and not possible or practical in all cases. Other countries are also mainly reluctant to accept such returned wastes. Classifying wastes according to customer may also increase the amount of waste generated in some cases, which is against the leading principle of radioactive waste management. When the VTT Centre for Nuclear Safety is no longer used, contaminated premises will have to be decommissioned, decontaminated or dismantled, generating radioactive wastes that will need to be processed, stored and disposed.

Notably, this is an appropriate time to plan and develop the Centre's waste management as it is only launching its operation. At the same time, however, it should be noted that the nuclear power companies' disposal facilities for low and intermediate level wastes will be operational and potentially also available for the disposal of the Centre's wastes only for as long as the power companies have their own needs for disposal.

Recommendation 9. The working group recommends that VTT examine the management of radioactive wastes generated in connection with its research activities and preparation for its costs as a whole and prepare a long-term plan also for the waste management of VTT Centre for Nuclear Safety, including its decommissioning. The Radiation and Nuclear Safety Authority should examine VTT's solution in terms of the requirements under the Radiation Act. The deadline for implementing

the recommendation is 31 December 2022 for VTT and 31 December 2023 for the Radiation and Nuclear Safety Authority.



Figure 11. VTT's new Centre for Nuclear Safety (top) and the building's hot chambers for research of radioactive materials (bottom) have already been completed. Planning the waste management of VTT Centre for Nuclear Safety is important and topical. Source: VTT

6 Situation and development plans for state-owned waste

State-owned wastes refer to radioactive wastes managed by the State (Figures 12 and 13) originating from health care, industrial and research facilities and similar plants as well as radioactive waste for whose management and disposal the State is responsible due to other reasons. These wastes are mainly solid or solidified, but also liquid in some cases.

This category includes radioactive wastes generated as a consequence of a disused sealed source rupture at Roihupelto. After the incident, the wastes were placed in interim storage as such to wait for a possibility for their processing, interim storage and disposal at a Finnish nuclear power plant.

The State has concluded an agreement between the Ministry of Social Affairs and Health and TVO on the interim storage and disposal of state-owned waste at Olkiluoto. Under this agreement, TVO has handed over storage space for the interim storage of state-owned wastes in the VLJ cave at Olkiluoto to be used by the State and administered by the Radiation and Nuclear Safety Authority. This storage space is not however suitable for processing waste.

Processing and interim storage of state-owned waste are possible in above-ground waste facilities at Olkiluoto under an operating licence granted by the Government in 2018. The operating licence of TVO's VLJ cave enables the disposal of the state-owned wastes in addition to other waste. Approx. 45 m³ of space in the VLJ cave has so far been used for the disposal of the state-owned waste.



Figure 12. Sealed source Kr-85. Photo: Jukka Mykkänen

Operators in Finland are currently using approx. 6,000 sealed sources containing radioactive substances, the majority of these in industry. Under the new Radiation Act that entered into force in 2018, a life cycle of 40 years is specified for sealed sources, and any sources older than this must no longer be used. A five-year transition period has been set for their decommissioning, and during this period until the end of 2023, hundreds of sealed sources will be decommissioned. After 2023, a smaller number of sealed sources will be decommissioned every year. Effective procedures for the management of sealed sources must be put in place in the future, either for their export / shipment abroad or management in Finland.

Disused sealed sources have been returned from Finland to other countries, and this procedure works well. After several decades, it is not always possible to find the original supplier or importer of sealed sources, but there are a few other operators in Europe who receive them. Returning them is extremely expensive, however: the costs may amount to hundreds of thousands of euros, and the returns tie up a great deal of resources of both the operator and the Radiation and Nuclear Safety Authority.

In the future, sealed sources may only be imported / shipped to Finland if their manufacturer has undertaken in writing to accept the sealed source once it is no longer used. However, if the half-life of the radioactive substance contained in the sealed source is short enough, the sealed source may be, after storage, released from supervision under the Radiation Act and subjected to supervision under the Waste Act. The usage time of sealed sources are long, however, and the manufacturer's commitment to accepting the returned source may erode over time and the costs may increase significantly.



Figure 13. Protective shields of sources containing radioactive substances. Photo: Jukka Mykkänen

In Finland, an operator may hand a decommissioned source containing radioactive substances to another operator who engages in radioactive waste management. Such operators were previously known as recognised installations, and a private company named Suomen Nukliditeknikka had sole rights to these actions. While the Radiation Act no longer assigns such a special role as recognised installation, no new operators offering radioactive waste management services have entered the market.

Suomen Nukliditeknikka receives sealed sources from operators, unpacks and re-packs them and delivers them to the state-owned waste storage at Olkiluoto (Figure 14). Under its safety licence, Suomen Nukliditeknikka may only receive sealed sources, and taking liquid or wet wastes to Olkiluoto for processing through this company is not possible. TVO receives the wastes, carries out activity determinations on them, and moves them to the storage administrated by the State in the VLJ cave. At the same time, the wastes are entered in the records of not only the Radiation and Nuclear Safety Authority but also TVO.

Based on activity measurements, the wastes are sorted in the interim storage into those ready for disposal and those placed in interim storage until they can be released from supervision. While most of the wastes can be placed in the silo for low or intermediate level waste in the VLJ cave, some of them do not meet the criteria for disposal in the VLJ cave.

Wastes that cannot be disposed of in the VLJ cave mainly are high-activity sealed sources whose properties were not taken into account when evaluating the long-term safety of the VLJ cave or which, at the disposal depth of the VLJ cave, could result in radiation doses at ground level without additional packaging.

Designing sturdier disposal packages and ensuring of their long-term safety would make it possible to dispose of these wastes in the VLJ cave, but this would require considerable amounts of additional work of TVO. Another option is the disposal of the sources deeper than the VLJ cave level, for example at Posiva's disposal facility, but this would also require extensive efforts in the form of evaluating long-term safety and including sealed sources in the first or subsequent operating licence of the facility. Alternatively, the design, construction and operation of a completely separate disposal facility would result in even more significant additional work and considerable costs in proportion to the number of the sealed sources to be disposed.

The number of such high-activity sealed sources in Finland is approx. 70, of which the most difficult ones in terms of disposal number around 10. The interim storage facility in the VLJ cave currently contains approx. 20 m³ of wastes whose disposal in the current packaging is not possible. The volume of this waste increases by approx. 0.1 m³ a year.



Figure 14. The state-owned waste storage facility is located in connection with the VLJ cave at Olkiluoto. Source: TVO

TVO will evaluate the long-term safety of wastes to be disposed of in Olkiluoto VLJ cave as part of a periodic safety assessment by the end of 2021. While the state-owned waste can be included in the review, a precondition for this would be knowing what types of wastes, waste volumes, nuclides and packages could come in for disposal, also over a longer period. Some inadequacies in waste data received from

operators have also been observed in other respects, and a more systematic way of submitting waste data would facilitate TVO's operation.

Fortum updated the long-term safety case of its VLJ cave in 2018, including in it all sources containing radioactive substances in the company's use. The operating licence for the cave enables the disposal of small quantities of wastes originating from outside the plant site, but so far, such wastes have not been placed in the cave.

Fennovoima has launched the design of its own VLJ cave at Hanhikivenniemi, and the disposal of wastes other than those generated on-site can be taken into account in the designs. Posiva is currently preparing an evaluation of the long-term safety of spent nuclear fuel and the low and intermediate level waste generated in connection with the company's activities for an operating licence application. The company is planning to submit the operating licence application in 2021.

Suggestion 5. The working group proposes that the Radiation and Nuclear Safety Authority and the nuclear power companies (TVO and Fortum) prepare guidelines for operators regarding the submission of waste data to facilitate waste management and record-keeping. The guidelines should be issued for the operator well in advance before the wastes are transported to the plant site. The guidelines should also be sent to the other nuclear power companies for information. The deadline for implementing this suggestion is 31 December 2021.

Suggestion 6. The working group proposes that the Radiation and Nuclear Safety Authority develop its guidelines to provide holders of safety licences for sealed sources with sufficient knowledge of the options for decommissioning the sealed sources, in other words their return abroad or disposal in Finland. The deadline for implementing this suggestion is 31 December 2019.

Recommendation 10. The working group recommends that the Radiation and Nuclear Safety Authority prepare a report on the current status of high-activity sealed sources, the properties of sources requiring disposal (number, quality) and their owners. The nuclear power companies and Posiva should map the preconditions and schedules for the disposal of high-activity sealed sources in their disposal facilities to ensure that, if necessary, a disposal facility exists for all high-activity sealed sources in Finland. The deadline for implementing the recommendation is 31 December 2022, and 31 December 2029 for Fennovoima.

7 Challenges and development plans associated with wastes released from regulatory control under the Nuclear Energy Act and the Radiation Act

Nuclear power companies and research institutes are finding it difficult to incorporate wastes released from supervision under the Nuclear Energy Act and the Radiation Act in waste management carried out pursuant to the Waste Act. The waste released from supervision under the Nuclear Energy Act at nuclear power plants includes approx. 100 tons of metal scrap and mixed waste a year per nuclear power plant, as well as dozens of tons of maintenance waste, accounting for more than one half of the power plant's yearly maintenance waste volume. While research institutes' wastes released from supervision are similar in type as maintenance waste produced by nuclear power plants, their volumes are small.

The nuclear power companies currently take their maintenance waste to landfills, which accept this waste under a derogation valid until 2022. The justification for the derogations issued to the landfills is that, due to its properties, the waste is not deemed suitable for processing and must thus be placed in a landfill. Research institutes are unable to bring any wastes to the landfill, especially solid organic wastes, and the wastes clog up the institutes' limited storage spaces (Figure 15). Maintenance waste from nuclear power plants and research institute waste mainly are combustible and would be suitable for energy use at incinerators and gasification plants.

Smelters, incinerators and landfills find accepting wastes released from supervision problematic, and companies have introduced 'zero tolerance' off their own bat: the

processing facilities refuse to accept wastes whose level of radioactivity can be observed by measurements. Waste released from supervision still has the stigma of radioactive waste, and processing facilities are uncertain about whether it is dangerous and should be handled as hazardous waste referred to in the Waste Act, which sets additional requirements on its processing.



The Centres for Economic Development, Transport and the Environment and Regional State Administrative Agencies can declare the waste not hazardous if its holder (a nuclear power company) can reliably prove that it does not have hazardous properties. Proving this is difficult, however, as provisions on the wastes are contained in several Acts (Waste Act, Nuclear Energy Act and Radiation Act), and the terminology used in them is not fully consistent. The environmental authorities feel they need the Radiation and Nuclear Safety Authority's expertise in assessing the hazardousness of the wastes. Terminological challenges may also prevent effective communication between authorities.

Figure 15. Research institutes' wastes released from supervision under the Radiation Act waiting for a facility to receive them. The waste volumes generated by research institutes are small compared to the quantities produced by nuclear power plants.

The possibility that the end product of any processing of wastes released from supervision is radioactive adds its own challenge to the discussion between the different actors. In particular, ashes and slag produced from the incineration of maintenance waste have been classified as hazardous waste under the Waste Act. Consequently, the preconditions for incinerating maintenance waste include preparing a risk assessment and drawing up a plan for how the end product can be safely used

regardless of its radioactivity. The processing of maintenance waste may also contaminate the incinerator systems.

Recommendation 11. The working group recommends that the Ministry of the Environment, the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority produce a guide on issues related to the management of wastes released from supervision. The Ministry of the Environment and the Radiation and Nuclear Safety Authority should cover this topic in training events for authorities and operators and deliver the training material to organisations participating in training. The deadline for implementing the recommendation is 31 December 2020.

Suggestion 7. The working group proposes that Fortum prepares a report on the activity level of ashes and slag produced when waste released from supervision is incinerated, the possibilities for further use of the ashes and slag, and controlling the contamination of incinerator equipment. The deadline for carrying out the suggestion is 31 December 2020.

8 National and international reporting on nuclear waste management

Provisions on reporting duties imposed on licensees under a waste management obligation are contained in the Nuclear Energy Act and Decree and the Radiation and Nuclear Safety Authority's regulations and guidelines. Licensees under a waste management obligation submit to the Ministry of Economic Affairs and Employment an annual report, a nuclear waste management plan every three years, and a decommissioning plan every six years. Additionally, licensees under a waste management obligation submit complementary information for the waste management scheme used as the basis for their financial provision for waste management every three years, as well as updated calculations annually. The licensees under a waste management obligation also submit to the Radiation and Nuclear Safety Authority a nuclear waste management report, a quarterly report and an annual report.

Finland reports on nuclear waste management as required under international conventions. Finland submits to the International Atomic Energy Agency (IAEA) a report referred to in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Finnish Treaty Series 36/2001), or a so-called Joint Convention report, every three years. The report describes how safety is addressed in the Finnish legislation and operation compliant with them. The Radiation and Nuclear Safety Agency prepared the latest report in 2017⁵, and it was assessed at the Review Meeting organised by the IAEA in 2018.

Finland submits a Member State Report required under the European Council Directive on the management of spent fuel and radioactive waste (Council Directive 2011/70/EURATOM) to the European Commission every three years. The report contains a description and a review of the directive's implementation. The Radiation

and Nuclear Safety Agency prepared the latest report in 2018⁶. The Joint Convention report can be used as a basis for preparing the report.

Finland is also obliged to periodically update the National Programme⁷ for the management of spent fuel and radioactive waste referred to in the Council Directive 2011/70/EURATOM. The National Programme must be updated taking into account technical and scientific progress as appropriate as well as recommendations, lessons learned and good practices from peer reviews. Member States shall periodically, and at least every 10 years, arrange for self-assessments of their National Programme and its implementation and invite international peer review of it. The preparation of the first report in 2015 was coordinated by the Ministry of Economic Affairs and Employment. For further details of this programme, see Chapter 9.

There may be potential for developing the reporting on nuclear waste management in order to eliminate any overlaps, and national reporting^{8,9,10} could possibly be of use in international reporting. In order to obtain synergy benefits, the reporting interval may also need to be readjusted. When preparing reports, it would also be a good idea to spend some time on self-assessment of the operations.

Licensees under a waste management obligation could also work together when preparing their reports. Posiva, for example, has prepared the nuclear waste management programme of its owners, TVO and Fortum, in which the main emphasis is on the planning and development of the encapsulation and disposal facility for spent nuclear fuel. In terms of nuclear waste management as a whole, it could be beneficial to strive for a situation where the licensees submit their reports in the same year.

Recommendation 12. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority investigate and, if necessary, develop the national reporting on nuclear waste management as well as the coordination between national and international reporting. This recommendation should be accounted for in developing legislation.

9 National Programme for the management of spent fuel and radioactive waste

The National Programme for the management of spent fuel and radioactive waste was prepared in Finland in 2015. The programme contains a plan for the management of spent nuclear fuel, other nuclear waste and other radioactive waste generated in Finland. It was prepared to serve as the national programme referred to in the Council Directive 2011/70/EURATOM. Provisions on drawing up this programme are contained in the Nuclear Energy Act for the part of nuclear waste and in the Radiation Act for the part of other radioactive waste. Under the directive and Finnish legislation, the programme must be reviewed and updated periodically, and a periodic self-assessment and an international peer review must be carried out on it.

The National Programme contains a spent fuel and radioactive waste management policy, which can be regarded as the strategy for managing radioactive waste generated in Finland. The programme contains both plans and concepts for implementing the strategy, including schedules. It also provides estimates of waste volumes and the costs of managing them.

Some shortcomings have been observed in the programme since it was prepared and following discussions with the Commission. After reviewing the national programmes, the Commission has among other things said that Member States' programmes are incomplete with the waste inventories and cost estimates submitted by the Member States, and also requested additional information from Finland. The Commission has additionally noted that in connection with drawing up the programmes, the implementation of environmental impact assessment procedures should also have been given careful consideration in compliance with Directive

2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment. An environmental impact assessment had not been carried out in Finland at that time, as the programme had not been considered to create a framework for licensing or approval decisions.

The National Programme is a key document when carrying out international reviews of Finland's nuclear waste management and other radioactive waste management. A review of the programme is to be carried out as an IAEA ARTEMIS review in 2022. Before the review, the National Programme needs to be updated. A self-assessment required under the directive and Finnish legislation should also be carried out before the international review. The need for and scope of the environmental impact assessment related to the programme should be established before the programme is updated.

Recommendation 13. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority update the National Programme for the management of spent fuel and radioactive waste before the international peer review (ARTEMIS). In connection with the programme update, an environmental impact assessment and a self-assessment of the programme should also be carried out. The deadline for implementing the recommendation is spring 2022.

Recommendation 14. The working group recommends that the Ministry of Economic Affairs and Employment establish a monitoring group to handle the recommendations and suggestions that will meet one to three times a year as needed. The tasks of the monitoring group would also include following national and international development in this field and preparing development suggestions.

10 Maintenance and development of competence and international cooperation

The nuclear power plants of Olkiluoto and Loviisa have established practices and competence regarding nuclear waste management developed over decades. For Fennovoima, developing competence is a topical question as the organisation grows. The challenge for Posiva lies in becoming an organisation operating a nuclear facility and, on the other hand, maintaining the valuable competence related to planning and development that the company has fostered for decades. The challenge facing VTT is maintaining the competence of the organisation of the the research reactor until its nuclear waste management measures have been completed on the one hand, and turning into an organisation decommissioning the research reactor on the other. The responsibility for maintaining competence related to nuclear facilities rests with the licensees. Technical support organisations, universities, higher education institutions and companies engaging in planning and development tasks related to nuclear waste management have extensive expertise in nuclear waste management. Maintaining and developing the authorities' competence is also important.

The number, years of work experience and educational backgrounds of persons involved in research, development and planning of nuclear waste management as part of the entire nuclear energy sector were investigated by means of surveys in 2010¹¹ and 2017¹². Persons working in research, development and planning tasks of nuclear waste management mainly have a Master's degree. The numbers of these persons had dropped between the surveys. However, new persons have also taken up research, development and planning tasks related to nuclear waste management, as the distribution of years of work experience is relatively even (0–5 years, 6–10 years, 11–20 years and over 20 years). An increased need for persons working in research, development and planning tasks related to nuclear waste management is anticipated at least until 2030.

Personnel competence can be developed and maintained through challenging projects. The disposal of spent nuclear fuel has been a great challenge for many years. As the project progresses, the viewpoint of Posiva's R&D activities is shifting towards product development of the disposal solution. According to Posiva's plans, the disposal concept will improve over the coming decades to become safer, more simple and less expensive. Posiva's evolution from a research and planning organisation into an implementer as the project progresses will, however, create an obvious need for updating the national division of labour and organisation of nuclear waste research. Maintaining competence is particularly critical for the evaluation of long-term safety, as these reviews are carried out and updated periodically, whereas a continuous research workload is required to maintain competence. The periodic safety assessment of nuclear waste facilities are carried out every 15 years as a rule. Several 10-year periods are within sight during which not a single long-term safety case will be conducted. This is a major challenge for both the licensee and the authority in terms of maintaining competence.

Posiva Solutions Oy, which was established in 2016, contributes to maintaining and developing competence in Posiva. The company draws on Posiva's organisation and competence in its business. While the company currently markets its design and development competence related to disposal activities, it is also planning to sell technology related to disposal in the future. Many other companies in Finland also see their existing competence in nuclear waste management creating export potential, and thus also possibilities for maintaining and developing their competence. In order to realise this potential, however, active efforts must be made to ensure that the competence would be exported in a Team Finland spirit.

In terms of competence development, as a challenge can also be considered the fact that no other great quandary equal to the disposal of spent fuel is in sight. Changes in the field of use of nuclear energy may create new competence needs, for example the nuclear waste management of SMRs and possibilities for international research cooperation. Challenges also play a key role in attracting new persons to the field. Young people have been educated in the nuclear energy sector, for example in the YTERA doctoral programme (Figure 16). YTERA, which focused on nuclear engineering and radiochemistry in 2012–2016, was highly successful; with moderate funding inputs from the Academy of Finland and the nuclear power companies, seven postgraduates received training, and participants in the programme also included more than 50 people in total who were working on doctoral dissertations in the participating organisations on funding received from other sources. The majority of these researchers found employment in the nuclear energy sector after graduation.



Figure 16. Students and teachers of the YTERA doctoral programme at their first annual seminar in Tvärminne, Hanko in 2012. Photo: Marjatta Palmu.

The good experiences from the YTERA programme led the Nuclear Energy Research Strategy Group¹³ (the YES working group) to recommend the establishment of a network of doctoral programmes in the nuclear energy sector in 2014. As a result of this recommendation, ENNUSTE (Doctoral Education Network in Nuclear Science and Technology) was established. ENNUSTE is a doctoral programme for approx. 150 students. Participants in the programme include universities, research institutes, authorities and industry representatives. In addition to national activities, it also participates in international networks. However, ENNUSTE does not benefit from the same funding as YTERA, and its activities have not got off the ground in the same way.

International research programmes are another important route to competence development, especially for young researchers. Euratom is about to launch two programmes: EURAD (European Joint Program on Radwaste) is an EJP (European Joint Programme) administrative project, which funds radioactive waste management, including research in disposal. For the part of radioactive wastes, the Euratom Horizon programme for 2019–2020 focuses on such areas as decommissioning and

waste management measures carried out before disposal. A research project related to radioactive waste management that is part of the 2019–2020 programme is to be integrated in the EURAD project later on.

One half of the funding for the programmes is provided by the EU, while the other half will be sourced as national co-funding. This may be a crucial question for a participating research organisation. The industry may also finance research. The idea is that the research projects financed under the programme will respond to national research needs. The starting point for coordinating international and national research related to nuclear waste management is that each participating Finnish organisation can apply to Euratom work programmes and KYT2022 research programme for funding with mutually complementary and supportive research project applications. While Finnish research in nuclear waste management could gain significant benefits from research within Euratom, the precondition for this is making the results of Euratom research available for the KYT2022 research community.

The different application periods of the programmes is a factor that should be noted in the coordination efforts. Additionally, the programmes about to be launched within the framework of Euratom focus on improving radioactive waste management in countries with less development, whereas the benefits for more advanced countries are likely to be scant. This will make forming mutually supportive national and international sub-projects challenging. The funding to be distributed also risks being fragmented into small streams, as a large number of organisations in the Member States wish to get their share. However, participation in international projects effectively promotes the development of competence and networks, and once established, the networks can also be used for such purposes as selling Finnish competence.

Recommendation 15. The Ministry of Economic Affairs and Employment, the Ministry of Education and Culture and the Ministry of Social Affairs and Health will map the competence related to nuclear waste management and assess the needs for high-level competence over the long term as well as secure funding for doctoral programme focusing on nuclear safety, nuclear waste management and radiochemistry. The deadline for carrying out the recommendation is 31 December 2022.

11 Executive summary

In June 2017, the Ministry of Economic Affairs and Employment appointed a National Cooperation Group on Nuclear Waste Management to examine the objectives, development measures and possible solutions for safe and cost-effective management of nuclear waste and other radioactive waste for the period extending from the present well into the future. Based on its deliberations, the working group issues 15 recommendations and 7 suggestions aiming to achieve these objectives.

The working group found that the requirements contained in the Nuclear Energy Act and the Radiation Act concerning the management of nuclear wastes and other radioactive wastes should be more harmonised and be independent of the manner in which the wastes are generated. The consistence of these Acts and consequentially applying international statutes and drafting of lower-level regulations have proven important issues in which further development is needed. In the working group's view, it is important that all radioactive waste existing and to be generated in Finland will be managed appropriately, regardless of its origin, producer or the method in which it was produced. Finland must have procedures covering the processing, storage and disposal of all nuclear wastes and other radioactive wastes generated in the country. This objective has not yet been achieved. It would be appropriate to have the capability to carry out the processing and disposal of wastes mainly relying on the existing infrastructure.

The licensing of nuclear facilities has mainly worked well in Finland. The licensing of nuclear facilities follow a chain of licensing stages defined in the Nuclear Energy Act, often beginning from the Government's decision-in-principle and continuing with a construction and operating licence granted by the Government. Following the operating licence, or several fixed-term operating licences, a decommissioning licence must be applied for the facility. The licences frequently contain terms that place restrictions on the construction or operation of the nuclear facility. The licence

terms often concern waste management and restrict the extent of construction or the amount of nuclear wastes to be processed, stored or disposed of. The licence terms can be amended if necessary. When amending licence terms, however, the same procedure used for granting the licence should be followed where appropriate.

There is a need to develop the licensing procedures for nuclear facilities, as making even a minor amendment to a licence terms is slow and expensive. This hampers the licensee's efforts to develop their activities and, in the worst case, prevents cooperation with other licensees. It has also been necessary to complement the operating licences with licences for operations granted by the Radiation and Nuclear Safety Authority, which may have made it more difficult to manage or control the whole. The nuclear facility licensees could include managing small operators' wastes in their actions if this does not affect electricity production or the sociological acceptability of the operation.

Practices related to licensing procedures may have become unnecessary restrictive over the decades. The manner in which the operator has applied for the licence and in which the Ministry of Economic Affairs and Employment has prepared the decision to be made on it to the Government have an impact on the licence to be granted. It has been found necessary to broaden the process of issuing licences, which previously was very stringent, in order to improve the operating environment and overall safety. This new practice was already followed in the operating licence granted to Olkiluoto 1 and 2 units in autumn 2018, also enabling the management of other radioactive waste at Olkiluoto. The ministry will continue the new practice thus established in the preparation of future operating licences.

In efforts to develop licensing procedures, adequate flexibility should also be striven for by legislative means, however preserving the key principles. Issues of political and sociological significance should be identified when developing the licensing procedures for nuclear facilities, and subjecting them to scrutiny by the Government and Parliament should be continued. The aspects with key importance for safety should continue to attract the attention they deserve. Civic participation and the possibilities of exerting influence provided for the municipalities in which the facilities are located and their neighbouring municipalities should also continue to be guaranteed. When developing the procedures, however, risk-awareness, making decisions at the correct level and the possibility of amendments should be addressed better than before.

Cooperation should also be developed on the interface of the Nuclear Energy Act, Radiation Act and Waste Act in the future. Waste released from supervision under the Nuclear Energy Act and the Radiation Act has been found harmless with respect to its radiation properties, which places it under supervision pursuant to the Waste Act. However, prejudices continue to be associated with such wastes which hamper and, in the worst case, prevent their appropriate processing. The authorities should work together to dispel prejudices by disseminating the required information adequately and at the right time.

Nuclear waste management involves a great deal of national and international reporting. It may be necessary to develop national reporting and to coordinate national and international reporting. The perspective of self-assessment should be included in the reporting, promoting the continuous improvement of the operations. The National Programme for management of spent fuel and radioactive waste should be updated before the Finnish programme is subjected to an international review in order to maximise the benefits of this review.

The different life cycle stages of a nuclear facility create challenges related to maintaining and developing competence for organisations. As the greatest challenges in the maintenance and development of competence have been identified an organisation's ability to maintain competence already acquired if the skills are only needed periodically. On the other hand, the organisation must also acquire new skills ahead of time before the next life cycle stage of the nuclear facility begins. As the life cycle of a nuclear facility may extend to decades or even exceed a hundred years, new persons should continuously be attracted to the field. A number of mutually complementary methods should be used to maintain and develop competence, including competence marketing; partnerships between universities, research institutes and the industry; national and international research; and doctoral programmes.

Based on its deliberations, the working group also proposes to the Safety Investigation Authority that the safety recommendation issued to the Ministry of Economic Affairs and Employment and the Ministry of Social Affairs and Health be closed. In keeping with the recommendation, the working group has developed procedures for ensuring the safe processing, storage and disposal in Finland of all radioactive waste generated in this country in case that returning it to the country of manufacture through importers proves inappropriate or impossible.

12 Working group's recommendations and suggestions

The working group has decided to issue the following recommendations and suggestions. One of the recommendations concerns establishing a monitoring group to oversee the handling of the recommendations and suggestions. The recommendations are measures either addressed to the authorities or they are of major national importance and strongly supported by the working group. The suggestions are measures addressed either directly to licensees or they support national activities. The monitoring group will follow up the implementation of the recommendations and be informed of the implementation of its suggestions.

Recommendations

Recommendation 1. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority together with the licensees investigate and, if necessary, develop the definition of nuclear waste and clarify definition of licensee under a waste management obligation in the Nuclear Energy Act. Aim of the recommendation is enabling the appropriate processing of the waste or product generated in different actions. The objectives also include harmonising national and international definitions. This recommendation should be accounted for in developing legislation.

Recommendation 2. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority prepare a document on the licensees' waste management obligation. This document would address the alternative solutions of waste management obligation and also

take into consideration the procedures and responsibilities related to the partial and full closure of disposal facilities. Any shortcomings and ambiguities associated with the waste management obligation in the legislation should be addressed when developing the Nuclear Energy Act. The deadline for implementing the recommendation is 31 December 2020 regarding the document, and the recommendation should be accounted for in developing legislation.

Recommendation 3. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority develop the licensing procedures under the Nuclear Energy Act and the Radiation Act to ensure that the requirements for and supervision of waste management procedures have been organised in proportion to the risks, regardless of the origin of the waste. This recommendation should be accounted for in developing legislation.

Recommendation 4. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority develop the licensing procedures and supervision measures under the Nuclear Energy Act and the Radiation Act to ensure that the licences enable cooperation in the management of all nuclear waste and other radioactive waste generated in Finland. The cooperation in waste management would take place as part of the licensees' business, ensuring that development efforts will not put the safety of waste management at risk. This recommendation should be accounted for in developing legislation.

Recommendation 5. The working group recommends that the Ministry of Economic Affairs and Employment prepare a document on the application of the current decision-in-principle procedure to nuclear facilities used for nuclear waste management, which have a construction licence or an operating licence. The further development of the decision-in-principle procedure should be taken into account when developing the Nuclear Energy Act if necessary. The objective of this document is to clarify when a nuclear facility project is modified to the extent that requiring a new decision-in-principle is justified. The deadline for implementing the recommendation is 31 December 2020 regarding the document, and the recommendation should be accounted for in developing legislation.

Recommendation 6. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority develop further the transition phase provisions related to operating licences and decommissioning licences as well as the procedures associated with licence expiry. This recommendation should be accounted for in developing legislation.

Recommendation 7. The working group recommends that the Radiation and Nuclear Safety Authority submit to the Ministry of Economic Affairs and Employment a report on the Swedish authorities' experiences from decommissioning of nuclear power plants. The deadline for this recommendation is 31 December 2021.

Recommendation 8. The working group recommends that VTT and the Ministry of Economic Affairs and Employment actively promote the return of spent nuclear fuel to the United States. If it cannot be returned to the United States, VTT should ensure that a national disposal solution can be found. VTT should prepare a progress plan for the interim storage and disposal of spent nuclear fuel in Finland together with Posiva and/or Posiva's owners. Under the existing agreement in principle, the negotiations should be initiated no later than 30 June 2020. The deadline for implementing the recommendation is 31 December 2022.

Recommendation 9. The working group recommends that VTT examine the management of radioactive wastes generated in connection with its research activities and preparation for its costs as a whole and prepare a long-term plan also for the waste management of VTT Centre for Nuclear Safety, including its decommissioning. The Radiation and Nuclear Safety Authority should examine VTT's solution in terms of the requirements under the Radiation Act. The deadline for implementing the recommendation is 31 December 2022 for VTT and 31 December 2023 for the Radiation and Nuclear Safety Authority.

Recommendation 10. The working group recommends that the Radiation and Nuclear Safety Authority prepare a report on the current status of high-activity sealed sources, the properties of sources requiring disposal (number, quality) and their owners. The nuclear power companies and Posiva should map the preconditions and schedules for the disposal of high-activity sealed sources in their disposal facilities to ensure that, if necessary, a disposal facility exists for all high-activity sealed sources in Finland. The deadline for implementing the recommendation is 31 December 2022, and 31 December 2029 for Fennovoima.

Recommendation 11. The working group recommends that the Ministry of the Environment, the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority produce a guide on issues related to the management of wastes released from supervision. The Ministry of the Environment and the Radiation and Nuclear Safety Authority should cover this topic in training events for authorities and operators and deliver the training material to organisations participating in training. The deadline for implementing the recommendation is 31 December 2020.

Recommendation 12. The working group recommends that the Ministry of Economic Affairs and Employment and the Radiation and Nuclear Safety Authority investigate and, if necessary, develop the national reporting on nuclear waste management as well as the coordination between national and international reporting. This recommendation should be accounted for in developing legislation.

Recommendation 13. The working group recommends that the Ministry of Economic Affairs and Employment, the Ministry of Social Affairs and Health and the Radiation and Nuclear Safety Authority update the National Programme for the management of spent fuel and radioactive waste before the international peer review (ARTEMIS). In connection with the programme update, an environmental impact assessment and a self-assessment of the programme should also be carried out. The deadline for implementing the recommendation is spring 2022.

Recommendation 14. The working group recommends that the Ministry of Economic Affairs and Employment establish a monitoring group to handle the recommendations and suggestions that will meet one to three times a year as needed. The tasks of the monitoring group would also include following national and international development in this field and preparing development suggestions.

Recommendation 15. The Ministry of Economic Affairs and Employment, the Ministry of Education and Culture and the Ministry of Social Affairs and Health will map the competence related to nuclear waste management and assess the needs for high-level competence over the long term as well as secure funding for doctoral programme focusing on nuclear safety, nuclear waste management and radiochemistry. The deadline for carrying out the recommendation is 31 December 2022.

Suggestions

Suggestion 1. The working group proposes that the Ministry of Economic Affairs and Employment and the Ministry of the Environment prepare a document on the environmental impact assessment procedure (EIA procedure), which describes the implementation of this procedure in the management of nuclear wastes and other radioactive wastes, and develop the EIA procedure in use of nuclear energy. The deadline for implementing this suggestion is 31 December 2020 regarding the document, and the suggestion should be taken into consideration in developing legislation, accounting for the jurisdictions of the different authorities.

Suggestion 2. The working group proposes that Fortum submit to the Ministry of Economic Affairs and Employment a report on experiences from the decommissioning of nuclear facilities in Sweden. This report could also contain clear proposals for developing the regulations subordinate to the Nuclear Energy Act in Finland. The deadline for this suggestion is 31 December 2021.

Suggestion 3. The working group proposes that VTT submit to the Ministry of Economic Affairs and Employment a report on experiences from the decommissioning of the research reactor. This report could also contain clear proposals for developing the regulations subordinate to the Nuclear Energy Act in Finland. The report is to be delivered together with the report on experiences submitted to the Radiation and Nuclear Safety Authority as required in the Regulatory Guides on nuclear safety and security.

Suggestion 4. The working group proposes that VTT work together with TVO or Fortum, striving to find a sustainable solution on commercial terms and prepare a progress plan for the management of VTT's low and intermediate level wastes and other radioactive wastes. The indicative deadline for carrying out the suggestion is 1 June 2020.

Suggestion 5. The working group proposes that the Radiation and Nuclear Safety Authority and the nuclear power companies (TVO and Fortum) prepare guidelines for operators regarding the submission of waste data to facilitate waste management and record-keeping. The guidelines should be issued for the operator well in advance before the wastes are transported to the plant site. The guidelines should also be sent to the other nuclear power companies for information. The deadline for implementing this suggestion is 31 December 2021.

Suggestion 6. The working group proposes that the Radiation and Nuclear Safety Authority develop its guidelines to provide holders of safety licences for sealed sources with sufficient knowledge of the options for decommissioning the sealed sources, in other words their return abroad or disposal in Finland. The deadline for implementing this suggestion is 31 December 2019.

Suggestion 7. The working group proposes that Fortum prepares a report on the activity level of ashes and slag produced when waste released from supervision is incinerated, the possibilities for further use of the ashes and slag, and controlling the contamination of incinerator equipment. The deadline for carrying out the suggestion is 31 December 2020.

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Appendix 1. Nuclear wastes generated in Finland

The number of licensees generating nuclear wastes in connection of or as a result of their operation is low, and their operations are centralised to a handful of sites. Two such nuclear power plant sites are in use, Olkiluoto in Eurajoki and Hästholmen in Loviisa. In addition, a nuclear power plant site is under construction at Hanhikiven-niemi in Pyhäjoki. A small research reactor site is also located in Otaniemi, Espoo.

Olkiluoto in Eurajoki

At Olkiluoto in Eurajoki, Teollisuuden Voima Oyj (TVO) operates two nuclear power plant units, Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2). The units have been operational for some 40 years. TVO is also in the commissioning stage of Olkiluoto 3 unit (OL3), the planned operating life of which is 60 years. The Government has granted these units with operating licences valid until the end of 2038.

At Olkiluoto, TVO has nuclear facilities intended for the nuclear power plant units' nuclear waste management. They include an interim storage facility for spent nuclear fuel (KPA storage), an interim storage facility for low and intermediate level wastes (MAJ and KAJ storage) and a disposal facility for low and intermediate level waste (VLJ cave). The power plant units also have premises for processing and interim storage of nuclear wastes.

The operating licences for TVO's interim storages were granted at the same time as the operating licences for nuclear power plant units OL1 and OL2, and they will remain valid until the end of 2038. According to the operating licence terms, TVO may process and storage both the low and intermediate level wastes generated at Olkiluoto as well as wastes generated elsewhere with similar activity levels when certain conditions are met.

The operating licence for TVO's VLJ cave will be valid until the end of 2051. The nuclear wastes generated while operating the nuclear facilities at Olkiluoto as well as other radioactive waste possessed by the Radiation and Nuclear Safety Authority generated in health care, industry, research and education may be disposed in the VLJ cave. In addition, the VLJ cave may be used for the disposal of TVO's own solidified unsealed sources and disused sealed sources. An interim storage facility administered by the Radiation and Nuclear Safety Authority is located in connection

with the VLJ cave. The preparation of a periodic safety assessment for the VLJ cave is about to be initiated, and it is to be submitted to the Radiation and Nuclear Safety Authority by the end of 2021.

Posiva Oy was established to manage the disposal of spent nuclear fuel generated by its owners, TVO and Fortum Power and Heat Oy, at Olkiluoto. Posiva's plant consists of nuclear facilities for the encapsulation of spent nuclear fuel and its disposal in bedrock. The plant also has premises for the processing, storage and disposal of operating and decommissioning waste from Posiva's nuclear facilities. Posiva's plant has a construction licence granted by the Government in 2015, and Posiva launched its construction in 2016. Posiva is planning to apply for an operating licence in 2021.

Hästholmen in Loviisa

Fortum has two operating nuclear power plant units at Hästholmen in Loviisa: Loviisa 1 (LO1) and Loviisa 2 (LO2). These units have been operating for some 40 years, and Fortum is currently considering their future. The operating licences granted by the Government for these units will be valid until the end of 2027 and 2030.

Fortum's plant site also contains an interim storage facility for spent nuclear fuel, a storage for solid nuclear wastes, a storage and solidification facility for liquid wastes, and a disposal facility for low and intermediate level waste. The operating licences for nuclear waste storages was granted in connection with the operating licences for the nuclear power plant units in 2007, and they will remain valid until the end of 2030. The operating licence for the disposal facility was granted in connection with the operating licence for the nuclear power plant units in 1998, and it will remain valid until the end of 2055. The operating licence for the disposal facility includes maintenance waste facilities 1 and 2 (HJT1 and HJT2) and a facility for solidified intermediate level waste (KJT). Rather than being included in the Government-granted operating licence, maintenance waste facility 3 of the disposal facility (HJT3) has a licence for operations for processing and storage of nuclear waste granted by the Radiation and Nuclear Safety Authority.

Under the disposal facility's operating licence, the low and intermediate level wastes generated in connection with the operation of nuclear power plant units LO1 and LO2 and the storage of spent nuclear fuel may be placed in the facility. In addition, the facility may be used for the disposal of small quantities of waste generated off-site.

Hanhikivenniemi in Pyhäjoki

At Hanhikivenniemi in Pyhäjoki, the construction of Fennovoima Oy's nuclear power plant Hanhikivi 1 is being planned, as well as the processing, interim storage and disposal facilities for nuclear waste associated with it, excluding an encapsulation and disposal facility for spent nuclear fuel, on the location of which Fennovoima will make a decision later.

Fennovoima submitted its application for a construction licence for Hanhikivi 1 nuclear power plant to the Government in summer 2015. The application concerns not only a nuclear power plant unit but also an interim storage facility for spent nuclear fuel (KPA storage) and interim storage facilities for low and intermediate level wastes. Fennovoima will apply for a separate construction licence for its disposal facility (VLJ cave). The disposal facility already has a valid decision-in-principle that covers the plant's operating and decommissioning wastes.

Otaniemi in Espoo

In Otaniemi, Espoo, is located VTT Technical Research Centre of Finland's FiR 1 research reactor, which has been used for e.g. research and teaching. The research reactor came from the United States, as did its fuel. The research reactor was turned off permanently in summer 2015, and VTT has applied to the Government for a licence for decommissioning and dismantling it. The low and intermediate level wastes produced while the research reactor was operating and the spent nuclear fuel have been stored in connection with the research reactor premises. VTT does not have its own interim storage and disposal facilities for nuclear waste, and it will need to collaborate with other operators to manage its nuclear waste. VTT is a state-owned, non-profit limited company under the ownership steering of the Ministry of Economic Affairs and Employment's Innovations and Enterprise Financing.

Appendix 2. Other radioactive wastes generated in Finland

Radioactive wastes have been and will be generated in Finland also in such fields as health care, industry and research.

Health care

In health care, radioactive substances are used in nuclear medicine and radiotherapy. Unsealed sources are mainly handled in nuclear medicine, which also generates low-level wastes. In radiotherapy, high-activity sealed sources are used as the source (^{192}Ir and ^{125}I). Some university hospitals also use old sources (^{226}Ra and ^{60}Co) for radiotherapy. Low-activity sealed sources are used to inspect radiotherapy equipment (^{90}Sr).

Efficient arrangements are in place for processing unsealed sources in nuclear medicine and wastes. Sources for radiotherapy are stored at the hospitals and removed as waste or returned to an overseas manufacturer. Returning ^{90}Sr , ^{226}Ra and ^{60}Co sources to other countries has turned out to be challenging, however, and they must be managed in Finland

Industry

Some 6,000 sealed sources are being used in industry. These sources are used in the analysis and measurement equipment of industrial processes. Of these, approx. 70 are high-activity sealed sources. Sources fall out of use as actions are discontinued and old sources are replaced by new ones. While high-activity sealed sources have been returned to foreign suppliers and manufacturers, there are some high-activity sealed sources in the country for which a foreign receiver can no longer be found, and they must be managed in Finland.

Research

Isotope laboratories and research institutes generate radioactive waste as part of their research activities. These wastes typically comprise gloves, protective clothing, cleaning equipment and other goods contaminated by radioactive substances. The wastes are stored at laboratories and research institutes, after which they can be removed as waste referred in Waste Act or placed in a disposal facility referred to in

Nuclear Energy Act. Disposal and removal of these wastes have proven challenging, however.

When isotope laboratories and research institutes are decommissioned, more radioactive waste is generated due to dismantling actions. The decommissioning of VTT's material research facilities is currently topical. The facilities and equipment of the facilities have been contaminated with radioactive substances, resulting in considerable volumes of radioactive wastes. In addition, a great number of activated objects and sources are located in the facilities' stores. VTT does not have its own storage and disposal facilities for radioactive wastes.

Other radioactive wastes

An accident while handling a disused sealed source occurred at Roihupelto in a building owned by Senate Properties in 2016. In this accident, several rooms and the ventilation system of Suomen Nukliditeknikka, and partly also the Radiation and Nuclear Safety Authority, became contaminated. In the course of the decontamination operation, radioactive wastes were produced from both premises, all of which were taken over by the Radiation and Nuclear Safety Authority. The wastes have been stored and processed in Järvenpää. An uncontaminated fraction has been separated from them and removed as waste referred in Waste Act. No agreement currently exists on the further processing and disposal of the remaining waste. It should be noted that a similar accident could also occur elsewhere in Finland, and this situation should thus not be seen as unique. The Safety Investigation Authority has written an investigation report on the accident⁴.

Every year, unclaimed (orphan) sources that have slipped supervision are found e.g. at metal recycling facilities and by refiners of recycled metals. These sources have mostly entered the country as a result of open international recycling trade. The sources may be returned abroad, or they must be managed in Finland.

Industrial processes also turn up disused metal pipes or other components suitable for metal recycling that contain radioactive substances naturally occurring in nature. These so-called NORM wastes (Naturally Occurring Radioactive Material) must also be managed in Finland.

Final Report of the National Cooperation Group on Nuclear Waste Management

In June 2017, the Ministry of Economic Affairs and Employment appointed a working group to examine the objectives, development measures and possible solution for safe and cost-effective management of nuclear waste and other radioactive waste for a period extending from the present well into the future. The working group met 13 times during its term. As a result of its deliberations, the group issued 15 recommendations and 7 suggestions. A monitoring group, which will meet one to three times a year as needed, will be established to handle the recommendations.

ISSN 1797-3562 (PDF)

ISBN 978-952-327-441-9 (PDF)

Electronic version: julkaisut.valtioneuvosto.fi

Publication sales: julkaisutilaukset.valtioneuvosto.fi