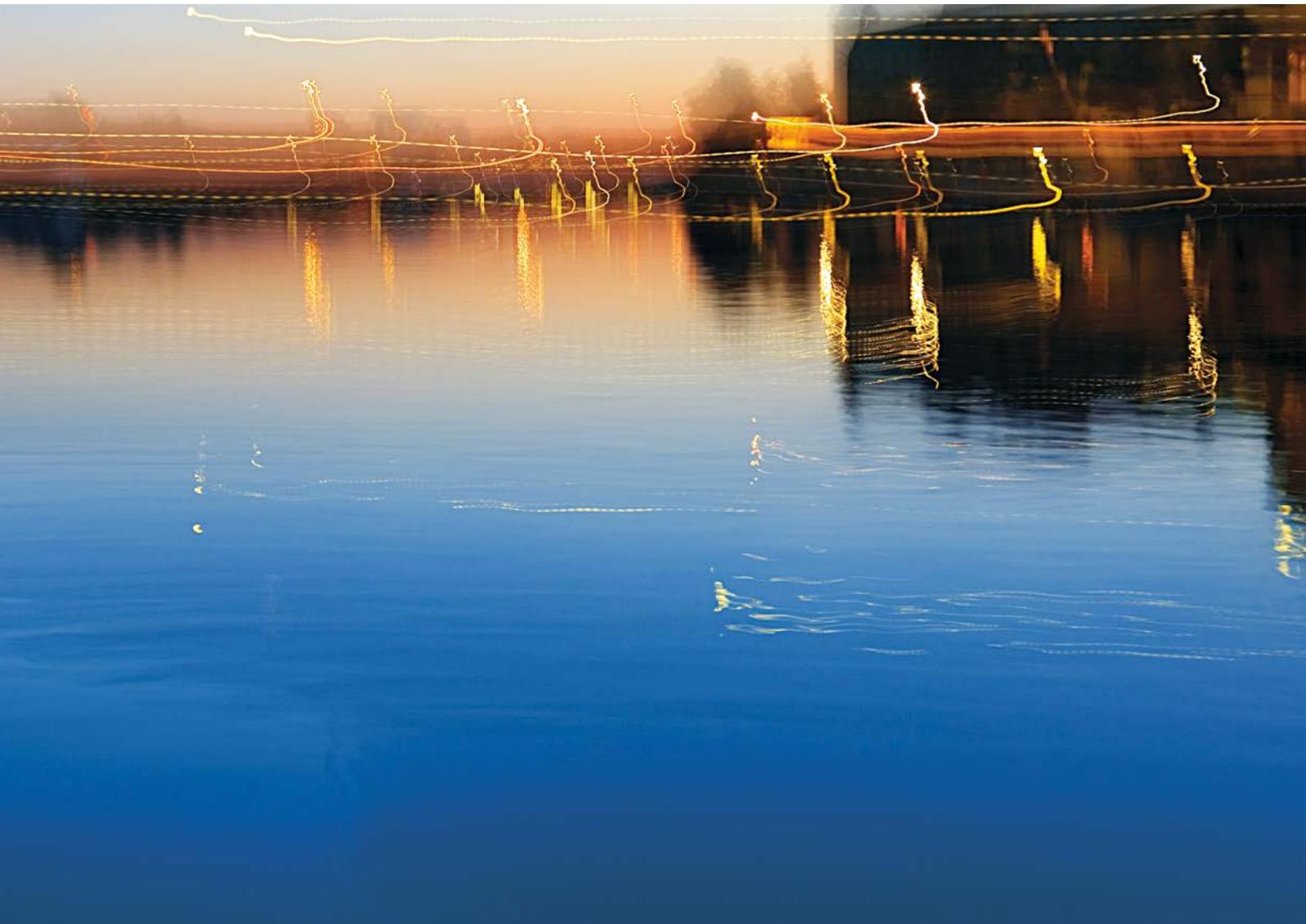


**FENNOVOIMA**

# **Environmental Impact Assessment Program for a Nuclear Power Plant**

September 2013





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# Summary



## Party responsible for the project and project background

Fennovoima Ltd (later on referred to as Fennovoima) is studying the construction of a nuclear power plant with the electric power of about 1,200 MW to Hanhikivi in Pyhäjoki. As a part of the study, Fennovoima is implementing an environmental impact assessment in order to assess the environmental impacts during the construction and operation of the plant in accordance with the Act on Environmental Impact Assessment Procedure (EIA Act, 468/1994).

In 2008, Fennovoima implemented an environmental impact assessment procedure (EIA procedure), which evaluated the impacts of the nuclear power plant with the electric power of about 1,500-2,500 MW, with one or two reactors, in three alternative locations: Pyhäjoki, Ruotsinpyhtää and Simo. In conjunction with the EIA procedure, the international hearing in accordance with the Espoo Convention was also implemented.

On 6 May 2010, the Council of State of Finland granted Fennovoima a Decision-in-Principle in accordance with the Nuclear Energy Act (990/1987) 11 §. The Finnish Parliament confirmed the Decision-in-Principle on 1 July 2010. The Hanhikivi headland in Pyhäjoki was selected as the location for the plant in the autumn of 2011.

Since the project that is the object of this environmental impact assessment was not mentioned as one of the plant alternatives in the original Decision-in-Principle appli-

cation, the Ministry of Employment and the Economy requires that Fennovoima updates the project's environmental impact assessment with this EIA procedure. Simultaneously, the international hearing in accordance with the Espoo Convention will be carried out.

## Alternatives to be assessed

As an implementation alternative, the environmental impacts during the construction and operation of a nuclear power plant with the electric power of about 1,200 MW will be assessed. The plant will be located in Northern Ostrobothnia, at the Hanhikivi headland in Pyhäjoki. The nuclear power plant will consist of one nuclear power plant unit with a pressurized water reactor. The supplier of this nuclear power plant will be a subsidiary of the Rosatom corporation.

The table below presents the preliminary technical specifications of the planned new nuclear power plant.

As a zero alternative, the assessment will estimate the situation, in which Fennovoima will not implement the nuclear power plant project. In the zero alternative, the need for electricity in Finland would be covered by increasing the import of electricity or through power plant projects of other parties.

Specification	Numerical value and unit
Reactor	Pressurized water reactor
Electric power	about 1,200 MW (1,100–1,300 MW)
Thermal power	about 3,200 MW
Thermal efficiency	about 37%
Fuel	Uranium dioxide UO <sub>2</sub>
Thermal load to be discharged to the water system	about 2,000 MW
Annual energy production	noin 9 TWh
Cooling water requirement	noin 40–45 m <sup>3</sup> /s

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

## Environmental impact assessment of the project

The Directive on Environmental Impact Assessment (85/337/EEC) issued by the Council of the European Community (EC) has been enforced in Finland through the EIA Act (468/1994) and EIA Decree (713/2006) by virtue of Appendix twenty of the agreement on the European Economic Area. The stages of the EIA procedure are presented in Figure 1.

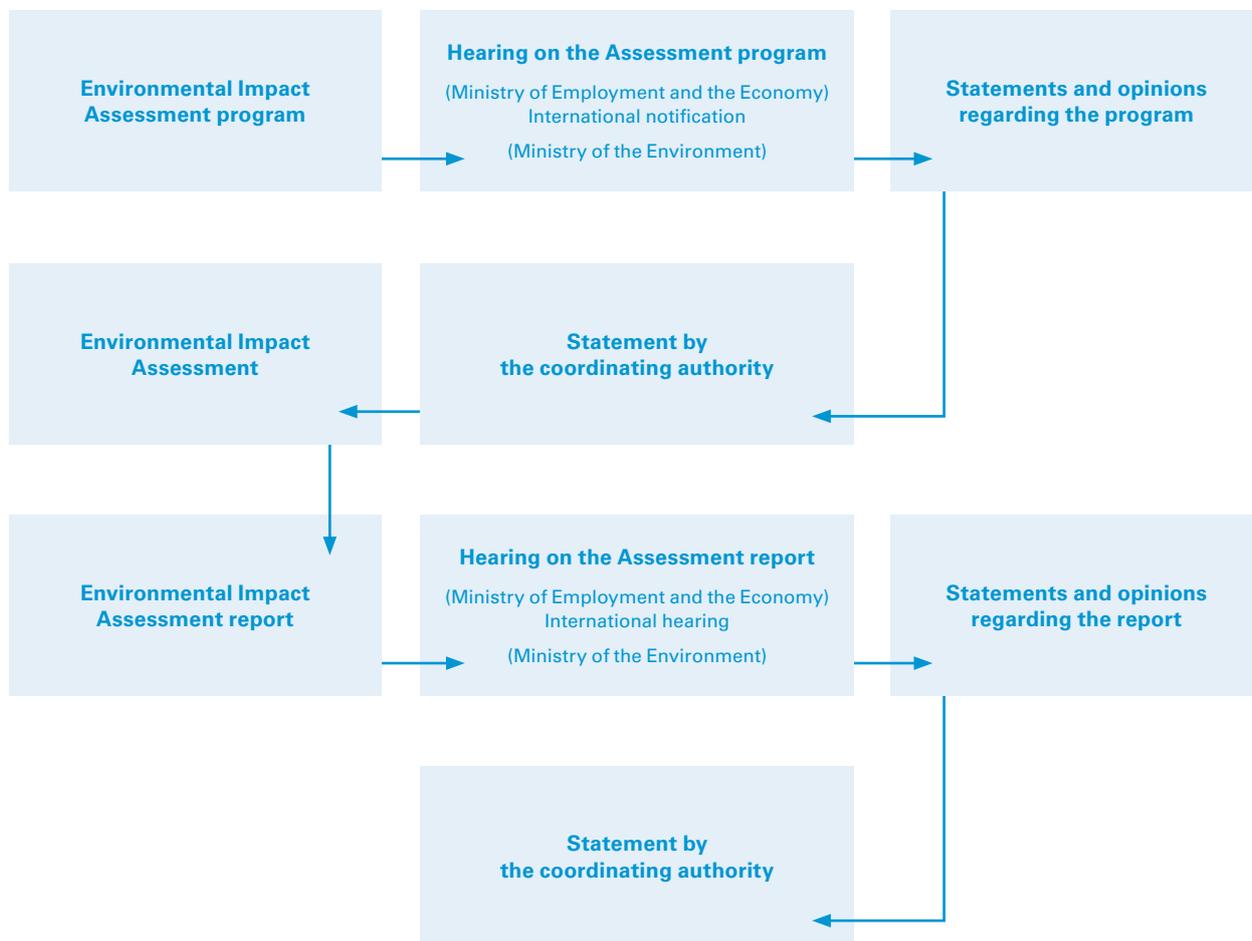
Based on this environmental impact assessment program (EIA program) and the opinions and statements expressed relating to it, an environmental impact assessment report (EIA report) will be prepared. The EIA report presents the data of the project and its alternatives, as well as a uniform assessment on their environmental impacts. The existing environmental studies and studies to be carried out during this environmental impact assessment procedure will be compiled to the EIA report.

In the EIA procedure for a nuclear power plant, the Ministry of Employment and the Economy will act as the coordinating authority. The coordinating authority will request statements from various authorities during the

EIA procedure. Also the residents of the site region, civic and environmental organisations and other stakeholders have the opportunity to take a stand on this EIA program, assessment of the environmental impacts and to the project. The coordinating authority of the EIA procedure notifies of the public display. This states more clearly how and when the opinions can be stated. The EIA report will be displayed publicly in due course, in order to allow expressing statements and opinions.

The Ministry of the Environment will act as the coordinating authority in the international hearing. If the target state decides on participating in the procedure, it will put the EIA program on public display for possible statements and opinions. The EIA report will be displayed in the same way. The statements and opinions expressed will be compiled by the Ministry of the Environment who will pass the data on to the coordinating authority to be taken into consideration in the coordinating authority's statements on the EIA program and the EIA report.

**Figure 1** Stages of EIA procedure.



## Schedule

The main stages of the EIA procedure and the planned schedule are presented in the following figure (Figure 2).

**Figure 2** Planned schedule of the EIA procedure.

Phase	2013					2014						
	8	9	10	11	12	1	2	3	4	5	6	
<b>EIA procedure</b>												
<b>EIA program</b>												
Composing the Assessment program												
Assessment program to the coordinating authority												
Assessment program on display												
Statement by the coordinating authority												
<b>EIA report</b>												
Composing the Assessment report												
Assessment report to the coordinating authority												
Assessment report on display												
Statement by the coordinating authority												
<b>Participation and interaction</b>												
Public hearing events												
<b>Hearing according to the Espoo Convention</b>												
Notification of the EIA program*												
International hearing												
Request for statements*												
International hearing												

\*by the Ministry of the Environment



**Figure 3** Location of the project and the countries in the Baltic Sea region including Norway.

## Description of the environment in the project area

### Location and land use planning

The project site is located on the west coast of Finland in Northern Ostrobothnia, at the Hanhikivi headland in an area of Pyhäjoki and Raahe municipalities (Figure 3). Altogether five different land use plans are legally in force; Hanhikivi regional land use plan, and local master plans as well as detailed master plans for the nuclear power plant area in the municipalities of Pyhäjoki and Raahe.

The immediate surroundings of the Hanhikivi site are scarcely populated. There is no industrial activity in the close vicinity of the headland. The population centre of Pyhäjoki municipality is located approximately five kilometres to the south of the headland. The centre of Raahe is located approximately 20 kilometres away. Approximately 140 people live permanently within a radius of five kilometres from the location area. Within a 20-kilometre radius, the number of permanent inhabitants is 11,300. There are some 20 holiday residences in the area of the Hanhikivi headland, and roughly a couple of hundred holiday residences within a distance of 20 kilometre

### Natural conditions

The Hanhikivi area is low-lying land-uplift coast with typical natural conditions of seaside meadows and low-lying bay overgrown by aquatic plants. The habitat type of the majority of the Hanhikivi headland is land-uplift coastal forest. The area is one of the significant succession forests, but this area is lacking more aged forests.

Less than two kilometres to the south of the project area lies the Natura 2000 area of Parhalahti-Syölätinlahti and Heinikarinlampi. This Natura area is also a nationally valuable wetland for birds and it belongs to the national protection program of valuable bird-rich wetlands. In the vicinity of Hanhikivi there is a naturally valuable classified (FINIBA) avifauna area, several nature conservation areas, and other areas of special attention.

In the Hanhikivi area, the overburden mainly consists of moraine. The bedrock comprises mainly meta-conglomerate. The headland area is classified as valuable rock area. The headland is also the location of a boundary mark, Hanhikivi, dating back to the historical period.

## Environmental impacts to be assessed

The closest classified groundwater region is located at approximately 10 kilometres' distance from the Hanhikivi area.

### Water systems

The coastal water area surrounding the Hanhikivi headland is shallow and its shores are rocky. The shoreline is open and water changes efficiently. Typical to the Gulf of Bothnia, the salinity of the water is low as is the number of species. The land-uplifting constantly changes the low-lying shore zone, which is a mixture of salty, freshwater and brackish water species. The sea area in front of the Hanhikivi headland is significant for both fish stocks and fisheries.

### Noise, traffic and air quality

At present, there are no activities causing significant noise or emissions in the vicinity of the nuclear power plant planned to the Hanhikivi headland area.

Highway 8 (E8) passes at approximately six kilometres distance from the location of the nuclear power plant site. The closest railway station and harbour are located in Raahe. The closest airport is located in Oulu at approximately 100 kilometres distance from Pyhäjoki.

In accordance with the EIA Act, the assessment will include studies of the environmental impacts caused by the approximately 1,200 MW nuclear power plant to:

- human health, living conditions and wellbeing,
- soil, water, air, climate, vegetation, living organisms and diversity of nature,
- community structure, buildings, landscape, cityscape and cultural heritage,
- utilisation of natural resources,
- mutual interdependencies of these factors.

The assessment particularly highlights the impacts that deviate from the impacts assessed in the EIA carried out in 2008 or those not covered by the 2008 EIA. In addition, the environmental impacts that are considered significant or felt as significant by the interest groups will be taken into consideration.

The assessment of the impacts will utilise the assessments performed for the EIA that was prepared in 2008 for the Fennovoima nuclear power plant, as well as other studies of the current state of the environment and environmental impacts of the project, completed after said assessment.

The following table presents a preliminary assessment of the environmental impacts of an approximately 1,200 MW plant compared to the 1,800 MW plant presented in the 2008 EIA, as well as the assessment methods of environmental impacts.

Impact	Preliminary assessment on the environmental impacts of an approximately 1,200 MW plant compared to the 1,800 MW plant presented in the EIA of 2008	Assessment methods
Impacts during construction	There are no significant differences in the impacts, since both the construction work and the duration and extent of construction are similar to those of a plant with a higher electrical power.	Assessment based on the assessments presented in the EIA of 2008 and the present data.
Impacts on air quality and climate	Radioactive emissions in normal conditions are similar, and the radiation dosages caused by them are of the same magnitude.  Other emissions to air and their impacts are of the same magnitude.	Assessment based on the assessment performed in the EIA of 2008 and the present emission data.
Impacts on water systems	Radioactive emissions in normal conditions are similar, and the radiation dosages caused by them are of the same magnitude.  The quantities of cooling and waste waters are smaller, the impact less than in the previous assessment.	The impacts of the cooling waters are assessed by modelling the dispersion of the thermal load to be directed to the water system. In addition to the modelling, the assessment is based on assessments performed in the EIA of 2008 and the updated present-state assessment on the water systems, as well as new emission data.

Impacts of waste and their treatment	The quantity of spent nuclear fuel and operating waste is smaller, in which case the impacts are at the most of the same magnitude. There are no significant differences in the quantity of other waste, in which case the impacts are of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and the present data, as well as additional assessments when necessary.
Impacts on soil, bedrock and groundwater	The extent and dimensions of construction and structures are of the same size or smaller, in which case the impacts are at the most of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the present-state assessments performed after it.
Impacts on vegetation, animals and conservation areas	There are no significant differences in the impacts, since emissions, noise, traffic and thermal load to be directed to the water systems, as well as other factors with possible impact on nature are smaller or of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the present-state assessments of nature performed after it.
Impacts on land use, structures and landscape	There are no differences in the impacts, since the extent and dimensions of construction and structures are of the same size or smaller.	Assessment based on the assessments presented in the EIA of 2008.
Impacts on traffic	There are no significant differences in the impacts, since the necessary transports for materials and personnel are of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the necessary updated.
Noise impacts	The sources and magnitude of noise are similar, so there are no significant differences in the impacts.	Assessment based on the assessments presented in the EIA of 2008.
Impacts of abnormal and accident situations	There are no differences in the impacts, since the requirements by the authorities to be set as the maximum sanction for the various plants due to these situations are the same.	Assessment based on the EIA of 2008 and on the additional assessments of the decision-in-principle.
Transboundary environmental impacts across the borders of the state of Finland	According to the preliminary estimate, the impacts of radioactive emissions generated only by a serious nuclear power plant accident could have impact outside of the borders of Finland.	Assessment based on the assessments presented in the EIA of 2008. Impacts exceeding the borders of the state of Finland are assessed also in conjunction with the international hearing in accordance with the Espoo Convention.
Impacts on people and society	There is no difference with regard to adverse impacts to wellbeing and health, since the emissions, noise, traffic and other factors with possible impact on humans are either smaller or of the same magnitude.  There are no significant differences in the impacts on regional economy and structure, or on the employment.	Assessment based on the assessments presented in the EIA of 2008 and on the assessments performed after it, as well as on a new resident inquiry, when necessary.
Impacts on energy markets	A new nuclear power plant will reduce Finland's dependency on the import of electricity and increase the supply on the electricity markets.	Assessment based on the assessments presented in the EIA of 2008.
Impacts of power plant de-commissioning	There is no significant difference in impacts, since, among others, the structures, methods of dismantling and the quantities of waste are of similar nature.	Assessment based on what was presented in the EIA of 2008.
Impacts of nuclear fuel production	In general terms, the impacts are the same.	Assessment based on the data presented in the EIA of 2008 and on updated dated as far as deviating from the EIA of 2008.
Impacts of associated projects	Associated projects, such as construction and utilisation of transport connections and access power transmission lines are the same, in which case also the impacts will be of the same magnitude. Due to the lower power, the needs for strengthening the power transmission network will be smaller.	Assessment based on the assessments presented in the EIA of 2008.

## Possible transboundary environmental impacts

According to the preliminary assessment, the impacts of radioactive emissions generated only by a serious nuclear power plant accident could extend outside the borders of Finland. This impact will also be assessed in conjunction with the international hearing in accordance with the Espoo Convention.

In conjunction with the 2008 environmental impact assessment and the additional assessment attached to the application for the Decision-in-Principle in 2009, the impacts of a nuclear power plant accident were modelled. The modelling was carried out using general and conservative assumptions which are not plant type specific. Thus the modelling will also apply to the assessment of the nuclear power plant accident of the plant alternative being assessed in this EIA procedure. The modelling studies carried out in 2008 and 2009 considered unfavourable weather conditions, as well as emission from a serious accident, containing 100 TBq cesium-137-nuclides. The modelling studies showed that with the assumed emissions, the need for population protection measures and long-term restriction on the use of land and water areas would be limited within a radius of 150 kilometres from the site in Pyhäjoki.

The EIA report presents an estimate on transboundary environmental impacts due to accident situations on the basis of the assessments described above.

At the present stage, no other impacts that could reach beyond the Finnish borders have been identified for the project. These other possible impacts are studied in more detail in the EIA report.

## Permits required by the project

No decisions relating to the project are made in the EIA procedure. Its objective is to produce information for the basis of decision-making.

Fennovoima has been granted the Decision-in-Principle in accordance with the Nuclear Energy Act (990/1987) for the construction of a nuclear power plant.

Since the project as the subject of this EIA was not mentioned as one of the plant alternatives in the original Decision-in-Principle application, the Ministry of Employment and the Economy has required additional studies.

According to the Decision-in-Principle, Fennovoima shall apply for a construction licence in accordance with the Nuclear Energy Act at the latest on 30 June 2015. The construction licence will be granted by the Council of State, provided that the prerequisites set in the Nuclear Energy Act for granting of a construction licence for a nuclear power plant are met.

The operating license for a nuclear power plant is granted by the Council of State, provided that the prerequisites listed in the Nuclear Energy Act are met and that the Ministry of Employment and the Economy has ascertained that provision for the cost of nuclear waste management has been arranged in a manner required by law.

In addition to the above, the project will in various stages require permits in accordance with the Environmental Protection Act, the Water Act, as well as the Land Use and Building Act.

# Glossary

## Activity (Bq)

Activity states the number of nuclear disintegrations in a radioactive substance per one unit of time. The unit of activity is becquerel (Bq) = one disintegration in one second.

## Bar

The unit of pressure (1 bar = 100 kPa). The atmospheric pressure is approximately 1 bar.

## Boiling water reactor

A type of light water reactor where the water that is used as a cooler and moderator boils when passing through the reactor core. The steam generated in the core is led directly to rotate the turbine.

## Bq (Becquerel)

The unit of radioactivity meaning one radioactive disintegration in one second. The radioactive content of food products is expressed in Becquerel per mass or volumetric unit (Bq/kg or Bq/l).

## Civic defence measure

In a radiation hazard situation that is generated by a serious nuclear accident, the essential protective measures to limit the radiation dosage to the population include shielding from risk indoors, taking iodine tablets and evacuation.

## Cooling water

Cold seawater is called cooling water, with which the steam coming from turbines is cooled back into water in the condenser (condensate). The condensate is pumped back to the reactor

(a boiling water reactor) or the steam generators (a pressurised water reactor) and it is evaporated. Cooling water is not in contact or mixed with the process waters of nuclear power plants.

## Decision-in-Principle

The use of nuclear energy in the production of electricity requires a Decision-in-Principle made by the Finnish Government that is then confirmed by the Finnish Parliament. The total benefit of the society constitutes a requirement of the Decision-in-Principle, as well as a favourable statement from the plant's future location municipality for the project and a positive preliminary safety assessment of the Radiation and Nuclear Safety Authority.

## Efficiency ( $\eta$ )

The ratio between electrical energy produced by a power plant and the reactor's thermal energy.

## EIA

EIA stands for Environmental Impact Assessment. In addition to assessing environmental impact, the object of the statutory EIA procedure is to improve the availability of data for citizens and their possibilities of participating in project planning and expressing their opinions on the project.

## Electric power (W)

The power with which the plant produces electrical energy that is supplied to the power grid.

## Final disposal

The permanent disposal of radioactive waste so that the disposal site does not need to be controlled and the radioactivity does not cause any danger to nature.

## Fission

Nuclear fission is the splitting of the heavy atom nucleus into two or more new nuclei, resulting in a release of a large quantity of energy, neutrons and neutrinos.

## INES

INES stands for International Nuclear Event Scale, which categorises events and accidents related to nuclear safety into eight categories (INES 0–INES 7).

## Ion

An ion is an electrically charged atom or molecule. Radiation that creates ions when hitting a medium is called ionising radiation.

## Ionising radiation

Electromagnetic radiation or particle radiation that produces free electrons and ions when hitting a medium. Ionising radiation can break chemical links within molecules, such as cut a DNA molecule which carries genotypes. As a result, ionising radiation is hazardous to health.

## Isotope

Isotopes are different forms of the same element that differ from each other in relation to the number of neutrons in the nucleus and the properties of the nucleus. Nearly all elements exist as several isotopes in nature. For example, hydrogen has three isotopes: hydrogen, deuterium and tritium, out of which, tritium is radioactive.

## Light water reactor

A reactor type where regular water is used as a cooling agent and moderator in the reactor core. The majority of the world's nuclear plant reactors are light water reactors.

## VVER

A plant series of a Russian pressurised water reactor.

## MW

Megawatt, the unit of power (1 MW = 1,000 kW).

## Nuclear fuel

A uranium- or plutonium-content compound to be used in nuclear power plant reactors that is packed so that it can be formed into a reactor core which causes a chain reaction based on the splitting of nuclei.

## Pressurised water reactor

A type of light water reactor where the pressure of the water that is used as a cooler and moderator is kept so high that it will not boil even at high temperatures. The water that is passed

through the reactor core transfers its heat in separate steam generators to the secondary circuit water which evaporates and is lead to rotate the turbine.

## Radiation

Radiation is either electromagnetic wave motion or particle radiation.

## Radioactivity

Radioactive substances disintegrate spontaneously into lighter elements or transmutations of the same element with smaller energy. The process releases ionising radiation which is either electromagnetic radiation or particle radiation.

## Sievert (Sv)

The unit of radiation dosage. The greater the radiation dosage, the more probable it is that it is hazardous to health. Often, millisievert (mSv) or microsievert ( $\mu$ Sv) units are used (1  $\mu$ Sv = 0.001 mSv = 0.000001 Sv).

## Spent nuclear fuel

Nuclear fuel is said to be used when it has been used in energy production in the reactor and taken out of the reactor. Spent nuclear fuel contains uranium splitting products, such as caesium, and it is highly radiating.

## Thermal power (W)

The power with which the plant produces thermal energy (thermal power).

## TEM

Ministry of Employment and the Economy (Coordinating authority for the EIA procedure)

## TWh

Terawatt hour is a unit of energy (1 TWh = 1 000 000 MWh).

## Uranium (U)

An element whose chemical symbol is U. The volume of uranium in the earth's crust is 0.0004% of all the elements (four grams in a ton). All isotopes of uranium are radioactive. The majority of natural uranium is the isotope U-238, the half-life of which is 4.5 billion years. Approximately 0.71 % of natural uranium is U-235 which is suitable as a fuel in nuclear power plants.

## 1,200 MW nuclear power plant

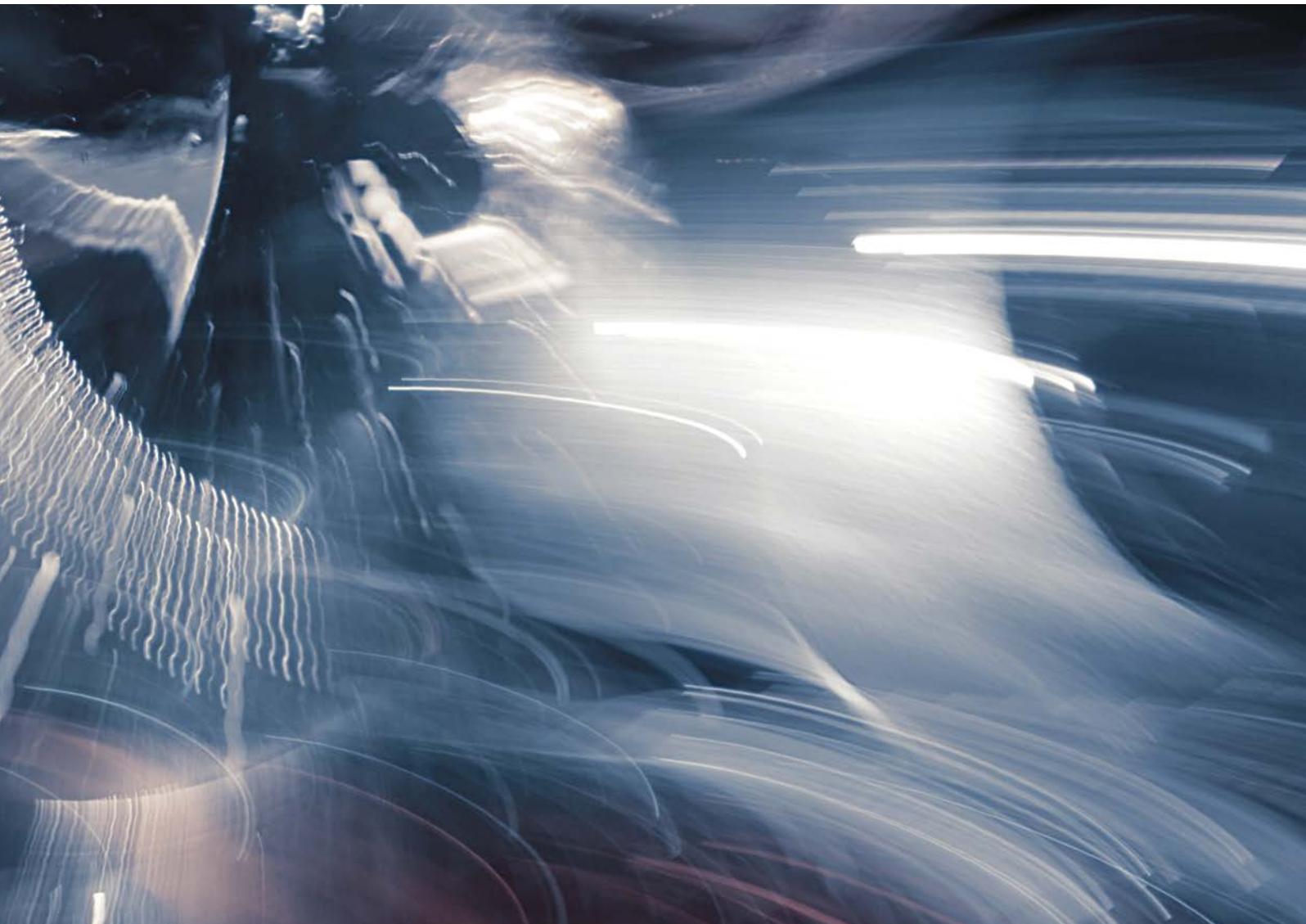
The approximately 1,200 MW nuclear power plants stands for the nuclear power plant with the electric power of approximately 1,100 to 1,300 MW that is being assessed in this EIA procedure.

## 2008 EIA

The environmental impact assessment procedure carried out in 2007 to 2009 for the nuclear power plant of Fennovoima Oy. The EIA report was submitted to the authority in 2008.

**1**

**Project**



Fennovoima Ltd (later on referred to as Fennovoima) is studying the construction of a nuclear power plant with the electric power of about 1,200 MW to Hanhikivi in Pyhäjoki. As a part of the study, Fennovoima is implementing an environmental impact assessment in order to assess the environmental impacts during the construction and operation of the plant in accordance with the Act on Environmental Impact Assessment Procedure (EIA Act, 468/1994).

## 1.1 Project background

In 2008, Fennovoima implemented an environmental assessment procedure (EIA procedure), which evaluated the impacts of the nuclear power plant with the electric power of about 1,500-2,500 MW, with one or two reactors, in three alternative locations: Pyhäjoki, Ruotsinpyhtää and Simo. (*Pöyry Energy Oy 2008a, 2008b*) In conjunction with the EIA procedure, the international hearing in accordance with the Espoo Convention was also implemented.

The Ministry of Employment and the Economy, acting as the coordinating authority, has noted in their statement upon the environmental impact assessment procedure (7131/815/2008), dated 20 Feb 2009, that the content of the EIA report fulfils the prerequisites of the EIA legislation, and the statement of the coordinating authority on the EIA program has been considered in the report. Moreover, the coordinating authority considered that

the EIA report describes the project's environmental impacts and their mitigation measures in an adequate and extensive manner. However, the coordinating authority required Fennovoima to deliver additional clarifications to the ministry for the handling of the application for Decision-in-Principle. Fennovoima delivered the required additional studies in two reports in April 2009 and October 2009.

On 6 May 2010, the Council of State of Finland granted Fennovoima a Decision-in-Principle in accordance with the Nuclear Energy Act (990/1987) 11 §. The Finnish Parliament confirmed the Decision-in-Principle on 1 July 2010. According to the Decision-in-Principle the Hanhikivi headland in Pyhäjoki and Karsikko in Simo are both suitable as the plant location site. The Hanhikivi headland in Pyhäjoki was selected as the location for the plant in the autumn of 2011. After this, all research and construction engineering works have been focused on the said location area, where land use plans of all three different levels of land use planning are legally in force, allowing the construction of a nuclear power plant.

The project that is the object of this environment impact assessment which relates to the approximately 1,200 MW nuclear power plant and whose supplier would be a subsidiary of the Russian Rosatom corporation, was not mentioned as one of the plant alternatives in the original Decision-in-Principle application. Therefore, the Ministry of Employment and the Economy has required that Fennovoima updates the project's environmental impact assessments with this EIA procedure.

## 1.2 Party responsible for the project

Fennovoima Ltd, the company responsible for the project, is a Finnish nuclear energy company that was established in 2007. Fennovoima is owned by Voimaosakeyhtiö SF, under which a total of 60 industrial and commercial enterprises, as well as energy companies, are grouped (Figure 1-1).

At present Rosatom company is negotiating the option to become a minority shareholder in Fennovoima.

## 1.3 Purpose of the project and reasons

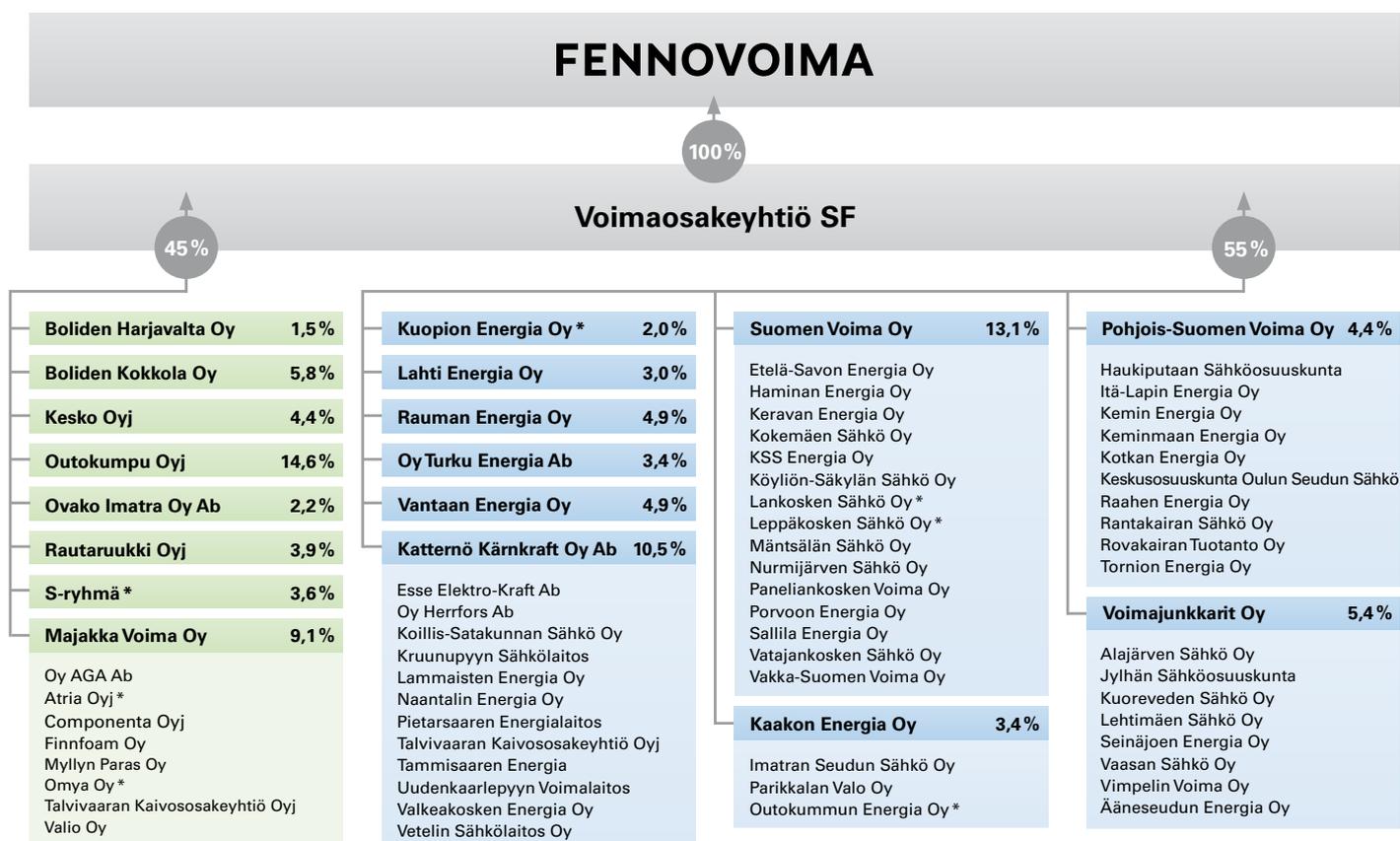
Nuclear power is an economic and efficient way to produce electricity. The price of electricity produced with nuclear power is stable and foreseeable.

Self-owned electricity production with a stable price supports the competitiveness of Fennovoima's owners and helps them operate and invest in Finland. Electricity that is produced by Fennovoima will go directly to its owners for cost price, in relation to the ownership share of each owner.

The ownership of electricity production in Finland is highly concentrated. Through Fennovoima, dozens of new owners will enter the electricity market and increase competition, which will benefit all users of electricity.

Nuclear power supports the climate objectives of Finland, because the electricity production is carbon dioxide-free. In 2012, approximately 20% of the electricity consumed in Finland was imported. Increasing our own production of electricity will decrease Finland's dependency on imported electricity and improve the national security of supply.

Figure 1-1 Structure of Fennovoima shareholders.



\* have renounced their shareholding in Fennovoima

## 1.4 Location and need for land use



Fennovoima's nuclear power plant site is located at the Hanhikivi headland in Pyhäjoki (Figure 1-2). The municipality of Pyhäjoki is located on the coast of the Gulf of Bothnia, between the municipalities of Raahе and Kalajo, in the south-western part of the province of Northern Ostrobothnia. The distance from Pyhäjoki to Oulu and Kokkola is approximately 100 kilometres.

The Hanhikivi site location area is located in the northern part of the municipality of Pyhäjoki, at a distance of less than 7 kilometres from the populated centre of the municipality. The north-eastern part of the Hanhikivi headland reaches the area of the city of Raahе so that the distance from the populated centre of Raahе is approximately 20 kilometres. There is no industrial activity in the location area.

The Radiation and Nuclear Safety Authority (STUK) has prepared a preliminary safety assessment, dated 19 Oct 2009, relating to the nuclear power project of Fennovoima.

Figure 1-2 Location of the municipality of Pyhäjoki.

Figure 1-3 Areas in the possession of Fennovoima at Hanhikivi. Areas in the possession of Fennovoima are indicated in green.



Map © National Land Survey of Finland 2012

voima, in conjunction with the handling of Fennovoima's application for a Decision-in-Principle. As part of the safety assessment, STUK has also assessed the suitability of the Hanhikivi plant site in Pyhäjoki. According to the statement by the Radiation and Nuclear Safety Authority, there are no such characteristics in the conditions of the site area that would prevent the construction of the nuclear power plant in accordance with the safety requirements or the implementation of safety and emergency planning.

A land area of at least 50 hectares will be required for the nuclear power plant buildings. Approximately 15 hectares of this area will be needed as the actual power plant site for the power plant buildings and auxiliary buildings and approximately 35 hectares will be needed for work-site operations during the construction period. In addition, there will be a need for an intermediate storage area for soil, parking area and accommodation areas.

The activities and spatial requirements required by the nuclear power plant have been taken into consideration in the development and land use plans prepared for the nuclear power plant. Land use planning required by the nuclear power plant is legally in force at all three different levels of land use planning: regional land use plan, local master plan and local detailed plan. The land use planning status of the Hanhikivi headland is explained in more detail under chapter 6.1.3.

The nuclear power plant is planned to be built to the central and northern part of the Hanhikivi headland. The majority of the area is in the possession of Fennovoima. At the moment, the company possesses a total of approximately 336 hectares of land and water areas (Figure 1-3). The company possesses areas either directly as the owner, through preliminary agreements for real estate sales or lease agreements. The leases of the areas have been made with an agreement that includes a binding preliminary agreement for the right to purchase the area.

Fennovoima will continue the requisition of areas in the Hanhikivi area with the objective to gain possession of all areas that have been planned for the nuclear power plant and its auxiliary activities in the local detailed plan. The acquisition of areas will primarily continue via voluntary agreements, but in May 2012 Fennovoima has also applied for a redemption permit from the Council of State, based on the Act on Redemption of Real Estate and Special Rights (Act 603/1977).

## 1.5 Estimate on the project schedule

Fennovoima's objective is to make the contract for plant supplying by the end of the year 2013. The scope of supply and the construction schedule will be defined in detail in the contract for supplying the plant. The construction

time period for the nuclear power plant is estimated to be approximately 6 years, but prior to the commencement of the plant construction works, the necessary infrastructure shall be built, and the required earth-moving works and water construction works performed.

The commencement of the nuclear power plant construction requires that the Council of State has granted Fennovoima the construction licence for the construction of a nuclear power plant in accordance with the Nuclear Energy Act.

The earth-moving work and water construction works in the plant area are estimated to start in 2015.

Prior to the commencement of the production of the nuclear power plant, Fennovoima will apply for the operating licence for a nuclear power plant, the environmental permit and other licences that are required for the plant in accordance with the Nuclear Energy Act.

## 1.6 Connection to other projects

### 1.6.1 Power transmission system

The project includes the construction of power transmission line connections from the power plant to the national grid i.e. the high-voltage electricity transmission network covering the entire country. Fennovoima will be responsible for the construction of the power transmission line connections from the power plant and the national grid company Fingrid Oyj (Fingrid) will be responsible for strengthening the network that is required for the national grid. According to preliminary estimations, two power lines of 400 kV and two of 110 kV will be required for the connection of the power plant to the national grid.

The environmental impact of the construction and operation of the power line to the national grid will be assessed in a separate EIA procedure which is expected to be started in 2014. Fingrid has prepared a preliminary study on the connection of the nuclear power plant to the national grid and on the strengthening measures that are required in the national grid. The necessary new power transmission lines have been taken into consideration in the work relating to the provincial land use plan that governs the land use planning in Northern Ostrobothnia. The size and technical characteristics of the plant affect the network solution to be implemented.

The new nuclear power plant may also require an increase in the national reserve power.

### 1.6.2 Disposal of spent nuclear fuel

The project includes the disposal of spent nuclear fuel from the plant operations in Finland according to the requirements of the Nuclear Energy Act. The disposal of spent nuclear fuel requires an EIA procedure and a Decision-in-Principle made by the Council of State.

With regard to the management of spent nuclear fuel, Fennovoima's primary plan is to join the disposal of spent nuclear fuel from the nuclear power plants currently operating in Finland. Posiva Oy (Posiva) is responsible for the disposal of spent nuclear fuel in Finland, and in 2012, it submitted an application to the Council of State, relating to the construction licence for the spent fuel disposal and encapsulating plant.

In 2012, the Ministry of Employment and the Economy set up a task force to guide the joint study of the power companies on the alternatives for the disposal of spent nuclear fuel. In January 2013, the Ministry published the final report of the task force. The most essential recommendation of the end report was that it is purposeful and cost-efficient in the disposal to aim at an optimised solution and to utilise the knowhow and experiences evolved in the industry through the Posiva project.

The Decision-in-Principle for Fennovoima requires that Fennovoima shall at the latest on 30 June 2016 present to the Ministry of Employment and the Economy either an agreement on the cooperation on nuclear waste disposal akin to the one presented in the Decision-in-Principle or an environmental impact assessment program relating to Fennovoima's own spent nuclear fuel disposal plant. In addition to this, the final report of the Ministry of Employment and the Economy also specifies that Fennovoima shall, in conjunction with the application for the construction licence, provide a specification for its disposal project that it has the necessary technological methods available for the implementation of the plans.

### **1.6.3 Nuclear power plant projects in Finland**

In May 2010, in addition to Fennovoima, the Council of State in Finland granted a Decision-in-Principle relating to the extension of TVO's Olkiluoto unit with a fourth unit. The fourth nuclear power plant unit designed for Olkiluoto shall have the electrical power of 1,000 to 1,800 MW. The TVO project is separate from the Fennovoima's nuclear power plant project. However, any combined impacts of the Fennovoima and the TVO project in the immediate vicinity of the sites will be assessed.

# 2

## EIA procedure



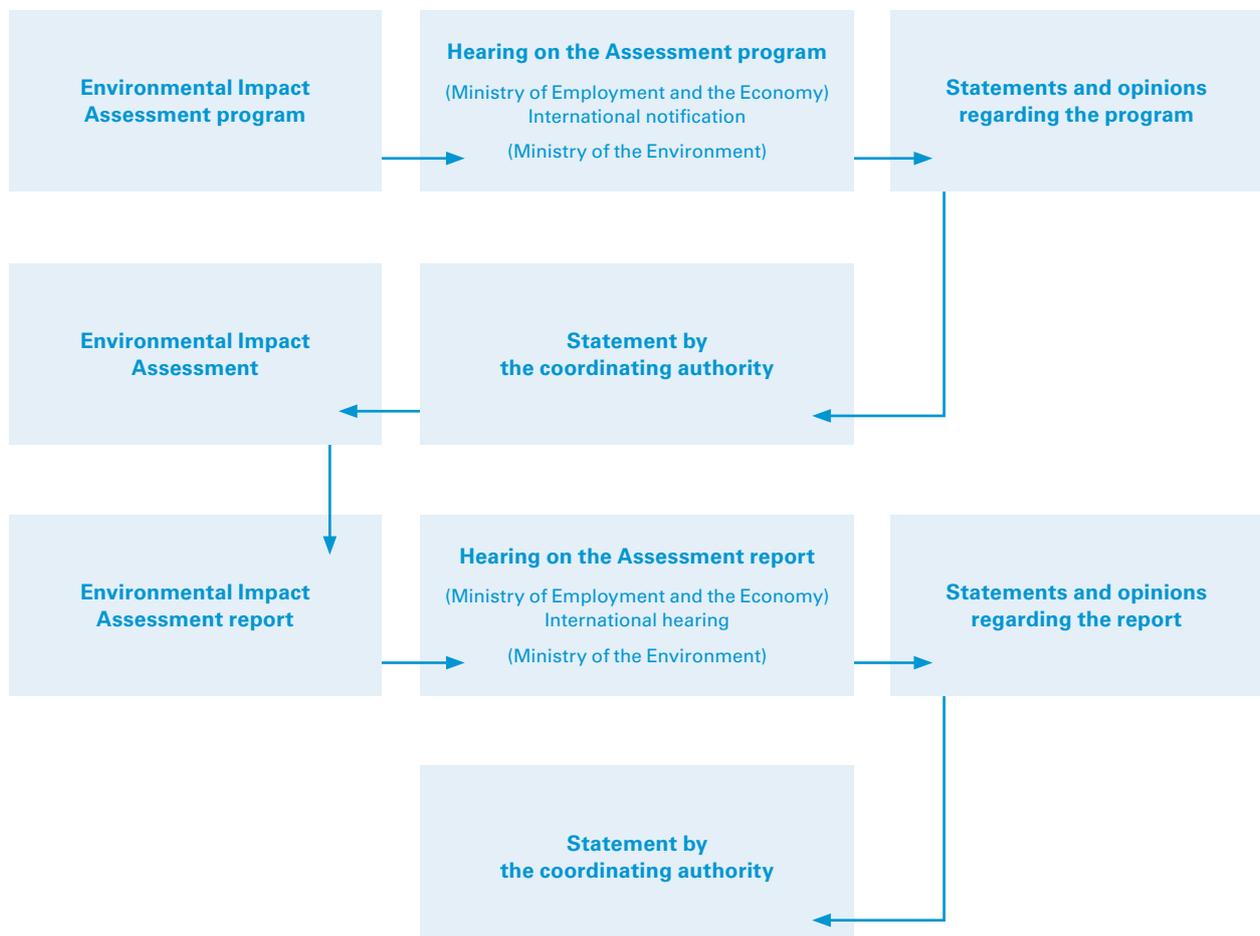
## 2.1 Legislation

The Directive on Environmental Impact Assessment (85/337/EEC) issued by the Council of the European Community (EC) has been enforced in Finland through the Environmental Impact Assessment Act (EIA Act 468/1994) and Decree on the Environmental Impact Assessment procedure (EIA Decree 713/2006) by virtue of Appendix XX of the agreement on the European Economic Area.

According to the Section 4 subsection 1 of the EIA Act (468/1994), the Environmental Impact Assessment procedure shall be applied to such projects and their changes, for which an assessment is required to enforce an international agreement binding on Finland or which may have significant adverse environmental impacts.

The environmental impact assessment across boundaries has been agreed in the so-called Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context). Finland has ratified this Convention of the United Nations Economic Commission for Europe (67/1997) in 1995. The Convention entered into force in 1997. In addition to this, Finland and Estonia have a bilateral agreement (51/2002) on the environmental impact assessment across boundaries. The nuclear power plant belongs to the project under the Espoo Convention, in which the international hearing shall be implemented.

**Figure 2-1** Stages of EIA procedure.



## 2.2 Objectives and contents of the EIA procedure

The objective of the EIA procedure is to improve the environmental impact assessment and uniform its consideration in planning and decision-making. The objective of the procedure is to increase the availability of information to the public and increase their possibilities to participate.

The environmental impacts of the project shall be studied in the statutory assessment procedure prior to commencing any actions that are deemed essential from the environmental impacts point of view. The EIA procedure does not involve any project-related decisions, but its objective is to generate information to back up decision-making.

The EIA procedure includes the program and report stages. (Figure 2-1). The Environmental Impact Assessment program (EIA program) is a plan for implementing the environmental impact assessment procedure and the required additional studies. The Environmental Impact Assessment report (EIA report) presents the characteristics and technical solutions of the project, as well as a uniform estimate on the environmental impacts of the project formed as the result of the assessment procedure.

### Assessment program

At the initial stage of the environmental impact assessment procedure, the EIA program will be prepared. The assessment program is a study on the current state of the project area, as well as a plan (work program) on which impacts shall be studied and how the studies shall be performed. The program presents, among others, the basic data of the project and the alternative to be studied, as well as the communications plan during the EIA procedure and an estimate on the project schedule.

The EIA procedure officially starts when the EIA program is submitted to the coordinating authority. The Ministry of Employment and the Economy will act as the coordinating authority for projects associated with nuclear facilities according to the Nuclear Energy Act. The coordinating authority will announce the public display of the EIA program in local newspapers and on the Ministry's website.

During the display period, citizens may express their opinions towards the EIA program to the coordinating authority. The coordinating authority also requests statements from the authorities on the program. The coordinating authority compiles the opinions expressed and statements on the EIA program, and will then issue its own statement based on these to the party responsible for the project.

### Assessment report

The actual assessment of the environmental impacts will be carried out based on the assessment program and the coordinating authority's statement relating to it, as well as on the basis of other statements and opinions. The results of the assessment work are presented in the environmental impact assessment report. The EIA report, among other things, presents:

- information presented in the EIA program as revised,
- description and technical specifications of the project,
- study on the project's relation to essential plans and programs,
- current state of the environment,
- alternatives to be assessed,
- environmental impacts of the project's alternatives and the zero alternative, and their significance,
- comparison of the alternatives assessed,
- prevention and mitigation methods for adverse impacts,
- proposal for the monitoring program of environmental impacts,
- description of the arrangement of interaction and participation during the EIA procedure,
- description of how the statement by the coordinating authority has been taken into consideration in the preparation of the assessment report.

The coordinating authority will announce the public display of the completed EIA report in the same manner as the EIA program. The assessment report will be displayed for the minimum period of one month, at which point statements will be requested from the authorities, and the inhabitants and other stakeholders will have the opportunity to express their opinions to the authority. The coordinating authority compiles the statements and opinions expressed on the EIA report, and issues its own statement based on these, latest within two months after the termination of the public display. The EIA procedure will end when the coordinating authority submits its statement on the EIA report.

The licencing authorities and the project owners will apply the EIA assessment report and the coordinating authority's statement on it as basic data in their decision-making process. The project-related licence decision must state how the assessment report and the related statement are taken into account in the decision.

## 2.3 EIA procedure schedule

The main stages of the EIA procedure and the planned schedule are presented in the attached figure (Figure 2-2). The environmental impact assessment procedure of the project was started in August 2013 with the preparation of the EIA program. The EIA procedure will be started officially, when the EIA program is submitted to the coordinating authority in September 2013. The environmental impact assessments will be carried out between September

2013 and February 2014. The aim is to submit the EIA report to the coordinating authority in February 2014. The EIA procedure will end at the issuance of the coordinating authority's statement in 2014.

The international hearing according to the Espoo Convention will be arranged during the public display period of the EIA program and the EIA report. The Ministry of the Environment will be responsible for the arrangements.

**Figure 2-2** Planned schedule of the EIA procedure.

Phase	2013					2014					
	8	9	10	11	12	1	2	3	4	5	6
<b>EIA procedure</b>											
<b>EIA program</b>											
Composing the Assessment program	■										
Assessment program to the coordinating authority		■									
Assessment program on display			■								
Statement by the coordinating authority					■						
<b>EIA report</b>											
Composing the Assessment report			■								
Assessment report to the coordinating authority							■				
Assessment report on display								■			
Statement by the coordinating authority											
<b>Participation and interaction</b>											
Public hearing events			■					■			
<b>Hearing according to the Espoo Convention</b>											
Notification of the EIA program*		■									
International hearing			■								
Request for statements*							■				
International hearing								■			

\*by the Ministry of the Environment

# 3

## Communication and participation plan



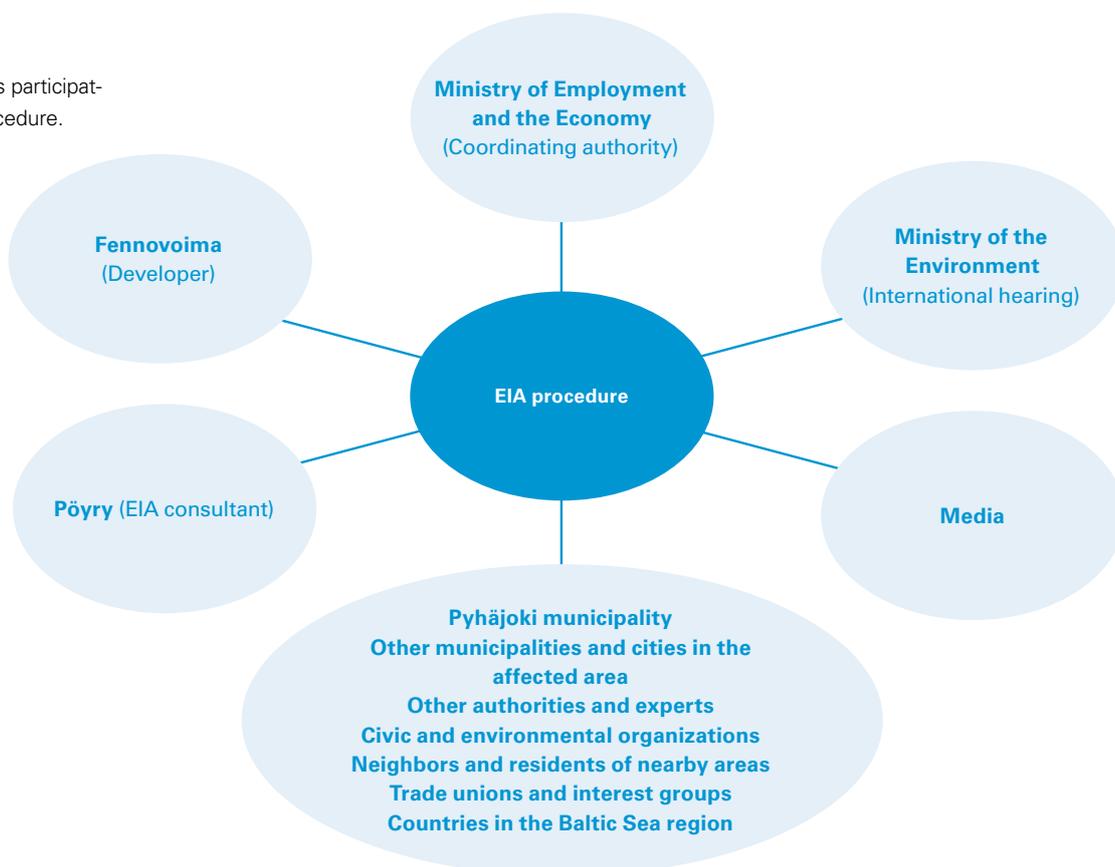
One of the main objectives of the EIA procedure is to improve project communication and the citizens' possibilities of participation. The communication and participation plan of the EIA procedure is presented in the following chapters in accordance with the stages of the EIA procedure. The parties participating in Fennovoima's EIA procedure are presented below (Figure 3-1).

### 3.1 Hearing and discussion events regarding the project's environmental impacts

The Ministry of Employment and the Economy will organise a public hearing event on the EIA program during the public display period of the program. The event shall take place on 17 October 2013 in Pyhäjoki. In the event, the nuclear power plant project and the assessment program will be presented. The public will have the opportunity to express their opinions on the environmental impact assessment work, to receive information and to discuss the EIA procedure with the owner, the coordinating authority and experts who have drawn up the EIA program.

The second public hearing event shall be organised on 14 March 2014 after the completion of the environmental impact assessment report. The results of the environmental impact assessment will be presented in the event. The public will have the opportunity to present their opinions on the environmental impact assessment carried out and on its adequacy.

**Figure 3-1** Parties participating in the EIA procedure.



## 3.2 Display of the assessment program and assessment report

The Ministry of Employment and the Economy will announce the public display of the assessment program after its completion in Pyhäjoki and its neighbouring municipalities. The display will be carried out utilising, among other things, the website of the Ministry of Employment and the Economy, municipal notice boards, as well as local and national media.

The announcement will state where the assessment program is displayed and where the statements and opinions relating to it shall be delivered. The prescribed time for delivering the opinions will start from the date the notification was published. The duration of the prescribed time is a minimum of 30 days and a maximum of 60 days in accordance with the EIA Act. In addition to this, the Ministry of Employment and the Economy will also request statements relating to the EIA program from various communities.

At a later stage of the EIA procedure, the EIA report will be displayed similarly and statements and opinions can be issued correspondingly.

## 3.3 International hearing

The Ministry of the Environment is responsible for the practical arrangements of the international hearing described in the Convention of the United Nations Economic Commission for Europe (67/1997) of the UN Economic Commission for Europe. The Ministry of the Environment will notify the environmental authorities of the neighbouring countries relating to the commencement of the EIA procedure of Fennovoima's nuclear power plant project and inquire about their willingness to participate. The notification will contain the EIA program summary document translated into the necessary languages, as well as the EIA program in Swedish or English.

In case a target country decides to participate in the procedure, it will place the EIA program on public display for possible statements and opinions. The EIA report will be displayed publicly similarly. The statements and opinions issued will be compiled by the Ministry of the Environment that will then pass the information to the coordinating authority in order to be taken into consideration in the coordinating authority's statement regarding the EIA program and the EIA report.

## 3.4 Resident survey

A resident survey will be carried out during the EIA procedure if considered necessary. The purpose of the resident survey is to increase interaction by providing Fennovoima with information about the residents' attitude towards the project and, on the other hand, by providing the residents with information relating to the project and its impact on their living environment.

## 3.5 Other communications

The EIA program and EIA report will be published on the Ministry of Employment and the Economy's website ([http://www.tem.fi/en/energy/nuclear\\_energy/eia\\_procedures\\_for\\_new\\_nuclear\\_power\\_projects](http://www.tem.fi/en/energy/nuclear_energy/eia_procedures_for_new_nuclear_power_projects)).

The EIA report and the EIA program will also be available on the Fennovoima website. The EIA section of the Fennovoima website includes further information on the nuclear power plant project and the procedure relating to it. In addition, the documents will be available at the Fennovoima's office in Pyhäjoki.



# 4

## Alternatives to be assessed



## 4.1 Implementation alternative

As an implementation alternative, the environmental impacts during the construction and operation of a nuclear power plant with the electric power of approximately 1,200 MW will be assessed. The plant will be located at the Hanhikivi headland in Pyhäjoki. The nuclear power plant will consist of one nuclear power plant unit of a pressurised water reactor.

In addition to the nuclear power plant, the project comprises the storage of spent nuclear fuel in the site area, the handling of low- and medium-level operating waste, storage and disposal, as well as the dismantling of the nuclear power plant, and handling and disposal of dismantling waste.

The project includes also:

- Cooling water intake and discharge arrangements
- Service water supply and handling systems
- Wastewater handling systems
- Construction of roads, bridges, embankments
- Construction of a harbour pier and harbour area, as well as a navigation channel for sea transportation.

## 4.2 Zero alternative

As a zero alternative, the assessment will estimate the situation in which Fennovoima will not implement the nuclear power plant project. In the zero alternative, the need for electricity in Finland would be covered by increasing the import of electricity or through power plant projects of other parties.

## 4.3 Previously assessed alternatives

The EIA report carried out in 2008 evaluated four alternative locations for a nuclear power plant: Pyhäjoki (Hanhikivi), Ruotsinpyhtää (Kampuslandet and Gäddbergsö) and Simo (Karsikko). The nuclear power plant alternatives that were assessed were a nuclear power plant consisting of one nuclear power plant unit with an electric power of 1,500 to 1,800 MW and a nuclear power plant consisting of two nuclear power plant units with a total electric power of 2,000 to 2,500 MW.

Construction stages and activities of the nuclear power plant, and their impacts on the environment have been studied in the previous EIA report. The impacts during the operation of the nuclear power plant have been studied separately for the following activities: cooling and wastewater, waste management, transportation and commuting traffic, abnormal and accident situation, combined impacts with other current projects, as well as the transboundary impact outside the borders of Finland. In addition to this, the EIA report describes the supply chain of nuclear fuel, the disposal of spent nuclear fuel and the decommissioning of the nuclear power plant. Based on versatile studies, Fennovoima selected Hanhikivi in Pyhäjoki as the location of the nuclear power plant in 2011.

# 5

## Project description



## 5.1 The operational principle of a nuclear power plant

A nuclear power plant turns heat into electricity similarly to large condensing power plants using fossil fuels. The main difference between a nuclear power plant and a traditional steam power plant is in the heat production method: heat in a nuclear power plant is generated in a nuclear reactor. The fuel used in a nuclear power plant is uranium dioxide (UO<sub>2</sub>) enriched by isotope U-235. The use of uranium as a fuel is based on heat generated in the splitting of atom nuclei i.e. fission. Conditions where the splitting of the U-235 nuclei creates a self-maintaining chain reaction are created in the reactor, resulting in controlled heat production. The fuel is enriched so that it contains 3 % to 5 % of isotope U-235. Natural uranium only contains 0.71 % of this easily splitting isotope.

The fuel is placed inside gas-tight sealed tubes i.e. fuel rods, in the form of ceramic pellets. The fuel rods are compiled as fuel bundles. In the fuel bundles, the fresh nuclear fuel can be handled and transported safely without any separate radiation protection.

When neutrons hit a fissionable atom nucleus (usually U-235), it splits into two lighter nuclei. At the same time, new neutrons, neutrinos and energy are released. Neutrons generated at the splitting of the nucleus can in turn cause new fissions which makes the chain reaction possible. The fission reaction is controlled in the nuclear

reactor, and the energy released in the reactor heats the water to produce high-pressure steam. The steam rotates the turbine which in turn drives the electric generator. More than one third of the thermal energy generated can be converted into electric power.

Heat generated in a nuclear power plant or other thermal power plants (coal, oil and gas plants) cannot be fully converted into electricity. As a result, a part of the heat generated is removed using condensers where the low-pressure steam from the steam turbines releases energy and turns back into water. Conventionally, the condenser is cooled down using cooling water taken directly from the water system. The cooling water is then returned to the water system with a temperature approximately 10 °C higher.

Spent nuclear fuel is highly radioactive. It is stored in an appropriate and safe storage facility, until it can be disposed of in a manner that is safe for people and the environment. In Finland, the disposal shall take place in deep bedrock.

The new nuclear power plant will be a so-called base load plant which means that it will be used continuously at a constant power, with the exception of a few week long maintenance outages that shall be carried out every 12 to 24 months. The estimated operational lifetime of the plant will be at least 60 years.

**Table 5-1** Preliminary technical specifications of the planned new nuclear power plant.

Specification	Numerical value and unit
Reactor	Pressurized water reactor
Electric power	about 1,200 MW (1,100–1,300 MW)
Thermal power	about 3,200 MW
Thermal efficiency	about 37%
Fuel	Uranium dioxide UO <sub>2</sub>
Thermal load to be discharged to the water system	about 2,000 MW
Annual energy production	noin 9 TWh
Cooling water requirement	noin 40–45 m <sup>3</sup> /s

## 5.2 General description of the plant type

The most popular reactor type in the world is the so-called light water reactor. Light water reactors use regular water to maintain the chain reaction and to transfer heat from the reactor. The alternative types of light water reactors are the boiling water reactor and pressurised water reactor. The pressurised water reactor of the planned new nuclear power plant is of the type AES-2006, which is the newest development stage of the Russian pressurised water reactor (VVER). Similar units have been ordered by several countries, in addition to which this plant type is currently being built to Russia. Finland also has extensive experience in Russian pressurised water reactors, as the VVER reactors have been operating in the two nuclear power plant units in Loviisa for more than thirty years.

In a pressurised water reactor, fuel heats the water but high pressure prevents the formation of steam. High-pressure water is led from the reactor to separate steam generators where the water circulates in thin tubes and heat is transferred to low-pressure water in a separate circuit

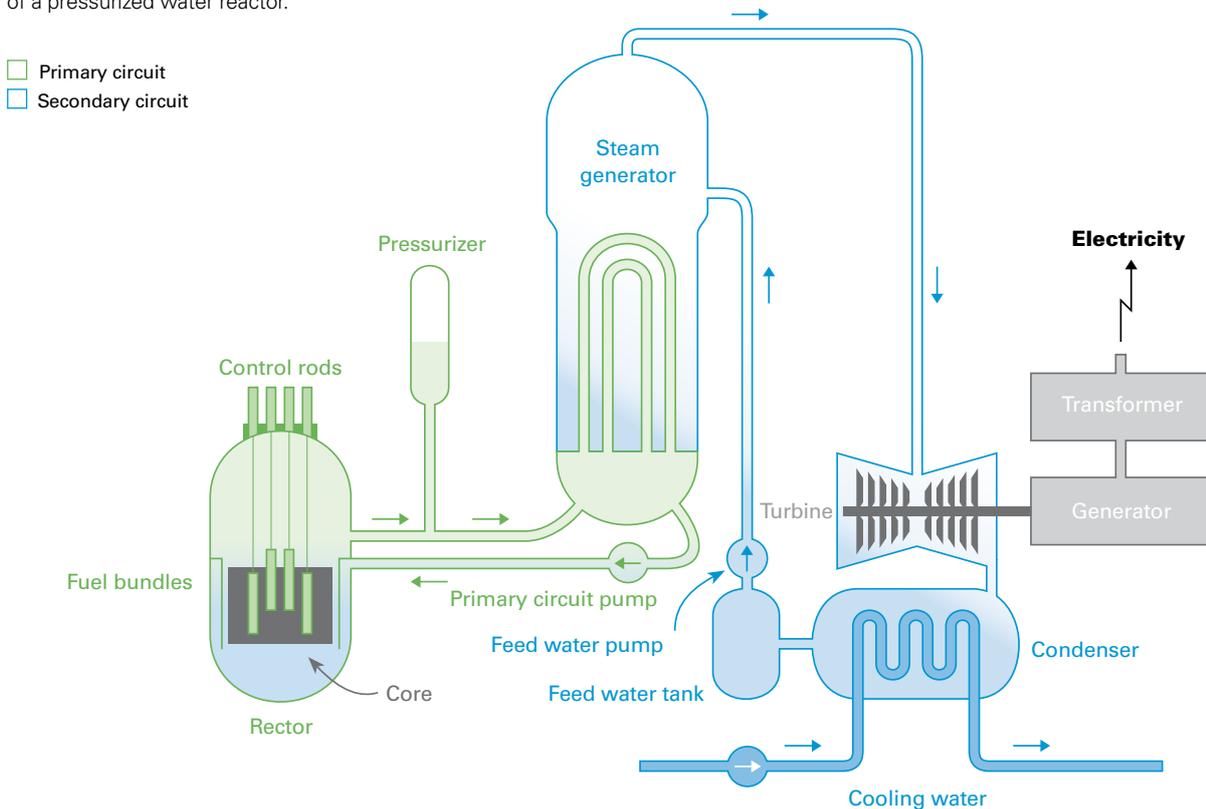
located around the tubes (secondary circuit, Figure 5-1). The water in the secondary circuit evaporates and the steam is led to rotate the turbine and electric generator. From the steam generators, pressurised water is pumped back into the reactor (primary circuit). In the reactor, the pressure is typically about 150 bar and the temperature is approximately 300 °C.

Because of the heat exchanger, the steam of the reactor system and that of the turbine plant are kept separate. As a result, the water in the secondary circuit is not radioactive.

## 5.3 Nuclear safety

The general principles of safety requirements set for nuclear power plants valid in Finland are prescribed in the Government Decrees 733–736/2008, and the details are issued in the YVL Guide (Nuclear Power Plant Guide) published by the Radiation and Nuclear Safety Authority. According to the Nuclear Energy Act, nuclear power plants must be safe and they must not cause any danger to people, the environment or property. The safety requirements must

**Figure 5-1** The operational principle of a pressurized water reactor.



be taken into consideration in the design of the plant. The holder of a licence authorising the use of nuclear energy is responsible for ensuring safe operation.

Nuclear power plants have long been developed, and will continue to be constantly developed with regard to safety and reliability, taking into consideration operating experience, research results relating to safety, as well as the development of science and technology. Safety systems have been improved throughout the years, e.g. by increasing the number of parallel subsystems and by implementing safety functions using several independent operating principles. Moreover, subsystems have been physically separate from each other so that they are not susceptible to a common risk factor such as fire. Nowadays, the design of nuclear power plants prepares for the worst possible accident, the melting of the reactor core. Even though such an accident, a so-called serious reactor accident, is highly improbable, plants must be designed to endure the effects of a serious reactor accident in such a manner that no significant environmental impacts are generated.

Experience gained from the Fukushima accident is also utilised in the safety design of nuclear power plants. The reliability of electric supply in conjunction with various extreme natural phenomena is considered more profoundly in the design of new nuclear reactors. Passive systems will succeed in cooling down the reactor even in possible cases of electric power loss.

The safety of nuclear power plants is based on following the defence in depth principle. Several simultaneous and independent protection levels will be applied to the design and operation of the nuclear power plant. For example, the dispersion of radioactive radiation from the fuel to the environment is prevented by the application of several technical dispersion barriers within each other. Such technical dispersion barriers include ceramic fuel pellets, metallic protective casing of fuel rods and the pressure-proof cooling circuits of the reactor. A gas-tight containment building surrounding the reactor forms the outermost barrier. Each of these barriers must be sufficient to independently prevent the dispersion of radioactive substances into the environment.

Light water reactors are designed to be naturally stable with regard to power control. In case the temperature of the fuel or cooling water rises, the power of the reactor decreases. If there is a cooling water leakage in the reactor the reactor will naturally shut down as the chain reaction stops.

All safety-related equipment and operations are designed based on special safety reviews, assuming even improbable failures and applying sufficient safety margins. In addition, high quality requirements are applied to the manufacture of safety-related equipment. Irrespective of this, all safety-relating planning always starts with the assumption that equipment failure may occur or the plant operator may make mistakes. For failures and mistakes, nuclear power plants are furnished with automatic safety systems.

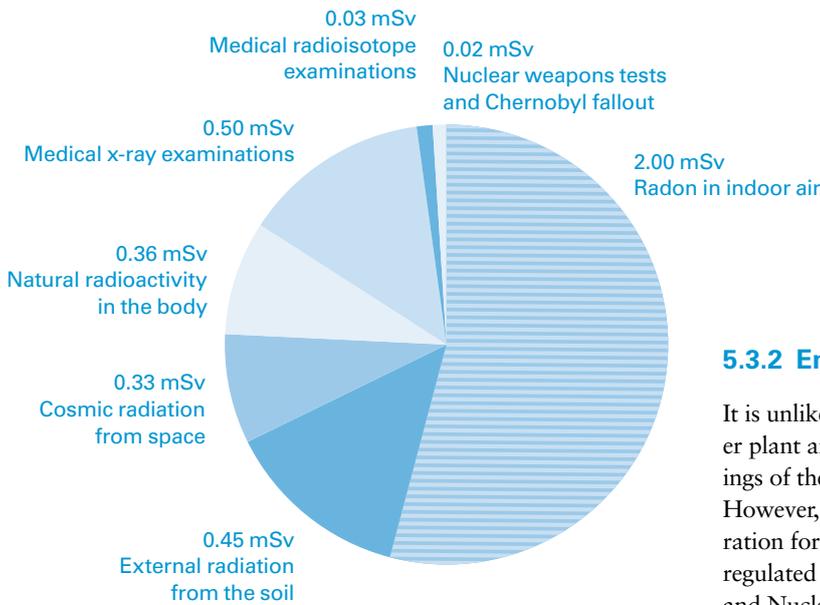
The capacity of safety systems is designed to be manifold in relation to the need so that they can be divided into several parallel subsystems. Due to their multiplicity, the safety systems operate reliably and the reliability can be improved by using several devices of different types to perform one task. For the melting of the reactor core, plants are equipped with special protection equipment and structures. The reliability of plants is maintained through continuous staff training and a high safety culture.

### 5.3.1 Radiation and control

An environmental radiation control program, as referred to in Section 27 of the Government Decree 733/2008 27 § and described in the YVL Guide 7.7 issued by the Radiation and Nuclear Safety Authority, will be drawn up for the plant. This program is used to control the emissions and the content of radioactive substances in the environment. The control program will include external radiation measurement, as well as analyses of air, samples representing the different stages of food chains leading to humans, and determination of radioactivity within the human body. In addition, the program will include samples of so-called indicator organisms that accumulate and concentrate radionuclides from the emissions. The program will define the sampling and analyses to be performed. Samples will be taken from various locations at different times of the year.

The external radiation will be measured continuously, resulting in the real-time data collection of the changes in radiation in the environment. The equipment will be part of the national radiation measurement network, thereby also serving the needs of regional control. The measurement result can be read in real-time, for example, at the Ministry of the Interior and at the Radiation and Nuclear Safety Authority. Radioactive substances can be easily detected in nature using technical measurement devices, and a different substance can be identified from each other even in very small concentrations. Thus it will be possible to identify artificial radioactive substances from nature's own radioactive substances. These include, for example, uranium in the ground and different radioactive products generated as it degrades, such as radon. Radon in indoor air causes more than half (2 mSv) of the annual average radiation dosage of Finnish people (3.7 mSv, Figure 5-2).

In addition to radiation originating from the soil and construction materials, natural radiation includes radiation originating from space and radioactive substances contained in foodstuffs. Depending on the municipality, radiation from the soil varies between 0.17 to 1 mSv/a (Figure 5-3). The highest quantities of external radiation occur in the rapakivi granite area in South-East Finland. The quantity of external radiation in the Pyhäjoki region is at the average level in Finland.

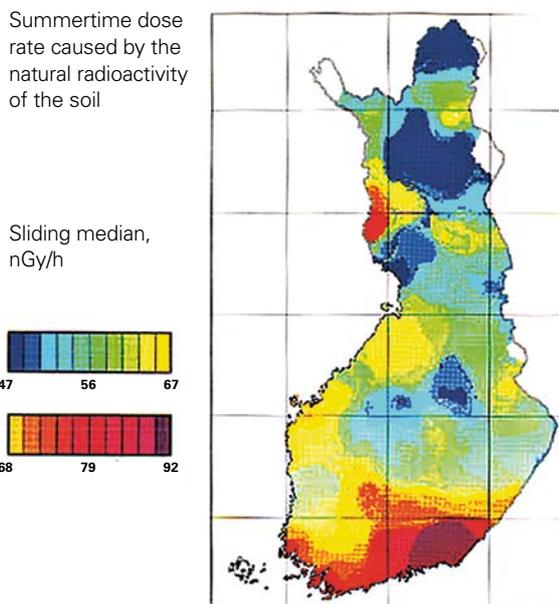


**Figure 5-2** The origin of the annual radiation dosage of Finnish people (an average of 3.7 mSv). (*Radiation and Nuclear Safety Authority, 2013a*)

### 5.3.2 Emergency operations

It is unlikely that an accident could occur in a nuclear power plant and lead to the need to take action in the surroundings of the nuclear power plant to protect the population. However, the principle of defence in depth calls for preparation for emergency operations. Emergency operations are regulated by detailed instruction issued by the Radiation and Nuclear Safety Authority. Emergency operations include plans for protecting people living or staying in the vicinity of the nuclear power plant against the impact of accidents. These emergency operations are described in more detail on the website of the Radiation and Nuclear Safety Authority ([www.stuk.fi](http://www.stuk.fi)) and in the EIA report of this project.

**Figure 5-3** External gamma radiation in Finland. Dosage speed in the air in the summer caused by natural radioactivity in the soil. The share of cosmic radiation (0.032  $\mu$ Sv/h) and neutron radiation (0.011  $\mu$ Sv/h) is not included in the numerical values. Meter reading in the terrain in the area of highest dosage presented on the map corresponds to the value of 0.12  $\mu$ Sv/h (including cosmic radiation). (*Radiation and Nuclear Safety Authority, 2013b*)



## 5.4 Procurement of fuel

The nuclear power plant with electric power of 1,200 MW will use approximately 20 to 40 tons of enriched uranium as fuel per annum. 200 to 350 tons of natural uranium will be required to produce this amount of fuel. Instead of natural uranium, reprocessed uranium can also be used.

When utilising other than natural uranium as fuel, the stages of nuclear fuel procurement include: excavation and enrichment of raw uranium, conversion, isotope enrichment or concentration, and manufacture of fuel bundles. Fennovoima may procure the services included in the above-mentioned stages from the market using long-term agreements with producers.

When utilising natural uranium as fuel, Fennovoima will procure all the procurement stages from the manufacturer of the fuel bundles. In this case, the excavation and concentration of raw uranium will be excluded in full from the supply chain.

Currently the largest uranium-producing countries are Kazakhstan, Canada and Australia. Other significant uranium producers include, among others, Russia, the United States and certain African countries. The most significant conversion plants are located in France, Canada, England, the United States and Russia.

The concentration market is dominated by four suppliers: AREVA (France), Urenco (Great Britain, Germany, and the Netherlands), Tenex (Russia) and USEC (the United States). In addition, Japan, China and Great Britain have concentration capacity. Depending on the plant type, suitable fuel bundle manufacturers are, among others, in Germany, Sweden, France, Great Britain and Russia.

## 5.5 Waste management

The basis for the management of radioactive waste generated in a nuclear power plant is that waste is isolated permanently from the environment. According to the Nuclear Energy Act, nuclear waste shall be handled, stored and disposed of in a permanent manner in Finland. The Nuclear Energy Decree defines in more detail that nuclear waste shall be disposed of in Finnish soil or bedrock. The disposal of nuclear waste is to be planned so that long-term safety can be secured without supervision at the disposal site. According to international and Finnish studies, the required nuclear waste management measures can be executed in Finland in a controlled and safe manner.

Radioactive waste generated in a nuclear power plant includes:

- High-level radioactive waste consisting mainly of spent nuclear fuel,
- Low- and medium-level radioactive operating waste (for example, waste generated during maintenance work at the power plant and waste generated in water purification).

In addition, a nuclear power plant generates conventional waste.

### 5.5.1 Spent nuclear fuel

When the reactor is operating, fission products generated through the splitting of heavy uranium nuclei remain in the fuel. The majority of the fission products are radioactive, so even spent nuclear fuel is highly radioactive.

After removing fuel from the reactor, the spent fuel will be stored for a few dozen years in the intermediate storage for spent fuel to be built next to the power plant, in which case the activity and heat generation of the spent fuel are significantly reduced. The intermediate storage can either be a dry storage or water pool storage. In the dry storage, spent fuel will be stored in capsules that have been designed for this particular use and that are cooled down passively by utilising the circulation of air. The capsules also act as the required radiation shield. The water pool storage consists of approximately 15 metre-deep water pools where water acts as a radiation shield and cools down the spent fuel. After the storage, the spent fuel from the power plant will be transported to the disposal site that is being built for this particular purpose.

According to the Nuclear Energy Act, the producer of nuclear waste shall be responsible for the management of the spent fuel that it has generated until the disposal facilities are sealed, and is obligated to be prepared to carry the costs for nuclear waste management. In order to cover the expenses, a preparation charge is added to the price of nuclear electricity. It is debited annually by the producer of nuclear electricity to the nuclear waste management fund administered by the Ministry of Employment and the Environment.

### 5.5.2 Low- and medium-level operating waste

The majority of waste generated during normal operation is low-level radioactive waste. This waste mainly consists of insulation material, paper, old industrial protective clothing, machine parts, plastic and oil, i.e. ordinary maintenance waste. Low-level operating waste can be further divided into very low-level and low-level radioactive waste types. Medium-level operating waste mainly consists of the ion-exchange masses from the process water purification systems and evaporation waste generated when purifying sewage waters.

Low- and medium level operating waste will be disposed of in the final repository (repository for operating waste). The repository will be constructed in the bedrock of the power plant site, and the construction was approved of by the Council of State in Finland by the Decision-in-Principle granted on 6 May 2010. Very low-level operating waste can be disposed of in a repository to be built separately in the ground, from which they can later be released from supervision once the radioactivity has been reduced to an adequately low level. After this, the waste can be delivered, for example, to recycling, incinerating plants or ordinary landfills. In a solidification plant to be built adjacent to the nuclear power plant, wet medium-level waste shall be dried or solidified into, e.g. concrete and disposed of in the operating waste repository.

### 5.5.3 Conventional waste

Conventional waste (e.g. paper, plastic and food waste) and hazardous waste (e.g. fluorescent lights and waste oils) will also be generated in the plant area. All waste will be managed as required by the power plant's environmental permit.

## 5.6 Radioactive emissions

The nuclear power plant will be designed and operated in such a manner that the quantities of radioactive substances released into the environment remain below the limits set in legislation and in the requirements of the licences.

All radioactive liquids and gases generated in the nuclear power plant will be collected, delayed to reduce radioactivity and filtered or treated otherwise. After filtering or treatment, very small quantities of radioactive substances will be released into the air and water in a controlled manner. Emissions released into the air contain noble gases, iodine, aerosols, tritium and radioactive coal isotope C-14. Emissions released into the water contain fission and activation products, as well as tritium. Emissions to the air will be released through the power plant's stack. Emissions released into the water system will be led to the cooling water channel.

## 5.7 Other emissions

### 5.7.1 Emissions into air

In cases of disturbance in the external power network connections, the electric supply of the nuclear power plant will be secured by diesel generators operating as reserve power source. Approximately 100 MW gas turbine plant will be possibly built in the plant site as a reserve power source for the nuclear power plant and the national grid.

The electric supply to other buildings in the plant site and to external lighting during failure situations will possibly be assured by using secured diesel generators.

The test use of the diesel generators will create some carbon dioxide, nitrogen dioxide, sulphur dioxide and particle emissions. The test use of the gas turbine will create small emissions of nitrogen oxide.

During the construction period, traffic will be heavy, especially in the fourth and fifth year of construction. The traffic quantities are estimated to be approximately 5,000 vehicles per day. During the operation of the nuclear power plant, the traffic is estimated to be approximately 600 vehicles per day.

Traffic will cause particle emissions, nitrogen emissions as well as carbon monoxide and carbon dioxide emissions.

### 5.7.2 Noise

The most noise-causing stage will be the first years of construction, when water construction works, blasting and excavation works and rock-crushing relating to the construction of the cooling water channels and the reactor pit take place. In addition, the construction site and the traffic relating to the site will cause noise emissions. In the operating stage, the most significant sources of noise from the plant area will be unit generator transformers, turbine building, seawater pumping station and the traffic to the site area.

## 5.8 Requirement and supply of water

### 5.8.1 Service water

The requirement for fresh service water in the nuclear power plant during the construction works will be 400 to 550 m<sup>3</sup>/d, depending on the construction stage of the power plant and on the number of constructors on site. When the plant is operating, the requirement for service water is estimated to be 550 to 650 m<sup>3</sup>/d. The majority of the service water, approximately 400 to 500 m<sup>3</sup>/d will be used to make the process water required by the power plant. Process water is produced by removing all salts from the water by using ion exchangers and/or reversal osmotic filters.

Fresh service water will primarily be procured from the water supply plant of the municipality of Pyhäjoki.

### 5.8.2 Cooling water

Part of the heat generated in the nuclear power plant will be conducted to the water system using direct cooling. Seawater will be used for the cooling of the turbine condensers. The planned seawater supply shall take place via a cooling water intake tunnel from the dock basin planned to be constructed to the west side of the Hanhikivi headland. The estimated flow rate of cooling water for a power plant with the electric power of approximately 1,200 MW will be approximately 40–45 m<sup>3</sup>/s applying an even flow of cooling water. The cooling water will be heated in the condensers by approximately 10 to 12 °C. The planned discharging manner of the cooling water to the sea is through shore discharge through the tunnel at the northern part of the Hanhikivi headland. The heated cooling water will mainly spread in the surface layer of the sea. The extent of the water area where the surface is heated by more than one centigrade is highly dependent on the weather conditions.

Alternative for the cooling water intake and discharge locations, as well as cooling methods were studied during the 2008 EIA procedure and later on in studies executed by Fennovoima. Factors taken into consideration in the selection of the planned intake and discharge locations include, among others, the surface and bottom current conditions and depth ratios of the water system, as well as other conditions relating to the status of the water system, its use and the environment.

## 5.9 Wastewater

Blasting, excavation and rock-crushing works will be performed in the nuclear power plant site during the construction stage. These works generate wastewater which contains solids and possibly also oil and nitrogen compounds. Wastewater will be handled appropriately, and their quantity and quality will be controlled regularly. Sanitary water will primarily be purified in the municipal waste water treatment plant.

Wastewater generated in the power plant includes sanitary water and process wastewater. Process wastewaters include, among other things, wastewater from washing plants, and wastewater from the raw water treatment and operations. Wastewater from the power plant will be handled appropriately using different types of purification methods before it is released to the sea or the sewage system. Sanitary water will be led to the municipal waste water treatment plant.

Rain water and general water from the plant area will be led through the necessary sludge separation and oil separation wells to the sea.

## 5.10 Comparison with the nuclear power plant assessed in the 2008 EIA

The following table (Table 5-2) presents the comparison of the characteristic of the approximately 1,200 MW power plant assessed in this EIA with the approximately 1,800 MW power plant assessed in the 2008 EIA. The numeric values in the table relating to the 1,800 MW power plant are based on the 2008 EIA and the more specific data on the characteristics of the plant issued later. The data relating to the 1,200 MW currently being assessed are preliminary estimates and they will be specified in more detail as the design work progresses.

**Table 5-2** Comparison of the characteristic of the approximately 1,200 MW power plant assessed in this EIA with the approximately 1,800 MW power plant assessed in the 2008 EIA.

Specification	Nuclear power plant with approximately 1,200 MW	Nuclear power plant with approximately 1,800 MW
Plant type	Pressurised water reactor	Pressurised water reactor
Electric power	about 1,200 MW	about 1,800 MW
Thermal power	about 3,200 MW	about 4,900 MW
Thermal efficiency	about 37%	about 37%
Fuel	Uranium dioxide UO <sub>2</sub>	Uranium dioxide UO <sub>2</sub>
Thermal load to be discharged to the water system	about 2,000 MW	about 3,100 MW
Annual energy production	about 9 TWh	about 14 TWh
Cooling water requirement	about 40–45 m <sup>3</sup> /s	about 65 m <sup>3</sup> /s
Service water quantity	550–650 m <sup>3</sup> /day	550–650 m <sup>3</sup> /day
Fuel consumption	20–40 t/year	30–50 t/year

Spent nuclear fuel	1,200–2,400 t (during the entire operating time of the plant)	2,500–3,500 t (during the entire operating time of the plant)
Low- and medium-level operating waste	about 5,000 m <sup>3</sup> (during the entire operating time of the plant)	about 6,000 m <sup>3</sup> (during the entire operating time of the plant)
Radioactive emissions to air	The quantity of radioactive emissions will be specified in more detail in conjunction with the composing of the EIA report. According to the preliminary information, the emissions will be similar to and the radiation dosages of the same magnitude as the emissions generated by the pressurised water reactor assessed in the 2008 EIA.	Tritium (T) 519 GBq/v Carbon-14 (C-14) GBq/v Iodines (I-131ekv.) 0.05 GBq/v Noble gases 830 GBq/v Aerosols 0.004 GBq/v
Other emissions to air	Diesel generator: some carbon dioxide, nitrogen dioxide-, sulphur dioxide and particle emissions.  Traffic: some carbon dioxide, nitrogen dioxide-, carbon monoxide and particle emissions	Diesel generator: some carbon dioxide, nitrogen dioxide-, sulphur dioxide and particle emissions.  Traffic: some carbon dioxide, nitrogen dioxide-, carbon monoxide and particle emissions
Radioactive emission to water	The quantity of radioactive emissions will be specified in more detail in conjunction with the composing of the EIA report. According to the preliminary information, the emissions will be similar to the radiation dosages of the same magnitude as the emissions generated by the pressurised water reactor assessed in the 2008 EIA.	Tritium (T) 55 000 GBq/v  Other beta and gamma 25 GBq/v
Noise	During construction noise will be generated by the construction works and site traffic.  In the operating stage, the most significant sources of noise will be unit generator transformers, turbine building, seawater pumping station and traffic.	During construction noise will be generated by the construction works and site traffic.  In the operating stage, the most significant sources of noise will be unit generator transformers, turbine building, seawater pumping station and traffic.
Traffic	During construction, approximately 5,000 vehicles per day.  During operation, approximately 600 vehicles per day.	During construction approximately 5,000 vehicles per day.  During operation approximately approximately 600 vehicles per day.



# 6

## Present state of the environment



## 6.1 Land use and built-up environment

### 6.1.1 Activities located in the area and in its vicinity

The Hanhikivi headland is located in Northern Ostrobothnia in the municipalities of Pyhäjoki and Raahe. Most of the headland, including the planned power plant site, is located in the region of the Pyhäjoki municipality, but a part of the northeast edge of the headland is located in the municipality of Raahe. The power plant location area is roughly indicated in the following figure (Figure 6-1).

The population centre of Pyhäjoki municipality is located approximately seven kilometres to the south of the headland. The village of Parhalahti is located approximately five kilometres away from the planned power plant site. The centre of Raahe is located approximately 20 kilometres away.

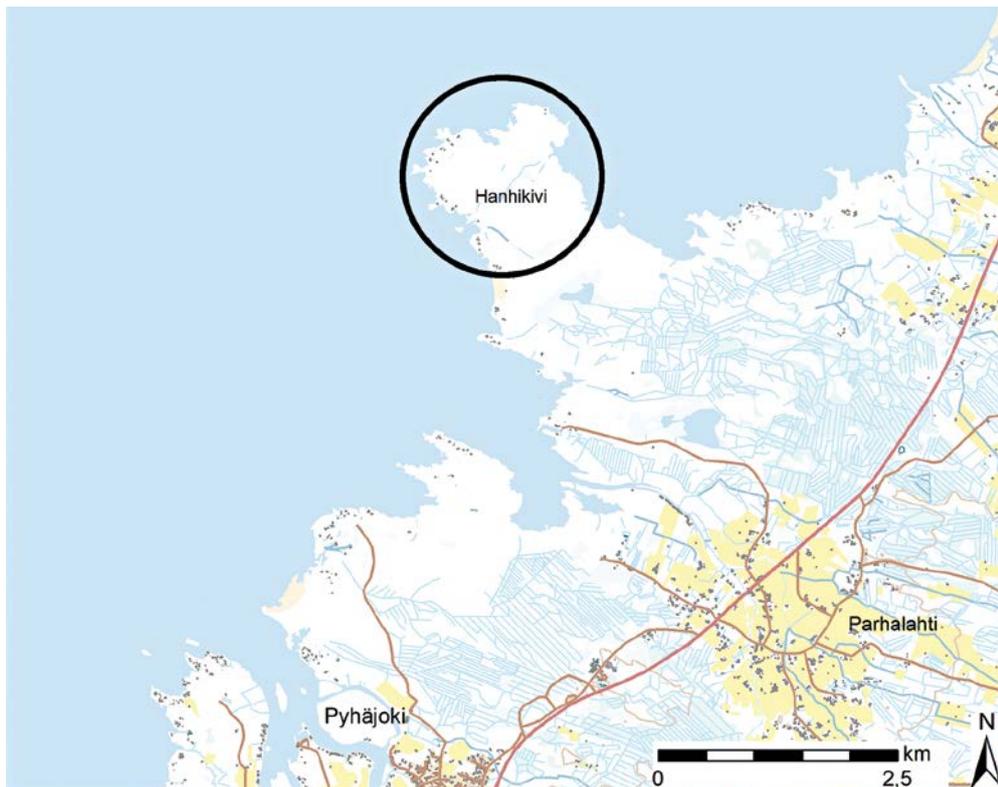
There is no industrial activity in the immediate vicinity of the Hanhikivi headland. There is, for instance, mechanical engineering industry in the Pyhäjoki region. In the town of Raahe, some 15 kilometres from the Hanhikivi headland, on the coast of the Gulf of Bothnia, Ruukki Plc has steelworks, Oy Polargas has air gas plants, and among other things, liquid gas storages. To the south of the municipality of Pyhäjoki, more than 20 kilometres from the Hanhikivi headland, there are danger zones of the Finnish Defence Forces Lohtaja site.

### 6.1.2 National land use guidelines

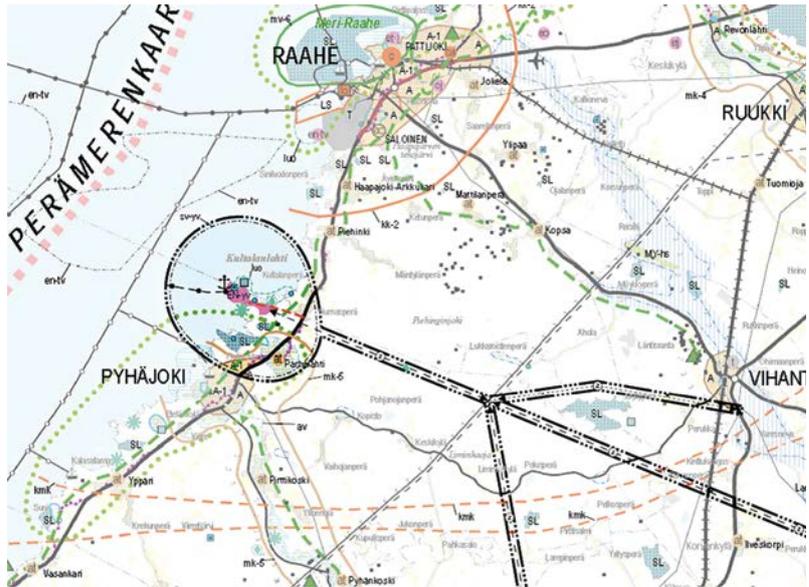
National land use guidelines (VAT) are a part of the land use planning system according to the Land Use and Building Act. The project's relation to the national land use guidelines has been handled in more detail in the Land use plan for a nuclear power plant in Hanhikivi (Council of Oulu Region, 2010) and in the land use specification of the detailed master plan for the nuclear power plant area in Hanhikivi (2010). The national land use guidelines have been adhered to in the land use planning of the area.

### 6.1.3 Land use planning

In the Hanhikivi headland area, land use is controlled by the regional land use plan for a nuclear power plant in Hanhikivi and the local master plans and local detailed plans for a nuclear power plant of the town of Raahe and the municipality of Pyhäjoki.



**Figure 6-1** Location area of the power plant roughly indicated in the area of the Hanhikivi headland.



**Figure 6-2** Hanhikivi headland area in the regional land use plan for a nuclear power plant in Hanhikivi (2010).

### Regional land use plan

The regional land use plan for a nuclear power plant is legally in force for the Hanhikivi headland area. On 7 April 2008, the Board of the Regional council in Northern Ostrobothnia decided to start composing a regional land use plan for a nuclear power plant project to be located in the Hanhikivi headland. The regional land use plan for a nuclear power plant in Hanhikivi was approved in the Assembly of the Regional Council's meeting on 22 February 2010 and ratified in the Ministry of the Environment (Decision No. YM/2/5222/2010) on 26 August 2010. By virtue of its ruling on 21 September 2011, the Supreme Administrative Court (KHO) dismissed two complaints made regarding the ratification of the land use plan, and after the public notices, the regional land use plan for a nuclear power plant has become legally in force.

The Hanhikivi power plant site is included in its entirety in the regional land use plan for a nuclear power plant in Hanhikivi (Figure 6-2). The defining of the land use plan area comprises the planned nuclear power plant and an exclusion area of approximately five kilometres around it, as well as the connection requirements for the power transmission line from the present 220 kV power transmission line to the power plant site, to the 400 kV national grid electric station in Nivala and to the alternative substation in Lumimetsä in Vihanti. In addition, the land use plan contains a reservation for a navigation route to the harbour to be located in the power plant site.

In the regional land use plan for a nuclear power plant, most of the Hanhikivi headland area, in total approximately 300 ha, has been marked as energy management area (EN-yv). The EN-yv area has been reserved for plants, buildings or structures that serve the production of energy, and based on the more detailed land use plans, one or two

nuclear power plant units can be located in the area, as well as a final repository for low- and intermediate level radioactive waste in accordance with the construction licence to be granted on the basis of the Nuclear Energy Act. In addition, auxiliary activities to a nuclear power plant, such as temporary housing and plants and structures relating to water treatment, can be located in the area.

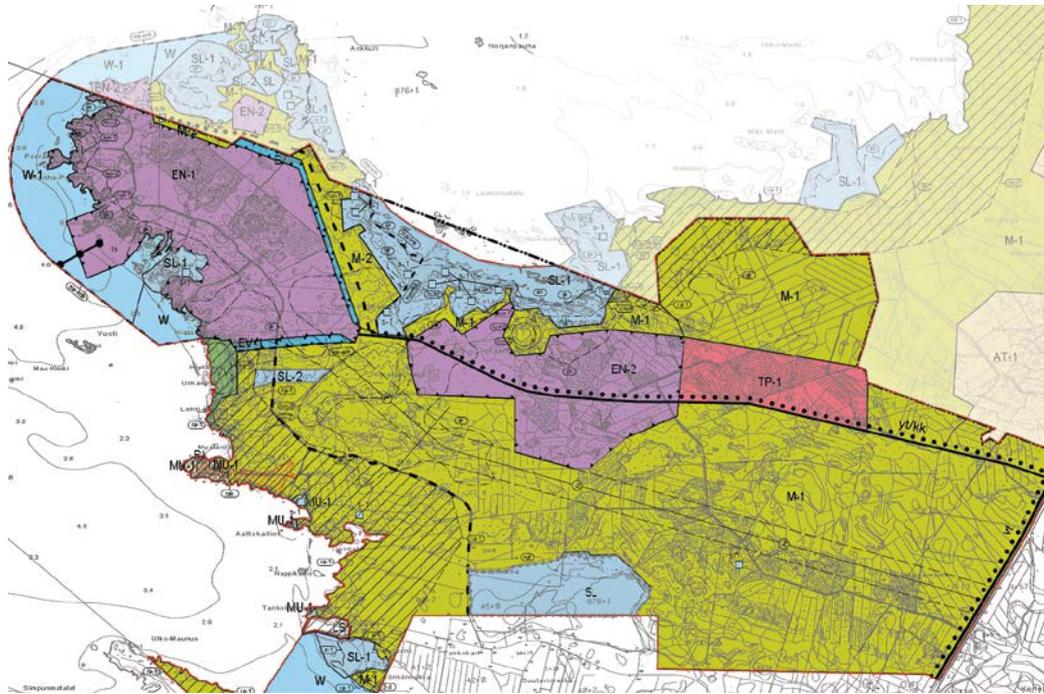
The regional land use plan for a nuclear power plant in Hanhikivi does not allow disposal of spent nuclear fuel in the Hanhikivi region, but spent nuclear fuel can be temporarily stored in the area until it can be transported to the disposal site. The storage time will be approximately 20 to 40 years.

Due to the historical significance of the nationally important Hanhikivi boundary stone located on the boundary of the EN-yv area its surrounding shall be maintained as open as possible.

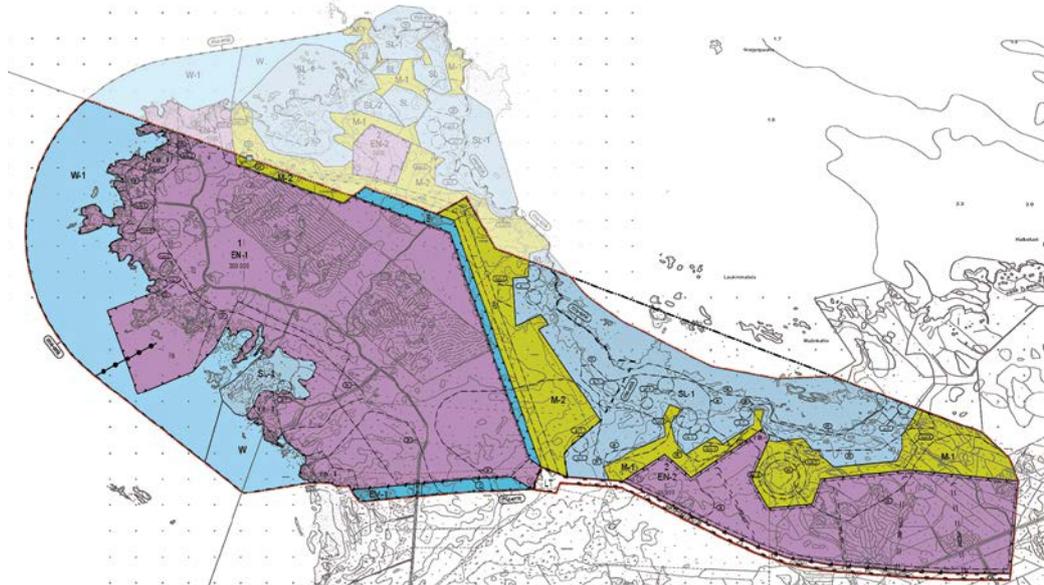
In the regional land use plan for a nuclear power plant, an exclusion area marking has been used to indicate the approximate boundaries of the exclusion area that is located at about five kilometres' distance from the nuclear power plant. The exclusion area includes the population of the village of Parhalahti on both sides of Highway 8.

The marking of the exclusion area indicates the exclusion area according to the YVL guide 1.10, issued by STUK, for which restrictions to the land use are in force. No plans shall be made in the area to locate any new dense population, hospitals or institutes, where significant numbers of people come or reside. The exclusion area shall also not be used to locate any significant manufacturing activities, to which an accident in the nuclear power plant could effect. In the area planning, possibilities for issuing a statement shall be reserved for the Radiation and Nuclear Safety Authority and the rescue authority.

**Figure 6-3** An extract from the local master plan for a nuclear power plant in Hanhikivi (2010), in Pyhäjoki. The local master plan for a nuclear power plant in Raahe is shown faded in the figure.



**Figure 6-4** Local detailed plan for a nuclear power plant in Hanhikivi (2010), in Pyhäjoki.



### Local master plans

In the Hanhikivi headland area, the local master plans for a nuclear power plant in Hanhikivi are legally in force in the town of Raahe and the municipality of Pyhäjoki. The local master plan for a nuclear power plant in Hanhikivi has been ratified in the municipal council of Pyhäjoki on 27 October 2010 and in the town council of Raahe on 15 November 2010. After the public notices, the land use plans have become legally in force in the summer of 2013.

In the local master plan (Figure 6-3), area reservations have been indicated on the Hanhikivi headland for the nuclear power plant and the required areas for auxiliary and maintenance activities. In addition, an area has been reserved in the plan for worksite activities. The plan indicates areas along the connection road from Highway 8 to the power plant site that shall remain in agricultural and forestry use. A part of the energy management area is coastal zone and water area at approximately 200 metres' distance from the shore and they have been indicated with

the marking W-1 as being area which can be used for the power plant's purposes and on which piers and other constructions and equipment that are required by the power plant can be built within the regulations of the Water Act. In addition, the nature conservation areas (SL, SL-1, SL-2) and the reserved protection green areas (EV, EV-1) have been indicated in the detailed master plan.

According to the general stipulation of the local master plan, the plan area is included in the exclusion area of the nuclear power plant.

### Local detailed plans

In the Hanhikivi area, the local detailed plans for a nuclear power plant in Hanhikivi are legally in force in the town of Raahe and the municipality of Pyhäjoki. The local land use plan for a nuclear power plant in Hanhikivi has been ratified in the municipal council of Pyhäjoki on 27 October 2010 and in the town council of Raahe on

15 November 2010. After the public notices, the land use plans have become legally in force in the summer of 2013.

In the local detailed plan for a nuclear power plant in Pyhäjoki (Figure 6-4), an energy management area has been indicated allowing the construction of a nuclear power plant. The local detailed plan indicates other necessary activities required by the nuclear power plant: residential area for temporary dwelling, other auxiliary activities' areas, as well as the necessary traffic area and, among others, an indicative sea lane. In addition, the local detailed plan indicates nature conservation areas and the historical stone Hanhikivi to be protected. Access to these areas is allocated through agricultural and forestry areas.

The entire cape of the Hanhikivi headland is to a great extent reserved as energy management block area with two area reservations (EN-1 and EN-2). The EN-1 area can be used for the construction of a nuclear power plant for the purpose of energy production, consisting of one or two nuclear power plant units. Temporary storage facilities

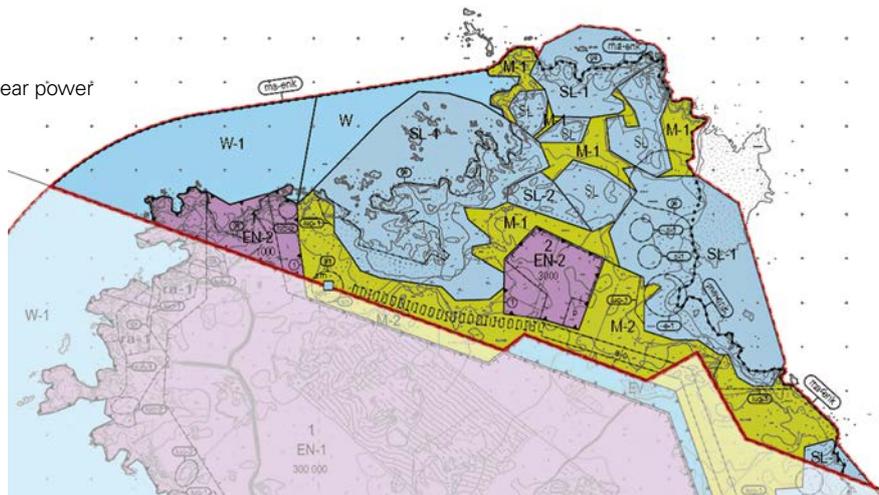
for spent nuclear fuel, as well as final disposal sites for low- and medium level operating waste can be built on the area. The final disposal sites include underground final repositories (disposal caves) and the entrance buildings and structures leading to them, as well as encapsulation plants and the related auxiliary facilities. Temporary storage of spent nuclear fuel is also allowed in the area.

The water area that can be used for the power plant's purposes and upon which, in the special areas, the piers and other such structures required by the power plant can be built in accordance with the regulations of the Water Act, has been indicated with the marking W-1 and other water area with the indication W.

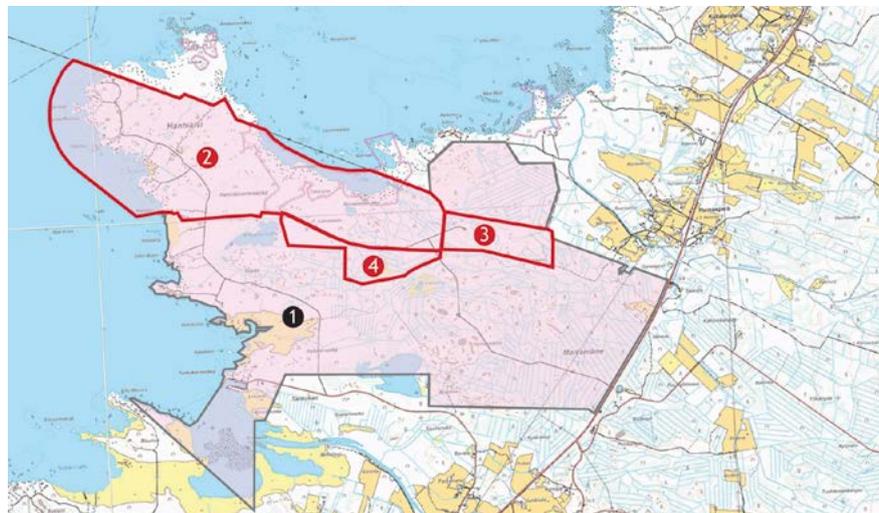
The local detailed plan indicates a total of 300,000 floor square metres of permitted building volume for the area EN-1 and 96,000 floor square metres for the area EN-2.

The local detailed plan of Raahе for a nuclear power plant (Figure 6-5) indicates block areas (EN-2), on which

**Figure 6-5** Local detailed plan for a nuclear power plant in Hanhikivi (2010), in Raahе.



**Figure 6-6** Combination of land use plans for the Hanhikivi headland area in Pyhäjoki.



**Area 1** Local master plan for the Hanhikivi nuclear power plant site (ratified on 27 October 2010). The local master plan covers the entire area as marked with pink in the figure.

**Area 2** Local detailed plan for the Hanhikivi nuclear power plant site (ratified on 27 October 2010).

**Area 3** Extension of the local detailed plan for the Hanhikivi nuclear power plant site, for blocks 2, 4, 5 and 6 (ratified on 22 May 2013).

**Area 4** Extension of the local detailed plan for the Hanhikivi nuclear power plant site, for block 3 (commenced on 27 March 2013).

auxiliary activities for the nuclear power plant, as well as activities related to construction and maintenance, dwelling and other such activities can be built. In addition, the local detailed plan indicates nature conservation areas and the historical stone, Hanhikivi, to be protected.

Access to these areas is allocated via an indicative vehicle access through agricultural and forestry areas. The part of the water area that can be used for the power plant's purposes and upon which, in the special areas, the piers and other such structures that are required by the power plant can be built in accordance with the regulations of the Water Act, has been indicated with the marking W-1.

The local detailed plan indicates a total of 4,000 floor square metres for the EN-2 areas.

In the Hanhikivi headland area, in addition to the local detailed plans for a nuclear power plant in Hanhikivi, a separate local detailed plan has been drawn up for worksite activities area which is located along the Hanhikivi connection road leading from Highway 8 to the power plant site. The worksite activities area belongs to the area under the local master plan for a nuclear power plant.

The local detailed plan of the worksite activities area (Figure 6-6, Area 3), called extension to the local detailed plan for the Hanhikivi nuclear power plant area in blocks 2, 4, 5 and 6, has been ratified in the municipal council of Pyhäjoki on 22 May 2013. An appeal has been made against the decision to the Oulu Administrative Court.

In the local detailed plan of the worksite activities area, the block areas for worksite and industrial activities have been formed to the immediate vicinity of the Hanhikivi nuclear power plant site. The local detailed plan indicates block areas for service buildings (P) and industrial and storage areas (T-1 and TY). In addition, the necessary traffic areas and protection green areas (EV) are indicated. The permitted building volume in the detailed master plan area has been indicated with a plot ratio (e) i.e. the floor surface in relation to the surface area of the plot or construction site.

In addition, local detailed planning work for the extension of the local detailed plan for a nuclear power plant in Hanhikivi, in block 3 has been started (Figure 6-6, Area 4). The area is located along the connection road leading from Highway 8 to the nuclear power plant site, on the south side of the road. On the north side, the extension of the plan is delimited to the local detailed plan for a nuclear power plant in Hanhikivi.

The objective of the local detailed plan is to locate auxiliary activities, as well as activities related to construction and maintenance to the immediate vicinity of the Hanhikivi nuclear power plant. The plan takes the possible new power transmission lines into account.

The municipal board of Pyhäjoki decided on the commencement of the land use planning project on 27 March 2013. Block 3 is part of the area under the local detailed plan for a nuclear power plant. A draft of the local detailed plan of the block 3 has been on display in the summer of 2013.

## 6.2 Landscape and cultural environment

Bare rock headlands and thin strata on top of the bedrock are typical characteristics of the Pyhäjoki coast. The cliffs are extensively bare above the shoreline as well. In large formations, the bedrock is fairly even in terms of topography. Representative glaciated rock can be seen, among others, in the rocky headlands of the west shore of the Hanhikivi headland. In the coastal area, the tips of headlands are predominantly rock or stony shore. The coves have low-lying stony shores and sands.

The terrain of the Hanhikivi headland, three kilometres long and one kilometre wide, is even and low-lying. Its highest parts rise to less than five metres above the sea level. The Hanhikivi headland and its immediate surroundings are mostly in their natural state, characterised by vegetation that is typical of the land uplifting coast. The succession series of the land uplift coastal forests cover most of the Hanhikivi headland, but the oldest stages i.e. aged forests are lacking in the area.

There are wide low-lying shore meadows along the north shore and base of the Hanhikivi headland. There are "fladas", sheltered bays beginning to separate pools during low water levels, along the shores of the Hanhikivi area. There are also gloe lakes in the area. Gloe lakes are lakes that have distinctly become separate from the shoreline, with a connection to the sea only during high water levels with southerly and westerly gales.

The Hanhikivi headland area is classified as a valuable bedrock area in terms of nature and landscape conservation (*Oiva Geographic information database 2012*).

There is a boundary mark, Hanhikivi, originating from the historic times, in the Hanhikivi headland, a fixed monument of antiquity protected by the Antiquities Act (295/63) and a nationally valuable site.

The nearest nationally important environment in terms of cultural history is the Parhalahti fishing harbour south of the headland (*RKY 2009*). In addition, there is a traditional landscape of regional importance on the northern shore of the Hanhikivi headland, Takaranta, and a traditional landscape of regional importance southwest of the headland, the Maunus shore meadows (*Northern Ostrobothnia Environment Center 1997*).

## 6.3 People and communities

The immediate surroundings of the Hanhikivi plant site are scarcely populated. Approximately 140 persons live permanently within a five-kilometre radius from the plant site. The nearest village, Parhalahti with approximately 400 inhabitants, is located at approximately five kilometres' distance. Within a twenty-kilometre radius, the number of permanent inhabitants is 11,300. The popula-

tion centre of the municipality of Pyhäjoki and the centre of Raahe are located within this area.

There are approximately 370,000 people living within a hundred kilometre distance from the power plant site. A significant number of these live in the Oulu region. The largest population centres in the area are Oulu, Kokkola, Raahe, Ylivieska, Kiiminki, Haukipudas, Kempele, Nivala, Oulunsalo and Kalajoki.

There are plenty of holiday residences on the Pyhäjoki coast. In the Hanhikivi headland area, there are fewer holiday residences (approximately 20 holiday residences) than elsewhere in the Pyhäjoki shore areas. The holiday residences are mainly located on the west coast of the headland, whilst the east coast is mainly nature conservation area. Within a twenty-kilometre radius, there are a couple of hundred holiday residences.

In the vicinity of Hanhikivi, at approximately ten-kilometre radius, there are four schools. The nearest school is a village school in the village of Parhalahti. The closest beach is located in the western part of the headland.

## 6.4 Traffic

Highway 8 (E8) runs at approximately six kilometres' distance from the nuclear power plant site. Traffic volume on the highway on working days in Pyhäjoki is approximately 3,000 to 4,000 vehicles per day. Of these, approximately 450 to 600 vehicles per day are heavy traffic. (*The Finnish Transport Agency 2013*). According to the municipality-specific growth estimates by the National Road Administration (*National Road Administration, 2007*) the traffic volumes in Pyhäjoki will increase by approximately four per cent by the year 2020.

The nearest railway station located in Raahe is about 25 kilometres from the Hanhikivi headland by road. This railway section is used for freight traffic only. The nearest passenger train station is in Oulainen, some 50 kilometres from Hanhikivi.

The nearest significant harbour is located in Raahe. The sea route from the harbour towards south in the direction of the High Coast / Kvarken runs on high sea at approximately 15 kilometres' distance from Hanhikivi.

The nearest airport is in Oulu, approximately 100 kilometres from Pyhäjoki.

## 6.5 Noise

There are no activities causing significant noise in the vicinity of the nuclear power plant at the Hanhikivi headland area. The location adjacent to the sea is rather favourable for the dispersion of noise, and in particular facilitates the dispersion of low frequency noise along the surface of the water allowing it to reach fairly far in calm weather.

## 6.6 Soil, bedrock and groundwater

The ground level in the Hanhikivi area varies between approximately 0 to +4 metres above the sea level. The overburden is typically 0 to 6 metres thick, depression 8 to 12 metres. The overburden consists mainly of sand and moraine, with the possibility of silt or clay as intermediate layers. In depressions, moraine can occur as the topmost layer. The overburden is mainly thin and disunited. (*Pitkäranta 2012*)

The area's bedrock mainly consists of metaconglomerate. The Hanhikivi metaconglomerate area is classified as valuable rock area. There are no significant fracture zones in the bedrock, but smaller crushing and cracks have been identified in surveys. On the east side of the Heinikarinpampi pond, there are numerous rock exposures.

The location area of the planned nuclear power plant is not located in a classified groundwater catchment area. The nearest classified groundwater catchment area (Kopisto, class I, identification 11625001) is located some 10 kilometres to the southeast from the power plant site.

No particular studies have been made regarding the water supply of the holiday residences located on the Hanhikivi headland. According to observations, some holiday residences have a groundwater well. (*Pitkäranta 2012*)

The groundwater level at the Hanhikivi headland area is at the level of approximately 0 to +1.5 above the sea level and according to observations, the pressure level of groundwater in bedrock is below the level of groundwater in soil (*Pitkäranta 2012*).

The calculated groundwater formation in soil and in bedrock in the Hanhikivi area (on a surface of 350 hectares) is approximately 1,000 cubic metres per day. According to surveys, the area's groundwater in soil and in bedrock does not entirely fulfil the quality requirements or quality recommendations for household water according to the decree of the Ministry of Social Affairs and Health (Stm 461/2000). (*Pitkäranta 2012*)

## 6.7 Air quality and climate

The winter is long in the area of the Gulf of Bothnia, and the temperature is relatively low for the most of the year. The location of the Gulf of Bothnia in the western part of a large continent and also near the Atlantic Oceans cases the climate to vary between marine climate and continental climate, depending on the prevailing winds.

In the surveying point of the Oulu airport, the average annual temperature was 2.4 °C between 1981 and 2010. The annual average precipitation was approximately 477 millimetres. (*Finnish Meteorological Institute 2012*) In Pyhäjoki, the prevailing direction of wind is from southwest (*Wind atlas 2012*).

There is no significant industry with regard to air quality in the region of the municipality of Pyhäjoki, and air quality is not controlled by measurements. The nearest air quality control takes place in the area of the town of Raahe, where the town monitors the impact of industry and traffic on the quality of air via an extensive air quality control program. Air quality in Raahe in the year 2012 was mainly good (Ramboll 2013).

The air quality in the Hanhikivi headland area can be estimate as being good, since there are no activities causing significant emissions in the immediate vicinity.

## 6.8 Water systems

### 6.8.1 General description

The coastal waters surrounding the Hanhikivi headland are shallow and the shores are rocky. Typical of the Gulf of Bothnia, the salinity of the water is low as is the number of species. The land-uplifting constantly changes the low-lying shore zone, which is a mixture of salty, fresh and brackish water species. The coast at the Hanhikivi headland is very open and waters change efficiently. Towards the high sea the shores get deeper very slowly, at first approximately one meter for a distance of 100 metres. A water depth of ten metres is reached about one kilometre from the northwest cape, and depressions of more than 20 metres deep are only found at 10 kilometres on the west side of Hanhikivi.

The water quality in the area is influenced by the general status of the Gulf of Bothnia and water from the Pyhäjoki River carried by draughts along the coast. The mean discharge of the Pyhäjoki River is 29 m<sup>3</sup>/s, and it empties at approximately six kilometres to the south from Hanhikivi. The nearest point sources of pollution are the Pyhäjoki water purification plant close to the estuary, the water plant of Raahen Vesi Oy and the Raahe works of Ruukki Metals Plc in front of Raahe, as well as since the year 2012 the Laiva gold mine of Nordic Mines Ab.

The sea area in front of the Hanhikivi headland belongs to the Oulujoki-Iijoki River Basin District, for which a water management plan has been drawn up (*Oulujoki-Iijoki River Basin District* 2009). The coastal waters of the river basin district have been divided into two types: inner and outer waters of the Gulf of Bothnia. The outer coastal waters in front of Hanhikivi are in good ecological state, but the narrow zone close to the coastline is classified as being satisfactory (Oulujoki-Iijoki River Basin District 2009, Hertta database 2013). At Hanhikivi, the sea area that has been classified as satisfactory reaches to the distance of approximately 0.5 to 1.0 kilometres from the coastline. The state of the coastal waters is deteriorated by eutrophication, which is sourced from the nutrients carried by the rivers, as well as the population and industry on the coastline.

The chemical status of the coastal waters in the Pyhäjoki region is classified as good.

### 6.8.2 Hydrology

In the Gulf of Bothnia, the variation in the height of water is mainly caused by winds, air pressure and quantity of water discharged by rivers (Kronholm *et al.* 2005). In addition, the water height in the Finnish coast is influenced by the reciprocating fluctuation of the water height in the Baltic Sea (the seiche phenomenon). The Gulf of Bothnia has its particular annual model of water height fluctuation. The water height is high in late autumn and descends towards late winter (Kronholm *et al.* 2005). After the late winter, the water height again rises until it reaches its autumn height. Some surveys in more details regarding the fluctuation and extreme values of the water height have been carried out (Johansson *et al.* 2010).

The influence of waves on the shore zone is significant due to the openness of the coast line. According to model simulations (Tuomi *et al.* 2011, VitusLab 2012), wave height of two to four meters occur regularly in front of Hanhikivi, and single waves can be even larger. The base friction of the long-reaching shallow area consumes the energy of the waves, and the waves are clearly weakened before reaching the Hanhikivi shore.

Draughts in the Gulf of Bothnia are mainly caused by wind, so their direction and strength vary greatly (Kronholm *et al.* 2005). The main draught of the prevailing southerly winds of Hanhikivi is from the south to the north. In the draught survey measurements carried out on high sea off Hanhikivi, during the winter of 2011 to 2012, the strongest draughts were directed towards southwest or northeast. Due to the effect of the Hanhikivi headland preventing draught, an area is formed in the cape where the draught speed are increased twofold in comparison to the draught speed at high sea.

Usually, the formation of ice begins in the inner bays of the Gulf of Bothnia in mid-November, and typically the ice is 70 cm thick along the coast in the north. The breaking up of ice starts in May in the Gulf of Bothnia. The formation of pack ice is typical of the region of the Gulf of Bothnia.

### 6.8.3 Water quality

Fennovoima has monitored the state of the sea area adjacent to Hanhikivi by water samples since the year 2009. In addition, the company has carried out continuous water quality surveying since the autumn of 2011. Continuously working measuring instruments are being used to monitor, among others, water temperature, salinity and turbidity.

The summertime temperature stratification of water and its intensity vary mainly according to the weather conditions. Since the stratification in the area is relatively easily dissolved and the base production is rather poor, the oxygen status remains good even in the hypolimnion. In general, the dilution of the bottom sediment (resuspension) due to the swell and draughts is the most significant factor turbidifying water. (Luode Consulting 2012a, 2012b and 2013)

During abundant water flow rates, the impact of river waters has been clearly detectable at the observation station nearest to the mouth of the Pyhäjoki River. This is shown in the water quality results, among others, as lower conductivity rates, slightly lower pH values, raised turbidity and colour values, as well as higher nutrient contents than in the surrounding sea area. The mean summer-time concentration levels for overall nutrient substances, according to the classification by Forsberg et al. (1980), demonstrate that the water in the area is harsh. However, based on the follow-up results, the phosphorus level in the vicinity of the mouth of the Pyhäjoki River has been slightly higher than in the remaining area, indicating slight eutrophication. The fluctuation of nitrogen over time and location has been relatively smaller than that of phosphorus. Similar to the nutrients, the chlorophyll 'a' contents, indicative of plankton production, have demonstrated a harsh or slightly eutrophic state of water. On the basis of inorganic nutrient ratios, phosphorus is the nutrient limiting the production of phytoplankton in the area.

#### 6.8.4 Bottom quality

The sea bottom of Hanhikivi is mainly coarse soil or bedrock, and also clay in places. According to an acoustic-seismic sounding survey (Rantataro et al., 2012) bottom erosion caused by gales and draughts as well as bucking of the pack ice against the bottom and the surface of the bottom is almost entirely rocky. The fine sand in the areas moves with the draughts. Organic sediment can only be found in sheltered bays in the shore zone.

Surveys regarding detrimental substances in the sediment have been carried out in the sea area of the Hanhikivi headland in 2009 and 2012 (Pohjatekniikka Oy 2009, Luode Consulting Oy 2012), but the number of samples is small due to the hard quality of the bottom. In the surveys carried out regarding detrimental substances in the sediment, no contaminate sediments were found, and in general the contents of detrimental substances were low.

#### 6.8.5 Aquatic vegetation

The aquatic vegetation in the Hanhikivi sea area has been studied in a survey carried out in 2009 regarding the current state of the aquatic vegetation (Ilmarinen ym. 2009). In 2012, the aquatic vegetation was studied in the form of a bioindicator survey (Leinikki & Syväranta 2012).

The aquatic vegetation of the area showed to have only few species. In the coastal areas and nearby waters of the Hanhikivi headland, among others, Charophyta meadows that classified as endangered (EN), and submerged aquatic vegetation intensive bottoms, classified as vulnerable (VU), in the threatened species classification in all of Finland, species that are included in the submarine biotypes of the Baltic Sea listed by the working group on endangered habitats in Finland (Raunio et al. 2008). The most significant Charophyta meadows are located in the

nature conservation area on the east side of the Hanhikivi headland (Takaranta seashore meadow and dune, LTA110013). There is insufficient data concerning the Gulf of Bothnia, relating to the frequency, vulnerability or sensitivity of said biotypes in order to be able to classify them. In addition, sublittoral macroalgae communities and euphotic layer benthos communities classified as near threatened (NT).

Most versatile aquatic vegetation by number of species was the low-lying bays of Takaranta and Juholanranta located on the east side of Hanhikivi.

#### 6.8.6 Bottom fauna

Bottom fauna studies have been carried out in the sea area off the Hanhikivi headland in the years 2009 and 2012 (Ilmarinen ym. 2009; Leinikki & Syväranta 2012).

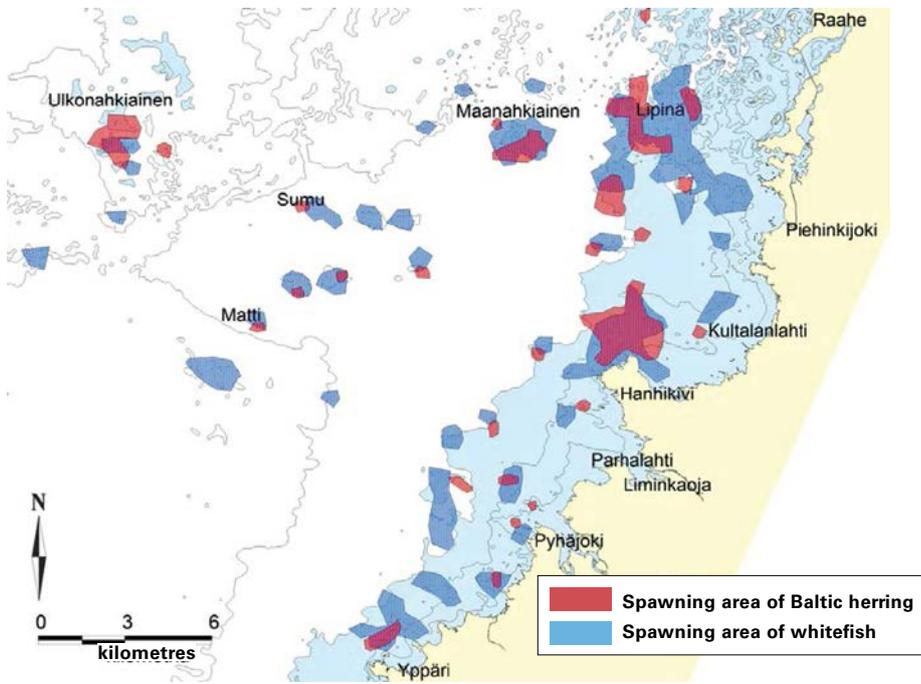
BBI indexes (Benthic Brackish water Index) calculated from sand bottom samples varied from adequate to excellent. The BBI Index has been developed to describe the status of bottom fauna communities in the low-salinity and low-species soft bottoms. Species presented in the bottom fauna samples were mainly nonbiting midges (*Chironomidae*), aquatic worms (*Oligochaeta*), benthic amphipods (*Monoporeia affinis*), benthic isopod crustaceans (*Saduria entomon*) and spionid polychaete (*Marenzelleria viridis*). The species were mostly influenced by the depth, bottom quality, as well as swell within an area of a few square meters. The species may also be influenced by the occurrence of vegetation, which in turn is strongly influenced by the swell.

#### 6.8.7 Fish stock

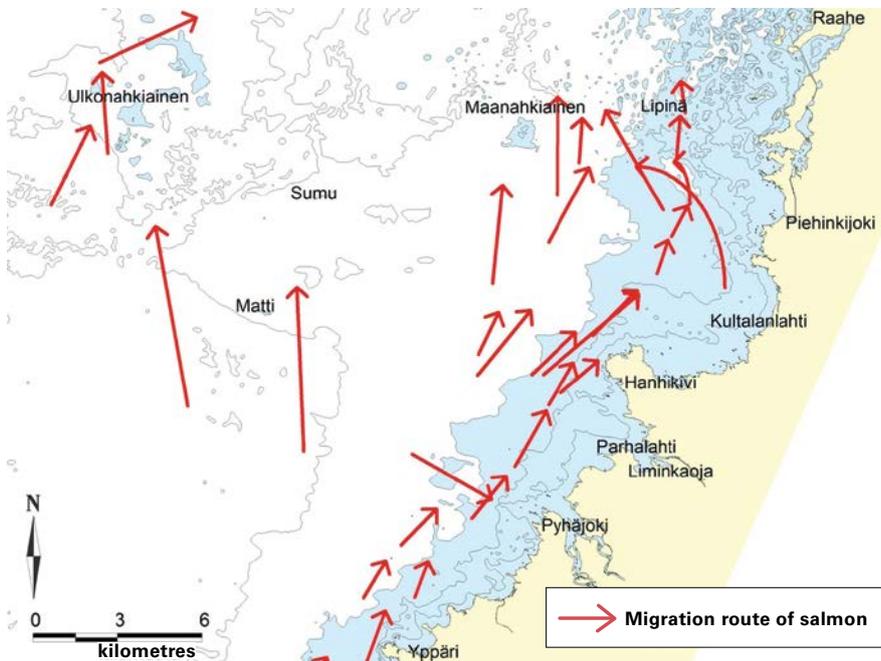
Fish stocks in the Hanhikivi headland area have been studied by fishing inquiries, experimental research fishing and fry catching (Fish and Water Research Ltd. 2012a & 2012b). A separate study on the social importance of fishing in the area has also been performed (Fish and Water Research Ltd. 2012c).

The coastal and high sea zones of the sea area off the Hanhikivi headland are significant for both fish stocks and fisheries. The endemic species in the area represent the typical fish stocks in the Gulf of Bothnia. Economically significant species include whitefish *Coregonus Whitegreni* and anadromous Baltic whitefish (*Coregonus maraena*), perch (*Perca fluviatilis*), Baltic herring (*Clupea harengus* L.), sea trout (*Salmo trutta trutta*), salmon (*Salmo salar*) and pike (*Esox Lucius*).

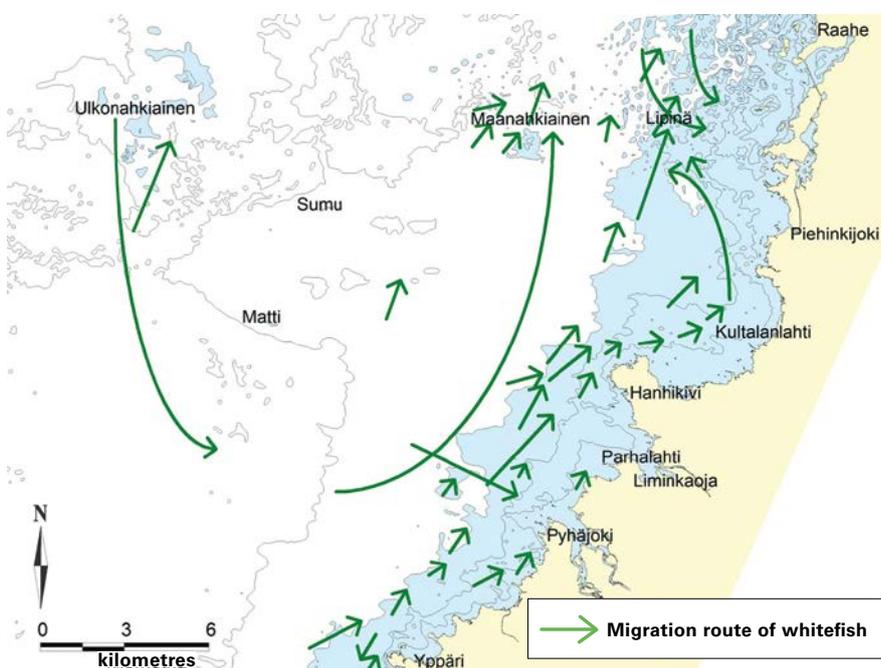
Based on the fry studies performed, the surrounding areas of the Hanhikivi headland are a significant fry production area for the whitefish, Baltic herring and vendace (*Coregonus albula*). Baltic herring spawns in the area mainly in the time period between the middle of June and middle of July. The most significant spawning areas for whitefish, Baltic herring and vendace are located at the northern part of the Hanhikivi headland, at Maanahkiainen and the Lipinä shallows (Figure 6-7). Spawning areas



**Figure 6-7** Spawning areas of whitefish (*Coregonus l. widegreni*) and Baltic herring (*Clupea harengus L.*) reported by professional fishermen (Fish and Water Research Ltd, 2012c).



**Figure 6-8** Spawning areas of whitefish (*Coregonus lavaretus*, lower figure) and salmon (upper figure) in the sea area of Pyhäjoki and Raahе, reported by professional fishermen (Fish and Water Research Ltd 2012c).



located further out in the sea include, among others the shallows of Matti and Sumu, as well as Ulkonahkiainen. Fries and spawning areas of spring-spawning fish species were found only in small quantities in the research area, and it seems that the principal spawning area of these species are located in the rivers, brooks and dikes mouthing in this area, as well as their deltas. Based on experimental research fishing, it seems that the extensive sand-bottom areas on the northeast side of the Hanhikivi headland act as feeding and growth areas for the early age groups of whitefish. (*Fish and Water Research Ltd 2012c*)

The migration routes of whitefish and salmon (Figure 6-8) run in the vicinity of the project site, but migration also takes place further out in the sea. Salmon often migrated towards north slightly further away from the coast. Lamprey (*Lampetra fluviatilis*) rises to spawn in the rivers and brooks of the area, and the Pyhäjoki River is classified as an important lamprey spawning river.

Mullet is regularly caught in the research area. In surveys carried out in 2012, no observations were made about mullet spawning in the Hanhikivi headland area.

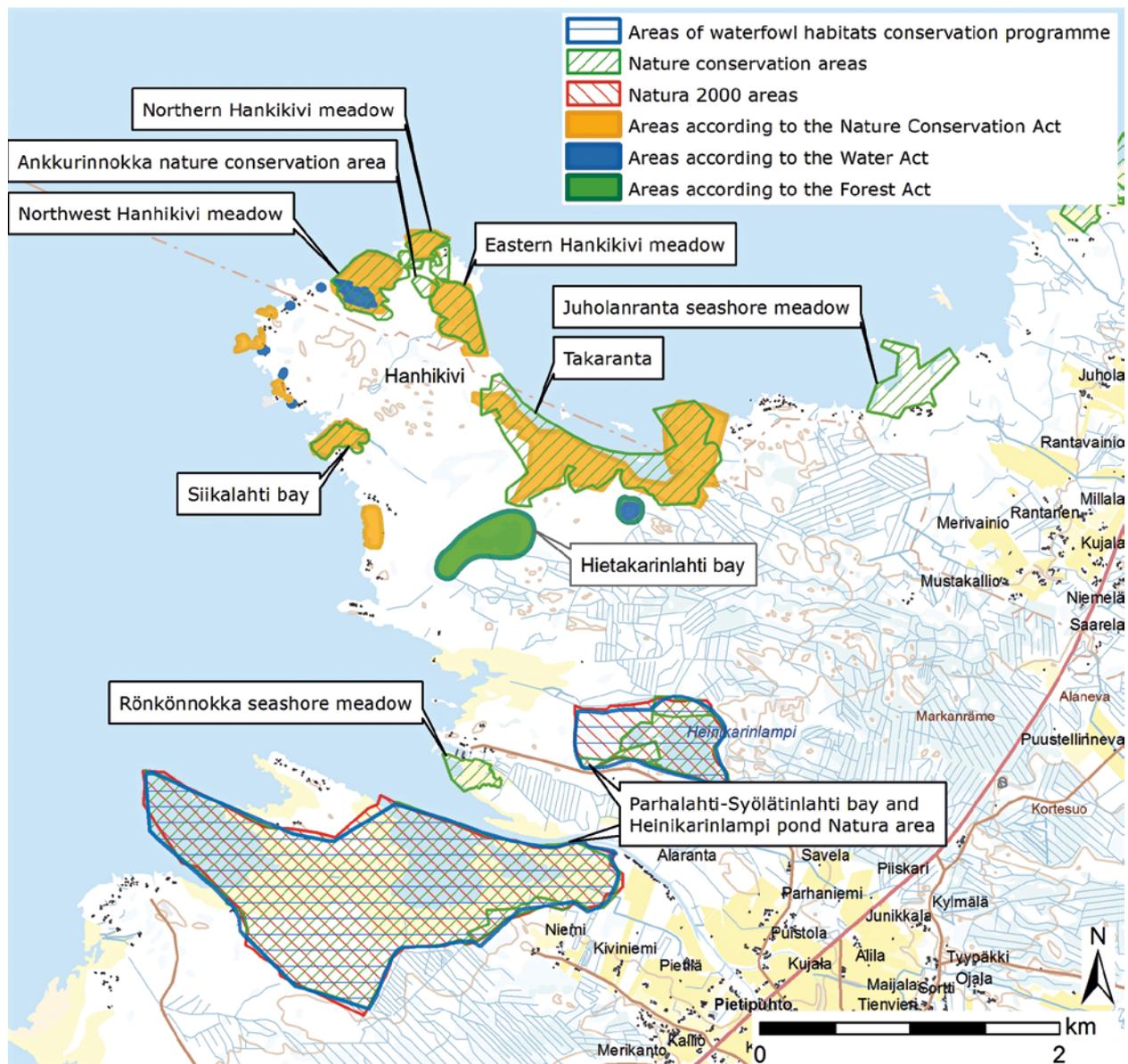
## 6.9 Vegetation, fauna and protected areas

### 6.9.1 Vegetation

#### General characteristics

The Hanhikivi area belongs to the western part of the Ostrobothnia-Kainuu mid-boreal vegetation zone. It is located on the land- uplifting coast of the Gulf of Bothnia, characterised by moist coastal meadows and low-lying bays that are becoming overgrown by aquatic plants.

**Figure 6-9** Nature conservation areas and areas of significance with regard to nature values.



Vegetation surveys have been carried out in the area in the years 2008 and 2009 (Pöyry Energy Oy 2009).

According to these surveys, in the east and north sides of the headland, there are extensive coastal meadows which mainly consist of low-growing rush (*Juncus*), hey and *Carex* meadows. The continental sides of the coastal meadows are lined with *Salix phylicifolia* bushes, which are gradually thickened so that they become deciduous seashore groves. When progressing towards the internal part of the headland and inland, there are spruce and mixed forests, as well as dryish pine heaths. At places, there are rocky and stony areas covered by reindeer-lichen, and at some places the forest becomes wooded marshland. The forests are reserved for forestry, they are in various development stages and they have been trenched.

### Threatened habitats

Several of the habitats existing in the Hanhikivi area have been determined in the assessment of endangered habitats in Finland (Raunio et al. 2008) as being critically endangered (CR), endangered (EN), vulnerable (VU) or near threatened (NT) in Southern Finland.

Land-uplifting coast ecological succession forests (CR) cover most of the Hanhikivi headland. In regional inspection, they probably belong to the ten most significant seashore succession forests (Pöyry Environment Oy 2009). Of the threatened habitats belonging to the succession series, in the area exist grove-like coastal deciduous forests (VU), grove-like coastal spruce forests (EN), recent coastal moorland spruce forests (EN) and dry coastal moorland spruce forests (EN). The oldest stages of the succession series i.e. aged forests are missing from the area.

Seaside meadows (CR) are concentrated on the north and east coasts of the Hanhikivi headland. Fladas (VU) i.e. low-lying bays, which are becoming separated from the sea, exist in the sheltered bays of Siikalahti and Lipinlahti, as well as in the north part of Hanhikivi. Gloe lakes (EN) on the shores of Hanhikivi are small and occur on the west and north side of the headland. Some of the gloe lakes present the habitat description well, but some of them are nearly overgrown and dried up. The habitat of lakes and ponds with occasional brackish water influence (VU) include, among others, Hietakarinalhti bay, Heinikarinlampi pond and Rovastinperukka.

Baltic Sea sand shores (EN) and grey dunes (VU) occurring in the Hanhikivi headland area are small in size and number. The largest of the sandy shores is the Hietalahti beach which is almost overgrown. Grey dunes occur locally in conjunction with sandy shores.

### Threatened species and species to be taken into consideration

There are five threatened or otherwise protected vascular plant species occurring in the Hanhikivi area (Pöyry Energy Oy 2009).

The vulnerable (VU) Siberian primrose (*Primula nutans* var. *jokelae*) has plenty of occurrences in the Hanhikivi headland area. The species can be found in Takaranta seashore meadows, the Ankkurinnokka nature conservation area, at the Lipinlahti bay, as well as in the surroundings of Parhalahti. The occurrences are concentrated on the east coast of the headland, and in 2009, the largest vegetations were observed in the Lipinlahti seashore meadow.

The occurrence of *Artemisia campestris* subsp. *Bothnica*, classified as critically endangered (CR) species has probably become regionally extinct (RE). Other threatened vascular plant species occurring in the area that have been classified as endangered (EN) include fourleaf mare's-tail (*Hippuris tetraphylla*), and as near threatened (NT) leathery grapefern (*Botrychium multifidum*) and flatstalked pondweed (*Potamogeton friesii*). The species were not found in the surveys of 2008-2009, but the present status of the species cannot be determined for example as having become extinct. Yellow flag (*Iris pseudacorus*), protected in Northern Ostrobothnia has a couple of occurrences on the west coast of the Hanhikivi headland.

Iceland Poppy, *Artemisia campestris* subsp. *Bothnica* and fourleaf mare's-tail (*Hippuris tetraphylla*) belong to the species listed in the EU Habitats Directive Appendix IV(b), which require tight protection. For plant species this protection means that the destruction and weakening of the occurrence sites of the species are prohibited.

### 6.9.2 Nature conservation areas and areas of significance with regard to nature values

Natura 2000 areas, nature conservation areas and other areas of significance with regard to nature values located in the surroundings of the Hanhikivi headland are presented on the map (Figure 6-9).

#### Natura 2000 areas

The *Parhalahti-Syölätinlahti* and *Heinikarinlampi* Natura 2000 areas (FI1104201) are located in the municipality of Pyhäjoki, less than two kilometres to the south from the power plant site. The area is also a nationally significant bird wetland, and it belongs to the national waterfowl habitats conservation programme.

#### Nature conservation areas

At the north cape of the Hanhikivi headland lies the *Ankkurinnokka* nature conservation area (YSA200525) consisting of four sub-areas. The nature conservation area of *Parhalahti-Syölätinlahti bay and Heinikarinlampi pond* (YSA202820) consists of several sub-areas located on both sides of the Parhalahti bay south of the Hanhikivi headland. The *Niemi* nature conservation area (YSA201321) is located to the south of the Parhalahti bay. Four nature conservation areas are located around the Heinikarinlampi pond: *Hanhimaa* nature conservation area (YSA200962), *Ojala* nature conservation area

(YSA201440), *Rantala swamp* (YSA206454) and *Pikkukallio* nature conservation area (YSA201321).

*Parhalahdi-Syöläinlahti bay and Heinikarinlampi pond* belong to the national waterfowl habitats conservation programme (LVO110253).

### Areas of Nature Conservation Act, Forest Act and Water Act

In the Hanhikivi headland area there exist several areas that are limited as protected habitat types in accordance with section 29 of the Nature Conservation Act: *Eastern Hanhikivi meadow* LTA202061 (seashore meadow), *Northwest Hanhikivi meadow* LTA202060 (seashore meadow), *Northern Hanhikivi meadow* LTA202062 (seashore meadow) and *Siiкалаhti* LTA202063 (seashore meadow) and *Takaranta* LTA110013 (seashore meadow and dune). To the south from Hanhikivi, there is the *Rönkönmokka* seashore meadow LTA203185. Approximately 2.5 kilometres from the Hanhikivi headland, in the region of the municipality of Raahе, is the *Juholanranta* seashore meadow (LTA110005).

In the area of the northwest coast of Hanhikivi, there are some glacial lakes which can be considered as protected habitat types in accordance with Chapter 2 Section 11 of the Water Act (2011/587) (*Pöyry Energy Oy 2009*). Further areas under the Water Act include the 'flada' located in the northwest meadow in Hanhikivi, and the small pond in Rovastinperukka. The coastal swamps of Hietakarinalahti and the immediate vicinity of the small pond in Rovastinperukka are mentioned as areas under the Forest Act.

In the years 2005–2006, the Hanhikivi areas were included in the 'Merestä metsäksi' pilot project (from sea to forest) belonging to the METSO Forest Biodiversity Program for Southern Finland. The objective of the project was, among others, to gather information on the status and natural values of the ecological succession forest, and to ensure biodiversity in the area voluntarily. During the program, 150 hectares of Hanhikivi areas were protected with the natural values trading agreements, environmental aid agreements and by purchasing land to the state. (*Ruokanen 2007*)

### Areas of significant avifauna

Hanhikivi is partially located in the Hietakarinalahti-Takaranta avifauna area (810235) classified as being nationally important under FINIBA-classification (Finnish Important Bird Areas). The surface area of the FINIBA-area is 171 hectares in total. The criterion species of the area is swan which is abundant in the area during the migration period.

The most significant areas regarding avifauna are the Hietakarinalahti bay and the surrounding canebreaks, the seashore meadow located to the north of the Hietakarinalahti bay as well as the Takaranta area. As a whole the Hanhikivi assessment area forms a representative area regarding the avifauna, where the species richness of nesting

avifauna and the abundance of birds are more abundant than normally. Hanhikivi is a regionally significant resting and feeding area of migratory avifauna.

### 6.9.3 Avifauna

Nesting avifauna surveys have been performed in the Hanhikivi headland in the years 2004 and 2006 (*Tuohimaa 2009*), 2008 (*Pöyry Environment Oy 2008*), 2009 (*Luoma 2009a*) and in 2013 (*Sito Oy 2013*). According to the surveys, the avifauna in the Hanhikivi area is versatile in species and abundant due to the variation in habitats. Versatile wetland bird species nest in the area. Meadow and canebreak species also exist in the coasts, as well as species related to harsh and sandy shores. In the interior parts of the headland, species related to mostly broad-leaved mixed forests occur. The species-richest areas are located outside the planned area in Takaranta, Heinikarinlampi pond, Hietakarinalahti bay, Parhalahdi bay and Syöläinlahti bay.

In the survey carried out in 2013 (*Sito Oy 2013*), vulnerable species (VU) observed in the planned area of the Hanhikivi headland and its surroundings included northern pintail (*Anas acuta*) and northern wheatear (*Oenanthe oenanthe*). The following near threatened species (NT) were observed: red-breasted merganser (*Mergus serrator*), goosander (*Mergus merganser*), willow grouse (*Lagopus lagopus*), black grouse (*Tetrao tetrix*), spotted crake (*Porzana porzana*), common redshank (*Tringa totanus*), common sandpiper (*Achitis hypoleucos*), wryneck (*Jynx torquilla*), wood warbler (*Phylloscopus sibilatrix*) and common rosefinch (*Carpodacus erythrinus*).

Species listed in the Appendix I of the EU Bird Directive observed in the area included hazel grouse (*Tetrastes bonasia*), black grouse, great grey owl (*Strix nebulosa*), spotted crake, common crane (*Grus grus*), common tern (*Sterna hirundo*) and black woodpecker (*Dryocopus martius*). Species of special responsibility for Finland included common goldeneye (*Bucephala clangula*), red-breasted merganser, goosander, black grouse, curlew (*Numenius arquata*), common sandpiper, common tern and common redstart (*Phoenicurus phoenicurus*). The conservation areas of these species listed in the Appendix I of the Bird Directive are not located in the planned area of the Hanhikivi headland.

Surveys of the spring and autumn migrations have been carried out in 2009 in the Hanhikivi assessment area (*Luoma 2009a and 2009b*). Based on these surveys, plenty of species especially large species such as cormorants, swans, geese and curlews migrate over Parhalahdi and Hanhikivi. The numbers of the migratory birds are remarkably high for Finnish measures and the migration is concentrated on an exceptionally limited area. The most important habitats for resting birds are the shallow shore water areas of the cape, sludgy shores and extensive opened coastal meadows. Essential resting and feeding areas are Takaranta, Parhalahdi and Syöläinlahti (*Tuohimaa 2009*).

#### 6.9.4 Other fauna

The swamp frog (*Rana arvalis*), a species listed in Appendix IV (a) of the EU Habitats Directive, was observed in these areas in 2010 (*Pöyry Finland Oy 2010*) and in five areas in 2011 (*Sito Oy 2011*). Two of the areas were the same in these surveys. With the exception of one area, all observation areas were located on the shores of open water gloes or small ponds with canebrake. One of the observation areas was a small pond located in a thicket. Based on these observations several areas are used annually by the swamp frog for spawning. However the number of individuals of swamp frog is small.

In the summer of 2012, a survey of bats belonging to the species listed in the EU Habitats Directive was carried out in the Hanhikivi area (*Suomen Luontotieto Oy 2012*). Northern bats (*Eptesicus nilssonii*) were observed as individual bats or pairs. The only confirmed nesting place of northern bats was located in the buildings of the Parhalahti Fish Harbour. No Daubenton's bats (*Myotis daubentonii*) were observed, even though there are several wetlands suitable for the species. On the basis of the terrain survey the bat species can be considered as being scarce. No suitable caves or larger rocky areas have been found in the area.

No occurrence of the Russian flying squirrel (*Pteromys volans*), a threatened species listed in Appendix IV (a) of the EU Habitats Directive and estimated as a vulnerable species (VU) has been observed in the area. The nearest observation data of an occurrence of the Russian flying squirrel is from approximately seven kilometres from the Hanhikivi headland (*Pöyry Environment Oy 2008*).

The terrestrial animals in Hanhikivi consists otherwise of typical forest species, such as elk (*Alces alces*), blue hare (*Lepus timidus*) and red squirrel (*Sciurus vulgaris*) (*Pöyry Environment Oy 2008*). Also roe deer (*Capreolus capreolus*) occur in the area.

# 7

## Environmental impact assessment and assessment methods



## 7.1 Impacts to be assessed and the scope of the assessment

In accordance with the EIA Act, the assessment will study the environmental impacts caused by a nuclear power plant with approximately 1,200 MW on:

- human health, living conditions and wellbeing,
- soil, water, air, climate, vegetation, living organisms and diversity of nature,
- community structure, buildings, landscape, cityscape and cultural heritage,
- utilisation of natural resources,
- mutual interdependencies of these factors.

The assessment particularly highlights the impacts that deviate from the impacts assessed in the EIA carried out in 2008 or those not covered by the 2008 EIA. In addition, the environmental impacts that are considered significant or felt as significant by interest groups will be taken into consideration.

The assessment of the impacts will utilise the assessments performed for the EIA that was prepared in 2008 for the Fennovoima nuclear power plant, as well as other studies of the current state of the environment and environmental impacts of the project, completed after said assessment. In the 2008 EIA assessment, in addition to the various location alternatives, two power plant alternatives were also assessed. The two power plant alternatives studied were a 1,500 to 1,800 MW plant consisting of one nuclear power plant unit and a 2,000 to 2,500 MW plant consisting of two nuclear power plant units. Those studies carried out for the 1,500 to 1,800 MW plant that are after revision applicable for this EIA will be utilized in the assessment work.

Studies carried out for the 2008 EIA and the Decision-in-Principle, and studies performed after these include, among others:

- Dispersion modelling of radioactive emissions in an accident situation
- Noise modelling calculations
- Background survey for assessment of regional economic impacts
- Renderings of impacts on the landscape
- Nature and water system surveys, including:
  - Avifauna surveys, spring monitoring and autumn migration of birds
  - Description of submerged nature, surveys of submerged historical monuments, survey of the benthos in the marine area, fisheries survey, fishing of lamprey in Pyhäjoki, surveys of fish

reproduction areas, phytoplankton studies, fish stocks and fry production, survey on leisure-time fishing, assessment on water construction works' impact on the fisheries, mullet report

- Survey on the water quality in the marine area, consideration of the local conditions and draughts in the cooling water modelling, survey on detrimental substances in the sediment, survey on banking areas, a sounding survey
- Primary ecological succession forests; The importance of the Hanhikivi area as a primary succession forest area; the position of the Hanhikivi area as an area of special importance with regard to habitat diversity; a list of threatened species and habitat, their protection in the project, as well as a plan for more detailed terrain surveying; a Natura assessment
- Surveys relating to the swamp frog, survey relating to bats
- Cooling water modelling, assessment of cooling water remote discharge alternative, considering of the combined impacts of wastewater and cooling waters
- Inventory of historical monuments in the area of the Hanhikivi headland
- Soil, groundwater and seismic studies
- The project's applicability in the national land use objectives
- Uncertainty caused by the climate change in the assessment of environmental impacts
- Risks and environmental impacts of spent nuclear fuel
- Essential environmental impacts of operating waste disposal
- Accident modelling

This EIA studies the impacts according to the assessment areas presented in the 2008 EIA. The assessment area stands for an area specified for each impact type, upon which said environmental impact is studied and assessed. The extent of the assessment area depends on the environmental impact being assessed.

## 7.2 Summary of assessment methods used

The following table (Table 7-1) presents a preliminary assessment on the environmental impacts of an approximately 1,200 MW plant in comparison with and 1,800 MW plant presented in the 2008 EIA, as well as a description of the environmental impact assessment methods.

**Table 7-1** Summary of the assessment methods used.

Impact	Preliminary assessment on the environmental impacts of an approximately 1,200 MW plant compared on the 1,800 MW plant presented in the EIA of 2008	Assessment methods
Impacts during construction	There are no significant differences in the impacts, since both the construction work and the duration and extent of construction are similar to those of a plant with a higher electrical power.	Assessment based on the assessments presented in the EIA of 2008 and the present data.
Impacts on air quality and climate	Radioactive emissions in normal conditions are similar, and the radiation dosages caused by them are of the same magnitude.  Other emissions to air and their impacts are of the same magnitude.	Assessment based on the assessment performed in the EIA of 2008 and the present emission data.
Impacts on water systems	Radioactive emissions in normal conditions are similar, and the radiation dosages caused by them are of the same magnitude.  The quantities of cooling and wastewaters are smaller, the impact less than in the previous assessment.	The impacts of the cooling waters are assessed by modelling the dispersion of the thermal load to be directed to the water system. In addition to the modelling, the assessment is based on the assessments performed in the EIA of 2008 and the updated present-state assessment on the water systems, as well as new emission data.
Impacts of waste and its treatment	The quantity of spent nuclear fuel and operating waste is smaller, in which case the impacts are at most of the same magnitude. There are no significant differences in the quantity of other waste, in which case the impacts are of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and the present data, as well as additional assessments when necessary.
Impacts on soil, bedrock and groundwater	The extent and dimensions of construction and structures are of the same size or smaller, in which case the impacts are at most of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the present-state assessments performed after it.
Impacts on vegetation, animals and conservation areas	There are no significant differences in the impacts, since emissions, noise, traffic and thermal load to be directed to the water systems, as well as other factors with a possible impact on nature are smaller or of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the present-state assessments of nature performed after it.
Impacts on land use, structures and landscape	There are no differences in the impacts, since the extent and dimensions of construction and structures are of the same size or smaller.	Assessment based on the assessments presented in the EIA of 2008.
Impacts on traffic	There are no significant differences in the impacts, since the necessary transports for materials and personnel are of the same magnitude.	Assessment based on the assessments presented in the EIA of 2008 and on the necessary updated.
Noise impacts	The sources and magnitude of noise are similar, so there are no significant differences in the impacts.	Assessment based on the assessments presented in the EIA of 2008.
Impacts of abnormal and accident situations	There are no differences in the impacts, since the requirements by the authorities that are to be set as the maximum sanction for the various plants due to these situations are the same.	Assessment based on the EIA of 2008 and on the additional assessments of the Decision-in-Principle.
Transboundary environmental impacts across the borders of Finland	According to the preliminary estimate, the impacts of radioactive emissions generated only by a serious nuclear power plant accident could have an impact outside of the borders of Finland.	Assessment based on the assessments presented in the EIA of 2008. Impacts exceeding the borders of the state of Finland are assessed also in conjunction with the international hearing in accordance with the Espoo Convention.

Impacts on people and society	There is no difference with regard to the adverse impacts to wellbeing and health, since the emissions, noise, traffic and other factors with a possible impact on humans are either smaller or of the same magnitude.  There are no significant differences in the impacts on regional economy and structure, or on employment.	Assessment based on the assessments presented in the EIA of 2008 and on the assessments performed after it, as well as on a new resident inquiry, when necessary.
Impacts on energy markets	A new nuclear power plant will reduce Finland's dependency on the import of electricity and increase the supply on the electricity markets.	Assessment based on the assessments presented in the EIA of 2008.
Impacts of power plant de-commissioning	There is no significant difference in impacts, since, among others, the structures, methods of dismantling and the quantities of waste are of a similar nature.	Assessment based on what was presented in the EIA of 2008.
Impacts of nuclear fuel production	In general terms, the impacts are the same.	Assessment based on the data presented in the EIA of 2008 and on updated data as far as deviating from the EIA of 2008.
Impacts of associated projects	Associated projects, such as the construction and utilisation of transport connections and access power transmission lines are the same, in which case the impacts will also be of the same magnitude. Due to the lower power, the needs for strengthening the power transmission network will be smaller.	Assessment based on the assessments presented in the EIA of 2008.

### 7.3 Assessment of the impacts during construction

The environmental impacts during the construction of the nuclear power plant will be studied as an entity of their own, since they differ from the impacts during the operation of the power plant in terms of temporal duration and also with regard to other characteristics. According to the preliminary estimate, the impacts occurring during the construction of the approximately 1,200 MW nuclear power plant being currently assessed, will not significantly differ from the impacts presented in the 2008 EIA, because the construction works, as well as the duration and extent of construction are similar to a plant with higher electric power.

The EIA report will describe the construction works of the power plant, water construction works and the traffic during the construction period. The report will also describe the plans for permanent roads, water management and other corresponding systems.

The EIA report will study the impacts of dust and noise generated by the construction activities during the different stages of the site. Other matters to be assessed include the stockpiling and crushing of soil materials and crushed rock, the batching plant, utilisation and final disposal of various materials, waste water treatment during the construction period, quality and handling of waste generated in the different construction stages, as well as the environmental impacts caused by the construction of the cooling water structures, the loading and unloading docks, and the related navigation route.

Impacts caused by the construction to, among others, soil and bedrock, water systems, vegetation and fauna will be presented. The impacts directed to the social environment, such as employment, wellbeing and safety of people, will be assessed among others by taking into account the feedback received in the course of the interaction with the stakeholders.

The assessment area of the actual construction works during the construction period is the power plant site and areas in its immediate vicinity, as well as traffic routes leading to the site.

### 7.4 Assessment of the impacts during operation

#### 7.4.1 Assessment of the air quality and climate impacts

The radioactive emissions from the approximately 1,200 MW nuclear power plant will in normal conditions be similar to those of the approximately 1,800 MW nuclear power plant assessed in the 2008 EIA. According to a preliminary estimate, the radiation dosages caused by radioactive emissions will be of the same magnitude as that presented in the 2008 EIA.

The EIA report will present the radioactive emissions to the air caused by the operation of an approximately 1,200 MW nuclear power plant. Their impacts on the

environment and people will be assessed on the basis of the assessment carried out in the 2008 EIA and existing research data. The assessment area of radioactive emissions will extend to approximately 10 to 20 kilometres from the power plant site.

According to a preliminary estimate, the impact of other emissions will be at the most of the same magnitude as that presented in the 2008 EIA. Emissions to the air, such as the emissions from reserve power production and the emissions from transportation, and their impact on the quality of air will be presented on the basis of assessments made in the 2008 EIA.

#### **7.4.2 Assessment of impacts on water systems**

According to a preliminary estimate, the load on the sea caused by the cooling and wastewater from the approximately 1,200 MW nuclear power plant currently being assessed will be smaller than the load from the approximately 1,800 MW nuclear power plant assessed in the 2008 EIA. The impacts to the water systems from the approximately 1,200 MW plant can preliminarily be estimated to be smaller than the impacts of the approximately 1,800 MW nuclear power plant assessed earlier.

Radioactive emissions to the water system will in normal conditions be similar to the emissions of the approximately 1,800 MW nuclear power plant assessed in the 2008 EIA, and the radiation dosages caused by radioactive emissions will be of the same magnitude as those presented in the 2008 EIA.

The wastewater load and radioactive emissions to the sea during the operation of the approximately 1,200 MW nuclear power plant currently being assessed will be presented. The impacts of the cooling water and wastewaters, as well as water intake, on the quality of water, biology and fish stocks, in particular on the migratory fish stocks and fisheries, and to other fauna will be assessed.

The impacts of warm cooling water will be assessed by modelling the dispersion of cooling water in the water system. As the design and engineering of Fennovoima's nuclear power plant progresses, the arrangements for intake and discharge of cooling water have become more detailed in comparison to the situation of the 2008 EIA. This more detailed data will be taken into consideration in the modelling to be carried out for the EIA report. Model calculations on the dispersion and flowing of cooling waters, as well as an estimate on the impacts of the thermal load on the temperatures and ice conditions in the immediate vicinity of the discharge area will be drawn up by applying the latest versions of three-dimensional flow, temperature and ice models. As a result of the model calculations, thorough dispersion calculation will be available as the basis for assessment of impacts on water systems and fisheries.

In addition to the cooling water modelling, the assessment of cooling water and wastewater impacts is based on the impact assessment presented in the 2008 EIA, the existing data from said water area and research data

gained after the 2008 EIA, as well as the environmental control data from plants existing in the Baltic Sea area, discharging corresponding wastewater and cooling water quantities to the sea.

Impacts to the water systems are assessed in an area extending to approximately 10 to 15 kilometres' distance from the power plant site. In addition, the changes taken place in the current state of the Gulf of Bothnia will be taken into account in a wider perspective.

#### **7.4.3 Assessment of the impacts of waste and their treatment**

The quantities of spent nuclear fuel and operating waste generated in an approximately 1,200 MW nuclear power plant currently being assessed will be smaller than those generated in an approximately 1,800 MW. Thus, the impacts can preliminarily be estimated as being at the most of the same magnitude as the impacts assessed in the 2008 EIA.

According to a preliminary estimate, the quantities of hazardous waste and municipal waste from an approximately 1,200 MW nuclear power plant currently being assessed will not differ significantly from the quantities presented in the 2008 EIA.

The EIA report will describe the quantities, qualities and treatment methods for waste, as well as present the relating environmental impacts on the bases of assessment presented in the 2008 EIA, and additional studies, when necessary.

#### **7.4.4 Assessment of impacts on soil, bedrock and groundwater**

According to a preliminary estimate, the impacts on soil, bedrock and groundwater from an approximately 1,200 MW nuclear power plant being currently assessed, will not differ significantly from the impacts caused by a 1,800 MW nuclear power plant presented in the 2008 EIA. The extent and dimensions of construction and structures will be of the same magnitude or smaller, in which case the impacts will be of the same magnitude or smaller.

Impacts on the power plant site soil and bedrock will be assessed with the help of soil and groundwater surveys carried out, area topography, soil quality, as well as the area required by the power plant and relating structures, and the dimensions of subterranean parts. In addition, the seismology of the area will be presented.

The data relating to the groundwater catchment areas in the vicinity of the plant area will be presented, possible risks to the groundwater will be described and the impacts of abnormal situation will be assessed.

#### **7.4.5 Assessment of impacts on vegetation, fauna and conservation areas**

According to a preliminary estimate, the emissions, noise, traffic volumes and other factors with possible impacts on

nature of the approximately 1,200 MW nuclear power plant being currently assessed, will be smaller than the corresponding factors of a 1,800 MW nuclear power plant presented in the 2008 EIA. Thus, the impacts on vegetation, fauna and conservation areas of an approximately 1,200 MW nuclear power plant being currently assessed are preliminarily estimated not to differ significantly from the impacts of a 1,800 MW nuclear power plant presented in the 2008 EIA.

The impact assessment is based on assessments to be carried out in other section of the EIA procedure, among others, on emissions, noise, traffic, and the thermal load to be discharged to the water system. The starting point for assessment is in the natural conditions of the plant site, which have been presented in the current state description based on the results of numerous nature studies in the years 2008 to 2013.

The direct and possible indirect impacts of the project on vegetation and fauna, as well as on biodiversity of nature and interactive relations are taken into consideration in the impact assessment.

In 2009, the Natura assessment was carried out regarding the Natura 2000 area in the Parhalahti-Syöläinlahti bay and Heinikarinlampi pond, located in the vicinity of the nuclear power plant site. According to the assessment, no significantly weakening impacts will be caused by the project alone, or in conjunction with other projects, to the habitats and bird species that are basis of conservation, or to the Natura 200 area as an entity. This EIA will utilise the previously performed Natura assessment.

#### **7.4.6 Assessment on impacts on land use, structures and landscape**

According to the preliminary estimate, the impacts of the approximately 1,200 MW nuclear power plant that is currently being assessed on land use, structures and landscape, will not differ from the impacts presented in the 2008 EIA, because the extent and dimensions of constructions are similar or smaller than the impacts of a 1,800 MW nuclear power plant presented in the 2008 EIA.

The EIA report will describe the impacts of the project on current and planned land use, as well as on the built-up environment with regard to the land use plans and development. The assessment area will extend in addition to the plant site also to the surroundings of the roads planned.

Impacts on landscape will be assessed based on the plans drawn up for the project and on existing studies. The assessment area to be applied will be the area in which the power plant buildings are clearly distinguished in the landscape.

#### **7.4.7 Assessment of the environmental impact of traffic**

The environmental impacts of traffic caused by an approximately 1,200 MW nuclear power plant that is currently being assessed, will not differ significantly from the

impacts caused by a 1,800 MW nuclear power plant, because the volume of the necessary material and passenger transports will be of the same magnitude, according to a preliminary estimate.

The most significant impacts of traffic in the project will be caused during the construction of the nuclear power plant. The data presented in the 2008 EIA report will be updated, and the changes in the traffic volumes due to the transport, as well as the vehicles and routes of transportation will be presented.

Noise impacts and impacts on wellbeing and traffic safety caused by traffic will be assessed on the basis of the 2008 EIA, and be updated, when necessary.

Assessment methods for emissions caused by transportation are present under chapter 7.4.1 and the assessment method of noise impacts under chapter 7.4.8.

#### **7.4.8 Assessment of noise impacts**

According to a preliminary estimate, the noise impacts from an approximately 1,200 MW nuclear power plant being currently assessed, will not differ significantly from the impacts caused by a 1,800 MW nuclear power plant, because the sources of noise and their magnitude will be similar in plants of both sizes.

With regard to noise impacts, noise caused by the construction works and the operation of plant will be assessed in the vicinity of the power plant and the traffic routes leading to it. The noise impact assessment will utilize the studies made for the 2008 EIA.

#### **7.4.9 Assessment of impacts in abnormal and accident situations**

According to a preliminary estimate, the impacts of possible abnormal and accident situations of an approximately 1,200 MW nuclear power plant being currently assessed, will not differ significantly from the impacts caused by a 1,800 MW nuclear power plant, since the authority requirements set as the maximum consequences due to these situations are the same for both nuclear power plants.

The EIA report will describe the grounds for the safety design of the new 1,200 MW nuclear power plant and present the possibilities to fulfil the statutory nuclear safety requirements. The EIA report will also describe the safety studies which will be carried out for the construction licence and operating licence according to the Nuclear Energy Act, as well as for supervision of the plant.

The EIA report will assess the environmental impacts of abnormal situations based on requirements set for a nuclear power plant by the authorities, and on the studies performed. The assessment of consequences of abnormal situations is based on extensive data available on the impacts of radiation on health and environment. Additional studies carried out for the 2008 EIA and the Decision-in-Principle will be utilized in the assessment of impacts.

The EIA report will present an imaginary accident case of a grade 6 accident according to the international INES rating (in the nuclear accident rating scale from 1 to 7, the grade 6 corresponds to a “serious accident”). The accident releases a quantity of radioactive substances that corresponds to the specified limit value for a serious accident according to the Section 10 of the Government Decree 733/2008. The direct radiation impacts and other impacts of the accident case will be assessed within a radius of at least 1,000 kilometres.

#### **7.4.10 Transboundary environmental impacts across the borders of Finland**

According to the preliminary estimate, the impacts of radioactive emissions generated only by a serious nuclear power plant accident could have impact outside of the borders of Finland. Impacts exceeding the borders of the state of Finland are assessed in conjunction with the international hearing in accordance with the Espoo Convention.

In conjunction with the 2008 environmental impact assessment and the additional assessment attached to the application for the Decision-in-Principle in 2009, the impacts of a nuclear power plant accident were modelled. The modelling was carried out using general and conservative assumptions which are not plant type specific. Thus the modelling will also apply to the assessment of the nuclear power plant accident of the plant alternative being assessed in this EIA procedure. The modelling studies carried out in 2008 and 2009 considered unfavourable weather conditions, as well as emission from a serious accident, containing 100 TBq cesium-137-nuclides. The modelling studies showed that with the assumed emission, the need for population protection measures and long-term restriction on the use of land and water areas would be limited within a radius of 150 kilometres from the site in Pyhäjoki.

The EIA report will present an estimate on transboundary environmental impacts due to accident situations on the basis of the assessments described above.

At the present stage, no other impacts that could reach beyond the Finnish borders have been identified for the project. These other possible impacts will be studied in more detail in the EIA report.

#### **7.4.11 Assessment of impacts on people and society**

##### **Health impacts, living conditions, wellbeing and recreational activities**

According to the preliminary estimate, the approximately 1,200 MW nuclear power plant that is currently being assessed cannot be estimated to differ distinctively from the 1,800 MW nuclear power plant assessed in the 2008 EIA with regard to environmental impacts or other impacts on people and society.

The EIA report will present the impacts of a 1,200 MW nuclear power plant on human health, wellbeing and

living conditions with regard to, among others, changes in the land use, impacts on landscape, increase in the radiation dosage caused by radioactive emissions, impacts on water systems, impacts on traffic, traffic safety, impacts on employment and noise. The EIA report will in addition study the impacts of possible accident situations. The assessment will emphasize the viewpoints highlighted by the stakeholders in the 2008 EIA and during this EIA procedure.

The inhabitants' attitude towards the project will be assessed, among others, on the basis of the opinions submitted on the EIA program, feedback gained during the EIA procedure and discussions on the media. A resident survey will be drawn up, when necessary, to the residents of the close neighbourhood of the planned power plant.

##### **Regional structure, economy and employment**

The impacts of the approximately 1,200 MW nuclear power plant currently being assessed on the regional structure, economy and employment will, according to a preliminary study, not differ distinctively from the impacts of the 1,800 MW nuclear power plant assessed in the 2008 EIA.

The project's impact on regional and municipal economy will be based on the 2008 EIA report, as well as on the studies carried out later on. The EIA report assesses the quantity of jobs created directly and indirectly by the construction and operation of the plant in the region of the power plant site.

#### **7.4.12 Assessment of impacts on the energy market**

The objective of the approximately 1,200 MW nuclear power plant that is currently being assessed is to increase the base-load electric power production capacity for the needs of the project shareholders. In addition, the new nuclear power plant will increase Finland's independence from the import of electricity and increase supply in the electricity market. As a nuclear power plant is characterised by the price stability of production costs, the project will also enhance the predictability of the electricity market.

The EIA report will present the impacts on the electricity market in the manner presented in the 2008 EIA report, taking into consideration the current estimates on the future status of the electricity market, fuel market, emissions trading and maintenance and supply security in a situation where the new nuclear power plant is in operation. The share of planned increase in electricity production capacity of the Nordic electricity market will be assessed on the basis of the earlier EIA report and the present electricity production capacity.

#### **7.4.13 Assessment of the impacts of power plant decommissioning**

According to a preliminary estimate, the impact of the decommissioning of the approximately 1,200 MW nuclear power plant that is currently being assessed, will not differ

significantly from the impacts presented in the 2008 EIA, since, among others, plant structures, dismantling methods and quantities of waste will be similar.

The environmental impacts of the decommissioning of a nuclear power plant will in due course be assessed in a separate EIA procedure. However, in order to present an overall picture of the lifecycle of a nuclear power plant, the EIA report will describe, on a general scale, the various stages of decommissioning and their duration, waste to be generated and waste treatment methods, as well as impact relating thereto.

#### 7.4.14 Assessment of the impacts of nuclear fuel production chain

The most important potential procurement sources of the nuclear fuel to be used in the approximately 1,200 MW nuclear power plant that is currently being assessed and the environmental impacts of nuclear fuel production and transportation will be described on the basis of the existing studies.

#### 7.4.15 Description of the impacts of associated projects

The impacts of the projects associated with the approximately 1,200 MW nuclear power plant being currently assessed, such as construction and use of traffic connections and the connecting power transmission lines, will be the same those in the 1,800 MW plant case. However, due to the lower electric power, the requirements for strengthening the power transmission line network are estimated to be lower. Preliminarily, the environmental impacts of associated projects are estimated to be similar to the impacts presented in the 2008 EIA. The impacts of the associated projects will be presented on the basis of the 2008 EIA. The environmental impacts during the construction and operation period of the power transmission lines will be assessed in a separate EIA procedure which is expected to commence in 2014 (Chapter 1.6.1).

## 7.5 Cumulative impacts with other projects

The cumulative impacts of the project will be assessed with other projects known in the immediate vicinity. For the assessment, such projects located in the immediate vicinity with potential combined impacts with the approximately 1,200 MW nuclear power plant project will be identified.

Preliminary identification of project with potential combined impacts with the planned nuclear power plant include a maritime wind farm planned by Rajakiiri Oy, to be located in the Maanahkiainen water area off the Raahe steelworks. The planned area of the maritime wind farm extends in the south at the closest at approximate-

ly 4 kilometres' distance from the Hanhikivi headland. Another wind farm is also being planned to the Ulkonahkiainen water area, located on the west side of the Maanahkiainen water area. The municipal council of Pyhäjoki approved Suomen Hyötytuuli Oy's land use planning request for the area in 2011, but the project has not progressed in 2012. (*Municipality of Pyhäjoki 2012*)

## 7.6 Assessment of zero alternative impacts

The zero alternative is not to implement the project. In this case, the environmental impacts of the project, both positive and negative, will not occur.

Environmental impacts of the zero alternative will be assessed on the basis of the previous EIA by reviewing the environmental impacts of alternative electric power production methods. The assessment will be based on public studies on the development of the electricity production structure and the environmental impacts of various production methods. The impacts of not implementing the project will be illustrated by emission calculations, taking into consideration the production of the corresponding quantity of electricity using other production methods and the Nordic average production structure with its average emission factors. Moreover the addition of emission-free electricity production methods will be taken into account. The assumptions applied in the 2008 EIA will be updated to correspond to the present situation.

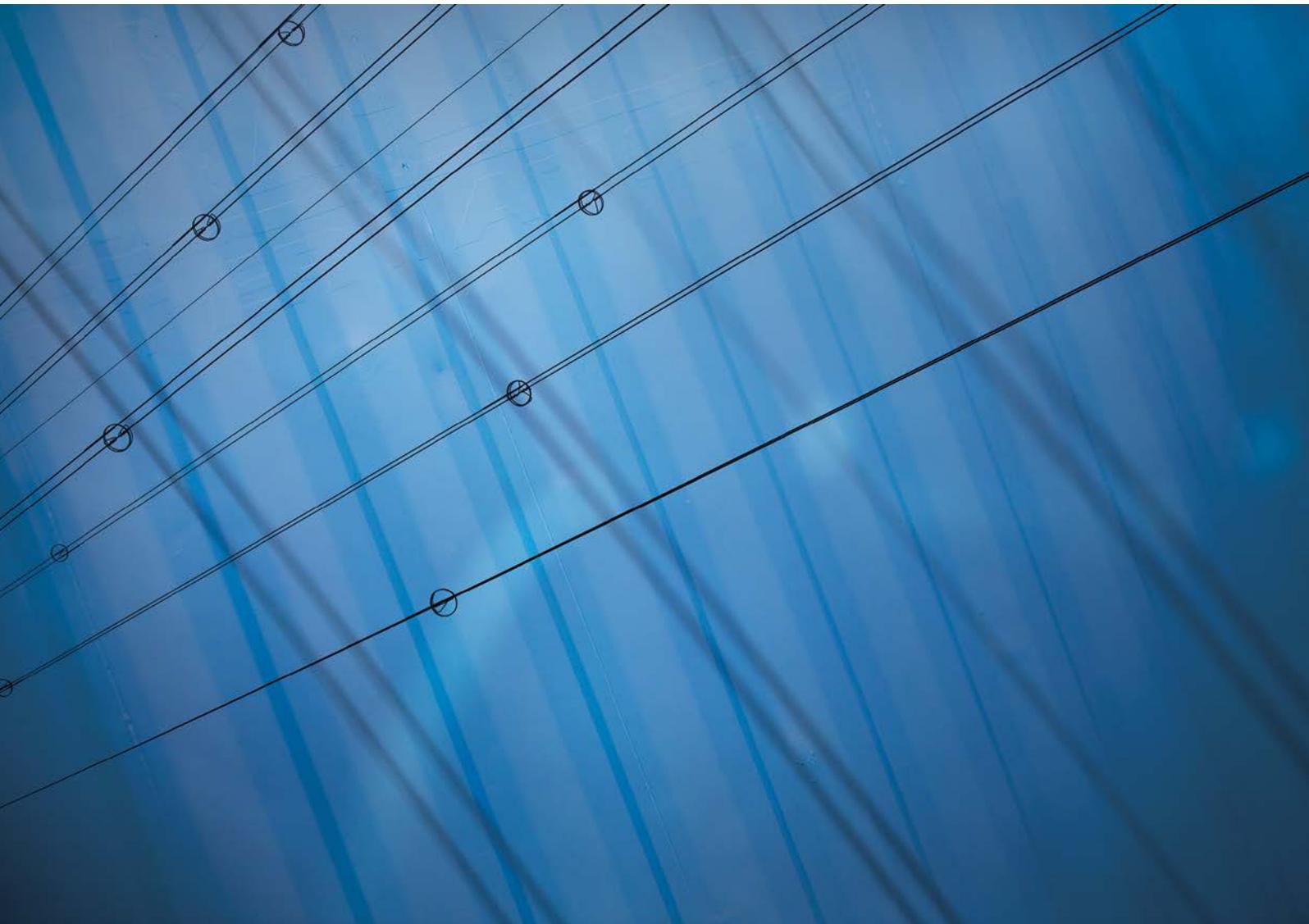
## 7.7 Comparison between alternatives

The comparison between alternatives will present the differences between the impacts of the approximately 1,200 MW nuclear power plant that is currently being assessed and the 1,800 MW plant presented in the 2008 EIA (one pressurised water reactor). These will be compared with the impacts of the zero alternative. The comparison will be executed by means of a qualitative comparison table. The major environmental impacts of different alternatives – positive and negative – will be recorded in this table in an illustrative and uniform manner. The environmental feasibility of the alternatives will also be assessed in this connection, based on the results of the environmental impact assessment.

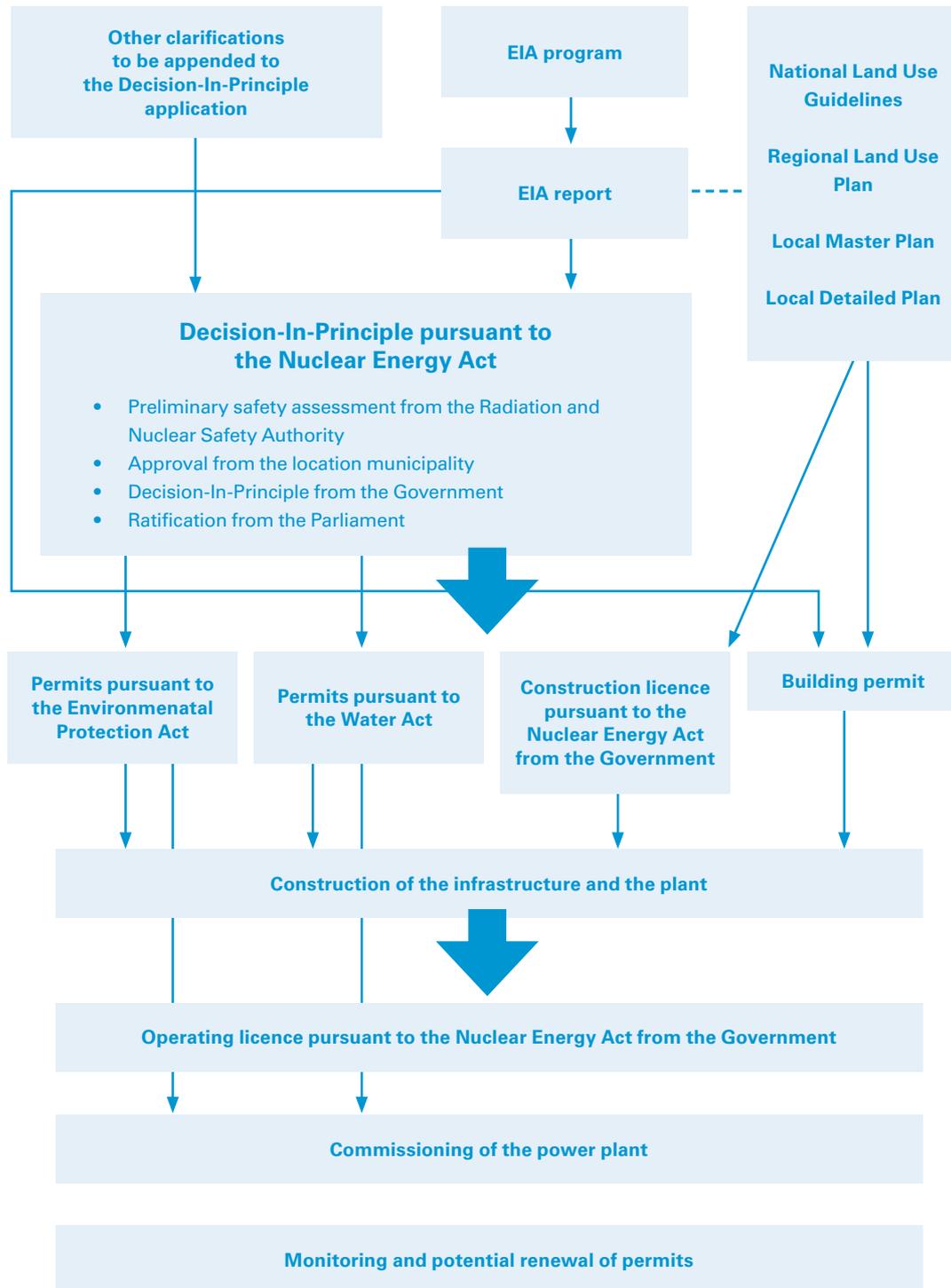
The significance of the impacts of the project will be assessed by comparing the impacts of the project with standards and guideline values on emissions and quality of the environment. In addition, the significance of the impacts will be assessed on the basis of information gained from the various stakeholders and the media.

# 8

## **Licences, permits, plans, notifications and decisions required by the project**



**Figure 8-1** Licencing and permitting procedures for the construction and operation of a nuclear power plant.



## 8.1 Land use planning

The implementation of a nuclear power plant project in Hanhikivi, Pyhäjoki, requires that the necessary area reservations have been made for a nuclear power plant in the land use planning for the plant location site. Land use plans in the Hanhikivi headland area, required by the project, have been drawn up for all levels of land use planning following the procedures required by the Land Use and Building Act (132/1999).

The Regional Council of Oulu was responsible for the preparation of the regional land use plan. The municipality of Pyhäjoki and the town of Raahe were responsible for the preparation of the local master plans and the local detailed plans. The land use plans are legally in force on all three land use planning levels. The land use planning in the Hanhikivi headland area is described in more detail under Chapter 6.1.3.

## 8.2 Environmental impact assessment and international hearing

According to the Act on Environmental Impact Assessment Procedure (468/1994) Chapter 4, subclause 1, the environmental impact assessment procedure shall be applied to projects, for which the enforcement of an international agreement binding to Finland requires an assessment, or which may cause significant adverse environmental impacts. Since the environmental impacts of one pressurised-water power plant with the magnitude of approximately 1,200 MW was not handled in the environmental impact assessment carried out in 2008, and the nuclear power plant belongs to the projects in accordance with the Annex I of the Espoo Convention, for which the EIA procedure must be applied, Fennovoima will implement a separate environmental impacts assessment procedure relating to this plant size and type.

The assessment of transboundary environmental impacts has been agreed upon in the so-called Espoo Convention (*Convention on Environmental Impact Assessment in a Transboundary Context*). Finland ratified this UNECE (*United Nations Economic Commission for Europe*) Convention in 1995. The Convention entered into force in 1997.

Parties to the Espoo Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland, if the adverse environmental impacts of the project being assessed are likely to affect the country in question. Correspondingly, Finland is entitled to participate in an environmental impact assessment procedure concerning a project located in the area of another country, if the impacts of the project are likely to affect Finland. The nuclear power plant belongs to

the projects under the Espoo Convention, for which it is agreed to implement an international hearing. In Finland, the arrangements fall under the responsibility of the Ministry of the Environment, but the coordinating authority will compile and consider all statements received in the international hearing.

## 8.3 Licences according to the Nuclear Energy Act

### 8.3.1 Decision-in-Principle

According to the Nuclear Energy Act (990/1987), the construction of a nuclear facility of considerable general significance shall require a government Decision-in-Principle to ensure that the project is in line with the overall good of society. A Decision-in-Principle is applied by submitting an application to the Council of State. The Ministry of Employment and the Economy must obtain a preliminary safety assessment from the Radiation and Nuclear Safety Authority, and a statement from the Ministry of the Environment, as well as the municipal council of the municipality intended to be the location site for the nuclear power plant, and from its neighbouring municipalities. The municipality of the planned location site must in their statement be in favour of the nuclear power plant in order for the Decision-in-Principle to be made.

Before the Decision-in-Principle is made, the applicant shall publish a general public description of the facility, drawn up according to the instructions and reviewed by the Ministry of Employment and the Economy, regarding the plant project, the estimated environmental impacts of the plant, and its safety.

The Ministry of Employment and the Economy shall provide the residents and municipalities in the immediate vicinity of the planned nuclear facility, as well as the local authorities with an opportunity to express their opinions on the project before the Decision-in-Principle is made. Furthermore, the Ministry shall arrange a public meeting in the municipality in which the planned site of the nuclear power plant shall be located. In this public meeting, the public shall have an opportunity to state their opinions. Those opinions shall be made known to the Council of State.

The Decision-in-Principle by the Council of State shall be issued to the Parliament for perusal. The Parliament may either revoke the Decision-in-Principle or let it remain in force, but it may not amend its content.

In January 2009, Fennovoima submitted an application for a Decision-in-Principle to the Council of State. On 6 May 2010, based on this application, the Council of State granted Fennovoima the Decision-in-Principle for the construction of a nuclear power plant. The Parliament ratified the decision on 1 July 2010.

Since the project as the subject of the current environmental impact assessment (one pressurised water plant with an electric power of approximately 1,200 MW) was not mentioned as one of the plant alternatives in Fennovoima's original Decision-in-Principle application, the Ministry of Employment and the Economy has required the following additional studies:

- Fennovoima shall update the environmental impact assessments of the project,
- Radiation and Nuclear Safety Authority shall assess the safety of the plant alternative,
- the municipality of Pyhäjoki shall make a statement on the issue, and
- the Ministry of Employment and the Economy shall arrange a public hearing regarding the project according to the Nuclear Energy Act.

After these studies, a statement will be made regarding the fact, whether the Decision-in-Principle in force will cover this plant alternative as well, or whether the Decision-in-Principle ratified by the Parliament in July 2010 shall be reintroduced to Parliament for new parliamentary proceedings.

### 8.3.2 Construction licence

The Council of State grants the licence for construction and operation of a nuclear facility. A construction licence may be granted if the Decision-in-Principle ratified by the Parliament has deemed the construction of a nuclear facility to be in line with the overall good of society and the construction of a nuclear facility meets the prerequisites for a granting a construction licence as depicted in Section 19 of the Nuclear Energy Act. These prerequisites include:

- the plans concerning the nuclear facility meet the safety requirements according to the Nuclear Energy Act and the safety of the employees and the population has been taken into consideration in an appropriate manner in the planning of operations,
- the location of the nuclear facility is appropriate with regard to safety and environmental protection has been taken into consideration in an appropriate manner,
- there is a local detailed plan in the location, which allows the construction of a nuclear power plant, and the applicant possesses the area required by the power plant operations,
- the methods and plans of the applicant for arranging nuclear fuel management and nuclear waste management are sufficient and appropriate,
- the applicant has sufficient expertise available, sufficient financial means and the applicant is otherwise considered to have the prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

According to the condition incorporated in the Decision-in-Principle, Fennovoima shall submit the construction application in accordance with the Nuclear Energy Act within five years from the date when the Parliament has decided on the ratification of the Decision-in-Principle i.e. at the latest on 30 June 2015.

### 8.3.3 Operating licence

Operating licence for a nuclear facility may be issued when the construction licence has been granted, provided that the prerequisites listed in Section 20 of the Nuclear Energy Act are met. These prerequisites include:

- the nuclear facility and its operation meet the safety requirements according to the Nuclear Energy Act and the safety of the employees and the population has been taken into consideration in an appropriate manner,
- the methods and plans for arranging nuclear fuel management and nuclear waste management are sufficient and appropriate,
- the applicant has sufficient expertise available and, in particular, the competence of the operating personnel of the nuclear facility and the operating organisation are appropriate,
- the applicant is considered to have financial and other necessary prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

The operation of the nuclear power plant shall not be started on the bases of a licence granted until the Radiation and Nuclear Safety Authority has ascertained that the nuclear facility meets the safety requirements set, and that the safety arrangements and emergency planning arrangements are sufficient and that the owner of the nuclear facility has, as provided by the Nuclear Liability Act, arranged indemnification regarding liability in case of nuclear damage. Furthermore, it is required that the Ministry of Employment and the Economy has ascertained that provision for the cost of nuclear waste management has been arranged in accordance with the provisions of law.

### 8.3.4 Notifications according to the Euratom Treaty

The Treaty establishing the European Atomic Energy Community (Euratom) requires that each Member state provides the Commission with plans relating to the disposal of spent nuclear fuel, (Article 37) and that the licensee submits to the Commission an investment notification (Article 41) and a notification regarding the technical characteristics of the plant (Article 78) for the supervision of nuclear substances.

## 8.4 Building permit

A building permit in accordance with the Land Use and Building Act (132/1999) shall be applied for in connection with all new buildings. The building permit application will be handled by the municipal building supervision authority that will, during the granting process, review that the plan is in accordance with the ratified local detailed plan and the building regulations. At the present, the handling of building permit applications in the municipality of Pyhäjoki is under the responsibility of the building and environmental supervision of the town of Raahe.

A building permit is required before construction works are started. The granting of a building permit for nuclear power plant buildings requires that the environmental impact assessment procedure is completed. During the project construction phase, building permits are also required for temporary storage and office buildings and the batching plant.

The commencement of earthmoving and excavation works in the plant area requires a landscaping or action permit in accordance with the Land Use and Building Act.

## 8.5 Permits according to the Environmental Protection Act and the Water Act

### 8.5.1 Permits required for construction

A permit in accordance with the Water Act (587/2011) is required for water construction works and structures to be located in the water system. Fennovoima has submitted permit applications in accordance with the Water Act to the Regional Administrative Agency in Northern Finland on 12 February 2013. The Regional Administrative Agency acts as the approving authority in this matter. There are three permit applications, the largest of which relates to the construction of a harbour and docks, cooling water intake structures, and a navigational route to the harbour. The second permit application concerns the cooling water discharge structures and third one relates to the maritime disposal area. The location for cooling water intake is planned to be located on the west coast of the Hanhikivi headland, in conjunction with the dock basin. The location of cooling water discharge on the coast would be located in the northern part of the Hanhikivi headland.

There are also activities at the construction site that require permits according to the Environmental Protection Act (86/2000) and the Environmental Protection Decree (169/2000) enacted on the basis of the Environmental Protection Act. Activities requiring an environmental permit are, among others, a rock-crushing station and a batching plant. These permit applications will be handled by the environmental protection authority of the municipality of Pyhäjoki.

### 8.5.2 Permits required in the operating phase

An environment permit must be obtained for the operation of a nuclear power plant. The permit shall be in accordance to the Environmental Protection Act (86/2000) and the Environmental Protection Decree (169/2000) enacted on the basis of the Environmental Protection Act. The environmental permit covers all regulations relating to the plant's environmental impacts, such as emission limits to the air and water, regulations on waste management and noise limits, as well as other matters relating to the environmental impacts, such as control and reporting of emissions.

As the permit authority, the Regional Administrative Agency in Northern Finland will grant the environmental permit, if the operations meet the requirements set by the Environmental Protection Act and other requirements set by legislation. In addition, the project must not contradict the land use planning of the area. The environmental impact assessment procedure must also be completed before the permit can be granted.

A water permit in accordance with the Water Act (587/2011) is required for the intake of cooling water and other required water.

## 8.6 Other permits

Other permit relating to this projects include permits for the import, possession and transportation of nuclear fuel, a permit or an agreement concerning wastewater discharge into the sewage system, permits according to the Chemicals Act, as well as permits concerning the construction of power transmission lines.

Permits concerning the import and possession of nuclear material, as well as for the transportation of nuclear fuel shall be applied for from the Radiation and Nuclear Safety Authority.

Fennovoima aims at making an agreement with the municipal water and sewage utility of Pyhäjoki regarding the centralised treatment of household and industrial wastewaters at the wastewater purification plant of the municipality. The agreement may contain stipulations relating to the quality and quantity of wastewater to be discharged into the sewage network.

During the operating phase of the plant, the storage and handling of chemicals requires a permit that shall be applied for from the Finnish Safety and Chemicals Agency (TUKES). The application and the permit are based on the Act (390/2005) on the safety of the handling of hazardous chemicals and explosives, the Decree (855/2012) on the supervision of handling and storage of hazardous chemicals, as well as the Decree (856/2012) on the safety requirements for industrial handling and storage of hazardous chemicals. A notification shall be made to the authority responsible for supervision of chemicals in the

municipality of Pyhäjoki regarding small-scale industrial handling and storage of chemicals.

The Nature Conservation Act (1096/1996) defines the conservation measures for species that are protected in Finland and strictly conserved under the EU Habitats Directive. The Centre for Economic Development, Transport and the Environment (ELY Centre) can grant a permission to deviate from the conservation measures under certain grounds. Fennovoima has been granted a permit for the destruction of the breeding ground of swamp frog and to transfer individual swamp frogs from the area, as well as for the destruction of the occurrence area of the yellow flag and to transfer individual plants. The permits concern the construction of the dock area, and they are not yet legally in force.

The construction of the 400 kV and 110 kV power transmission lines requires a construction permit according to the Electricity Market Act (588/2013). The Energy Market Authority is the approving authority.



# 9

## Prevention and mitigation of adverse impacts

The possibilities for preventing or limiting the adverse impacts of the project and its associated projects, by means of design or implementation will be studied during the assessment work. A report on the mitigation measures and nuclear safety systems will be presented in the assessment report.

# 10

## Uncertainty factors

The available environmental data and the assessment of impacts always involve assumptions and generalisations. Similarly, the available technical data is still preliminary. The lack of sufficient data may cause uncertainty and inaccuracy in the assessment work.

During the assessment work, the potential uncertainty factor will be identified as comprehensively as possible and their impact on the reliability of impact assessment will be considered. These matters will be described in the assessment report.

# 11

## Project impact monitoring

A proposal for the content of the environmental impact monitoring program will be prepared in conjunction with the impact assessment.

The objective of monitoring is to:

- provide information on the impacts of the project,
- investigate which changes have resulted from the project implementation,
- investigate how the impact assessment results correspond to reality,
- investigate how the measures for mitigating adverse impacts have succeeded, and
- initiate necessary measures if significant unforeseen adverse impacts occur.

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