



## VVER NUCLEAR WASTE MANAGEMENT REGULATORY EXPERIENCE IN FINLAND

Tero Varjoranta, Director, Radiation and Nuclear Safety Authority - STUK

### ABSTRACT

About 30 % of all electricity produced in Finland is generated by nuclear power. Four reactors, with a total capacity of 2 656 MW<sub>e</sub>(net), are currently in operation. At Loviisa, there are two 488 MW<sub>e</sub> VVER units (recently upgraded 440-units) and at Olkiluoto two 840 MW<sub>e</sub> BWR units. At the Loviisa plant conditioning, storage and final disposal of low- and intermediate-level wastes from reactor operation will take place at the NPP sites. Intermediate level ion-exchange resins and evaporation concentrates are currently stored in tanks. However, a license application for constructing a solidification plant based on cementation is currently under STUK's regulatory review. The construction of the final repository for I/LLW at the Loviisa site was started in 1993 and the Government granted the operating licence in 1998. The nuclear legislation requires disposal of spent fuel into the Finnish bedrock. Spent fuel will be stored in water pools for some decades and thereafter, encapsulated and transferred to an underground repository at a depth of about 500 m in crystalline bedrock. The amount of spent fuel from the Loviisa plant during its planned lifetime of 40 years, will be about 1070 tU. Because about 330 tU has been shipped to the Russia, a storage capacity of approximately 740 tU is needed. Extension of the interim wet storage capacity will be completed in 2000 at the Loviisa NPP. There will be enough storage capacity until early 2010s. Site selection process, technical plans and safety assessment for final disposal of the spent fuel has been carried out in Finland since 1983. Last year, the first of the three licensing phases, so called Decision in Principle, was submitted to the Government. STUK's preliminary safety assessment was favourable and the municipality of Eurajoki volunteered to host the disposal facility. The Government's decision, which is subject to Parliament's endorsement, is expected later this year. The two other licensing phases are construction permit (expected in 2010) and operating license (expected in 2020). Wastes from the decommissioning of the reactors are planned to be disposed of in underground repositories co-located with the repositories for operational reactor wastes at the power plant sites. The utilities shall maintain decommissioning plans for the nuclear power plants. Updated plans must be submitted to the authorities for review at regular intervals of five years.

### I. FINNISH NATIONAL POLICY FOR NUCLEAR WASTE MANAGEMENT

According to the Nuclear Energy Act of 1987, licences for nuclear facilities are granted by the Government. However, in the first authorisation phase (Decision in Principle), the

Parliament has the right to overrule the Government's decision on building major nuclear installations, such as a nuclear power plant or a waste disposal facility. The consent of the proposed host municipality for the nuclear installation is a necessary prerequisite for the Decision in Principle. Furthermore, a positive statement by the Radiation and Nuclear Safety Authority (STUK) on the safety of the facility is called for.

The principles of the waste management policy were originally set in the Finnish Government's policy decision of 1983 and later in the decisions by the Ministry of Trade and Industry (MTI). These decisions set also a target schedule for the preparatory works of waste management. The general safety regulations are issued by the Government while STUK gives the detailed ones.

The utilities have the financial and operational responsibility for nuclear waste management. They founded in 1995 a joint company, Posiva Oy, for the research, development, planning and later implementation related to spent fuel disposal. MTI oversees that implementation of waste management and related R&D complies with the national policy and that financial provisions for future waste management costs are adequate. STUK is responsible for the control of nuclear safety and for the technical and safety related review of licence applications and other important documents.

The Advisory Committee on Nuclear Energy gives support to MTI and the Advisory Committee on Nuclear Safety to STUK in their major duties concerning nuclear energy and safety. To guarantee the financing of future waste management operations, money is collected from the utilities to the State Nuclear Waste Management Fund according to the annual decisions by MTI.

Conditioning, storage and final disposal of low- and intermediate-level wastes from reactor operation, as well as waste from their decommissioning, will take place at the NPP sites.

The owner of the Olkiluoto NPP, Teollisuuden Voima Oy (TVO), has opted for storing and, later on, disposing of its spent fuel in a deep geological repository in Finland. The owner of the Loviisa NPP, Fortum Oy (earlier IVO), has since 1997 also followed this strategy. Earlier FORTUM shipped spent fuel to the USSR/Russia, based on the initial contractual arrangement with the supplier of the reactors and its fuel.

To ensure that the financial liability is covered, the utilities must each year present cost estimates for the future management of nuclear wastes. The latest cost estimates, based on waste quantities at the end of 1999 and decommissioning of NPPs, arise to about FIM 6 600 million (USD 1 100 million) with no discounting.

The utilities are obliged to set aside a certain amount of money each year to the State Nuclear Waste Management Fund. The funded money covers currently about 90 % of the liability. For the outstanding liability, i.e. due to future costs not yet covered by the contributions paid into

the fund, the licensee must furnish securities as a precaution against insolvency. The administrative procedures are described in detail in the nuclear energy legislation.

## 2. LOW AND INTERMEDIATE WASTE; REACTOR WASTE

The general safety requirements for nuclear power plants, decided by the Government in 1991, address reactor waste. The more detailed safety requirements are given in the decisions and guides of STUK, especially in regulatory guides YVL 8.1 - 8.3. The safety assessments for storage of spent fuel and reactor waste have been included in the FSARs for the nuclear power plants.

The estimated total amounts (as packed) of different waste types, employed in the safety analyses of the repositories, are the following:

Utility	Dry main- tenance waste	Solidified wet waste	Decommissioning waste	
			activated	Contaminated
TVO; Olkiluoto	5 600 m <sup>3</sup>	3 100 m <sup>3</sup>	5 500 m <sup>3</sup>	23 700 m <sup>3</sup>
Fortum; Loviisa	2 400 m <sup>3</sup>	5 400 m <sup>3</sup>	4 500 m <sup>3</sup>	8 800 m <sup>3</sup>

At Loviisa, reactor wastes are stored in tanks (wet wastes) and in storage rooms (solid wastes) at the plant.

Low and intermediate level wastes from reactor operations are disposed of in the bedrock of the power plant sites. The construction of the repository at the Loviisa site was started in 1993 and the Government granted the operating licence in 1998. The designs of the Olkiluoto and Loviisa repositories are somewhat different mainly because of the local geological conditions. At Olkiluoto the host rock massif favours vertical silo-type caverns, whereas at Loviisa horizontal tunnels are more suitable.

The bedrock of the Loviisa site on the island of Hästholmen consists of rapakivi granite. The repository is located at the depth of approximately 110 m in a zone of very saline groundwater. Accordingly, the groundwater around the repository is almost stagnant. The repository consists of two tunnels for dry maintenance waste and a cavern for immobilised wet waste. This cavern has been excavated but the construction and installation works will be completed later.

The repository has been excavated at the depth of approx. 110 meters in the bedrock at the island of Hästholmen where the Loviisa power plant is located. The present repository consists of two finished rock caverns for LLW and an excavated cavern for solidified ILW. The construction and installation work of engineered barriers of the ILW cavern, consisting mainly of concrete structures, will be completed later.

In early 1998, STUK completed a review of the Final Safety Analysis Report (FSAR) and other relevant documents and submitted its statement on FORTUM's application for the operation license to the Ministry of Trade and Industry. In April 1998, the Government granted the license for the repository.

The construction of the first section of a repository for reactor waste arising from Loviisa nuclear power plant was completed in 1998 and a tunnel was commissioned for the storage of waste by virtue of an operating permit issued by STUK. By the end of the year, 660 m<sup>3</sup> of low level radioactive maintenance waste had been moved to the tunnel end in question. In May 1999 STUK conducted a commissioning inspection in accordance with section 20 of the Nuclear Energy Act on the basis of which the facility's completed sections were approved for final disposal. The extension, construction and commissioning of a cavern for solidified waste require separate approvals by STUK in accordance with the facility's operating licence and section 112 of the Nuclear Energy Decree.

Fortum Power and Heat Oy intends to build a solidification facility for medium level waste on the site of Loviisa nuclear power plant because the plant's onsite storage for liquid waste will fill up in the next few years. A Preliminary Safety Analysis Report for the facility was submitted to STUK for review.

No safety-related problems occurred in the handling, storage and final disposal of reactor waste. The volume of reactor waste at the end of the year was about 2000m<sup>3</sup>.

### 3. SPENT FUEL MANAGEMENT

Between 1981 and 1996, fifteen shipments of spent fuel from Loviisa to the Russia were performed and in total about 330 tU of spent fuel was shipped. Casks of TK-6 type and a special train were leased from Russia for the transportation. Due to the Amendment of the Nuclear Energy Act, the shipments were finished at the end of 1996.

#### Storages

The amount of spent fuel from the Loviisa plant during its planned lifetime of 40 years, will be about 1070 tU. Because about 330 tU has been shipped to the Russia, a storage capacity of approximately 740 tU is needed.

At the Loviisa plant, the storage capacity is about 300 tU. In addition to the refuelling pools, there is a pool, where fuel is stored in baskets, and a newer fuel rack pool. After the ongoing enlargement the storage capacity will be 610 tU. Finishing work on the building and pre-

operational tests were carried out in 1999. STUK reviewed among other things the piping, ventilation and electrical plans as well plans for and reports on pre-operational testing. The new storage extension is due for completion in 2000.

The general safety requirements for nuclear power plants, decided by the Government in 1991, address also interim storage of spent fuel. The more detailed safety requirements are given in the decisions and guides of STUK. The safety assessments for storage of spent fuel and reactor waste have been included in the FSARs for the nuclear power plants.

No major safety-related incidents associated with interim storage of spent fuel have occurred.

#### Final disposal concept

The nuclear legislation requires disposal of spent fuel into the Finnish bedrock. Spent fuel will be stored in water pools for some decades and thereafter, encapsulated and transferred to an underground repository at a depth of about 500 m in crystalline bedrock.

The encapsulation plant is planned to be located at the disposal site. Spent fuel would be encapsulated in copper-iron canisters each containing 12 VVER fuel assemblies. The canister design consists of an inner cast iron insert as a load-bearing element and an outer container of oxygen-free copper to provide a shield against corrosion. The canisters are emplaced in boreholes drilled at the floors of tunnels, which are constructed at a depth of about 500 m in crystalline rock of good quality. The annulus between the canister and the rock walls of the boreholes will be filled with compacted bentonite. During closure the tunnels will be backfilled with a mixture of crushed rock and bentonite.

#### Status of final disposal project

Years 1999 and 2000 are important years in nuclear waste management in Loviisa VVER and in Finland in general. The first of the three licensing steps towards a final repository of spent fuel, the so-called Decision in Principle, started early 1999 by Posiva company's submittal. In this step, expected to be over by late 2000, the Finnish Government is to decide whether the project of disposal is in line with the overall good of society. For the decision, STUK was to make a preliminary statement on the safety of the facility and the host municipality (or municipalities if there are several candidates) to state their acceptance of siting the facility. A positive decision can only be made by the Government if both STUK's and the municipalities' statements are positive and it has still to be endorsed by the Parliament.

For the Decision in Principle safety review, STUK has made a proposal for general safety requirements which the Finnish Government accepted early 1999. The regulation covers the operational phase of the encapsulation and disposal facility as well as the post-closure safety of the spent fuel repository. The other two licensing steps are Construction Permit (expected round 2010) and Operating License (round 2020).

In accordance with Nuclear Energy Law, the application for the Decision in Principle included an Environmental Impact Assessment (EIA) report for the planned facility. For this purpose Posiva started the formulation of a programme for the EIA process at all four candidate sites for a spent fuel disposal facility in the early 1997's. At this stage, a comprehensive public interaction programme was launched consisting of a large number of public meetings and brainstorming sessions, distributing various printed material and videotapes and different presentations at local fairs and other public gatherings. The EIA programme was officially submitted to the Ministry of Trade and Ministry (the contact authority) early in 1998 and, on the basis of comments from a number of parties concerned and expert, the Ministry gave its statement on the programme in June 1998. The statement emphasises the importance of a complete review of all environmental and social aspects of the project in the EIA report, including a fairly extensive summary of radiation safety analyses for the operational and post-closure phases. The Ministry also called for enhanced discussion and assessment of alternatives to Posiva's reference concept.

In accordance with the Espoo Convention the EIA programme was also submitted to review by Sweden, Russia and Estonia. They had expressed their interest in participation in the process.

Posiva submitted the EIA report to the Ministry in early 1999. After that the Ministry asked for statements from the local and central authorities and opinions from the public on the EIA report. After the hearings, the Ministry gave its positive statement, which completed the EIA process.

The pre-designs of the encapsulation and disposal facilities, operational and post-closure safety assessments and summaries of site characterisation are included in Posiva's Decision in Principle application and in its reference reports. Even though site investigations were done in four candidate sites (*Loviisa, Eurajoki, Äänekoski and Kuhmo*), Posiva company included only Eurajoki in its Decision in Principle submittal. Therefore, spent nuclear fuel from Loviisa VVER is now planned to be disposed in Eurajoki, which hosts the Olkiluoto NPPs.

STUK made a safety related reviews of the documents submitted to support the Decision in Principle -application. These documents included an updated safety assessment, summaries of site investigations and renewed technical plans for the encapsulation and disposal facility. The basis for STUK's preliminary safety appraisal concerning the application for a decision in principle on a disposal facility for nuclear fuel was to apply the safety requirements contained in a decision made by the Council of State in 1999. STUK obtained numerous external expert assessments in support of its own assessment. These included detailed assessments from ten high quality experts from outside Finland and statements and assessments on special issues from four domestic research institutes. This preliminary safety judgement, which was submitted to the Ministry of Trade and Industry in early 2000, included, among others, the below conclusions:

- Prerequisites stipulated in the Nuclear Energy Act as regards the making of a decision in principle have been fulfilled in STUK's sphere of authority.

- Based on the research conducted so far, Olkiluoto is suited for a disposal site.
- There are no significant safety risks related to the operation of the disposal facility.
- The research work carried out so far suggests that requirements concerning long-term safety can be fulfilled; confirmation of this requires further R&D in the long term, however.
- The manner of implementation and timing of the final disposal includes a wealth of flexibility and, therefore, the modification of the disposal concept, the recovery of waste from it and even the employment of a completely different strategy is possible in case technical advances support them.

The progress has been in good compliance with the Government's policy decision of 1983.

#### 4. WASTES FROM DECOMMISSIONING

Wastes from the decommissioning of the Loviisa VVER reactors are planned to be disposed of in underground repositories co-located with the repositories for operational reactor wastes at the power plant sites. The utilities shall maintain decommissioning plans for the nuclear power plants.

By virtue of a decision made by the Ministry of Trade and Industry in 1991, decommissioning plans for domestic nuclear power plants are to be maintained and the updated plans are to be reported every five years. Such plans were last reported in late 1998 and STUK gave a statement about them to the Ministry in 1999.

The plan for the Loviisa NPP is based on immediate decommissioning. Besides the dismantling wastes, also activated metal components accumulated during the operation of the reactors will be disposed of in those repositories. The engineered barriers are selected taking account of the radiological and other safety related characteristics of each waste type. A special feature the decommissioning plans is the emplacement of large components, such as pressure vessels and steam generators, in the disposal rooms as such, without cutting them in pieces.

According to the updates, the utilities have been working on their decommissioning plans, owing to which the estimated occupational doses are significantly lower than in the earlier plans. STUK's statement found proposed solutions appropriate and recommended that the method be further developed.