FENNOVOIMA

Environmental Impact Assessment Report for a Nuclear Power Plant

SUMMARY

February 2014

Contact information

Party responsible for the project: Fennovoima Oy
Postal address: Salmisaarenaukio 1, FI-00180 Helsinki, Finland
Tel. +358 20 757 9222
Contact person: Kristiina Honkanen
E-mail: forename.surname@fennovoima.fi

Coordinating authority: Ministry of Employment and the Economy
Postal address: P.O. Box 32, FI-00023 Government, Finland
Tel. +358 29 506 4832
Contact person: Jorma Aurela
E-mail: forename.surname@tem.fi

International hearing: Ministry of the Environment
Postal address: P.O. Box 35, FI-00023 Government, Finland
Tel. +358 400 143 937
Contact person: Seija Rantakallio
E-mail: forename.surname@ymparisto.fi

More information regarding the project's environmental impact assessment is also provided by:
EIA consultant: Pöyry Finland Oy
Postal address: P.O. Box 50, FI-01621 Vantaa, Finland
Tel. +358 10 3324388
Contact person: Minna Jokinen
E-mail: forename.surname@poyry.com

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1 Project

Background of the project

Fennovoima Ltd. (hereinafter "Fennovoima") is studying the construction of a nuclear power plant of approximately 1,200 MW at Hanhikivi headland in Pyhäjoki, Finland. As part of the studies, Fennovoima will carry out an environmental impact assessment as laid down in the Act on Environmental Impact Assessment Procedure (468/1994; hereinafter "the EIA Act") to study the environmental impacts of the nuclear power plant's construction and operation.

In 2008, Fennovoima implemented an environmental impact assessment (EIA) to assess the impacts of the construction and operation of a nuclear power plant of approximately 1,500–2,500 megawatts that consists of one or two reactors at three alternative locations: Pyhäjoki, Ruotsinpyhtää, and Simo. An international hearing procedure pursuant to the Espoo Convention was also performed in connection with the EIA procedure.

Fennovoima received a Decision-in-Principle in compliance with section 11 of the Nuclear Energy Act (990/1987) on May 6, 2010. Parliament confirmed the Decision-in-Principle on July 1, 2010. The Hanhikivi headland in Pyhäjoki was selected as the plant site in the autumn of 2011 (Figure 1).

The nuclear power plant of approximately 1,200 MW which is the object of this environmental impact assessment and the supplier of which is a company belonging to the Russian Rosatom Group was not mentioned as one of the plant alternatives in Fennovoima's original application for a Decision-in-Principle. This is why the Ministry of Employment and the Economy required that Fennovoima updates the project's environmental impact assessment with this EIA procedure. The international hearing procedure in compliance with the Espoo Convention is simultaneously implemented.

Figure 1. The project site and the Baltic Sea region countries, including Norway.

Assessed alternatives

The implementation alternative being assessed consists of the environmental impacts from the construction and operation of a nuclear power plant of approximately 1,200 MW. The plant will be constructed on the Hanhikivi headland in Pyhäjoki. The plant will consist of one nuclear power plant unit of the pressurized water reactor type. The zero-option assessed is not implementing Fennovoima's nuclear power plant project.

In addition to the nuclear power plant itself, the project will include interim storage of spent nuclear fuel on site, as well as treatment, storage, and final disposal of low and intermediate level operating waste. The following are also included in the project scope:

- Intake and discharge arrangements for cooling water
- Supply and handling systems for service water
- Treatment systems for wastewater and emissions into the air
- Constructing roads, bridges, and banks
- Constructing a harbor area, wharf, and navigation channel for sea transport.

The report also describes the nuclear fuel supply chain, the final disposal of spent nuclear fuel, and decommissioning of the nuclear power plant. A separate EIA procedure will be applied to the latter two at a later date. A separate EIA procedure will also be applied to the transmission line connection to the national grid.

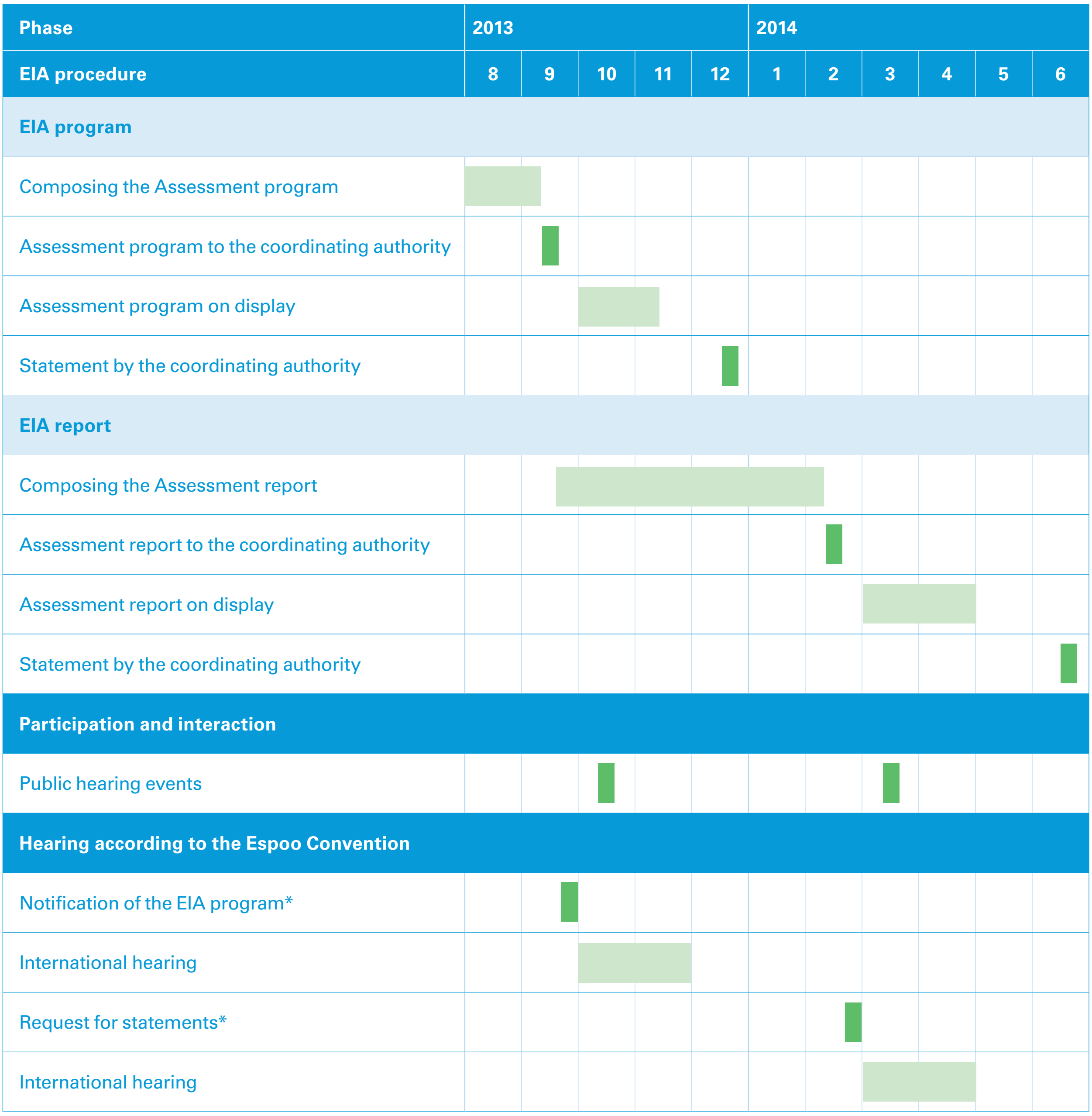
Schedule

Key stages and planned schedule of the EIA procedure are presented in Figure 2.

2 Environmental impact assessment and stakeholder hearing procedure

EIA procedure

The environmental impact assessment procedure is based on the Council Directive on the assessment of the impacts of certain public and private projects on the environment (85/337/EEC) that has been enforced in Finland through the EIA Act (468/1994) and the EIA Decree (713/2006). The objective of the EIA procedure is to improve the environmental impact assessments and to ensure that environmental impacts are consistently taken into account in planning and decision-making. Another objective is to increase the availability of information to citizens and the possibility for them to participate in the planning of projects. The EIA



*by the Ministry of the Environment

Figure 2. Schedule of the EIA procedure.

procedure does not involve any project-related decisions nor does it solve any issues pertaining to permits or licenses.

The EIA procedure consists of the program and the report stages. The environmental impact assessment program (EIA program) is a plan for arranging an environmental impact assessment procedure and the required investigations. The environmental impact assessment report (EIA report) describes the project and its technical solutions, and offers a consistent assessment of the environmental impacts based on the EIA procedure.

The environmental impact assessment in a transboundary context as laid down in the Espoo Convention is also applied to the Fennovoima nuclear power plant project. Parties to the Convention have the right to take part in an environmental impact assessment procedure carried out in Finland if the state in question may be affected by the adverse environmental impacts of the project to be assessed. The Finnish Ministry of the Environment coordinates the international hearing procedure. The Ministry submits all statements and opinions it has received to the coordinating authority to be taken into account in the coordinating authority's statements regarding the EIA program and the EIA report.

The stages of the EIA procedure are presented in Figure 3.

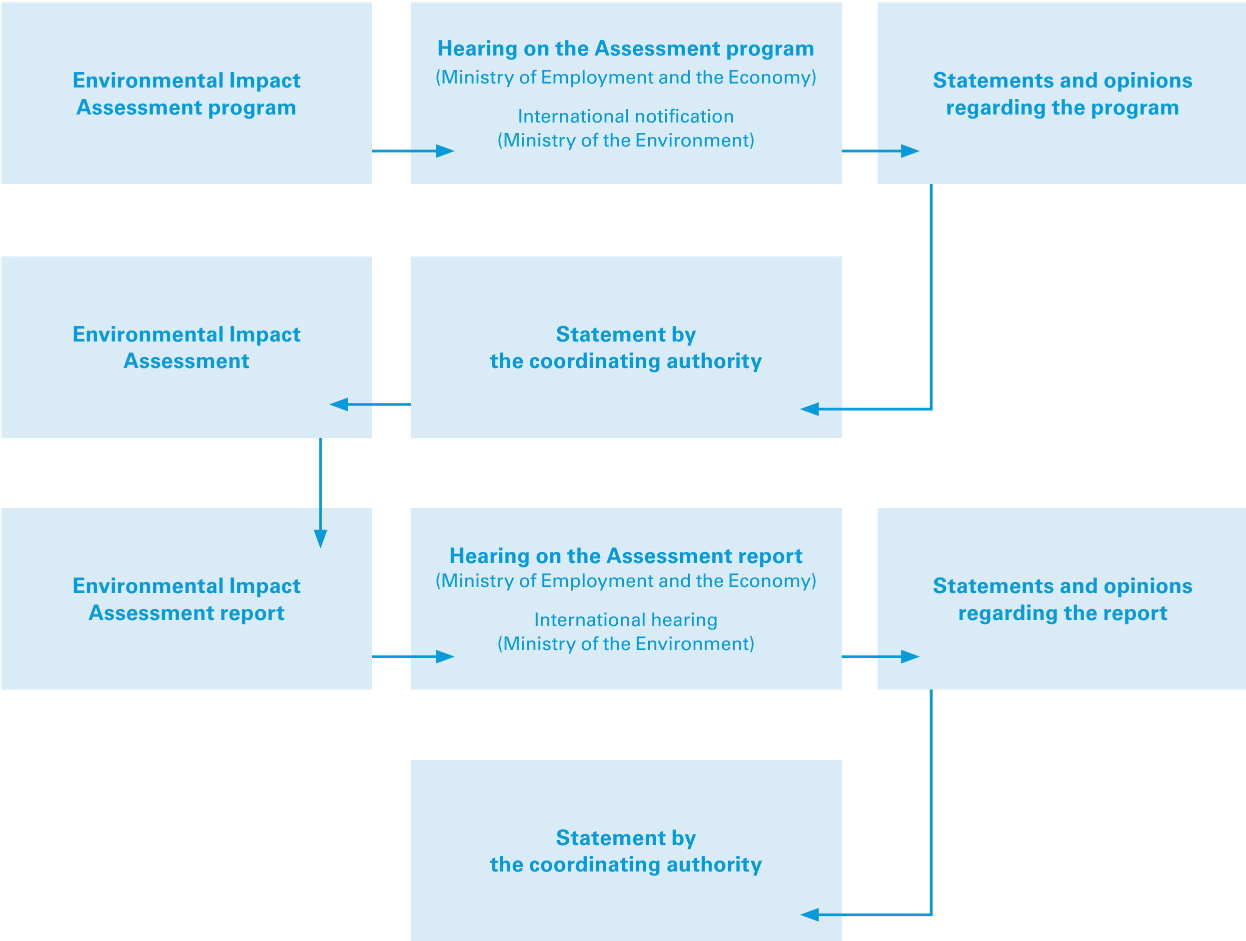


Figure 3. Stages of the EIA procedure.

National and international hearing

On September 17, 2013, Fennovoima submitted the EIA program concerning the nuclear power plant project of approximately 1,200 MW to the Ministry of Employment and the Economy, which acts as the coordinating authority. The Ministry of Employment and the Economy requested statements on the EIA program from various authorities and other stakeholders, and citizens also had the opportunity to present their opinions. The EIA program was available for reviewing in Finland from September 30 to November 13, 2013 and available for international reviewing from September 30 to November 28, 2013.

A total of fifty-one statements and opinions regarding the EIA program were submitted to the Ministry of Employment and the Economy. Fifty-seven statements and notifications were submitted in the international hearing process. Sweden, Denmark, Norway, Poland, Germany (two federated states), Latvia, Estonia, Russia, and Austria announced that they will participate in the EIA procedure.

The Ministry of Employment and the Economy issued its statement on the EIA program on December 13, 2013.

The opinions of Finnish stakeholders on the project were studied by implementing a resident survey in the area surrounding the planned plant site and by arranging group interviews during the EIA procedure. The opinions received were taken into account in assessing the environmental impacts.

The environmental impact assessment report has been drawn up on the basis of the EIA program and the related opinions and statements. The EIA report was submitted to the coordinating authority in February 2014. Citizens and stakeholders will have the opportunity to voice their opinions on the EIA report by the deadline specified by the Ministry of Employment and the Economy. The EIA procedure will end when the Ministry of Employment and the Economy issues its statement on the EIA report.

3 Project description and plant safety

Operating principle of the plant

Nuclear power plants produce electricity in the same manner as condensing power plants using fossil fuels: by heating water into steam and letting the steam rotate a turbogenerator. The main difference between nuclear power plants and conventional condensing power plants is in the heat production method: in nuclear power plants, the heat is produced in a reactor using the energy released by splitting atom nuclei, whereas in condensing power plants, the water is heated by burning suitable fuel, such as coal, in a boiler.

The most widely used reactor type is the light water reactor. The reactors of the nuclear power plants currently in operation in Finland are light water reactors. The alternative types of light water reactors are the boiling water reactor and the pressurized water reactor. The type considered for this project is the pressurized water reactor.

In a pressurized water reactor, fuel heats the water but high pressure prevents the water from boiling. The heated high-pressure water is led from the reactor to steam generators. In the steam generators, the water is distributed into small-diameter heat transfer tubes. The heat transfers through the walls of the tubes into the water circulating in a separate circuit, which is the secondary circuit. The water in the secondary circuit turns into steam, which is then led to the turbine rotating a generator (Figure 4). As the reactor system and the secondary circuit are completely separated from each other, the water circulating in the secondary circuit is not radioactive.

In nuclear power plants, more than one third of the thermal energy generated in the reactor can be converted into electric energy. Rest of the heat produced is removed from the power plant using condensers. In the condensers, low-pressure steam from the steam turbines releases energy and turns back into water. Condensers are cooled using cooling water taken directly from a water system. The cooling water, the temperature of which rises by 10–12 °C in the process, is then returned back to the water system.

Nuclear power plants are best suited as base load plants, which mean that they are used continuously at constant power except for a few weeks' maintenance outages at 12–24-month intervals. Plants are designed for an operational lifetime of at least 60 years.

Description of the plant type

The Rosatom AES-2006 pressurized water reactor that is being studied in this project is a modern, third-generation nuclear power plant. The AES-2006 plants are based on VVER technology, which has been developed and used for more than 40 years and consequently offers the benefit of long-term operational experience. The version of the plant under consideration for Fennovoima's project is the latest development step in the VVER plant series. VVER plants have a history of safe operation spanning over 30 years in the Loviisa nuclear power plant.

Table 1 shows the preliminary technical data of the planned new nuclear power plant.

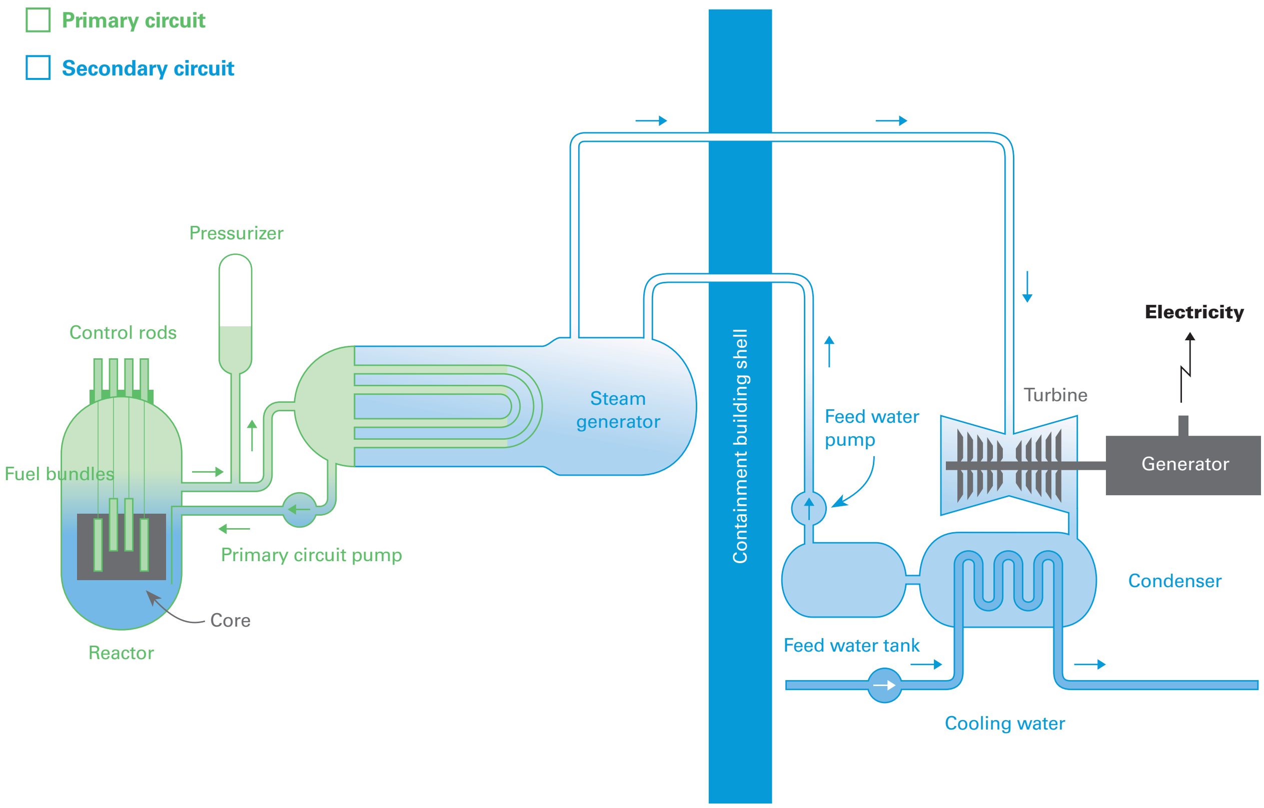


Figure 4. Operating principle of a pressurized water reactor.

Table 1. Preliminary technical specifications of the planned new nuclear power plant.

Description	Value and unit
Reactor	Pressurized water reactor
Electric power	Approximately 1,200 MW (1,100–1,300 MW)
Thermal power	Approximately 3,200 MW
Efficiency	Approximately 37 %
Fuel	Uranium dioxide UO_2
Fuel consumption	20–30 t/a
Thermal power released in cooling to the water system	Approximately 2,000 MW
Annual energy production	Approximately 9 TWh
Cooling water consumption	Approximately 40–45 m^3/s

The safety of the plant is based on both active and passive systems. Active systems are systems that require a separate power supply (such as electric power) to operate. Among the important safety features of the AES-2006 are additional passive safety systems, driven by natural circulation and gravity. Being independent from the supply of electric power, they will remain in operation even in the unlikely event of total loss of power supply and unavailability of the emergency power generators. The possibility of a severe reactor accident, meaning a partial meltdown of the reactor core, will be considered in the design of the plant. To cope with a severe accident, the containment building will be equipped with a core catcher. The plant type features a double-shell containment building. The outer containment shell is a thicker structure made of reinforced concrete that is capable of withstanding external collision loads, including a passenger airplane crash.

Nuclear safety

The safety requirements related to the use of nuclear energy are based on the Finnish Nuclear Energy Act (990/1987) which states that nuclear power plants must be safe and shall not cause any danger to people, the environment, or property.

The regulations of the Nuclear Energy Act are further specified in the Nuclear Energy Decree (161/1988). The general principles of the safety requirements set for nuclear power plants are laid down in Government Decrees (734/2008, 736/2008, 716/2013, and 717/2013). Their scope of application covers the different areas of the safety of nuclear energy use. Detailed regulations on the safety of nuclear energy use, safety and emergency preparedness arrangements, and nuclear material safeguards are given in the regulatory guides on nuclear safety (YVL Guides) issued by the Radiation and Nuclear Safety Authority (STUK). Various national and international regulations and standards also control the use of nuclear energy.

The safety of nuclear power plants is based on the defense-in-depth principle. Several independent and supplementary protection levels will be applied to the design and operation of the Fennovoima nuclear power plant. These include the following:

- Prevention of operational transients and failures through high-quality design and construction, as well as appropriate maintenance procedures and operation.
- Observation of operational transients and failures and returning the situation to normal using protection, control, and safety systems.
- Management of design basis accidents using existing and planned safety features.
- Observation and management of severe accidents using the accident management system.
- Mitigation of the consequences of releasing radioactive substances through emergency and rescue operations.

The nuclear power plant will be equipped with safety systems that will prevent or at least limit the progress and impact of failures and accidents. The safety systems will be divided into several parallel subsystems, the combined capacity of which will be designed to exceed the requirement several times over (the redundancy principle). The overall system consisting of multiple redundant subsystems will be able to perform its safety functions even in the case of the failure of any single piece of equipment and the simultaneous unavailability of any piece of equipment contributing to the safety function due to maintenance or any other reason. This redundancy ensures the operational reliability of the safety systems. Reliability can be further improved by utilizing several pieces of equipment of different types to perform the same function. This eliminates the chance of type-specific defects preventing the performance of the safety function (the diversity principle). The redundant subsystems will be separated from each other so that a fire or a similar incident cannot prevent the performance of the safety function. One alternative for implementing the separation is to place the subsystems in separate rooms (the separation principle).

The nuclear power plant will be designed to withstand the loads resulting from various external hazards. These include extreme weather conditions, sea and ice-related phenomena, earthquakes, various missiles, explosions, flammable and toxic gases, as well as intentional damage. Other factors that will be taken into account in the design include the eventual impacts of climate change, such as the increasing frequency of extreme weather phenomena, increase in the temperature of seawater, and rises in the average sea level.

Construction of the nuclear power plant

The construction of a nuclear power plant is an extensive project. The first phase of construction, which will take approximately three years, will feature the construction of the infrastructure required for the plant and performance of civil engineering work.

The earthworks will include bedrock blasting and rock excavation work performed for the purpose of constructing the cooling water tunnels and the power plant excavation, as well as the filling, raising, and leveling of the plant area and the supporting areas. Hydraulic engineering works, including soil and rock excavation work performed for the purpose of building the navigation channel, the harbor area, and the cooling water intake and discharge structures, will be carried out simultaneously with the earthworks.

The harbor basin, the navigation channel, the auxiliary cooling water inlet channel, and the cooling water intake structures will be located in the western and northwestern parts of the Hanhikivi headland. The cooling water discharge structures will be located on the northern shoreline. According to the plan, the cooling water will be taken from the harbor basin located on the western shore of the Hanhikivi headland using an onshore intake system and discharged at the northern part of the headland.

The actual power plant construction work will begin after the completion of the infrastructure and the civil engineering works. The construction of the power plant will take 5–6 years, including installation work carried out at the plant. The commissioning of the plant will take 1–2 years. The objective is to put the plant into operation by 2024.

Radioactive emissions and their control

Radioactive emissions into the air

According to the Government Decree (717/2013), the radiation dose to individual inhabitants of the surrounding area caused by the normal operation of a nuclear power plant may not exceed 0.1 millisieverts per year. This limit value is the basis for determining the limits for emissions of radioactive substances during normal operation. Emission limits will be established for iodine and inert gas emissions. The emission limits are separately specified for each nuclear power plant. In addition to iodine and inert gas emissions, the nuclear power plant will release tritium, carbon-14, and aerosols into the air. Even at the theoretical maximum level, the annual emissions of these substances will remain so low that setting separate emission limits for them is not necessary in Finland. However, these emissions will still be measured.

The Fennovoima nuclear power plant will be designed so that the emissions of radioactive substances remain below all set emission limits. Furthermore, Fennovoima will determine its own emission targets for the nuclear power plant. These targets will be stricter than the set emission limits.

The radioactive gases generated in the nuclear power plant will be processed using the best available technology. Gaseous radioactive substances will be directed into a cleaning system, where the gases will be dried, delayed, and filtered using charcoal filters, for example. Gaseous emissions can also be filtered using efficient high-efficiency particulate air (HEPA) filters. The cleaned gases will be released into the atmosphere via the vent stack. Radioactive emissions into the air will be monitored and measured in the several stages of the gas treatment systems, and finally at the vent stack.

Radioactive emissions into the sea

As in the case of emissions into the air, power plant-specific emission limits will be set for radioactive emissions into the sea. Furthermore, Fennovoima will determine its own emission targets, which will be stricter than the set emission limits. In Finland, tritium emissions have been approximately 10 % and other emissions clearly less than 1 % of the set emission limits. The amount of tritium from a nuclear power plant in seawater decreases to an insignificant level at a very short distance from the plant.

Radioactive liquids from the controlled area will be led to the liquid waste treatment plant where they will be cleaned so that their activity level falls well below the set emission limits before they are released into the water system. The water, which will contain only a low level of radioactivity, will be released into the sea after the treatment process. The level of radioactivity in the water released into the sea will be determined using a representative sample and by conducting measurements at the outlet line before the water is released into the cooling water discharge tunnel. The goal is to minimize the volume of emissions into the sea by, for example, recycling the process and pool water and by minimizing the generation of wastewater.

Waste management

In addition to conventional waste, radioactive waste is generated during the operation of a nuclear power plant. This waste is divided into two main categories:

- Very low, low and intermediate level waste, i.e. operating waste (such as low level waste generated during maintenance or repairs and components, and equipment removed from inside the reactor pressure vessel that have been activated by neutron radiation, which are intermediate level waste)
- High level waste, i.e. spent nuclear fuel.

The basic principle for the management of radioactive waste generated in the nuclear power plant will be permanent isolation of the waste from the environment. The party under the nuclear waste management obligation (in practice, the owner of the nuclear power plant) will be responsible for the implementation of nuclear waste management and liable for covering the related expenses. According to the Nuclear Energy Act, nuclear waste must be treated, stored, and permanently disposed of within Finland.

Operating waste

Whenever possible, solid radioactive waste will be sorted at the site where the waste is generated. For storage or final disposal, maintenance waste will be packed in vessels, typically 200-liter drums. Before waste is packed in the storage or disposal vessels, its volume will be decreased using various methods, such as compression or mechanical or thermal cutting. Wet and liquid radioactive waste, ion exchange resins, sludge materials, and concentrates will be processed by drying. Wet waste will be solidified in cement order to facilitate safe handling and final disposal. The properties of the waste will be characterized for further treatment and final disposal of the waste.

For the final disposal of low and intermediate level waste, Fennovoima will build an operating waste repository in the bedrock of the plant site, at a depth of approximately 100 meters. The operating waste repository for low and intermediate level waste may be either a rock silo or a tunnel. Of these, the latter solution is more probable. In the case of a tunnel-type repository, the waste would be transported in via a vehicle access tunnel. Very low level waste may also be placed in a surface repository on ground level. Should Fennovoima decide not to build a surface repository, the very low level waste will be disposed of in the operating waste repository in the same way as low and intermediate level operating waste.

Spent nuclear fuel

Following removal from the reactor, the spent nuclear fuel will be transferred to the reactor hall water pools, where they are allowed to cool down for 3–10 years. From the reactor hall, the spent fuel will be transferred to interim storage, where it will remain for a minimum of 40 years prior to final disposal. During the interim storage period, the activity and heat generation of the spent fuel will continue to decrease significantly. After the interim storage, the spent fuel will be transported to a final disposal site built for this particular purpose.

Water pools or dry storage will be used for interim storage of the spent nuclear fuel. The water pools will be located in a building made of steel-reinforced concrete, for instance. The water will act as a radiation shield and cool the spent fuel. In dry storage, the spent fuel is packed in special containers designed for the purpose.

The spent fuel will be disposed of in the Finnish bedrock. The final disposal will be implemented using the KBS-3 concept developed in Sweden and Finland. In the final disposal solution following this concept, the spent fuel will be encapsulated in copper canisters, surrounded with bentonite clay, and deposited in deposit holes drilled deep in the bedrock. As the disposal of spent fuel will not begin until the 2070s at the earliest, technological developments in the field can also be taken into account in the planning of Fennovoima's final disposal solutions.

At present, Fennovoima is preparing an overall plan on the final disposal of spent nuclear fuel. One of the main goals of the overall plan is to determine an optimal final disposal solution which will be able to, for its part, promote cooperation between Fennovoima and the other Finnish parties under the nuclear waste management obligation.

A condition included in the Fennovoima Decision-in-Principle states that Fennovoima must have an agreement on nuclear waste management cooperation with the parties currently under the nuclear waste management obligation or start its own EIA procedure for the final disposal project by summer 2016. The final disposal of Fennovoima's spent fuel will require the completion of an EIA and a Decision-in-Principle procedure, as well as a construction license and an operating license, regardless of the location of the final disposal facility.

Water supply

Water consumption and water supply

Fresh water (service water) will be needed at the power plant for potable water and for preparing the plant's process waters. The power plant will consume service water approximately 600 m^3/day. The plan is to obtain the service water from the local municipal water utility.

Cooling water

The cooling water consumption will vary depending on the amount of energy produced. A plant of approximately 1,200 MW will require approximately 40–45 m^3/sec of seawater to cool the condensers. According to the plan, the cooling water will be taken from the harbor basin located on the western shore of the Hanhikivi headland using an onshore intake system and discharged at the northern part of the headland. Major impurities and objects will be removed from the cooling water before it is led into the condensers. After the cooling water has passed through the condenser, it will be discharged back into the sea through the cooling water discharge channel. The temperature of the water will rise by 10–12 °C in the process.

Wastewater

The power plant will generate wastewater both as a result of using potable water and through the operation of the plant. Sanitary wastewater will include water from sanitary facilities and shower rooms, for example. The plan is to transfer the sanitary wastewater to the municipal wastewater treatment plant. Wastewater generated during the operation of the plant will include various types of washing water, wastewater resulting from the production of the circulating water, and wastewater from operation. These will be properly treated and either taken to the municipal wastewater treatment plant or discharged into the sea.

4 Present state of the environment

Location and land use planning

The project site is located in Northern Ostrobothnia on the western coast of Finland on the Hanhikivi headland in the municipalities of Pyhäjoki and Raahe (Figure 5). The Hanhikivi regional land use plan for nuclear power, partial master plans for the nuclear power plant site in the areas of Pyhäjoki and Raahe, and local detailed plans for the nuclear power plant site in Pyhäjoki and Raahe have been ratified for the Hanhikivi headland area.

The immediate surroundings of the Hanhikivi headland site are sparsely populated and no industrial activity is

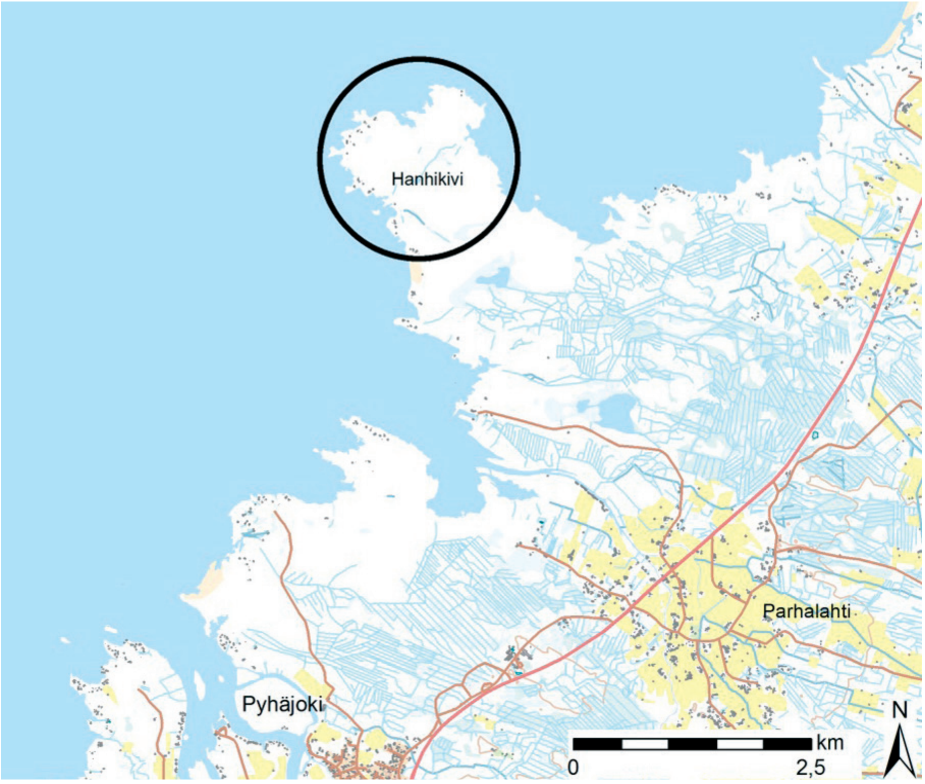


Figure 5. Location of the power plant site in the area of the Hanhikivi headland.

practiced in the immediate surroundings of the headland. The center of Pyhäjoki is located a little over five kilometers south of the headland. The center of Raahe is located approximately 20 km from the headland. The village of Parhalahti located a little over five kilometers from the nuclear power plant will be included in the plant's five-kilometer protective zone. Approximately 440 permanent residents live within the protective zone. There are 11,600 permanent inhabitants within a twenty-kilometer radius of the site. There are approximately twenty holiday homes on the Hanhikivi headland and a couple of hundred holiday homes with the twenty-kilometer zone.

Main road 8 (E8) is approximately six kilometers from the nuclear power plant site. The closest railway station and port are in Raahe. The closest airport is in Oulu, approximately 100 km from Pyhäjoki.

Natural conditions

The Hanhikivi headland area is low-lying land-uplifting coast, the typical features of which include seaside meadows and paludifing shallow bays. The most prevalent habitat type on the Hanhikivi headland is the forests of land uplift coast. The area is a significant natural forest succession site, but there are no mature forests in the area.

The Parhalahti-Syölätinlahti and Heinikarinlampi Natura 2000 area is located approximately two kilometers to the south of the project site. The Natura 2000 area is also an avifauna area of national significance, and it is included in the Finnish Waterfowl Habitats Conservation Program.

There are a Finnish Important Bird Area (FINIBA), several nature conservation areas, and other important objects in the immediate surroundings of the Hanhikivi headland. Five endangered or otherwise protected vascular plant species and the moor frog, a species included in the species listed in Annex IV (a) to the Habitats Directive, have been found in the area.

The most significant bird flocking areas are Takaranta to the east of the project area and Parhalahti. A large number of bird species have been found in the areas due to the varied habitats. Most of the areas important in terms of avifauna are located in the coastal area of the Hanhikivi headland that includes water areas, coastline, and representative forest compartments. The proportion of deciduous forests in the area is large. This is why specific species have been observed in the area in large quantities.

The loose soil in the Hanhikivi headland is mainly moraine. The bedrock is mainly metaconglomerate. The Hanhikivi headland area has been classified as a valuable area in terms of nature and landscape, and it is also a valuable bedrock area. There is a boundary mark originating from historical times, Hanhikivi, on the headland.

The nearest classified groundwater area is located approximately ten kilometers from the Hanhikivi headland.

Water systems

The coastline around the Hanhikivi headland is very open, and water changes efficiently in the area. The depth of the water around the Hanhikivi headland increases very slowly, initially at a rate of one meter per 100 m distance. The water quality at the Hanhikivi headland depends on the general state of the Bay of Bothnia and water coming from the Pyhäjoki river running along the coast. Pyhäjoki river empties approximately six kilometers from the plant site on the south side of the Hanhikivi headland. The quality of the seawater in front of the headland corresponds to the water quality typically found along the coast of the Bay of Bothnia. According to the ecological classification of the Finnish environmental administration, the water quality of the sea in front of the Hanhikivi headland is moderate or good, and excellent farther away from the shore (more than two kilometers away). The state of the coastal waters is affected by eutrophication caused by nutrients carried by rivers, as well as the population centers and industries found in the coastal regions. There are several small gloe lakes and one flada on the Hanhikivi headland.

The shores of the Hanhikivi headland are gently sloping and open to the waves. The most sheltered and diverse areas are the shallow bays on the eastern side of the headland. There are not many species of aquatic vegetation. Charophyte meadows, which have been found all along the coastline, are one of the most representative underwater habitat types.

The sea in front of the Hanhikivi headland is significant both in terms of the fish stock and in terms of fishery. The fish species typically found in the area are those typically found in the whole of the Bay of Bothnia. Species of economic significance include the sea-spawning whitefish (*Coregonus l. widegreni*), common whitefish, perch, herring, vendace, sea trout, salmon, and pike. Spawning river lampreys can also be caught in the rivers emptying into the area. Furthermore, endangered graylings have been found in the area. The surroundings of the Hanhikivi headland are an important spawning area for whitefish, herring, and vendace. There are some whitefish and salmon migration routes close to the project area, but they also migrate further out to sea.

5 Assessed environmental impacts

Premise of the assessment

In compliance with the EIA Act, the assessment has covered the environmental impacts of the approximately 1,200 MW nuclear power plant on:

- Human health, living conditions, and wellbeing
- Soil, water systems, air, climate, vegetation, organisms and biodiversity
- Infrastructure, buildings, landscape, cityscape, and cultural heritage
- Utilization of natural resources
- Mutual interdependencies of these factors.

The assessment particularly focused the impacts that deviate from the impacts assessed in the EIA of 2008 or those not covered by the 2008 EIA. Environmental impacts considered significant or felt significant by the stakeholders have also been taken into account.

The impact assessment has utilized the studies and surveys executed for the EIA of 2008, as well as environmental studies and impact assessments of the project completed after said EIA. The studies and surveys prepared earlier have been updated when necessary to correspond to the current situation and the 1,200 MW nuclear power plant currently being assessed. The following additional studies and surveys were implemented for the environmental impact assessment described in this EIA report:

- Resident survey and small group interviews
- Modeling of the spread of radioactive releases in the case of a severe accident
- Noise emission modeling
- Cooling water modeling.

Furthermore, calculations included in the 2008 EIA, such as traffic volume calculations, calculations of the impacts on regional economy, and emissions from the zero-option, were updated.

Land use and the built environment

The land use plans for the nuclear power plant site are legally in force and indicate the areas required by the nuclear power plant. The land use plans enable construction of the planned nuclear power plant on the Hanhikivi headland, and implementation of the project will not require any changes to the current land use plans.

The main buildings and operations of the power plant will be located in the middle and northern parts of the Hanhikivi headland, in an area marked as an energy management block area in the local detailed plan for the nuclear power plant by the municipality of Pyhäjoki. The total block area is 134.6 hectares. The local detailed plans of the municipalities of Pyhäjoki and Raahe for the nuclear power plant site also include areas allocated for buildings required for nuclear power plant support operations.

The construction of the nuclear power plant will change the land use at the actual plant site and in its surroundings. The holiday residences on the western shore will be removed, and it will no longer be possible to use the western shore for recreational purposes. The new road connection planned for the nuclear power plant will not cause any significant changes in the land use of the area. Figure 6 is a modified aerial image indicating what the nuclear power plant would look like on the Hanhikivi headland.

The construction of the power plant will have an impact on the municipalities' infrastructure. It will restrict land use in the plant's protective zone but enable new construction in settlements and villages as well as along roads. Densely populated areas, hospitals, or institutions in which a large number of people will visit or reside, or significant industrial activities which could be affected by an accident at the nuclear power plant, cannot be placed inside the protective zone. Plans for holiday homes or recreational activities in the area must ensure that the preconditions for appropriate rescue activities will not be placed at risk.

The project will increase the significance of Raahe as a strong industrial region, which may improve the preconditions needed for the development of land use.

Landscape and cultural environment

In addition to the actual construction site, landscape impacts during construction work will be caused by heavy traffic required by the transport of large building parts and its requirements, new road connections and the improvement of current roads. High cranes will be visible in the landscape from far away.

The power plant will be placed in a visible area at the tip of a headland reaching out into the open sea. The headland is currently a location that is in its natural state in the landscape. The surroundings of the plant will be clearly different from the environment in terms of size and character, and the plant will clearly change the landscape. The landscape status of Takaranta, a seashore meadow of regional importance, will change.

The status of the nationally valuable Hanhikivi monument of antiquity as part of the landscape and the character of its immediate surroundings will significantly change. The monument will remain accessible.

Soil, bedrock, and groundwater

Normal operation of the nuclear power plant will not have any significant impacts on the soil or bedrock. The risk of soil contamination will be eliminated by proper technical means, such as drainage arrangements for overflow water and wastewater.

Excavation of the bedrock will reduce the geological value of the Hanhikivi headland. As indicated by the land use plans, representative parts of the bedrock will be left visible.

Groundwater level and pressure may decrease during construction and also during operation due to the drying measures of the structures. The project may influence the quality of groundwater, mainly during construction, due to the use of explosives and injecting of the bedrock. The impact on groundwater will remain fairly local and minor when the proper mitigation and prevention means are used.

Flora, fauna, and conservation areas

Some of the forests and seashores on the Hanhikivi headland will be changed into constructed environment, which means that species in those areas will disappear or change. The construction activities will not involve any nature conservation areas or seashore meadows protected by the Nature Conservation Act; nor will the construction activities have any direct impacts on them. Hanhikivi headland is an area of regional significance due to its representative as natural forest succession series of the land uplift coast. The construction activities will cause partial fragmentation of this habitat type, which has been classified as highly endangered.

Figure 6. A modified aerial image of the nuclear power plant on the Hanhikivi headland.

No endangered plants grow in the areas where construction will take place, nor have any Siberian flying squirrels or bat nesting or resting places been found there. Two exemptions from the protection measures have been granted to Fennovoima, one concerning the removal of a small breeding place of the moor frogs and one concerning the transfer of moor frogs from the area to a breeding place suitable for the species. The noise during construction may temporarily disturb the birds close to the power plant construction site and the road.

The discharging of warm cooling water into the sea during the operation of the plant may indirectly contribute to the paludification of the seashore meadows and make habitats less favorable to the protected Siberian primrose.

Construction or operation of the nuclear power plant is not expected to cause any significant adverse impacts on the protected habitats or species or the integrity of the Parhalahti-Syölätinlahti and Heinikarinlampi Natura 2000 area. The area influenced by noise during construction and operation will be less than one kilometer from the power plant site, which means that the noise will not disturb, even temporarily, the avifauna in the Natura 2000 area. The dredging work will cause some turbidity but not – according to the assessment – in the Natura 2000 area. The turbidity of the seawater off the coast of the Hanhikivi headland also naturally increases during storms or periods of heavy rainfall. The cooling water impacts will not extend to the Natura 2000 area.

Water systems and fishery

Impacts of construction

Dredging during the construction of the navigation channel, the harbor area, the auxiliary cooling water inlet channel, and the cooling water discharge area, as well as the construction of protective piers, will cause temporary turbidity of the seawater. The seabed in the area to be dredged mainly consists of quickly settling rough-grained materials, such as sand and gravel. When such rough-grained materials are dredged, the turbidity will spread to approximately 10–100 meters from the dredging or deposit site, while the dredging of more fine-grained materials may cause turbidity of the water in an area extending up to five kilometers from the site. The dredging is not expected to cause any releases of nutrients or contaminants into the sea. There are Charophyte meadows in the cooling water discharge area. These meadows will be lost. The area that will be changed by the construction is small, however. According to the observations made, Charophyte meadows are fairly common in the sheltered bays which can be found along the north and south coastline of the Hanhikivi headland.

Fishing in the construction areas and in their immediate vicinity will not be possible during the hydraulic construction works. The construction activities in the sea area may also drive away fish from a larger area and temporarily influence the migration routes of fish. Excavation, in particular, will cause powerful underwater noise that may drive away fish from an extensive area. The impact will most likely be significant in an area extending at least one kilometer from each blasting place. The construction activities in the sea will destroy some whitefish (*Coregonus l. widegreni*) and herring spawning areas in the dredging areas. The fishing activities in the area mainly focus on whitefish. Whitefish come to the area to feed on herring spawn. Thus, the project may have adverse impacts on the fishing of whitefish in the project site's immediate vicinity.

Impact of cooling water and wastewater

The impacts on water systems include the impacts caused by warm cooling water, purified process and washing waters, and water intake. The purified process water, washing water, and sanitary wastewater will only cause minor nutrient loads when compared to, for instance, the loads entering the sea area through the local rivers. Since the water will also be mixed with the cooling water and the cooling water will be discharged into the open sea area, the eutrophication caused by the waters will be marginal.

The fact that the cooling water used at the power plant will be discharged into the sea will increase the temperature of the seawater close to the discharge place. The power plant's impact on the temperature of the sea has been studied with the help of a three-dimensional flow model.

The temperature of the seawater will increase by more than 5 °C in an area of approximately 0.7 km^2 in the immediate vicinity of the cooling water discharge place, and the temperature of the seawater will increase by 1 °C in an area of approximately 15 km^2. The thermal impacts will be at the highest in the surface water (0–1 meters below the surface) and decrease at greater depths (Figure 7). According to the modeling results, the temperature increase will cease at a depth of more than four meters.

In the winter, the thermal load from the cooling water will keep the discharge area unfrozen and cause the ice to be thinner, mainly to the north and east of Hanhikivi. The scope of the open water area and the area where the ice is thinner will largely depend on the temperature during the early winter. According to the modeling results, the annual differences in the thickness of the ice will even out further into the winter months, as the ice becomes thicker overall, in such a manner that the open water area will be 2.4–2.5 km^2 by February–March. At this time of the year, the open water area will extend approximately 2-5 kilometers from the discharge place and the area with thinner ice approximately 0.5–2 km further than the open water area.

The project is not expected to have any adverse impacts on the zooplankton population: no significant changes in the zooplankton populations of cooling water discharge areas have been observed in Finnish or foreign studies. The project is expected to increase the total primary production of aquatic vegetation and change the composition of species by increasing the growth of filamentous algae in the warming area, for instance. These impacts are expected to extend to roughly the area where the average temperature increase will be at least one degree Celsius. Since no significant changes to the primary production are expected, the amount of organic matter accumulated on the seabed is expected to remain low, which means that no significant impact on the benthic fauna will occur. The cooling water discharges are not expected to cause anoxia in deep water or significantly increased blooming of cyanobacteria.

Possible adverse impacts on fishing include the build-up of slime in nets and, in the summertime, hindering of whitefish fishing, especially in the fishing grounds north of Hanhikivi. The area that remains unfrozen in the winter will hinder ice fishing but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area in the wintertime. The cooling water and the resulting impacts are not expected to influence the ability to use fish as human food.

Radioactive emissions into the sea

Radioactive emissions into the sea will include tritium and other gamma and beta emissions. The emissions will be so low that they will not have any adverse impacts on people or the environment.

The Fennovoima nuclear power plant will be designed so that the emissions of radioactive substances remain below all set emission limits. Furthermore, Fennovoima will determine its own emission targets for the nuclear power plant. These targets will be stricter than the set emission limits. Radioactive liquids will be led to the liquid waste treatment plant where they will be processed so that their activity level will fall well below the emission limits.

The strict emission limits and supervision of the emissions from the nuclear power plant keep the emissions very low. The impact of radiation on the environment will be extremely minor when compared to the impact of radioactive substances existing normally in nature.

Emissions into the air

Radioactive emissions

The radioactive gases generated during the operation of the nuclear power plant will be processed using the best available technology to minimize the emissions. Gaseous radioactive substances will be collected, filtered, and delayed to decrease the amount of radioactivity. Gases containing small amounts of radioactive substances will be released into the air in a controlled manner through the vent stack and the emissions will be measured to verify that they remain below the set limits. The remaining released radioactive substances will be effectively diluted in the air.

The Fennovoima nuclear power plant will be designed so that the emissions of radioactive substances remain below all set emission limits. Furthermore, Fennovoima will determine its own emission targets for the nuclear power plant. These targets will be stricter than the set emission limits. The strict emission limits and continual monitoring will keep the emissions of the nuclear power plant very low. The radiation impact on the environment will be insignificant when compared to the impact of radioactive substances existing normally in nature.

According to the preliminary data, the radioactive emissions into the air will be higher than those of the currently operating Finnish nuclear power plants. The emissions will, however, still remain well below the emission limits set for the currently operating Finnish nuclear power plants. The radiation exposure caused by the emissions will remain low, since with these emission values the radiation dose will remain clearly below the limit value of 0.1 millisieverts per year laid down in the Government Decree (717/2013). For reference, the average annual radiation dose of a person living in Finland is 3.7 millisieverts.

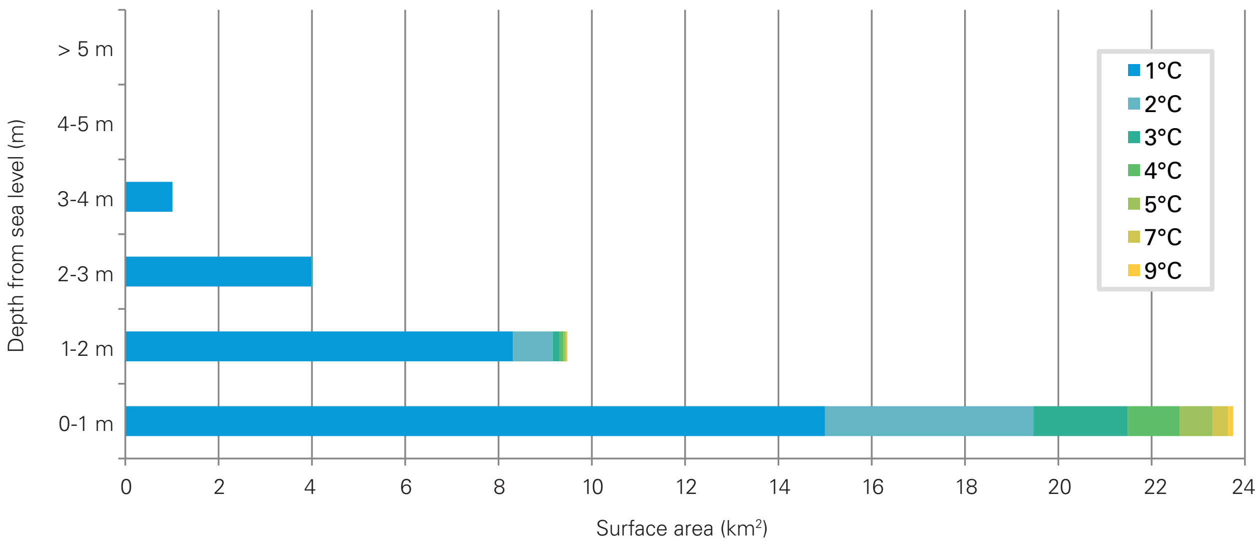


Figure 7. Areas where the temperature increase will exceed 1, 2, 3, 4, 5, 7, and 9 degrees Celsius at the average temperature in June.

Other emissions into the air

Excavation work, construction site traffic, and specific functions, such as rock crushing, will generate dust during the construction of the nuclear power plant. The dust will influence the air quality mainly at the construction site. The traffic emissions will increase significantly during the construction phase, particularly during the period of the heaviest construction activities. Since the air quality in the area is currently good and the period of heavy traffic will be limited in duration, the traffic emissions during construction will not have any significant impacts on the air quality in the area.

During operation of the nuclear power plant, emissions will be generated by the emergency power system and commute traffic. These emissions are not estimated to have any significant impacts on the air quality.

Waste and waste management

The handling and final disposal of the operating waste will not cause any significant environmental impacts when the facilities are properly designed and the waste management actions are properly implemented. Final disposal facilities will be monitored and the radioactive substances contained in the operating waste will become safe for the environment over time.

The handling and interim storage of the spent nuclear fuel will be safe and do not cause any significant environmental impacts due to the careful design and execution of the facilities. During interim storage for decades, the status of spent fuel will be regularly monitored. A separate EIA procedure shall be arranged on the final disposal and transportation of spent nuclear fuel.

The handling of conventional or hazardous waste at the nuclear power plant will not give rise to any environmental impacts. The sorted waste fractions will be processed outside the power plant site in appropriate manner.

Traffic and traffic safety

Traffic volumes will clearly increase during the construction period, particularly during the years when the construction activities are at the heaviest. Traffic volumes on main road 8 to the north of the Hanhikivi headland will increase by approximately 64 %. The increase will be slightly smaller on the south side, approximately 39 %.

The total traffic volume on main road 8 in the immediate vicinity of the intersection leading to the nuclear power plant will increase by approximately 15 %. The volume of heavy traffic will increase by approximately 6 %.

The new road to be built from the main road to the nuclear power plant will be designed to be suitable for power plant traffic. The intersection from the main road will include preselection lanes and the speed limits to ensure the safety and smooth flow of traffic.

Noise

According to noise emission modeling, the noise caused by the project will remain below the guideline values set for residential areas and areas including holiday residences, both during the construction and operation of the plant.

During the noisiest construction phase, i.e. when excavation and rock crushing work is underway, the average daytime noise level at the closest holiday residences will be approximately 40 dB(A). This value still remains clearly below the guideline value for holiday residences of 45 dB(A). The noise level in the closest nature conservation areas (the meadow in the northwestern corner of the Hanhikivi headland and the Siikalahti seashore meadow) may, according to the modeling results, be approximately 50–53 dB(A).

During the heaviest construction phase, the traffic noise of 55 dB(A) and 50 dB(A) from the road leading to the Hanhikivi headland will spread to fairly narrow zones, and there are no residences within the areas affected. The zone where the noise will be approximately 45 dB(A) will extend to a small part of the nature conservation area and an important bird area near the road connection.

The noise carrying from the nuclear power plant during its normal operation to the residential areas and areas including holiday residences will be fairly minor. The average noise level at the closest holiday residences will remain below 30 dB(A). The noise caused by the power plant traffic will also be minor, remaining clearly below the guideline values for residential areas.

People and society

According to the results of the resident survey and group interviews residents and other stakeholders have very different views on the nuclear power plant project and there are local groups both opposing and supporting the project. Opposition is often based on the perceived risks and fears associated with nuclear power plants, and the belief that nuclear power is ethically questionable. The supporters emphasize its positive economic impacts and environmental friendliness.

The municipality of Pyhäjoki will receive major property tax revenue during the construction phase. The revenue will vary in relation to the stage of completion of the nuclear power plant. The annual employment effect of the construction phase in the economic area will be approximately 480–900 man-years. The project will boost business in the economic area, and demand for private and public services will grow.

The property tax revenue to the municipality of Pyhäjoki during the operation phase has been evaluated to be approximately € 4.2 million per year. The annual employment effect in the economic area will be 340–425 man-years. The arrival of new residents, boosted business, and escalated building activity will increase tax revenue. The population base and housing stock will increase.

Normal operation of the nuclear power plant will not cause any radiation impacts on human health. Moving in the power plant site and using the site for recreational purposes will not be allowed, which means that it will no longer be possible to use the area for hunting, etc. Warm cooling water will melt or weaken the ice and, as a result, will restrict recreational activities on ice during the winter, such as fishing or walking. On the other hand, it will extend the open water fishing season.

Impacts of abnormal and accident situations

Nuclear accident

The impacts of a nuclear power plant accident have been assessed based on a severe reactor accident. The spread of any radioactive release caused by a severe accident, the consequent fallout, and the radiation dose received by the general public have been modeled in compliance with the requirements laid down in Government Decree (717/2013) and the YVL Guides of the Radiation and Nuclear Safety Authority. The modeling results are indicative only, and they are based on assumptions in which the radiation doses have been overestimated. More detailed studies of nuclear safety and accident situations, and their consequences required by the nuclear energy regulations will be executed as the project proceeds.

The assumed release in this survey was the severe accident limit value laid down in the Government Decree (717/2013), a cesium-137 release of 100 TBq, which corresponds to an INES 6 accident.

The modeled severe reactor accident would not cause any direct or immediate health impacts on people in the immediate vicinity of the facility. The radiation doses during the first two days after the accident would be a maximum of 23 mSv if no civil protection actions were implemented. The dose is clearly below the limit for showing changes in the blood count, which is 500 mSv. The radiation dose caused by the release during the entire lifetime of a person living five kilometers from the plant would be approximately 150 mSv for a child (over the course of 70 years) and approximately 76 mSv for an adult (over the course of 50 years). Theses doses are lower than the dose received by the average Finn during their entire lifetime from natural sources.

In the case of the modeled severe accident, all the people living less than two kilometers from the plant would have to be evacuated. People living up to three kilometers from the plant would have to take shelter indoors. Children living up to five kilometers from the plant should take an iodine tablet. There would be no need for adults to take an iodine tablet, however.

Short-term restrictions on the use of agricultural and natural products could be necessary. The use of mushrooms as food might have to be restricted in an area extending to around 50 km from the plant in the direction the emissions have spread. The use of freshwater fish as food might have to be restricted in an area extending to around 300 km from the plant. The use of reindeer meat might have to be restricted in an area extending up to 1,000 km from the plant in the direction the emissions have spread.

Other abnormal and accident situations

Other potential abnormal and accident situations mainly include chemical and oil leaks that may contaminate the soil or groundwater. Furthermore, situations posing a radiation danger may occur due to fire or human error, for example. Such situations will be prevented by means of technical measures and by training personnel.

Decommissioning of the power plant

The impacts of decommissioning will remain minor, provided that the radiation protection of the people participating in the decommissioning is properly arranged. Waste generated during the demolition phase will be similar to the waste generated during the plant's operation, and it can be treated in the same way as operating waste. Most of the waste generated during the decommissioning of the nuclear power plant will not be radioactive.

A separate EIA procedure will be executed to assess the environmental impacts of the decommissioning phase of the nuclear power plant.

Nuclear fuel production chain

There will be no impacts from the nuclear fuel production chain in Finland. The impacts will be assessed and regulated in each country producing nuclear fuel according to national regulations.

The environmental impacts of uranium mining operations are connected with the radiation of the uranium ore, the radiation impacts of the radon gas released from the ore, and wastewater. Any environmental impacts caused by the conversion, enrichment, and production of fuel assemblies are related to the handling of dangerous chemicals and, to a lesser extent, the handling of radioactive substances. The environmental impacts of the different stages of the production chain, beginning with mines, will be governed by legislation as well as international standards and audits by independent parties.

Intermediate products transported in the nuclear fuel production chain are, at the most, slightly radioactive. The transport of radioactive substances will be carried out in compliance with national and international regulations on the transport and storage of radioactive substances.

Energy markets

The Fennovoima nuclear power plant will improve the maintenance reliability of electricity supply by reducing Finland's dependence on fossil fuels and imported electricity as well as maintaining the Finnish electricity production capacity. The fact that Fennovoima's nuclear power plant will be built in a new location will also improve the maintenance reliability concerning potential failures in power transmission.

The new nuclear power plant will make Finland more self-sufficient in terms of electricity production.

Zero-option

The assessed zero-option is that Fennovoima's nuclear power plant project will not be implemented. In this case, the impacts of the project described in this environmental impact assessment report will not be realized.

If the new nuclear power plant unit is not constructed in Finland, the same amount of electricity must be produced by other means. The assumption is that, in such a case, 20% of the nuclear power plant's electricity production capacity of 9.5 TWh would be replaced with separate electricity production in Finland. The remaining 80 % would be produced abroad. The replacement electricity would most likely be produced in coal-fired power plants. The production to replace the Fennovoima nuclear power plant in Finland and abroad would cause a little less than seven million tonnes of carbon dioxide emissions, a little less than six thousand tonnes of both sulfur dioxide and nitrogen oxide emissions, and a little less than a thousand tonnes of particle emissions per year. The impacts of the sulfur dioxide, nitrogen oxide, and particle emissions would be mainly local, while the impact of the carbon dioxide emissions would be global.

Cumulative impacts with other known projects

The nuclear power plant and wind farm projects currently active in the region will create an energy production area of national significance. The area that is currently in its natural state or used for agricultural production will become a large-scale energy production zone.

The project may have a cumulative impact with the planned Parhalahti wind farm project in terms of recreational activities, as both the nuclear power plant and the wind farm project will limit land use opportunities and make hunting in the area more difficult.

Dredging to be implemented in connection with the sea wind farm project and a project of soil extracting from the sea could have a cumulative impact on the fish stock and thus fishing as the result of increased turbidity of the water if the dredging and extracting operations are simultaneously implemented.

The environmental impacts of the construction and operation of the grid connection will be assessed in a separate EIA procedure.

6 Transboundary environmental impacts

The normal operation of the nuclear power plant does not cause any transboundary environmental impacts.

In order to assess the impacts of a nuclear power plant accident, the EIA procedure has included dispersion modeling of a radioactive release caused by a severe reactor accident as well as the consequent fallout and radiation dose to population. The studied release was the cesium-137 release of 100 TBq laid down in the Government Decree (717/2013), which corresponds to a severe reactor accident (INES 6). The impacts of a release five times higher than that were also assessed. The release that is five times higher corresponds to an INES 7 accident.

Impacts of the modeled severe nuclear accident

The modeled severe reactor accident would not cause any immediate health impacts on the population in the surrounding areas under any weather conditions. Civil protection measures would not be necessary outside Finland. The radiation dose caused by the accident would remain outside Finland statistically insignificant.

The Hanhikivi nuclear power plant site is located approximately 150 km from the coast of Sweden. If the wind were to blow to the west and the weather conditions were unfavorable, a child living on the coast of Sweden would receive a lifetime dose of a maximum of 8 mSv, and an adult a lifetime dose of 4 mSv at most. At the Norwegian border approximately 450 km from the power plant site, the release would cause a dose of a maximum of 4 mSv for children and 2 mSv for adults. On the coast of Estonia approximately 550 km from the power plant site, the maximum lifetime dose for children would be 3 mSv and 2 mSv for adults. The dose on the coast of Poland approximately 1,100 km from the power plant site would remain below 1 mSv for adults and below 2 mSv for children. The plant site is approximately 1,850 km from the Austrian border in Central Europe. Even if the weather conditions were unfavorable, the release would cause a lifetime dose of 1 mSv at most for a resident of Austria. In comparison, a resident of Austria may during their lifetime receive a dose of more than 200 mSv from natural background radiation.

A severe accident may increase the radioactivity of reindeer meat or freshwater fish species to a level that requires temporary restrictions on their use as food. The use of freshwater fish may have to be restricted in the coastal areas of northern Sweden. The restrictions on freshwater fish can be limited to specific rivers and lakes in the worst fallout zone. The use of reindeer meat may have to be restricted in Sweden, Norway, and the northwestern part of Russia. However, the radioactivity of reindeer meat can be reduced by preventing reindeer from eating lichen, because cesium accumulates in lichen. This could mean that reindeer would have to be transferred from the worst fallout zone. The reindeer could also be kept in enclosures feeding on clean food until the radioactivity in the fallout zone has decreased to an acceptable level. If these restrictions were followed, the radioactivity in reindeer meat or freshwater fish would not pose any danger to people.

Assessment of the impacts of an INES 7 accident

If the release were the release that is five times higher than the 100 TBq release discussed above (more than 50,000 TBq of iodine-131 equivalents), the accident would be classified as an INES 7 accident. Such a high release is theoretically impossible in terms of noble gases, because the release would mean that five times more noble gases than the reactor contains would be released.

Such a fivefold release would not cause any immediate health impacts. If the wind were to blow to the west and the weather conditions were otherwise unfavorable, the lifetime dose of a child on the coast of Sweden would be approximately 37 mSv and the lifetime dose of an adult approximately 18 mSv. Under similar unfavorable conditions, the radiation dose at the Norwegian border could be a maximum of 14 mSv for children and 7 mSv for adults. The radiation doses in the other countries bordering the Baltic Sea would remain below 12 mSv for children and 6 mSv for adults even if the weather conditions were unfavorable. The lifetime radiation dose in Austria would not exceed 5 mSv for children and 2 mSv for adults.

Such a fivefold release would give rise to restrictions on the use of food products outside of Finland. The use of reindeer meat would have to be restricted in the fells of Sweden, Norway, and northwestern Russia, depending on the direction the release has spread. Also depending on the direction the release has spread, restrictions on the use of freshwater fish could be necessary in Sweden, Norway, northwestern Russia, and the Baltic states. If grazing of cattle were not limited, restrictions on the use of meat could be necessary in the coastal areas in northern Sweden.

7 Comparison of the alternatives

The differences between the impacts caused by the currently assessed plant of approximately 1,200 MW and the impacts caused by the 1,800 MW plant assessed in 2008 are mainly due to updates made in the project's technical design, new data on the present status of the environment, and stricter safety regulations. According to the assessment, the plant size or the specified plant type will not change the environmental impacts in any significant way.

The environmental impacts caused by the 1,200 MW plant are different from the impacts caused by the previously assessed 1,800 MW plant mainly in the following respects:

- The impacts on water systems and fishery will be slightly reduced because, according to the new cooling water modeling results, the cooling water would warm up the seawater in a somewhat smaller area.
- The impacts on flora, fauna, and conservation areas will be slightly reduced due to the lower cooling water load.
- According to the preliminary data for the nuclear power plant type AES-2006, the radioactive emissions into the air will be higher than those from the 1,800 MW plant assessed in the EIA of 2008. The Fennovoima nuclear power plant will be designed so that the emissions of radioactive substances remain below the values given in the preliminary data and reach the level of EIA of 2008 and the emission limits of the currently operating Finnish nuclear power plants at the most.
- The relative increase in traffic volumes is slightly lower than in the previous assessment due to the fact that the current traffic volume has increased and the growth forecasts have been changed. The traffic volumes are still the same for both plant alternatives, however.
- The spread of noise emission during operation of the plant is slightly different from the results of the previous noise modeling due to the changed plant layout. The sources of noise, the magnitude of noise, and the volume of traffic are similar for both plant sizes.
- The volumes of operating waste and spent nuclear fuel will be lower, which means that the impacts will be less.

If the zero-option was chosen, i.e. the project was not implemented, neither the negative nor the positive impacts would be realized. The Hanhikivi headland would remain in its current state. The positive financial impacts (such as improved employment rate and tax revenue) would not occur. Substitutive electricity production would cause environmental impacts, such as emissions into the air.

8 Prevention and mitigation of adverse environmental impacts

An environmental management system will be used to link the nuclear power plant's environmental issues to all of the power plant's functions, and the environmental protection will be continuously improved.

Fears and perceived threats caused by nuclear power can be mitigated by arranging proper communication so that the local residents will have enough information about how the nuclear power plant works and how its safety is ensured. Active communication with all stakeholders can be used to enhance the communication between the organization responsible for the project and the local residents. Furthermore, public events and information events can be arranged locally.

Adverse impacts on people or the environment during construction will be mitigated and prevented by, for instance, performing especially noisy activities at the suitable locations, constructing noise barriers, and guiding and scheduling traffic. The increased turbidity of the seawater due to construction activities in the sea area can be controlled or limited with the data provided by continuously operating measuring buoys on the prevailing flows. Access to the seashore areas at the plant site and other construction site areas including protected species or habitats will be prevented with fences and proper markings.

Social impacts caused by the construction can be mitigated by decentralizing the accommodation facilities of the employees into the neighboring municipalities and arranging a variety of training for foreign and local employees.

The nuclear power plant will be designed so that the emissions of radioactive substances remain below all set emission limits. The best available technology will be used to minimize emissions when handling radioactive gases and liquids during operation, and the emissions will always be kept as low as reasonably achievable. Radioactive emissions will be continuously monitored by means of measuring and sampling.

Fish can be prevented from being drifted into the cooling water intake system through a variety of technical methods and with the technical design of the cooling water intake systems.

The general disadvantages caused by the local warming of the seawater to fish and fishery can be compensated by implementing a fishery subsidy. The disadvantages caused to professional fishermen can be compensated on a case-by-case basis. Paludification of the seashore meadows can be prevented by grazing or clearing common reeds and bushes.

Potential accidents involving the use of chemicals and the processing of radioactive waste will be prevented with technical measures and by providing training to the employees. The power plant facilities will contain systems for the safe handling and transportation of waste and the monitoring of the amount and type of radioactive substances. The spent nuclear fuel will be handled safely at all stages of the waste management process.

The plant will be designed in such a manner that the probability of a severe accident is minimal. The risk of radioactive releases will be minimized by applying the defense-in-depth safety principle. The risk of accidents and abnormal situations will be minimized by applying strict quality and safety requirements, and by applying the continuous improvement principle. The impacts of a release caused by an accident can be clearly mitigated by means of civil protection measures. Protection measures influencing the food industry and restrictions on the use of food products can clearly reduce the radiation dose due to food ingestion.

9 Project feasibility

The project is feasible in terms of the environmental impacts. No such adverse environmental impacts that could not be accepted or mitigated to an acceptable level were identified during the environmental impact assessment.

Furthermore, the project will have positive environmental impacts, such as the impact on the local economy and the fact that the project will increase the local carbon dioxide -free energy production capacity.

10 Monitoring of environmental impacts

The impacts caused by the nuclear power plant's construction and operation on the environment will be monitored with monitoring programs approved by the authorities. The programs will include the monitoring of emissions and the environment as well as detailed reporting procedures.

Radioactive emissions will be monitored by means of process and emission measurements inside the plant and by monitoring radioactive substances and radiation present in the environment. Radioactive emissions into the water and air will be monitored with reliable radiation monitoring systems. The plant's radiation monitoring program will include measuring external radiation with dosimeters and continuously operating meters as well as analyzing the radioactivity of the outdoor air and representative samples of different stages of food chains. This will ensure that the emissions into the air and water will not exceed the plant-specific emission limits ratified by the Radiation and Nuclear Safety Authority and that the radiation exposure caused by the emissions will remain as low as reasonably achievable.

Conventional emissions will be monitored in compliance with the obligations laid down in the water and environmental permits. The monitoring of emissions will include the following, for instance:

- Monitoring water systems
- Monitoring fishery
- Monitoring emissions into the air
- Monitoring noise emissions
- Monitoring flora and fauna
- Waste management record.

The data obtained during the environmental impact assessment and issues raised in the public display events, statements, group interviews, and resident survey will be utilized in the monitoring of the social impact. The working methods created during the EIA procedure can also be utilized when monitoring the social impacts of the project and when communicating with the stakeholders.

11 Permits and licenses required by the project

The EIA procedure does not involve any project-related decisions nor does it solve any issues pertaining to permits or licenses; instead, the objective is to produce information to serve as a basis for decision-making.

The Finnish Government has granted Fennovoima a Decision-in-Principle in compliance with the Nuclear Energy Act (990/1987). Since the project that is being assessed in this EIA was not mentioned as a plant alternative in the original application for a Decision-in-Principle, the Ministry of Employment and the Economy has required further surveys.

According to the Decision-in-Principle, Fennovoima must apply for the construction license in compliance with the Nuclear Energy Act by June 30, 2015. The construction license will be granted by the Finnish Government, provided that the requirements for granting the construction license for a nuclear power plant prescribed in the Nuclear Energy Act are met.

The operating license will also be granted by the Finnish Government, provided that the requirements of the Nuclear Energy Act are met and the Ministry of Employment and the Economy has stated that the provisions for nuclear waste management costs have been made as required by law.

In addition, the project will, at different phases, require permits in compliance with the Environmental Protection Act, the Water Act, and the Land Use and Building Act.

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