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**WORKING PAPER**  
**Identifying remaining socio-technical challenges at  
the national level: Finland**

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UNIVERSITY OF JYVÄSKYLÄ



UNIVERSITY  
OF TAMPERE

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# 1 Introduction

This research report is part of the research programme *International Socio-Technical Challenges for Implementing Geological Disposal* (InSOTEC; see [www.insotec.eu](http://www.insotec.eu)). The research programme is funded by the Seventh Framework Programme Theme [Fission-2010-1.1.2] [Research activities in support of implementation of geological disposal] (Grant agreement no: 269906). The basic assumption of the InSOTEC Project is that in the case of the geological disposal of nuclear waste social and technical issues are not separate entities, but issues relevant to study as interconnected or even as interwoven.

This particular report is a contribution to Work Package 1 and its subtask 1.1. The aim of Work Package 1 is to identify the most significant socio-technical challenges for implementing the geological disposal of nuclear waste. To achieve this objective a comparative analysis including several countries was performed. This report focuses on the socio-technical challenges in Finland. The aim of this report is firstly to investigate the research trends in the recent Finnish social science literature and to investigate how socio-technical issues are handled in some public documents. In addition to these nuclear waste management experts are interviewed.

For the purposes of Work Package 1 four different angles were taken for closer examination. The second chapter is a description of the current state of affairs in Finland, with a brief overview of the nuclear waste management history, the main actors and their responsibilities, the policy decisions and the current situation as regards R&D and the communities affected. The chapter was written by Matti Kojo (University of Tampere).

The third chapter provides a brief overview of the social sciences research trends in radioactive waste management. The purpose of this review was to identify research trends in the last two decades in Finland. This report moreover includes two small scale empirical studies. Subchapter 3.2 presents a brief review of public documents and exchanges with key actors, which in the Finnish case means interviews with experts. The public documents in this report consist of a limited selection of written statements regarding the extension of the final disposal facility for spent nuclear fuel. The written statements and the interviews served as supplementary material examining the issues raised in the discussion in the planning for a decision on an extension and the discussion on the future challenges for nuclear management. The third section was written by Anna Nurmi (University of Jyväskylä).

In the conclusion section we discuss the results from the empirical studies and reflect over the socio-technical dimension of the challenges observed of Finnish nuclear waste management. The fourth section was written by Anna Nurmi, Matti Kojo and Tapio Litmanen (University of Jyväskylä).

We gratefully acknowledge all the people who collaborated in this work by giving their time for interviews, responding to questions in e-mails and sending research material.

## 2 Description of current status quo - Finland<sup>1</sup>

### 2.1 Actors and their responsibilities in brief

The current Finnish nuclear power programme consists of four nuclear power plant (NPP) units built in the 1970s and early 1980s. Since then the units have been modernised and upgraded. In 2010 nuclear power produced 25 percent of Finland's electricity. Two NPP units are operated by Teollisuuden Voima (TVO) at the Olkiluoto site in the municipality of Eurajoki and two by Fortum Power and Heat (FPH, formerly Imatran Voima, IVO, currently part of the Fortum Consortium) in the municipality of Loviisa. A fifth unit - 1600 MW EPR type - is under construction at Olkiluoto. The pulp and paper industry and FPH are the biggest owners of TVO. The State of Finland is the biggest owner of Fortum Consortium<sup>2</sup>.

In 2010 the Parliament of Finland ratified two Decisions-in-Principle (DiP) regarding nuclear new build (Litmanen and Kojo, 2011). TVO was granted permission to build a fourth NPP unit (1450–1650 MW) in Eurajoki and Fennovoima, a new power company established in 2007, to build its first unit (1250–1700 MW) in the municipality of Pyhäjoki. Pyhäjoki will be the third nuclear community in Finland. The municipality has no previous experience of the nuclear industry. Fennovoima is owned by Voimaosakeyhtiö SF (66 percent) and E.ON Kärnkraft Finland (34 percent). Voimaosakeyhtiö SF is owned by 69 Finnish regional and local energy companies and by companies in trade and industry.

Although the Government approved the nuclear new build for TVO and Fennovoima in 2010 it rejected the NPP application of Fortum Power and Heat (See e.g. Litmanen, 2010, p.285). The National Coalition Party especially argued that all the three applications should be approved if the safety and environmental requirements were met. After the rejection Fortum lobbied the new government formed after the parliamentary elections of 2011 to include a positive statement regarding the Fortum NPP application (Yle 28 February 2011). However, the Fukushima accident of March 2011 changed the public attitude and the new Government also decided not issue new DiPs during the period 2011–2015.

The main actors in nuclear waste management are the utilities TVO, Fortum and Fennovoima, the nuclear waste management company Posiva (owned by TVO and FPH), the Ministry of Employment and the Economy (formerly the Ministry of Trade and Industry, MTI) and the Radiation and Nuclear Safety Authority (STUK). The utilities, which are licensees under the nuclear waste management obligation, (in 2011 TVO and FPH), are responsible for nuclear waste management, its planning, implementation and costs. Fennovoima is not yet a licensee under the nuclear waste management obligation. The Ministry is responsible for overall management and supervision in the nuclear energy sector and also directs the planning and implementation of nuclear waste management. STUK,

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<sup>1</sup> Partly based on the subchapter "Finland" in Päiviö Jonsson and Andersson (eds. 2010, p.12) by Matti Kojo and the report "Community divided" by Mika Kari, Matti Kojo and Tapio Litmanen (2010).

<sup>2</sup> Even though the state is a majority shareholder in Fortum (50.8 % at 31.12.2009) and the company is listed on the Helsinki stock exchange, a publicly listed company is run on commercial principals. (Litmanen, 2010.)

operating under the Ministry of Social Affairs and Health, is responsible for the supervision of nuclear safety and the use of radiation.

## 2.2 Legislation and the DiP procedure

In 1978 the Atomic Energy Act, dating from 1957, was amended to take account of nuclear waste management. According to the amendments the licence holder of an NPP unit assumes responsibility for all measures and costs relating to nuclear waste management. Under the Atomic Energy Act, detailed regulations were incorporated into the licences issued to NPP units (Posiva, 1999, p.3). The first licences were issued in the late 1970s.

The Nuclear Energy Act was passed in 1987, replacing the Atomic Energy Act of 1957. In 1994 the Nuclear Energy Act was amended to include the prohibition of nuclear waste import and export. The shipment of spent nuclear fuel (SNF) from the Loviisa NPP to the Soviet Union, and later Russia, took place in the period 1981–96. The amendment of the Act caused IVO to rearrange its SNF management. As a result, Posiva, the nuclear waste management company, was established by TVO and IVO in 1995.

The Nuclear Energy Act and the Decree were amended in 2008.<sup>3</sup> As part of the legislative reform, a number of the relevant Government decisions were replaced by Government decrees. The decrees entered into force on 1 December 2008. For example, the Government Decision 478/1999 regarding the safety of disposal of spent nuclear fuel (SNF) was replaced by the Government Decree 736/2008, issued on 27 November 2008. (See Kari, Kojo, and Litmanen 2010, p.13.)

The balance of power in licensing a nuclear facility is stipulated in the Nuclear Energy Act. The first step is the Decision-in-Principle procedure, which is launched by an application submitted to the Ministry of Employment and the Economy by a company. However, a company usually takes into account the Government programme which may include statements regarding energy policy in general or nuclear energy in particular, giving the line of the government. The timing of submitting an application is at the discretion of the applicant.

The DiP procedure consists of several phases, e.g. background accounts by the Ministry, statements and a public gathering. The statements are requested by the Ministry (of Employment and the Economy). For example, a statement regarding safety issues by the Finnish Radiation and Safety Authority (STUK) is compulsory. According to the Nuclear Energy Act STUK could halt the procedure if serious safety reasons were to be found. The government makes the DiP regarding a facility. According to the Act the government needs to take into account the overall good of society, which in practice means that the decision is political in nature. If the DiP is favourable, then Parliament decides on ratification. Before the ratification is decided in a plenary session of Parliament, the

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<sup>3</sup> Parliament approved the Government's legislative proposal for amending the Nuclear Energy Act (Government Bill 117/2007) on 7 May 2005, and the amended Act entered into force on 1 June 2008.

parliamentary committees prepare their reports. A committee is free to hear any experts or stakeholders, but the gatherings are not public. It is also important to bear in mind that the Parliament cannot change the contents of the DiP. Parliament either approves or rejects the Government's DiP.

The proposed host municipality plays a decisive role in the DiP procedure in relation to siting. According to the Nuclear Energy Act, the local council of the municipality where the facility would be located has a right of veto which cannot be overruled by the Government. Thus the site selection of a nuclear facility is dependent on the approval of the local council. The right of veto is also valid in the event of an expansion of the spent nuclear fuel repository. For example, the local council of Eurajoki approved the expansion plans by Posiva in 2008 and 2009 (see Kari, Kojo, and Litmanen, 2010, p.18). The right of veto is an important source of power for the host municipality in relation to the site selection process, but the Finnish host municipalities also exercise power in relation to the nuclear industry in determining the annual percentage of property tax on nuclear facilities in the range stipulated by legislation governing taxation of property. Economic issues have been in a central role in the relationship between Eurajoki and the nuclear industry (see Kojo, 2009.)

### **2.3 National nuclear waste policy**

The arrangements related to nuclear waste management in Finland were determined by the governmental policy decision of 1978 (Suominen, 1999, p. 26). The aims and timetable for Finnish nuclear waste management were set out in the governmental policy decision of 1983.

In the late 1970s the Finnish nuclear waste policy was planned to be based on reprocessing. In the governmental policy decision of 1983 reprocessing was still priority number one. The plan was to transport SNF abroad, permanently. SNF management of IVO followed this line until 1996, when the ban on export and import came into force. TVO negotiated for a reprocessing contract in the 1970s, but as it was found too expensive, and as the other contract requirements were also strict, no contract was ever signed. In the 1980s TVO focused on the final disposal of SNF and adapted the KBS3 concept from Sweden. Later, in the 1990s, due to the decisions of the Ministry of Trade and Industry in 1991 and 1995 final disposal of SNF became the only solution available to the companies and in 1994 the Nuclear Energy Act was amended with the final disposal concept. According to the decision by the Council of State in 1999 the repository must be retrievable if necessary. (Suominen, 1999; Sandberg, 1999; see also Darst and Dawson, 2010; Lehtonen, 2010.)

The DiP application in which Posiva proposed Eurajoki as the location of the repository was submitted in May 1999. The local council of Eurajoki approved a statement in favour of this in January 2000. Before this TVO, Posiva and the Municipality of Eurajoki had agreed on a benefit package for the municipality (Kojo, 2009, p.181–185). The Government took the DiP in December 2000 and Parliament ratified the decision in May 2001. Another DiP was ratified by Parliament in May 2002 due to the extension of the repository for SNF produced by the Olkiluoto 3 NPP unit. The

excavation of the underground rock characterization facility as part of the repository began in 2004. In 2008–09 Posiva submitted two further DiP applications for extensions to the SNF repository (see Nurmi, Kojo, and Litmanen, 2009).

Posiva's application of 2008 covered a maximum disposal capacity of 9000 tU. Furthermore, Posiva implemented an EIA procedure for the further expansion of the repository in 2008 because of the NPP application by Fortum. A second DiP application was submitted by Posiva in March 2009 covering a total capacity of 12000 tU. However, as the DiP application for an NPP unit by Fortum was rejected by the Government in May 2010, Parliament approved only the expansion of the repository for SNF arising from TVO's Olkiluoto 4 project. The DiP in favour of Posiva's plan was ratified by 159 votes to 35. (Kari, Kojo, and Litmanen 2010, p.13–14.)

A whole new chapter in Finnish nuclear waste policy will begin if Fennovoima decides to apply for a DiP for a second SNF repository. This option was introduced in the Government's prerequisite to Fennovoima in May 2010 (Kojo, 2010). In July 2010 Parliament was in favour of a joint national solution, but the Government programme of Prime Minister Jyrki Katainen (National Coalition Party) of June 2011, looks only for a national solution. Earlier the minister responsible, Mr. Jyri Häkämies (National Coalition Party) has been ready to support the negotiations between the companies but not to force them to co-operate in accordance with the Nuclear Energy Act. The Ministry of Employment and the Economy has also been reluctant to violate the property rights of Posiva to the facility.

Fennovoima's prime option is co-operation with Posiva, which would allow access to the ONKALO underground research facility at Olkiluoto. As mentioned above, the Government did set the planning of the final disposal facility of their own as a second prerequisite to Fennovoima if the company failed to reach agreement with Posiva and its shareholders in a time frame of six years. The power companies have been arguing over national nuclear waste policy since the establishment of Fennovoima in 2007. Fennovoima calls for a joint national solution, and insists that this is the will of Parliament. Posiva has constantly emphasized that it will take care for SNF produced by Posiva's shareholders only (i.e. TVO and FPH). From Posiva's viewpoint there is no national solution but a final disposal project which has been developed under the nuclear waste management obligation. The obligation is licence-holder specific and has been conferred on TVO and FPH. (Kojo, 2010.)

In March 2012 the Ministry of Employment and the Economy established a working party with the aim to address joint nuclear waste management in Finland. This was due to the political decision by the Cabinet Committee on Economic Policy in February 2012 that the Ministry can take measures to force the licensees under waste management obligation to implement joint nuclear waste management if the requirements of the Nuclear Energy Act were fulfilled. In the working party all three power companies (TVO, Fortum and Fennovoima), the waste management company Posiva and the Ministry are represented, but not the municipalities, not even the Municipality of Eurajoki. The working party is scheduled to submit its final report by the end of 2012.

In practice a second repository in Finland would provide additional disposal capacity of thousands of tons of uranium. According to the then STUK director general Laaksonen (retired in January 2012),

the safety of the repository would not be a concern. Furthermore, it was noted by a STUK director that hundreds of candidate sites had already been identified in the 1980s. These sites only needed further investigation. (*Satakunnan Kansa*, 23 and 24 April, 2010.)

**Definition: What is nuclear waste?**

According to the Nuclear Energy Act nuclear waste means: a) radioactive waste in the form of spent nuclear fuel or in some other form, generated in connection with or as a result of the use of nuclear energy; and b) 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; (1420/1994).

The used nuclear fuel from the reactors in Loviisa and Olkiluoto are defined as high-level radioactive waste in Finland and is going to be disposed of in the Olkiluoto nuclear waste repository. Intermediate-level waste is e.g. compounds that are used during water circulation. Low-level waste is waste that has been contaminated with radioactive substances and is called maintenance waste. The annual amount of reactor waste makes for Olkiluoto 150 to 200 m<sup>3</sup> and for Loviisa reactor 100 to 150 m<sup>3</sup>. (Posiva, 2012.) Low and intermediate-level waste is disposed in 60-100 meters deep storages in the area of the NPPs. Also wastes that origin from research, industry or social service and that are under responsibility of the state are disposed of in a central storage at Olkiluoto. Waste that origin from the nuclear power plants is under the Nuclear Energy Act, when again other radioactive wastes are under the Radiation Act. (STUK, 2009.) The now existing reactors are filled with about 70 tonnes of new fuel annually. This is also the amount of spent nuclear fuel that is stored to wait for the final disposal. (Posiva, 2012.)

According to the Nuclear Energy Decree (12.2.1988/161, Section 1) spent nuclear fuel means “nuclear material that has been used as nuclear fuel for the production of nuclear energy and that contains significant amounts of nuclear waste”. Furthermore, according to the Government Decree (736/2008) on the safety of disposal of nuclear waste Issued in Helsinki 27 November 2008 short-lived waste shall refer to nuclear waste, the activity concentration of which after 500 years is below the level of 100 megabecquerels (MBq) per kilogram in each disposed waste package, and below an average value of 10 MBq per kilogram of waste in one emplacement room; long-lived waste shall refer to nuclear waste, the activity concentration of which after 500 years is above the level of 100 megabecquerels (MBq) per kilogram in a disposed waste package, or above an average value of 10 MBq per kilogram of waste in one emplacement room.

## 2.4 Timetable

The timetable for the Finnish nuclear waste management was set out in the governmental policy decision of 1983. According to the decision, SNF management involved site selection by 2000 and application for a construction licence by 2010, to be operational by 2020. The timetable of 1983 has so far been re-scheduled once. In 2003 the Ministry of Trade and Industry (MTI) decided that the licence holders must submit the final applications for the construction licence by 2012 at the latest. The change in the timetable was justified by ensuring the safety of the repository. (Kari, Kojo, and Litmanen, 2010, p.12.)

In October 2011 the CEO of Posiva announced in an interview that a timetable differing from the Swedish waste management company SKB (Svensk kärnbränslehantering Ab) created extra challenges for Posiva. Posiva had co-operated with SKB which was planning to start final disposal in 2025, five years later than Posiva. The Finnish Broadcasting Company interpreted that Posiva would re-consider the timetable although no decisions had so far been taken. (*YLE Satakunta*, 4 October, 2011.) The DiP of 2000 is valid until 2016. According to Posiva's current plans, the final disposal is scheduled to start in 2020 and end in 2112. The repository would be sealed up by 2120. As Parliament agreed to issue the new NPP DiPs in July 2010, the sealing schedule will be changed. (Kari, Kojo, and Litmanen 2010, p.12–13.) A timeline with the milestones in Finnish nuclear waste management can be found in Appendix 1.

## 2.5 Research, development and demonstration (RD&D) programme

From the administrative viewpoint the current Finnish nuclear waste research can be classified into 1) research ensuring the availability of nuclear technological expertise required by the authorities for the preparation of decision-making, 2) research required for the supervision of nuclear waste management and 3) research related to planning, implementation and development. The first category is organized into research programmes in public administration, the second falls under other public administration programmes i.e research conducted in support of STUK's advisory duties and the third is conducted by the licence-holders under their nuclear waste management obligation. (Ministry of Employment and the Economy 2010, abstract.) The categories may overlap to some extent but the limited resources have been evinced to justify the fact that the Finnish public sector's research programme (JYT2001, 1997–2001) never aimed to conduct independent full-scale performance assessments of a spent fuel repository (Rasilainen, 2002, p.15). The focus of the JYT2001 programme was set

*“... on studies to reduce uncertainties associated with the basic principles and main phenomena related to geological disposal of spent nuclear fuel, and to be able to model*

*these phenomena more accurately and reliably for the purposes of safety assessment. The second primary objective of the public sector's research was to develop and introduce new methods for research and analysis." (Rasilainen, 2002, p.15.)*

Publicly financed nuclear waste research was launched in Finland in the early 1970s. Since 1989, when the first research programme period coordinated by public administration started, there have been six research periods: 1989–1993, 1994–1996, 1997–2001, 2002–2005, 2006–2010 and the latest since 2011. (Ministry of Employment and the Economy, 2010, p.10.; see also Litmanen, 2008.) Organizing of research programme was reconsidered in 1996 and in 2000–2001. In 1996 the Ministry set up a group of senior experts to review the status of nuclear waste management and the related research needs. As a result the emphasis in the technical studies was contested related to the geological disposal of SNF. (Rasilainen, 2002, p.14.)

In 2000–2001 a working group nominated by the Ministry recommended that in the future, too, research programmes on nuclear safety be divided into two separate programmes. These are: (1) safety research related to nuclear power plants and (2) research on nuclear waste management. In line with the recommendation the Ministry established the Finnish Research Programme on Nuclear Waste Management in 2002 (KYT programme <http://kyt2014.vtt.fi/eng/index.htm>). To provide funding for the KYT programme a State Nuclear Waste Management Fund<sup>4</sup> was established in 2004. The status of the Fund was safeguarded by the amendment to the Nuclear Energy Act of 2004, which imposed a financial provision obligation on those under a waste management obligation, mainly the power companies. Thus the Fund collects its financial resources from those responsible for nuclear waste management who are obliged to pay annually 0.08 % of their respective assessed liability. The current level of annual funding is 1.7 M€. In addition to State Nuclear Waste Management Fund funding, research organizations may direct their own funding into their research projects. (Rasilainen, 2004, p.4.; MEE, 2010, p. 12 - 13.)

The KYT programme organization includes the Steering Group, thematic Support Groups and the Coordinator. The Steering Group of the first KYT programme consisted of the representatives of the Ministry, STUK, Posiva, Fortum, TVO and TEKES<sup>5</sup>. (Rasilainen, 2004, foreword.) The current Steering Group also includes representatives of the Ministry of the Environment and Fennovoima, but TEKES is no longer represented. Half of the eight members of the Steering Group represent the nuclear industry, which can be seen as an indication of the influence of the private sector on the steering of publicly administrated research programmes.

The emphasis of the research programmes is on technical and natural sciences, but social sciences also have a part. The research period 1994–1996 was the first to include social sciences (MTI, 1996, p.11). The volume of research funding for social sciences increased 1997–2001, when the focus was on observing the EIA procedure in the candidate municipalities. The need for social sciences research was based on the amendments to the Nuclear Energy Act, the Act on EIA procedure and the

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<sup>4</sup> In Finnish Valtion ydinjätehuoltorahasto VYR

<sup>5</sup> The Finnish Funding Agency for Technology and Innovation

controversial views on the site selection by the residents of the candidate municipalities (MTI, 1996, p.15; Rasilainen, 2002, p.14, Litmanen, 2008, p.434–440). The need for interactive communication programme between local residents and authorities was also recognized, but it was not seen possible to fund such activity by the JYT-programme. The main aim of the communication programme would have been to bring the concerns of local residents to the attention of the authorities and forming a considered view of the final disposal plan in these sites. (MTI, 1996, p.15–16.) In 2002–2005 social sciences were excluded (see Rasilainen, 2004, p.14) but in the period 2006–2010 some funding was again granted for studying public perception at the local level (see MEE, 2010, p. 27; Kari, Kojo, and Litmanen, 2010).

In the latest period, called KYT2014, research subjects are divided into (1) new and alternative nuclear waste management technologies, (2) research into the safety of nuclear waste management and (3) sociological research related to nuclear waste management. (MEE, 2010, p.17.) From the viewpoint of the branch of sciences the organizing of the research programme reflects a boundary between social and technical. According to KYT2014 Framework Programme (MEE, 2010, p.27) the purpose of the sociological research in the KYT2014 Research Programme is “to support decision-making and related preparations”. As research themes are mentioned the views of various actors and groups on nuclear waste management, and the final disposal of SNF in particular, ethical debate and issues related to long-term duration.

According to Rasilainen (2002, p.15) Posiva’s research programme has been essentially based on repeated safety assessments of the proposed disposal concept, supported by the site investigations and other safety-related research, in line with its mission. TVO and Posiva have published safety assessments of spent fuel disposal in 1985, 1992, 1996 and 1999. Since 2003 Posiva has prepared three three-year plans for the nuclear waste management of the Olkiluoto and Loviisa nuclear power plants. These TKS reports (Posiva, 2003; 2006; and 2010) have included plans for future research, technical design and development work as well as assessments of the state of nuclear waste management, with particular reference to the preparations for the disposal of SNF. TKS-2003 covered the research period extending from 2004 to 2006, TKS-2006 covered the period extending from 2007 to 2009 and TKS-2009 covered a detailed plan extending from 2010 to 2012 and a general plan covering the subsequent three-year period from 2013 to 2015. The latest report (TKS-2009) also provided a direct response to the requirements concerning the report to be submitted to the MEE as stated in Section 28 of the Nuclear Energy Act. (Posiva, 2010, p.3.) At the same time as the TKS-2009 programme the MEE was provided with a construction licence readiness report, the final disposal facility's pre-licence material for the construction licence application. The material shows the current readiness of the reports required for the licence application, and specifies what parts of the material required for the licence still need to be supplemented. (Kari, Kojo, and Litmanen, 2010, p. 12.)

## **2.6 The formal and informal role and (in) activity of civil society stakeholders**

The Finnish nuclear energy legislation includes obligations in relation to public participation and informing residents. The Act (468/1994) on Environmental Impact Assessment (EIA) Procedure applies to all projects that may have considerable negative environmental impacts, and the related Decree (713/2006) states that the construction of a nuclear facility must always be subjected to the EIA. According to the Nuclear Energy Decree the Decision-in-Principle (DiP) application must be accompanied by an EIA report. Thus an EIA procedure must be implemented before submitting the DiP application.

Public participation in accordance with the Nuclear Energy Act of 1987 consists of the dissemination of information and a public gathering. The applicant is responsible for compiling an overall description of the facility and making it generally available after a check by the Ministry (see Posiva, 2009). The description, for example, is circulated to every household in the intended municipality. The Ministry is responsible for arranging a public gathering in the municipality in which the planned site of the facility is located. Opinions may be given either orally or in written form. According to the Nuclear Energy Act the opinions presented “shall be made known to the Government” by the Ministry. The public gathering is formal in nature. No debate is allowed between participants, therefore mediation, for example, is not possible. Furthermore, feedback is only given by the applicant after several months. The public gathering is open to all, but in practice it is arranged only in those municipalities that are included in the DiP application as alternative locations. The main purpose of public participation carried out in accordance with the Nuclear Energy Act is to offer residents an opportunity to voice their comments directly to the highest national decision-maker i.e. the minister responsible and the government. The general philosophy would seem to be that nobody should interpret the feedback but that the decision-maker should receive an authentic message from the residents. In practice authenticity is safeguarded by recording the oral statements given in the public gathering. (Päiviö Jonsson and Andersson, 2010, p.14.) This arrangement, however, offer no opportunity to create a dialogue between the different affected parties in the gathering.

In the EIA and DiP procedure meetings, which were held in 2008 and 2009 in Eurajoki in relation to the repository expansion plan, the number of participants was low.<sup>6</sup> Interest was raised mostly by questions on project information and project decision-making. The topics discussed in the public meetings were wide-ranging. The comments and concerns typically raised have to do with other current nuclear projects or energy policies and were less directed at the spent nuclear fuel repository expansion issue. The public attendees clearly viewed all contemporary nuclear projects in the same light and the need for a general discussion on nuclear power was evident. The EIA procedure was criticized as seeming illogical and premature. On the other hand, the assessment was considered important. Criticism regarding inadequate provision of answers to questions was expressed. (Nurmi, Kojo, and Litmanen, 2009.)

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<sup>6</sup> Posiva implemented the EIA procedure in four candidate municipalities (Eurajoki, Kuhmo, Loviisa and Äänekoski) between 1998 and 1999 (see Hokkanen, 2007).

## 2.7 The current role of affected or potentially affected communities

Eurajoki and Loviisa are the municipalities that are currently most affected by SNF management. The former is the host of TVO NPP with SNF in the water pools. The Olkiluoto site of the SNF disposal facility also located in its area. The latter is the host of Fortum NPP. The amount of SNF in Loviisa NPP area is smaller than in Olkiluoto, as all SNF produced by the Loviisa NPP was transported to the Soviet Union and Russia from 1981 to 1996.

The third municipality that will be affected is Pyhäjoki. Fennovoima announced in October 2011 that the new NPP unit would be located in Pyhäjoki. Fennovoima has planned its SNF management on the idea that it would co-operate with Posiva, but Posiva has rejected this. If Fennovoima is unsuccessful in its negotiations with Posiva and its owners, Fennovoima will be compelled to launch a site selection process to find a site for its own SNF facility. (Kojo, 2010.) Such a process would raise the question whether Pyhäjoki or some other municipality might also be a societally suitable community with suitable bedrock for the final disposal of SNF.

The municipality of Eurajoki has already reacted on the SNF management of Fennovoima. Although the local council of Eurajoki approved the repository expansion for the needs of TVO in 2008 and Fortum in 2009, in March 2010 the local government reported to the Minister of Economic Affairs that the municipality was concerned about the way issues related to municipal decision-making in accordance to the Nuclear Energy Act were handled in the case of Fennovoima. The municipality was especially concerned that it was not given a chance to issue its statements although the Fennovoima application for a DiP gave the impression that SNF generated by company would be disposed of in Olkiluoto. The local government noted that the municipal council has the right of veto, which cannot be overruled by either the Government or Parliament. According to the municipality the procedure is also of great importance in building and strengthening openness and confidence between the applicant, the municipality and the residents. (Kari, Kojo, and Litmanen, 2010, p.18.)

The host municipalities have a formal role in the site selection process thanks to the veto right as explained in subchapter 2.2. The Municipality of Eurajoki has also had temporary and more permanent liaison groups with the nuclear industry (see Kojo, 2009) which allow better means for discussions over some issues under planning. The Finnish municipalities have not, however tried to establish an arena or partnership for safety issues such as that in Belgium. The permanent liaison group between the municipality and the industry is more based on the idea of information exchange only between the parties.

## 3 Identifying remaining socio-technical challenges in Finland

### 3.1 A review of social sciences studies on radioactive waste management

#### 3.1.1 Methods and data

The review continues research conducted at the University of Jyväskylä in 1990–1999 by Litmanen and Kaunismaa (1999; see also Heikka et al. 2001). The earlier study has been taken into consideration in this review, with the exception of the years in which the social science studies for this report were conducted (1999–2010). The results of the review are based on the earlier social sciences study as well as the search made for this particular review. In this report social science studies are defined as sociological, socio-political, political, economic, judicial, communication studies.

The literature reviewed for this study consisted mainly of different work conducted in universities, a few popular books and theses or postgraduate work accomplished in universities. Some of the master's theses also serve as working reports for Posiva or the Radiation and Nuclear Safety Authority (STUK). One important difference from the earlier study is that in this study a few articles published in scientific journals are also included in the study. The articles were thought to reflect the most recent ideas on nuclear waste management and were therefore included in the analysis. The search for social sciences studies was made mainly as a library search, using library database search engines<sup>7</sup>. Various stakeholders' Internet databases were also consulted such as STUK, Posiva, VTT, The Ministry of Employment and the Economy. STUK, for example, had a very extensive publication listing.

Some limitations were imposed on the preliminary listing of the publications. The abstracts of the publications served as the selection criterion, thereby eliminating possibly irrelevant cases. Limitations were also imposed on publications of 2011 and on non-scientific publications, leaflets or texts. It is also important to note that some book chapters (not independent articles) that were found in the library search as independent search results were in this analysis combined to one study which they represented. Articles from books with several authors were regarded as their own publications, thus omitting the book from the listing.

The library search was conducted identically with a common library engine *LINDA* as well as in universities' own databases<sup>8</sup>. The common database for all universities did not offer as many results as did the universities' own databases. Theses were the most problematic to locate. Some master's

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<sup>7</sup> The library search was made using database search machines. The command searchwords used were: ydinjäte, (nuclear waste) ydinpolttoaine (nuclear fuel) and loppusijoitus (final disposal) ydinjätehuolto (nuclear waste management) and the English words "nuclear waste". The words were shortened to "ydinjät?" "loppusij" and "ydinjätehuolto?" to cover a broader result. The search was also limited to the years 1999-2011 and if possible to publications published in Finland.

<sup>8</sup> Universities included in the search were: the University of Jyväskylä, the University of Turku, the University of Helsinki, the University of Eastern Finland, the University of Lapland, the University of Vaasa, the University of Oulu and Åbo Akademi University.

theses may therefore be missing from the research due to different storage procedures in different universities.

As one criterion we used saturation, which in this case meant that after the same publications started to come up frequently, and no new publications were found, the search was abandoned. The title of the publication functioned as the primary selection criterion for the publications included in the literature listing. In this case we took into account publications that could be thought to have a connection to sociological, socio-political, political, economic, legal and communications studies. Publications that were suggested by the library database (keywords) were also included in the listing, even if the title of the publication did not give any indication of the actual content. In this part of the study publications that very clearly belonged to the natural and technical sciences were not taken into consideration due to the enormous number of them. Studies focusing on nuclear power plants /technology were excluded. For example, surveys of particular nuclear power plants or the image of a single nuclear power plant were therefore not included in this report. However, publications considering power plants more generally including waste storage or transportations etc. were included. Nuclear waste management was used as the most important criterion in choosing the publications. This limitation is in line with the study conducted earlier (Litmanen & Kaunismaa, 1999). Although a fairly broad viewpoint was adopted in our primary listing, there is a possibility that the list lacks some studies because of these limiting procedures.

After this procedure a more detailed reading was made of the remaining publications. The total number of items was 111. The detailed reading was made of the abstract, foreword and conclusion sections.

### **3.1.2 Research trends**

The social scientific research themes quite clearly follow the development of the Finnish nuclear waste management process. In this research report the research trends are presented in four five-year time periods: 1) 1990-1994, 2) 1995-1999, 3) 2000-2004 and 4) 2005-2010.

The research in the years 1990 to 1994 focused mostly on the nuclear waste dispute and was conducted at the University of Jyväskylä (see. e.g. Litmanen 1994). From 1995 onwards an increase in the number of research themes is apparent. The research themes clearly reflect the site selection period for a final disposal facility. The research from this period examines opinions, information needs and economic factors in the different municipalities. In a working report written by Osmo Kurki in 1995, the information needs of different stakeholders as well as the viewpoints and opinions of the various possible siting municipalities were examined. Kurki writes that of the municipalities examined in his report residents in Eurajoki were most positively disposed towards nuclear waste disposal. (Kurki, 1995.)

It is possible to see a preparation towards the EIA assessment procedure. Studies on the economic and political structures in the municipalities were conducted in all municipalities (Ollikainen and Rimpiläinen, 1997). Working reports made by Posiva prepared the EIA process by compiling information about different factors in the municipalities but also by organizing stakeholder and

public meetings. Public meetings were organized before the actual EIA meetings concentrating on the interaction. (Leskinen, Paldanius and Turunen, 1997.)

The preparation of the EIA procedure and the EIA process itself contributes greatly to the different research areas. The most active year in the research areas is 1999. A total of 31 different publications included in this review were published that year. Many of these research reports were the output of the Public Sectors Research Programme (JYT). Keeping in mind that this report focuses on social sciences studies only, it is a fairly large number. The peak year of 1999 mirrors the EIA process and the preparation for the DiP of 2000. Studies on opinions, attitudes and psychological and social effects were well represented (e.g. Paavola & Eränen, 1999). Economic effect studies as well as the local entrepreneurs' readiness to take part in the construction project were examined. (e.g. Ronkainen & Ukkonen, 1999.) Jurisprudence studies addressed the possibility of consultative referenda and examined issues related to importing. Political studies focused on argumentation and the opposition groups. The articles and studies from the universities mainly focused on the conflict and the decision-making process of the siting. (see e.g. Litmanen, 1999; Litmanen, Hokkanen and Kojo, 1999.)

The active period of 1999 also had its impact on the research conducted in 2000 and 2001. Thereafter the research is mainly concerned with the EIA, media research, argumentation and social acceptance. One interesting fact is the infrequent studies, which examine the legal rights of coastal states to intervene in possible transportations and a study about technical and economic retrievability. One might assume that issues like transportation and retrievability might be addressed more in the future, when the construction phase of the disposal plant begins. One distinctive feature for the time period 2000-2004 is media research and studies on decision-making. The media research examines both general discussions in newspapers but also the work of journalists (Tommola, 2001; Raittila, 2001). Decision-making and participation are examined broadly in working reports but also in a book published in 2002 (Raittila et al., 2002). The role of participation and the influence of the EIA (see. e.g. Hokkanen & Kojo, 2003) are discussed during this time period.

In 2004 a book was published on Finnish nuclear politics. In several articles in this book the decision-making process around Eurajoki accepting and becoming the site for a nuclear waste site is described (Kojo, 2004). The assessment of the EIA was also one of the themes discussed. The EIA process was examined and evaluated, especially from the perspective of public participation.

In the last period 2005-2010 onwards the research focuses on the host municipality Eurajoki, including image research and socio-economic research. From 2008 on a small change is again discernible towards information needs. The political decision-making is also examined, now with a target audience in other countries (See e.g. Litmanen & Kojo, 2011). Eurajoki is still examined as a local research object, but at the end of 2009 and 2010 wider issues like knowledge and democracy are also among the research topics. One might assume that this "large scope" would be the themes of the near future as well.

For the purposes of this report a simplification of the research themes was made, so that the different studies could be presented as a figure. Figure 1 below presents the time periods and simplified research themes.

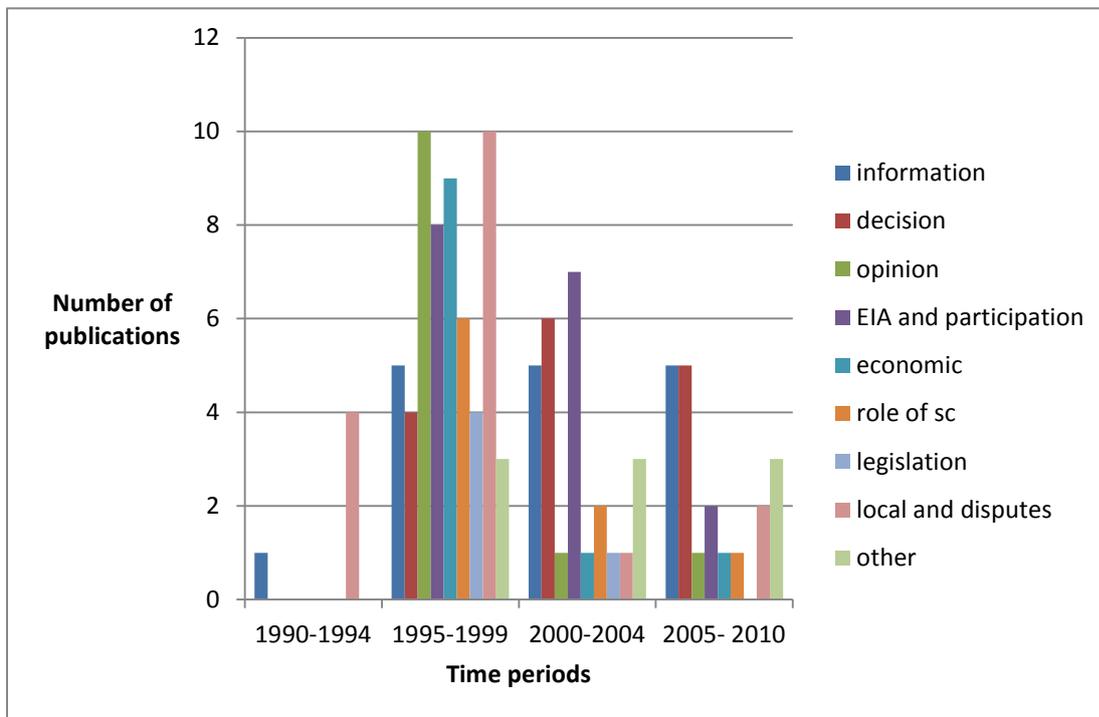


Figure 1 Social science research themes during different time periods

## 3.2 Review of public documents

### 3.2.1 Methods and data

For the purpose of this project it was agreed that public documents should be examined. For the Finnish part the public documents consisted of written statements made on the EIA assessment report and statements accompanying the application for a DiP for an extension of the nuclear waste repository for spent nuclear fuel. These public documents were chosen as research material for this report in the belief that they represent issues that could be deemed significant or challenging when decisions on nuclear waste management were taken. The statements also enabled examination of one stakeholder group, municipalities, that would have otherwise not been represented in the research material.

The statements serving as research material in this report belonged to three different gatherings; the EIA assessment and two gatherings regarding the DiP for the upcoming Decision-in-Principle at that time. The table below presents the three different requests for statements (Table 1). The EIA

assessment report is attached to the application for a DiP, although in these gatherings the first application for a DiP was submitted before the commenting procedure for the EIA report had ended. The two DiP applications were for an increase in the fuel capacity for possible new power plants in Olkiluoto and Loviisa. The background for the statements is an already positive Decision-in-Principle in 2000 and 2002. The statements in this report belong therefore to a time when the DiP about a geological disposal facility had already been taken, but an extension of the repository was needed for the plans of the power companies to build new nuclear reactors.

Requested statements	Date <sup>9</sup>
Request for statements for the EIA report	10.11.2008-12.1.2009
Request for statements for expansion Olkiluoto 4 reactor (9000 Ut)	19.9.2008-19.11.2008
Request for statements for expansion Loviisa 3 reactor (3000 Ut)	13.5.2009-15.7.2009

**Table 1 The different gatherings and timetable for requested comments**

The total number of written statements is great, but for the purposes of this report only 21 statements were examined. The selection of which statements to include in this brief analysis was based on the statement of the contact authority in the EIA process, which includes a summary of issues articulated in the statements. After a brief reading of this summary nine stakeholders were chosen for closer scrutiny. The selection was based on those stakeholders who seemed to have raised interesting viewpoints on the matter that could perhaps be seen as challenges for nuclear waste management. In this phase some municipalities situated near the final disposal plant were also taken into consideration. The municipality of Eurajoki, the host municipality for the disposal facility, was selected for the analysis even though it seemed that their statements did not articulate issues. The material for this analysis consisted therefore of three stakeholder groups:

- National Radiation and Safety Authority, Ministry of Employment and the Economy (contact authority), Ministry of the Environment
- Statements of the municipalities; Municipalities of Eurajoki, Nakkila, Luvia and Rauma<sup>10</sup>

<sup>9</sup> According to information from the web pages of the Ministry of Employment and the Economy.

- NGO Statements of Greenpeace and The Finnish Association for Nature Conservation

The total number of written statements chosen for this report was 21 in answer to the three different requests for comments presented above. Note that some of the organizations did not give statements in answer to every request for comments. The Decision-in-Principle and the environmental impact assessment progressed partly in parallel. Table 2 below presents the number of written statements given by different stakeholders.

Request for statements	Number of statements
Request for statements for the EIA report	National authorities 3 Municipalities 4 NGOs 2
Request for statements for extension for Olkiluoto 4 reactor (9000 Ut)	National authorities 1 Municipalities 4 NGOs 2
Request for statements for extension for Loviisa 3 reactor (3000 Ut)	National authorities 1 Municipalities 3 NGOs 1

**Table 2 Numbers of the selected statements by different stakeholders**

### 3.2.2 Analysis

The analysis of public documents was conducted in two stages. First a brief thematic reading to screen the issues mentioned in the statements was made. These issues were collected into a different list forming the basis for the analysis. The second part of the analysis was conducted by collecting the most frequently emerging themes and by looking at these more closely. These themes were fairly few, since the contents of the statements were often repeated in the different commenting procedures'. Therefore the themes emerging in this thematic analysis also reflect the overall discussion at that time.

For the purposes of this report the most frequently mentioned issues in the statements are discussed. A more specific and detailed analysis would necessitate more diverse data. The discussion

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<sup>10</sup> Neighboring municipalities to the host municipality Eurajoki.

presented here should be seen as an example of the issues talked about at that time, not an in-depth analysis.

### **3.2.3 Issues discussed in the statements**

#### ***Endurance of the barriers***

Criticism against the extension of the disposal facility was deemed problematic. The research on the corrosion of the copper canisters was considered insufficient and lacking a scientific base. The behaviour of the copper was found problematic because of corrosion, and the nearby sea was seen as a possible risk exacerbating the corrosion. The fuel type from the new NPPs was also considered problematic as it was not known how the copper canisters and the engineered and natural barriers would work with the new type of fuel. Problems of not knowing how the canisters would react were seen as a risk.

An ice age was mentioned in the statements and it was fraught with uncertainty. The NGOs pointed out that the ice age may entail seismological activity and the effects on the disposal facility were therefore unpredictable. Contradictory information about how deep in the ground the permafrost might reach was also considered problematic by the NGOs. The permafrost was feared to cause pressure on the canisters and therefore also breakages if it entered the cave. Possible water masses that might form as a result of an ice age were considered problematic for the disposal facility. The calculations and predictions about an ice age were claimed to lack a scientific base and rely on speculation. Climate change was thought to cause problems and even sudden unpredictable changes, such as a rise in the sea level.

#### ***The extension of the repository***

The extension of the repository was deemed risky because of the area where the extension was planned to be situated had not yet been examined. The suitability of the area was hence unknown. An extension was also seen in the future to endanger existing facilities. The NGOs criticized this while other stakeholders only commented that the new area had to be examined properly before disposal got under way. The NGOs were worried that the extension would affect the quality of the future disposal facility by taking risks to fit more fuel into the disposal facility.

The fuel from the NPPs currently under construction differs from the fuel from the older reactors. This fact was seen to entail great uncertainties; for example, it is not easy to know the effects on the bedrock and the engineered barriers. This needed further investigation in the estimation of the NGO's and authorities. A discussion on what kind of waste and how much the final amount of disposable waste was going to be was, according to these statements, called for.

Other information related to the extension also raised questions. Material, mining waste, transportation and traffic were mentioned. The increase in traffic was mentioned in one of the statements of the municipalities. The municipality in question wanted more exact information on the

effects of an increase of traffic. In addition to normal traffic increase the transportation of radioactive waste from the Loviisa NPP to Eurajoki also raised some questions. Comments made on transport issues were that the increase has not been taken into consideration and that the calculations of a possible transport accident had only been counted as effects on human beings, forgetting the impacts on the environment. Even the host municipality Eurajoki, which in other statements took no stand and merely acquiesced to the extension project, reacted on the transport issue. The municipality of Eurajoki commented that it could not be sure to support transports from other NPPs to Eurajoki. Transports were also commented on in statements that transports might concern the residents and that transports in other countries had been subjected to harassment.

### ***Long-term safety - an issue to be resolved***

Long-term safety was an issue subjected to both criticism and trust. However, those commenting on long-term safety pointed out that there were still many issues to be resolved and a certain level of safety to be achieved before a positive decision on the construction licence was possible. Long term-safety, however, was thought to be presented well enough for present needs. This meant that safety issues were to be followed up, and new decisions to be taken in light of new facts. The Radiation and Safety Authority had pronounced the information adequate and sufficient for the needs of the law of the present but stressed the need for more research.

Problems with long-term safety issues were perceived in the uncertain claims and information. Uncertainties that affected the long-term safety concerned the bedrock, engineered barriers, and the behaviour of the copper. Research and information about safety issues were called for.

Some of the statements contained argumentation about the safety of geological disposal as a better solution than intermediate storage. Intermediate storages are thought to be more susceptible in case of war and terrorism, thereby constituting risks to society.

### ***Municipalities would like to be better informed***

In the statements of municipalities it appeared that they represented local people and therefore wanted more information on the project. One neighbouring municipality in particular stressed that a good information dissemination policy was needed and suggested that an information programme would be useful. Another municipality hoped that neighbouring municipalities would be guaranteed participation in radiation monitoring by law.

## **3.3 Interviews with experts**

### **3.3.1 Methods and data**

The issue of socio-technical challenges in this report was also examined with the help of expert interviews. Six semi-structured interviews were conducted in October 2011 on the subject

“challenges in nuclear waste management”. The interviewees were from the Radiation and Nuclear Safety Authority, Ministry of Employment and the Economy, Posiva Oy, Fennovoima Oy, Greenpeace and the Ministry of the Environment. The selection of the interviewees was made on the basis of various documents related to nuclear waste management research. The interviews are not representing the organisations official views on the discussed matters.

Anonymity was agreed on with the interviewees before conducting the interviews. Therefore the markings “H1”, “H2” referring to the transcription material are used in the citations in this report. The aim in the interviews was to concentrate on challenges for the nuclear waste management and further discuss their socio-technical nature. Because the focus of the study was not on the differences between the opinions of the experts, the results of the interviews were not differentiated by theme. The texts in the citations were translated from Finnish to English by the authors.

In order to be able to consider the issues of interest, the interviewees were given the question sheet to be used in the interview in advance. This was the wish from some of the interviewees and it was also thought that the topic of the interview is such that a little time to reflect on the issues might be useful. The participants had prepared for the interviews, which could perhaps be seen in the duration of the interviews, lasting from 40 minutes to one hour. Many of them had made notes and prepared the answers. The interviews were recorded and later transcribed. The interviews were mainly conducted at the workplaces of the interviewees, with one exception which was conducted in a café.

### **3.3.2 Analysis**

Based on the transcriptions a thematic analysis was conducted. The thematic analysis at this point only describes *what* the participants said, without going deeper into *how* the participants described the issues addressed in the interviews. The transcribed texts were read through and four themes were chosen for closer scrutiny. These issues included 1) the history of nuclear waste management; 2) future developments in overall nuclear waste management; 3) challenges and issues to be resolved in the immediate future; and 4) challenges especially in the safety of nuclear waste disposal.

The themes were combined from different questions and answers, such as discussions about innovations that often related to future demands and the possibility of solving possible problems in the future. Discussion about developments in history also often concerned which part of nuclear waste management the interviewees deemed crucial or challenging. The challenges were identified from the transcribed text by selecting those parts where the interviewee talked about challenges or reflected on what may or may not be a possible risk or cause problems. The use of the semi-structured interview form was useful when conducting the analysis. Similar questions for each interviewee helped to identify the themes significant for the analysis. Even though the questions were the same for all, the questions were broad, leaving space for the discussion to develop. There is, of course, also always a risk that the questions of the interviewer influence the outcome of the discussions, even if a certain space is left open for the dialogue to develop. In this part of the analysis only the content is processed.

At the beginning of the interview the word socio-technical was discussed. Even though the participants were asked to think about the questions from a more societal point of view, there were not many ideas as to what could be societal or in this case socio-political dimensions in nuclear waste management. It is important to note that the starting point for the interviews was to discuss societal aspects of nuclear waste management, which greatly influenced the responses. An interesting point was, however, that when discussing challenges for the future, social acceptance and social stability were mentioned several times and clearly assumed importance in the discussions.

### **3.3.3 Themes**

#### ***Breakthroughs or significant developments in nuclear waste management history***

The interviewees were asked to think of the developments they considered significant for the development of nuclear waste management in Finland. Every participant referred to decisions of a political nature, defining the development or path chosen (for more information see introduction).

*"I think that the important solutions weren't only technical, they were political decisions or what would you like to call them..." H1*

The interviewees referred mainly to changes in the law and political decisions as well as the decision to collaborate with Sweden. Many also mentioned the decision to start to work with the KBS-solution as significant.

*H2: "...but great significant decisions that have far-reaching affects of which one is the decision to choose a geological final disposal method, this KBS-3 // and then, the second significant thing, a second important event was when it was decided that nationally [repetition].. that nuclear waste management should be taken care of nationally and not to export and import nuclear waste." H2*

#### ***Issues that need to be resolved***

Issues that should be resolved in the immediate future were discussed with the interviewees. This issue partly overlapped with research needs, which was also a question to be discussed. The answers on this issue were very wide and many noted the long time-scale of the disposal project. The long time-scale places demands on research and it could be seen that the time schedule for the construction licence had its effects on the answers as well. One participant talked about scenarios that have to be proven safe in accordance with the application for the construction licence. These scenarios were related to the buffers, characteristics of the bedrock and the defence-in-depth in the final disposal facility.

Waste in intermediate storage in the nuclear power plants was also mentioned, often followed by the notion that intermediate storage was deemed risky. Stress tests related to electricity capacity in the NPPs was also mentioned, this again often in connection to the accident in Fukushima. One

participant mentioned that especially then, if the disposal is delayed, the safety in interim storages should be scrutinised even more closely.

*“it may very well be the case that this disposal underground is the best solution, but we want the processes to be done properly and with time and not like that, that they are going to be disposed of just for political reasons. And then of course it should be resolved that especially if we have to wait a longer time for the final disposal then those interim storage solutions should be improved because they are not secured in the same manner as for example nuclear reactors.” H4*

Many of the interviewees considered that product development was crucial in the near future. Not everything was certain or complete, hence product testing and development were constantly needed. Test results are awaited and some research findings are still uncertain. For example, more information is still needed on the bedrock characteristics and the actual concrete disposal has still to be done, about which further knowledge would again be gained.

*“ And then the challenges that there are, are, of course, technical, those we have been sussing out and in a way they are related to these human built dispersion barriers and their reliability then in use, and of course have all the elements been taken into consideration and which elements have been unnoticed...” H4*

Some of the interviewees thought that there was nothing special currently on the agenda and stressed the importance of the stability of the process.

*“H5: It suits very well that we continue now as we are, in Finland, that is, that the research focuses on the elements that are important.” H5*

One interviewee pondered about the challenge that the disposal facility was to be constructed in stages and at the same time the waste was going to be disposed of in the facility and parts of the facility was to be closed down. The interviewee saw a challenge especially in how the Nuclear Energy Act was up to date with this process and how the licences were to be solved.

*“well, in my opinion the biggest challenge at the moment is the upcoming construction licence.. sort of how the construction license is formulated, that is not very clear that in the same time in a way the challenge is in that that Onkalo is sort of supposed to be constructed in periods and then at the same time it will be starting to fill up with the fuel during construction and then partially also be closed up. And these three stages are going to be ongoing at the same time...” H6*

One participant saw as an international challenge that many countries do not have a waste management programme. The fact that Finland has a nuclear waste programme was mentioned by others as well, seeing it perhaps as a part of stability and consensus for the development.

### ***Future demands***

Challenges for the future (the term “future” was not given a time frame) were perceived in concrete problems, but also in wider developments and abstract thoughts. Some considered that there were

no challenges and that the development should proceed as planned and the development or process should be taken care of.

*H2: "There are hardly any at all. It will change in the same way as nuclear power use in general, it will become mundane and stop being such a mystical horror. " H2*

One interviewee predicted that nuclear waste would cease to be something risky and scary and be seen as something normal, while again another said that nuclear waste was going to raise public discussion if the use of nuclear power increased. Possible risks or accidents would also increase the discussion among the public.

*"Well, that depends of course a lot on whether there are going to be more reactors built or not. Because then in a way, I think, a more pivotal societal question will emerge, that is also more discussed if these [reactors]are completed here. " H4*

It was hoped that the dispute about the nuclear power company Fennovoima's nuclear waste management would be solved. Other radioactive material, such as research reactors and other research material should be disposed of. Safety had to be constantly improved. Some interviewees mentioned monitoring while the disposal plant was under construction as a challenge. A future challenge was also the shutdown of old nuclear power plants.

The fuel type of the new reactors was also deemed challenging in the sense of how this might influence the interim storage and final disposal.

*H6: "That of course what I already mentioned that the fuel type of these new [nuclear] plants and the waste management solutions are surely one thing that will.. in which the extent to which they influence the intermediate storage questions and the final disposal questions." H6*

When discussing future developments in Europe, the issue of multinational disposal facilities cropped up. Common disposal facilities or a common solution was seen as a good but difficult idea to implement. Some conjectured that it would be hard to come to an understanding on within whose borders the facility might be situated. Some again thought that collaboration was achievable in this matter. A common facility and R&D programme was seen as practical because a joint project would be more economical. Comments that every country would need its own waste programme were also made, with the notion that the waste would be taken care of in this way. A common disposal facility would also mean less risk.

*" I am actually quite sure that this is the way that things are going to be done, because there are countries that have only one nuclear power plant there, or then they have waste originating from some time during the existence of the nation. It is not sensible for them to start building their own disposal plant. No, they might not have the resources, no personnel, not the technique and no money either."...H1*

*"I do not consider it very likely that in the EU region one common [disposal facility] or even two common, but then again I think it is very likely that small countries in central Europe and small East European countries will find each other//... " H2*

Some interviewees seemed to think that Europe was critical towards nuclear waste management and that this was a problem in finding a solution for nuclear waste. The accident in Fukushima was thought to increase polarization on the matter in Europe. Research and development was seen as far more positive and some technological collaboration projects were mentioned. Collaboration was predicted to be challenging, but fruitful.

### ***Challenges for nuclear waste management***

Challenges were seen in the development processes in the future that would cause society to become unstable or collapse. A change in politics, meaning that decisions would be made that would impede the process was a possibility. To maintain the social acceptance and dialogue with society was likewise deemed challenging.

*"Some kind of challenge is to maintain the societal acceptability, and sort of interact and expose oneself to critique, even inappropriate critique and sort of build one's own activity into such that, could I say an objective detective could see it to be on solid ground..//"* H2

One interviewee also mentioned that the nuclear business should work together in order to preserve its social acceptability. Social acceptability was mentioned very often in different forms. Many participants said that if the societal pressure or "tone" were to change it would be a challenge.

Some interviewees mentioned the availability of the material used in the disposal process, such as bentonite, as one possible challenge. The economic developments could also have their influence on the materials. One possible challenge could as well be if many countries wanted to engage in the same type of disposal at the same time, which would affect the availability and price of material.

New information about the site that could impede the disposal was mentioned as one challenge. The suitability and capacity of the bedrock and new emerging information that needed to be taken into account were mentioned. Challenges were also seen in the process itself, would everything work according to plan? Reflection on the methods used and the tests done was seen in some answers clearly related to the uncertainty of the future.

*"Well of course if something in the research that is now done, some surprising turn and we would find immediately that this had not been looked into at all, or that this would lead to this and this and it is not acceptable, then of course at least more research would be needed and a longer time perspective."* H6

It was deemed important to solve the waste issue. To leave the problem unsolved for coming generations was described as unfair. Many queried what would happen to the waste if not disposed of. A safe final disposal was seen as the best option for the environment. To wait for alternative solutions was also deemed a bad idea, since the waste had to be taken care of the whole time and

new solutions might take several decades to come. One interviewee mentioned that one possible challenge or problem could be the turning point for shutting down NPPs and disposal of the waste. Is there a space between these two that has not been taken into consideration?

The long time-scale was seen challenging for modelling, but also for predicting what society would be like. The fact that in the future someone might try to get into the cave was deemed risky. Environmental challenges again were not seen as problems. Some described climate change to be so slow that it would be possible to react to the changes. Some perceived no risks in climate change.

### ***Safety challenges***

The interviewees discussed safety challenges mostly in terms of why they thought the solution was safe. The perception of the solution as a safe one often relied on the facts and test results from the project. Challenges and risks were acknowledged, but they were seen as part of the model, meaning that they had been taken into account.

*“... but in that way I see it as challenging the fact that we discuss such long time spans that it is not enough that we do one analysis and it will give us the answer 57 and it is like this, no, one has to do an extensive amount of research and then there again is the wondering about how much information is enough..” H3*

One concrete safety challenge mentioned was the flow of the groundwater and if the groundwater does not flow as predicted. A challenge was also seen in gathering long-term information on different issues as well as how to maintain the knowledge.

Human intrusion and the risks inherent in this was seen as a risk for the disposal facility and the nuclear power plants. The nuclear power plants were considered more risky than the disposal facility. A few other external risks for the disposal facility were also mentioned. An ice age and the melting of ice were discussed. An ice age was seen to happen after such a long time that the effects should be relatively small if indeed any. Contradictory viewpoints on what would happen to the bedrock as well as the possible effects on the canisters were presented. Some estimated that external risks might exist, others did not.

*H2: “External threats. Yes of course there are these different natural phenomena that will affect the credibility of long-term safety, of course they exist, but to be prepared and to be protected against them in one way or another is part of the concept. Therefore I don’t think that there are such threats that would threaten so that one should worry about them.” H2*

*H4 “.. but history has shown that the worst threats in nuclear power and otherwise in technology aren’t those that are discussed and those that people know how to be prepared for, they are those that no one came to think of beforehand.” H4*

## 4 Conclusions: Interconnectedness of technical and social

This report is a contribution to Work Package 1 and its subtask 1.1 as a part of the project *International Socio-Technical Challenges for Implementing Geological Disposal* (InSOTEC). The aim in this report has been to identify the most significant socio-technical challenges for implementing geological disposal of spent nuclear fuel in Finland. In order to identify socio-technical challenges three different sets of data were analysed. Firstly, trends and research objectives in the field of social science in the last two decades were studied and a brief review presented. Secondly, public documents which in this report are in the form of a selection of written statements were analysed and thirdly six interviews with experts in the nuclear waste management field were conducted. Although this research material is limited in order to enable an extensive in-depth analysis of remaining socio-technical challenges, the use of different kinds of data provided an insight into the phenomenon of interconnectedness of social and technical. In this last section of the report we will discuss the findings of the report and try to highlight some issues that in our own opinion are challenging for the current nuclear waste management and, more importantly, try to show the connection between the social and technical through some examples.

The involvement of the socio-political and techno-scientific aspects of radioactive waste and its management was one of the three general conclusions by Bergmans et al. (2008, p.66–68). Bergmans et al. (2008, p.67) state that the technical-social divide is largely an artificial one. Issues such as the definition of waste and safety are not just technical but also political statements and choices. The authors note that the importance of social aspects of RWM is recognized but has not led to a thorough integration of the social and technical aspects in decision-making. Technical issues are not brought into the public arena and social issues are often narrowly reduced e.g. to the socio-economic. When technical issues are brought into the public arena, it is only after the techno-scientific community has come to a conclusion on the solution to the problem. Bergmans et al. (2008, p.68) conclude that the biggest challenge for the future lies in working towards a closer integration of the technical and social aspects. As means for integration the authors propose that the scientific and expert community should become more reflexive about the social assumptions implicit in the technical work and continue the efforts to make the technical debate accessible to lay arguments and more responsive to social needs (Bergmans et al., 2008, p.68).

In this report we have used the term socio-technical as a term for the interconnectedness of the social and technical. According to Trist (1981) the conceptual innovation of the term took place during the studies undertaken by the Tavistock Institute in the British coal mining industry (Trist 1981, p.7). Prior to this pioneering research, it was normal in the sociology of work, as Eric Trist (1981) describes, to work with the idea of the separate social and technical systems of an organization. The conceptual innovation discerns the organization's socio-technical systems instead of perceiving them only as social systems. "The social and technical systems were the substantive factors – the people and the equipment" (Trist, 1981, p.10).

The term socio-technical is widely used in the socio-technical regimes literature and has evolved from the term technological regimes as Geels and Kemp (2007) indicate. The term *technological*

regime is used when referring to the community of engineers, either when thinking about its cognitive routines or about rule-sets in complex engineering and production processes, whereas *socio-technical regime* includes scientists, users, policymakers and societal groups besides engineers and firms (Geels and Kemp, 2007, p.443). The benefit of using the term socio-technical regimes instead of technical regimes comes from the fact that behind cognitive routines of engineers and designers are larger societal-technical entities such as institutional arrangements and formal regulations and material aspects, e.g. specific technological infrastructures, creating a stabilized socio-technical environment. For Smith et al. (2005) socio-technical regimes are relatively stable configurations of institutions, techniques and artefacts, as well as rules, practices and networks that determine the normal development and the use of technologies.

### ***The results of the social science review***

The results of the social science review of research trends and topics have been presented in four different time periods. During the first time period, from 1990 to 1994, the social science research focused mostly on the nuclear waste disputes. Interests in conflicts are related to the advancement of the nuclear waste management programme where the focus was at that time on the search of a suitable place for a disposal facility. The factors affecting the research during the second period (1995–1999) were; 1) the site selection process and 2) the preparation of the EIA procedure. As the decision on a facility for the disposal of nuclear fuel was approaching, a great amount of social science literature was produced to support the decision-making. The research themes included among others opinions and attitudes, information needs and economic factors in the different municipalities. During the period from 2000 to 2004 research focused mainly on the EIA, media and information research, argumentation and issues relating with social acceptance. Conflicts and the decision-making processes were also addressed. Besides these themes there were sporadic studies on e.g., transportation and retrievability. After the Decision-in-Principle the EIA was evaluated with special emphasis on public participation and its impacts. As mentioned earlier in the report, retrievability is a question which has not been a burning issue in Finland. As Lehtonen writes, the reason for this may have to do with the legal framework of nuclear waste management. Lehtonen also argues that the knowledge production in nuclear waste management has been left to the few, thereby decreasing the discussion on the matter. Finns also trust their authorities and the information they present. (Lehtonen, 2010.)

During the period 2005–2010 the host municipality Eurajoki was the focus of research. Researchers were interested in questions related to the municipality's image and socio-economic issues. As the time for applying for a construction licence for the final disposal facility is approaching more interest has now been paid to information needs, the attitudes of the residents of the area and the political decision-making. Besides these studies, which focused on the local level, wider general issues such as knowledge and democracy have been taken up.

The research trends in social sciences follow the overall development in nuclear waste management. The Finnish Public Sector's Research Programmes (JYT2 and JYT2001) and later the Finnish Research Programme on Nuclear Waste Management (KYT) have directly influenced the research trends by framing the research agenda and by funding. One starting point of the abovementioned research

programmes has been the usefulness of such studies to the nuclear industry (MEE, 2010). The research trends of Finnish social scientific research, however, also reflect the general trends in Europe, and more specifically Sweden (see e.g. Solomon et al. 2010; Berner et al. 2011). The independent academic research (e.g. Litmanen 2001; Kojo 2005; Hokkanen 2007) has been in a lesser part.

The literature review gives us an insight into one aspect of the socio-technical environment. Research needs are something that are brought about by technical needs in the nuclear waste management, but also decided upon discursively inside the socio-technical environment. One example could be the siting decision, which is not only the result of technical facts but also a political as well as a social decision. One could also say that to some extent the research subjects are also part of the political system, by feeding information to the regulative system, which became apparent in the changing themes by time.

### ***The findings of written statements***

The political or social nature can be seen well in the written statements examined in this report. A thematic analysis was made of selected written statements belonging to the decision-making process of the extension of the final disposal facility. The selected statements were thought to supplement the expert interviews by giving some stakeholders a voice in nuclear waste management. The issues discussed in these statements could clearly be seen to relate to the particular political decision, but more general challenges could also be found. Four wider themes could be discerned in the statements: 1) endurance of the barriers, 2) the extension of the repository, 3) long-term safety, 4) the municipalities need for more information. Despite the fact that themes could partly reflect the overall discussion important to the decision-making, challenges that could be deemed socio-technical clearly also emerged. Scientific and epistemological uncertainty regarding the technical durability of the copper canisters and the properties of copper were discussed in the statements. Related to these issues the fuel type of new NPPs was also discussed. Greenpeace, for example, have raised the issue of the increased burn-up rate in the public debate (Greenpeace 3 Feb 2009; Greenpeace 6 Aug 2008.)

The need for a larger disposal facility due to the further construction of nuclear power was seen as a challenge. Earlier plans were based on smaller amounts of spent fuel, but the need to construct extra space for new waste quantities was seen to necessitate more research and planning. Here one can see how the technological project is affected by political decisions to allow further construction of nuclear power. Long-term safety issues related to uncertainties and lacking information were often mentioned as issues needing follow-up. Uncertainties were seen e.g. in the engineered barriers and bedrock characteristics. Moreover keeping municipalities informed about technical and social issues seems to be a real communication challenge for the nuclear industry, scientists and authorities. A clear communication strategy was required in some statements of the municipalities. Organizing the participation of neighbouring municipalities in radiation protection and surveillance were also deemed important.

The statements could be seen as one example of the discourse where the technical information is partly being handled related to a political process. The level of safety, uncertainty and methods of

research are evaluated from upon the application of the implementer. In some statements it can be seen that more information is still needed. The dynamics of the socio-technical can be discerned, revealing the actors, the discourse where demands are set and then the technical feasibility as well as the technical design of the artefacts. The statements also point towards scientific knowledge. Somebody has to decide when uncertainties are manageable and also the relevant methods and measures for this. It is a collective of social discourse, scientific facts, testings, trust etc.

### ***The findings of the expert interviews***

While in the written statements uncertainty could be seen as a challenge for the technological solution, then again the experts interviewed described uncertain issues rather as problems that are going to be solved. (See also Lempinen & Silvan-Lempinen, 2011, p.4.) Uncertainty in several issues was conceded, but it seemed to belong to the process and was under constant scrutiny and development. Some, of course, found these uncertainties more worrying than others. Issues that were mentioned as unsolved or under research were the groundwater flows, the melting waters of the ice age, and the reliability of information in the sense of whether the right models and tests had been used. The fuel of the new NPPs was also discussed. Very few environmental risks regarding the disposal facility were perceived. Changes possible due to climate change were seen to be slow and remediable. Then again, human intrusion into the facility was seen as a risk. Intermediate storages were also seen to be far more risky than geological disposal, often mentioned with reference to events in Fukushima as one example. According to the National Report on Stress Tests for Nuclear Power Plants, various safety functions have been studied and improvements have been planned for possible accidents, changes in weather conditions and securing the electrical supply in the power plants. (Routamo, 2011.)

The political consensus and stability of the energy policy was seen as important especially by some of the interviewees, although the results might have been influenced by the fact that the interviews concentrated on societal aspects of nuclear waste management. Stability was deemed important in order to solve the disposal problem nationally and internationally. The stability of society as a threat to the disposal project could, however, also be seen as a challenge although more related to social acceptance and confidence. The discussion of stability can also be likened to the thought of the predictability of the future and hence could be a challenge for Finnish nuclear waste management. Technical innovation is not excluded from the social environment, but heavily dependent on it.

One could perhaps see in the issues discussed in the interviews thoughts of the level of tolerable uncertainty, uncertainties still exist, but at the same time models for coping with this uncertainty are being developed. This is, for example, explained as the mode of work. The discussion also holds a notion of reflexivity; it is important to be prepared for unplanned issues, or the plans have to be changed after possible challenges. This notion originates in concerns about what will happen in the future and if some developments in the society may endanger the project. One challenge in the future might also be how to secure on-going up-to-date research nationally and internationally and how to ensure the preservation of knowledge for hundreds or thousands of years. Even in spite of measures to preserve knowledge and to train new generations to work with these issues, the challenge seems to be very abstract.

One recent dispute that did not come up directly in the research materials of the report but could be seen as a challenge in the near future is the arrangement of SNF management of Fennovoima and the site selection process for a possible second SNF repository in Finland. The fact that the experts interviewed did not touch on this issue which has been debated by the power companies quite intensively in public (see Kojo, 2010) but only the stability of energy policy in general, may reflect the caution and reserve of the Finnish nuclear waste management establishment. When Fennovoima's NPP project develops, information and co-operation with locals in the new nuclear power community Pyhäjoki will surely be one challenge in the future as well. Problems would also occur if the bedrock in Olkiluoto should turn out to be unsuitable for the extension, or even for the whole repository, which at least would necessitate new plans for the extension area or a delay in the timetable.

As the previous sections indicate, the remaining socio-technical challenges are very tightly bound to the progress of the already started nuclear waste programme. As explained in Chapter 2, the public research programme KYT has an influence on the research conducted. The nuclear industry is well represented on the steering body of the programme which can be seen as an indication of the influence of the private sector on the steering of publicly administrated research programmes. The nuclear power companies as well as the Safety and Radiation Authority, however, also conduct their own research. Which challenges are the most striking of those emerging in the analyses is difficult to say, since the different data handled the issue somewhat differently. When reflecting on the geological disposal of spent nuclear fuel as a technological innovation process, one can see that it has been an enormous and lengthy scientific-technological enterprise consisting of many kinds of socio-technical interaction. For instance, research, product development, testing processes and design have been and continue to be challenges for management projects both in Finland and in Sweden, who have cooperated for decades. The evolution of the technological project continues, but the time for submitting the application for a construction licence is approaching at the end of 2012. In one sense the construction licence is a knot which ties technical and political issues together once again. In the history of this technological project there have been several occasions when not only technological plans have been under political consideration. The decision to start to develop the Swedish KBS-3 concept in the 1970s was one and the Decision-in-Principle in 2001 was another.

## List of Abbreviations

DiP	Decision-in-Principle
EIA	Environment Impact Assessment Procedure
FHP	Fortum Power and Heat Oy
IVO	Imatran Voima Oy
JYT	Public Sectors Research Programme
KTM	MTI, MEE (Ministry of Trade and Industry, later Ministry of Employment and the Economy)
KYT	Finnish Research Programme on Nuclear Waste Management
NPP	Nuclear power plant
SNF	Spent nuclear fuel
SKB	Svensk kärnbränslehantering Ab (the Swedish nuclear waste company)
STUK	Säteilyturvakeskus (the Radiation and Nuclear Safety Authority)
TEKES	The Finnish Funding Agency for Technology and innovation
TKS	Programme for Research, Development and Technical Design
TVO	Teollisuuden Voima Oyj
VYR	The National Nuclear Waste Management Fund

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## APPENDIX 1

### Timeline for milestones in nuclear waste management in Finland<sup>11</sup>

**1955** The Government nominates a committee to discuss possible use of nuclear energy.

**1957** The Atom Energy Act passed by Parliament.

**1976** The Ministry of Trade and Industry nominates a commission (APO) to investigate issues regarding nuclear waste and nuclear fuel.

**1977** Loviisa I nuclear power reactor is finished.

**1978** March: The APO committee published its research reports. According to the report, the reprocessing of high-level nuclear fuel is not sensible and therefore nuclear waste should be exported abroad. The committee further states that MTI should start immediate research and development programme in nuclear waste management as well as take the main responsibility for the monitoring.

**1978** April: The Council of State takes a Decision-in-Principle on organizing nuclear waste management. According to the decision the planning of the nuclear waste management is an issue for the waste producer under monitoring by the government. The waste producer should also meet the costs.

**1978** The power companies start a nuclear waste committee financed by TVO and IVO.

**1979** TVOs Olkiluoto I reactor completed.

**1980-1982** Geological investigations. Geological suitability for high-level nuclear waste.

**1980** The committee states again that the nuclear waste should be exported abroad.

**1983** A regional preliminary investigation on the geological areas gives a result of 327 possible sites.

**10.11.1983** The Council of State states in its DiP the targets of the research and development activities in nuclear waste management. The first alternative is to export the waste. TVO was, however, obligated to prepare for final disposal. According to the decision a site for a possible final disposal facility had to be chosen before the end of 2000.

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<sup>11</sup> Partly based on the timeline presented in Raittila, Hokkanen, Kojo and Litmanen 2002: Ydinjäteihme suomalaisittain.

**1987** TVO chooses, after many investigations, five areas for preliminary siting investigations.

**1987** The Nuclear Energy Act replaces the Atomic Energy Act of 1957. The DiP procedure guarantees the municipalities the right of veto.

**1991** The decision on the objectives of nuclear waste management by the Ministry of Trade and Industry.

**1993** Parliament rejects the DiP for a new NPP unit.

**1994** Parliament approves amendments to the Nuclear Energy Act. Nuclear waste produced in Finland must be processed, stored and disposed of in a permanent manner. Export and import of nuclear waste is forbidden.

**1995** The decision on objectives of nuclear waste management by the Ministry of Trade and Industry.

**1996** The last transportation to Russia from the IVO NPP is delivered.

**1997–1999** Posiva implements EIA procedure in four municipalities Eurajoki, Kuhmo, Loviisa and Äänekoski.

**1998–2000** A benefit package for the Municipality of Eurajoki negotiated by TVO, Posiva and Eurajoki.

**1999** Decision by the Council of State on the safety of final disposal of spent nuclear fuel.

**1999** Posiva submits a DiP application for a final disposal facility for SNF (total 6500 tU of SNF).

**2000** The municipal council of Eurajoki votes in favour of the nuclear waste disposal facility.

**21.12.2000** The Council of State decides on a nuclear waste disposal facility in Eurajoki.

**2001** Parliament ratifies the DiP covering disposal of 4000 tU of SNF.

**2002** The Council of State makes a DiP on the extension of the disposal facility to accommodate the SNF from TVO Olkiluoto 3 NPP unit.

**2002** Parliament ratifies the DiP covering the disposal of total 6500 tU of SNF.

**2004** The construction work for the underground rock characterisation facility Onkalo begins.

**2008** Posiva EIA procedure for the extension of the disposal facility at Olkiluoto.

**2008** Government Decree (736/2008) on the safety of disposal of nuclear waste issued.

**2010** The Council of State approves the DiP for Olkiluoto 4 NPP unit and Fennovoima NPP unit. Fortum NPP application is rejected.

**2010** The Council of State approves the DiP for an extension to the disposal facility to accommodate the SNF from TVO's Olkiluoto 4 NPP unit.

**2010** Parliament ratifies the DiP covering disposal of total 9000 tU of SNF.

**2011** Fennovoima announces that Pyhäjoki will be the municipality where the new power plant will be built.

**2012** The Ministry of Employment and the Economy established a working party to account the joint nuclear waste management in Finland.

## APPENDIX 2

### List of Finnish Social Science literature on nuclear waste management in years 1990-2010<sup>12</sup>.

Finnish titles glossed by the author if no English title could be found in the databases.

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