FENNOVOIMA

Environmental impact assessment program for spent nuclear fuel encapsulation plant and final disposal facility

INTERNATIONAL HEARING, SUMMARY

August 2016

1 Organization responsible for the project and background of the project

The organization responsible for the project as laid down in the Environmental Impact Assessment Act (468/1994) is Fennovoima Oy (hereinafter referred to as “Fennovoima”), a Finnish nuclear power company established in 2007. Fennovoima is building a nuclear power plant with a generating capacity of approximately 1,200 MW on the Hanhikivi headland in Pyhäjoki. Fennovoima submitted a construction license application for a nuclear power plant pursuant to the Nuclear Energy Act (990/1987) to the Government in the end of June 2015.

In accordance with the Decision-in-Principle granted to Fennovoima in 2010, by the end of June 2016 Fennovoima must present to the Ministry of Economic Affairs and Employment either a final disposal cooperation agreement signed with the parties currently under the nuclear waste management obligation (Teollisuuden Voima Oyj and Fortum Power and Heat Oy) or an environmental impact assessment program for its own encapsulation plant and final disposal facility (an EIA program).

With the EIA program, Fennovoima supplements the nuclear power plant construction license application and launches the impact assessment procedure required by the prerequisite included in the 2010 Decision-in-Principle for its own spent nuclear fuel encapsulation plant and final disposal facility.

Fennovoima has also started cooperation with the Finnish nuclear waste management company Posiva Oy by signing a service contract with its subsidiary Posiva Solutions Oy. The owners of Posiva Oy are Teollisuuden Voima Oyj and Fortum Power and Heat Oy. Posiva Oy is responsible for the final disposal of the spent nuclear fuel generated by its owners, research associated with final disposal, and other expert tasks belonging to its scope of operations. This service contract ensures that the expertise of Posiva Oy, gained over the course of almost 40 years, can be utilized in the final disposal of spent nuclear fuel by Fennovoima. Furthermore, Fennovoima will continue its negotiations with the parties currently under the nuclear waste management obligation on long-term cooperation in the final disposal of spent nuclear fuel.

2 Environmental impact assessment procedure

According to the Act on Environmental Impact Assessment Procedure (468/1994) and the Decree on Environmental Impact Assessment Procedure (713/2006), an environmental impact assessment procedure is mandatory for facilities that are designed for the processing and final disposal of irradiated nuclear fuel. The objective of the EIA procedure is not to make any decisions concerning the project or the final disposal location of spent nuclear fuel; instead, the objective is to produce information to serve as a basis for decision-making and to be taken into account during the permit procedure. The objective of the EIA procedure is to contribute to the environmental impact assessment and to ensure that environmental impacts are always taken into account in planning and decision-making. Another objective is to increase the availability of information to stakeholders and the possibility for them to participate in planning projects.

The EIA procedure consists of the program phase and the report phase. The EIA program is a plan for arranging the environmental impact assessment procedure and the required additional studies. The submission of the program will initiate a research phase of several years, during which the environmental impact of the spent nuclear fuel final disposal project, the geological characteristics of the alternative locations, and their suitability for final disposal will be studied. The EIA report to be prepared later will describe the project’s characteristics and technical solutions and offer an assessment of its environmental impact based on the EIA procedure. The EIA report will be enclosed with the Decision-in-Principle application for the spent nuclear fuel encapsulation plant and final disposal facility.

The EIA procedure will officially start when the EIA program is submitted to the coordinating authority. The coordinating authority for this EIA procedure is the Ministry of Economic Affairs and Employment. The coordinating authority will announce the public display of the EIA program. During the display period, stakeholders may express their opinions about the EIA program to the coordinating authority. The coordinating authority will also request statements on the program from various authorities. The coordinating authority will compile the opinions and statements on the EIA program and issue its own statement based on these to the organization responsible for the project. The EIA report will also be placed on public display for the issuance of statements and opinions.

3 International hearing

In Finland, the Ministry of the Environment is responsible for the practical arrangements relating to the international hearing referred to in the UN Economic Commission for Europe (UNECE) Convention on Environmental Impact Assessment in a Transboundary Context (67/1997; also called the Espoo Convention).

The Ministry of the Environment will notify any affected parties about the start of the EIA procedure for the spent nuclear fuel final disposal project and identify their willingness to take part in the Finnish EIA procedure. A public summary of the EIA program translated into all the necessary languages and the EIA program translated into Swedish or English will be enclosed with the notification.

The states notified will place the EIA program on public display for statements and opinions. The EIA report will also be displayed at a later phase of the EIA procedure. The Finnish Ministry of the Environment will compile the statements and opinions and send them to the coordinating authority to be taken into account in the statements on the EIA program and the EIA report. All statements on the EIA report will be taken into account during the project's permit procedure.

4 Project description

The EIA procedure is a study of Fennovoima's spent nuclear fuel final disposal project, which consists of an encapsulation plant above ground level and a final disposal facility located several hundred meters deep in the bedrock. The illustration below (Fig. 1) shows the underground and aboveground parts of the encapsulation plant and final disposal facility.

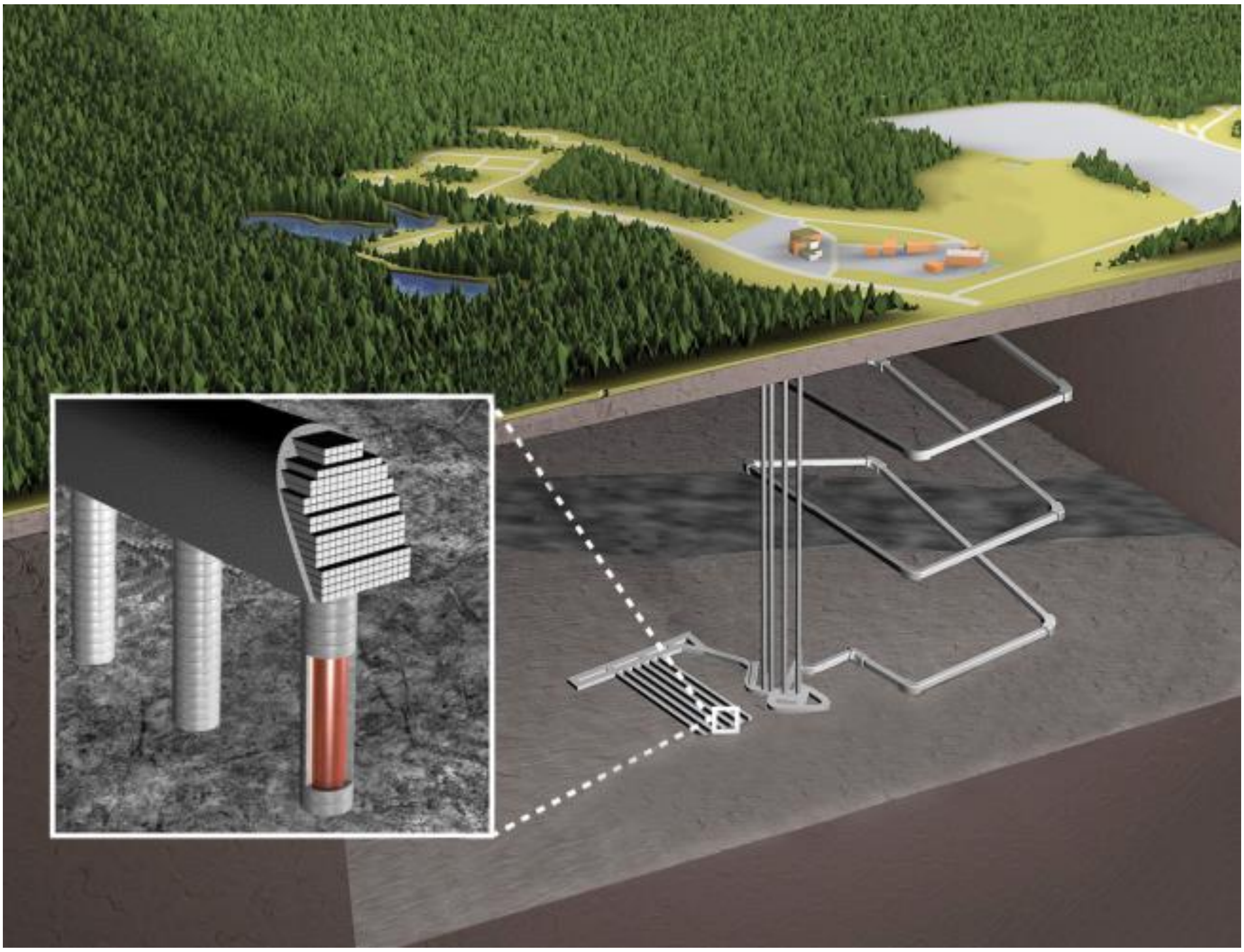

Figure 1. Illustration of the encapsulation plant and final disposal facility. Structures above ground include the encapsulation plant, a ventilation building, a hoist building, research and office facilities, and maintenance and storage halls. The underground final disposal facility will consist of the final disposal tunnels, central tunnels, and underground auxiliary technical facilities, among others. A vehicle tunnel and vertical shafts, such as a personnel shaft, a canister shaft, and ventilation shafts, will go from ground level to the final disposal facility. The close-up shows a filled final disposal tunnel and a copper disposal canister (in red) surrounded by bentonite. Image by Posiva Oy (edited).

The goal of the final disposal project is permanent final disposal in the Finnish bedrock of the spent nuclear fuel generated by Fennovoima's Hanhikivi 1 nuclear power plant. During the operation of the nuclear power plant, around 1,200–1,800 tons of spent uranium nuclear fuel will be generated. This corresponds to around 700–900 disposal canisters.

Fennovoima's spent nuclear fuel final disposal plan is based on the KBS-3 concept. The KBS-3 concept is based on the multibarrier principle, where radioactive substances in the spent nuclear fuel are isolated with several redundant protective structures (barriers). The barriers ensure that the radioactive substances in the spent nuclear fuel do not come into contact with the living environment or people. In a disposal solution according to the KBS-3 concept, the spent nuclear fuel is inserted into a copper disposal canister with a cast iron insert, surrounded with bentonite clay, and placed in final disposal holes drilled deep into the bedrock. The disposal can take place in vertical (the KBS-3V concept) or horizontal (the KBS-H concept) drilled holes.

The project consists of the following phases: preliminary investigation phase, research and planning phase, construction phase, operational phase, and decommissioning phase. Some of the project phases can be implemented partially simultaneously. These phases of the project are described in more detail below.

Preliminary investigation phase

The goal of the preliminary investigation phase is to identify intact, sufficiently large and homogeneous blocks of bedrock that can be further studied to assess their suitability for final disposal.

In addition to an interpretation of deformation zones or a lineament interpretation, the most important suitability characteristics of the research areas will be determined, including lithology, size, number of outcrops, topography (differences in elevation), geophysics, mineral potential, existence of nature conservation and groundwater areas, and hydrogeology. In addition, environmental issues related to the research areas, such as land use planning and land use, settlements, real estate, landscape, cultural history, nature, conservation areas, and the transport network, will be studied during the preliminary investigation phase.

The potential of the areas for further investigation will be assessed based on the geological and environmental studies. Socio-economic factors and public acceptance will also be taken into account in the final selection.

Research and planning phase

The research and planning phase will start with detailed studies of the geological properties of the research areas that may be suitable for final disposal. The geological studies will include deep drilling and research realized in boreholes to study, for instance, the quality of the bedrock, the groundwater and flow conditions, and the mechanical properties of the bedrock. A description (or model) combining data from various branches of science will be prepared for each research area to be used when assessing suitability of the area for final disposal.

More detailed information about the final disposal concept for Fennovoima will be collected during the research and planning phase.

Construction phase

The research facility will be constructed during the construction phase, followed by the underground final disposal facility and the related structures above ground level.

The underground research facility will be a tunnel or shaft excavated into the bedrock. It will be connected to the final disposal facility later. The research facility can be used to study the bedrock in more detail using geological, hydrological, and geochemical research methods to obtain more information about the geological properties and groundwater conditions at the final disposal depth. The studies will verify the suitability of the selected site for final disposal. The research facility tunnel will be created by means of drilling and blasting. The estimated volume of the tunnel is around 350,000 m^3.

The final disposal facility to be excavated into the bedrock will consist of several parts, such as final disposal tunnels, central tunnels, and auxiliary underground technical facilities. A vehicle tunnel and vertical shafts, such as a personnel shaft, a canister shaft, and ventilation shafts, will go from ground level to the final disposal facility. The final disposal tunnels will be excavated in stages, depending on the amount of spent fuel to be placed in the final disposal facility, probably by means of drilling and blasting. The excavation will be completed with great care to ensure that the bedrock’s properties that are favorable towards final disposal are not compromised. The depth of the final disposal facility will be determined by the geological properties of the selected final disposal site. In any case, the final disposal will take place at a depth of several hundred meters. According to preliminary estimates, the volume of the final disposal tunnels will be around 200,000–250,000 m^3. Construction of the final disposal facility for the spent nuclear fuel generated by Fennovoima will require around 50 hectares of bedrock suitable for final disposal.

An encapsulation plant for spent nuclear fuel will be constructed above ground level. Other auxiliary facilities will also be constructed above ground level, such as a ventilation building, a hoist building, a research facility, offices, a building housing tunnel technology elements, maintenance halls, storage halls, and staff facilities. According to a preliminary estimate, around 30 hectares will be required to construct the buildings above ground level. If necessary, new roads and power lines will also be built for the area.

Operational phase

Transport of spent nuclear fuel

After interim storage in the Fennovoima nuclear power plant area, the spent nuclear fuel will be transported in transport containers specifically designed for this purpose to the encapsulation plant to be built at the final disposal site.

Transport containers specifically designed for this purpose will be used to transport the spent nuclear fuel from the Hanhikivi nuclear power plant to the encapsulation plant. The purpose of the transport containers is to protect the fuel from damage during transport and to protect the environment from the fuel in case of an accident. The containers must pass several different tests in order to be approved for use in the transport of spent nuclear fuel.

A transport report by Fennovoima states that large amounts of radioactive substances cannot spread into the environment in connection with a potential accident involving the transport of spent nuclear fuel. Even in the most severe case, mainly only the transport personnel and any people in the immediate vicinity of the accident site could be exposed to elevated radiation levels. The transport containers will be designed in compliance with the statutory requirements in such a manner that an accident during transport cannot have any direct health impacts. Guides for the transport of nuclear-use items and nuclear waste by the Finnish Radiation and Nuclear Safety Authority (STUK) and guides by the International Atomic Energy Agency (IAEA) will be taken into account when planning the transport of spent nuclear fuel.

The spent nuclear fuel may be transported from the Hanhikivi nuclear power plant to the encapsulation plant and final disposal facility by road or using a combination of road, rail, and sea transport, depending on the location of the encapsulation plant.

In road transport, a special carriage hauled by a truck will be used. Road transport will take place under supervision, and each transport will be escorted by supervision and security personnel. In urban areas, police patrols will close off the crossing streets as the transport convoy passes the area. Taking into account the required stops, the average speed of the transport convoy will be approximately 35 km/h. If road transport is used, the transport convoy will start at the Hanhikivi nuclear power plant and proceed via Hanhikiventie road to Highway 8, and from there to the final disposal site.

If only road transport were to be used, around 120–180 transport convoys would drive from the nuclear power plant to the encapsulation plant and final disposal facility during the entire final disposal operational phase. The final disposal phase is expected to take around 20 years.

In rail transport, the train carrying the spent nuclear fuel may not encounter any train carriages carrying hazardous substances, all level crossings will have to be guarded, and the speed of the train will have to be limited to a maximum of 40 km/h. In rail transport, the spent nuclear fuel will first be transported by road from the Hanhikivi nuclear power plant to a railroad stop at the port in Raahe. The transport distance will be approximately 27 kilometers. At the Raahe railroad stop, the transport container will be transferred to a low loader wagon designed for special heavy transport. From the Raahe railroad stop, the rail transportation convoy will proceed towards the final disposal site, where the transport container will be transferred by road from the nearest rail transport offloading site to the final disposal site.

Sea transport will start at the Hanhikivi nuclear power plant. The planned dock basin and port to be constructed on the Hanhikivi headland are designed in such a manner that spent nuclear fuel can be transferred to a vessel at that location for sea transport. Sea transport of spent nuclear fuel requires a vessel specifically designed for the transport of high-level nuclear material.

More specific transport methods and routes to the alternative final disposal sites will be determined in separate transport reports. Transport reports for the different modes of transport will be prepared in such a manner that they can be used in the EIA report.

Encapsulation of spent nuclear fuel

The term “encapsulation plant” refers to a nuclear facility where spent nuclear fuel is packed into disposal canisters. A disposal canister is a massive metal container with a cast iron insert and a copper shell (Fig. 2).

Figure 2. The insert and outer shell of a disposal canister. The image shows a canister for Olkiluoto 1 and 2. It has a diameter of 1.05 meters and is 4.8 meters long. Image by Posiva Oy. The Fennovoima canisters will be slightly longer and have a different type of insert.

At the encapsulation plant, the spent nuclear fuel will be taken in the transport container to a reception area at the encapsulation plant. The nuclear fuel elements will be transferred via remote control inside strong radiation protection walls from the transport container to the disposal canister. Once the canister is full, the air inside it will be replaced with protective gas, the cover of the insert will be screwed shut, and the leaktightness of the insert will be verified. The surface of the canister will be cleaned to remove any impurities. After encapsulation, the cover of the copper canister will be welded shut. After verification of the leaktightness of the weld, the disposal canister will be transferred in an elevator or via a vehicle tunnel to a disposal tunnel deep within the bedrock.

The encapsulation plant will be designed in such a manner that the personnel will work in areas protected from radiation. There will be negative pressure in the nuclear fuel processing facilities to prevent radioactive releases from spreading from the processing facilities to the other parts of the plant during exceptional situations. Under normal conditions, no radioactive substances will be released into the encapsulation plant rooms.

The worst-case scenario for the encapsulation plant is an accident where a canister falls from a canister hoist in such a manner that the fuel rods inside the canister are damaged and the canister itself is also damaged. Such an accident could lead to gaseous and particulate radioactive releases into the encapsulation plant, which would be collected by the filters of the ventilation system. The plant's filtering systems will clearly reduce the amount of releases. According to the statutory requirements, no radioactive releases into the environment that exceed the limit and guideline values may occur at the encapsulation plant.

All structures of the encapsulation plant and final disposal facility will be designed and constructed in compliance with nuclear energy sector regulations and in such a manner that any accidents, even accidents during the different handling sequences of the spent nuclear fuel leading to major damage to the nuclear fuel, cannot pose any immediate health hazards to the personnel or the local residents.

Low and intermediate level operating waste, such as air and water filters, protective clothing and gloves, and radioactive solutions from the decontamination of radioactive surfaces, will be generated at the encapsulation plant during its operation. This waste will be processed and packaged. Separate facilities for the processing of low and intermediate level waste will be constructed at the encapsulation plant. The operating waste will be placed in a separate underground room in this area.

Final disposal of spent nuclear fuel

The term "final disposal facility" refers to tunnels for the final disposal of spent nuclear fuel hundreds of meters deep in the bedrock.

The disposal canister will be transferred to the underground facility directly from the encapsulation plant on a pallet in an elevator or via a vehicle tunnel. The disposal canister will be taken to the actual final disposal tunnel with a transport vehicle specifically designed for this purpose.

Final disposal tunnels will be excavated in advance in the final disposal facility for the final disposal of each batch of spent nuclear fuel. The location of each final disposal tunnel will be verified by drilling a research hole and conducting geological and hydrogeological studies. A geological survey of the final disposal tunnel and leakage water studies will be conducted to determine where the final disposal holes should be drilled.

The final disposal holes will be drilled in the final disposal tunnel in advance. The final disposal holes will be filled in order, starting from the one at the back of the tunnel. A copper plate and blocks of bentonite will be placed in the bottom of each final disposal hole before the disposal canister. Bentonite is a type of naturally occurring clay that is able to retain large amounts of water and swell to up to ten times its original volume. The swollen bentonite will seal the space surrounding the copper canister; this will prevent water from touching the canister and also prevent radioactive substances from accessing the bedrock in case of a leak. In addition, the bentonite buffer around the canister will protect the canister from mechanical stress (any movements of the rock).

When the final disposal holes have been filled with canisters and sealed with bentonite, the tunnel will be filled and its mouth will be sealed with a plug structure specifically designed for this purpose. Final disposal holes and tunnels will be filled in stages throughout the final disposal operation phase.

Decommissioning of the final disposal facility

At the decommissioning phase, the final disposal tunnel and other underground facilities will be filled and sealed. Of the buildings above ground level, the encapsulation plant and the ventilation building will be demolished in the manner required for the demolition of a nuclear facility, unless they can be used for another purpose. Any other unnecessary buildings above ground level will also be demolished.

The encapsulation plant and final disposal facility will be considered decommissioned once the underground facilities have been closed in the manner required by the Nuclear Energy Act and the Nuclear Energy Decree and there are no longer any structures or facilities containing radioactivity above the ground level. When the facilities have been demolished, the area will be landscaped in the required manner. The Finnish Radiation and Nuclear Safety Authority will approve the decommissioning. Once the Finnish Radiation and Nuclear Safety Authority has determined the encapsulation plant and final disposal facility to be properly decommissioned and the area free of radioactivity, the responsibility for the nuclear waste will be transferred to the Government, pursuant to the Nuclear Energy Act. According to the Nuclear Energy Act, final disposal must, in its entirety, be implemented in such a manner that no monitoring is required afterwards in order to ensure its safety.

5 Justification for geological final disposal

Geological final disposal refers to a solution for the final disposal of spent nuclear fuel where the spent fuel is isolated deep underground so that its impacts on the environment are equal to or less than those of naturally occurring radioactivity. According to the Nuclear Energy Agency (NEA), an OECD organization, geological final disposal is the most recommendable nuclear waste management strategy.

The Finnish Nuclear Energy Act (990/1987, section 6a) requires that spent nuclear fuel must be handled, stored, and permanently disposed of in Finland. The spent nuclear fuel management solution selected by Finland is geological final disposal. Development of the final disposal technology started in the 1970s.

Storing spent nuclear fuel for hundreds of years at ground level is not a viable alternative in Finland, because the Nuclear Energy Act states that spent nuclear fuel must be permanently disposed of in Finland. The spent nuclear fuel may be further processed, i.e. turned into recycled or reprocessed nuclear fuel in a reprocessing facility built for this purpose. Finland does not have any reprocessing facilities for spent nuclear fuel, nor is building one in Finland considered technically or financially viable. Due to section 6a of the Finnish Nuclear Energy Act, spent nuclear fuel cannot be exported to be reprocessed abroad. That is why long-term storage and reprocessing are not studied as alternative implementation methods in this EIA program.

Therefore, the only possible spent nuclear fuel management alternative is geological final disposal in the Finnish bedrock. The technical solution selected for the Fennovoima final disposal project is a solution based on the KBS-3 concept, where the spent nuclear fuel is packed into canisters and placed deep into the bedrock. Other potential final disposal solutions based on the bedrock (such as deep drilling or a hydraulic cage) were deemed, already in the 1990s, not to be as well adapted to Finnish conditions (*Posiva Oy's EIA report 1999*). The KBS-3 concept has been found to be a suitable final disposal solution for Finland, and selecting this concept enables cooperation with other Nordic nuclear waste management companies utilizing the same concept.

6 Final disposal safety principles

According to the general safety principles applied to nuclear waste management, final disposal may not result in any health hazards or any other damage to the environment (people, flora, or fauna), or property. This principle applies far into the future: the final disposal operations may not cause any health hazards or environmental damage even in the future.

In Finland, nuclear waste management is governed by the Nuclear Energy Act (990/1987) and the Nuclear Energy Decree (161/1988), which both entered into force in 1988. Among other thing they determine the general principles on the utilization of nuclear energy, realization of nuclear waste management, permits required for the utilization of nuclear energy, related supervision, and the competent authorities.

The Finnish Radiation and Nuclear Safety Authority (STUK) oversees the safety of the processing, storage, and final disposal of nuclear waste. Several obligations for producers of spent nuclear fuel have been specified to ensure proper planning of the final disposal of spent nuclear fuel. STUK reviews all plans for safe final disposal, starting from the research and planning phase. STUK's regulations and nuclear safety guides pursuant to the Nuclear Energy Act include more detailed regulations on nuclear waste management.

The safety of the KBS-3 final disposal concept is based on the multibarrier principle (several redundant barriers) in compliance with section 30 of regulation no. Y/4/2016 from the Finnish Radiation and Nuclear Safety Authority. The safety of final disposal up to a million years from now must be proven with sufficient confidence. This is why the term "long-term safety" is used when referring to final disposal. It covers environmental radiation safety also after the decommissioning of the final disposal facility.

7 Licenses required for the project under the Nuclear Energy Act

The EIA report to be prepared at a later date will be enclosed with the Decision-in-Principle application for the spent nuclear fuel encapsulation plant and final disposal facility. According to the Finnish Nuclear Energy Act, the construction of a nuclear facility with a noticeable general significance requires a Decision-in-Principle issued by the Finnish Government and ratified by the Parliament concerning the fact that the construction of the nuclear facility will be in line with the overall benefit of the society. Construction of the final disposal facility at the selected location will also require approval from the Finnish Radiation and Nuclear Safety Authority, a preliminary safety assessment, and approval from the local municipality. In addition to the Decision-in-Principle, a construction license and an operating license pursuant to the Nuclear Energy Act are required. The construction and operating licenses for the encapsulation plant and final disposal facility will be granted by the Government. A construction license may be granted if the Decision-in-Principle ratified by Parliament has deemed the construction of the nuclear facility to be in line with the overall benefit of the society and the preconditions for granting a construction license for a nuclear facility in section 19 of the Nuclear Energy Act are met. Statements and opinions issued during the international hearing included in the EIA procedure will also be taken into account during the construction license phase in accordance with the Espoo Convention.

Many other licenses, notifications, and decisions are also required for the construction and operation of the spent nuclear fuel encapsulation plant and final disposal facility.

8 Studied alternatives and project location

The research, construction, operational, and decommissioning phases of Fennovoima's own encapsulation plant and final disposal facility will be studied during the EIA procedure. The capacity of the encapsulation plant and final disposal facility will be 1,200–1,800 tons of uranium. The chosen technical implementation alternative is the KBS-3 method where the final disposal of nuclear fuel can take place either in vertical holes (KBS-3V) or in horizontal holes (KBS-3H) drilled in final disposal tunnels. The EIA procedure will also include a study of the transport of spent nuclear fuel. Other issues covered by the impact assessment include the impacts of ancillary projects, such as the construction of roads and power lines.

The alternative locations are (Figures 3 and 4):

- Option 1: Eurajoki
- Option 2: Pyhäjoki (Sydänneva)

The applicability of the alternative locations for final disposal will be assessed during the EIA procedure.

Of the alternative locations listed in this EIA program, the preliminary research phase has been completed at Pyhäjoki. One research area that may be suitable for final disposal (Sydänneva) was identified. The preliminary research phase at Eurajoki will start after the filing of the EIA program. The research area will be determined before the EIA report phase.

Another studied alternative is the zero-option, i.e. not constructing the spent nuclear fuel encapsulation plant and final disposal facility. In this option, the spent nuclear fuel would be stored for several decades in an interim storage facility for spent nuclear fuel at the nuclear power plant site on the Hanhikivi headland in Pyhäjoki. Finnish nuclear legislation requires that spent nuclear fuel is permanently disposed of, however, which is why prolonged storage cannot be the final solution for the disposal of spent nuclear fuel.

Figure 3. Locations of Pyhäjoki and Eurajoki.

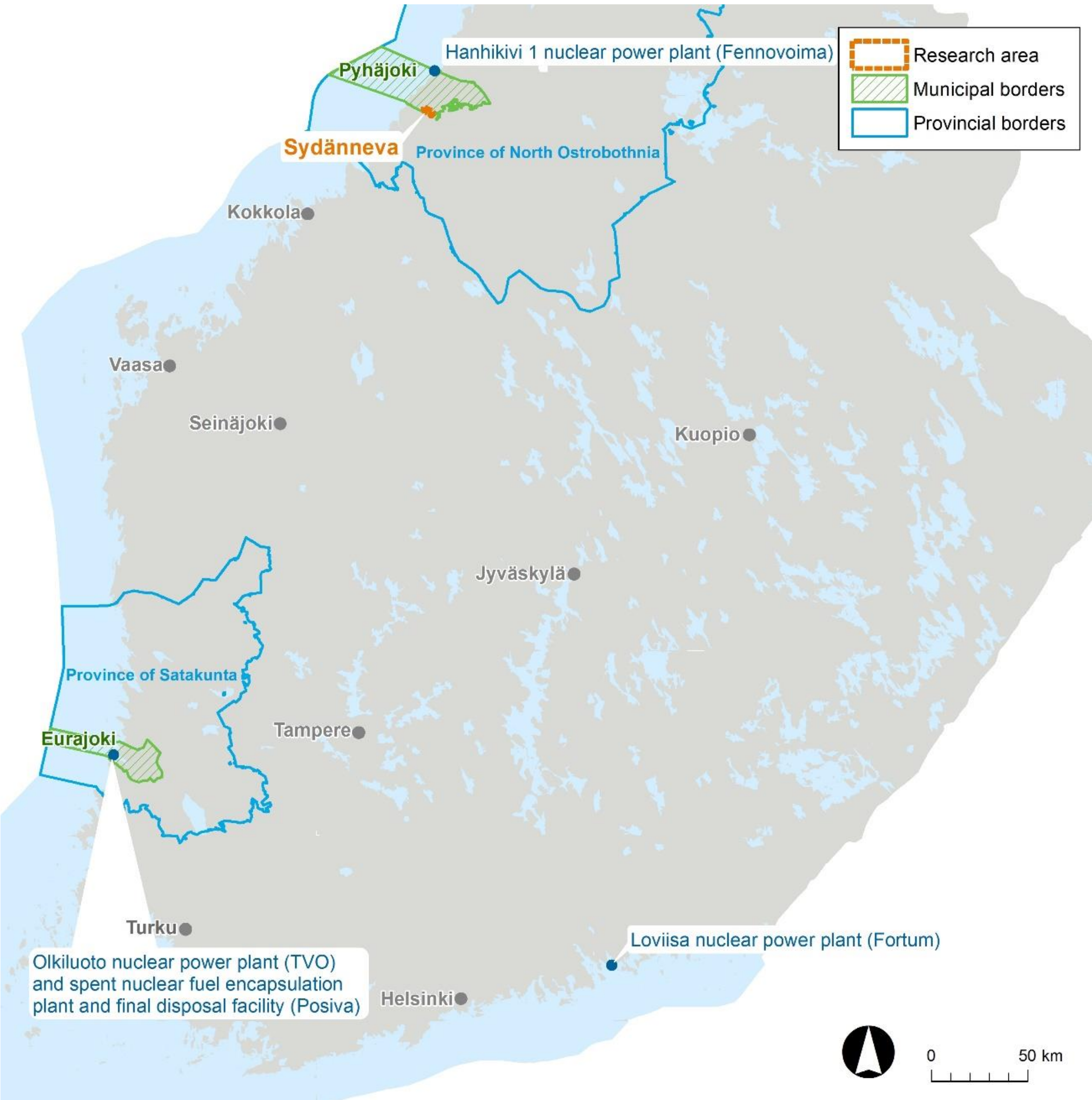

Figure 4. The alternative locations.

Eurajoki

Since Eurajoki has already been selected as the final disposal location of spent nuclear fuel originating in Finland in the Posiva Oy's selection process, Fennovoima has decided to study the applicability of Eurajoki as an alternative location in the Fennovoima spent nuclear fuel disposal project. Fennovoima plans to determine the research area suitable for final disposal together with Posiva before preparing the EIA report. This procedure enables the utilization of the latest geological information available to Posiva when limiting and determining the research area. A targeted research area within the municipality of Eurajoki will be specified, and further studies in the research area will be completed before the preparation of the EIA report.

The municipality of Eurajoki is in the province of Satakunta, and it is limited by the Baltic Sea in the west. Nuclear power plants owned by Teollisuuden Voima Oyj and the ONKALO research facility of the planned encapsulation plant and final disposal facility of Posiva Oy are located at Olkiluoto in Eurajoki. In 2015, Posiva Oy received a construction license for the encapsulation plant and final disposal facility at Olkiluoto in Eurajoki. According to the construction license, a maximum of 6,500 tons of spent uranium nuclear fuel may be placed in the final disposal facility at Olkiluoto.

Pyhäjoki

Applicability of the Finnish bedrock for final disposal of highly radioactive spent nuclear fuel has been studied since the late 1970s, and an area that may be suitable for final disposal in the Pyhäjoki region was determined based on national selection studies. In 2015, the Geological Survey of Finland studied the geological properties of the Pyhäjoki region in more detail. A target area delimited by lineaments (fracture zones) that may be suitable for final disposal was identified, and a smaller research area (Sydänneva) within this target area was determined.

The municipality of Pyhäjoki is in the province of Northern Ostrobothnia, and it is limited by the Baltic Sea in the east. The selected site for a nuclear power plant owned by Fennovoima Oy is the Hanhikivi headland, which is around 18 kilometers to the north of the planned research area.

9 Project schedule

The submission of the program will initiate a research phase of several years, during which the geological characteristics of the alternative research areas and their suitability for final disposal will be studied. The suitability of the final disposal site is subject to numerous safety-related criteria pertaining, in particular, to the bedrock conditions, which it will take several years or even decades to investigate with a dedicated research program. The schedule for the research phase will be further specified based on the research program. The research program will be drafted separately for each research area.

The environmental impact assessment for the final disposal project and the preparation of the EIA report will start towards the end of the research activities. The EIA report will be completed in time to allow for the selection of the spent nuclear fuel final disposal site in the 2040s. According to the current plans, the disposal of Fennovoima's nuclear fuel is expected to begin at the earliest in the 2090s, in accordance with the nuclear power plant construction license application. The estimated total project period is more than 100 years.

10 Environmental impacts to be assessed

In this project, the term "environmental impact" refers to the direct and indirect impacts of the project on the environment. In the assessment, the impacts during all the different project phases (see Chapter 4) are studied. According to the EIA Act, an environmental impact assessment must cover the environmental impact of the project on the following:

- Human health, living conditions, and well-being
- Soil, water systems, air, climate, flora, fauna, and biodiversity
- Infrastructure, buildings, landscape, cityscape, and cultural heritage
- Utilization of natural resources
- Mutual interaction between the above-mentioned factors.

At this point in time, the most important identified environmental impacts of the project are impacts on the soil, bedrock, and groundwater due to the underground construction activities and long duration of the project. Furthermore, impacts on humans, particularly those that can be experienced in different ways by different people, may become important during the project period. In the EIA report, the significance of environmental impacts will be assessed by, for instance, comparing the tolerance of the environment with regard to each environmental burden, taking into account the current status and environmental load of the area. Furthermore, environmental impacts that are considered significant or felt to be significant by the stakeholders will be taken into account. Experienced environmental impact assessment experts will perform the assessment.

The environmental impact assessment will take into account the environmental impacts in the research area as well as those that extend outside the area. In this context, "assessment area" refers to the area defined for each type of impact in which the environmental impact in question is examined and assessed. The objective is to determine an assessment area so large that significant environmental impacts cannot be expected to occur outside the area. However, if it becomes apparent during the assessment work that a specific environmental impact has a respective affected area larger than is estimated, the scope of the observed and affected areas will, in that connection, be redefined for the impact in question. Thus, the actual definition of affected areas will be carried out in the environmental impact assessment report as a result of the assessment work.

The table below (Table 1) includes a summary of the studied environmental impacts and the methods used in the assessment.

Table 1. Summary of the studied environmental impacts and the methods used in the assessment.

ASSESSMENT AREA	ENVIRONMENTAL IMPACT ASSESSMENT AND THE METHODS USED
Land use and built environment	An expert assessment of the project's relationship with current and planned regional structure, infrastructure, land use, and land use objectives. Inconsistencies in land use and change needs will be assessed. In addition, distances from objects in the built environment will be studied with the help of maps.
People and communities	An expert assessment of the project's impact on people's well-being and living conditions based on quantitative and qualitative assessments from the other studied issues. People's experience of effects will also be taken into account. Health impacts will be assessed in compliance with instructions from the Finnish Radiation and Nuclear Safety Authority. In addition, effects on business, employment, and the regional economy will be assessed based on separate surveys. The following will be completed for the impact assessment: - Survey of the population within a five-kilometer radius and a twenty-kilometer radius from the site - Resident survey - Small group events and interviews - Analysis of current socioeconomic status - Survey of impact on the image of local municipalities
Landscape and cultural environment	An expert assessment of the project's relationship with the landscape in a broader sense, the local landscape and cityscape, and views of the research area. The project's impacts on the built cultural environment and archaeological cultural heritage sites will also be assessed. Photomontages will be prepared to support the assessment, and inventories of historical monuments will be completed, if necessary.

Assessment area	Environmental impact assessment and the methods used
Soil, bedrock, and groundwater	A preliminary assessment of the applicability of the bedrock for final disposal operations will be made based on geological surveys and interpretations and modeling made based on the geological surveys. The EIA report will also include an assessment of the project's impact on the soil, bedrock, and groundwater. The conditions of the area's bedrock and soil, as well as hydrological and hydrogeochemical conditions, will be determined with several studies and modeling, such as: - Studies of the soil surface - Studies in boreholes at a depth of around 500–1,000 m - Research excavations and supplementary structural geology surveys and geophysical measurements (seismic reflection, electromagnetic probing, electric probing, gravity measurements, etc.) - Preliminary 3D model of structural geology and hydrogeology - Special geophysical measurements (in situ thermal conductivity, tomography, mise-a-la-masse, etc.) and any necessary additional drilling
Flora, fauna, and protection sites	An expert assessment of the project's impact on flora, fauna, habitat types, and targets with importance for the preservation of nature, as well as on natural diversity and interaction on a wider scale (ecological connections, etc.). At the minimum the following environmental surveys will be completed to support the assessment: - Vegetation and habitat type surveys - Survey of nesting birds - Necessary surveys of Habitats Directive species (such as Siberian flying squirrel, bat, and moor frog) In the case of Natura 2000 areas, it will be assessed whether there will be any impact on the natural values due to which they are protected that require a Natura 2000 assessment as laid down in section 65 of the Nature Conservation Act.
Water systems	An expert assessment of the project's impact on surface water systems based on available research data and completed studies. Water systems and small water systems in the area will be surveyed, and the limitations of the catchment areas of the small water systems and water discharge directions will be determined. If necessary, surface water depth, sediments, water quality, and aquatic organisms in the research and drilling areas will be studied.
Climate and air quality	An expert assessment of the project's emissions into the air. Already existing studies and assessments will be utilized in the assessment. The emissions will be compared with the set guideline and limit values. To support the assessment of the climate conditions, a weather station may be installed in the research area to monitor the wind direction and temperature, etc. Snow and frost measurements will be taken in connection with the geological research program. Radioactive emissions generated mainly under exceptional situations and during accidents will be assessed as described under *Exceptional situations and accidents* below.
Transport and traffic	A calculated estimate of the changes caused by the project in current traffic volumes and an expert assessment of the impact of transport on traffic and safety of traffic. A separate transport report will be prepared to support the assessment. It will cover transport routes, alternative transport methods, radiation doses to the transport personnel and people living along the transport route, and any related health risks, for example. The transport report will also cover any exceptional situations and accidents.

Assessment area	Environmental impact assessment and the methods used
Noise	The noise impact assessment will be done by means of noise modeling. Noise caused by the activities performed during the different project phases and related transport activities in the immediate vicinity of the project site (to a radius of approximately two kilometers from the activities) will be studied. In the assessment, the noise caused by the project will be compared to the area's current noise level and guideline noise values.
Vibration	An expert assessment of the impact of vibration during excavation of the bedrock and transport during the project period. The intensity of vibration will be assessed in relation to the distance based on available information about the source of vibration and previous experience.
Waste and by-products, and their utilization	An expert assessment of the by-products and waste generated during the different project phases, their quantities, properties, and processing options, as well as their impact on the environment.
Utilization of natural resources	An expert assessment of the utilization of natural resources, including utilization of the blasted stone generated by the project and the consumption of materials during the project period.
Exceptional situations and accidents	A risk analysis to identify exceptional situations and accidents associated with the project will be prepared to study the potential accident risk types and their probability during the different project phases. The risk of exceptional situations and accidents during the transport of spent nuclear fuel will also be separately studied in the transport report to be prepared. The impact of accidents on human health and the environment will be studied based on safety analyses and the requirements imposed on the final disposal operations. Radiation doses caused by accidents and the areas affected by radiation will be assessed. The consequences of exceptional situations will be assessed based on research data on the health and environmental impact of radiation. Instructions from the Finnish Radiation and Nuclear Safety Authority will be followed when assessing releases during exceptional situations and accidents and their impact.
Long-term safety	Long-term safety will be modeled with computer software. Issues to be modeled include hydrological, chemical, thermal, mechanical, and biological processes. The EIA report will present the bases for the safety design of the encapsulation plant and final disposal facility as well as an assessment on compliance with the currently valid safety requirements. The radiation doses to humans and other organisms and radioactive release rates at ground level that were modeled in the environmental impact assessment will be compared to the safety requirements in legislation and the nuclear safety guides published by STUK.
Combined impacts with other projects	According to the currently available information, no projects that could have any combined impact with the encapsulation plant and final disposal facility are planned for the immediate vicinity of the research areas. This issue will be examined in more detail in the EIA report.
Transboundary impacts	Based on the preliminary estimate, the Fennovoima final disposal project does not have any transboundary environmental impacts. A separate transport report, a risk analysis for exceptional situations and accidents, and long-term safety modeling will be completed for the project. One of the issues examined in these studies is whether the impacts could extend beyond the borders of Finland.

11 Possible transboundary environmental impacts

Based on a preliminary estimate, the Fennovoima final disposal project will not have any transboundary environmental impacts.

A transport report by Fennovoima states that large amounts of radioactive substances cannot spread into the environment in connection with a potential accident involving the transport of spent nuclear fuel. The transport containers will be designed in compliance with the statutory requirements in such a manner that an accident during transport cannot have any direct health impacts. Even in the most severe case, mainly the transport personnel and any people in the immediate vicinity of the accident site could be exposed to elevated radiation levels. The radiation exposure to the general public will be lower in the case of sea transport than in the case of road or rail transport, as residences are farther away from the shipping channels and there are not many residents along the transport routes. Since the impacts would be limited to the immediate vicinity of an accident site, no impacts in the neighboring countries in case of an accident are to be expected. For example, Pyhäjoki is located more than 100 kilometers and Eurajoki more than 140 kilometers from the border between Finland and Sweden.

The worst-case scenario for the final disposal of spent nuclear fuel is an accident where a canister falls from a canister hoist in the encapsulation plant in such a manner that the fuel rods inside the canister are damaged and the canister itself is also damaged. Such an accident could lead to gaseous and particulate radioactive releases into the encapsulation plant. The encapsulation plant's filtering systems would clearly reduce the amount of any releases from the plant. According to the statutory requirements, no radioactive releases into the environment that exceed the limit and guideline values may occur at the encapsulation plant. The plant will be designed in such a manner that the doses caused by the postulated transients and accidents will be lower than the limit values set in the requirements, even in the immediate vicinity of the final disposal area. No impacts in the neighboring countries are expected even in the worst-case accident scenario.

A separate transport report, a risk analysis for exceptional situations and accidents, and long-term safety modeling will be completed for the project. One of the issues examined in these studies is whether the impacts could extend beyond the borders of Finland. The project's environmental impacts (such as quality, quantity, and affected area) will be studied in more detail in the EIA report. The EIA report will include an estimate as to whether the project will cause any transboundary impacts. Transboundary impacts will also be studied during the international hearing pursuant to the Espoo Convention.

12 Contact information

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