FENNOVOIMA

Environmental Impact Assessment Report for a Nuclear Power Plant

October 2008

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Published by: Fennovoima Oy

Layout and design: Antturi Design Oy
Photos: Studico Oy and HeliFoto Oy

Printing: Lönnberg Painot Oy, Helsinki
Printed in September 2008

ISBN 978-952-5756-05-0

The original language of the environmental impact assessment is Finnish. Versions in other languages are translations of the original document which is the document Fennovoima is committed to.

Fennovoima's EIA report is available electronically at **fennovoima.fi**

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Fennovoima Ltd.

Preface

In the fall of 2007, Fennovoima Oy (Fennovoima) launched an environmental impact assessment procedure (EIA) for a nuclear power plant project regarding the construction of a nuclear power plant in four alternative localities. In June 2008, the EIA procedure was continued in three alternative localities (Pyhäjoki, Ruotsinpyhtää and Simo).

On January 30, 2008, Fennovoima submitted the environmental impact assessment (EIA) program to the Ministry of Employment and the Economy, which acts as the coordinating authority for the project. The program was placed on display for public inspection from February 5 to April 7, 2008. During the EIA program stage, The Ministry of Employment and the Economy and Fennovoima organized open public meetings in each alternative locality. The Ministry of Employment and the Economy issued a statement on the EIA program on May 7, 2008 (Appendix 1).

Following the Ministry of Employment and the Economy's request for statements, 69 communities submitted a statement concerning the EIA program to the coordinating authority. A total of 153 opinions on the EIA program were submitted. Of these, 35 were from Finnish communities and organizations, four from foreign communities and organizations, and 113 from private individuals from various countries.

The environmental impact assessment report has been drawn up on the basis of the EIA program and the related statements and opinions. Furthermore, a monitoring group consisting of representatives of different communities was established in each alternative locality to gain valuable additional information for the preparation of the EIA report. Fennovoima's project has increased knowledge on nuclear power in the new localities and resulted in active local dialog and public involvement.

This EIA report is one of the most extensive, if not the most extensive, environmental impact assessment reports prepared in Finland during the validity of the EIA Act. It is a comprehensive description of the current state of the environment in the alternative location sites, the project's environmental impacts, their significance and the prevention and mitigation of possible adverse effects.

Fennovoima will attach the EIA report to its application for a decision-in-principle, which it will submit to the Finnish Government by the beginning of 2009. The realization of a nuclear power plant project in any locality requires a statement of recommendation concerning the construction of the nuclear power plant to be issued by the municipality in question.

The EIA report was prepared by Pöyry Energy Oy on the assignment of Fennovoima. A large number of experts from Pöyry Energy Oy took part in the assessment of environmental impacts and the preparation of the EIA report. The experts most centrally involved in the assessment procedure were:

- Mr. Mika Pohjonen, M.Sc. (Agric.) (project manager)
- Ms. Sirpa Torkkeli, M.Sc. (Eng.) (environmental expert)
- Suomen YVA Oy: Mr. Hannu Lauri, M.Sc. (Eng.)

and Mr. Jorma Koponen, M.Sc. (Eng.) (cooling water modeling)
- Ms. Laura Kyykkä, M.A. and Ms. Tuija Hilli, M.Sc. (Agric.) (water system experts)
- Mr. Eero Taskila, M.A. (fishing industry)
- Ms. Minna Jokinen, M.Sc. (Eng.) (environmental expert, traffic, transportation and construction)
- Ms. Terhi Fitch, M.Sc. (Agric.) (environmental expert, monitoring)
- Ms. Riitta Ståhl, M.Sc. (Eng.) (energy industry expert)
- Mr. Arto Ruotsalainen, M.A., Mr. Sakari Grönlund, M.A. and Ms. Saija Miettinen, M.Sc. (Eng.) (social impact assessment)
- Mr. Juha Pitsinki, M.Sc. (Eng.), M.Sc. (Econ.) and Mr. Anders Lindholm, M.Sc. (Eng.) (assessment of regional economic impacts)
- Mr. Mike Lewis, B.Sc. (nuclear power technology)
- Mr. Markku Tuomenoja, M.Sc. (Eng.) (project manager, technical design)
- Mr. Pasi Rajala, M.Sc. (Eng.) (land use and planning)
- Mr. Carlo Di Napoli, M.Sc. (Eng.) (modeling and assessment of noise impacts)
- Mr. Lauri Erävuori, M.A., Ms. Sari Ylitulkkila, M.A., Mr. Tommi Lievonen, M.A., Ms. Soile Turkulainen, M.A. and Mr. Juha Parviainen, M.A., Ms. Anni Korteniemi, M.A., Ms. Tiina Sauvola, undergraduate student, Biology, Ms. Kukka Pohjanmies, undergraduate student, Biology (assessment of impacts on nature)
- Ms. Mariikka Manninen, Landscape Architect and Mr. Jarkko Männistö, Architect (visualization and assessment of impacts on the landscape)
- Ms. Mirja Kosonen, M.A. (assessment of health impacts)
- Ms. Karoliina Joensuu, undergraduate student, Engineering and Arts (environmental expert)

- Finnish Institute of Marine Research: Ms. Milla Johansson, M.A., Mr. Kimmo Kahma, Ph.D. and Ms. Hanna Boman, M.A. (extreme phenomena on the sea level)
- Finnish Meteorological Institute: Mr. Seppo Saku, M.A. and Mr. Ari Venäläinen, Ph.D. (extreme weather phenomena)
- Platom Oy: Mr. Kalevi Puukko, Mr. Tero Lytsy, B.Eng. and Mr. Jani Laine, M.Sc. (Eng.) (operating waste)

The Ministry of Employment and the Economy will request a number of statements concerning this EIA report and organize public meetings in Pyhäjoki, Ruotsinpyhtää and Simo in cooperation with Fennovoima. In addition, an international hearing procedure pursuant to the Espoo Convention will be applied to the project. Furthermore, all those wishing to present their opinion on the report will have an opportunity to do so. Fennovoima will gratefully receive all opinions concerning the report and use them to ensure that all environmental impacts will be sufficiently taken into consideration as the project progresses.

We wish you a good read!

Fennovoima is studying the construction of a nuclear power plant in three alternative locations: Pyhäjoki, Ruotsinpyhtää and Simo. Rocky seashore in Finland in 2008.

Fennovoima's parent company is Voimaosakeyhtiö SF, which has a 66% shareholding, and is owned by 48 local energy companies operating in Finland as well as 15 industrial and retail companies. The minority shareholder is E.ON Nordic AB with a shareholding of 34%. Fennovoima is to produce electricity for the needs of its owners at cost price.

Summary

The project and its justification

In January 2008, Fennovoima Oy (hereinafter Fennovoima) launched an environmental impact assessment procedure (EIA) regarding the construction of a new nuclear power plant in Finland. Fennovoima is studying the construction of a power plant consisting of one or two reactors with an electrical output of 1,500–2,500 MW to one of the following municipalities: Pyhäjoki, Ruotsinpyhtää or Simo.

Fennovoima's parent company is Voimaosakeyhtiö SF which has a 66% shareholding, and is owned by 48 local energy companies operating in Finland as well as 15 industrial and retail companies. The minority shareholder is E.ON Nordic AB with a shareholding of 34%. Fennovoima is to produce electricity for the needs of its owners at cost price.

Energy production must be increased in order to secure the operational requirements for and expand the operations of Finnish industry and commerce. In 2007, about 90 TWh of electricity was used in Finland (*Finnish Energy Industries 2008a*) and the demand for electricity is estimated to continue growing.

Fennovoima's shareholders account for nearly 30% of all electricity consumed in Finland. One of the main purposes of the project is to increase competition in the electricity market. Furthermore, the project's impact on the regional economy will be significant. The new nuclear power plant will increase carbon dioxide emission free energy production, reduce Finland's dependence on imported electricity and replace coal- and oil-operated power plants.

Implementation options to be assessed

The alternative location sites for the nuclear power plant are:

- The Hanhikivi headland in the municipality of Pyhäjoki. The distance to the center of the municipality of Pyhäjoki is less than 7 kilometers. The northeast part of the Hanhikivi headland is located in the town of Raahe. The distance to the center of Raahe is about 20 kilometers.
- The Kampuslandet island and the Gäddbergsö headland in the municipality of Ruotsinpyhtää. The distance to the center of the municipality of Ruotsinpyhtää is approximately 30 kilometers.
- The Karsikkoniemi headland in the municipality of Simo. The distance to the center of the municipality of Simo is approximately 20 kilometers.

During the EIA program stage, the alternative sites inspected also included Norrskogen in Kristiinankaupunki. Fennovoima Oy completed the investigations for these alternative in June 2008.

The impacts of the alternative cooling water intake and discharge locations will be assessed for each site.

The main alternative for the project to be analyzed in the environmental impact assessment is a nuclear power plant with electric power of 1,500–2,500 MW. The power plant can also be constructed in a manner suitable for combined district heating production. The nuclear power plant will consist of one or two light-water reactors (pressurized-water or boiling water reactors) and a disposal site for low- and medium-level waste produced by the reactors.

The project includes the disposal of spent nuclear fuel created by the nuclear power plant operations in Finland according to the requirements of the Nuclear Energy Act.

Project options

Fennovoima was specifically established to prepare, design and implement a nuclear power plant project to cover its owners' needs for electricity, and its plans do not include other alternative power plant projects. According to the estimates of Fennovoima's owners, other means cannot be used to achieve the required electrical power, delivery reliability and price.

The report describes the energy saving actions of Fennovoima's shareholders. They have engaged in systematic improvements in the efficiency of the use of electricity voluntarily and have achieved considerable savings. However, these means have not and will not be able to achieve such reductions in energy use that the nuclear power plant project would be unnecessary. By implementing all of the energy saving actions that have been decided or are under consideration, energy savings only equaling the annual production of a power plant of about 24 MW could be achieved.

Alternative site locations for the nuclear power plant.

The zero-option under inspection is that Fennovoima's nuclear power plant project will not be implemented. In the zero-option, the shareholders' increasing demand for electricity would be covered by increasing imports of electricity and/or through other operators' power plant projects.

Project schedule and the design stage

Preplanning for the nuclear power plant has been carried out in the alternative locations during 2008.

Fennovoima's objective is to start construction work at the selected plant site in 2012 and start energy production at the new nuclear power plant by 2020.

Environmental impact assessment procedure

The Directive on Environmental Impact Assessment (EIA, 85/337/EEC) issued by the Council of the European Community (EC) has been enforced in Finland through the EIA Act (468/1994) and Decree (713/2006). Projects to be assessed through the environmental impact assessment procedure are prescribed by the EIA Decree. According to the project list of the EIA Decree, nuclear power plants are projects to which the assessment procedure is to be applied.

Fennovoima submitted the EIA program concerning its nuclear power plant project on January 30, 2008 to the Ministry of Employment and the Economy, which acts as the coordinating authority. The Ministry of Employment and the Economy requested statements on the EIA program from different authorities and other stakeholders, and citizens had the opportunity to present their opinions. The EIA program was placed on public display from February 5 to April 7, 2008. The Ministry of Employment and the Economy issued its statement on the EIA program on May 7, 2008.

The environmental impact assessment report (EIA report) has been drawn up on the basis of the EIA program and related opinions and statements. The EIA report was filed with the coordinating authority in October 2008. Citizens and various stakeholders have the possibility to present their opinions on the EIA report during the time determined by the Ministry of Employment and the Economy. The EIA procedure will end when the Ministry of Employment and the Economy issues its statement on the EIA report.

One of the goals of the EIA procedure is to support the project design process by producing information concerning the project's environmental impacts at as early a stage as possible. Participation of citizens, which is an essential part of the EIA procedure, aims to ensure that various stakeholders' views of the project's impacts are also taken into account at a sufficiently early stage. During the EIA procedure, Fennovoima has launched technical preplanning for the project in all of the alternative sites and land use planning in two municipalities. Preplanning has been performed in close cooperation with environmental experts who carry out the assessment work. The EIA report and the stakeholder interaction that materialized during the EIA procedure, as well as the collected data, act as an important support for the more detailed further design and land use planning for the project.

Statements on the assessment program and other participation

The requested organizations submitted a total of 69 statements on the assessment program to the coordinating authority. The submitted statements mainly considered the program to be appropriate and comprehensive. A total of 153 opinions on the EIA program were submitted, of which 35 were from Finnish organizations and associations, four from foreign organizations and associations and 113 from private individuals from various countries.

The statements and opinions discuss the project-related factors very widely. The cooling water impact assessment has been requested to include the impact of warm water that increases eutrophication and impacts on migrating fish. In addition, the impact of the nuclear power plant and the surrounding safety zone on nearby residents and their everyday lives has raised plenty of interest. The statements and opinions have also dealt with the impact of radioactive emissions, the possibilities of reducing the emissions and the project's impact on the regional economy and the value of nearby properties. Various opinions suggested that the environmental impact assessment should be supplemented by taking into consideration the entire lifecycle of the project, including the environmental impacts of the processing of uranium, decommissioning the plant units, nuclear waste management and transportation. The opinions also discussed the social significance of the project and the need for assessing alternative energy production methods. The aim has been to take into account the questions, comments and views presented in the statements and opinions as comprehensively as possible in the drafting of the EIA report and associated surveys.

A monitoring group consisting of project-related stakeholders has been established in each of the municipalities being considered. The groups have met three times during the EIA procedure. During the public display of the EIA program, Fennovoima and the Ministry of Employment and the Economy organized open public events in all of the municipalities. Furthermore, other events concerning nuclear power and Fennovoima's project have been organized in the municipalities. Fennovoima has also established offices in all of these municipalities where information about nuclear power and Fennovoima's project has been available for everyone interested in the project. Information about the project has also been provided in Fennovoima News which was distributed in the region of each of the municipalities as a supplement to local newspapers. In addition, Fennovoima publishes the Sisu magazine distributed to stakeholders.

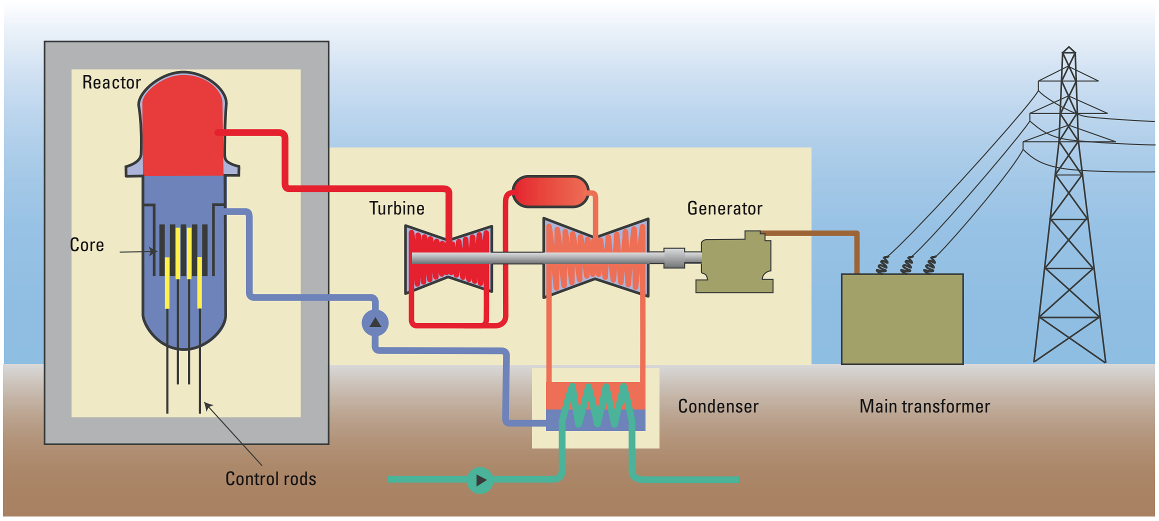
Project description

Technical description

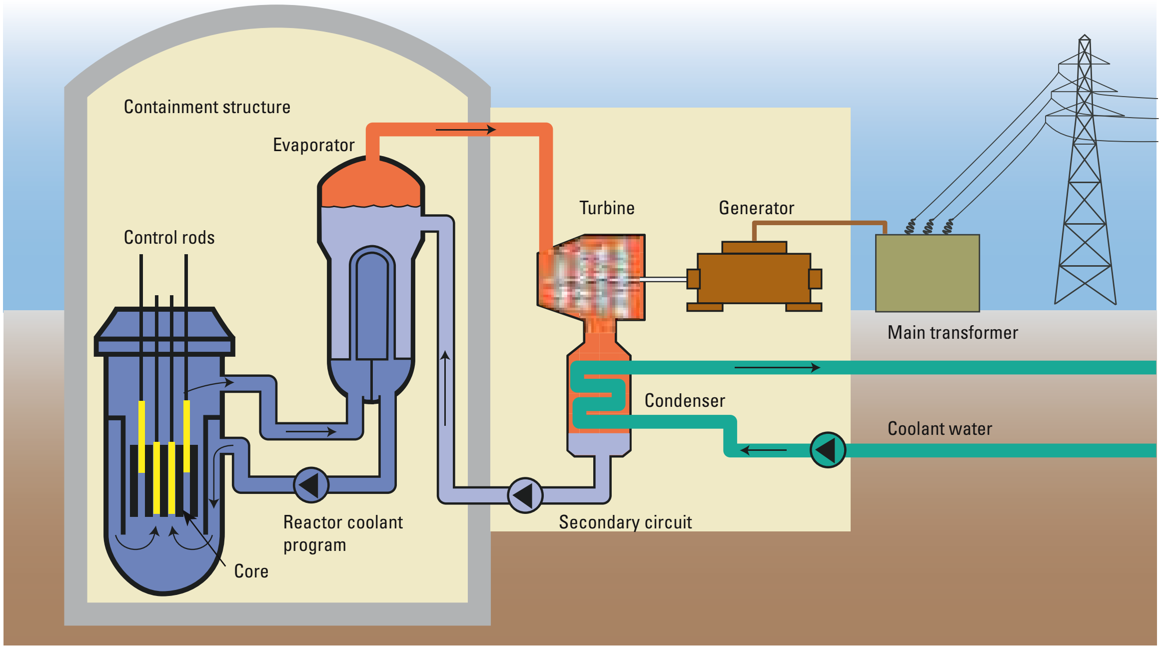
The alternative plant types inspected in the project are the boiling water reactor and the pressurized-water reactor. Both of the reactor types are light water reactors that use regular water to maintain the chain reaction, to cool the reactor and to transfer heat from the reactor core to the power plant process.It is possible to add an intermediate circuit at the low pressure end of both plant types to obtain sufficiently high temperature thermal energy from the process for district heating use.

The heat created in the fission of uranium atom cores used as fuel in the nuclear reactor heats the water in order to produce high-pressure steam. The steam rotates the turbine, which, in turn, drives the electric generator.

A boiling water reactor operates at a pressure of approximately 70 bar. Fuel heats up water in the reactor, and the steam coming from the reactor is led to rotate



The operating principle of a boiling water reactor.



The operating principle of a pressurized water reactor.

Description		
	Option 1 (one large unit)	**Option 2 (two smaller units)**
Electrical power	1,500–1,800 MW	2,000–2,500 MW
Thermal power	about 4,500–4,900 MW	about 5,600–6,800 MW
Efficiency	about 37 %	about 37 %
Fuel	Uranium oxide UO_2	Uranium oxide UO_2
Thermal power released in cooling to the water system	about 3,000–3,100 MW	about 3,600–4,300 MW
Annual energy production	about 12–14 TWh	about 16–18 TWh
Cooling water requirement	55–65 m^3/s	80–90 m^3/s

the turbine. The steam returning from the turbines is led to a condenser, where it releases its remaining heat into water pumped from the water system and condenses into water. The cooling water and the steam returning from the turbine and condensing into water are not brought into direct contact with each other. The boiling water reactor has a more simple steam generation process than the pressurized water reactor. On the other hand, the steam is slightly radioactive when the plant is running and no one can stay close to the turbine during operations.

In a pressurized water reactor, fuel heats the water, but the high pressure (150–160 bar) prevents the formation of steam. The high-pressure water coming from the reactor is led to steam generators where the water in a separate secondary circuit is vaporized, and this steam is led to rotate the turbine and electrical generator. Because of the heat exchanger, the steam in the reactor system and turbine plant is kept separate. As a result, water in the secondary circuit is not radioactive.

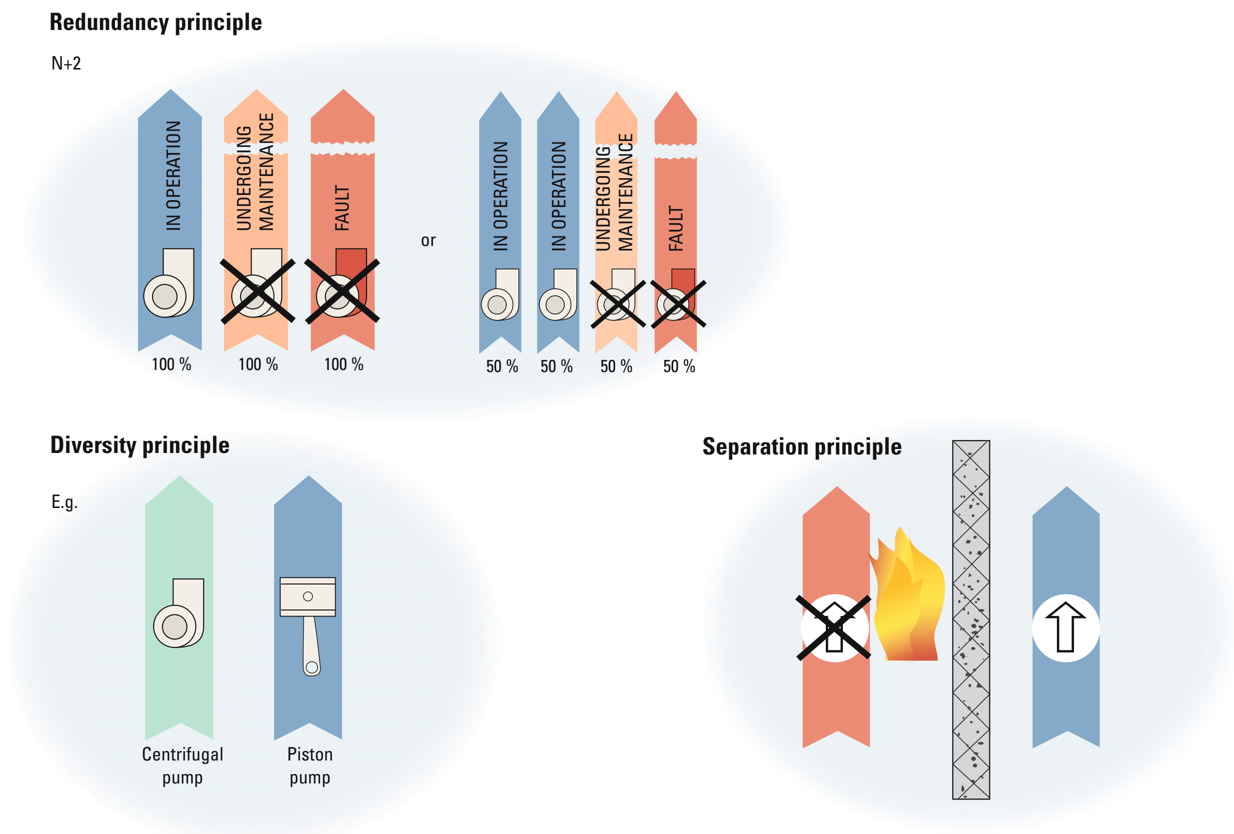
The nuclear power plant is a base load plant, which will be used continuously at constant power, except for a few weeks' maintenance outages at 12–24-month intervals. The plant's planned operational lifetime will be at least 60 years. The Fennovoima nuclear power plant will be primarily designed as a condensing power plant. The preliminary technical parameters of the planned nuclear power plant are shown in the table beside. Preliminary technical specifications of the planned nuclear power plant

Of all the light reactor types available on the market, Fennovoima has selected the following three reactor options suitable for Finland for closer inspection:

- EPR by Areva NP, a pressurized water reactor of about 1,700 MWe,
- ABWR by Toshiba, a boiling water reactor of about 1,600 MWe, and
- SWR 1000 by Areva NP, a boiling water reactor of about 1,250 MWe.

Nuclear safety

According to the Finnish Nuclear Energy Act (990/1987), nuclear power plants must be safe and they must not cause any danger to people, the environment or property. The regulations of the Nuclear Energy Act are specified in the Nuclear Energy Decree (161/1988). The general principles of the safety requirements for nuclear power plants applicable in Finland are prescribed in the Finnish Government decisions 395-397/1991 and 478/1999. Detailed regulations concerning the safety of nuclear energy, safety arrangements, preparations and the supervision of nuclear materials are issued in the nuclear power plant guides by the Radiation and Nuclear Safety Authority (STUK, YVL Guide, see www.stuk.fi). Legislation concerning nuclear energy is currently being revised.



Design principles of safety systems.

Safety is the central principle when designing a new nuclear power plant to be constructed. The safety of nuclear power plants is based on following the defense in depth principle. Several simultaneous and independent protection levels will be applied to the design and use of the power plant. These include:

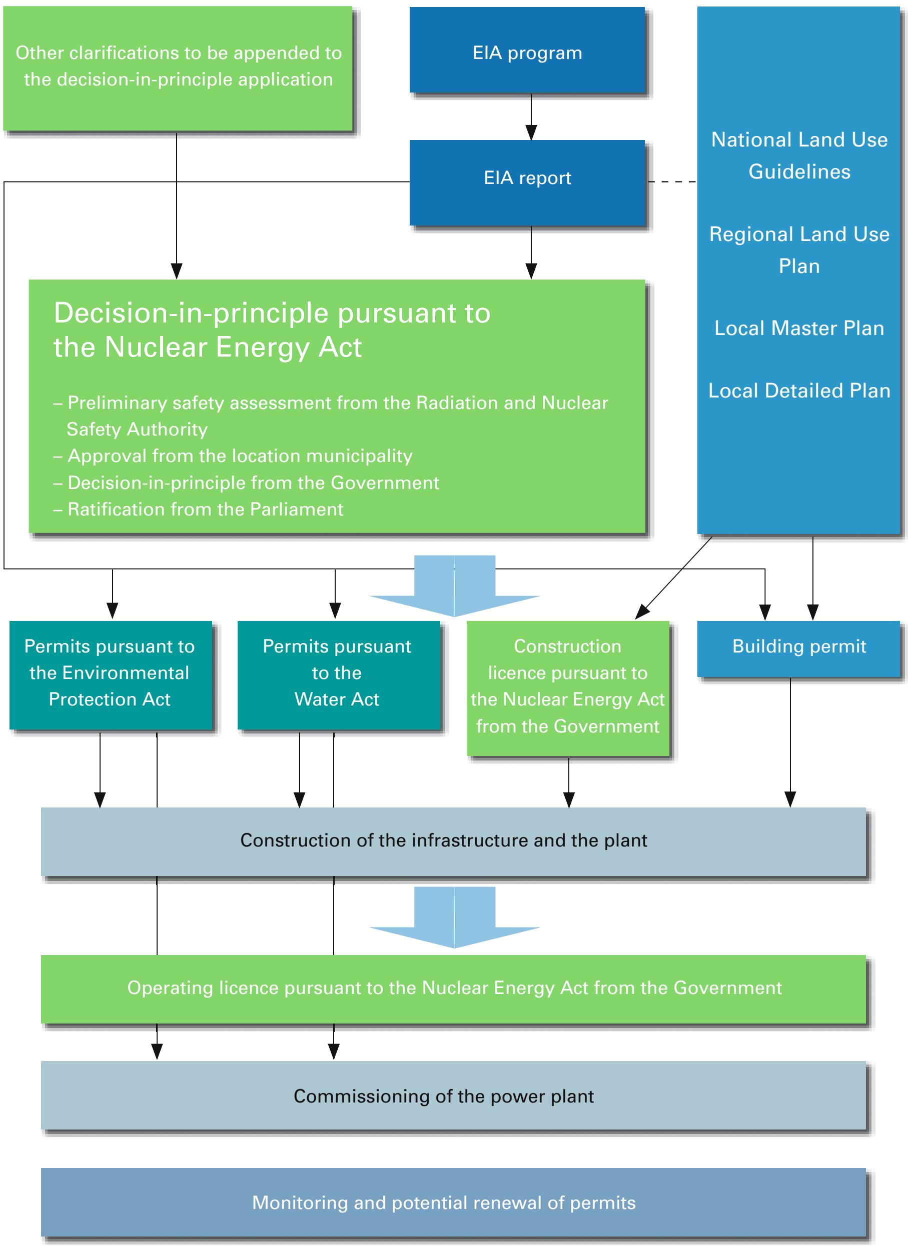
– the prevention and observation of operational malfunctions and faults
– the observation and management of accidents
– the reduction of the consequences of the release of radioactive substances.

Nuclear power plants are designed so that the failure of operations at one protection level does not result in any danger to people, the environment or property. In order to guarantee reliability, each of the levels is to be built on several supplementary technical systems, as well as limitations and regulations related to the use of the power plant.

Tested technology will be applied to the design of the nuclear power plant and all processes are designed to be naturally stable. The capacity of the power plant's safety systems is designed to be manifold in relation to the need so that the systems can be divided into several parallel subsystems.

Safety planning ensures that radioactive substances contained in the plant, fuel in particular, can be prevented from spreading as reliably as possible in all situations. Radioactive fuel is prevented from spreading into the environment using several technical spreading barriers within each other. Each of these barriers must be sufficient to independently prevent the spreading of radioactive substances into the environment.

The nuclear power plant will be constructed so that it is protected against outside threats, such as extreme weather conditions, different flying objects, explosions,



License procedure in the construction and operation of a nuclear power plant.

burning and poisonous gases and intentional damage.

The nuclear power plant will follow a high safety culture and developed quality assurance measures. The objective is to protect the plant from failures and employees from radiation. Supervision of the use and safety of nuclear energy is the responsibility of STUK and the safety of the nuclear power plant will be monitored through different authority inspections.

When applying for a decision-in-principle, STUK will prepare a preliminary safety assessment for Fennovoima's application, assessing how these reactor options inspected by Fennovoima meet Finland's nuclear safety requirements. The detailed implementation of the safety solutions for the plant option selected will be described in great detail when Fennovoima applies for a construction permit for the nuclear power plant. The structures implemented in construction and the results obtained from test operations will be assessed as a whole when Fennovoima applies for the operating permit for the nuclear power plant.

Licenses required by the project

According to the Nuclear Energy Act (990/1987), the construction of a nuclear power plant with a noticeable general significance requires a decision-in-principle issued by the Finnish Government and ratified by Parliament concerning the fact that the construction of the nuclear power plant will be in accordance with the total benefit of the society. The decision-in-principle requires a recommending statement concerning the location of the nuclear power plant to be issued by the planned location municipality of the nuclear power plant. A binding decision on the project investment cannot be made until Parliament has ratified the decision-in-principle. The construction permit will be granted by the Finnish Government if the requirements for granting the construction permit for a nuclear power plant prescribed in the Nuclear Energy Act are met. The operating permit will also be granted by the Finnish Government if the requirements listed in the Nuclear Energy Act are met and the Ministry of Employment and the Economy has stated that the preparations for nuclear waste management costs have been organized as required by law. In addition, the project will, at different stages, require licenses pertaining to the Environmental Protection Act, the Water Act and the Land Use and Building Act.

The project's environmental impact

For the environmental impact assessment, a report of the current status of the environment and the affecting factors have been conducted in each of the alternative sites and municipalities on the basis of available information and reports made for the EIA procedure.

The available environmental information and impact assessment always include assumptions and generalizations. Similarly, the available design information is preliminary at this stage. This causes inaccuracies in inspection work. Furthermore, any uncertainties related to the assessment methods have been assessed. However, any uncertainties related to all of the said factors are known fairly well and they have been taken into account when assessing the impacts. As a result, the significance and magnitude of environmental impacts has been identified reliably and the conclusions do not include any significant uncertainties.

The project's environmental impacts have been inspected by comparing the changes caused by the project and the different options to the current situation and assessing the significance of the changes.

For the impacts related to the nuclear power plant's construction stage, the following stages and functions have been inspected separately:

- Construction work for the power plant
- Construction of the navigation channel and harbor quay
- Building cooling water structures
- Construction of road connections
- Construction of power lines
- Transportation and commuter traffic.

The following have been inspected with regard to impacts during operations:

- Impacts of cooling water and wastewater
- Waste management
- Transportation and commuter traffic
- Irregular and accident situations
- Combined effects with other known projects
- Impacts crossing the boundaries of Finland

Furthermore, the following have been described with regard to environmental impacts:

- Acquisition chain for nuclear fuel
- Final disposal of spent nuclear fuel
- Decommissioning of the power plant

The assessed impacts include:

- – Impact on land use and regional structure
- Impact on water systems and the fishing industry
- Impact of radioactive and other emissions
- Impact on flora, fauna and protected sites
- Impact on the soil, bedrock and groundwater
- Impact on the landscape and cultural environment
- Noise impacts
- Impact on living conditions, comfort and health
- Impact on the regional economy
- Impact on traffic and safety

Land use and the built environment

The area of the power plant site which covers the central power plant functions will be about 10 hectares. The plant site will be specified in each municipality as design and planning proceed. The plant activities in the preliminary plans, excluding cooling water intake and discharge structures, harbor quay, and accommodation and parking areas, are expected to require an area of about 100 hectares at each alternative location. Ground area will also be required for new road connections to be built. The power line leading to the plant will restrict land use on a strip 80–120 meters wide depending on the column type.

The construction of the nuclear power plant will restrict land use in the plant's safety zone, but enable new constructions in settlements and villages and along roads. STUK will define the safety zone for the plant later, but, in the inspection work, it has been assumed to extend to a distance of about five kilometers from the plant.

Pyhäjoki

The holiday homes located on the west coast of the Hanhikivi headland and some of the holiday homes located on the southwest coast of the headland will be removed through the construction of the nuclear power plant and the southwest coast cannot be used for recreational purposes. The new road connection will not cause any significant changes in land use. The Hanhikivi historical monument will remain accessible. The significance of Raahe as a strong industrial region will become stronger, which may improve the conditions for the development of land use.

Ruotsinpyhtää

Most of the current holiday home areas in the Ruotsinpyhtää location may be preserved. The use of the areas for recreation or outdoor activities will be restricted. On the Kampuslandet island, the new road route will not be in conflict with current land use. In the Gäddbergsö headland, the new road connection will mainly follow the layout of the existing road. A large part of the nuclear power plant's safety zone is already included inside the safety zone of the Hästholmen plant, so there will be no significant changes in land use restrictions. The construction of the nuclear power plant will strengthen the position of the Loviisa region as a center for energy production, which may improve the conditions for the development of land use.

Simo

The holiday homes located on the south coast of Karsikkoniemi will be removed through the construction of the nuclear power plant. The current Karsikontie road can be used as a road connection. New road connections may be necessary for current land use and any rescue routes but they will not affect land use. The construction of the nuclear power plant will restrict the building of new residential areas indicated in the middle of Karsikkoniemi. The significance of the Kemi-Tornio region as a strong industrial region will become stronger, which may improve the conditions for the development of land use.

Construction of the nuclear power plant

In the case of one unit, the construction of the nuclear power plant will take about six years and about eight years in the case of two units. During the first construction phase of approximately two years, the necessary roads, as well as excavation and civil engineering work, for the power plant and other buildings will be completed. The actual plant construction work and the partly parallel installation work will take about 3–5 years, and commissioning of the plant will take about 1–2 years.

Impacts related to the construction site functions include dust, noise, landscape impacts, impacts on flora and fauna, and impacts on the soil, bedrock and groundwater. The construction site functions create local dust, and its impact on air quality will mostly be restricted to the construction site. The construction stage will also create impacts on people's living conditions and comfort. The impacts on the regional economy will mainly be positive as economic operations increase in the region.

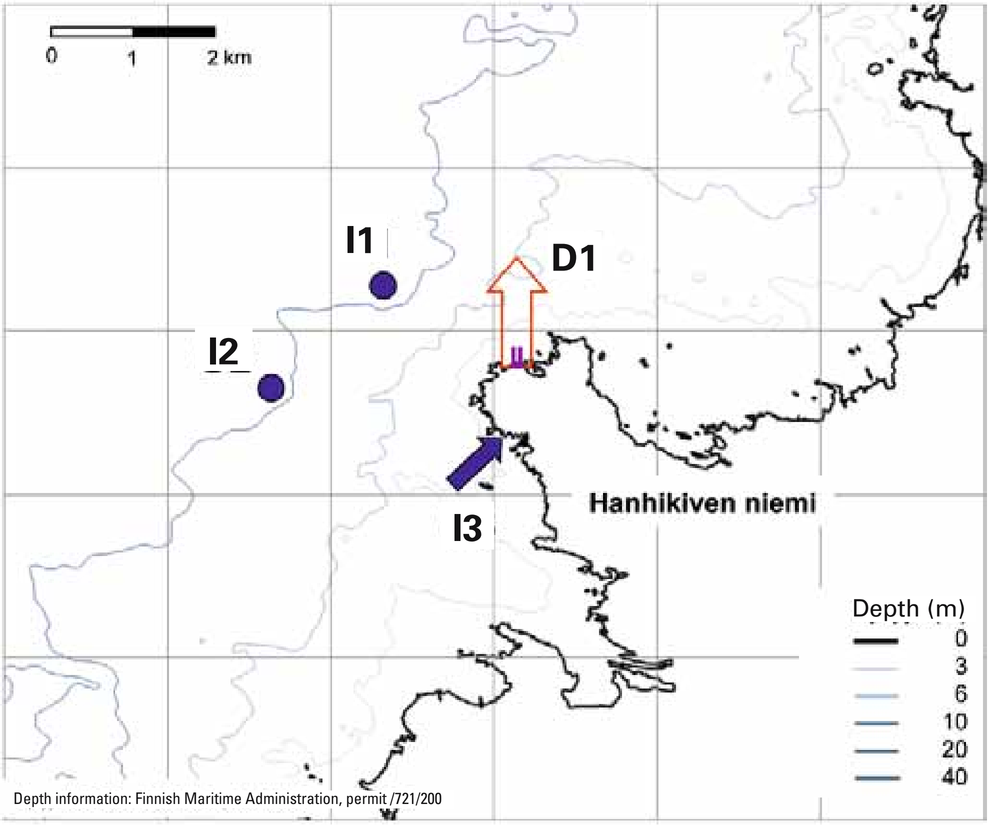
Radioactive emissions

Fennovoima's nuclear power plant will be designed so that its radioactive emissions fall below the set limit values. The plant's radioactive emissions will be so low that they will not have any adverse impact on people or the environment.

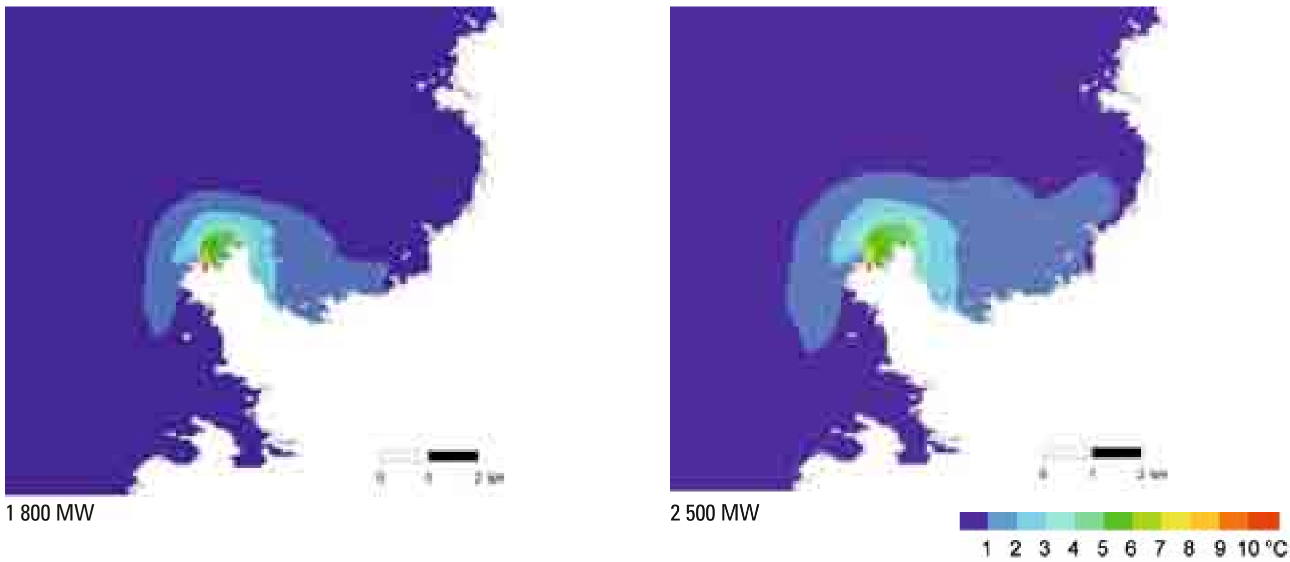
Other emissions

Traffic during construction will increase emissions significantly in all of the alternatives. However, traffic will only be especially frequent during the fourth or fifth year of construction. In other construction years, traffic volumes and emissions will be considerably lower. Construction-related traffic emissions are not estimated to have any significant impacts on air quality in the areas surrounding the alternative location sites.

In all of the options, traffic to the plant runs mostly along highways or motorways. The traffic volumes on these roads are fairly high, and traffic during the nuclear power plant's operating stage will not cause a significant change in the volumes and, as a result, in traffic emissions and air quality. The nuclear power plant's traffic emissions can be assessed to have an impact on air quality mostly along smaller, less operated roads leading to the nuclear power plant. The current air quality is assessed to be good in all of the location sites. The nuclear power plant's traffic emissions will not reduce the air



Cooling water intake and discharge sites in Hanhikivi headland, Pyhäjoki. The blue circles refer to bottom intakes, the blue arrow refers to shore intake and the red arrow means the discharge site.



Temperature increase in the surface layer as a June average value (bottom intake I2 – discharge D1).

quality so significantly that it would have adverse impacts on people or the environment.

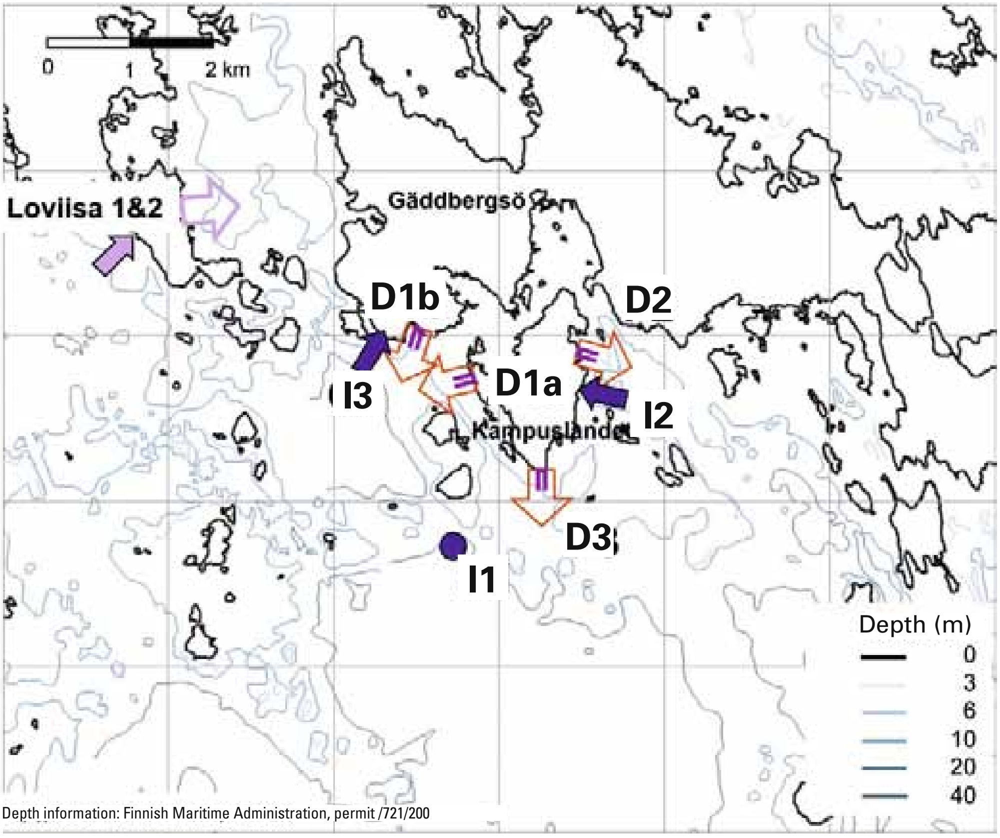
The emission volumes of reserve power and heat production will be very small and will not have an impact on the air quality of the alternative sites.

Water system and the fishing industry

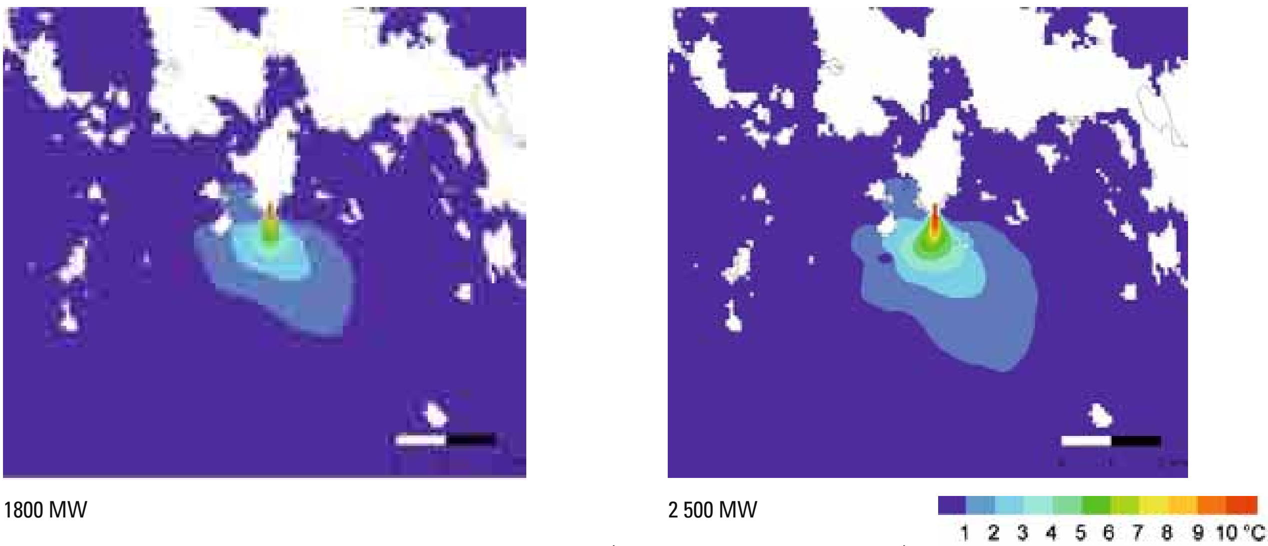
The conduction of the cooling water used at the power plant to the sea will increase the water temperature close to the discharge site. The extent of the warming sea area will be defined by the size of the power plant and, to some extent, by the chosen intake and discharge options. The power plant's impact on the sea temperature and the differences between the different intake and discharge options were assessed using a three-dimensional flow model for each municipality.

Pyhäjoki

Three different intake sites and one discharge option were studied in Pyhäjoki. Two of the intake alternatives



Cooling water intake and discharge sites in Ruotsinpyhtää. The blue arrows show shore intakes, the blue circle intake from the bottom (tunnel) and the red arrows show the discharge sites. The purple arrow indicates the existing Loviisa plant's intake and discharge location.



Temperature increase in the surface layer as a June average value (bottom intake I1 – discharge D3).

are for bottom intake (I1 and I2) and one for shore intake (I3).

A temperature increase of more than five degrees centigrade will be limited to the area surrounding the cooling water discharge site. The temperature increase can mainly be observed in the surface layer (at a depth of 0–1 m).

In winter, the thermal load of cooling water keeps the discharge site unfrozen and causes ice to thin out mainly to the north and east of Hanhikivi. The unfrozen area or thin ice area (thickness less than 10 cm) is about 8 km² for the 1,800 MW power plant option and about 12 km² for the 2,500 MW power plant option.

Proliferation of aquatic vegetation and phytoplankton will increase in the impact area of cooling waters. In Pyhäjoki, the sea area is open and there are only few nutrients available, because of which the impacts are assessed to be minor. According to the assessments, cooling water discharge will not cause anoxia in deep waters or significantly increased flowering of blue-green algae. The project will not have an impact on water quality.

Possible adverse impacts on fishing include the build-up of slime in nets and, in the summertime, hindering whitefish fishing especially on the fishing ground north of Hanhikivi. In winter, the unfrozen area of water will hinder ice fishing but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area.

The impacts of cooling water will mainly be restricted to a distance of a few kilometers from the discharge site and they will not have a wider impact on the condition of the Bothnian Bay.

Ruotsinpyhtää

Three different intake and discharge sites were studied in Ruotsinpyhtää. One of the intake alternatives is for bottom intake (I1) and two are for shore intake (I2 and I3). The modeling also took into account the effect of cooling water from the existing nuclear power plant in Loviisa.

A temperature increase of more than five degrees centigrade will be limited to the area surrounding the cooling water discharge site. The temperature increase can mainly be observed in the surface layer (at a depth of 0–1 m).

The smallest warming area will be caused by the discharge site (D3) directed to the open sea area south of Kampuslandet, whereas the largest area will be caused by the discharge site (D2) directed to the shallow area east of Kampuslandet.

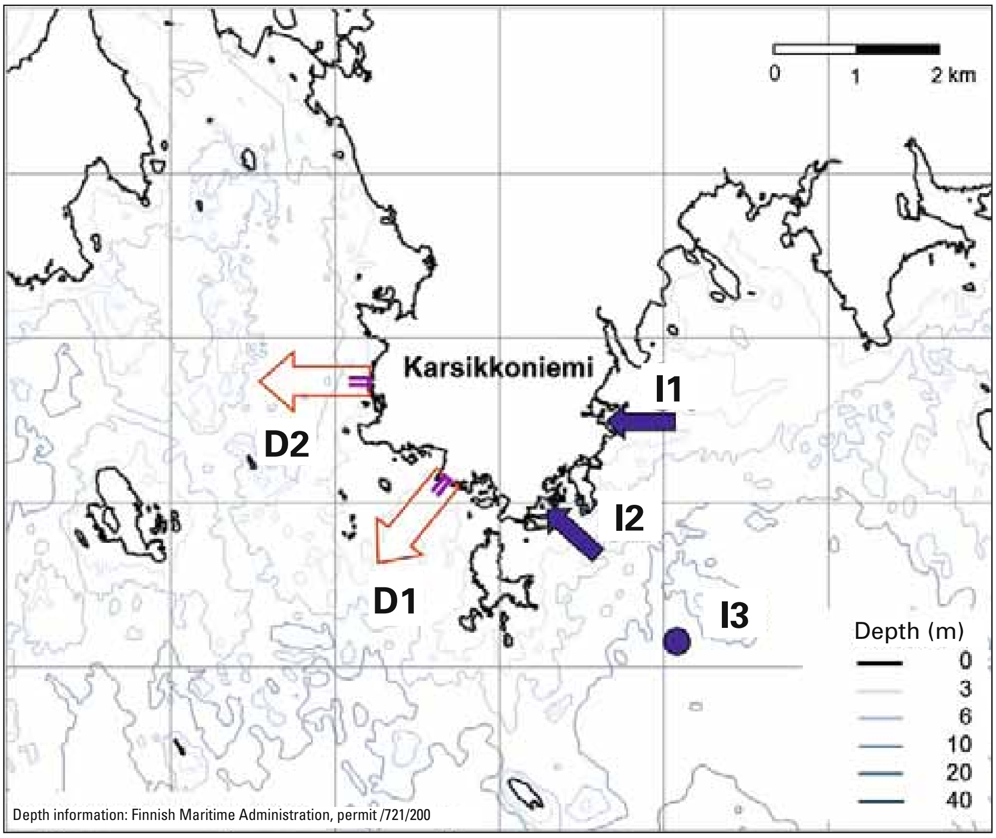
The smallest areas to warm up will be reached by using the bottom intake option (O1) and shore intake west of Kampuslandet (O2). Shore intake west of Kampuslandet (O3) will result in the largest area to warm up.

In winter, the uniform area of thin or nonexistent ice cover will expand. The unfrozen area or thin ice area (thickness less than 10 cm) varies from 3 to 5 km^2 for the 1,800 MW power plant option and from 4.5 to 5.5 km^2 for the 2,500 MW power plant option.

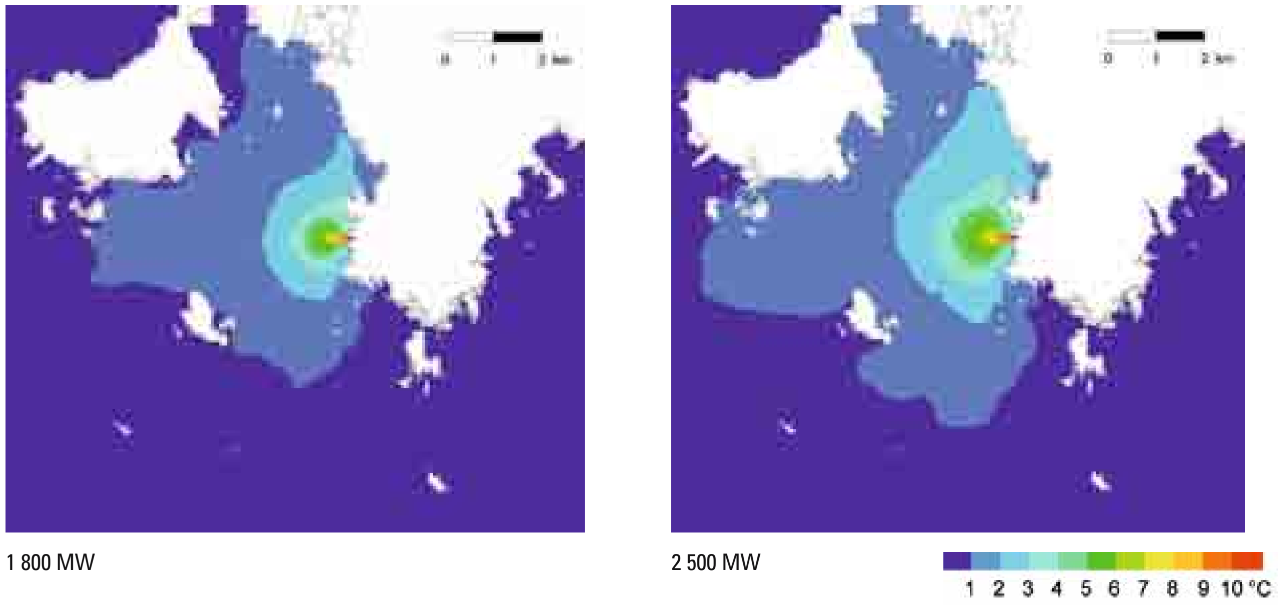
Proliferation of aquatic vegetation and phytoplankton will increase in the impact area of cooling waters. Due to eutrophication, flowering of blue-green algae may increase locally, particularly if the mostly shallow sea area east of Kampuslandet is chosen as the discharge site. The project may have local adverse impacts on the oxygen level near the bottom of basin areas. The impacts will be smaller if the option (D3) directed towards the open sea is chosen as the discharge site.

In bottom intake, nutrient concentration may increase slightly at the discharge site and intensify the impact of thermal load to some extent.

Possible adverse impacts on fishing include the build-up of slime in nets and decreased catching efficiency of



Cooling water intake and discharge sites in Karsikko, Simo. The blue ball refers to bottom intake, the blue arrows refer to shore intake and the red arrows indicate discharge sites.



Temperature increase in the surface layer as a June average value (bottom intake I3 – discharge D2).

traps in the affected area of cooling waters. In winter, the unfrozen area of water will hinder ice fishing but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area.

The impacts of cooling water will mainly be restricted to a distance of a few kilometers from the discharge site and they will not have a wider impact on the condition of the Gulf of Finland.

Simo

Three different intake sites and two discharge sites were studied in Simo. Two of the intake alternatives are for shore intake (O1 and O2) and one for bottom intake (O3).

A temperature increase of more than five degrees centigrade will be limited to the area surrounding the cooling water discharge site. The temperature increase can mainly be observed in the surface layer (at a depth of 0–1 m).

The discharge option (D1) directed towards the open sea area southwest of Karsikko will cause a smaller warming area than the option west of Karsikko (D2). The bottom intake option (I3) will cause the smallest warming area during summer. There is not much difference between the shore intakes (I1 and I2) with regard to the warming area.

In winter, the uniform area of thin or nonexistent ice cover will expand. The unfrozen area or thin ice area (thickness less than 10 cm) varies from 7 to 9 km^2 for the 1,800 MW power plant option and from 9 to 13 km^2 for the 2,500 MW power plant option.

Proliferation of aquatic vegetation and phytoplankton will increase in the impact area of cooling waters. The discharge site directed to the open sea (D1) is assessed to cause minor eutrophication. In discharge to the more sheltered and already nutrient-rich Veitsiluoto Bay, eutrophication will probably increase relatively more. Cooling waters are assessed not to cause anoxia in hypolimnion.

Possible adverse impacts on fishing include the build-up of slime in nets and decreased catching efficiency of traps in the affected area of cooling waters. According to assessments, cooling waters will not have an impact on fish migration. In winter, the unfrozen area of water will hinder ice fishing but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area.

The impacts of cooling water will mainly be restricted to a distance of a few kilometers from the discharge site and they will not have a wider impact on the condition of the Bothnian Bay.

Soil, bedrock and groundwater

The most significant impact on soil, bedrock and groundwater will be caused during the nuclear power plant's construction stage. Construction work will be planned so that there will be as few adverse impacts as possible. During construction, all earth-moving, excavation and dredging masses are to be utilized on the site in different landfills and landscaping work. The foundation waters and rain waters drained from the construction site will contain more solids and any oil and nitrogen compounds than waters normally drained from tarmac-covered yards. The quality and volume of water drained to the sea from the construction site will be monitored. The project will not have any adverse impacts on usable groundwaters.

Flora, fauna and protection sites
Noise and other operations during the construction stage may disturb fauna close to the power plant site. Construction work will cause some of the living environments to change permanently. The project's design and implementation will take into account the natural values of the regions, if possible. Construction work is to be scheduled so that they will cause as little damage as possible to nesting bird stocks. Protection sites or areas for protected species will be avoided when locating buildings and other infrastructure.

Pyhäjoki
The Hanhikivi area is rich in bird species. The planned plant site will be located in an area where the avifauna mainly consists of forest species. The Hanhikivi headland is on the route of migrating birds and acts as a staging area for many species. Power lines will increase the risk of migratory bird collisions.

There are a few occurrences of endangered and otherwise noteworthy plant species at the Hanhikivi headland. If the habitats of the species outside the construction areas are retained, the occurrence of the species in the area would probably not deteriorate.

The Hanhikivi headland area would change and nature in the area would become so fragmented that the area's significance as a model of uninterrupted succession development, i.e. slow change in flora and fauna in the uplift area, would clearly deteriorate.

The project area includes the nature conservation area of Ankkurinnokka and several habitat types defined in the Nature Conservation Act. The overgrowing of protected shore meadows may intensify.

The closest Natura area is located about two kilometers away, south of the area. The project is assessed not to have significant adverse impacts on the protection criteria of the Natura 2000 area.

Ruotsinpyhtää
The observed bird species can mostly be deemed regular species for coastal and inland archipelago areas. The area does not include any habitat entities of major significance to bird species. The project is assessed not to cause any major adverse impacts on the avifauna. Power lines will increase the risk of migratory bird collisions.

Most of the natural characteristics of the area are mainly common for the shore area, and the forests are highly managed. Therefore, the project's impacts on biodiversity would remain relatively low.

There are no nature conservation areas or habitat types in accordance with the Nature Conservation Act in this area. The closest nature conservation areas are approximately three kilometers to the northwest and southwest. According to assessments, the project will not have an impact on the nature conservation areas.

The closest Natura area is approximately 1.5 kilometers south of Kampuslandet at its closest. The project is assessed not to have significant adverse impacts on the protection criteria of the Natura 2000 area.

Simo
The birdlife at Karsikkoniemi is versatile due to the versatile habitat structure of the area.

The areas which would change the most are located in the inner parts of the Karsikkoniemi headland where there are no significant sites considering the avifauna or other animals, except for the Lake Karsikkojärvi, and in the Laitakari and Korppikarinnokka area which are significant for avifauna. Power lines will increase the risk of migratory bird collisions.

There are plenty of occurrences of endangered and otherwise noteworthy plant species at Karsikkoniemi headland. Construction may destroy some of the occurrences from the area.

There are no nature conservation areas in the assessment area. There are a few habitat types in accordance with the Nature Conservation Act in this area. The overgrowing of protected shore meadows may intensify on the western shore of Karsikkoniemi.

The closest Natura area is located at Ajos headland, approximately 3.5 kilometers from the assessment area. A slight heat impact from the cooling waters may occasionally extend to the area. The project is assessed not to have significant adverse impacts on the protection criteria of the Natura 2000 area.

Landscape and cultural environment
The nuclear power plant will alter the landscape considerably. The pictures on the next page illustrate the impact of the nuclear power plant on the landscape in the alternative locations, both for the one-unit and two-unit alternatives. In Pyhäjoki, the character of the surroundings of the Hanhikivi antiquity and the position of the Takaranta seashore meadow would change. In Kampuslandet, Ruotsinpyhtää, the nuclear power plant would impact the cultural landscapes of provincial value and the surroundings, scenery and position in the overall setting. In Ruotsinpyhtää, the nuclear power plant would be located in the vicinity of the existing nuclear power plant. In Karsikkoniemi, Simo, the landscape is in a state of change, and the nuclear power plant would be placed as an annex to the Kemi industrial zone. The landscape status of a nationally important fishing village will change.

Traffic and safety
The increase in traffic at the nuclear power plant's construction stage will be notable in all of the options. However, traffic will only be especially frequent in the fourth or fifth year of construction. As a result, any ad-

Photomontage: The nuclear power plant in Pyhäjoki (and Raahe) (1 unit).

Photomontage: The nuclear power plant in Pyhäjoki (and Raahe) (2 units).

verse traffic impacts will only cover this limited period.

At the operating stage, the nuclear power plant's traffic will only have a minor impact on traffic volumes on the main routes in the alternative sites. The planned improvement projects for routes leading to the alternative sites will improve traffic safety, and according to assessments, nuclear power plant traffic will not reduce the traffic flow and safety.

Noise

The noisiest stage during the construction of the nuclear power plant will be the first years of construction when functions that cause significant noise include the rock crushing plant and concrete mixing plant. During the operating phase, the most significant noise impact will occur in the immediate vicinity of the turbine hall and the transformer.

Simo

During the construction phase, the daytime guide value of 45 dB(A) will be exceeded on a few dozen existing holiday properties in the vicinity of the power plant. The night-time guide value of 40 dB(A) will be exceeded on a maximum of 10 existing holiday properties in the vicinity of the power plant and on a few holiday properties close to the road. The holiday homes located on the south coast will probably be removed with the implementation of the project.

Pyhäjoki

The daytime guide value will be exceeded on about 15 existing holiday properties in the vicinity of the power plant and on 10 holiday properties near the road. The night-time guide value will be exceeded on about 15 to 20 existing holiday properties in the vicinity of the pow-

Photomontage: The nuclear power plant in Kampuslandet, Ruotsinpyhtää (1 unit).

Photomontage: The nuclear power plant in Kampuslandet, Ruotsinpyhtää (2 units).

er plant. Some of the holiday residences on the west and southwest coast will be removed with the implementation of the project.

Ruotsinpyhtää

During the construction phase in the Kampuslandet location, the daytime guide value will be exceeded on about 20 existing holiday properties in the vicinity of the power plant and on 10 holiday properties near the road. In the Gäddbergsö location, the daytime guide value will be exceeded on less than 20 existing holiday properties in the vicinity of the power plant and on about 30 holiday properties near the road.

During the operating phase in the Kampuslandet location, the night-time guide value will be exceeded on no more than about 10 existing holiday properties in the vicinity of the power plant. In the Gäddbergsö location, the night-time guide value will be exceeded on a few existing holiday properties in the vicinity of the power plant.

Impact on people and society

The nuclear power plant project will have significant impacts on the regional economy, employment, the property market in the surroundings of the location site, the population, industrial structure and services. During the construction phase, the project's municipal tax revenue will be EUR 2.8 to 4.5 million in the economic areas, and property tax revenue in the location municipality will be determined by the stage of completion of the nuclear power plant. The employment impact of the construction stage on the economic area will be 500–800 man-years. During the operating stage, property tax revenue in the location municipality

Photomontage: The nuclear power plant in Gäddbergsö, Ruotsinpyhtää (1 unit).

Photomontage: The nuclear power plant in Gäddbergsö, Ruotsinpyhtää (2 units).

will be EUR 3.8 to 5.0 million a year and municipal tax revenue EUR 1.9 to 2.4 million a year in the economic area. In the economic area, employment impact will be 340–425 man-years annually. The arrival of new residents, boosted business and escalated building activity will increase tax revenue. The population and residence bases will grow and, as a result, the demand for private and public services will increase.

A number of people will move close to the nuclear power plant during the construction stage and the demand for services will increase. The accommodation of a large group of employees in a new municipality may also include negative impacts. Increased traffic and noise caused by construction work may have a local impact on comfort.

Normal operation of the nuclear power plant will have no radiation-related, detectable impact on the health, living conditions or recreation of people living in the vicinity. Access to the power plant area will be prohibited and the area cannot be used for recreational purposes. Warm cooling water will melt or weaken the ice and, as a result, restrict recreational activities on ice during the winter, such as fishing or walking.

The opinions of those living and operating in the surrounding areas of the location sites on the nuclear power plant site were identified through group interviews and resident surveys. The opinions varied greatly and groups for and against the project have been established in the areas. Opposition is often based on risks and fears associated with nuclear power plants, and on the belief that nuclear power is ethically questionable. The supporters emphasize its positive economic impacts and environmental friendliness.

Impact of the use of chemicals

The use of chemicals and oils at the nuclear power plant

Photomontage: The nuclear power plant in Karsikkoniemi, Simo (1 unit).

Photomontage: The nuclear power plant in Karsikkoniemi, Simo (2 units).

will not cause any adverse environmental impacts under normal conditions. The risks of chemical accidents will be taken into account in the design of the plant. The probability of an accident where a dangerous volume of chemicals or oils can enter the atmosphere, water system or soil is low.

Impact of waste management

Regular waste created at the nuclear power plant will be sorted, sent for treatment, utilization and final disposal in a manner required by waste legislation and environmental license decisions. Waste handling at the plant will not cause any significant environmental impacts.

Sufficient facilities for the handling and disposal of low- and medium-level power plant waste will be built at the nuclear power plant. The facilities will contain systems for the safe handling and transportation of waste and the monitoring of the amount and type of radioactive substances. The disposal facilities for low- and medium-level waste can be built in underground facilities and the disposal facilities for very low-level waste can also be built in facilities located in the ground. Once the use of the final disposal facilities is terminated, the connections will be sealed and will not require any supervision afterwards. Any radioactive substances contained in the waste will become safe for the environment over time. Careful planning and implementation will help to eliminate significant environmental impacts caused by the treatment and final disposal of operating waste.

Spent nuclear fuel will be transported to a repository located in Finland by sea or road.

Impact of decommissioning the power plant

The new nuclear power plant's estimated operating life is at least 60 years. As a result, the decommissioning of

Fennovoima's plant is estimated to begin in 2078 at the earliest.

The most significant environmental impacts of decommissioning will arise from the handling and transport of radioactive decommissioning waste generated during dismantling of the controlled area of the plant. The most radioactive portion of such waste will be treated and disposed of similarly to operating waste. As many of the dismantled contaminated plant parts and equipment as possible will be cleaned so that they can be released from the radiation authority's control and either recycled or disposed of at a general landfill site. The plant's systems will be sealed so that radioactive substances cannot spread into the environment.

The majority of waste generated through the nuclear power plant's dismantling operations is not radioactive and can be treated similarly to regular waste. Environmental impacts in the plant area and nearby roads caused by the dismantling, treatment and transportation of the nuclear power plant's non-radioactive structures and systems include dust, noise and vibration. Furthermore, in road sections with only a little traffic, the emissions of increasing traffic will have an impact on air quality.

Decommissioning can be performed so that the power plant site will be released for other operations or some of the buildings will be left at the site and utilized for other purposes, or energy production or other industrial operations will be continued at the site.

Impact of a nuclear accident

Nuclear power plant incidents and accidents can be categorized using the international INES scale into Categories 0–7 which illustrates the severity of nuclear power plant incidents. Categories 1–3 indicate incidents that reduce safety and Categories 4–7 refer to different types of accidents. An accident is considered to be at least in Category 4 if any civic defense measures must be started outside the plant.

In order to assess impacts caused by a nuclear power plant accident, the spreading of radioactive emissions caused by a serious reactor accident (INES 6) have been modeled as an example case, as well as the resulting fallout and radiation dose for the population. Using the modeling results, the environmental impacts caused by an accident of Category 4 on the INES scale have also been assessed. It is not justified to include an assessment of an accident more serious than INES Category 6 in an environmental impact assessment because the occurrence of such an accident must be practically impossible in order to grant a construction and operating license for a nuclear power plant in Finland.

According to the limit value set by the Government Decision (395/1991), the caesium-137 emission caused by the modeled accident is 100 TBq. The model includes such a number of nuclides that corresponds to more than 90 percent of the radiation dose caused.

The spreading calculation of radioactive emissions is based on the Gaussian spreading model and its versions suitable for short and long distances. The spreading of a radioactive emission and radiation dose calculation have been modeled at a distance of 1,000 km from the nuclear power plant.

Impact of a serious accident

According to the Government Decision (395/1991), a serious reactor accident, i.e. an accident caused by the melting of the fuel core, shall not cause direct adverse health effects to the population in the vicinity of the nuclear power plant or any long-term restrictions on land use.

The likelihood of a serious nuclear accident is extremely low. In the event of such an accident, the impacts of a radioactive release on the environment will strongly depend on the prevailing weather conditions. The most important weather factor for impacts is rain, which will effectively flush down the radioactive substances included in the emission cloud. If the weather conditions are unfavorable, the impacts of the emission in the areas where rain occurs will be higher but the total impact area will, on the other hand, be smaller than in case of typical weather conditions.

The season also has an impact on the contamination of food products. Following a serious accident (INES 6), it is not likely that the use of agricultural products will be restricted in the long term. Short-term restrictions on the use of agricultural products may apply to areas within a 1,000 km radius of the plant without any protective measures aimed at livestock or food production. In case of unfavourable weather conditions, restrictions on the use of various kinds of natural produce may have to be issued in areas affected by the greatest fallout. For example, long-term restrictions on the consumption of certain mushrooms may be required in areas up to 200–300 kilometres of the accident site.

Under the threat of a serious accident, the population will be evacuated, as a protective measure, from an approximately five kilometer wide safety zone surrounding the facility. In unfavorable weather conditions, protection may be necessary indoors within a maximum of 10 kilometers. The use of iodine tablets may also be necessary according to guidelines issued by the authorities. Serious accidents will have no direct health impacts.

Impact of a postulated accident

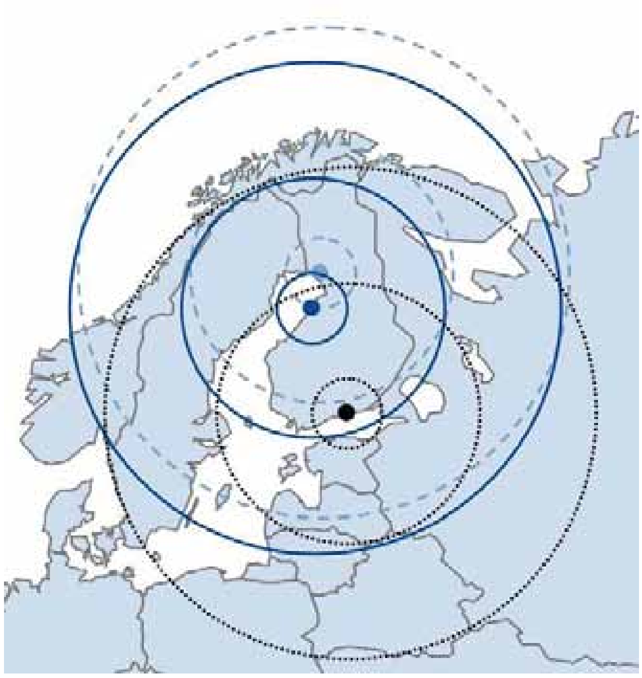
In the event of an INES Category 4 accident, no protective measures will be needed in the vicinity of the nuclear power plant. The INES Category 4 includes postulated accidents that are used as design criteria for the design of nuclear power plants' safety systems.

Impact of the nuclear fuel production chain

A nuclear power plant uses about 30–50 tons of enriched uranium as fuel per year; 300–500 tons of natural uranium will be required to produce this amount of fuel. The impact of the fuel acquisition chain will not be directed at Finland. The arising impacts will be assessed and regulated in each country according to local legislation.

The environmental impacts of uranium mining operations are associated with the radiation of the uranium ore, radiation effect of the radon gas released from the ore, tailings and wastewater. Any environmental impacts from the production steps of conversion, enrichment and fuel rod bundles are related to the handling of dangerous chemicals and, to a lesser extent, the handling of radioactive materials. The environmental impacts of the different stages of the production chain, starting from mines, are increasingly prescribed by international standards and audits carried out by external parties, in addition to legal regulations.

In the fuel production chain, the intermediate products and fuel assemblies transported from the mines to the power plant are slightly radioactive at most. The transportation of radioactive materials will be carried out in compliance with national and international regulations on transport and storage of radioactive materials.



Zones of a 100, 500 and 1,000 kilometer radius surrounding the alternative locations. The plant sites from north to south are Simo, Pyhäjoki and Ruotsinpyhtää.

Impact on the energy market

The Nordic electricity market is very dependant on hydroelectricity production which has a significant impact on the price of electricity. Using the new nuclear power plant intended for the production of basic power, the price fluctuation caused by hydroelectricity can be reduced because the role of hydroelectricity in the formation of the price of electricity will be reduced. It has been calculated that the construction of the sixth nuclear power plant unit will reduce the market price of electricity on the stock exchange, as well as the price to be paid by consumers. The new nuclear power plant will improve the maintenance reliability of electricity production by reducing Finland's dependency on fossil fuels and imported power.

Environmental impacts crossing Finland's borders

The only transboundary impact during normal operation of the nuclear power plant will be the regional economic impact in the region of Haparanda. The impacts of an extremely unlikely serious nuclear power plant accident would likewise extend outside Finland's borders.

Impact on regional economy

Especially at the Simo location, the direct and indirect employment-related impacts of the project would extend to Haparanda and the surrounding areas in Sweden due to the proximity of the national border. Even today, cooperation between Tornio and Haparanda is extensive, and many basic municipal services and leisure activity facilities are shared. The training and recruiting of labor is also at least partly planned jointly. Depending on circumstances such as the actions taken by the municipality itself (such as training and supplying workforce, supplying services, supplying housing), there may be significant benefits for Haparanda.

Impact of a serious nuclear power plant accident

The impacts of a serious nuclear power plant accident have been illustrated from the area surrounding the plant up to a distance of 1,000 kilometers. The exact layout of the studied area around each alternative plant location is illustrated in the figure above.

With regard to local agricultural products used as food, the fallout in typical weather conditions will be so small that long-term restrictions are not required on their use. Without any protective measures aimed at livestock or food production, short-term usage restrictions of no more than a few weeks may be necessary in areas up to 1,000 kilometers from the power plant site until concentrations of I-131, which is significant to the buildup of radiation doses, have decreased sufficiently. The half-life of I-131 in agricultural products is about 8 days.

In case of an accident during unfavorable weather, it is also probable that restrictions on the use of various kinds of natural produce will have to be issued in areas affected by the greatest fallout. For example, long-term

The Environmental Impact Assessment Program was completed in spring 2008. First buds of spring in Pyhäjoki, 2008.

restrictions on the consumption of certain mushrooms may be required in areas up to 200–300 kilometres from the power plant site.

The modeled serious reactor accident in the example does not cause any immediate health impacts on the surrounding population in any weather conditions. To limit the thyroid radiation dose, children should take iodine tablets when recommended by authorities within a distance of 100 kilometers from the accident site in all weather conditions. This impact could therefore extend to the northeastern corner of Sweden in the case of the Simo location, or the northern coast of Estonia in the case of the Ruotsinpyhtää locations. No other civic defense measures would be necessary in other countries.

In addition to a serious accident, the impacts of a postulated accident (INES 4) have been assessed. Its impacts would not cross Finland's borders.

Impact of the zero-option

If a new nuclear power plant is not built in Finland, its production will probably be substituted mainly by imported power. The rest of the electricity will be produced in Finland by utilizing the existing or new power production capacity which would mostly consist of separate electricity production and, to a small extent, of combined power and heat production.

If the Fennovoima project is not implemented, the current status of the environments of the inspected location sites will possibly be affected by other projects, functions and plans.

Prevention and reduction of adverse environmental impacts

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

At the construction stage, adverse noise impacts or other disturbances in the immediate vicinity of the plant can be reduced by scheduling as many of the particularly noisy or otherwise disturbing actions to be carried out in the daytime and communicating their schedule and duration. In addition, the location of the functions and temporary noise protection can be used to reduce the adverse noise impact of the construction site significantly.

The biological adverse impacts caused by construction work on water systems close to cooling water structures or routes and the harbor quay and navigation channel can be reduced by scheduling the construction work to take place at the most biologically inactive time.

Social impacts during construction can be reduced by decentralizing the accommodation of the workers to nearby municipalities in addition to the location municipality. The impacts caused by cultural differences can be reduced through training organized for foreign employees.

The impact of power lines on land use, the landscape and natural resources can be reduced by taking the impact into account as well as possible in the design of the power line route and in the column solutions. The impacts caused by the construction of roads can be reduced through thorough design of the road routes and construction work.

The only means available to significantly reduce the thermal load to the water systems is so-called combined production, i.e. a power plant that would produce electricity and also district heating or industrial steam. Implementing the Fennovoima nuclear power plant project as a combined electricity and heat generation plant is possible from a technical viewpoint, and also possibly feasible from an economical viewpoint if the thermal energy demands is high enough. Fennovoima will study the future district heating demand, production methods and their environmental and climatic impacts at various sites, especially in the Helsinki Metropolitan area.

Local impacts in water systems from the use of cooling water can be alleviated by means of a variety of technical solutions. The location and shape of the affected area of cooling waters can be influenced through the placement of the intake and discharge structures. Fish can be prevented from being driven into the cooling water intake system through different technical measures and through design of the cooling water intake systems.

Impacts during the nuclear power plant's operating stage on nature and animals can be reduced particularly by taking into account the birdlife of the area during operation. The risk of birds colliding with power lines can be reduced by improving the visibility of the power line using bird warning spheres.

The location of the power plant in the landscape can be improved by selecting the correct surface materials and colors, planning building locations carefully and adding plants.

The impacts on the nearby traffic volumes and safety can be reduced through different technical solutions that improve the traffic flow and safety and by organizing bus transport for the personnel to the worksite.

Noise impacts can be reduced by placing buildings that prevent noise and functions that cause noise from spreading and selecting building materials and technologies that dampen noise.

Emissions of radioactive substances can be reduced through appropriate technical measures and they will be monitored continuously through measurements and sampling.

Waste and wastewater generated during the construction and operation of the nuclear power plant will be treated appropriately. The objective is to minimize the volume of waste generated. The majority of the waste generated will be utilized by recycling or by using it in energy production.

The chemical storage will be built according to the requirements set by the Chemicals Act and related regulations. Any leaks will be prepared for through structural means. Any chemical damage will be prevented using safety instructions and by training the personnel.

Fears related to nuclear power plants can be alleviated by providing information about the risks and impacts related to nuclear power in an active, appropriate and clear manner.

The nuclear power plant's design will prepare for the possibility of operational malfunctions and accidents. An up-to-date contingency plan will be prepared for the nuclear power plant and its surroundings, and there will be drills in its use at regular intervals.

A decommissioning plan for the nuclear power plant will be drawn up at the initial stages of plant operation. One of the primary objectives of the plan is to ensure that dismantled radioactive components will not cause any harm to the environment.

Feasibility of the project

As a result of the environmental impact assessment, none of the project's implementation options were identified to have such adverse environmental impacts that they could not be accepted or reduced to an acceptable level. Thus, the project is feasible. However, the impacts of the different options differ from each other with regard to certain impact types and these differences should be taken into account when selecting and developing the project's implementation options.

Monitoring program for environmental impacts

The environmental impacts of the nuclear power plant project must be monitored in accordance with the monitoring programs approved by the authorities. The monitoring programs define the specific details of load and environmental monitoring and reporting to be performed. The release of radioactive materials from the nuclear power plant will be monitored through continuous measurements and sampling. In addition, the radiation measurements in the power plant area and its vicinity will ensure that the radiation dose limits defined in regulations issued by the authorities will not be exceeded. The monitoring of the project's regular emissions includes the following subfields:

- Monitoring cooling water and wastewater
- Monitoring water systems
- Monitoring the fishing industry
- Monitoring the boiler plant
- Waste records
- Noise monitoring.

The project's impact on people's living conditions, comfort and well-being has been assessed and the information obtained will be used to support design and decision-making, and to reduce and prevent any adverse impacts.

Contents

Fennovoima is to produce electricity for the needs of its owners at cost price. Finnish building tradition in Pyhäjoki, 2008.

One of the main purposes of Fennovoima's project is to increase competition in the electricity market. New actors and new electricity production capacity located in Finland are key preconditions for strengthening confidence in the open electricity market among industry and commerce and consumers.

1 Project

1.1 General description of the project

Fennovoima Ltd. (hereinafter "Fennovoima") is examining the construction of a nuclear power plant with the electric capacity of 1,500 – 2,500 MW in Finland. The objective is for the power plant to start the production of electricity by 2020.

The project inspects the construction of the nuclear power plant at three alternative localities and four location areas (Figure 1-1):

- Hanhikivi headland in Pyhäjoki
- Kampuslandet island and Gäddbergsö cape in Ruotsinpyhtää
- Karsikkoniemi headland in Simo.

During the EIA program stage, the inspected alternative localities also included Norrskogen in Kristiinankaupunki. Fennovoima Oy completed the investigations for this alternative in June 2008.

The nuclear power plant alternatives being assessed are

- A plant with the electric capacity of 1,500 – 1,800 MW with one nuclear power plant unit and reactor
- A plant with the electric capacity of 2,000 – 2,500 MW with two nuclear power plant units and reactors each with an electric capacity of 1,000 – 1,250 MW

The power plant will mainly be designed to be a condensing power plant but, depending on its size, design can also prepare for utilizing the loss heat produced by the plant directly or through district heating.

1.2 Party responsible

The company responsible for the project is Fennovoima Ltd., a Finnish energy company established in 2007. Fennovoima's parent company is Voimaosakeyhtiö SF with a shareholding of 66%, which is owned by 48 local energy companies operating in Finland as well as 15 industrial and retail companies (Figure 1-3). E.ON Nordic AB is a minority shareholder in Fennovoima with

Figure 1-1. Alternative site locations for the nuclear power plant

a shareholding of 34%.

Agreements have been made to ensure that the majority of Fennovoima Oy remains in the ownership of Voimaosakeyhtiö SF.

Fennovoima is to produce electricity for the needs of its owners at cost price. Each owner receives production capacity in the power plant by the amount corresponding to their share of ownership. In accordance with this cooperative-like operating model, making a profit is not Fennovoima's objective as a company; profits are distributed to shareholders as electrical energy at a lower cost.

Nearly two-thirds of Finland's local electricity retailers are participating in the Fennovoima project. The majority of these companies are owned by municipalities, and are obliged to deliver electricity in their respective geographical areas of responsibility. The obligation to deliver requires the company to deliver electricity at a reasonable cost to all willing consumers whose place of use is located in the company's area of responsibility. The local retailers taking part in the project have approximately 900,000 consumer customers across Finland – households and local communities.

The industrial and retail companies taking part in the project represent different aspects of Finnish industry and commerce. They include companies in the fields of metal, chemical and building material industries, as well as retail and services. Participants include both listed companies and family businesses with thousands of sites and places of electricity use around Finland in total. These Fennovoima shareholders that require electricity in their own operations employ more than 90,000 people directly in Finland. In addition, these companies have a significant indirect employment impact.

Fennovoima has the considerable expertise in nuclear power of its technical partner, E.ON, in different phases of the project. E.ON is the second-largest nuclear power company in Europe and the sixth-largest in the world. It has extensive experience in the construction, operation and decommissioning of nuclear power plants. Currently, E.ON is the principal shareholder and responsible license holder in nine and minority shareholder in 12 nuclear power plants in Europe.

Fennovoima's quality management system and guidelines will be composed in accordance with Finnish legislation, rules by the authorities and the ISO 9000 standard, as well as the recommendations of the International Atomic Energy Agency (IAEA). Prior to

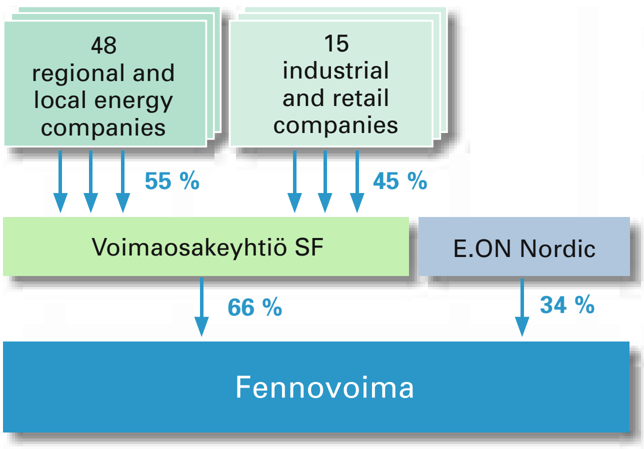


Figure 1-2. Fennovoima's ownership structure.

- AGA
- Alajärven Sähkö
- Atria
- Boliden Harjavalta
- Boliden Kokkola
- Componenta
- E.ON Nordic
- Esse Elektro-Kraft
- Etelä-Savon Energia
- Finnfoam
- Haminan Energia
- Herrfors
- Hiirikosken Energia
- Imatran Seudun Sähkö
- Itä-Lapin Energia
- Jylhän Sähköosuus-kunta
- Jyväskylän Energia
- Kemin Energia
- Keravan Energia
- Kesko
- Koillis-Satakunnan Sähkö
- Kokemäen Sähkö
- Kotkan Energia
- Kruunupyyn Sähkö-laitos
- KSS Energia
- Kuopion Energi
- Kuoreveden Sähkö
- Köyliön-Säkylän Sähkö
- Lahti Energia
- Lankosken Sähkö
- Lehtimäen Sähkö
- Leppäkosken Sähkö
- Mondo Minerals
- Myllyn Paras
- Mäntsälän Sähkö
- Nurmijärven Sähkö-myynti
- Omya
- Oulun Seudun Sähkö
- Outokummun Energia
- Outokumpu
- Ovako Bar
- Paneliankosken Voima
- Parikkalan Valo
- Pietarsaaren Energialaitos
- Porvoon Energia
- Rantakairan Sähkö
- Rauman Energia
- Rautaruukki
- Rovakairan Tuotanto
- Sallila Energia
- Seinäjoen Energia
- Suomen Osuuskaup-pojen Keskuskunta
- Tammisaaren Energia
- Turku Energia
- Uudenkaarlepyyn Voimalaitos
- VSV Energiapalvelut
- Valio
- Valkeakosken Energia
- Vantaan Energia
- Vatajankosken Sähkö
- Vetelin Sähkölaitos
- Vimpelin Voima
- Ålands Elandelslag
- Ääneseudun Energia

Figure 1-3. Project participants.

the construction of the plant, the company will also adopt an environmental management system conforming to the ISO 14001 standard.

1.3 Purpose of the project and reasons

Energy production must be increased in order to secure the operational requirements for and expand the operations of Finnish industry and commerce. Fennovoima's 64 shareholders require electricity in their own operations and their own customers at a competitive and stable price. Fennovoima's shareholders account for nearly 30% of all electricity consumed in Finland. One major nuclear power plant unit will cover less than a half of the total electricity need of Fennovoima shareholders.

One of the main purposes of Fennovoima's project is to increase competition in the electricity market. New actors and new electricity production capacity located in Finland are key preconditions for strengthening the confidence in the open electricity market among the industry and commerce and consumers.

Fennovoima will study the construction of a nuclear power station at a new site of the facility. According to Fennovoima's estimates, the regional economic impacts of the project are significant and support the government's regional political efforts, which are aimed to be directed at areas suffering from structural changes. In addition, Fennovoima considers the project to decrease developmental differences between areas and promote the balanced development of the country.

The new nuclear power plant will increase energy production free from carbon dioxide emissions, reduce Finland's dependence on imported electricity and replace, among others, coal-operated power plants decommissioned due to environmental reasons and ageing. Fennovoima considers its project to comply with Finnish policies on climate and energy strategy.

The Ministry of Employment and the Economy is preparing a new climate and energy strategy for Finland. The new EU objectives concerning greenhouse gas emissions, increasing renewable energy sources and energy efficiency are in its background. The EU Commission proposed measures to controlling climate change in January 2008. The objective is to cut greenhouse gas emissions by 20% from the level of 1990 by 2020. The EU climate strategy proposes that carbon dioxide emissions should be decreased by 60% to 80% in industrialized countries by 2050. The additional construction of nuclear power can support the fulfillment of these objectives.

The total consumption of energy and electricity per capita is high in Finland internationally. The consumption of energy is increased by Finland's cold climate, sparse population and long distances, as well as the significant position of energy-intensive basic industry in the Finnish economy.

During the last few decades, the share of electricity in the total consumption of energy has increased constantly, and this development will likely continue. Therefore, in terms of the environment, it is advantageous to generate the electricity required using methods with as low emissions as possible, such as nuclear power.

In 2007, about 90 TWh of electricity was used in Finland. Finnish Energy Industries and the Confederation of Finnish Industries EK have estimated the consumption of electricity to amount to approximately 107 TWh in 2020 and approximately 115 TWh in 2030. (*Finnish Energy Industries 2008a*) The electricity consumption forecast takes into account the increase of energy efficiency alongside technological evolution, renewing hardware and increasing social govern-

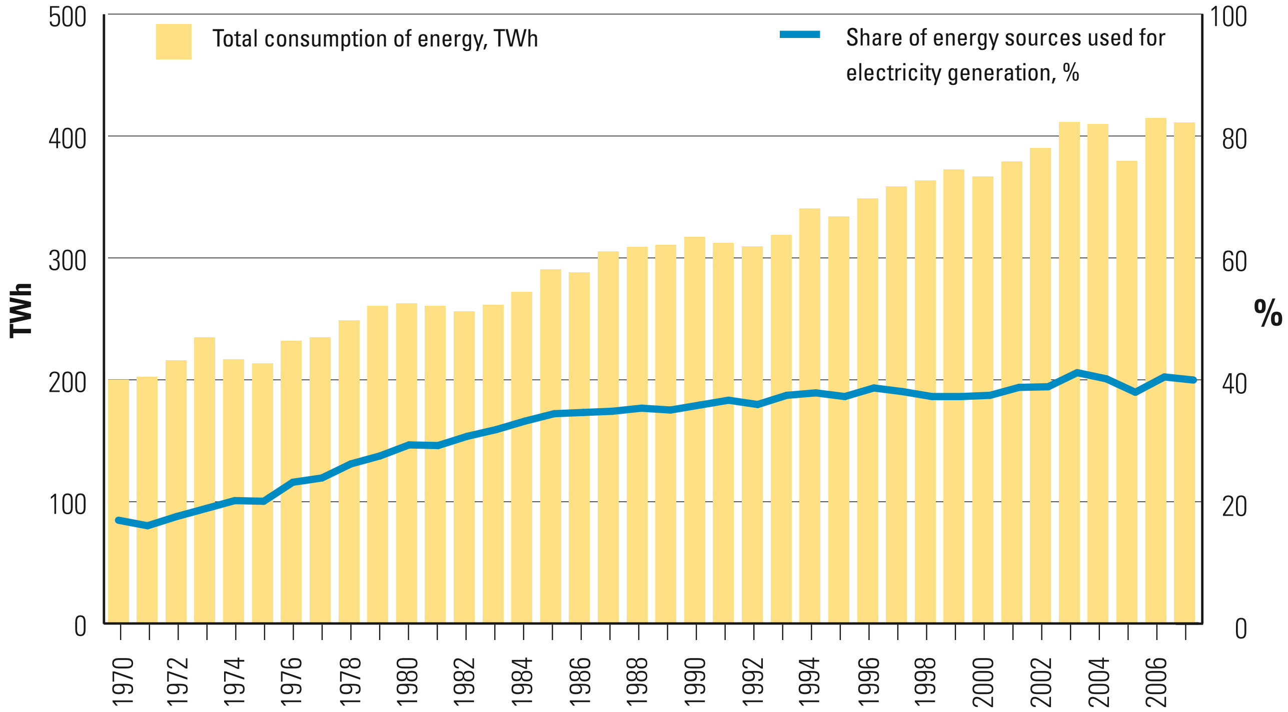


Figure 1-4. Total energy consumption and share of energy sources used for electricity generation. *(Statistics Finland 2008).*

ing. The demand for electricity is estimated to increase the most in the metal industry and services. (*Finnish Energy Industries 2008b*) Both industries are strongly represented among Fennovoima shareholders.

Securing Finnish electricity supplies and fulfilling the challenging climate objectives require energy saving and increasing the efficiency of electricity use, increasing the use of renewable energy sources and new nuclear power. These measures do not contradict; they are all required to meet the need for electricity.

1.4 Implementation options to be assessed

1.4.1 Location alternatives

Fennovoima inspected alternative locations for the new nuclear power plant in 2007 and 2008. The thorough investigations surveyed the suitability of more than 30 different areas as the possible location of a nuclear power plant. Gradually, the number of the areas was eliminated to three. The inspection of technical suitability concerned, among others, the geological properties of the areas, possibilities of connecting to the national grid, factors which are essential in terms of plant safety and the cooling systems and logistics-related factors. The environmental suitability inspection studied the situation of the areas' land use planning as well as the suitability of the areas with regard to the different environmental impacts. Based on these inspections and the EIA program phase, the following alternative locations of the site were selected for the evaluation of environmental impacts:

- Hanhikivi heandland in Pyhäjoki
- Kampuslandet island and Gäddbergsö cape in Ruotsinpyhtää, and
- Karsikkoniemi headland in Simo.

The pre-inspections conducted when selecting the locations examined several alternative locations for road connections, cooling water intake and discharge sites and the harbor pier related to these locations with regard to their technical and environmental aspects. The options inspected in the EIA procedure were selected on the basis of these inspections.

The cooling water intake and discharge options selected for the EIA inspection and their impact are presented in Chapter 8. The intake and discharge sites presented are preliminarily presented for models and reports to be conducted in the environmental impact assessment. The final locations of the intake and discharge sites will be selected on the basis of the environmental factors identified in the impact assessment, any additional models required and more specific technical reports.

Option 1: Pyhäjoki: Hanhikivi headland (Figure 1-5)

The area is located in the north part of the municipality of Pyhäjoki. The distance to the town centre is less than 7 kilometres. The distance to the town centre is about 6 to 9 kilometers. The northeast part of the Hanhikivi cape is located in the town of Raahe. The distance to the centre of Raahe is about 20 kilometers

Option 2: Ruotsinpyhtää: Kampuslandet island and Gäddbergsö headland (Figure 1-6, Figure 1-7)

The area is located in the south part of the Ruotsinpyhtää municipality. The distance to the village is more than 15 kilometers.

Option 3: Simo: Karsikkoniemi cape (Figure 1-8)

The area is located on the west side of the municipality of Simo. The distance to the town centre of Simo is about 20 kilometers. Karsikkoniemi cape reaches the southeast boundary of the municipality of Kemi.

1.4.2 Power plant alternatives

The nuclear power plant alternatives assessed are

- A plant with the electric power of 1,500 – 1,800 MW with one nuclear power plant unit and reactor
- A plant with the electric power of 2,000 – 2,500 MW with two 1,000 – 1,250 MW nuclear power plant units and reactors.

The inspected nuclear power plants are of the light water reactor type, as are the majority of commercial nuclear reactors in the world. The nuclear power plants currently in use and under construction in Finland are also of the light water reactor type.

1.5 Project options

1.5.1 Zero-options

The zero-option is that Fennovoima's nuclear power plant project will not be implemented. In the zero-option, the shareholders' increasing demand for electricity would be covered by increasing the export of electricity and/or through the power plant projects of other operators. With regard to Fennovoima shareholders, this might translate into refraining from investments associated with their operation and even downsizing existing operations in Finland. The impacts of the zero-option will be described in Chapter 8 in a separate section.

1.5.2 Fennovoima shareholders' possibilities of energy saving

Fennovoima shareholders have engaged in extremely systematic improvements in the efficiency of the use of electricity voluntarily and have achieved considerable savings. The combined improvement in the efficiency of the use of electricity by the shareholders in 1998 – 2007 amounted to about 800 GWh annually, corresponding to circa one per cent of annual electricity production in Finland.

Figure 1-5. Photomontage: Location of the nuclear power plant in Pyhäjoki (and Raahe). There is one power plant unit in the figure. A figure of the two power plant unit option is presented in Chapter 8, in the section concerning impacts on landscape.

Figure 1-6. Photomontage: Nuclear power plant in Kampuslandet in Ruotsinpyhtää. There is one power plant unit in the figure. A figure of the two power plant unit option is presented in Chapter 8, in the section concerning impacts on landscape.

In the future, it will be more difficult to carry out measures to improve the efficiency of the use of electricity, as most shareholders' most significant, technically and economically feasible economy measures have already been implemented. The impact of economy measures currently being implemented or decided by Fennovoima shareholders amounts to about 200 GWh annually. In addition, Fennovoima shareholders are considering investments with a potential annual impact of about 40 GWh on electricity consumption. The new energy saving possibilities of the shareholders are estimated to correspond to the annual output of approximately one 30 MW plant. The energy-saving measures of Fennovoima shareholders are described in more detail in Chapter 8.

1.5.3 Total need for electricity in Finland and possibilities of savings

The total need for electricity in Finland depends on the general economical and social development, on which Fennovoima has only little influence. Thus energy savings in Finland will not be reviewed as an alternative of the nuclear power plant project in this report.

However, Chapter 8, the section on the impacts of the zero-option, will present existing programs and decisions related to energy saving and improved energy efficiency launched in Finland, and their significance for the demand of electrical energy will be assessed.

1.5.4 Other power plant projects

The inspection of the power plant projects of other parties acting in the electricity market as an alternative to Fennovoima's project is not possible because the plans or actions of these parties are not known to Fennovoima and Fennovoima cannot influence them.

Fennovoima was specifically established to prepare, design and implement a nuclear power plant project, and its plans do not include other alternative power plant projects. Only nuclear power makes it possible to meet Fennovoima shareholders' needs in terms of the amount of energy produced, production reliability, safety and price.

1.6 Limitation of the project's environmental impact assessment

According to the Nuclear Energy Act, the construction of a nuclear power plant requires a decision-in-principle from the Finnish Government and confirmed by Finnish Parliament. The environmental impact assessment report referred to in the Act on Environmental Impact Assessment (hereinafter ”EIA Act”, 468/1994) must be enclosed with the decision-in-principle application.

The activities of the project to be inspected in the environmental impact assessment are:

Figure 1-7. Photomontage: Nuclear power plant in Gäddbergsö in Ruotsinpyhtää. There is one power plant unit in the figure. A figure of the two power plant unit option is presented in Chapter 8, in the section concerning impacts on landscape.

Figure 1-8. Photomontage: Nuclear power plant in Karsikkoniemi in Simo. There is one power plant unit in the figure. A figure of the two power plant unit option is presented in Chapter 8, in the section concerning impacts on landscape..

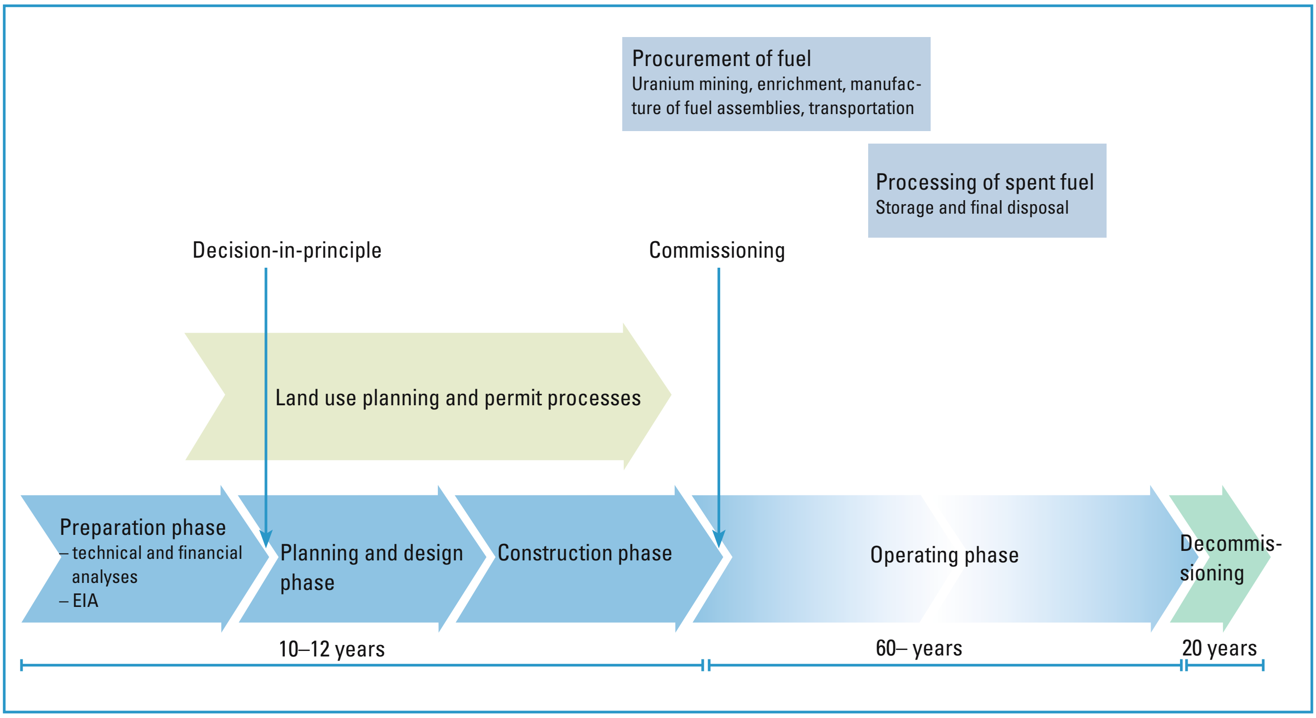


Figure 1-9 Nuclear power plant project lifecycle.

- activities during the construction and operation of the nuclear power plant
- intake and decommissioning arrangements for cooling water
- acquisition and handling systems for process water and sewage disposal
- handling, storage and disposal of low- and medium-level power plant waste
- the intermediate storage of spent nuclear fuel created through the operations in the plant area
- other waste management
- traffic and transportation associated with the operations of the plant
- construction of roads, bridges and banks
- construction of a loading platform and navigation channel for sea transport
- construction of power transmission connections from the plant's switch field to the edge of the power plant area

This EIA report also describes the environmental impacts of the following entities in order to present an overall picture of the environmental impacts of the project throughout its lifecycle:

1) production and procurement of fuel
2) disposal of spent nuclear fuel
3) decommissioning of the power plant, handling and disposal of decommissioning waste
4) construction of power transmission connections to the national grid.

Of these, the activities of item 1) take place outside the boundaries of Finland and are subject to environmental legislation in other countries. With regard to these activities, Fennovoima is a customer, not the licensee. The activities of items 2), 3) and 4) are projects referred to in EIA legislation in Finland, and EIA reviews of their own will be carried out once they become topical.

1.7 Project timetable

During 2008, preliminary planning of the Fennovoima nuclear power plant project has been carried out in the alternative site locations, including the surveying and investigation of the areas' geological conditions, preliminary area planning and planning of cooling water intake and decommissioning locations. The preliminary planning has also surveyed the necessary roads, quays, electricity network connections, water intake and waste water treatment and discharge in the locations.

Fennovoima has acquired land in the area of the alternative site locations and proposed the commencement of land use planning processes required for a nuclear power plant at the site locations. The land use situation in the alternative locations is presented in Chapter 8, in the section concerning the impacts on land use and the built surroundings.

If the Finnish Government makes a decision-in-principle and Parliament approves it, Fennovoima will select the plant site, conclude the power plant related acquisition agreements and apply for a construction permit for the nuclear power plant according to the Nuclear Energy Act and apply for other licences required to start the construction process. The permit and land use planning processes required by a nuclear power plant are presented in Chapter 4.

The objective of Fennovoima is to start construction work in the selected plant site in 2012. Before starting production in the nuclear power plant, Fennovoima will apply for an operation permit according to the Nuclear Energy Act, an environmental license and the other licenses required for the power plant. Fennovoima's objective is that the new nuclear power plant can be commissioned by 2020.

1.8 Connection to other projects

With regard to each location option, the project includes the possibility of utilizing the heat produced by the nuclear power plant in processes other than electricity production. For example, loss heat from the plant in Simo could be utilized as such in keeping the the Ajos Port free from ice. In Ruotshinpyhtää, the plant could produce district heating for the needs of the Helsinki Region and other surrounding municipalities.

The utilization of heat for processes other than electricity production comprises a project supplementing Fennovoima's power plant project and its implementation depends also factors other than the Fennovoima project. The technical-economical possibility for implementing the utilization of heat and the environmental impact of the implementation must be assessed separately for each project. This report includes a preliminary assessment of the impact of the combined production option on the power plant and its environmental load. Other environmental impacts have been limited outside this EIA procedure. For example, the conduction of heat through a district heating tunnel from Ruotsinpyhtää to the Helsinki Region will reguire a separate EIA procedure. If the utilization of loss heat and the implementation of the combined production option will be possible for implementation, the environmental reports or environmental impact assessments required by the extent of the project will be carried out.

The utilization of heat has been assessed considering the reduction of environmental damage in the Fennovoima project in Section 10.2.2.1 of the EIA report.

The project includes the disposal of spent nuclear fuel created by the nuclear power plant operations in Finland according to the requirements of the Nuclear Energy Act.

According to a decision-in-principle made by the Finnish Government in 2000 and confirmed by Parliament in 2001, the spent nuclear fuel from Finnish operational nuclear power plants will be disposed of in a disposal site plant to be constructed in Olkiluoto in Eurajoki. The decision-in-principle concerned the four nuclear power plants in use at the time. In 2002, the Finnish Government made a decision-in-principle on the construction of the disposal site plant expanded so that also the spent nuclear fuel from the nuclear power plant currently under construction in Olkiluoto can be disposed of in the plant.

Posiva Oy (Posiva) is preparing the construction of a spent nuclear fuel disposal plant in Olkiluoto, Eurajoki, in accordance with the decisions-in-principle made by the Finnish Government. According to Posiva, the research, development and planning phase of the disposal plant in Olkiluoto will continue until 2012. The detailed implementation plans and the construction of the plant will take place between 2013 and 2020. The objective is to begin disposal activity in 2020. *(Posiva 2008a)*

The environmental impacts of spent nuclear fuel disposal activities have been assessed in the EIA process carried out by Posiva in 1997–1999. That assessment assumed the amount of spent nuclear fuel to be 9,000 tons of uranium, which is assessed to be sufficient for the needs of six nuclear power plants. At the beginning of 2008, Posiva also initiated a completely new EIA process to expand the disposal plant to meet the needs of one new nuclear power plant. Posiva submitted the EIA program concerning the expansion of the disposal facilities to the Ministry of Employment and the Economy on 13 May 2008.

In its statement on the EIA program concerning the extension of Posiva's disposal facility in June 2008, Fennovoima stated that the EIA process should inspect a sufficient amount of spent nuclear fuel taking into consideration the disposal of the spent nuclear fuel of all nuclear power plants planned in Finland in the Olkiluoto disposal site.

For the disposal of spent fuel from new nuclear power plants, a separate decision-in-principle made by the Finnish Government and confirmed by Parliament will be required in addition to the environmental impact assessment.

Interaction with interest groups is an important part of the EIA procedure. Meeting in Helsinki, 2008.

Participation of the general public, which is an essential part of the EIA procedure, aims to ensure that various stakeholders' views of the project's impacts are also taken into account at a sufficiently early stage.

2 EIA procedure, communications and participation

2.1 Need and objectives of EIA procedure

The objective of the EIA procedure is to improve the environmental impact assessment and to align its consideration in planning and decision-making. Another objective is to increase the availability of information to Finnish citizens and their possibilities of participation in the planning of the projects. The EIA procedure does not involve any project-related decision and it does not solve any licensing issues.

The Directive on Environmental Impact Assessment (EIA, 85/337/EEC) issued by the Council of the European Community (EC) has been enforced in Finland through the Act on Environmental Impact Assessment (EIA Act, 468/1994) and EIA Ordinance (713/2006). They have also enforced the Convention on Environmental Impact Assessment in a Transboundary Context approved by the United Nations Economic Commission for Europe (UNECE).

According to point 7 b) of the project list in § 6 of chapter 2 of the EIA Decree, nuclear power plants are projects subject to the assessment procedure. The Ministry of Employment and the Economy acts as the EIA coordinating authority for projects associated with nuclear facilities according to the Nuclear Energy Act.

The environmental impact assessment report (EIA review) referred to in the EIA Act must be enclosed with the decision-in-principle application for the Government's permit to build a new nuclear power plant.

2.2 Key stages of the EIA procedure

The environmental impact assessment procedure is di-

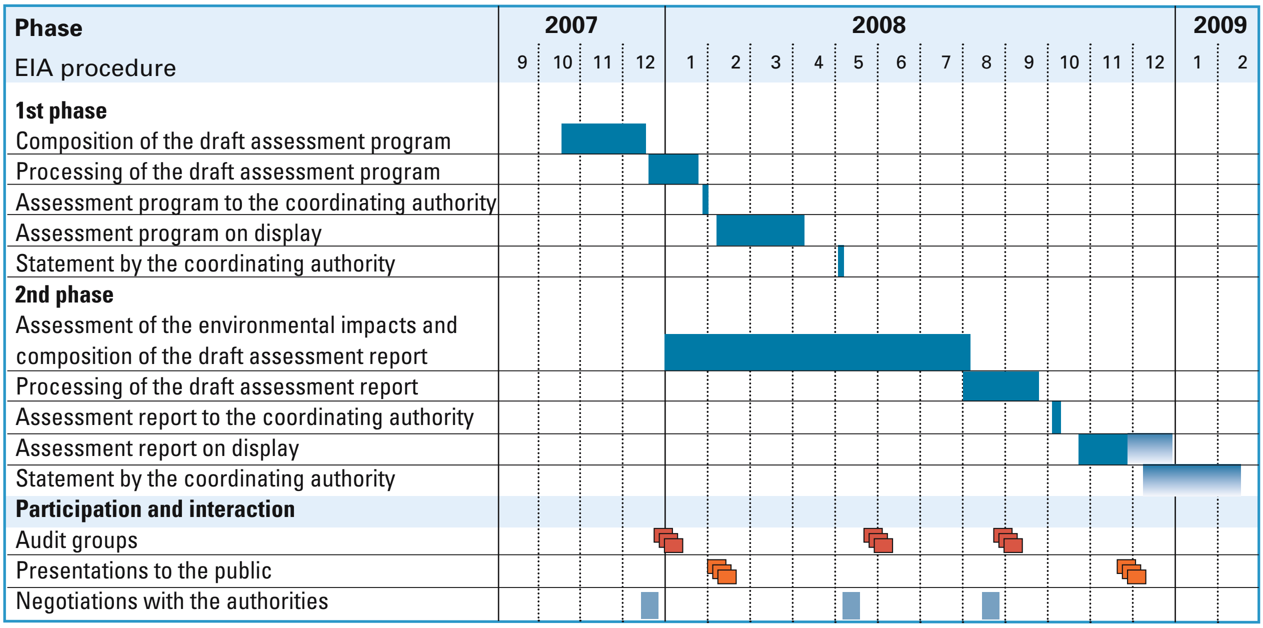


Figure 2-1. Key stages and timetable of the EIA procedure.

vided into two stages. The first phase involved making an environmental impact assessment program (EIA program). The EIA program presented the options of implementing the project as well as a plan for carrying out the environmental impact assessment procedure and the required surveys.

Fennovoima submitted the EIA program on 30 January 2008 to the Ministry of Employment and the Economy, which is the coordinating authority. The Ministry of Employment and the Economy requested statements on the EIA program from different authorities and other stakeholders. In addition, citizens had the possibility to voice their opinions of the EIA program and its extensiveness. The EIA program was displayed between 5 February and 7 April 2008 for statements and opinions. The Ministry of Employment and the Economy compiled all statements and opinions and issued its own statement on the EIA program on 7 May 2008.

In the second phase of the environmental impact assessment procedure, the EIA report – this document – was compiled on the basis of the EIA program and the statements and opinions issued. The key stages of the EIA procedure are illustrated in the enclosed figure (Figure 2-1).

The EIA review presents information about the project and a uniform summary of the project's environmental impact created as a result of the assessment procedure. In addition, it presents:

- options to be assessed
- current status of the environment
- environmental impacts of the presented options and their significance
- comparison of the alternatives assessed
- prevention and reduction methods for hazardous impacts
- proposal for the monitoring program of environmental impacts
- methods on how interaction and participation have been arranged during the EIA procedure
- the extent to which the statement of the Ministry of Employment and the Economy on the assessment program has been taken into account in the assessment.

Citizens and various stakeholders have the possibility to voice their opinions of the EIA review as well during the display time determined by the Ministry of Employment and the Economy.

2.3 Communications and participation

2.3.1 Audit group work

Regional audit groups were established to monitor the EIA procedure, one for each alternative site location. Representatives of stakeholders associated with the project were summoned as members of the audit groups as extensively as possible. The audit groups also suggested communities to be involved as members of the audit group. The audit groups were supplemented based on this.

The purpose of the audit groups has been to advance communications between the project leader, the authorities and other interest groups. The following communities were appointed to the audit groups (situation as per June 2008). The communities that did not take part in the meetings are italicized.

Pyhäjoki

- The Municipality of Alavieska
- Hanhikivi.net
- Jokilaakso Rescue Department
- The Town of Kalajoki

- *The Western Finland Environmental Permit Authority*
- The Municipality of Merijärvi
- MTK-Pyhäjoki
- The Town of Oulainen
- Oulu Trade Center, Raahe Trade Center Department
- The State Provincial Office of Oulu
- *The Parhalahti Joint Society*
- *The Parhalahti Town Committee*
- The Parhalahti Farmers' Society
- Perämeren kalatalousyhteisöjen liitto (Union of fishing organizations in the Gulf of Bothnia)
- Partners in the Piehinki Fishing Corporation
- The Piehinki village association
- *Pohjoisen perämeren ammattikalastajat (Professional fishermen in the northern Gulf of Bothnia)*
- The Council of Oulu Region
- The TE Centre for Northern Ostrobothnia
- The North Ostrobothnia Regional Environment Centre
- Posiva
- Pro Hanhikivi
- The Municipality of Pyhäjoki
- *The Pyhäjoki Parish*
- Entrepreneurs in Pyhäjoki
- The Pyhäjoki Region Nature Conservation Society
- The Raahe District bird watchers Surnia ry
- The Town of Raahe
- The Raahe District Joint Municipal Authority of Healthcare
- The District of Raahe
- The Municipality of Siikajoki
- *The Safety Technology Authority*
- *The Ministry of Employment and the Economy*
- The Municipality of Vihanti

Ruotsinpyhtää
- The Municipality of Elimäki
- The State Provincial Office of Southern Finland
- Etelä-Suomen Merikalastajain Liitto
- Itä-Uudenmaan ja Porvoonjoen vesien- ja ilmansuojeluyhdistys
- Regional Council of Itä-Uusimaa
- Itä-Uudenmaan luonnon- ja ympäristönsuojeluyhdistys
- The Eastern Uusimaa Rescue Department
- The Town of Kotka
- The Municipality of Lapinjärvi
- *The Municipality of Liljendal*
- Loviisa fishing area
- The Town of Loviisa
- The Loviisa Healthcare District
- The Western Finland Environmental Permit Authority
- Nylands Fiskarförbund
- The Municipality of Pernaja
- Pernå Fiskargille
- *Posiva*
- Pyhtää fishing area
- The Municipality of Pyhtää
- Pyhtään Luonto
- The Municipality of Ruotsinpyhtää
- Skärgårdens Vänner i Strömfors
- Strömfors Fiskargillet
- Strömfors fishing area - Pernå fishing area - Ruotsinpyhtää fishing area
- The Safety Technology Authority
- *The Ministry of Employment and the Economy*
- *The Uusimaa Regional Council*
- The TE Centre for Uusimaa
- The Uusimaa Regional Environment Centre
- *Östra Nylands Fågel och naturskyddsförening*
- Loviisan Seudun Eränkävijät

Simo
- Hepolan pientaloyhdistys
- The Municipality of Ii
- The Town of Kemi
- Kemin lintuharrastajat Xenus
- Kemin Seudun Luonnonsuojeluyhdistys
- The Municipality of Keminmaa
- Central Gulf of Bothnia fishing area
- Kuivaniemen Luonto
- *The Lapland Chamber of Commerce*
- The Regional Council of Lapland
- The Lapland Ornithological Society
- Lapin luonnonsuojelupiiri (Lapland nature conservation society)
- *The State Provincial Office of Lapland*
- Lapland Rescue Department
- The TE Centre for Lapland
- The Lapland Regional Environment Centre
- The Länsi-Pohja Healthcare District
- *The Western Finland Environmental Permit Authority*
- Maksniemen Erämiehet
- *The Maksniemi village association*
- *The Maksniemi cooperative of water supply and sewerage*
- Partners in joint Maksniemi water areas
- Gulf of Bothnia fishing area
- Perämeren kalatalousyhteisöjen liitto (Union of fishing organizations in the Gulf of Bothnia)
- Pohjoisen perämeren ammattikalastajat (Professional fishermen in the northern Gulf of Bothnia)
- *Posiva*
- *The Municipality of Ranua*
- The Municipality of Simo
- Simon mökkiläisyhdistys (Simo cottage society)
- Simonkylä Joint Society
- The Simoniemi village association
- The Municipality of Tervola
- *The Town of Tornio*
- *The Safety Technology Authority*
- *The Ministry of Employment and the Economy*

Each audit group met three times during the EIA procedure.

The audit groups met for the first time during the EIA program stage. The meetings were held in Pyhäjoki on 8 January 2008, in Simo on 9 January 2008 and in Ruotsinpyhtää on 10 January. In the meetings, the project, EIA procedure and the project's EIA program draft were presented to the audit group members. The audit groups commented on the EIA program draft both in the meeting and afterwards during the time reserved for comments.

The comments received from the audit groups paid attention to, e.g. the project's impacts on waters, fish, land use and value of properties, as well as the means of livelihood and opportunities for leisure activities. Matters of particular interest also included the safety of the nuclear power plant, taking different kinds of risks and accident situations into consideration and the disposal of spent nuclear fuel.

All comments and specifications received in the meetings and afterwards were comprehensively taken into account when drawing up the EIA program, as far as they were related to the EIA program. Comments, information and sources of information not related to the EIA program were taken into account in the implementation of the EIA procedure and in the EIA report and related surveys.

The location descriptions in the EIA program were specified further with the help of the local knowledge of the audit groups. Important information was received on, e.g. the nature conservation and bird areas and cultural historical environments in the immediate surroundings of the site locations. The audit groups also provided important further information for surveys carried out in the assessment and planning them.

The audit groups met for the second time in the EIA report composition phase. The meetings were held in Ruotsinpyhtää on 21 May 2008, in Simo on 26 May 2008 and in Pyhäjoki on 27 May 2008. The statement on the EIA program by the coordinating authority – the Ministry of Employment and the Economy – and taking it into account in the composition of the EIA report and the implementation of the EIA procedure were discussed in the meetings. In addition, the contents of the surveys made for the EIA, their current status and some results available at the time were presented to the audit group members.

In the audit group meetings, the issues that inspired questions included the cooling water dispersion model and assessment of water impacts, nature surveys and their implementation and the assessment of impacts on recreational use. Of location-specific questions, particular attention was paid to impacts on fishing and fish stocks and the conservation areas in the surroundings of the site locations.

The audit groups met for the third time at the end of August 2008.

2.3.2 Public meetings

Fennovoima and the Ministry of Employment and the Economy organized public meeting at each alternative locality at the EIA program stage. The meetings were arranged as follows:

- In Ruotsinpyhtää on 11 February 2008. About 130 people were present.
- In Simo on 12 February 2008. About 120 people were present.
- In Pyhäjoki on 13 February 2008. About 170 people were present.

Project-related plans and the associated EIA procedure were presented to the public in the meetings. The public had the possibility to voice their opinions of the environmental impact assessment work and its sufficiency and discuss with Fennovoima, the ministry and the experts who had been involved in composing the EIA program.

In Ruotsinpyhtää, the public's comments brought out the question of the routing of required power lines. In addition, comments paid attention to the practical implementation of the environmental impact assessment and the monitoring of the impacts. The impacts of thermal load in the cooling waters gave rise to debate, as did stakeholders' possibilities to participate.

In the meeting in Simo, issues concerning the safety of the nuclear power plant and the emissions from the operation of the plant were discussed. The comments also pointed out the effects of sudden changes in sea level on the safety of the nuclear power plant, among others. Attention was also paid to nuclear waste and uranium mines.

Radiation and its health effects were discussed in the Pyhäjoki public meeting. In addition, e.g. the radioactivity of the Baltic Sea was discussed. The debate also concerned the citizens' possibilities to have a say and taking the surrounding areas' inhabitants into account in project planning and the EIA procedure.

The key questions of the public meetings were also repeated in the statements and opinions issued on the EIA program. Taking them into consideration in the composition of the EIA report and the related surveys are discussed in Chapter 2.6.

The issues that were raised in the public meetings were also inspected as a part of the project's social impact assessment.

Second public meetings on the project and its EIA procedure will be organized in November 2008 in Pyhäjoki, Ruotsinpyhtää and Simo. The results of the environmental impact assessment and the EIA report will be presented in the meetings.

2.3.3 Other communications and participation

Fennovoima has opened offices to each EIA locality. The offices were opened in January–February 2008, and they are open two days a week. The office hours and activities of the offices have been advertised in regional newspapers. Inhabitants and others interested in the project have been able to receive information on nuclear power and the Fennovoima project from the offices. During the EIA procedure, the offices in different locations have been visited by a total of 1,000 people. The local offices have also been contacted by telephone. The most common discussion and question topics have included the project's financial impact on the municipality and region, the selection criteria for the locations, Fennovoima's ownership and background organizations, the impact on nature and the living environment, technical and safety issues, waste issues, alternative forms of energy production, energy savings and the project's impact on tourism and the region's image.

Fennovoima organized a separate public meeting on the project at each EIA locality in fall 2007, already before the beginning of the EIA procedure. The project has been presented also during the EIA procedure in various meetings to stakeholders, companies and other communities interested in the project. Stakeholders have requested presentations of the project particularly through the offices' contact managers. In Simo, Fennovoima's technical experts have taken part in open college seminars and lecture series.

In May 2008, Fennovoima organized regional invitation seminars at each EIA locality to regional decision-makers, officials, industry and commerce and the media. The meetings addressed the current status of the Fennovoima project. During spring 2008, the project has been presented to councils, boards and technical committees of various municipalities.

Fennovoima distributed the Fennovoima-uutiset newsletter to the region of each locality in March 2008. The newsletter was distributed as an enclosure between local newspapers as follows: Meri-Lapin Helmi on 12 March 2008, Pyhäjoen Kuulumiset on 12 March 2008, Loviisan Sanomat on 14 March 2008 and Östra Nyland on 15 March 2008. The newsletter discussed the EIA procedure, Fennovoima and nuclear power and safety in general. The newsletters varied by region so that the newsletter published for each locality contained views of the project by representatives of said region. The local pages also contained an introduction to the regional office and the Fennovoima contact manager of the area.

Fennovoima also publishes its own stakeholder magazine, Sisu. The first issue was published in February 2008. The magazine is published four times a year and distributed to stakeholders.

Representatives of the Radiation and Nuclear Safety Authority have also made speeches in various meetings on nuclear power at the EIA localities.

As a part of the social impact assessment included in the environmental impact assessment, a questionnaire was distributed among regular and recreational residents of the surroundings of the site locations. In connection with the resident survey, a brochure on the project and its EIA program was sent. The resident survey investigated the attitudes of the residents of the surrounding areas towards the project and their views of the project's environmental impacts. Chapter 8 discusses the sampling of the resident survey and the results of the survey by locality. In addition, stakeholder interviews were performed in each EIA area to survey the views of the residents and actors of the surrounding areas. The interviews were carried out by way of group interviews beginning with a brief summary of the project. The information received from the stakeholder interviews is discussed in more detail by locality in Chapter 8.

Local knowledge was utilized where possible also in connection with the composition of other surveys carried out as part of the assessment. The observations of local bird watchers were utilized in surveying the avifauna of the site locations and their surroundings. The bird watchers' observations provided the experts who composed the report with long-term information in the support of their assessment work. The experts who assessed the present situation of the fish stock and impacts on it were in contact with local fishermen to obtain additional information in support of their work.

2.4 Display of the assessment program

The environmental impact assessment procedure commenced on 30 January 2008, when Fennovoima submitted the assessment program conforming to the EIA Act to the Ministry of Employment and the Economy. Notice of the initiation of the assessment procedure was published on 5 – 7 January in the Helsingin Sanomat and Hufvudstadsbladet newspapers and in the following regional newspapers: *Pyhäjoki region*; Kalajokilaakso, Keskipohjanmaa, Pyhäjokiseutu, Raahelainen Raahen Seutu and Vieskalainen; *Ruotsinpyhtää region*; Borgåbladet, Uusimaa, Kymen Sanomat, Loviisan Sanomat, Östra Nyland – Kotka Nyheter and Etelä-Suomen Sanomat; *Simo region*; Kaleva, Lounais-Lappi, Meri-Lapin Helmi and Pohjolan Sanomat.

The assessment program was on display to the public between 5 February and 7 April 2008 in the following municipal or environmental offices: Pyhäjoki, Ruotsinpyhtää, Simo, Raahe, Alavieska, Vihanti, Merijärvi, Siikajoki, Oulainen, Kalajoki, Pyhtää, Lapinjärvi, Pernaja, Elimäki, Loviisa, Anjalankoski, Keminmaa, Tervola, Ranua, Ii and Kemi. In addition, the assessment program was displayed on the web sites of the Ministry of Employment and the Economy and Fennovoima.

The Ministry organized a public meeting at each EIA locality in cooperation with Fennovoima (Chapter 2.3.2).

2.5 The coordinating authority's statement on the EIA program

The ministry of Employment and the Economy issued its statement on the EIA program on 7 May 2008 (Appendix 1). In its statement, the Ministry of Employment and the Economy finds that Fennovoima's environmental impact assessment program meets the requirements of EIA legislation with regard to content, and it has been processed in accordance with the requirements of EIA legislation. The matters pointed out by the coordinating authority and taking them into account in the EIA report and any reference to an appropriate section of the EIA report is presented in the following table (Table 2-1).

Table 2-1. Taking the coordinating authority's statement on the assessment program into consideration in the EIA/EIA report

Requirement in the statement by the Ministry of Employment and the Economy	**Addressed in the EIA/EIA report**
1) In addition, the statements and opinions have also presented other questions, comments and views that the party responsible for the project should address. In the assessment report, the party responsible for the project must appropriately and sufficiently address the questions presented. The party responsible for the project must submit an account of measures with which the party responsible for the project will supplement the assessment within three weeks of the date of the statement to the Ministry. The shortcomings or erroneous information clearly pointed out in the EIA program by the statements and opinions must be corrected. The Ministry proposes that the party responsible for the project attach a table to the EIA report, specifying the issues pointed out by the coordinating authority, the response to them by the party responsible for the project and any reference to the appropriate section of the EIA report.	Chapter 2, the section on statements and opinions, includes a table addressing the issues raised in the statements and opinions issued and responding to them in the EIA report. Shortcomings and any erroneous information pointed out in the EIA program have been corrected in the relevant sections of the EIA report. This is the required table.
2) In addition, the questions presented in international assessment must be replied to in the international assessment summary to be composed from the report. Material to be translated into the respective languages of other countries must be sufficient and contain the information specified in Appendix II of the Espoo Convention. A separate section on transboundary impacts shall be attached to the assessment report. The material must present how the comments of the countries participating in the EIA procedure in compliance with the Espoo Convention have been taken into consideration.	The questions presented in international assessment and the related responses and issued comments and taking them into consideration are discussed in Chapter 2. The transboundary impacts are presented as a separate subchapter in Chapter 8 of the EIA report as well as the EIA report summary, which will be used in international hearing. The summary presents the information specified in Appendix II of the Espoo Convention.
3) In the environmental impact assessment, the different project implementation options should be compared as extensively as possible and the comparison must be presented in the EIA report. Different options refer to, for instance, different site location options, amount of thermal power (number of plant units), different cooling water intake and discharge options and/or utilization of cooling water.	The impacts are presented separately by site location, water impacts with different thermal powers as well as in the case of different intake and discharge options. The differences or lack of differences between the options are inspected also with respect to other impact types, as the option set-up as such requires it.
4) The planned sites of the power plant units must be clearly defined as a part of the presentation and assessment of other land use. In addition, the exclusion area must be clearly defined. The project's impacts on cultural historic environments and antiquities at each site location must be assessed. According to the statement of the National Board of Antiquities, the audit groups must be supplemented with experts in cultural historic environments.	The alternative locations and municipal boundaries of the power plant units are presented in map images in Chapter 1 of the EIA report. The exclusion zones are presented in Chapter 8 in the section on civic defense. The impacts on cultural historic environment and antiquities are presented in Chapter 8 in the section on impacts on landscape. Invitations to the meetings of the audit groups will be sent to the National Board of Antiquities and provincial museums.
Project description and options	
5) The Ministry considers that the assessment report must include an overview of nuclear power plants currently in the market that are suitable for the inspected project.	Chapter 3 of the EIA report presents brief descriptions of the plant options planned for the inspected project.

Requirement in the statement by the Ministry of Employment and the Economy	Addressed in the EIA/EIA report
6) Similarly, the bases of the nuclear power plant's safety design with regard to limiting the emissions of radioactive substances and environmental impacts must be presented, as must an estimate of the opportunities for fulfilling the current safety requirements.	The requested matters are presented in Chapter 6 on nuclear safety.
7) The Ministry considers that it might be beneficial for communications concerning the project if the assessment report briefly presented the general outline of the cost structure of the project and its options.	The project's cost structure is presented in Chapter 7.10.
8) The Ministry recommends that the assessment report briefly present the energy-saving measures and measures to improve energy efficiency by the applicant's shareholders.	Fennovoima will conduct a survey of its shareholders' electric energy saving and efficiency plans.
Impacts and assessing them	
9) In inspecting the environmental impacts of warming, the available base materials should be utilized as extensively as possible. The uncertainties of computational results should be presented in an illustrative manner.	The environmental impacts of the thermal load caused by the cooling waters are inspected by locality in Chapter 8. Both national and international research data on the environmental impacts of thermal load are used as the basis of the assessment. The methods of cooling water modeling and the related uncertainties are presented in Chapter 7.
10) Also, the cooling water intake and discharge options must be presented clearly and any remote intake and discharge options should be inspected..	The possible intake and discharge options that have been estimated to be suitable for closer inspection based on preliminary expert survey have been chosen for inspection by locality. The locations of the intake and discharge options are presented on a map.
11) The cooling water calculations must be presented conservatively and so that they take into account the combined effect of the thermal load of existing and planned power plants in the area in full.	Conservative estimates of the amount of cooling water, warming and total thermal load have been used in cooling water modeling. The methods are described in Chapter 7. In Ruotsinpyhtää, the combined thermal load of the existing Loviisa 1 and 2 nuclear power plant units and the possible new Loviisa 3 nuclear power plant unit has also been assessed with the thermal load caused by both main options of the project. The impacts are assessed by locality in Chapter 8 in the section assessing the combined effects of the Fennovoima project with other projects.
12) The Ministry also recommends that it be separately assessed for each site location option the case of a single power plant unit, concerning a power plant unit with a maximum electrical power of 1,800 MW and maximum thermal power of 4,900 MW, and on the other hand the case of two power plant units in which nuclear power plant units with a maximum electrical power of 1,250 MW would produce thermal power of 6,800 MW.	This will be done. It has also been stated in the EIA program.
13) In its EIA report, Fennovoima shall inspect the environmental impacts of the required power transmission connections in the areas of the different site locations.	The environmental impacts of power transmission connections are described by locality in Chapter 8 in the section concerning the impacts of associated projects. Nature surveys will be conducted for the line routes from the site area all the way to the preliminary master plan boundary. The actual EIA procedure for the power transmission connections will be the responsibility of Fingrid Oy, the national grid company.

Requirement in the statement by the Ministry of Employment and the Economy	Addressed in the EIA/EIA report
14) The EIA report must describe various accident situations that cause radioactive emissions and describe with illustrative examples the extent of the areas of impact and the impacts of the emissions on humans and nature.	Various nuclear power plant accidents are described in Chapter 8 in the section on irregular and accident situations. The same chapter describes the area of impact of a severe accident and assesses the impacts of the resulting emissions on humans and nature.
15) Also, a description of the follow-up measures in case of a possible severe accident must be included in the EIA report.	The follow-up measures in case of a severe accident are described in Chapter 8 in the section on irregular and accident situations.
16) The assessment must also discuss the environmental impacts of radioactive substances on the countries in the Baltic Sea region and Norway.	Chapter 8, the section on irregular and accident situations discusses the environmental impacts of radioactive substances at different distances from the location sites in case of a severe accident.
17) In addition, the corresponding more detailed inspections on Sweden must be made for all site locations on the cost of the Gulf of Bothnia	Chapter 8, the section on irregular and accident situation describes how the impacts of a severe accident reach Sweden.
18) Also, possible phenomena caused by climate change and preparing for them must be inspected as irregular situations (sea level fluctuations, other abnormal weather phenomena). The impacts of land-uplift must also be taken into account.	Changes to sea level possibly caused by climate change are inspected based on a survey made by the Finnish Institute Of Marine Research on a locality-specific basis in Chapter 8 under General description of waters and hydrologic data. The same chapter also describes the impacts of land-uplift on sea level. Land-uplift and possible sudden changes caused by climate change, such as storms and exceptional temperatures, and preparations for them in connection with the design of the plant are described in Chapter 6 on nuclear safety.
19) Impacts on water quality and biological factors must be assessed with sufficient thoroughness. The status of water habitats in the areas of impact must be surveyed on all levels of the ecosystem. The surveys must go into the species as well as its abundance and distribution, as well as the quality of habitats. After these basic surveys, the impact of heat load and waste waters on the different factors of the water ecosystem and the entire system must be assessed.	The impacts on waters and fish stock are discussed on a locality-specific basis in Chapter 8. New biological field studies (“basic surveys”) of the water ecosystem will not, however, be made, as they cannot produce significant added value in terms of the assessment of impacts.
20) The project’s impacts on the ecological values of Natura 2000 areas must be inspected in sufficient detail, on a natural habitat and species-specific basis in order to be able to appropriately assess if the project alone or together with other projects significantly reduces those ecological values of Natura 2000 areas because of which the areas have been selected in the Natura 2000 network.	Impacts on ecological values are discussed on a locality-specific basis in Chapter 8. The EIA will not, however, generate a Natura assessment but will assess the need for making a Natura estimate, based on which decisions on conducting the actual Natura assessment will be made.
21) The socioeconomic assessments connected with the EIA procedure must assess the project’s impacts on employment in detail both during the construction and during the operation of the plant, taking the special characteristics of all localities and areas into consideration. The methods used must be described and their selection justified.	The project’s impacts on employment are described on a locality-specific basis in the sections on the impacts on people and society based on the survey of the regional economic impacts to be made. The methods are described and justified in Chapter 7.

Requirement in the statement by the Ministry of Employment and the Economy	Addressed in the EIA/EIA report
22) The Ministry considers it justified that the party responsible for the project inspects on a general level the environmental impacts of the fuel procurement chain and also the company's possibilities of influencing this chain.	Environmental impacts are described in Chapter 8. The company's possibilities of influencing the fuel procurement chain are discussed in Chapter 3.
23) Pro Hanhikivi ry's statement sections on the possibilities of energy saving, nuclear waste management (see appendix 1) and pack ice and the actual Hanhikivi erratic must be taken into consideration in the EIA report.	Fennovoima shareholders' possibilities of energy saving are discussed in Chapter 1 in the section on the options to be assessed in the EIA. Spent fuel intermediate storage solutions and transportation and their impacts are described in Chapter 3 under Waste management and in Chapter 8 in the section on the impacts of waste management. The possible spent fuel disposal solutions are described in Chapter 3. The area's ice conditions are described on a locality-specific basis in Chapter 8. The possibility of pack ice and potential risks caused by it are taken into account in the design of the nuclear power plant (Chapter 6 on nuclear safety). The Hanhikivi issue is discussed in Chapter 8 in the section assessing the impacts on landscape and cultural historic environments.
24) Furthermore, the assessments of the Pyhäjoki area must take into account the impacts on conservation areas that are important in terms of avifauna and bird-watching in the area, as is suggested in several statements and opinions.	The project's impacts on recreational opportunities in the areas, such as bird-watching, are discussed on a locality-specific basis in the chapter on impacts on people and the society. The project's impacts on avifauna are discussed in Chapter 8 in the assessment of impacts on vegetation and animals.
25) In the assessment of the environmental impacts of cooling waters, Fennovoima must inspect the case where there are three nuclear power plants on the island of Hästholmen (Fortum Power and Heat Oy) and also the power plant units conforming to the Fennovoima project in the Loviisa/Hästholmen area.	In Ruotsinpyhtää, the thermal load caused by the existing Loviisa 1 and 2 nuclear power plant units and the possible new Loviisa 3 nuclear power plant unit together with the thermal load caused by the project is assessed. The impacts are inspected in Chapter 8.
26) With regard to contingency plans and rescue services, the possible combined impacts of two power plant areas must also be taken into consideration in different kinds of irregular and accident situations.	Contingency plans and rescue are described in Chapter 8 in the section on irregular and accident situations. With regard to Ruotsinpyhtää, the chapter also takes the nearby location of the nuclear power plant in Loviisa into account separately.
27) The EIA report must inspect the relationship between the nuclear power plant and the airport.	The relationship between the nuclear power plant and the Kemi-Tornio airport functions are discussed in Chapter 8 in the section on impacts on people and society. Taking external threats into account in the design of the nuclear power plant is discussed in Chapter 6 on nuclear safety.
28) In their statement, the partners in joint Maksniemi water areas have commented on, e.g. water currents, and they must be assessed in the EIA report.	Impacts on water currents are taken into account and assessed when assessing the impacts on waters.
29) The Ministry proposes that it should be considered if utilizing the cooling waters of the nuclear power plant to keep the Ajos deep-water harbor open by cooling water of the nuclear power plant could be assessed as stated by the Town of Kemi in its statement.	Possibilities of utilizing the thermal load of the cooling water are inspected in Chapter 10 on the prevention and alleviation of adverse impacts.

Requirement in the statement by the Ministry of Employment and the Economy	Addressed in the EIA/EIA report
Nuclear waste management	
30) The report must inspect nuclear fuel and nuclear waste management as a whole.	The requested issues are discussed in Chapter 3 in the sections on nuclear fuel procurement and waste management.
31) The environmental impacts of the disposal site of low- and medium-level power plant waste must be inspected on a site location-specific basis. The inspection should also itemize the processing of plant decommissioning waste. The structure of the disposal plant must be made clear, i.e. using appropriate illustrations. The permit plan of the plant must also be described in the EIA report.	The environmental impacts of the disposal of low- and medium-level power plant waste is inspected in Chapter 8, in which text concerning any differences between the localities will be added. The processing of decommissioning waste is inspected in Chapter 8 in the section on the decommissioning of the power plant. The structure of the disposal solution is inspected in Chapter 3 in the section on waste management. The plant's permit plan is described in Chapter 4 on permits.
32) The management of spent nuclear fuel must be described generally, at the same level as fuel procurement has been described.	Described in Chapter 3.
33) The management of spent fuel at the site location must be described on a site location-specific basis, and e.g., the description of spent fuel intermediate storage must include visualization.	The storage solutions of spent fuel are described in Chapter 3 in the section on waste management and their impacts on a site location-specific basis in Chapter 8, in the section on the impacts of waste treatment. The text also describes any differences between the localities.
34) The description of spent fuel management must also include any transportation of spent fuel away from all the alternative site locations using the means of transportation considered appropriate by Fennovoima.	The transportation of spent nuclear fuel in connection with the project is described in connection with the sections on waste management in Chapters 3 and 8.
35) The environmental impact assessment of the disposal of spent nuclear fuel from the Fennovoima project must be performed once Fennovoima's plans for arranging nuclear waste management are specified.	The environmental impact assessment of the disposal of spent nuclear fuel will be performed at a later stage in an EIA process of its own.
Plan for arranging the assessment process and associated participation	
36) The Ministry requests that it be further considered how the influence of participation is presented in the assessment report.	Participation has influenced the implementation of the EIA process through audit group work, opinions issued on the EIA program and information received from the assessment of social impacts. This is separately discussed in Chapter 2. In addition, there has also been an abundance of other interaction between the authors of the EIA report and citizens and civic organizations, and the information received from that has been utilized in relevant chapters of the EIA report and surveys associated with them.
37) The sampling methods of resident surveys and methods of group discussions must be described and their use must be justified in the EIA report.	The resident survey sampling methods and methods of group interviews are described and justified in Chapter 7 in the sections on impacts on people and society.

Requirement in the statement by the Ministry of Employment and the Economy	Addressed in the EIA/EIA report
38) The Ministry of the Environment thinks that it would nevertheless be justified to submit the possible application for a decision-in-principle only after the coordinating authority has issued its statement on the EIA report after circulation for comment. The Ministry of Employment and the Economy does not consider it a good arrangement for the EIA report and application for a decision-in-principle for the same project seeking a statement at the same time. The Ministry does hope that the coordinating authority could at least circulate the EIA report for comments before the application for a decision-in-principle is submitted to the Government.	In its consideration on the submission of the application for a decision-in-principle, Fennovoima will take the requirements of the EIA Act and the Nuclear Energy Act, as well as the recommendations of the Ministry of Employment and the Economy, into account.

2.6 Statements and opinions received on the assessment program

In addition to a notification published in newspapers, the Ministry of Employment and the Economy requested in writing statements on the EIA program from various ministries, authorities, specialist organizations and representatives of town and municipalities, as well as associations and organizations.

The requested parties submitted 69 statements to the Ministry of Employment and the Economy. The submitted statements considered the program primarily appropriate and extensive. The questions, comments and views presented in the statements have been taken into account in the drafting of the EIA report and associated surveys.

153 opinions on the EIA program were submitted to the Ministry of Employment and the Economy, of which 35 were from Finnish organizations and associations, four from foreign organizations and associations and 113 from private individuals (several opinions had more than one signatory or sender) from various countries. Five lists of names were submitted to the Ministry of Employment and the Economy from the alternative site locations, objecting the project as a whole. Various opinions suggested that the environmental impact assessment should be supplemented by taking into consideration the entire lifecycle of the project, including the environmental impacts of the processing of uranium, decommissioning of the plant units, nuclear waste management and transportation. The opinions have also discussed the social significance of the project and the need for assessing alternative energy production methods. Several opinions object to nuclear power in general or specifically the location of a nuclear power plant in the areas included in the assessment. In most cases, the basis of objection is the reluctance of landowners to sell their land for the purposes of the project or the project's possible impacts on the nature of the surrounding areas, conservation areas, landscape, real estate or residents of the surrounding areas. The central aspects that were presented in the statements and opinions and taking them into account in the EIA report and associated surveys are discussed in the enclosed table (Table 2-2). The table does not include issues that have already been presented in the requirements of the statement of the Ministry of Employment and the Economy and have therefore already been discussed earlier in this chapter (Table 2-1).

Table 2-2. The central and frequently repeated comments presented in the statements and opinions on the EIA program and taking them into account in the EIA work.

Matter presented in statements and opinions	How the matter has been taken into account in the assessment
Project	
The quality and environmental goals of Fennovoima Ltd.'s organization and operation system must be described.	The requested quality and environmental goals are described in Chapter 1.
The EIA must take into account the entire lifecycle of the project.	Chapter 8 of the EIA report discusses the entire lifecycle of the nuclear power plant from construction to decommissioning and final disposal of power plant waste. In addition, the circulation of nuclear fuel is described from uranium mines to the disposal of spent fuel.
The project's relationship with the EU energy and climate strategy and goals concerning renewable energy sources must be assessed.	The relationship of the project to, e.g. the EU's energy strategy, EU's climate and energy package and Finland's energy and climate strategy is described in Chapter 5.

Matter presented in statements and opinions	How the matter has been taken into account in the assessment
The options of nuclear waste management must be inspected on the basis of current information.	The options of nuclear waste management are inspected in Chapter 3 in the section on waste management.
The quality and environmental goals of fuel procurement must be described. The project's relationship with the uranium mine projects underway in Finland must be described. Different phases of the fuel production chain must be inspected on a general level. The environmental impacts of uranium mine activities must be described. The transportation of fuel and their safety must be discussed. It should be assessed if MOX fuel can be used in the reactors to be assessed.	The quality and environmental goals set for fuel procurement are discussed in a separate section in Chapter 3. The uranium to be used as nuclear fuel will be procured from the international market, and there is no connection with the mining projects underway in Finland. The procurement of nuclear fuel is discussed in a separate section in Chapter 3. Chapter 8 discussed the different phases of the fuel production chain, including mining, transport and storage, and their environmental impacts. Technically, the use of MOX fuel is possible (Chapter 3, section on fuel procurement).
The contents of the application for a decision-in-principle and construction license must be described. An overall view of the project's permit procedure should be presented. The license procedures required by the Nature Conservation Act should be described. The regional plan, master plan and detailed plan required by the project should be mentioned.	The content of the applications is described in Chapter 4. Chapter 4 describes the key license procedures required by the project and presents a diagram of them. Said license procedures are described in Chapter 4. Land use plans required by the nuclear power plant are discussed in general in Chapter 4 and on a locality-specific basis in Chapter 8.
It should be described how the nuclear power plant prepares for the risk of terrorism and oil transport vessel accidents.	The design of the of the nuclear power plant prepares for external threats, such as different kinds of intentional malicious damage and possible oil accidents in the sea area near the nuclear power plant (Chapter 6 on nuclear safety).
The required power line, road, route and port projects should be assessed.	The required associated projects are described in Chapter 3 and their impacts are assessed on a locality-specific basis in Chapter 8. Traffic and power line routes will be subject to corresponding nature assessments as the project area. With regard to power line routes, the assessment extends to the preliminary master plan boundary. From that point onwards, the reviews are the responsibility of Fingrid Oyj, the national grid company.
EIA procedure, communications and participation	
Selection of audit group participants, their selectiveness and the composition of the groups should be presented.	Members of the audit groups are listed in Chapter 2. The same chapter also discusses the formation of the audit groups.
Environmental impacts	
The impacts should be presented illustratively, making use of maps.	Maps and figures are utilized in all chapters of the report where appropriate and possible.
The timetable of the project's EIA procedure is too tight to compose sufficient surveys. Nature surveys should be made for a sufficiently large area and long time span.	The timetable is a normal EIA timetable, and all the surveys can be made within it in the extent required by the EIA procedure.

Matter presented in statements and opinions	How the matter has been taken into account in the assessment
The impacts of water engineering work must be assessed. The assessment must take into account foreign substances possibly present in the sediment. The amount of dredging masses and where they will be placed must be described.	The assessment of the impacts of water engineering work is a part of the assessment of construction-time impacts (Chapter 8). In the assessment of impacts, the foreign substances possibly present in the sediment will be taken into account. The amount of dredging masses and disposal is described in Chapter 3.
The traffic, noise and dust impacts during construction should be assessed.	Construction-time environmental impacts are described on a locality-specific basis in Chapter 8.
Possibilities of purifying and reducing air emissions should be assessed. Information on how the "best available technique" will be implemented to reduce radioactive emissions into the air and how this will be realized must be provided.	In assessing emissions into the air, also their purification and limitation using the best available technique will be assessed. Application of the best available technique in the project is discussed in Chapter 3.
The methods of purifying radioactive liquids must be described. Information on how the "best available technique" will be implemented to reduce radioactive emissions into water and how this will be realized must be provided. The possible radioactivity of waste water and its impacts should be surveyed. The tritium emissions must also be taken into account. Possible impacts on the rise of the concentrations of radioactivity in fish must be assessed.	Methods of purifying radioactive waste water are described in Chapter 3. The application of the best available technique in the project is discussed in Chapter 3. The amounts of radioactive substances, including tritium, carried into the sea with cooling water discharged from the nuclear power plant are discussed in Chapter 3 and impacts in Chapter 8. Normal operation of the nuclear power plant has no impacts on the concentrations of radioactivity in fish. Possible impacts caused by an accident situation are discussed in the section on irregular and accident situations (Chapter 8).
The water dispersion calculations should be performed extensively, taking seasons and weather conditions into account. The principles and assumptions of the dispersion model should be described.	Modeling of cooling waters has been performed taking these issues into account. The methods used are described in Chapter 7.
The impacts of warm cooling water on eutrophication and furthermore the impacts of eutrophication on fish stocks should be assessed.	The impacts on waters, fish population and the fishing industry are assessed by locality in the sections on the impacts on waters and the fish industry (Chapter 8).
The impacts on the reproduction of fish and spawning areas should be assessed. Particular attention should be paid to migratory fish, such as salmon and trout. The increase of fish diseases should be assessed. The numbers of fish sucked into the cooling water intake should be assessed. The project's impacts on ice conditions should be assessed. Impairment of the possibility to engage in ice fishing should be assessed.	Impacts on migration will be taken into particular consideration. Fish diseases are discussed in the section on the impacts on the fishing industry (Chapter 8). The numbers and species of fish driven into the cooling water intake are inspected in Chapter 8 based on existing data. The impact of the thermal load of the cooling water on ice conditions is inspected by way of modeling by locality and the impacts of weakening of ice on moving on ice are described in Chapter 8.
The risk of an increase in new species should be taken into account.	New species are discussed in the section on impacts on waters by locality (Chapter 8).
The capacities, emissions, water conductions and impacts of raw water supply and handling systems and different kinds of waste water treatment plants should be presented.	The operation and emissions of service water supply and operation systems and waste water treatment plants are described in Chapter 3 to the extent that they are a part of the project. The impacts are described in Chapter 8.

Matter presented in statements and opinions	How the matter has been taken into account in the assessment
The description of the current status of the natural environment of different localities should be supplemented compared to the EIA program.	As a part of the environmental impact assessment, the current status of the environment of each location and their surroundings has been surveyed on the basis of various sources and also by way of field studies, and the results are utilized in this report both in the descriptions of the current status of the environment and the assessment of impacts in Chapter 8.
Local knowledge should be utilized in assessing the impacts on nature. Nesting and migratory avifauna should also be surveyed.	In different surveys associated with the EIA, contact has been maintained with local parties in as many-sided a manner as possible. In connection with the assessment of impacts on the nature, contact has been made both with local authorities and, e.g. local fishermen and birdwatchers. The nesting and migratory avifauna of the locations and their surroundings have been assessed as a part of the nature surveys.
The current situation of land use planning and pending land use projects should be described by locality. It should be assessed how the project will advance national area use goals. The impacts of the project on community structure should be described.	Kunkin paikkakunnan kaavoitustilanne ja ydinvoimalaitoksen Each location's land use situation and needs for changing land use planning in connection with the construction of the nuclear power plant are described in the sections on the impacts on land use, landscape and built environment (Chapter 8). Taking the project into account in land use planning is discussed on a general level in Chapter 4. The project's relationship with national area use goals is described in Chapter 8 on the impacts on land use. The project's impacts on community structure are described in Chapter 8. They are also being examined and described in ongoing land use plan procedures.
The impacts of the nuclear power plant on the surroundings' lighting conditions should be assessed.	Impacts on lighting are assessed by locality as part of the project's impacts on landscape (Chapter 8).
Impacts on traffic volumes and traffic safety during the construction and operation of the nuclear power plant should be assessed.	Chapter 8 discusses the impacts on traffic volumes and traffic safety during the construction and operation of the nuclear power plant by locality.
The noise impact of the project should be assessed and particular attention should be paid to holiday homes.	The project's noise impact is assessed by locality in Chapter 8. The assessment takes into account the lower guidelines of holiday home areas.
The nearest sensitive sites of each locality should be described at a sufficient distance. The impacts on functions in the exclusion area, such as schools and beaches, should be assessed. The location of permanent housing and holiday homes in the area of the exclusion area should be assessed.	The sensitive sites in the vicinity are described on a map by locality in the sections on impacts on people and society (Chapter 8). The location sites have been selected so that there are as few population centers in the exclusion area as possible. The project's impacts on any functions in the exclusion area are assessed by locality in Chapter 8. The number of permanent residents at different distances from the nuclear power plant is presented by locality in the sections on impacts on people and society (Chapter 8). The location of holiday homes in the vicinity of the power plant area is also described.
The negative sentiments and fears towards the project within the population of the surrounding areas should be assessed.	A resident survey and group interviews have been conducted at each location area. These have explored, for instance, project-related fears. They are discussed by locality in the sections on impacts on people and society (Chapter 8).

Matter presented in statements and opinions	How the matter has been taken into account in the assessment
The project's impacts on recreational opportunities in the nearby areas, such as picking mushrooms and berries, fishing, skiing on ice and ice fishing should be assessed.	The project's impacts on the living conditions, comfort and recreation of the residents of the nearby areas are discussed by locality in a separate section in Chapter 8. Also, the project's impacts on the fishing industry are discussed by locality in the sections on impacts on waters and the fishing industry.
The health effects of radioactive emissions should be assessed. The assessment should take the results of the recent German study on cases of leukemia in children into account.	The health effects of radioactive emissions are described in Chapter 8, which also takes the mentioned German study into account. The health effects of a serious nuclear accident are discussed in the chapter on irregular and accident situations.
The project's impacts on the economy of the locations' municipality and neighboring municipalities should be assessed. The project's impacts on the value of properties in the nearby area should be assessed. The domestic content during the construction of the project should be assessed.	The project's impacts on municipal economy and trade and industry have been investigated. They are described by locality in the sections on impacts on people and society (Chapter 8). The project's impacts on the real estate market are assessed by locality in Chapter 8. Domestic content is assessed in Chapter 8.
The disposal of spent fuel and its impacts should be described.	The different options for the disposal of spent fuel are described in Chapter 3 and their impacts in Chapter 8.
Possible uses of the power plant area after the decommissioning of the nuclear power plant should be described.	The possible uses of the power plant area after the decommissioning of the nuclear power plant are described in the chapter on the decommissioning of the nuclear power plant (Chapter 8).
A summary of the survey of irregular and accident situations should be presented. Also other accidents and nuclear accidents should be assessed. An INES level 7 event and its impacts should be assessed.	The section on irregular and accident situations (Chapter 8) presents a summary of the results of the investigations. In addition to nuclear accidents, the chapter also describes other types of accident situations that might happen at the plant. The most serious nuclear accident that is possible in modern plants is of INES level 6. Its impacts have been assessed.
The hazardous chemicals used at the nuclear power plant and how they are stored should be described.	The paragraph on chemical accidents in the chapter on irregular and accident situations describes the chemicals used at the plant and their management.
The project's impacts on rescue arrangements and civic defense should be described. The possibilities of arranging evacuation should be assessed in different localities.	Rescue and impacts associated with civic defense and preparations are described in the section on irregular and accident situations.

The content of the statements and opinions issued on the EIA program were also utilized in the assessment of the project's social impacts (Chapter 8).

2.7 Display of the assessment report

The Ministry of Employment and the Economy will notify of the public display of the assessment report after the report has been submitted to it. According to the EIA Decree, opinions and statements concerning the assessment report must be submitted to the coordinating authority within the time specified by the coordinating authority, which is at least 30 and at most 60 days.

2.8 International hearing

The environmental impact assessment across boundaries has been agreed upon in the Convention on Environmental Impact Assessment in a Transboundary Context. Finland ratified this Convention of the United Nations Economic Commission for Europe (67/1997) in 1995. The Convention entered into force in 1997.

Parties to the Convention have the right to take part in an environmental impact assessment procedure carried out in Finland if the country in question is affected by the hazardous environmental impacts of the project to be assessed. Correspondingly, Finland has the right to take part in an environmental impact assessment procedure of a project located in another country if the project's impact may affect Finland.

This assessment in a transboundary context is applied to Fennovoima's nuclear power plant project. In

Finland, the Ministry of the Environment is responsible for the practical arrangements of the international hearing, and it will submit the received statements and opinions to the Ministry of Employment and the Economy, which is the coordinating authority. The Ministry of the Environment notified the following foreign authorities of the project: Swedish Environmental Protection Agency (Sweden), Ministry of Environment (Denmark), Ministry of Environment (Norway), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), Ministry of Environment (Poland), Ministry of Environment (Lithuania), Ministry of Environment (Latvia), Ministry of Environment (Estonia), Ministry of Natural Resources (Russia) and Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria). The EIA program translated into Swedish or English and the international hearing document translated into the languages of said countries, describing the project, its options and the contents and schedule of the commencing environmental impact assessment, were enclosed with the notification.

Sweden, Lithuania, Norway, Poland, Germany (state of Mecklenburg-Vorpommern), Estonia and Austria notified of taking part in the EIA procedure and issued their statements on the EIA program.

Several international statements discussed the same issues as other statements and opinions issued on the EIA program. Particular attention was paid to the impacts of accidents and irregular situations, impacts on waters and fish population, questions related to the disposal and intermediate storage of spent nuclear fuel and the need for taking the entire lifecycle of the project into account in the assessment. In addition to these questions, the statements paid particular attention to impacts across boundaries. Central topics of the questions and comments of the international statements are discussed in the enclosed table (Table 2-3) to the extent that they differ from the comments and questions presented in other statements and opinions. In addition to the issues presented in the table, the statements presented certain comments and questions pertaining to the Finnish energy policy, for instance, that are beyond the sphere of the EIA procedure. In its statement, Lithuania presented no comment whatsoever on the EIA program.

Table 2-3. Central and frequently repeated issues of the statements issued on the EIA program in the international hearing and taking them into account in the environmental impact assessment to the extent that they differ from the comments presented in other statements and opinions.

Matter presented in statements	How the matter has been taken into account in the assessment
Justification of the need to increase energy production.	The purpose of the project is to respond to Fennovoima shareholders' increasing need for electricity. The reasons for this are presented in Chapter 1 of the EIA report.
Irregular and accident situations	
Minimizing the risks and impacts of irregular and accident situations.	The risks and possible impacts of irregular and accident situations will be minimized in the design of the nuclear power plant (Chapter 6 on nuclear safety).
The reason for using an accident of the Nuclear Event Scale (INES) level 6 in the accident modeling.	In a modern plant, an INES level 6 accident is the worst possible. The methods of the assessment of the impacts of accident situations, including accident modeling, are justified in Chapter 7.
Assessment of radiation impacts across boundaries (by water and air).	The impacts of a nuclear power plant accident are assessed in proportion to distance from the nuclear power plant. These results of assessment can also be applied to assessing the impacts extending across boundaries. The transboundary radiation impacts during the normal operation of the nuclear power plant are discussed in Chapter 8, which discusses the impacts extending across boundaries in a separate section.

Matter presented in statements	How the matter has been taken into account in the assessment
Communications to other countries and their population in case of a radiation accident.	The radiation authorities of Nordic and other European countries are engaged in close cooperation. In case of a possible radiation accident, the countries in the possible area of impact will be informed without delay. The authorities of each country are responsible for communications to the population in their own area.
Assessment of impacts on waters and fish population across borders.	The impacts on waters and fish population are assessed by locality in Chapter 8. In addition, impacts extending to the area of other countries, in particular, are discussed in a separate section in Chapter 8.
Discussion of the risks of the normal operation of the plant and taking the results of the recent German study on leukemia cases in children into account.	Health risks from radiation during the normal operation of the nuclear power plant are discussed in Chapter 8, which also takes into account the German studies mentioned in the statement. Different irregular and accident situations during the operation of the plant are discussed in a separate section in Chapter 8.
Safety issues of low- and medium-level waste storage; in particular, radiation barriers.	The storage of low- and medium-level waste is described in Chapter 3.

After the EIA report has been completed, the authorities of the countries participating in the EIA will be sent the EIA report translated into Swedish or English and a summary of the EIA report translated into the language of said country.

2.9 End of the assessment process

The EIA procedure will be ended when the Ministry of Employment and the Economy issues its statement on the EIA report. After the EIA procedure, the license authorities and Fennovoima will use the assessment report and the statement of the Ministry of Employment and the Economy as the basic material in their decision-making processes.

2.10 Interaction between design and EIA

One of the goals of the EIA procedure is to support the project design process by producing information concerning the project's environmental impacts. The purpose is to produce information as early as possible into the design phase, so as to take environmental impacts into account throughout the design process from the beginning. Participation of citizens, which is an essential part of the EIA procedure, aims to ensure that various stakeholders' views of the project's impacts are also taken into account in a sufficiently early stage.

During the EIA procedure, Fennovoima has initiated the technical preliminary planning of the project, and its results have enabled assessing the project's impacts in this EIA report and the associated surveys. As the environmental impact assessment advanced, preliminary planning has been advanced in close cooperation with the environmental specialists performing the assessment. Experts have had a significant role in, e.g. deciding the location of the cooling water intake and exhaust locations and designing their structure. Participation in association with the EIA procedure has supported the planning process by specifying the initial data and by directing towards taking location-specific special features into account.

The EIA report and the stakeholder interaction that materialized during the EIA procedure, as well as the collected data, are important for the more detailed further planning of the project. Thanks to the extensive participation of the stakeholders, the initial data concerning the site locations and their environment have been specified and confirmed. With stakeholder interaction, the project planners have achieved contacts for obtaining locality-specific additional information.

The EIA report also presents the safety plans of a nuclear power plant. A fisherman tying his nets in Simo, 2008.

The strong layer of rock isolates the spent fuel from the environment and external impacts for a sufficiently long period. Possible ground movements and future ice ages are also taken into account when designing the repository facility.

3 Technical description of the project

3.1 The operational principle of a nuclear power plant

A nuclear power plant produces electricity by heating water into steam and letting the steam rotate a turbo generator in a manner similar to large condensing power plants using fossil fuels. The main difference between a nuclear power plant and a traditional condensing power plant is in the method of producing the energy for heating the water: in a nuclear power plant the heat is produced in a reactor using the energy released by splitting atom nuclei, whereas in condensing power plants the water is heated by burning suitable fuels, such as coal or wood, in the boiler.

It is possible to connect an intermediate circuit to the low-pressure end of the turbine plant of both plant types. The circuit is used to recover thermal energy with a sufficiently high temperature from the process for district heating use.

The plant types considered for this project are a boiling water reactor and a pressurized water reactor, (the operation of which is discussed in more detail in sections 3.2.1 and 3.2.2. In a boiling water reactor (Figure 3-1) the steam from the reactor rotates the turbine, which is connected to an electric generator. In a pressurized water reactor (Figure 3-2), the high-pressure water coming from the reactor is led to steam generators where the water in a separate secondary circuit is vaporized, and this steam is led to rotate the turbine and electrical generator.

In Finland, the fuel used in nuclear power plants is isotope U-235 -enriched uranium dioxide (UO_2). Enriched uranium dioxide contains 3–5 per cent of isotope U-235, while natural uranium only contains 0.71 per cent of this readily fissile isotope. The fuel is placed

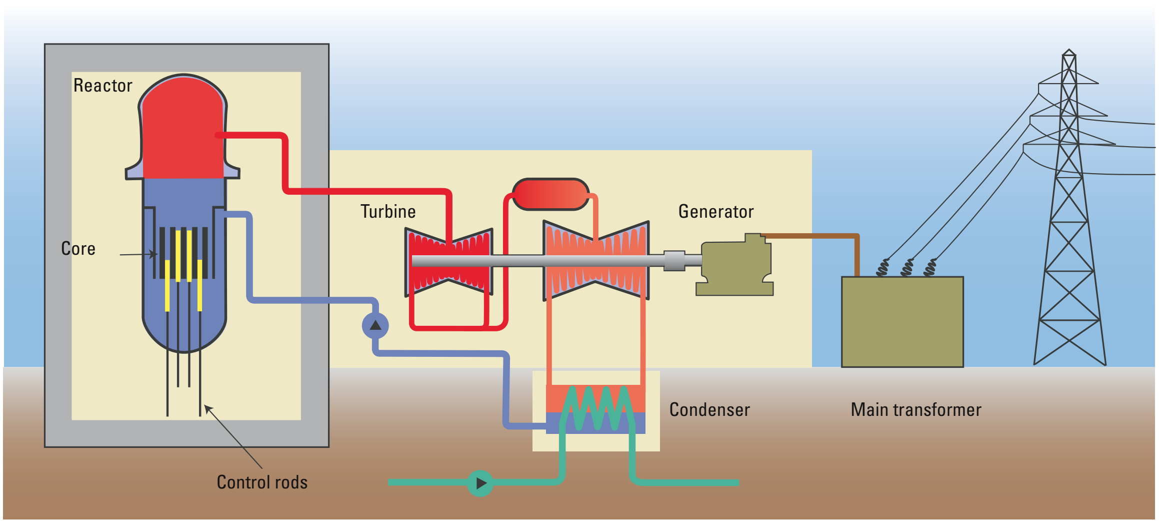


Figure 3-1. The operational principle of a boiling water reactor.

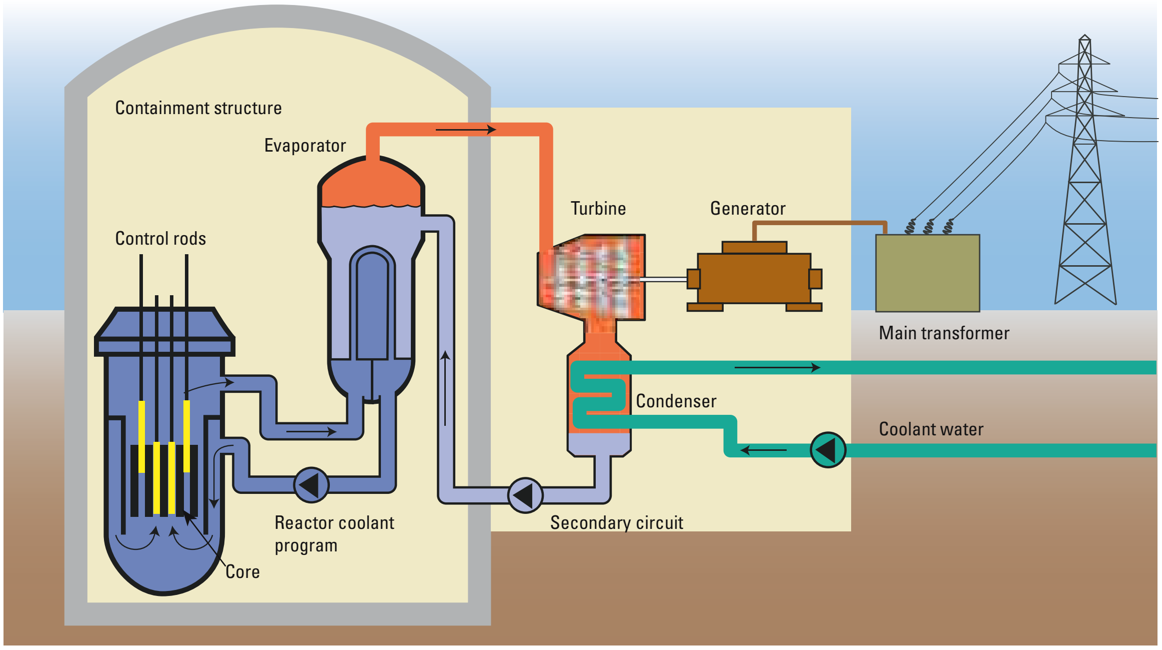


Figure 3-2. The operational principle of a pressurized water reactor.

in the reactor as ceramic pellets in hermetically sealed tubes, i.e. fuel rods, which are compiled into fuel assemblies (Figure 3-3).

The use of uranium as a fuel is based on heat created in the reaction during splitting of the atom nuclei, i.e. fission. When neutrons hit a fissionable atom nucleus, it splits into two lighter nuclei. At the same time, new neutrons, neutrinos and energy are released. The neutrons created when the nucleus splits can cause new fissions, which makes the chain reaction possible. The fission of U-235 nuclei forms a self-maintaining, controlled chain reaction that facilitates controlled heat production.

In a nuclear power plant, more than one-third of the thermal energy created in the reactor can be converted into electrical energy.

Heat produced in a nuclear power plant or other thermal power plants (such as coal, oil or gas plants) cannot be fully converted into electricity. As a result, part of the heat produced is removed from the power plant using condensers, where the low-pressure steam from steam turbines releases energy and turns back into water. In Finland, the condenser is cooled down using cooling water taken directly from the water system. The cooling water is then returned back to the water system with a temperature about 10–12 °C higher.

Another alternative for the so-called direct water cooling described above is to dissipate the surplus heat direct into the atmosphere using cooling towers. Cooling towers may be as high as 200 meters. Cooling towers are commonly used in areas where the water resources are scarce, such as by the rivers of Central Europe. Independent of the nuclear power plant's reactor type, a turbine plant can be equipped with a sufficient number of district heat exchangers. The turbine is optimized

Figure 3-3. Nuclear fuel: fuel pellets, fuel rods, fuel rod assembly.

Table 3-1. Preliminary technical specifications of the planned nuclear power plant.

Description	Alternative 1 (one large unit)	Alternative 2 (two smaller units)
Electrical power	1,500–1,800 MW	2,000–2,500 MW
Thermal power	about 4,500–4 900 MW	about 5,600–6,800 MW
Efficiency	about 37 %	about 37 %
Fuel	Uranium oxide UO_2	Uranium oxide UO_2
Thermal power released in cooling (to the water system)	about 3,000–3,100 MW	about 3,600–4,300 MW
Annual energy production	about 12–14 TWh	about 16–18 TWh
Cooling water requirement	55–65 m^3/s	80–90 m^3/s

into the best possible balance for different methods of use. Common use does not have an impact on the nuclear power plant's nuclear safety properties because the changes do not need to be targeted at the power plant's nuclear parts.

The turbine plant of a nuclear power plant intended for combined production will be designed in all cases to be capable of operating in condensing use so that the plant can also operating in summer when the demand for heat is low. With regard to the low-pressure rotor, a full-sized turbine is practically best-suited with the malfunction- and fault-tolerance requirements set for the national grid.

The access of radioactive substances to the district heating network is prevented by transferring heat from the turbine circuit to the district heating network using a closed and pure intermediate circuit. The maintenance of a district heating network will slightly increase the power plant's consumption of raw water.

A nuclear power plant is best suited to a so-called base load plant, which means that it will be used continuously at constant power, except for a few weeks' maintenance outages at 12–24-month intervals. The plant's planned operational lifetime will be at least 60 years.

The preliminary technical parameters of the planned nuclear power plant are shown in the table below (Table 3-1).

Fennovoima's nuclear power plant will mainly be designed as a condensing power plant. The utilization of the nuclear power plant's loss heat as such will not require any changes to the actual power plant. In order to conduct heated water from the condenser to the target of utilization over a long distance (several kilometers) will, however, require a separate pumping station to be built in the plant site, as well as a channel or pipeline from the plant to the target. The size of the pumping station depends on the heat needs.

The production of district heating will require a

Figure 3-4. EPR pressurized water reactor, Areva NP.

Figure 3-5. ABWR boiling water reactor, Toshiba.

higher temperature than that provided by the condenser of a nuclear (condensing) power plant. As a result, the power plant's turbine plant should be altered. There will be no changes required in the reactor and connected systems. For combined production of electricity and district heating, the nuclear power plant's low-pressure turbines will be equipped with intermediate recoveries of suitable pressure where some of the steam transferring through the turbine will be guided to the heat exchanger which supplies the district heating network. The removal of steam from the turbine process will reduce the electric output produced at the power plant. If the share of steam removed from the turbine is great, it would be useful to adjust the turbine's flow parts correspondingly for a flow smaller than condenser use, even if this would reduce the efficiency of condensation production. According to Fennovoima's inspections, each 5 MW of produced district heat will reduce the volume of produced electricity by about 1 MW. Even in combined production, it will not possible to transfer all of the thermal energy that is conducted into the sea from a condensing plant to the district heating network. As a result, a reactor with an electric output of 4,300 MW which produces 1,600 MW of electricity and 2,700 MW of loss heat in condenser use could, in combined operations, produce 1,200 MW of electricity, 2,000 MW of district heat and 1,100 MW of loss heat.

If the district heat produced was used to replace district heat produced using fossil fuels, the carbon dioxide emissions would be reduced. Loss heat conducted into the sea would be reduced by a maximum of 1,600 MW. The consumption of district heat is at its highest in win-

Figure 3-6. SWR 1000 boiling water reactor, Areva.

Table 3-2. Reactor type alternatives for Fennovoima.

	Toshiba ABWR	EPR	SWR 1000
Manufacturer, country	Toshiba Japan	Areva NP France/Germany	Areva NP France/Germany
Electric power, MW	1,600–1,800	1,600–1,800	1,000–1,250
Thermal power, MW	4,300–4,900	4,300–4,900	2,700–3,400
Reactor type	Boiling water	Pressurized water	Boiling water
Main type of safety systems	Active and passive	Active	Passive and active
Plant used as the model	Hamaoka-5	Olkiluoto 3	Gundremminge C

ter and, as a result, the reduction of loss heat would reduce the impact of the power plant on the ice cover in the sea area. In summer when the demand for district heating is low, the sea water will warm up as in condenser use.

3.2 Nuclear power plant units

The most popular reactor type is the so-called light water reactor. Moreover, the reactors in the current nuclear power plants in Finland are light water reactors. Light water reactors use regular water to maintain the chain reaction, to cool the reactor and to transfer heat from the reactor core. The alternative types of light water reactors are the boiling water reactor and the pressurized water reactor.

3.2.1 Boiling water reactor

A boiling water reactor operates at a pressure of approximately 70 bar. Fuel heats the water, which evaporates and forms steam at a temperature of just below 300 °C. The steam is led directly to the turbine that rotates the electric generator (Figure 3-1). Steam returning from the turbines is led to a condenser, where it releases its remaining heat into water pumped from the water system and condenses into water. The cooling water and the steam returning from the turbine and condensing into water are not brought into direct contact with each other.

The heated cooling water continues back to the water system, but the steam condensed into water is pumped to pre-heaters where it is heated using steam taken from the turbine before the water is led back to the reactor. The condenser is under-pressurized, so that any leakage flows towards the process and not outwards from the plant's steam circulation.

The boiling water reactor has a more simple steam

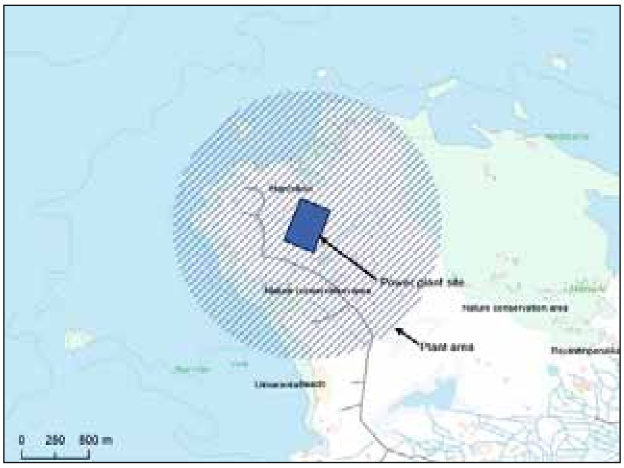


Figure 3-7. Preliminary area plan for the nuclear power plant, Pyhäjoki.

Figure 3-8. Preliminary area plan for the nuclear power plant, Ruotsinpyhtää, Kampuslandet.

generation process than the pressurized water reactor. On the other hand, the steam is slightly radioactive when the plant is running and no one can stay close to the turbine during operations. The radioactivity of the steam rapidly decreases after the reactor is stopped.

The current power plant units in Olkiluoto, Finland, have boiling water reactors.

3.2.2 Pressurized water reactor

In a pressurized water reactor, fuel heats the water, but the high pressure (150–160 bar) prevents the formation of steam. High-pressure water is led from the reactor to separate steam generators, where the heat is transferred to low-pressure water in a separate circulation circuit (secondary circuit) at a lower pressure (60–70 bar). Pressurized water is pumped back into the reactor from the steam generators (primary circuit). The maximum temperature of water inside the reactor is about 300 degrees centigrade. Water in the secondary circuit evaporates and the steam is led to the turbine that rotates the electric generator. (Figure 3-2)

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

In Finland, the current reactors at Fortum's Loviisa power plant and the reactor in the new power plant unit under construction in Olkiluoto are pressurized water reactors.

3.2.3 Nuclear power plant types chosen for the project

Fennovoima has made a preliminary assessment of all light water reactor types on the market and chosen three reactor alternatives suitable for Finland for closer analysis. The alternatives are:

EPR by Areva, a pressurized water reactor of about 1,700 MWe, SWR 1000 by Areva, a boiling water reactor of about 1,250 MWe, and ABWR by Toshiba, a boiling water reactor of about 1,600 MWe.

Fennovoima would build one of the high-power reactors (*Areva's EPR or Toshiba's ABWR*) in its power plant. SWR-1000 is a reactor with smaller power, and two units would be installed in the Fennovoima plant.

EPR (European Pressurized water Reactor) is a large pressurized water reactor developed by the French-German consortium Areva NP (Figure 3-4). It combines the key elements of the earlier pressurized reactor types of both countries, the German Konvoi and the French N4. One of the basic principles in the design work has been to use, as much as possible, technical solutions that have been tried and tested in earlier plants. EPR's safety design is based on so-called active safety systems, which operate on auxiliary power and for which there is a wealth of experience from plants currently in operation. In deviation from the plants currently in operation, the possibilities of reactor core melting accidents and external threats such as collision by a passenger aircraft have been addressed at the very basic stages of designing the EPR. EPR plants are currently under construction in Finland and France. EPR plants have also been purchased for China, and projects aimed at constructing them are in progress in Great Britain, the USA and South Africa.

Toshiba's ABWR (Advanced Boiling Water Reactor) is a model based on General Electric's ABWR, further jointly developed by Toshiba and Westinghouse Sweden Figure 3-5). There are four ABWR plants in operation in Japan, and two more are under construction in Japan and two in Taiwan. In ABWR plants, the original safety design is also based on active systems, but Toshiba has also added so-called passive safety systems to the plant; they operate driven by natural forces. Toshiba's ABWR version being offered to Fennovoima is also equipped

Figure 3-9. Preliminary area plan for the nuclear power plant, Ruotsinpyhtää, Gäddbergsö.

Figure 3-10. Preliminary area plan for the nuclear power plant, Simo.

with reactor core melting accidents and passenger aircraft collisions in mind.

SWR 1000 (SiedeWasserReaktor) is an advanced boiling water reactor by Areva NP (Figure 3-6). Its process design is based on the latest German boiling water reactor technology that is currently used in, for example, the Gundremminge B and C plants in Germany. The safety design of the SWR 1000 utilizes the natural properties of the plant processes, and the primary safety systems are passive. The possibilities of reactor core melting accidents and external threats such as the collision by a passenger aircraft have been addressed in the very basic stages of designing the SWR 1000.

3.3 Best Available Technique (BAT) and energy efficiency of the plant

The aim is to minimize the generation of emissions and waste materials with the technology and techniques to be applied in the nuclear power plant. The best available and sufficiently tested techniques are applied to managing emissions and waste materials. The possible techniques to be applied are discussed in this EIA Report in the sections concerning radioactive emissions, waste waters and waste management. The amount of emissions from the plant to the environment will be considerably smaller when compared to existing nuclear power plants.

Best available techniques are also applied to designing the safety-related aspects of the plant. The bases for the plant's safety design are discussed in Chapter 6.

About 4–8 per cent of the total electrical power generated by the plant is required by the plant itself, mainly for pumping cooling water and feed water, and for air conditioning. Part of the heat generated in the process is used for heating the plant buildings.

Direct cooling of the condenser with constantly cool seawater is the best solution from the efficiency of electricity generation point of view. Technically, it is possible to produce district heating and process steam in addition to electricity in a nuclear power plant. This improves the overall efficiency of the process, but it also slightly reduces the production of electricity. The possibilities for producing and utilizing district heating and steam are discussed in Chapter 10.

3.4 Plant area activities and land usage requirements

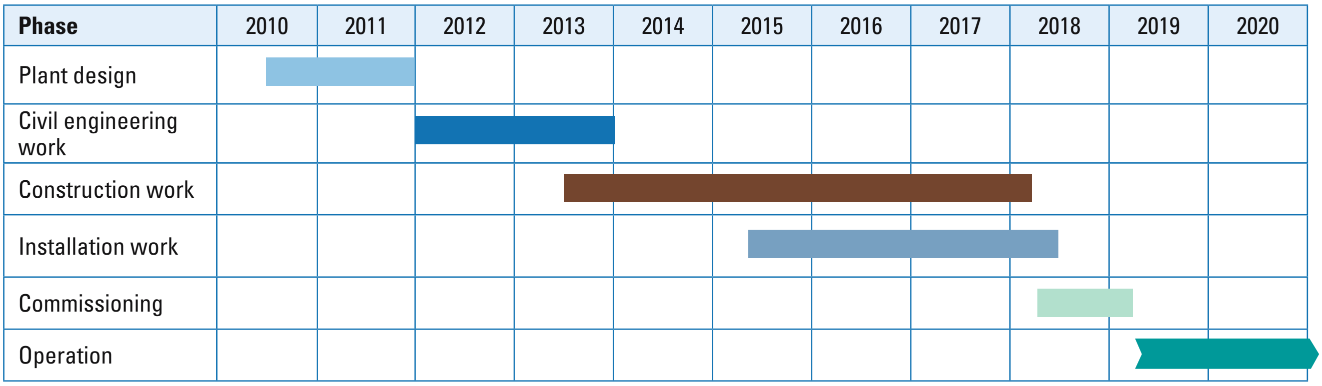
The location of nuclear power plant activities according to the preliminary plan in the location alternatives of Pyhäjoki, Ruotsinpyhtää and Simo are shown in the figures below (Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10).

The figures show the indicative plant area referred to in section 1.10 of the Nuclear Power Act; it will be further defined for each alternative location as the planning process advances. The plant area will be accurately defined in conjunction with processing the construction permit for the nuclear power plant. The size of the power plant area shown in the figures is approximately 10 hectares, and the area contains all the major activities of the power plant.

A typical nuclear power plant includes the following buildings:

- reactor containment building and auxiliary buildings (containing, for example, the spent fuel cooling pools, fresh fuel storage and equipment that may contain radioactive fluids)
- building for treatment of radioactive waste
- fresh fuel storage
- intermediate storage pools for spent fuel
- final repository for operating waste
- control room building
- emergency diesel generators and gas turbine
- turbine building
- electrical building

Table 3-3. Estimated time schedule for the power plant project.



- transformer and switch fields
- seawater pumping station
- tanks and structures associated with water treatment (fresh water pumping station, fresh water storage, raw water treatment, waste water treatment)
- administration building (including a health center, canteen and other auxiliary premises)
- training and visitors' center
- fire station, firefighting water pumping station and reservoirs
- other auxiliary and maintenance buildings (such as mechanical workshops and stores).

The area requirements of the main buildings of the nuclear power plant are estimated at about 20,000 m² and the volume requirements at about 1,000,000 m³. The maximum height of the reactor buildings is about 60 meters. The highest structure is the vent stack at 100–120 meters. The area of the intermediate storage pools for spent fuel is about 2,000 m². The area required by the final repository of operating waste is about 20,000 m².

Areas will also have to be reserved for site activities during the construction phase, intermediate storage for soil and rock materials, parking and accommodation. The power plant unit structures also include cooling water intake and discharge tunnels and structures, as well as loading and offloading facilities for sea transport, etc.

The plant activities, excluding cooling water intake and discharge structures, harbor quay, and accommodation and parking areas, in the preliminary plans are expected to require an area of about 100–200 hectares at each alternative location.

In Pyhäjoki, the preliminary location of the power plant unit/units is in the central and northern part of the Hanhikivi headland (Figure 3-7).

In Ruotsinpyhtää, the preliminary location of the power plant unit/units is in the southwestern part of the Gäddbergsö peninsula (Figure 3-9) or in the southern part of Kampuslandet island (Figure 3-8).

In Simo, the preliminary location of the power plant unit/units is on the south-eastern part of Karsikkoniemi (Figure 3-10).

Fennovoima will acquire possession of the land areas required for the nuclear power plant.

Table 3-4. Estimated mass quantities generated during the nuclear power plant construction work.

	Solid volume m³		
Generated mass	**Pyhäjoki**	**Ruotsinpyhtää**	**Simo**
Excavation and rock blasting masses from the plant area	160,000	G 260,000 K 200,000–280,000	200,000
Rock blasting masses from cooling water structures	290,000–310,000	G 440,000–460,000 K 110,000–120,000	370,000–380,000
Dredging and rock blasting masses from the navigation channel and offloading and loading place	168,000	G 94,000 K —	91,000
TOTAL	618,000–638,000	G 794,000–814,000 K 310,000–400,000	661,000–671,000

G=Gäddbergsö, K=Kampuslandet

3.5 Constructing the nuclear power plant

3.5.1 Description of the building site

Constructing a nuclear power plant is a large project. The construction will take about 6–8 years; six years in the case of one unit and eight years in the case of two units. At maximum, the worksite will have 3,500–5,000 employees depending on the number of units. A parking area and accommodation for some of the construction site workers will be built in the vicinity of the plant area.

During the first construction phase of approximately two years, the necessary roads as well as excavation and civil engineering works for the power plant building and other buildings will be completed. The work includes, among other things, quarrying, rock blasting and building site leveling work. The land masses generated in the process will be temporarily stored at the plant area.

The actual plant construction work and the partly parallel installation work will take about 3–5 years, and commissioning of the plant will take about 1–2 years.

3.5.2 Safety and environmental issues regarding the site

Safety and site plans are to be drawn up before commencing work. When drawing up the safety plan, the general requirements for safety on building sites and the specific safety requirements and instructions issued by Fennovoima will be taken into account. The safety plan will present, among other things, the traffic arrangements during the construction phase and the safety regulations applicable to employees. The site plan will include details of use of the site area, such as offloading and loading places, and the locations of machinery and land masses.

In conjunction with drawing up the safety and site plans, a risk assessment will be carried out, analyzing, inter alia, hazardous work and procedures carried out on the site, risk of accidents, industrial hygiene, management of the site and the integration of different contractors and activities.

An environmental management system and set of environmental guidelines will also be drawn up for the construction project. This is a proactive way of ensuring that all parties on the building site take care of environmental matters in compliance with regulations, permits and best practices.

The requirements and particular characteristics regarding the nuclear power project and the site will be taken into account when providing employees with induction training.

The matters regarding the contracts of employment of foreign workers will be established and arranged in advance in close co-operation with public authorities and trade unions. Care will be taken to ensure that the workers receive the necessary training and instructions in a language they understand.

3.5.3 Civil engineering work

Earth-moving work

Earth-moving work produces large amounts of excavation, rock blasting and dredging masses. The largest single source of these masses is the excavation work for the cooling water intake and discharge tunnels. All masses are to be utilized on the site for different landfills and landscaping work. Due to the low elevation in Pyhäjoki, approximately one million additional cubic meters of masses will be required for landfills. The table on previous page (Table 3-4) shows an estimate of the generated mass quantities and their utilization.

Building of the navigation channel and harbor quay

An offloading and loading place will be built in the plant area or its immediate vicinity for sea transport of heavy items during the construction phase. The quay to be built is about 100 meters long and 30 meters wide. The quay will also be available for use during the operating phase, if required.

Depending on the location, dredging and rock blasting work will be required to level the sea bed where the quay support structures are laid. In addition, a five-meter deep and approximately 30-meters wide navigation channel to the offloading and loading place will be built. The dredging masses generated during the navigation channel work will be used for filling the back of the offloading and loading place and the jetty. The mass quantities for each location alternative are shown in the table on previous page (Table 3-4).

In the Pyhäjoki option, the plant quay is planned to be east of the plant area; there are good connections to deeper waters. The sea bed will have to be dredged and blasted for the quay. The length of the required new navigation channel is about one and a half kilometers.

In the Ruotsinpyhtää Gäddbergsö option, the quay can be built west of the plant area. Dredging and blasting work will also be required in front of the quay. The existing navigation channel will have to be made deeper in the 500-meters stretch between Björkholmen and Lindholmen to make it suitable for nuclear power plant transportations.

In the Ruotsinpyhtää Kampuslandet option, the harbor will be placed north-east of the plant area by a sufficiently deep navigation channel, which means there will be little need for dredging. Building the quay will not require much dredging or blasting either.

In the Simo option, the plant quay is planned to be west of the plant area. The front of the quay must be dredged, and some rock will have to be blasted. A 500-meter navigation channel will be built from the harbor to the navigation channel heading to Veitsiluoto.

The location of the quays in the different plant location alternatives is shown in conjunction with the associated projects on the maps at 3.14, while the location of navigation channels is shown in Chapter 8.

Cooling water intake and discharge structures
Cooling water is to be taken from the sea outside the plant, either from the bottom or the shore, and led to the power plant in a tunnel running about 40 meters under the seabed. The intake and discharge points are shown in the maps in Chapter 8.

Intake from the bottom
In this context, intake from the bottom refers to an intake structure located some 0,5–3 kilometers from the shoreline. The intake structures are located on the sea bottom, at a depth of about 10–25 meters, and cooling water is conducted to the plant via a tunnel. The required tunnel length is about 500–3,500 meters, depending on the location alternative. In case of bottom intake, all structures are located under water. The required backup intake structures can be built close to the shoreline in conjunction with the intake tunnels. The location of the bottom intake point will be marked in a manner approved by the maritime authorities.

The intake structures will be so dimensioned that the flow at the mouth of the intake remains low (flow rate about 0,2–0,3 m/s). This reduces the amount of solids carried by the cooling water and prevents the mixing of water layers at different temperatures.

Shore intake
Shore intake refers to an intake structure built by the mainland or island shoreline. When a shore intake is built, the shore will be excavated and/or blasted and the bottom dredged as required at the intake point so that cooling water intake can take place at a depth of about 0–15 meters. Cooling water is conducted to the plant via a tunnel. Most of the structures are under water. A quay-like concrete structure will be visible above the water.

When designing and building both bottom and shore intake structures, factors such as the impact of algae, various impurities, supercooled water and possible pack ice are to be addressed.

Discharge structures
Warmed cooling water is conducted from the power plant to the seashore via a tunnel and discharged in the sea through the cooling water discharge channel. The required discharge tunnel length is about 200-2,100 meters, depending on the plant location. The discharge channel is a structure about 30 meters wide, divided by two about 10-meter wide banks, and a few tens of meters long, depending on the location.

3.6 Procurement of nuclear fuel

A nuclear power plant uses about 30-50 tons of enriched uranium as fuel per year; 300-500 tons of natural uranium will be required to produce this amount of

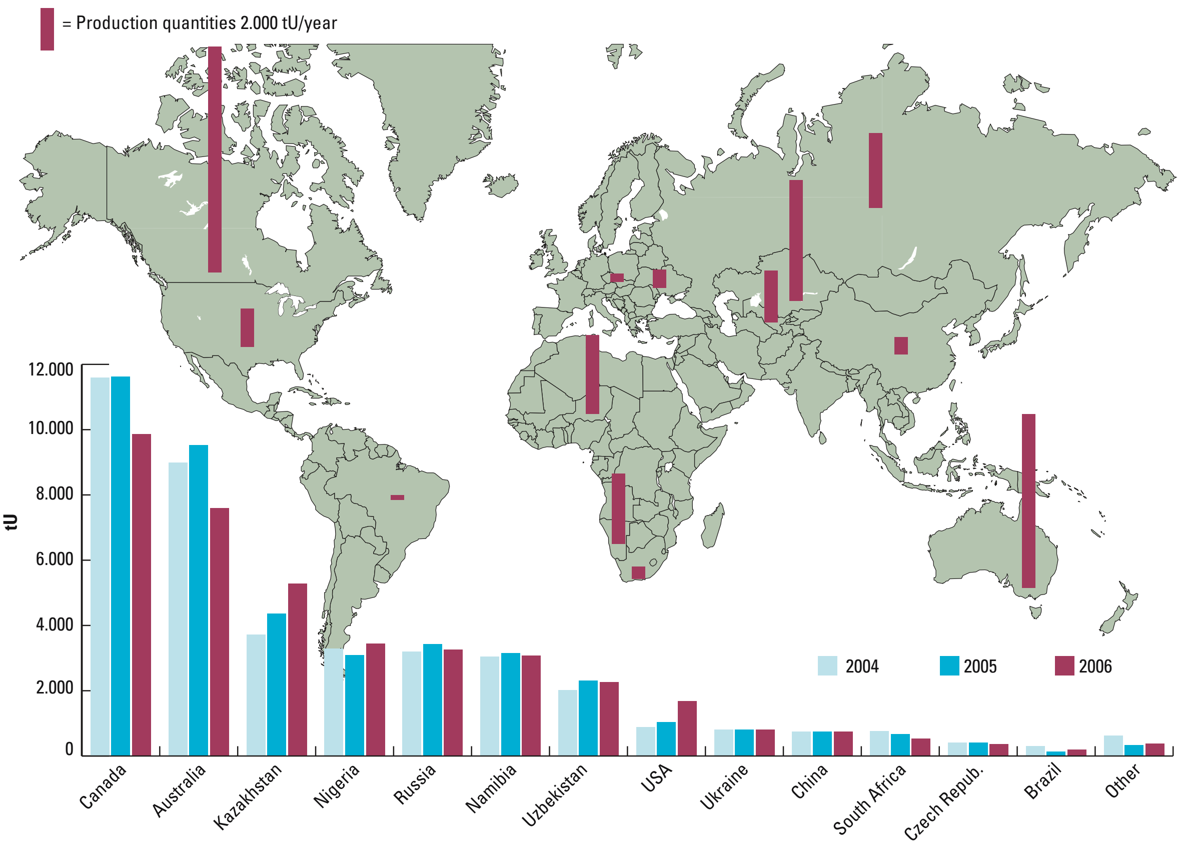


Figure 3-11. Annual production of natural uranium by country. *(WNA 2007)*

fuel. A nuclear power plant usually stocks enough fuel for one year's operation. When required, larger quantities of nuclear fuel can easily be stocked for reasons of security of supply.

The number of fuel rod assemblies and the total quantity of uranium in the nuclear power plant reactor varies with reactor size and type. The reactor holds about 120–200 tons of uranium. Each fuel rod assembly typically spends three to five years in the reactor.

The procurement of nuclear fuel is divided into the following steps: excavation and enrichment of uranium, conversion, isotope enrichment and manufacture of fuel rod assemblies. The different phases of the nuclear fuel production chain are described in more detail in Chapter 8 under the section discussing the nuclear fuel production chain. The producer of nuclear energy can purchase ready-made fuel rod assemblies or outsource the different manufacturing stages to different actors. The availability of fuel is usually secured through long-term supply agreements

3.6.1 Availability of fuel

Uranium is purchased from global markets. In 2006, the world's nuclear power plants required about 62,000 tons of uranium. The world's total nuclear power capacity was 370 GWe in 2006. According to the basic scenario by WNA, the World Nuclear Association, the nuclear power generation capacity will increase to 520 GWe by 2030. The higher scenario predicts a generation capacity of 730 GWe in 2030. In the basic scenario, nuclear power capacity will increase by over 40 per cent from the current figure by 2030 and, consequently, the demand for uranium will increase to 110,000 tons per annum. *(Kwasny et al 2007, WNA 2007)*.

The production of natural uranium currently covers about two-thirds of the demand for uranium. The balance of the uranium on the market originates from reducing the stockpiles of weapon-grade uranium, re-enrichment of depleted uranium generated in the fuel uranium isotope enrichment process, re-processing of spent fuel and from uranium stockpiles.

Production of uranium

Uranium is a relatively common element, present in varying concentrations almost everywhere on Earth. Granite, for example, typically contains 0.0004 per cent of uranium, and sea water one thousandth of that. The highest uranium concentrations can be found in the Canadian mine regions, even in excess of 20 per cent in places. At the moment, the deposits that can be feasibly utilized contain a minimum of 0.1 per cent of uranium.

The amount of uranium produced in 2007 was just under 50,000 tons. The largest producers of uranium in 2006 were Canada with 25 per cent, Australia with 19 per cent and Kazakhstan with 13 per cent of the total production of uranium in the world. Other large producers in recent years include Nigeria, Russia and Namibia. The 12 largest producer countries produced 98 per cent of the total production of uranium in 2006, some 45,000 tons. During recent years, the production has increased at the fastest rate in Kazakhstan. (*Kwasny et al 2007*)

The companies producing most natural uranium are Cameco, RTU and AREVA; they accounted for over 50 per cent of the total production in 2007.

In 2006, the largest uranium mine was Key Lake/ Mc Arthur River in Canada; its production of 7,200 tons represented 18 per cent of the world's total production. The next largest were Ranger and Olympic Dam in Australia, both with a 10 per cent share, and Rössning in Namibia with an 8 per cent share of total production. (*Kwasny et al 2007*)

The currently known economically exploitable uranium resources total 4.7 million tons. In addition, the total of uranium resources exploitable using conventional methods are estimated at some 10 million tons. During recent years, the estimates of the sizes of known uranium deposits have increased, mainly as a result of re-assessment of earlier known resources. It is very likely that the current ongoing extensive prospecting operations will result in finding new deposits. Even the currently known resources are sufficient to cover the increase in demand due to the expected increase in nuclear power generation capacity. (*OECD and IAEA 2006*)

Secondary sources of uranium

Of the uranium currently on the market, about 20,000 tons per annum comes from so-called secondary sources. In addition to natural uranium, the other uranium sources include the mixing of high-enriched (U-235 content over 20 percent) uranium from military sources, mainly nuclear weapons and submarines, with depleted uranium, re-enrichment of depleted uranium generated in the fuel uranium enrichment process and re-processing of spent fuel. In addition, there are some uranium stockpiles accumulated by investors operating on the raw material markets around the world.

As a result of the disarmament process, uranium from decommissioned nuclear weapons has been utilized in nuclear fuel production for several years in the USA and Russia, for example. Nuclear weapons contain high-enriched uranium and almost pure fissile plutonium.

Some quantities of depleted uranium from isotope enrichment processes have been sent to Russia for re-enrichment. Depleted uranium is stored because it is used as a raw material for nuclear fuel and can be utilized for producing fuel in the future. Depleted uranium is also used for manufacturing mixed oxide fuel (MOX), a mixture of uranium oxide and plutonium oxide.

The plutonium separated by reprocessing spent nuclear fuel can be recycled into MOX, and the uranium can be reprocessed for re-use as nuclear fuel. The plutonium can be used for producing MOX as received, but the uranium first has to be re-enriched. There are reprocessing plants in France, Great Britain, Russia and Japan. Mixed oxide fuel is produced in France and England, for example.

Of the uranium from secondary sources, currently about 19 per cent or 3,400 tons per annum comes from reprocessing of uranium. It is estimated that the amount of uranium from reprocessing will increase to 6,500 tons per annum by 2020. The extent to which MOX and reprocessed uranium is used will depend on the market price for uranium and on political decisions related to the use of recycled fuel. The use of MOX is permissible in several European countries and Japan. The Finnish nuclear power plants do not use reprocessed uranium. (*Kwasny 2007, Nuclear Review 2007, WNA 2008a*)

Future outlook for the uranium markets

The world market price of uranium rose sharply during the period 2002–2007, after which the price has been steadily decreasing. The reasons for the price increases include uncertainty regarding the future availability of ex-military uranium and the accumulation of stockpiles. As a result of the increasing uranium prices, extensive uranium prospecting operations have been initiated around the world, and there are plans for opening new mines and extending the operation of existing ones.

Unlike fossil fuels, price of the fuel is only a minor part of the overall production costs in nuclear power production. The price of uranium accounts for less than one-third of the cost of uranium fuel. Therefore, even a significant increase in the price of uranium will have little effect on the production cost of nuclear power.

Uranium will continue to be mainly available from the current largest producer countries.

The relationship of the project with uranium mine projects in progress in Finland

During recent years, international mining companies have initiated uranium prospecting operations in Finland. The first claim applications were submitted to the Ministry of Trade and Industry in the fall of 2005. Fennovoima will procure the uranium required for the nuclear power plant from the world market. Uranium is processed in several stages in production plants in different countries before it can be used in the reactor of a nuclear power plant. Therefore, the possible future production of uranium in Finland is not connected to Fennovoima's nuclear power plant project.

Availability regarding the different production steps of uranium fuel

There are four conversion companies, and the conversion plants are located in France, Great Britain, Russia and the USA. The capacity of the conversion plants will increase in the next few years. (*WNA 2008b*)

There are also four enrichment companies, and the plants are located in the Netherlands, France, Germany, Great Britain, Russia and South America. There are also major enrichment plants in France, Germany, England and Russia, plus many minor plants around the world. New centrifuge plants are being built in France and the USA. The capacity of the existing centrifuge plants can also be gradually increased by increasing the number of centrifuges.

Zirconium, the material required for fuel rod cladding, is readily available. About five per cent of total zirconium consumption in the world is currently used for uranium fuel manufacture.

There are five suppliers of fuel rod assemblies. There are production plants for fuel rod assemblies suitable for light water reactors in, among other places, Sweden, Germany, Spain, France, the USA and Russia. There is currently overcapacity in the manufacture of fuel rod assemblies, which means that the demand can be matched, even as it increases when new nuclear power plants are built. The standardization of the fuel used in light water reactors increases the flexibility of fuel supplies and improves availability.

3.6.2 Quality and environmental goals set for nuclear fuel procurement

The quality requirements set for nuclear fuel are associated with the functionality and reliability of the fuel. Functionality includes the flexibility of use, high rate of energy production and service life in the reactor. Reliability includes the fuel rods remaining in good condition under all operating conditions, and even under exceptional circumstances.

Exacting quality standards have been defined for the design and manufacture of fuel rod assemblies. Fuel manufacturers and purchasers operate thorough quality control programs and procedures in order to ensure the compliance of the finished fuel rod assemblies with the requirements set. Quality control includes specific tests and inspections for fuel materials, assemblies and their components, as well as for the equipment used in their manufacture. Quality assurance is based on monitoring by an external evaluator and on monitoring the test and inspection results in order to ensure that the work processes in different manufacturing stages and the associated inspections are carried out in compliance with requirements and that the end result meets the requirements set for it. The programs must comply with the requirements set by the national nuclear power authorities of both the producer's country and the buyer's country. In addition, all major nuclear fuel suppliers also apply the international quality assurance standards for nuclear fuel as defined in ISO 9000 to their operations.

The Radiation and Nuclear Safety Authority (STUK), as required by the Nuclear Energy Decree, supervises that nuclear fuel is designed, manufactured, transported, stored, handled and used in compliance with the relevant rules and regulations. The requirements regarding the said phases are set out in the nuclear power plant instructions for nuclear materials issued by STUK (*YVL 6.2 – YVL 6.8*).

In addition to quality parameters, the buyers also pay attention to the environmental aspects of the fuel procurement process. Environmental impact-related issues are assessed in accordance with the criteria set by the buyer's own environmental policy. The fuel supplier can be expected to operate an environmental management system or to produce other evidence of acceptable environmental management. The minimum requirement is that the producer operates in compliance with national legislation and regulations.

The WNA, WANO (World Association of Nuclear Operators) and IAEA (International Atomic Energy Agency) have produced international instructions and guidelines for best practices with regard to both safety and the environment to be observed in the different stages of nuclear fuel production. The principles of the WNA guidelines are particularly intended for countries where legislation is not yet of the standard that would ensure taking environmental aspects into account to a sufficient degree. (WNA 2008c)

The buyers of nuclear fuel carry out audits in the companies and production plants operating at the different stages of the uranium production chain. One purpose of the audits is to get a picture of the standard of environmental management, the degree to which environmental regulations and standards are observed, and matters pertaining to industrial safety in the companies forming part of the fuel production chain.

During the audits, attention is paid to, *inter alia*, emissions caused by the operations and their monitoring, transportations, subcontracting, contribution to services for local population, safety and security, risk analyses, handling of exceptional situations and radiation protection. In the audits, attention is also paid to possible areas in need of improvement and these are discussed with the production company.

The negotiating power of the uranium fuel buyer also depends on the purchasing volumes. One of the shareholders of Fennovoima, the energy company E.ON, has the operating license for 9 nuclear power plant units and a shareholding in 12 nuclear power plant units in Europe, making it a fairly major buyer of nuclear fuel.

3.7 Chemicals used during operation

At nuclear power plants, chemicals are used to desalinate process water and to regulate chemical reactions in the water circulation systems of the plant. Chemicals are also used to clean the equipment and pipelines of the closed steam circulation. The chemicals included in significant amounts include hydrazine, sulfuric acid, sodium hydroxide – i.e. caustic soda – or other chemicals with similar properties. Light fuel oil is used as the fuel for emergency diesel engines. Oil is used to lubricate rotary machinery.

The chemicals to be used in the nuclear power plant and their respective quantities will, to a certain degree, depend on the type of reactor chosen for the plant. Boric acid is used for the regulation of reactivity in the pressurized water reactors. The total quantity of chemicals used for water treatment and other parts of the system is about 100–200 tons per annum. The amount of light fuel oil stored for the emergency power generators is one to two tons per annum.

The chemical storage tanks and chemical stores are to be built in compliance with the Chemicals Act and regulations issued pursuant to it, as well as SFS standards. In the eventuality of leaks, all premises containing chemical tanks or storage facilities are drained to protective pools, slurry and oil separation wells and neutralization pool.

If more than 10 tons of toxic materials or more than 1,000 tons of corrosive, irritant or hazardous materials are stored, a permit for extensive storage and handling of such chemicals will be applied for from the Safety Technology Authority. When required, permits for storing lesser amounts of chemicals will be applied for on the basis of chemical-specific limits, and the required notifications will be issued to the chemical supervision authorities or rescue services authorities, for example.

The relevant safety instructions and regulations will be adhered to when transporting chemicals. The transportation of hazardous chemicals is governed by Act on the Transport of Dangerous Goods (719/1994) and other regulations of lower degree issued pursuant to it.

3.8 Water requirements and supply

3.8.1 Cooling water requirements and discharge in the sea

The cooling water requirement varies in line with the amount of energy produced. Two 1,250-megawatt units need a total of some 85 m^3/s of sea water for cooling the condensers. With one 1,800-megawatt unit, the cooling water requirement is about 61 m^3/s. The cooling water is taken from the sea in front of the power plant at a depth of 0–25 meters, depending on the location.

Before the cooling water enters the condensers it is cleaned of major impurities or objects by passing it through a coarse bar screen, with about 10-centimeter openings between the bars, located at the mouth of the cooling water structure. After that, the cooling water passes through a finer screen and finally through a traveling band filter, for example. The traveling band filters have a mesh opening of about 1 mm^2 and they remove the last particles that could cause erosion when passing through the condenser pipes or other parts of the cooling water system. After the cooling water has passed through the condenser, it is discharged back into the sea, about 10–12 degrees warmer, through the cooling water discharge channel.

The alternatives for intake and discharge points and the impacts of cooling water are discussed separately for each alternative location in Chapter 8.

3.8.2 Service water requirements

Fresh water is needed at the power plant both for tap water and for preparing process waters for the plant. An estimate of the fresh water requirements of the power plant during the construction and operating phases is shown in the table by fraction (Table 3-5). The power plant needs a service water supply capacity of about 600 m^3/day.

Table 3-5. An estimate of service water requirements during the construction and operation of the plant.

Service water requirements		m^3/day
During construction	Tap water Concrete mixing station	300–450 100
During plant operation	Tap water Process water	150 400–500
During annual maintenance	Tap water	250

3.8.3 Supply and treatment of service water

Four alternatives for the supply of the necessary fresh water for the power plant were analyzed in the preliminary plans: supply of water from the municipal water plant, from groundwater, by purification of fresh surface waters, or by desalination of sea water. For all location alternatives, the primary alternative is a centralized water supply from the municipal water plant, which is then responsible for the water quality. The supply of water from the municipal plant may be limited by the capacity of the plant and the length of the required supply pipelines.

Groundwater was analyzed as the secondary alternative. Groundwater is usually of such good quality that it requires little treatment. However, the supply of groundwater is limited by the location of sufficiently plentiful groundwater deposits and the length of the required supply pipelines. The third alternative is using surface waters, such as river water, for tap water. However, surface water requires thorough treatment, for which a separate treatment plant has to be built. The quality and availability of surface water also varies greatly from one season to another. As the last alternative, the option of producing tap water by desalinating sea water through reverse osmosis was analyzed. The advantage of this alternative is the secure supply of raw water. However, the method would require a separate water production plant.

The process water required for the plant is made from tap water by removing all salts using an ion exchanger and/or reverse osmosis filtration. The planned capacity of the total desalination plant is about 50 m^3/h.

At the power plant, the service water is stored in fire-fighting water and clean water reservoirs. Water is pumped from the reservoirs as required.

The following sections discuss the potential primary service water supply arrangements by alternative location. The alternatives will be further specified as the planning work advances.

3.8.3.1 Pyhäjoki

There is currently no water supply network of sufficient capacity near the power plant. The Pyhäjoki region does not have sufficiently abundant groundwater deposits either. The water quality and flow rate in Pyhäjoki river will not allow the river water to be used for the water supply needs of the power plant.

Raahen Vesi Oy obtains most of its water from the Vihanti groundwater area, from where water would also be available for the needs of the power plant. It is estimated that the required pipeline would be 25–30 kilometers long.

3.8.3.2 Ruotsinpyhtää

The raw water required by the power plant can be obtained from Loviisan Vesi Oy, which has sufficient water supply capacity to also cover the requirements of the power plant. The supply lines can be laid on the seabed and connected to the town’s existing pipeline network on the Vårdö headland some 14 kilometers away from the power plant.

3.8.3.3 Simo

The fresh water required for the power plant can be obtained from Kemin Vesi Oy, which gets its raw water from Meri-Lapin Vesi Oy. Ninety per cent of the raw water comes from the groundwater pumping stations in Tervola. The rest, 10 per cent, comes from Kemin Vesi Oy’s own groundwater pumping station in Ajos. The length of the required water supply pipelines is about six kilometers.

3.9 Waste water

The power plant generates waste water both as a result of using tap water and through plant operations. Social waste water includes water from sanitary facilities and shower rooms, for example. Waste water generated in power plant operation includes water used for washing, as well as the waste water resulting from the production and use of process water.

Waste water can either be treated at the plant area, or

The quality of water coming from the power plant is monitored. A brook in Ruotsinpyhtää, 2008.

passed to an existing waste water treatment plant nearby. The volume and treatment of the created waste water are discussed in more detail in the following chapters.

3.9.1 Rinsing waters from cooling water screens

Cooling water carries algae, fish and other solids to the plant. These materials are removed using screens and different filters, and these are cleaned by regular rinsing with water. The solid materials separated from the rinsing water are treated as bio waste, and the water is led back to the sea. Waste waters from cleaning cooling water screens are produced at the rate of some 24,000 m³/day.

3.9.2 Social waste water

Social waste water can be either treated in nearby municipal waste water treatment plants or by building a waste water treatment plant for the power plant. All location alternatives allow draining waste water to the municipal sewage network. If a dedicated waste water treatment plant is built at the power plant, it will be dimensioned for a capacity of 100 m³/h. The process steps in a waste water treatment plant are pre-treatment, aeration, pre-sedimentation, biological treatment, post-sedimentation and sludge compaction. The treated waste waters are drained via a volume and quality metering point to the cooling water discharge channel and from there to the sea. This provides for maximal dilution of the purified waste waters. The sludge produced in the waste water treatment process is pumped from the sedimentation pools via compaction pools to sludge pools and from there on to the municipal waste water treatment plant or other destination for treatment as a bio waste.

During the construction phase, the loading of social waste water is bigger than during the operating phase because more people are working in the area. It is estimated that social waste waters are produced at the rate of some 300–450 m³/day. During the operating phase, the volume of social waste waters is estimated to be normally about 150 m³/day and about 250 m³/day during annual maintenance. An estimate of the loading to waterways caused by the social waste waters generated during the construction phase and the operating phase is shown in the table below (Table 3-6). The annual social waste water loading during the construction phase corresponds to the waterways loading caused by some 1,500–2,300 persons within the scope of municipal waste water treatment. For the operating phase, the loading corresponds to that of approximately 750 persons (1,200 during maintenance stoppages).

Table 3-6. An estimate of the loading to waterways caused by treated social waste waters during the construction phase (300–450 m³/day) and operating phase (150 m³/day).

	content mg/l	construction phase kg/a	operating phase kg/a
Total phosphorus (P)	0,5	55–85	30
Total nitrogen (N)	30–40	3 300–6 600	2000
Biological oxygen demand (BOD_7)	15	1 600–2 500	800
Solids (SS)	5	550–850	300

3.9.3 Waste waters from laundry

A dedicated laundry will be established for the purpose of washing protective clothing worn in the controlled area inside the power plant building, i.e. the area where radioactive substances may be present. The laundry waste waters will be treated mechanically at the liquid waste treatment plant in order to reduce radioactivity. After radiation control, the treated laundry waste waters are drained in the cooling water discharge channel. It is estimated that laundry waste waters are produced at the rate of some 20 m^3/day. The laundry waste waters produce a phosphorus load of some 10 kg per annum.

3.9.4 Other waste waters

Process water refers to water circulating in a closed-circuit steam process. The total desalination process used in producing process water requires the regeneration of ion exchange resins. At the desalination plant, the regeneration is carried out using water with sodium hydroxide or sulfuric acid added. The acidic and alkaline waters created in the regeneration process are drained to the neutralization pool. The reject water from the reverse osmosis equipment of the desalination plant is also drained to the neutralization pool. The waters are neutralized to a pH range of 5–9 before draining them to the cooling water discharge channel. These waste waters mainly contain salts created in the neutralization process. The total volume of waste waters generated at the desalination plant is estimated to be about 100 m^3/day.

Waste waters are also created from filter rinsing and decanting waters, floor washing waters, laboratory sewage waters and neutralized waste waters created in the decontamination process. They may contain radioactive materials, and they are treated in the power plant's own liquid waste processing plant. After that, they are drained to the sea together with the cooling water via a radiation control point.

It is estimated that these waste waters are produced at the rate of some 400 m^3/day. The annual phosphorus loading is estimated at 10–40 kg, and the maximum annual nitrogen loading at some 4,500 kg. In the case of a pressurized water reactor, the resulting boron loading to waterways is about 6,000–10,000 kg/a.

3.9.5 Rain and foundation waters

Rain and foundation waters (waters to be drained in order to keep the building foundations dry) will be led to the sea via the necessary sedimentation wells and oil separators.

Rock blasting, quarrying and crushing will take place in the area during the construction phase. The foundation waters and rain waters drained from the construction site will contain more solids and possibly oil and nitrogen compounds than waters drained from the yards during plant operation. The quality and volume of water drained to the sea from the construction site will be monitored.

3.10 Waste management

3.10.1 Waste management during the construction phase

Stipulations regarding waste management during the construction phase are contained in the Waste Act (1072/1993) and Waste Decree (1390/1993), as well as in the Government Decision (295/1997) regarding construction waste. In addition to the above, the local regulations concerning waste management must be applied. In accordance with the Government Decision, the building contractor is responsible for the waste generated in the course of the construction work, for minimizing the amount of waste generated, for recycling as much as possible of the waste for further useful use, and for ensuring that the waste materials do not cause any health or environmental hazards. The following types of waste must be sorted at the site as a minimum: metal, non-impregnated wood, concrete, brick, mineral tile, ceramic and gypsum waste, soil, rock and dredging waste. Hazardous waste shall be handled, stored and transported in compliance with the relevant regulations.

Waste management during the construction phase will be organized so that the party responsible for waste management, for example the project leader, main contractor or plant supplier, concludes a waste management agreement with a waste management company. The environmental plan of the construction site contains detailed instructions regarding the entire waste management in accordance with waste hierarchy. The primary goal is to reduce the amount of waste generated, after that the waste should be utilized for material or energy, and only as the last alternative should the waste be finally deposited in an appropriate manner. Waste management is based on efficient sorting at the place where waste is generated, and on uniform and efficient provision of instructions to all different parties and companies operating on the site regarding the appropriate waste management procedures.

3.10.2 Waste management during the operating phase

Ordinary waste (household waste, packing waste, metal waste, etc.) and hazardous waste (batteries, fluorescent tubes, oily filters, etc.) is generated in a nuclear power plant like in any other power plant or industrial plant.

In the course of operating the nuclear power plant, care is taken in compliance with the principles of Waste Act (1072/1993) that as little waste as possible is generated. In practice, instructions are provided as part of the plant's operating system that contains procedures and regulations for various matters including the environment, occupational healthcare and industrial safety. As large a portion as possible of ordinary waste is sent for useful use. All waste transported away from the plant is taken to a waste management company that holds all necessary permits.

Unlike other power plants, nuclear power plants produce radioactive waste in the course of their operation. It is divided into two main categories:

- low- and medium-level operating waste (e.g. maintenance waste and waste created through purification of water coming from radioactive systems or areas).
- high-level waste, i.e. spent fuel.

The basis for the management of radioactive waste created in a nuclear power plant is that waste is isolated from the environment for good. The owner of the nuclear plant is responsible for organising waste management and also bears the related cost. According to the Nuclear Energy Act, nuclear waste must be treated, stored and finally deposited in a manner intended as permanent in Finland. The Nuclear Energy Decree further specifies that the nuclear waste must be deposited 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. In Finland, the Ministry of Employment and the Economy and the Nuclear Safety Authority are responsible for controlling the adherence to the principles of nuclear waste management, safety requirements and regulations.

The above areas of waste management are discussed in more detail below. Demolishing waste generated in conjunction with decommissioning the plant is discussed in Chapter 8, in the section concerning decommissioning of the power plant.

3.10.2.1 Ordinary waste

The waste quantities vary, depending on, for example, the maintenance carried out on any given year. Ordinary waste consists of iron and metal sheet scrap, wood, paper and cardboard waste, as well as biowaste and energy waste. Hazardous waste includes waste oil and other oil-contaminated waste, fluorescent tubes, solvents and chemicals, as well as electrical and electronic scrap.

The amount of ordinary waste in the case of a single-reactor plant is estimated at max. 600 tons and hazardous waste at max. 100 tons per annum. If the plant has two reactors, the amount of waste generated will be slightly bigger.

Most of the waste generated can be utilized by recycling or by using it in energy production. Sorted waste is sent for treatment and for final depositing in an appropriate manner. All waste and hazardous waste is handled and treated by companies holding all necessary permits.

3.10.2.2 Operating waste

Operating waste refers to solid and liquid low- or medium-level waste generated in handling radioactive liquids and gases, and in maintenance and repair work carried out in the controlled area. Most of the operating waste contains radioactive substances in such quantities that the special requirements of the Nuclear Energy Act (*990/1987*) must be observed regarding their handling, treatment, storage and final disposal.

Operating waste is divided into low- and medium-level waste on the basis of its radioactivity content (*STUK 2005*):

- Low-level waste, i.e. waste with so low activity that it can be handled without any special radiation protection arrangements. The activity content of such waste is no more than 1 MBq/kg.
- Medium-level waste, i.e. waste with such level of activity that efficient radiation protection arrangements are required for handling them. The activity content of such waste is between 1 MBq/kg and 10,000 MBq/kg.

The radionuclides contained in operating waste usually originate from the activation of the reactor's structural materials and leaks of fission products and transuranium elements to the primary circuit water as corrosion products of structural materials as a result of damaged protective jackets of fuel rods. Radionuclides are carried to operating waste through different cleaning systems.

In terms of the health effects of radioactive radiation emanated during the handling of operating waste, the most important radionuclide is cobalt isotope Co-60 which as a strong emitter of gamma radiation causes most of the radiation exposure of the personnel involved in waste handling and processing. However, Co-60 is a relatively short-lived radionuclide so it is not relevant in terms of final disposal of operating waste. What are Relevant in terms of final disposal are the long-lived radionuclides Sr-90 and Cs-137, which decay to an insignificant level in about 500 years. When considering the even longer term, very long-lived radionuclides such as Tc-99, I-129, Cs-135 and plutonium isotopes can be deemed the most relevant, but their concentration in the operating waste is very low.

Amounts, origin and type of waste materials generated during operation

Most of the operating waste is dry waste, mainly contaminated waste generated in conjunction with maintenance and repair work, such as protective clothing, plastic, paper, insulation material, small metal objects, air conditioning filters, electric cables and cleaning utensils. They usually have low-level activity.

In addition to the above, operating waste includes metal waste, wet waste and hazardous waste (discussed under "Ordinary waste"), and demolition waste (discussed in Chapter 8, in the section concerning decommissioning of the power plant).

Metal waste includes obsolete tools, equipment and machine parts that have been contaminated with radioactive materials. They mainly constitute low-level waste. Metal waste also includes parts and equipment removed from inside the reactor pressure vessel that have been activated by neutron radiation; they constitute medium-level waste.

Wet waste mainly consists of radioactive concentrates and masses accumulated as a result of treating plant waters, such as ion exchange resins, filter support media, evaporation residues, corrosion sludge, active carbon sludge and sludge accumulated as a result of cleaning activities.

Bringing unnecessary materials to the controlled area is avoided in order to minimize the amount of waste generated there. The generation of waste can also be prevented by careful planning and implementation of maintenance operations, by choosing the right work methods, by efficient sorting of waste and by favoring reusable materials as far as possible.

The amounts of operating waste generated annually in a typical 1,300-megawatt pressurized water reactor plant and in a boiling water reactor plant built in the 1980s are shown in the table below (Table 3-7). (*VGB 2004*). The plant types shown in the table were used as models (reference plants) for planning Fennovoima's plant alternatives. Following various treatments, the amounts of waste for final disposal are considerably smaller.

Table 3-7. Amounts of operating waste in a 1,300-megawatt nuclear power plant. *(VGB 2004)*.

	PWR	**BWR**
Operating waste	m^3/a	m^3/a
Ion exchange resins (medium-level activity)	2	7
Filter waste (low-level activity)	1	2
Metal (low- and medium-level activity)	2	6
Evaporation concentrate (waste water treatment)	18	20
Solid waste	170	250
Total	200	280

Treatment of operating waste

According to the instructions issued by STUK, the nuclear power plant must have sufficient facilities for handling and storing low- and medium-level waste. Systems must be designed for the facilities that allow the safe handling and transfer of waste, and measuring the amount and type of radioactive substances contained in them.

Waste is collected from the plant premises without delay. As far as possible, waste is sorted at the time it is collected in such a manner that further processing becomes easier. For storage or final disposal, maintenance waste is packed in vessels that make moving the waste easier, prevent the spreading of radioactive contamination and reduce the risk of fire. Before final disposal, the volume of waste is minimized using different methods and equipment. The spreading of contamination is prevented by equipping the collection equipment with suction or filtering for escaping air, or by using a handling method that does not generate dust.

For further treatment and final disposal of the waste, its properties are determined. This so-called characterization means that the chemical, physical and radiological properties of the waste or waste package are established by different measurements. Details of each lot of waste are collected in a bookkeeping and monitoring system. In this way, the characterization details of a certain lot of waste accompany it all the way to final disposal.

Compression or compacting is a commonly used system that efficiently reduces the volume of compressible waste, typically to at least half and even to one-tenth of the original volume. Non-compressible waste is cut into smaller pieces using mechanical or thermal cutting methods.

Wet and liquid radioactive waste, ion exchange resins, sludge materials and concentrates are processed by drying. When required, wet waste is solidified using a binding material such as concrete or bitumen in order to facilitate safe handling and final disposal.

Hot compacting is a new method, particularly suitable for used ion exchange resins. It involves drying and heating the resins, after which the steel drums filled with heated resin are compacted into pellets. The volume of the end product is considerably smaller than when solidifying in binding agents.

Quantities of operating waste for final disposal

Estimates of operating waste for final disposal after treatments annually generated by the alternative power plants being discussed are shown in the table on page 85 (Table 3-8).

The waste materials are packed for final disposal. Typical packing methods for low-level waste include drums, boxes and containers made of steel. Concrete boxes are also used. Typical packing methods for medium-level waste include boxes made of concrete and cylindrical tanks. The packages for medium-level waste act as radiation protection, and often also as technical release obstacles in final disposal.

Waste that does not need to be handled, stored and finally disposed of as radioactive waste, even when paying due attention to radiation safety principles, can be released from control on the basis of set activity limits. The basic requirement for radiation safety in the release procedure is that the annual dosage caused to the general population or the personnel in the waste processing site by the materials originating from the nuclear

Table 3-8. Estimated annual accumulation of operating waste, packed in final disposal vessels, for the different plant alternatives.

	1 Unit EPR/PWR 1,800 MWe	1 Unit ABWR/BWR 1,800 MWe	2 Units SWR/BWR 2 x 1,250 MWe
DRY WASTE			
Compressible Packed in drums, compacted using a 200-ton compactor and packed in concrete boxes each holding 16 drums			
Very low-level	130 m^3/v	190 m^3/v	260 m^3/v
Low-level	3 m^3/v	4 m^3/v	6 m^3/v
Medium-level	6 m^3/v	6 m^3/v	8 m^3/v
Non-compressible Packed in concrete boxes, each holding 16 drums			
Very low-level	55 m^3/v	80 m^3/v	110 m^3/v
Low-level	7 m^3/v	9 m^3/v	13 m^3/v
Medium-level	5 m^3/v	5 m^3/v	7 m^3/v
TOTAL FOR DRY WASTE:	210 m^3/v	290 m^3/v	400 m^3/v
WET WASTE In drums packed in concrete boxes, each holding 16 drums			
Very low-level	11 m^3/v	–	–
Low-level	–	64 m^3/v	90 m^3/v
Medium-level	57 m^3/v	57 m^3/v	80 m^3/v
Other diverse masses (both low- and medium-level)	10 m^3/v	13 m^3/v	18 m^3/v
TOTAL FOR WET WASTE:	70 m^3/v	140 m^3/v	190 m^3/v
GRAND TOTAL:	280 m^3/v	420 m^3/v	600 m^3/v
Grand total for the entire service life of the plant (60 years):	17,000 m^3	25,000 m^3	35,000 m^3

plant and released from control does not exceed 10 µSv. Waste released from control no longer constitutes operating waste and can be disposed of or re-used like ordinary waste.

Final disposal of operating waste

The principle of final disposal is to isolate the radioactive substances contained in the waste materials from living nature so that the safety of the environment is not put at risk at any stage.

The final disposal methods of low- and medium-level waste can be roughly divided into two categories on the basis of the disposal place:

- underground repositories
- repositories placed in the ground or above ground.

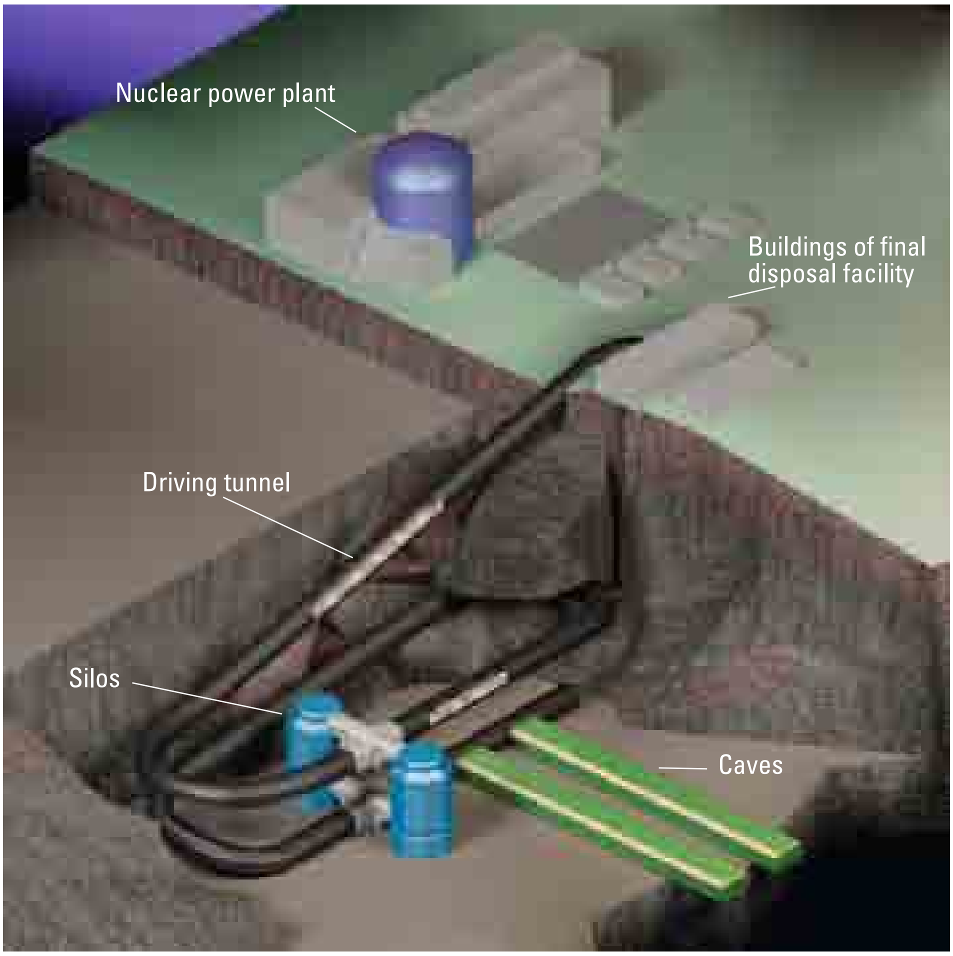
In Finland, the repositories for low- and medium-level waste from the existing nuclear power plants are built inside the bedrock in the plant areas. In several countries, for example in Sweden, France and the US, a certain part of the waste is disposed of above ground.

In repositories of the rock cave type, the operating waste is disposed of underground inside a space, tunnel, cave or silo quarried to the necessary depth. Olkiluoto and Loviisa have rock cave-type final repositories reaching to a depth of about 100 meters. In Olkiluoto, the silos are 35 meters high and 24 meters in diameter. In Loviisa, the about 100 meter long tunnels act as the final repository for low-level dry operating waste, while solidified medium-level wet waste is disposed of in a cave of about 300 m^2.

Sweden also uses a rock cave-type final disposal solution for operating waste, called SFR (*slutförvar för radioaktivt driftavfall*). The final repository for operating waste, designed to cater for the Swedish nuclear power plants, is located at the Forsmark nuclear power plant, 50 meters below sea level. The repository consists of a concrete-insulated silo and four rock caves. The capacity of the final repository designed to cater for the Swedish nuclear power plants (12 units, in all about 10,500 MW) is 63,000 m^3. Since 1988, some 1,000 m^3 of waste has been deposited there annually.

A ground repository can be a dumping site above ground that is covered with insulating layers of clay or geotextile, for example. The repository may also be under the ground level. The repository may have a vault-like structure, and it may be a space totally sealed off by technical release barriers. After sealing, the structure is still covered with land masses and landscaped.

Figure 3-12. Possible structure of the final repository for low- and medium-level waste.



In underground repositories, bedrock is the primary release barrier. When required, the binding material and waste container also act as a barrier for spreading, in addition to which concrete structures can be used and the space between waste containers can be filled with clay.

In ground repositories, the principal spreading barrier is a concrete slab built as the foundation; it will prevent the uncontrolled spreading of seepage waters into the environment. The waters generated in the area are collected into a collection well and cleaned, as necessary, before draining them into the environment.

Possible solutions for final repository of operating waste to be used for the new nuclear power plant.
Possible low- and medium-level waste repository alternatives for the power plant being discussed are:

- final disposal of waste in a repository of rock silo type
- final disposal of waste in a repository of rock cave type.

For low- and medium-level waste, four separate caves have been preliminarily foreseen 30–100 meters below ground, depending on the geological properties of the final disposal area. A joint driving tunnel will be built for the caves. The structure of the final disposal facility corresponds to the VLJ cave of the Loviisa power plant. The cave for medium-level waste is reinforced when required and lined by concrete spraying and equipped with a bridge crane for filling. The low-level caves can be filled using an ordinary forklift, for example.

The capacity of the final disposal facilities has been calculated on the basis of the amount of waste generated during 60 years of operation of two nuclear power plant units of approximately 1,250 MW_e each. The preliminary storage capacity of the rock facility is for a silo-type solution about 43,000 m^3 and for a cave-type solution about 29,000 m^3. In the case of a single power plant unit, the required capacity would be somewhat smaller. A possible final repository structure is shown in the figure below (Figure 3-12).

In addition, a ground depository may be built for very low-level waste with an average activity content of less than 100 kBq/kg.

3.10.2.3 Spent nuclear fuel

About 40–60 tons of uranium is removed from the reactor of the nuclear power plant as spent fuel each year. During the 60 years of operation of the nuclear power plant, a total of some 2,500–3,500 tons of spent nuclear

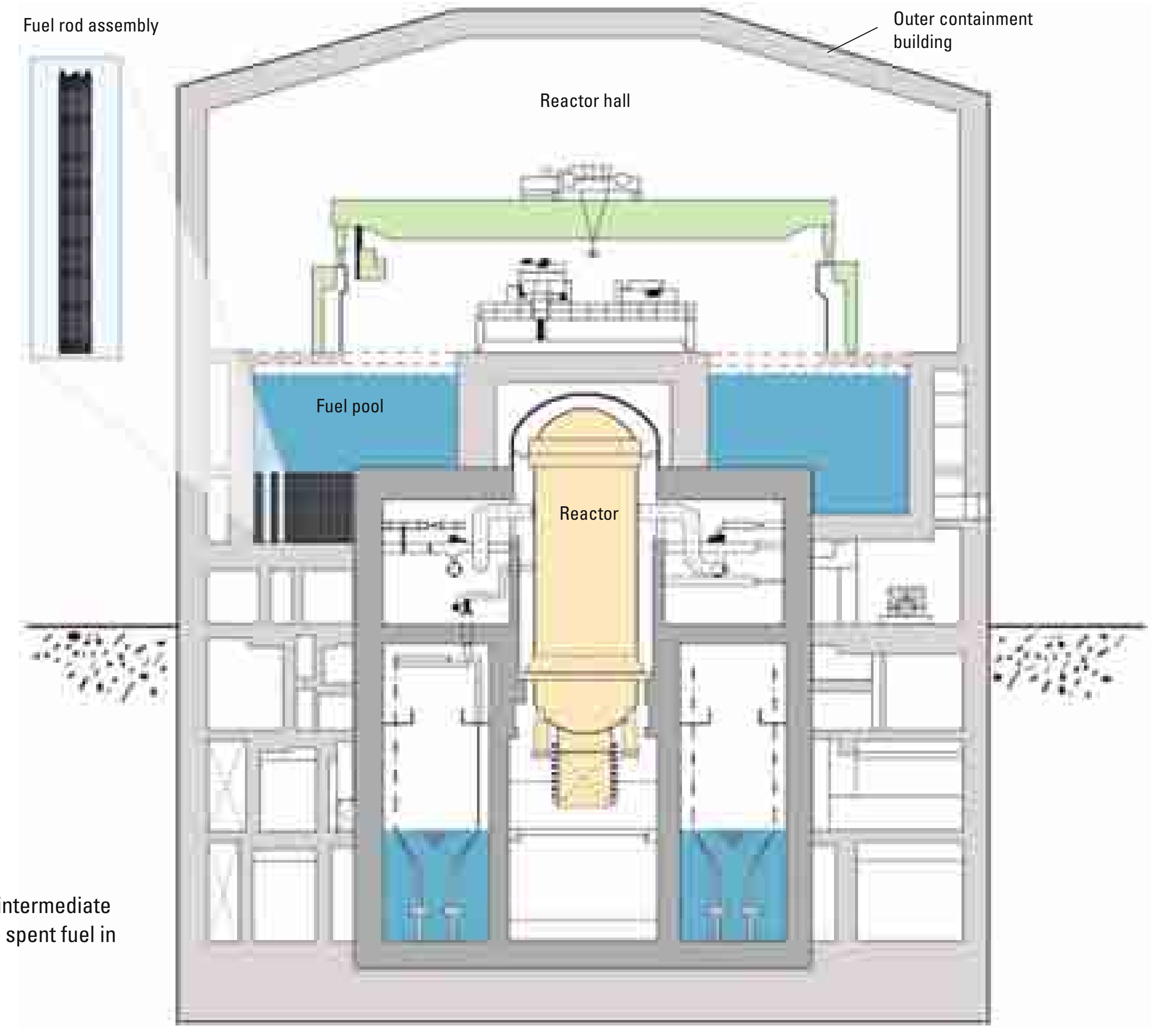


Figure 3-13. An intermediate storage pool for spent fuel in the reactor hall.

Figure 3-14. Dry storage of spent fuel *(E.ON 2008)*.

fuel will be generated.

95 per cent of the spent nuclear fuel is uranium isotope U-238 and one per cent uranium isotope U-235. Spent nuclear fuel contains new elements formed through the uranium decay process and neutron capture. Most of the new elements are fission products and the rest are heavier elements than uranium, so-called transuranium elements. Fission products and transuranium elements are radioactive.

The higher the burnup of the fuel, the higher the radionuclide (radiation-producing atom nuclei) content and the higher the temperature it produces. There are no significant differences in the properties of boiling water reactor fuel and pressurized water reactor fuel as far as final disposal is concerned.

According to the Nuclear Energy Act, the producer of nuclear waste shall be responsible for the maintenance of the spent nuclear fuel it has produced until the disposal facility is sealed, and is obliged to pay for all of the nuclear waste management expenses. In order to cover the expenses, a preparation charge is debited by the producer of nuclear electricity to the nuclear waste fund administered by the Ministry of Employment and the Economy so that the fund has the necessary funds for organizing waste management.

Possible intermediate storage solutions

After removing them from the reactor, the spent fuel rod assemblies are moved to the water pools in the reactor hall, where they are allowed to cool for a few years.

The activity and heat production of the fuel reduces quickly during the first year after removal from the reactor. After cooling down for a few years, the fuel rod assemblies, contained in a radiation shield, are moved from the reactor hall to intermediate storage for a few tens of years to wait for final disposal. During intermediate storage, the activity and heat generation of the spent fuel further decrease significantly.

Spent nuclear fuel is stored in water pools (Figure 3-13) or in so-called dry storage (Figure 3-14). The pools are located, for example, in a building made of steel-reinforced concrete. Water acts as a radiation shield and cools the spent fuel. In the case of dry storage, the spent fuel is packed in special drums. The heat

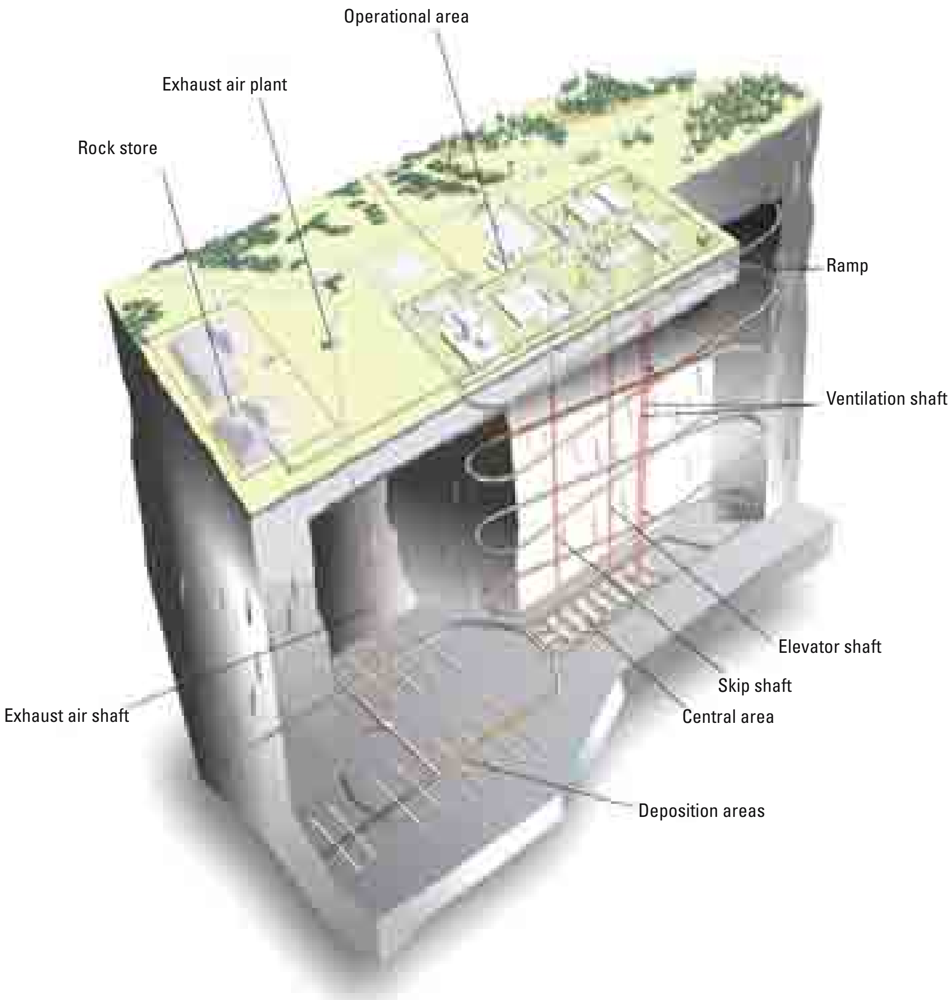


Figure 3-15. Possible structure of a spent fuel repository facility currently planned in Sweden. *(SKB 2008)*

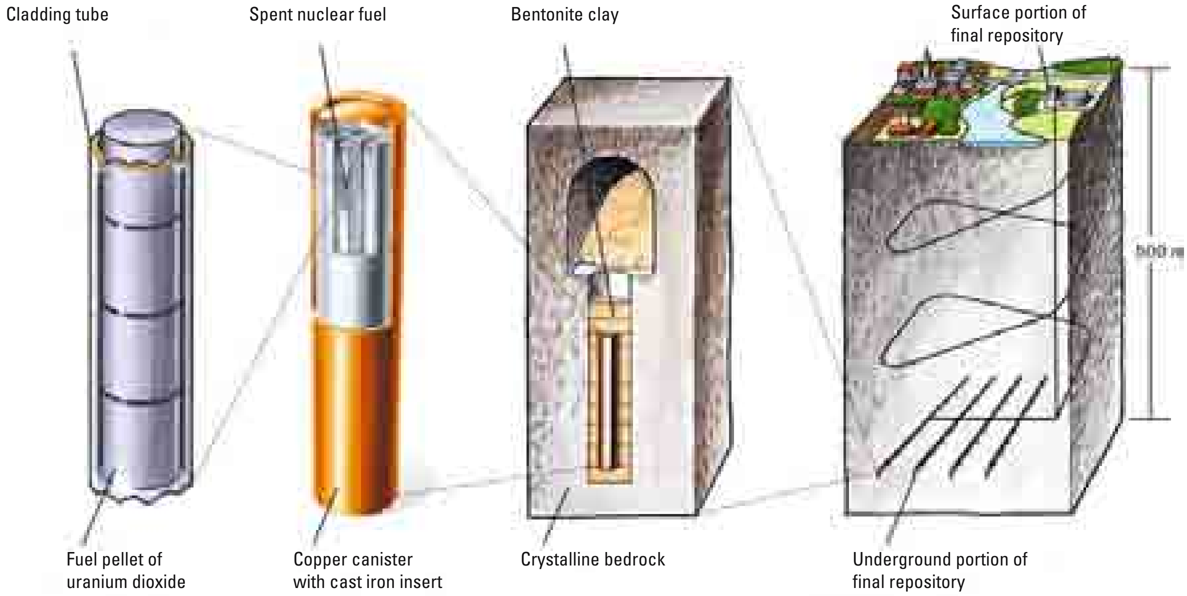


Figure 3-16. Protective layers in final disposal of spent fuel, repository solution KBS-3. *(SKB 2008)*

released by the spent fuel is conducted into the surrounding air through the drum material. Alternatives for dry storage of spent fuel have been developed in several countries. The dry storage methods are mainly based on drums made of steel, cast iron or concrete, or on concrete modules. When concrete containers are used, the spent fuel is additionally packed in a gas-tight thin metallic jacket. The drums can also be used to transport spent fuel. The drum prevents the spreading of radioactivity contained both in gas and in particles. Air conducts heat less than water, so the temperature of the fuel decreases slower. The drums are stored outdoors or in a dedicated storage building. The storage facilities are cooled as required.

The water pools for intermediate storage at the current power plants in Loviisa and Olkiluoto are located in the plant area. Also in the case of the nuclear power plant planned by Fennovoima, the intermediate storage of spent fuel is to be located in the plant area.

After the intermediate storage, the power plant's spent fuel is transported to the disposal site plant built for this particular purpose. For transportation, the fuel is transferred to a transport vessel that can be transported to the final repository by road, railroad or sea.

Possible processing and final disposal solutions

Reprocessing

Part of the spent nuclear fuel can be returned back to the fuel circulation through reprocessing. At the reprocessing plant, chemical processes are used to separate uranium, plutonium and uranium's split products from the used nuclear fuel. Uranium and plutonium can be recycled for the fuel production. Other materials, mainly split products, have to be finally disposed of.

The waste, which needs to be finally disposed of, is solidified, for example in glass. Solidified waste is high-level waste that will be tightly encapsulated and finally disposed of in the same manner as for example used nuclear waste. The low- and medium-level waste generated in reprocessing is also finally disposed of in an appropriate manner. According to the Finnish Nuclear Energy Act, all spent nuclear fuel in Finland must be processed in Finland. There are no reprocessing plants for spent nuclear fuel in Finland, therefore it is not possible to recycle uranium and plutonium from spent nuclear fuel.

Disposal

According to the Nuclear Energy Agency (NEA), an OECD organization, geological final disposal is the most recommendable nuclear waste management strategy. The NEA also recommends that final disposal is implemented in steps because that allows taking scientific advances and political changes into account in waste processing.

Preparations for the final disposal of spent nuclear fuel have already been in progress in Finland for 30 years. The final disposal solutions for spent fuel being currently developed in Finland by Posiva Oy and in Sweden by

SKB (Svensk Kärnbränslehantering AB) follow the KBS-3 (Kärn Bränsle Säkerhet) concept originally developed in Sweden.

Posiva Oy is a company established in 1995 to handle the transportation of spent nuclear fuel from power plants to the disposal site and manage the actual disposal, any related research and other expert tasks within its field. Posiva's founding shareholders are Teollisuuden Voima and Fortum Power and Heat Oy. Posiva began building an underground research facility, "ONKALO", in the bedrock of Olkiluoto in 2004. Posiva intends to start disposal of spent fuel in 2020.

In final disposal solutions according to the KBS-3 concept, the spent fuel is encapsulated in copper capsules, surrounded with bentonite clay and placed deep in the bedrock. Bentonite is an exceptionally soft and plastic mineral. It consists of so-called smectitic clay, which gives it special properties. It is capable of absorbing large quantities of water, and consequently increases its volume up to ten-fold in the right circumstances. At the end of the storage phase, the tunnels are filled with bentonite clay.

The repository will consist of an encapsulating plant above ground, and its associated auxiliary facilities, plus a final disposal facility quarried deep into the bedrock (Figure 3-15).

In order to be suitable for final disposal, the bedrock area must be geologically stable and free of large cracks. The rock area must also be of ordinary quality in the sense that even future generations will have no need to quarry rock exactly where the repository is.

According to the KBS-3 solution, horizontal, about 250 meters long, tunnels are placed some 40 meters apart. The tunnel floors have storage shafts about every 6 meters. The copper capsules are placed in the vertical storage shafts drilled in the tunnels to a depth of about 500 meters.

In Olkiluoto, according to the current plans, the final disposal will take place in one level some 420 meters below ground level. Individual copper capsules are placed in the horizontal shafts drilled in the floors of the repository tunnels, or in horizontal disposal tunnels. *(Posiva 2008b)*.

The copper capsules are five meters long and about one meter in diameter. The airtight capsules have a five-centimeter thick outer jacket of copper to protect the fuel waste from corrosion and any strains possibly caused by bedrock movement. The inside of the capsule has iron reinforcement. The amount of spent fuel to be stored in each capsule depends on the amount of heat it generates.

A bentonite clay layer several tens of centimeters thick protects the capsules against bedrock movements and the corrosive effects of groundwater. Should the copper capsule become damaged, the bentonite clay would nevertheless prevent water from entering the capsule. Bentonite clay also acts as a buffer that prevents radioactive radiation from escaping from the capsule. The strong layer of rock isolates the spent fuel from the environment and external impacts for a sufficiently long period. Possible ground movements and future ice ages are also taken into account when designing the repository facility. Disposal deep into the bedrock guarantees mechanically and chemically stable conditions in the repository. The bedrock also limits the amount of groundwater coming into contact with the disposal capsules (Figure 3-6).

The geological surveys carried out in the repository area investigate the quality of rock and its cracking properties, water permeability and the movements of groundwater. Data is acquired through surface surveys and measurements, as well as test drillings. The ground movements are monitored by a network of seismic instruments. The comprehensive results are compiled into models, the most important being the bedrock model and the groundwater model. The models allow assessing, *inter alia*, the significance of groundwater movements from the point of view of the safety of the final disposal of nuclear fuel. (*SKB 2003, Posiva 2003, Finnish Energy Industries 2007*)

3.11 Transportation and commuter traffic

3.11.1 Traffic during the construction phase

There is considerable commuter traffic to and from the site during the construction phase, compared with the present situation. The number of workers peaks during the fourth year of construction when there are about 3,500 persons building a one-unit nuclear power plant. In case the two-unit option is chosen, there will be about 5,000 workers during the fourth or fifth year of construction.

Temporary accommodation will be built for guest workers near the plant site, from where commuting will take place on foot or by bus. About one-third of the workforce employed during the construction phase will be accommodated in these quarters. When calculating the traffic volumes, these workers are assumed to travel to the nearest town or municipal center two and a half times a week on private business. It is further assumed that two-thirds use a car.

About two-thirds of the workforce during the construction phase live near the plant, and they are assumed to commute from home. Of these workers, two-thirds are assumed to use a car, and they are assumed to drive to and from the plant once per working day.

In addition to commuter traffic, a maximum of 50 heavy transports will arrive the plant every day. Road transport includes building materials, equipment and components.

In all, the volume of person traffic during the construction phase from Monday to Friday will, in the case of single-unit plant, be about 4,000 private vehicles per day, and the volume of heavy traffic will be about 100 heavy vehicles per day. In the case of two-unit plant, the traffic volumes will be about 5,750 private vehicles and about 100 heavy vehicles per day.

A summary of the traffic volumes is shown in the next chapter.

3.11.2 Traffic during the operating phase

During operation there will be about 400 persons working in a single-unit plant and some 500 in a two-unit plant. It is assumed that three in four workers will commute by car. The volume of commuter traffic will therefore be about 600 vehicles per day. Regular bus transport will be organized from the neighboring municipality to the site. In addition, there will be maintenance and goods transports to the plant, resulting in a traffic volume of about 30 vehicles per day. Spent fuel is transported to the repository about four times a year.

There is normally little goods transportation and personnel traffic inside the plant area.

During annual maintenance, the number of workers visiting the plant increases by about 500, of which three in four are assumed to be accommodated in the accommodation quarters built during the construction phase. Of these workers, two-thirds are assumed to use a car and are assumed to drive to the area at the beginning of the week and back for the weekend. These workers are assumed to travel to the town or municipal center two and a half times a week on private business. The other annual maintenance workers commute from neighboring areas.

A summary of traffic volumes during the construction and operating phases is shown in the table below (Table 3-9).

Table 3-9. Estimated traffic volumes at the nuclear power plant during the construction and operating phases.

	Number of vehicles per day	
	Single unit plant	**Two-unit plant**
Construction phase		
Person traffic	4,000	5,750
Heavy traffic	100	100
Operating phase		
Normal operation		
Person traffic	600	750
Heavy traffic	30	40
Annual maintenance		
Person traffic	1,150	1,300
Maintenance and goods traffic	10	15

3.12 Radioactive emissions

During normal operation, the plant will release a small amount of atmospheric and aquatic emissions of radioactive substances, such as inert gases (xenon and krypton), gaseous activation products (carbon-14), halogens (iodine) and active substances in aerosol form.

The radioactive substances are generated in the nuclear reactor during its operation. The nuclear reactions produce radioactive fission products, in addition to which activation products are generated as the neutrons released in the fission process (splitting of nuclei) react with the reactor materials. The radioactive substances are mainly inside the fuel rods. A small fraction of the radioactive substances is also contained in the reactor cooling system and its associated cleaning and waste systems.

The radioactive aquatic and atmospheric emissions released from the plant are cleaned by filtration and de-

Table 3-10. Annual atmospheric radioactive emissions of the nuclear power plants in Olkiluoto, Loviisa and Essenbach, Germany.

Radioactive emissions, GBq/a	Olkiluoto 1 & 2 2 x 860 MW	Olkiluoto em. limits	Loviisa 1 & 2 2 x 488 MW	Loviisa em. limits	Isar 1 878 MW	Isar 1 em. limits	Isar 2 1 400 MW	Isar 2 em. limits
Tritium	300	–	200	–	–		–	
Carbon-14	767	–	233	–	–		–	
Iodine (I-131eq.)	0.135	114	0.004	220	0.048	11	–**	11
Inert gases	400	17,700,000	6,467	22,000,000	3,012	1,100,000	1,120	1,100,000
Aerosols	0.03	–	0.1	–	–**	37	0.0001	30

* no limit set
**emissions below detection limit

layed so that their radiation effect on the environment is very small compared to the effect of naturally occurring radioactive substances. The gaseous emissions are directed to the vent stacks of the power plant while the aquatic emissions are drained to the sea in cooling water. The emissions are metered to ensure that they are below the set limits. (*STUK 2008*)

3.12.1 Radioactive emissions to the atmosphere

According to the Government Decision (VNp 395/1991), the operation of a nuclear power plant may only cause a maximum radiation dose of 0.1 millisieverts per year to individual nearby inhabitants. This limit value is the basis for determining the limits for emissions of radioactive substances during normal operation. Numerical activity limits will be shown for iodine and inert gas emissions. The set emission limits are power plant -specific. In addition to iodine and inert gas emissions, the nuclear power plant also produces atmospheric emissions of tritium, carbon-14 and aerosols. Even at their theoretical maximum levels, the annual emissions of these substances are so low that it has not been necessary to set separate emission limits for them. When determining the annual radiation dosage for inhabitants in the neighboring areas, the above iodine, inert gas, tritium, carbon-14 and aerosol emissions are taken into account.

The Fennovoima nuclear power plant will be designed so that its emissions of radioactive substances are below all set limits.

The table on the previous page (Table 3-10) above shows by way of example the annual average emissions of nuclear power plants in Olkiluoto, Loviisa and Essenbach, Germany, during the period 2004–2006 (*STUK 2005, STUK 2006, STUK 2007*). The reactors in TVO's nuclear power plant units in Olkiluoto are of the boiling water type, and both units have a net electrical power of 860 MW (*TVO 2008*). Fortum's Loviisa units have pressurized water reactors, both with a net electrical power of 488 MW (Fortum 2008). The older of E.ON's nuclear power plant units in Essenbach, Isar 1, is a boiling water reactor with a net electrical power of 878 MW. Isar 2 is a pressurized water reactor plant with a net electric power of 1,400 MW (*E.ON 2008*). The atmospheric emissions of the nuclear power plants have been less than one per cent of the emission limits set.

The radioactive gases produced in the nuclear power plant are processed using the best available techniques. The gaseous radioactive substances are to be directed to the gaseous emissions cleaning system, where the gases are dried, delayed and filtered using active carbon filters, for example. Gaseous emissions can also be filtered using efficient HEPA (High Efficiency Particulate Air) filters. After treatment, the gaseous substances are released to the atmosphere through the vent stack. Radioactive atmospheric emissions are monitored and measured in many different stages in the emission treatment systems, and finally at the vent stack.

The table below (Table 3-11) shows the estimated annual maximum emissions of radioactive substances produced by the Fennovoima nuclear power plant. The estimates are based on experience of existing power plants as well as on the design data of new pressurized and light water reactor plants (*Environment Agency 2008a, b*).

Table 3-11. Estimated annual maximum emissions of radioactive substances from the Fennovoima nuclear power plant.

	1 unit PWR, 800 MW	1 unit BWR, 800 MW	2 units BWR, 2 x 500 MW
	GBq/a	GBq/a	GBq/a
Tritium	519	1,665	2,313
Carbon-14	363	120	165
Iodine (I-131eq.)	0.05	0.12	0.17
Inert gases	830	1,584	2,200
Aerosols	0.004	2	3

3.12.2 Radioactive emissions to the aquatic environment

Liquid radioactive emissions are created in the liquid waste treatment systems of the plant where used ion exchange resins from the purification circuits of the plant's process systems are treated and the pool and drainage water from the plant, such as sump and laundry wa-

Table 3-12. Aquatic emissions from existing nuclear power plants during 2004–2006.

Radioactive emissions, GBq/a	**Olkiluoto 1 & 2 2 x 860 MW BWR**	**Olkiluoto em. limits**	**Loviisa 1 & 2 2 x 488 MW PWR**	**Loviisa em. limits**	**Isar 1 878 MW BWR**	**Isar 1 em. limits**	**Isar 2 1,400 MW PWR**	**Isar 2 em. limits**
Tritium	2,167	18,300	16,000	150,000	470	18,500	20,667	48,000
Other beta and gamma	0.6	296	0.8	890	0.08	110	*	55

* emissions below detection limit

ters, are purified. The aim is to minimise the volume of aquatic emissions, for example by recycling process and pool waters and by minimizing the production of waste waters. The actual radioactive emissions to the aquatic environment from Finnish power plants (*STUK 2005, STUK 2006, STUK 2007*) and from the German example plant (*E.ON 2008*) on average during years 2004–2006 are shown in the table on previous page (Table 3-12). In Finland, the tritium emissions have been about 10 percent and the other emissions well below one percent of the set emission limits. The content of tritium from nuclear power plants in sea water decreases to an insignificant level close to the plants. Power plant-specific limit values are set for radioactive emissions of tritium and other substances to the aquatic environment in a similar manner as for atmospheric emissions.

Pressurized water reactors utilize boric acid, which generates tritium in neutron reactions, which is why the tritium emissions of pressurized water reactors are higher than those of boiling water reactors. Tritium-containing waters, like other radioactive liquids, are cleaned before draining to the water system so that the emissions are well below the limits set for both reactor types.

A dedicated liquid waste treatment plant will be built for the plant, which will treat all waters coming from the controlled area that may contain radioactive emissions. The cleaning methods for radioactive aquatic emissions include collection in monitoring tanks and delaying, evaporation, ion exchange filtration, separation of solids using mechanical filtration, slurry centrifuges or separators. The radioactivity of water is determined from a representative sample before discharging to the cooling water discharge tunnel.

The treatment of ion exchange resins, sludge materials and other wet waste generated in treating the waste waters from the nuclear power plantis described in the section discussing waste management.

An estimate of the radioactive emissions released to the sea by the nuclear power plant is shown below (Table 3-13). The estimates are based on the design data of new pressurized and light water reactor plants (*Environment Agency 2008a, b*).

Table 3-13. An estimate of the maximum amount of radioactive emissions released from Fennovoima's nuclear power plant to the sea.

	1 unit, EPR/PWR GBq/a	1 unit, ABWR/BWR GBq/a	2 units, SWR/BWR GBq/a
Tritium	55,000	1,600	2,200
Other beta and gamma	25	4	6

3.13 Atmospheric emissions

3.13.1 Emissions from emergency power and heat generation

The use of emergency generators and the emergency heating plant produce sulfur dioxide, nitrogen oxides, micro particles and carbon dioxide as a result of burning fuel. Diesel oil is used as the fuel for emergency diesel engines, and light fuel oil for the emergency heating plant. Under normal circumstances, the emergency generators and emergency heating plant are only used for trial operation purposes. The emergency heating

Table 3-14. The emissions from nuclear power plant transportation and commuter traffic during weekdays, both during the construction phase and the operating phase.

	Pyhäjoki		Ruotsinpyhtää		Simo	
	one unit	two units	one unit	two units	one unit	two units
Construction phase (tons/a)						
CO	171	254	146	215	147	216
NO_x	43	60	37	50	37	51
PM	1	2	1	2	1	2
SO_2	0.2	0.3	0.2	0.2	0.2	0.2
CO_2	5,479	7,718	4,647	6,513	4,676	6,542
Operating phase (tons/a)						
CO	26	32	22	27	22	27
NO_x	7	9	6	8	6	8
PM	0.2	0.3	0.2	0.2	0.2	0.2
SO_2	0.03	0.04	0.02	0.03	0.02	0.03
CO_2	914	1,136	768	953	771	955

Figure 3-17. The current road network in the vicinity of the Pyhäjoki location alternative and the road connection to be upgraded and locations of power lines and the harbor quay to be built.

plant may also be used for heat generation when annual maintenance is carried out during the winter months.

The annual emissions from the emergency power plant and the emergency heating plant under normal circumstances are very small. In a year, they produce about 0.3 tons of sulfur dioxide, about 1.4 tons of nitrogen oxides, less than one ton of particles and about 750 tons of carbon dioxide.

3.13.2 Traffic emissions

When calculating the emissions of transportation and commuting, use was made of the traffic emissions calculation guidelines and average emission factors per km published in the unit emission project of the Building and community technology department of VTT (*VTT 2002*).

The commuting distance of workers traveling to work from home was estimated to be the same as the average distance from the nearest population centers to the plant. The guest workers coming from abroad or from further away in Finland were not assumed to go home for the weekends. Instead, the external workers working on the plant during annual maintenance were assumed to normally go home for the weekends. These workers may live anywhere in Finland, so the distances they travel to work may vary greatly. This being the case, the emissions caused by traveling to work are also distributed over a wide area and have little effect on individual areas. This is why the commuting emissions in these cases were calculated using the same distances as for those commuting from home.

The emissions of road transportation were calculated using the same principles as those used for the commuting emissions of annual maintenance workers.

The emissions from nuclear power plant transportation and commuter traffic during weekdays, both during the construction phase and the operating phase, are shown on previous page (Table 3-14).

3.14 Traffic connections and power lines

There are associated projects extending beyond the plant area linked with the construction of a nuclear power plant, such as building traffic connections or upgrading existing ones, building navigation channels and quays, and building power lines. Two 400-kilovolt power lines and one 110-kilovolt line are required to connect the nuclear power plant to the national grid.

The associated projects required for each alternative location are shown below. However, the navigation channels to be built are shown in Chapter 8 on navigation charts in conjunction with describing the impact of

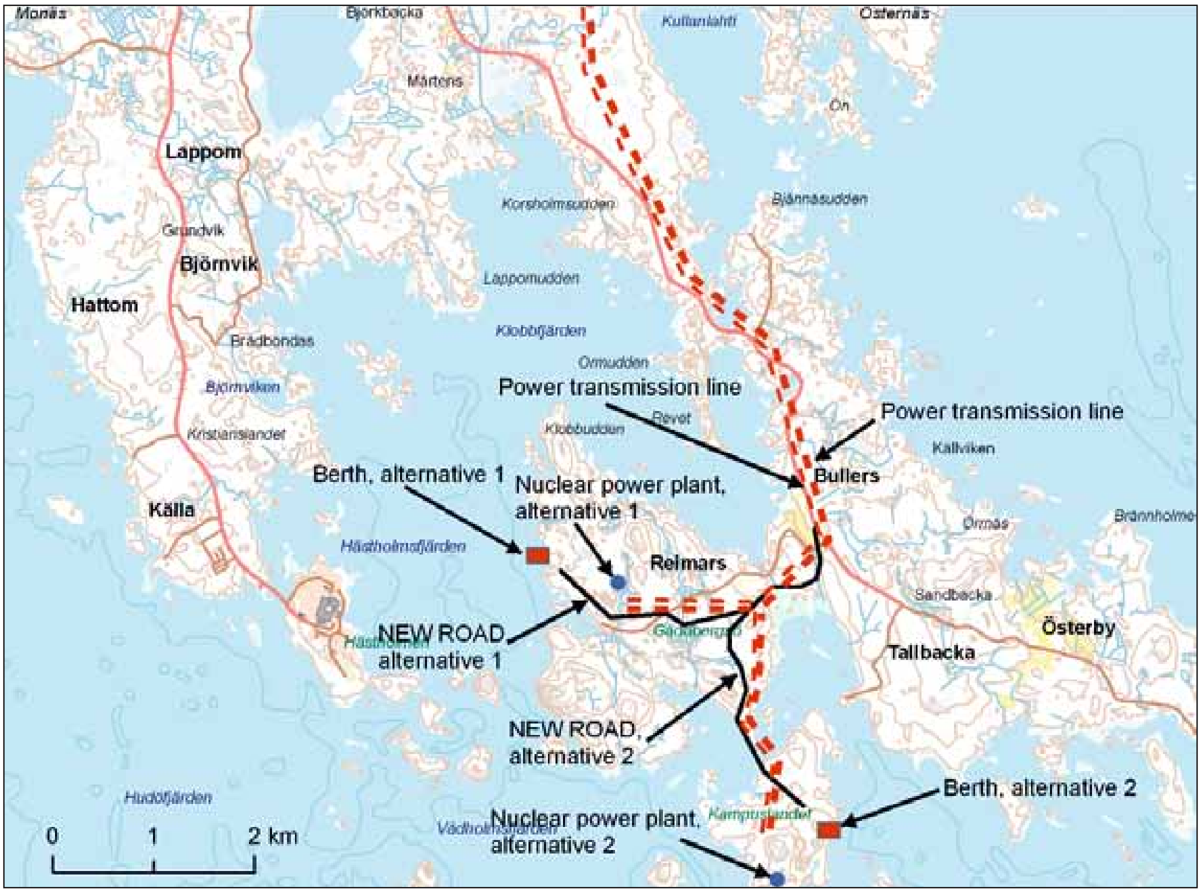


Figure 3-18. The current road network in the vicinity of the Ruotsinpyhtää location alternative and the planned new road connections and locations of power lines and the harbor quay to be built.

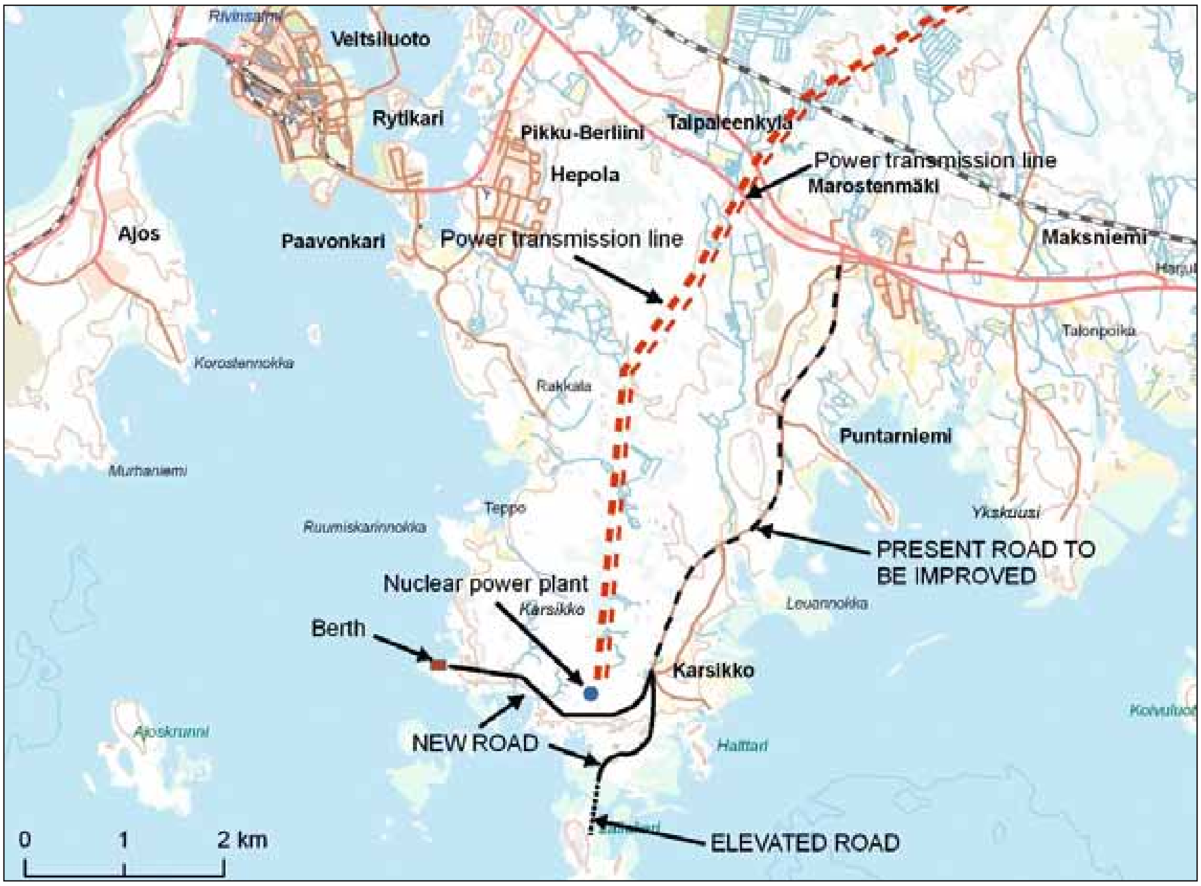


Figure 3-19. The current road network in the vicinity of the Simo location alternative and the new road connections and roads to be upgraded and locations of power lines and the harbor quay to be built.

construction work.

The channels presented here are tentatively positioned for the modelling and investigations to be carried out for the assessment of the environmental impacts. The final position of the channels will be selected based on the environmental factors coming up in the assessment, and additional modelling in case required or more specific technical investigations

3.14.1. Pyhäjoki

Trunk road 8 (E8) runs through the village of Parhalahti about 5 to 6 kilometers from the planned plant location (Figure 3-17). A smaller private road, Puustellintie, runs from the trunk road to the tip of the Hanhikivi headland. Puustellintie is not suitable for the transportation needs of a nuclear power plant, which means that a new road of just under five kilometers has to be built.

The plant can be connected to the 400-kilovolt grid through the Pikkarala–Ventusneva transfer line or the Uusnivala switching station. The Pikkarala–Ventusneva line has a voltage of 220 kilovolts at the moment, but Fingrid is planning to replace it with a 400-kilovolt line. A total of some 90 kilometers of 400-kilovolt power line will be required. The planned 110-kilovolt connection point is in Pyhäjoki, some 10 kilometers from the planned location.

3.14.2 Ruotsinpyhtää

Trunk road 7 (E18) bypasses the town of Loviisa on the northern side (Figure 3-18). On the eastern side of the town there is access from the trunk road to Saaristotie, leading to the tip of the Vahterpää headland, from which Reimarsintie separates and leads to the tip of the Gäddbergsö headland.

Building a nuclear power plant either in the Gäddbergsö area or on the island of Kampuslandet requires upgrading a 7.4 km stretch of Saaristotie and reinforcing one of the bridges on it.

If Gäddbergsö is chosen, about 2.5 kilometers of new road must be built from Saaristotie. With the Kampuslandet alternative, some 3.5 kilometers of new road must be built, and a 220-meter long bridge has to be built from Gäddbergsö to Kampuslandet.

The plant can be connected to the 400-kilovolt grid through the Kymi–Länsisalmi transfer line or the Hikiä switching station. A total of some 145 kilometers of 400-kilovolt power line will be required. The planned 110-kilovolt connection point is in Loviisa, some 20 kilometers from the planned location.

3.14.3 Simo

Trunk road 4 bypasses the Simo location alternative on the northern side (Figure 3-19). Karsikontie separates from the trunk road and leads to the tip of the Karsikkoniemi headland. Karsikontie has recently been upgraded and is in good condition. For the transports required by the nuclear power plant, a stretch of just under five kilometers of the road has to be broadened and a new road of just over one kilometer has to be built from Karsikontie to the plant area.

An embankment road will possibly be built to the Laitakari island for the purpose of building and maintaining the cooling water structures.

The plant can be connected to the 400-kilovolt grid through the Keminmaa–Pikkarala and Petäjäskoski-Pyhänselkä transfer lines. A total of some 70 kilometers of 400-kilovolt power line will be required. The planned 110-kilovolt connection point is in Kemi, some 10 kilometers from the planned power plant location.

The location of power lines is assessed in the EIA report. Scenery in Simo 2008.

Building a nuclear power plant involves many different licenses, permits and notifications. A shed in Pyhäjoki, 2008.

According to the Nuclear Energy Act, the construction of a nuclear facility of considerable general significance, such as a nuclear power plant, shall require a Government decision-in-principle in that the construction of the nuclear power plant is in line with the overall good of society.

4 Permits, plans, notifications and decisions required for the project

The permits, notifications and decisions related to the construction and operation of a nuclear power plant are illustrated in a chart (Figure 4-1).

4.1 Land use planning

4.1.1 General

Land use and building are regulated by the Land Use and Building Act (132/1999) and Decree (895/1999). The planning system includes the national land use objectives and three different zoning plan levels: regional plans, master plans and town plans.

The national land use objectives were approved in the Finnish Government on November 30, 2000 and they entered into force on June 1, 2001. On February 2, 2007, the Ministry of the Environment started preparations for reviewing the national land use objectives. The purpose is to proceed so that the objectives could be decided upon during 2008.

The purpose of the national land use objectives is to ensure that nationally significant matters are taken into consideration in land use and planning all over the country. The national land use objectives must be taken into account and advanced in the actions of the state's authorities and regional and municipal planning.

The objectives are mainly implemented in regional planning where the objectives are combined with regional and local conditions and objectives. The objectives are also to be taken into consideration in the regional plan and programs. The nature of some objectives requires that they must be taken directly into account in

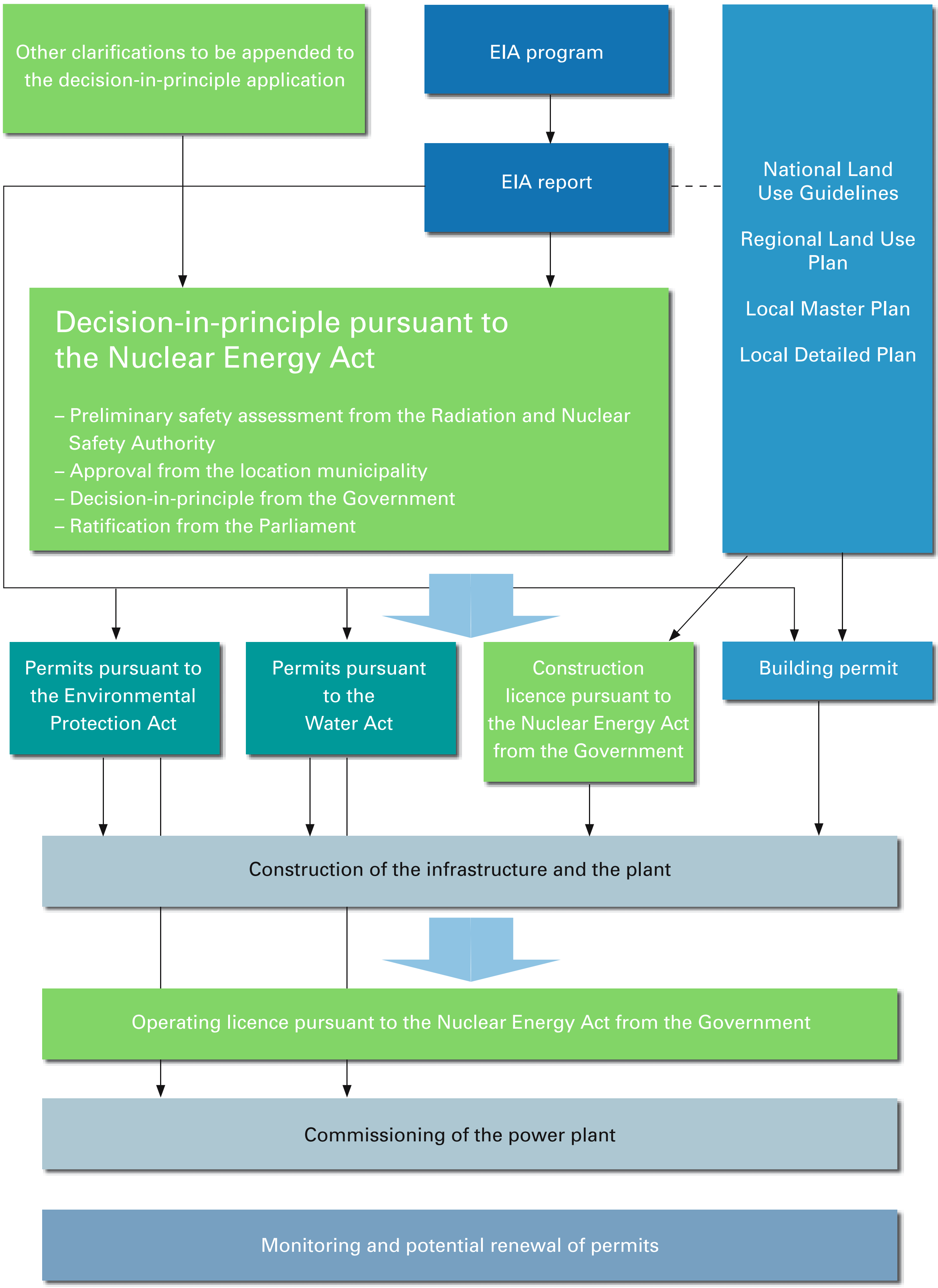


Figure 4-1. Permit procedure in the construction and operation of a nuclear power plant.

municipal planning. In municipalities, the master plan comprises the central plan level when concretizing the national land use objectives and the regional plan.

The regional plan is a master plan of land use within a region or its sections. It presents the principles of land use and the urban structure and indicates areas important for regional development. The purpose of the regional plan is to settle national, regional and local issues regarding land use. The regional plan can also be prepared in stages, as a plan concerning a certain entity.

The regional plan prescribes planning in municipalities and other land use planning by the authorities. The plan is presented on a map using plan symbols and regulations. The regional plan also includes a review, presenting the plan's objectives, impacts and other information required for the interpretation and preparation of the plan.

The regional association is responsible for preparing the regional plan and it is approved by the regional council. The plan is ratified by the Ministry of the Environment, after which it becomes legally valid. A complaint against the council's decision can be filed to the Ministry of the Environment, which can be used in complaint to the Supreme Administrative Court.

The master plan is a municipality's general land use plan. Its purpose is to place different urban functions, such as housing, services, workplaces and recreation areas, and organize connections between them. Master planning solves the principles of targeted development and prescribes the preparation of town plans for the area.

The master plan can apply to the entire municipality or a certain area, in which case it is called a component master plan. The plan is presented on a map, including plan symbols and regulations and a review.

The municipality is responsible for preparing the master plan. The plan is approved by the town or community council. If municipalities have prepared a common master plan, it is approved by a joint body and ratified by the Ministry of the Environment. The master plan will enter into force once its approval is publicly announced.

The town plan defines the future use of an area. The plan solves the environment to be preserved and what and how it can be built. The plan can show the location, size and purpose of buildings. The town plan can apply to an entire residential area, including housing, work and recreational areas, or a single lot. The town plan is prepared by the municipality.

The town plan includes the town plan map and plan symbols and regulations. The town plan includes a review describing the plan's preparation process and central features.

Building in coastal areas can be prescribed with a shore plan.

4.1.2 Planning required by the project

The implementation of the project requires that the regional plan, master plan and town plan of the area eventually selected by Fennovoima indicate area reservations, that the municipal plans have been approved and the regional plan has been ratified and all plans are legally valid.

None of the alternative location municipalities have been prepared for the nuclear power plan in their land use planning before the project.

In fall 2007, Fennovoima started to prepare planning and, during 2008, the Ministry of the Environment submitted a letter that clarifies the plan processes to the associations of the municipalities and Regional Environment Centers. The Ministry has also issued general instructions for issues related to the plan process and concerning trans-boundary impacts in accordance with the Land Use and Building Act in authority negotiations held at the plan preparation stage during April and May 2008.

The preparation and change needs for the regional, master and town plans of each location area under inspection have been identified during the environmental impact assessment procedure. The planning situation and needs of each municipality are inspected in Section 8 on the basis of the planning situation valid at the moment of writing this document (September 2008).

4.2 Permits in accordance with the Nuclear Energy Act

The Nuclear Energy Act (990/1987) prescribes the general principles of the use of nuclear energy, the implementation of nuclear waste management and the licenses required for using nuclear energy. The purpose of the act is to ensure that the use of nuclear energy is in the overall interest of society and safe for people and the environment.

4.2.1 Decision-in-principle

According to the Nuclear Energy Act, the construction of a nuclear facility of considerable general significance, such as a nuclear power plant, shall require a Government decision-in-principle in that the construction of the nuclear power plant is in line with the overall good of society. The decision-in-principle is applied for using an application submitted to the Government. A nuclear power plant project for which the decision-in-principle is applied can consist of one or more nuclear power plants that comprise an operational or other entity. The application can also concern two or more alternative nuclear power plant projects in different locations.

In addition to basic project information, the decision-in-principle application must include reports of the expertise and financial operational conditions available to the applicant and the nuclear facility's general significance for the nation's energy management, the use of other nuclear power plant and their nuclear waste management. For each nuclear power plant project, the application is to include rough descriptions of the plant's technical operational principles, the safety principles to be followed in the project, a rough plan of nuclear fuel management and the applicant's plans for organizing nuclear waste management. The application is also to include rough descriptions of the ownership and administrative relationships in the planned location and its suitability for its intended purpose as well as a report of the functions and planning arrangements in the nuclear power plant's planned location and its surroundings.

The Ministry of Employment and the Economy must obtain a preliminary safety assessment on the basis of the application from the Radiation and Nuclear Safety Authority and a statement from the Ministry of the Environment, as well as from the municipal council of each municipality intended to be the site for the facility and from their neighboring municipalities.

Before the decision-in-principle is made, the applicant shall, according to the instructions issued by the Ministry of Employment and the Economy, compile a general public description of the plant project, the environmental effects it is expected to have and its safety, and have these checked by the Ministry. The report must be publicly available. The Ministry of Employment and the Economy shall provide the residents and municipalities in the immediate vicinity of the nuclear facility, as well as the local authorities, with an opportunity to present their opinions towards the project before the decision-in-principle is made. Furthermore, the Ministry shall arrange public events in the alternative location municipalities for the nuclear power plant where the public shall have an opportunity to give their opinions. These opinions shall be made known to the Government.

According to the Nuclear Energy Act, the site municipality must, in its statement, support that the plant is to be located in the municipality so that the Government can prepare a favorable decision-in-principle regarding the plant location. The Government shall also state that it is possible to build and operate the plant so that it is safe and does not cause any danger to people, the environment or property. In addition, the Government must also consider the decision for the overall good of society paying special attention to the following:

– the nuclear power plant's necessity for the nation's energy management
– the suitability of the nuclear power plant's planned location and the nuclear power plant's environmental impacts
– nuclear fuel and nuclear waste management.

The Government's decision-in-principle shall be forwarded to Parliament for perusal. Parliament may reverse the decision-in-principle or decide that it remains in force as such, but it cannot amend its content. The permit applicant cannot make any significant and financially binding acquisition agreements related to the construction of the plant before the decision-in-principle enters into force.

4.2.2 Construction permit

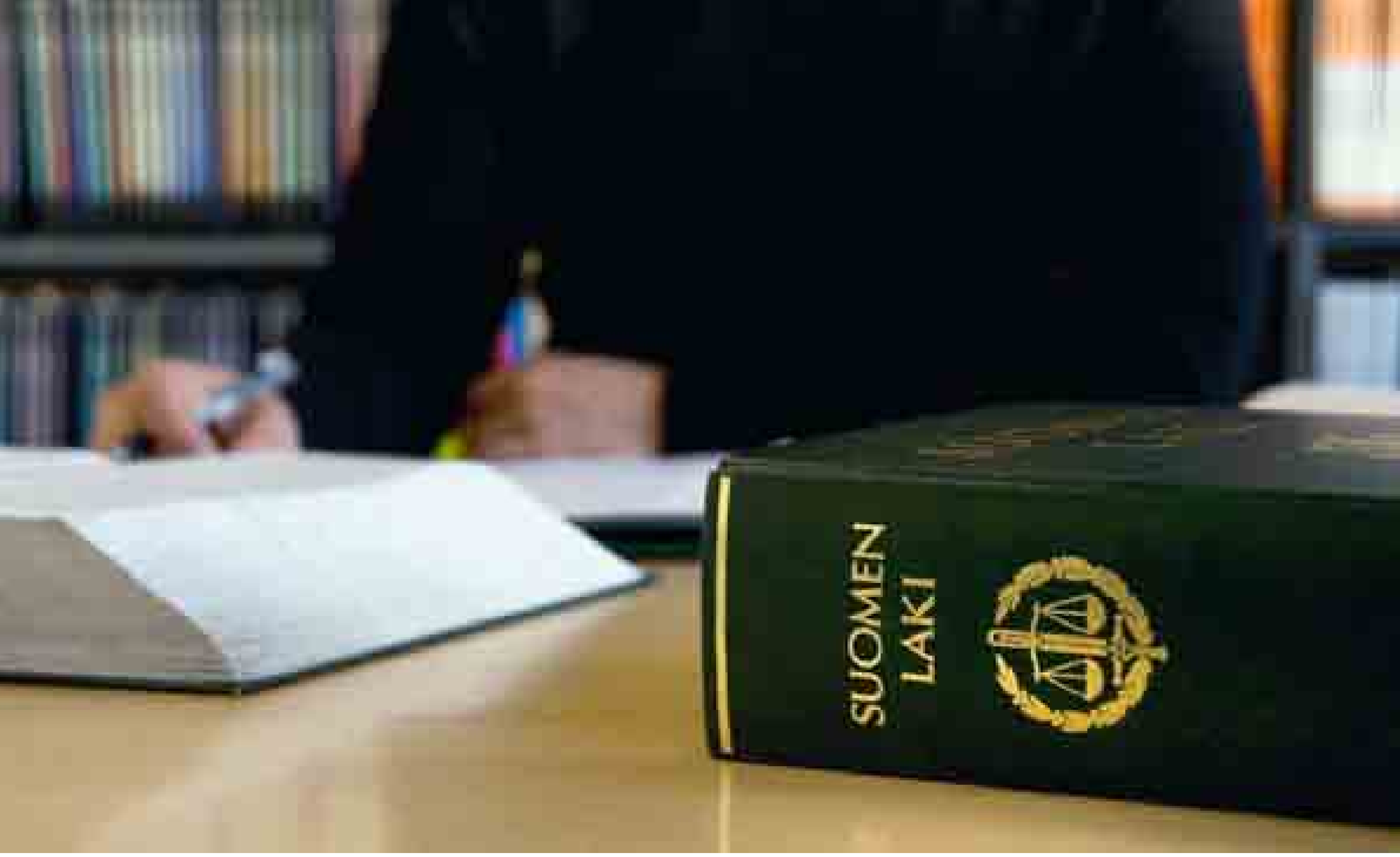
The construction permit for a nuclear facility is granted by the Government. The construction permit can be granted if the decision-in-principle ratified by Parliament has deemed the construction of a nuclear facility to be in line with the overall good of society and the prerequisites for granting a construction permit for a nuclear facility as provided in Section 19 of the Nuclear Energy Act are also met. These prerequisites include:

– Any plans concerning a nuclear facility must meet the statutory safety requirements. According to the act's primary safety principle, the safety of nuclear energy use must be kept at as a high level as possible through practical measures and, in order to develop safety even further, the procedures that can be regarded as justified considering experience, safety studies and scientific and technical development are to be implemented.
– The safety of employees and residents has been taken appropriately into account in operational planning.
– The location of the nuclear facility is appropriate with regard to safety and environmental protection has been appropriately taken into account.
– The area is reserved in the town plan for the construction of a nuclear facility as referred to in the Land Use and Building Act (132/1999) and the applicant has management over the area as required by the plant operations.
– The methods and plans available to the applicant for arranging nuclear fuel and nuclear waste management are sufficient and appropriate.
– The applicant has the necessary expertise available, possesses sufficient financial conditions, and is otherwise considered to have the prerequisites to engage in its operations safely and in accordance with Finland's international contractual obligations.

4.2.3 Operating permit

The Government grants the permit to operate a nuclear facility. The permit to operate a nuclear facility can be issued as soon as the permit has been granted to construct it, provided that the prerequisites listed in Section 20 of the Nuclear Energy Act are met. These prerequisites include:

– The nuclear facility and its use meet the statutory safety-related requirements and the safety of employees and residents, as well as environmental protection, have been taken appropriately into account.
– The methods available to the applicant for arranging nuclear waste management are sufficient and appropriate.



The Nuclear Energy Act contains stipulations on the general principles for using nuclear energy. Studying a law book in the Viikki Science Library in Helsinki in 2008.

- The applicant has sufficient expertise available and, in particular, the competence of the operating staff and the operating organization of the nuclear facility are appropriate.
- The applicant is considered to have the financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

Operation of the nuclear facility shall not be started on the basis of the permit granted until the Radiation and Nuclear Safety Authority has ascertained that the nuclear facility meets the prerequisites prescribed by law and the Ministry of Employment and the Economy has stated that provision for the costs of nuclear waste management has been arranged in a manner required by law.

4.3 Announcements and notifications pursuant to the Euratom Treaty

The European Atomic Energy Community (Euratom) Treaty requires that the licensee submits an investment notification (Article 41) to the Commission and declares the technical characteristics of the facility for its control (Article 78). The treaty requires that the Member State provides the Commission with plans relating to the disposal of radioactive waste (Article 37).

4.4 Building permit

A building permit in accordance with the Land Use and Building Act (132/1999) must be applied for regarding the new buildings included in the power plant. The building permit is obtained from the building permit authorities of the municipality in which the plant is located, which, when granting the permit, will ensure that the construction plan is in accordance with the ratified town plan and the building codes.

For large projects, such as the construction of a power plant, the building permit can be applied for the power plant building and other related structures and buildings in one or more parts.

A building permit is required before construction can be started. The issuance of a building permit requires that the environmental impact assessment procedure has been completed.

4.5 Flight obstacle permit and no-fly zone

According to the Aviation Act (1242/2005), a flight obstacle permit is required for setting a device, building, structure or sign that extends more than 30 meters above the ground. The permit is required as an enclosure with the building permit. The flight obstacle permit is applied for from the Finnish Civil Aviation Authority. The application must include a statement provided by the appropriate airline service supplier (Finavia). The flight obstacle permit will also be applied to large cranes during the construction process.

According to the Aviation Act, a no-fly zone can be prescribed in the vicinity of nuclear power plants through a Government decree. A no-fly zone refers to a part of airspace with defined limits above a nation's land area or territorial waters where it is forbidden for aircraft to fly. However, the no-fly zone is not directly a requirement for nuclear power plants and its size is not prescribed by law. The surrounding areas of the Loviisa and Olkiluoto nuclear power plants are prescribed as no-fly zones through a Government decree. A no-fly zone will also be defined for Fennovoima's nuclear power plant.

4.6 Permits pursuant to the Environmental Protection Act and the Water Act

A permit pursuant to the Environmental Protection Act shall be required for operations that cause a danger of pollution to the environment. A permit is required for the operations on the basis of the Environmental Protection Act (86/2000) and the Environmental Protection Decree (169/2000) enacted on the basis of the Environmental Protection Act. In order to grant the permit, it is required that the operations do not cause any health damages, significant pollution of the environment or a danger of pollution. The region's Environmental Permit Authority, the Regional Environment Center or the municipality's environmental protection authority acts as the authorizing body depending on the project's significance and the project entity.

The Water Act (264/1961) regulates permits for water economy projects. These include the construction of a pier, bridge, dam, water pipeline and cable in the water system, fairway dredging and water conduction to be used as liquid. The authorizing body in water economy projects is the Environmental Permit Authority. Affairs related to polluting the water systems will be handled by virtue of the Environmental Protection Act.

4.6.1 Permits required for construction

A permit pursuant to the Water Act will be required for building the pier and cooling water routes, as well as for dredging any fairways and banking the dredging waste. In addition, the construction of any elevated roads or bridges will require a permit pursuant to the Water Act.

Furthermore, the worksite has functions that require permits in accordance with the Environmental Protection Act. These include the rock-crushing plant, wastewater treatment plant and concrete batching plant. These will also require permits construction.

4.6.2 Permits required for operations

An environmental permit must be obtained for the operations of the nuclear power plant. The environmental permit covers all matters relating to environmental impacts, such as atmospheric and aquatic releases, the plant's waste management and noise impacts. The authorizing body for the project is the Environmental Permit Authority of the region where the site will be located. The authorizing body grants the environmental permit if the operations fulfill the requirements prescribed by the Environmental Protection Act and other legislation. In addition, the project must not contradict land use planning for the area. The environmental impact assessment procedure must also be completed before the permit can be granted.

A permit pursuant to the Water Act will be required for conducting waters relating to the power plant's operations from the water system.

The charting of historical relics is part of the EIA procedure. Traditional fence in Simo, 2008.

4.7 Legal impacts of protection measures

Areas protected in different ways are located in the project areas and their vicinity. If the implementation of the project is considered to have a detrimental effect on the protected area, a permit required by legislation must be obtained for deviating from the protection decisions. The most significant regulations are described below. The project's impacts on the protected areas are described in Section 8 on a municipality-specific basis.

4.7.1 Nature Conservation Act

The Nature Conservation Act (1096/1996) includes several alternative means for organizing conservation. This section describes the most central for this project.

The impacts related to the ***Natura 2000 network's areas*** must be assessed if the project is considered to reduce the area's Natura values significantly. The authorities must not grant a permit for implementing the project if the assessment procedure indicates that it is likely that the project will significantly reduce these values.

However, the permit can be granted if the Government decides in a plenary session that the project is to be implemented for the very important overall good of society and there is no alternative solution. If the area has a habitat and/or nature type primarily to be protected in accordance with the Habitats Directive (92/43/EEC), there are special requirements for granting the special exemption and the EU Commission's statement must be obtained.

Any areas belonging to ***habitat types protected directly by virtue of law*** must not be changed so that the preservation of the habitat type's characteristics is endangered. However, the Regional Environment Center can grant a special exemption if the protection objectives of the habitat type in question are not significantly endangered or the protection of the habitat type prevents the implementation of a project or plan that is very important for the overall good of society.

A private protected area can be terminated or its preservation declarations reduced if the preservation of the area prevents the implementation of a project or plan that is very important for the overall good of society. The permit for changing a protection decision must be applied for from the Regional Environment Center.

4.7.2 Antiquities Act

Fixed antiquities are preserved by virtue of the Antiquities Act (256/1963) without a separate preservation decision. If the non-implementation of the project causes unreasonable damage compared to the significance of an antiquity, a permit for a special exemption can be granted.

4.8 Permits required for connected projects

The establishment of ***public roads*** is prescribed by the Highways Act (503/2005). Depending on the extent of the road project, the preparation of a general plan and road plan might be required. The Finnish Road Administration acts as the authorizing body.

The construction of ***400 kV and 110 kV transmission lines*** requires a building permit pursuant to the Electricity Market Act (386/95). The Energy Market Authority is the authorizing body. The construction of a transmission line of more than 15 kilometers long and of more than 220 kV requires an EIA procedure. Building permit applications for smaller transmission lines must be attached with a report of environmental impacts in accordance with the Electricity Market Act.

4.9 Other permits

Other permits of relevance to this project include permits for the import and transportation of nuclear fuel, a permit for wastewater discharge into the sewage system, permits pursuant to the Chemicals Act and permits for pressure equipment.

For importing nuclear fuel and materials, certain nuclear equipment and devices, as well as nuclear energy data materials, permits must be obtained from the Ministry of Employment and the Economy and the Radiation and Nuclear Safety Authority. The permits concern import, transport routes, transport equipment and packages, as well as transport arrangements with contingency and safety plans.

Wastewater discharge into the sewage system must be agreed on with the water and sewage utility of the municipality of the location, which can specify the requirements concerning the quality and volume of wastewaters discharged into the sewage system.

The use of dangerous chemicals is regulated by the Act on the Safety of Handling Dangerous Chemicals and Explosives (390/2005). Permit applications concerning the large-scale use and storage of dangerous chemicals are to be submitted to the Safety Technology Authority (TUKES). For minor industrial handling and the storage of dangerous chemicals, a report must be submitted to the rescue authority.

The design, manufacture, installation, repair and inspection of ***pressure equipment*** are regulated by the Pressure Equipment Act (869/1999). Pressure equipment includes, for instance, boilers, heat exchangers, process pipelines and pressure tanks. Hazards associated with significant boiler units must be assessed in order to ensure their safe operation. The safety of pressure equipment and compliance with instructions is supervised by the Safety Technology Authority and, in the case of nuclear power plants, also the Radiation and Nuclear Safety Authority.

Conservation plans have been taken into account in the EIA process. Water flowing in Pyhäjoki, 2008.

Nuclear power can replace fossil energy production forms based on combustion processes and reduce the average carbon dioxide emissions of electricity production in Finland.

5 The project's relationship with the use of natural resources and plans and programmes concerning environmental protection

The most central plans and programs for the project (Table 5-1) include national objective programs and international commitments. These do not generally obligate operators directly, but their objectives can be introduced at the operator level through environmental permits

Through protection programs (Table 5-2), it is possible to reserve areas for nature or landscape conservation purposes in order to protect nationally significant values. However, the areas related to protection programs are not proper nature conservation areas that are protected areas by virtue of the Nature Conservation Act.

Table 5-1. The project's relationship with the most central plans and programs.

Name	Content	Relationship with the project	Reference
United Nations Framework Convention on Climate Change, UNFCCC	In the Framework Convention on Climate Change organized in Kyoto in December 1997, the new approved EU objective was to reduce the total volume of greenhouse gas emissions by eight per cent from the 1990 level. The obligation must be achieved in 2008–2012, which is known as the first commitment period. For Finland, the objective of reducing greenhouse gas emissions was set at 0% below the 1990 baseline, i.e. the emissions must be at the 1990 level during the period of 2008–2012. Negotiations over setting a new objective are in progress.	Nuclear energy production does not directly create greenhouse gas emissions. The test use of reserve power required by a nuclear power plant (e.g. reserve diesel and boiler plants) generates very small volumes of carbon dioxide emissions. Nuclear power can replace fossil energy production forms based on combustion processes and reduce the average carbon dioxide emissions of electricity production in Finland.	Kyoto Framework Convention on Climate Change 1997. EU states agreed upon the mutual division of the emission reduction objectives through the Kyoto Protocol. The next conference between the parties to the Protocol (COP 14) will be held in Poland in December 2008.
EU energy strategy	The objective of the EU energy strategy is to secure competitive and pure availability of energy corresponding to the control of climate change, increasing global demand for energy and future insecurities in energy deliveries. In order to achieve the objectives of the energy strategy, a ten-point action plan has been defined. The plan includes the development of EU's internal energy market, securing service reliability for energy, commitment to the reduction of greenhouse gases and the future of nuclear power.	The future of nuclear power is one of the ten points of the energy strategy's action plan. According to the plan, the Commission regards nuclear energy as a noteworthy energy source so that the tight emission objectives can be achieved. According to the Commission, EU should maintain and develop its technological leading position in nuclear energy. The Commission also proposes that the authorities of the Member States increase the efficiency of nuclear power-related permit procedures and remove unnecessary restrictions.	The Energy Policy for Europe was published on January 10, 2007.
EU climate and energy package	The European Commission's climate and energy package is a wide legislation proposal concerning the Member States. The EU is committed to reducing greenhouse gases by 20 % by 2020 from the emission level in 1990 and increasing the share of renewable energy in the total energy use within the EU to one-fifth. The emission reduction objective will increase to 30% if the new global emission reduction agreement can be achieved. In addition to renewable energy, the increase in energy efficiency and investments in pure forms of energy, such as the recovery and storage of carbon dioxide, are regarded as measures with which the objectives can be achieved.	If nuclear power replaces power plants removed from operations that use non-renewable energy sources (e.g. coal plants), the average carbon dioxide emissions in energy production can be reduced without increasing the share of non-renewable energy production forms. This helps Finland achieve the EU objectives set for reducing greenhouse gas emissions.	The EU published the package related to renewable energy and climate change on January 23, 2008.

Name	Content	Relationship with the project	Reference
Finnish energy and climate strategy	The restriction of greenhouse gas emissions according to the United Nations Framework Convention on Climate Change will mainly be implemented through emission trading in accordance with the Kyoto Protocol and following the Kyoto mechanisms. The strategy takes into consideration Finland's starting points for international negotiations regarding the restriction of global greenhouse gas emissions after the Kyoto period. The preparation of Finland's new climate and energy strategy is currently in progress. The starting points of the new strategy are the objectives in accordance with the EU climate and energy package. The proposal is expected to be handled in Parliament at the beginning of the 2008 fall term.	The construction of the new nuclear power plant unit is in line with the energy strategy. According to the national energy strategy, energy production in Finland is to be kept versatile and as self-sufficient as possible. According to the strategy, no production form which has no or low emissions or is neutral for emissions, sustainable and profitable for the cost structure, including nuclear power, should be excluded.	A report of measures to be carried out in the energy and climate policy in the near future approved by the Government on November 24, 2005, has been issued to Parliament. As a result of the report, Parliament approved a statement in accordance with the Commerce Committee's report on June 6, 2006.
Air Pollution Control Program 2010	The European Parliament and Council Directive 2001/81/EC on national emission limits for impurities in air, i.e. the National Emission Ceiling Directive, issued in October 2001 defines the maximum emission limits for each Member State in 2010 concerning sulphur oxides, nitrogen oxides, organic compounds and ammonia. Finland executes the National Emission Ceiling Directive with a program approved by the Government. The program includes a plan for reducing emissions. The means of reduction for energy production mainly include the renewal of energy production plants and the new emission regulations to be entered into force, because Finland has already made significant investments in the reduction of nitrogen emissions at the end of 1980 and the beginning of 1990s. The Ministry of the Environment and other operators are following how the national program can be implemented. In 2006, an assessment report was submitted to the European Commission, according to which emission development has been sufficient for reaching the objectives.	Nuclear power production does not create emissions that are limited by the National Emission Ceiling Directive. The replacement of energy production based on combustion processes with nuclear power supports the objectives set in the Directive for Finland.	Program approved by the Government on September 26, 2002, National Emission Ceiling Directive 2001/81/EC.

Name	Content	Relationship with the project	Reference
Record concerning the Convention on Long-Range Transboundary Air Pollution for Abating Acidification, Eutrophication and Ground-Level Ozone	The record concerning the Convention on Long-Range Transboundary Air Pollution was signed in Gothenburg in 1999 and was entered into force through Decree no. 40/2005 in Finland. The objective of the record is to control and reduce emissions of sulfur, nitrogen, oxides, ammonia and volatile organic compounds that are caused by human activities and are likely to have detrimental effects on health, ecosystems, materials and plants due to acidification, eutrophication or ground-level ozone caused by long-range air pollution. The parties to the Convention are obligated to reduce their emissions so that the emission levels fall below the limits set for each party in 2010.	The record binds Finland as a state; it does not bind single operators. The commitments are to be fulfilled using control methods aimed at operators as deemed appropriate by the state. Nuclear power production does not directly create emissions that are limited in the record. Nuclear power production can replace energy production forms based on combustion processes and reduce the total emissions in Finland.	Decree 40/2005 on the execution of the record related to the Convention on Long-Range Transboundary Air Pollution
Guidelines for water protection until 2015	The guidelines for water protection define the national needs and objectives for water protection until 2015. The decision presents measures to be taken for reaching a good status in water systems and preventing any deterioration. The guidelines for water protection also support the preparation and execution of the EU sea protection strategy and the action plan between the Baltic countries for protecting the Baltic Sea. The central objectives of the plan include the reduction of eutrophication and heavy loads caused by detrimental substances, the protection of groundwater and water habitat, the reduction of damage caused by hydraulic construction and the regulation and repair of water systems.	The limit values defined in the environmental permit will be followed in the cleaning of the nuclear power plant's wastewater. The heat load transferred to the water system along with the cooling water constitutes the most significant impact of the nuclear power plant on the water system. Cooling waters do not contain any nutrients or detrimental substances.	Government's decision-in-principle (November 23, 2006) concerning the water protection objectives until 2015

Table 5-2. The project's relationship with conservation programs.

Name	Content	Relationship with the project	Ratified by the Government
Strategy for Protecting Biodiversity and Sustainable Use of Nature 2006–2016. (Continuation to the Finnish National Biodiversity Strategy 1997–2005)	The objective is to stop the deterioration of Finnish nature's biodiversity by 2010 and stabilize the positive development of the state of the Finnish nature during 2010–2016. The purpose is to prepare for global changes in the environment and the climate change in particular that threaten Finnish nature by 2016. The objective is also to strengthen Finland's position in the preservation of global natural biodiversity using the means of international cooperation.	Nuclear power can replace energy production forms based on combustion processes and reduce the average carbon dioxide emissions of electricity production in Finland. The reduction of greenhouse gas emissions in energy production helps to control climate change.	2006
Forest Biodiversity Program for Southern Finland 2008–2016 (METSO) (Continuation to the action plan for preserving forest biodiversity in Southern Finland, the west parts of the Oulu Province and the southwest parts of the Lapland Province (METSO's experimental stage 2003–2007)	The objective of the program is to stop the decline in forest habitat types and forest types and to stabilize the favorable development of nature's biodiversity by 2016. At the experimental stage of the program, forest biodiversity protection and economic use have been attempted to be combined by developing new voluntary protection methods for securing biodiversity in private forests. One such method based on voluntariness is natural values trading where the forest owner is committed to maintaining the area's natural values for a specific period in exchange for compensation.	*Pyhäjoki:* The Hanhikivi region was a model area in the "From Sea to Forest" cooperation network of the METSO experimental project (2004–2006). In 2005 and 2006, approximately 150 hectares was decided to be protected in the region through natural values trading for a ten-year period.	2008
Natura 2000 network	Nature's biodiversity in the European Union area is to be preserved using the Natura 2000 network, and the protection objectives in accordance with the Habitats and Birds Directives are to be implemented. The general objective of the Habitats Directive is to achieve and maintain a favorable protection level for certain species and habitat types. Species must be preserved in their natural habitat in the long term and their natural range must not be narrowed. In addition, there must be a sufficient number of living environments for species to secure the preservation of the population in the long term. The general objective of the Bird Directive is to maintain certain bird populations at a level which corresponds to the ecological, scientific and cultural requirements.	Closes Natura areas: *Pyhäjoki:* The Parhalahti-Syölätinlahti and Heinkarinlampi regions located south of the Hanhikivi cape. *Ruotsinpyhtää:* The Pernajanlahti and Pernaja islands sea protection area is located, at its nearest point, at a distance of one kilometer from the south and northwest side of Kampuslandet. The Vahterpää area's coastal lakes are located about five kilometers east of Kampuslandet. *Simo:* The Natura area called the Islands of the Bothnian Bay is located, at its nearest point, at a distance of about five kilometers west of the location area. The Musta-aapa swamp area is located about ten kilometers northeast of the project area. A means test assessment for the Natura assessment will be prepared for these areas as part of the EIA procedure. On the basis of the assessment, the environmental authority decides whether a Natura impact assessment needs to be prepared for these areas as referred to in the Nature Conservation Act.	1998

Name	Content	Relationship with the project	Ratified by the Government
Protection program for bird waters	The objective of the protection program for bird waters is to preserve the included areas as natural as possible. The purpose is that a conservation area pursuant to the Nature Conservation Act is formed for each area.	Closest areas belonging to the program: *Pyhäjoki:* The Parhalahti-Syölätinlahti and Heinkarinlampi areas are located at a distance of few kilometers from the project area. *Ruotsinpyhtää:* The Kullafjärden bird water protection area is located, at its nearest point, at a distance of about four kilometers from the project area. The project's impact on these areas will be assessed in the EIA procedure.	1982
Protection program for herb-rich forests	The objective is to preserve the biodiversity and quality of Finland's herb-rich forests.	Closest areas belonging to the program: *Ruotsinpyhtää:* The Nyckelskinnsberget grove is located at a distance of about five kilometers from the project area. The project's impact on this area will be assessed in the EIA procedure.	1989
Shore protection program	The basic objective is to preserve the program areas that are unbuilt and in a natural state in order to protect the sea and lake habitat.	Closest areas belonging to the program: *Ruotsinpyhtää:* The Pernajanlahti coast is located in the sea area about four kilometers from the site. The project's impact on these areas will be assessed in the EIA procedure.	1990
Esker protection program	The purpose of protection is that the characteristic geological, geomorphic and landscape features of the program's nationally significant esker areas are not changed significantly.	Closest areas belonging to the program: *Ruotsinpyhtää:* The Källa and Hamnholmen areas are located about four kilometers from the site. The project's impact on these areas will be assessed in the EIA procedure.	1984
Mire protection program	The mire protection program is to preserve a sufficient number of samples of our rich mires throughout the country. The majority of the protected areas represent mire combinations, i.e. aapa and raised bogs. The protected areas also include good bird areas.	Closest areas belonging to the program: *Simo:* The Musta-aapa swamp area is located about ten kilometers northeast of the project area. An area belonging to the mire protection program is located in the Maksniemi region at a distance of about seven kilometers from the site. The project's impact on these areas will be assessed in the EIA procedure.	1979, täydennys 1981
Nationally valuable landscape protection areas	The Government decision obligates the development and support landscape management in areas. The national land use objectives referred to in the Land Use and Building Act require that valuable landscape areas are taken into account in land use.	Closest areas belonging to the program: *Simo:* The cultural landscape at the mouth of the Simojoki river area is located about five kilometers east of the project area. The project's impact on these areas will be assessed in the EIA procedure.	1995

Environmental programs and plans have been taken into account in the EIA process. A water lily in Ruotsinpyhtää, 2008.

Nuclear power plants observe a strict safety culture. Boat shed in Pyhäjoki, 2008.

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

6 Nuclear safety

Safety is the primary objective in the design, construction and operation of a nuclear power plant. Nuclear safety covers all of the measures with which the safety of employees, residents and the environment is ensured when using nuclear energy with regard to radioactive radiation.

The safety and reliability of nuclear power plants is continuously being developed. In order to ensure the safe operation of nuclear energy, strict safety culture, special safety principles and regulations, as well as developed quality assurance methods, are followed in the design and operation of a nuclear power plant. The use of nuclear energy comprises operations subject to a license regulated by legislation. Safety requirements are taken into account in the design of the plant. The applicant of the permit related to the use of nuclear energy (holder later) is solely responsible for the safety of the operations.

6.1 Nuclear safety requirements

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

The regulations of the Nuclear Energy Act are detailed in the Nuclear Energy Decree (161/1988). The general principles of the safety requirements set for nuclear power plants are issued in Decisions of Council of State 395–197/1991 and 478/1999. Their scope of application covers different sections of the safe use of nuclear energy. Detailed regulations for the safety, emer-

The application for a decision-in-principle regarding the nuclear power plant is submitted to the Government. Stairs of the parliament house in 2008.

gency and safety planning and nuclear material control of the use of nuclear energy are issued in the nuclear power plant guide series (*YVL Guides*) issued by the Radiation and Nuclear Safety Authority (*STUK*).

Legislation concerning nuclear energy is currently being revised. On May 7, 2008, Parliament approved the Government bill for revising the Nuclear Energy Act (Government Bill 117/2007) and the revised act entered into force on June 1, 2008. In addition, the revision of the Government Decrees concerning nuclear safety (to replace Decisions of Council of State 395–198/1991, 478/1999) has advanced far. At the same time, the Radiation and Nuclear Safety Authority has launched preparations aimed at the long-term revision of the YVL Guide. The objective is to update the guide system's structure and revise them so that the number of individual guides can be reduced. According to the act for revising the Nuclear Energy Act as approved by Parliament, the leading principle of nuclear safety is that the safe use of nuclear energy is maintained at such a high level as possible through practical measures. Safety must be developed further on the basis of experience and safety studies, taking into account scientific and technological development. According to the defense in depth principle, the safety of nuclear facilities must be ensured using successive and independent protective measures. This safety principle must be extended to the plant's operational and structural safety. The possibility of operational failures and accidents must also be taken into account in the design of nuclear power plants.

The legislation and instructions concerning nuclear safety have taken into account international agreements and safety requirements, such as the International Atomic Energy Agency's (IAEA) guidelines (*STUK 2008, IAEA 2008*).

The fulfillment of the safety requirements will be assessed for each plant unit in great detail. On the basis of their consideration, STUK and the license holder can set design objectives that are tighter than the valid safety requirements. The safety requirements followed in Finland are considered to be tight internationally.

6.2 Nuclear safety principles and their implementation

The safety of nuclear power plants is based on the defense in depth principle. Several independent and supplementary protection levels are to be applied to the design and use of the power plant (Figure 6-1) (*IAEA 2000*):

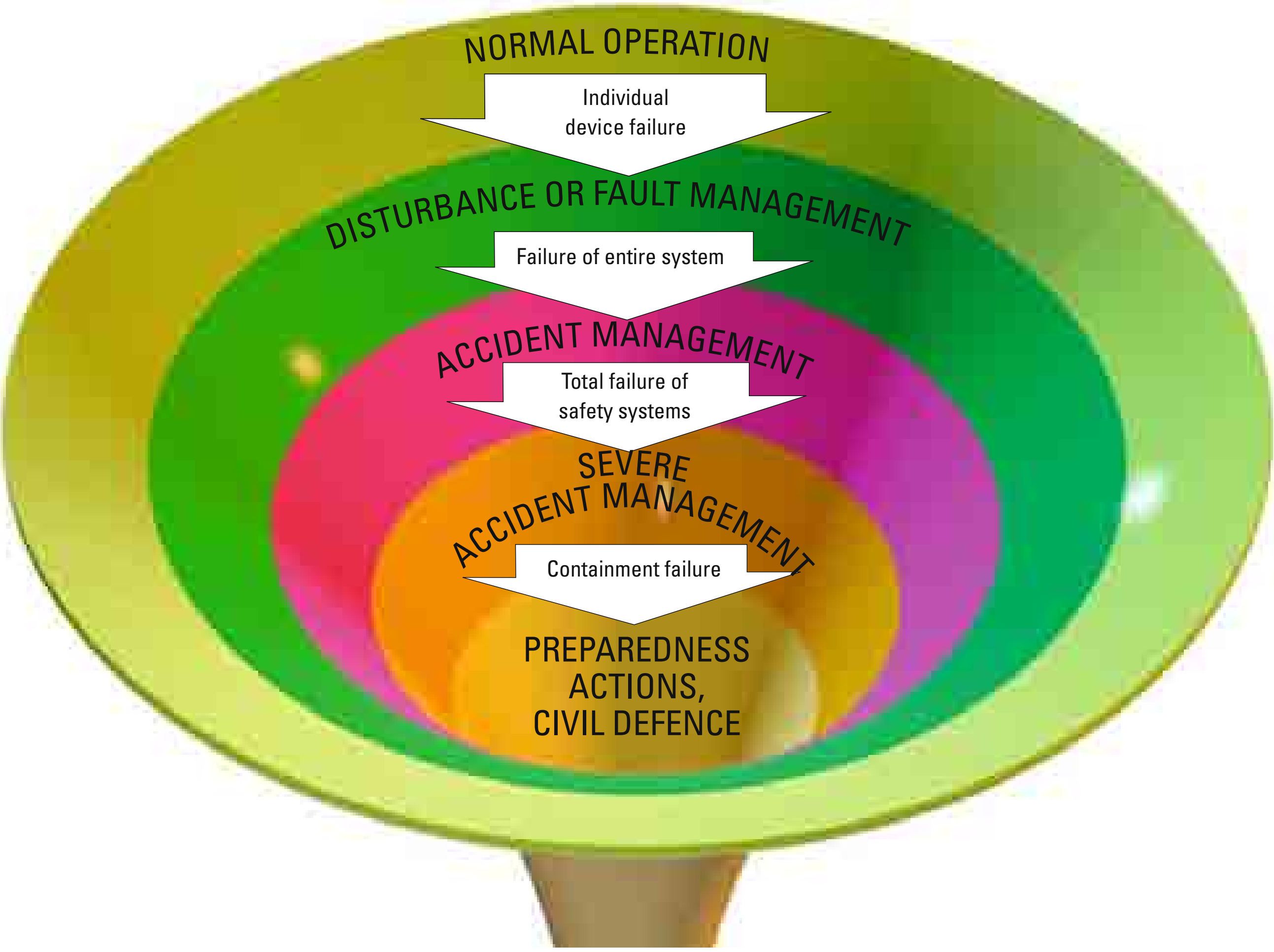


Figure 6-1. Several levels of protection are applied to the design and operation of nuclear power plants in accordance with the defense in depth principle.

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

Nuclear power plants are to be designed so that the failure of operations at any single protection level does not result in danger to people, the environment or property. In order to guarantee reliability, each of the levels is to be built on several supplementing technical systems, as well as limitations and regulations related to the use of the power plant.

Proven technology will be applied to the design of the nuclear power plant and all processes are designed to be naturally stable. For example, reactors will be designed to be naturally stable with regard to power control. This means that the reactor's inherent feedbacks will limit any uncontrolled increases in power. Safety in light water reactors is increased because a temperature increase in the coolant controls the power increase and a coolant leakage in the reactor shuts down the chain reaction.

All safety-related equipment and functions will be designed on the basis of special safety inspections, taking into account improbable failures and applying sufficient safety margins. In addition, high quality requirements will be applied to the manufacture of safety-related equipment. As part of efficient quality control, the nuclear power plant's systems, devices and structures will be divided into categories on the basis of their significance to safety. The more important the category, the higher quality is required. Despite all of this, safety planning always starts from the assumption that there may be equipment failure or plant operators may make mistakes. The design of the plant will take into account internal incidents, such as device failures and mistakes made by plant operators, and external factors, including exceptional weather and environmental conditions, risks related to the operation of cooling water routes, such as clogging, and plane crashes, etc. The nuclear power

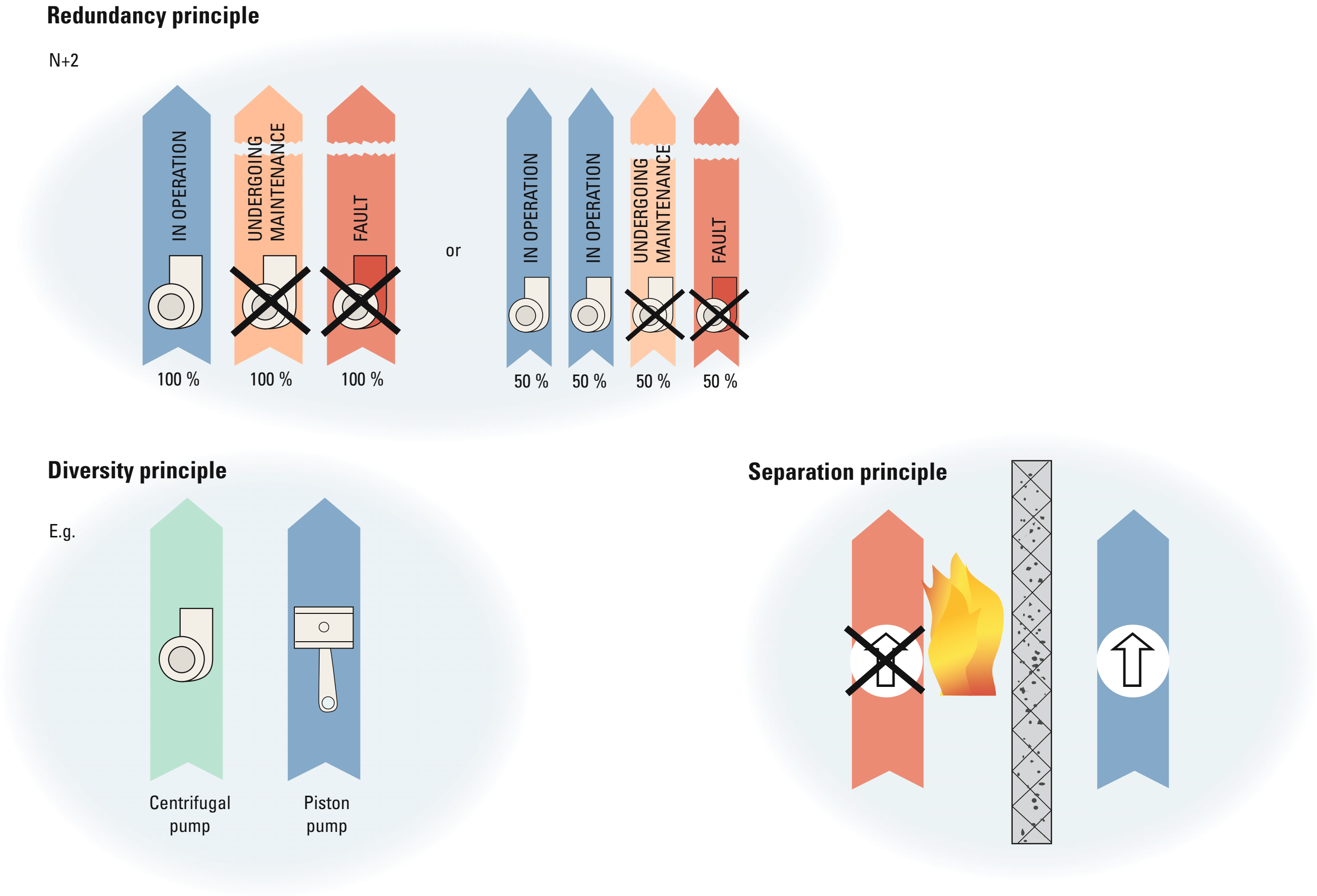


Figure 6-2. Design principles of safety systems.

plant will be equipped with safety systems, using which the progress and impact of failures and accidents can be prevented or limited.

The capacity of the safety systems will be designed to be redundant in relation to the need so that they can be divided into several parallel subsystems (Figure 6-2). The system entity consisting of redundant subsystems is able to perform its safety functions, even if any single device in the system fails and, simultaneously, any devices affecting the safety function is disabled for maintenance purposes. Because of redundancy, the safety systems will operate reliably and the reliability can be improved by using several devices of different types to perform one task. For severe accidents (melting of the fuel core), the plant will be equipped with special protection equipment and structures. Due to the improbability of such accidents, it is sufficient for the systems designed for the purpose that each system can perform their safety function, even if any single device in the system fails (*STUK 2004*).

The nuclear power plant's safety planning ensures that radioactive substances contained by the plant, fuel in particular, can be prevented from spreading as reliably as possible in all situations. Radioactive fuel is prevented from spreading to the environment using several technical ***spreading barriers*** inside one another (Figure 6-3). Each of these barriers must be sufficient to independently prevent the spreading of radioactive substances into the environment.

The ***first barrier*** is formed by the gas-tight and mechanically durable, metallic cladding of fuel rods. The ***second barrier*** consists of the reactor's pressure-resistant and tight cooling circuit. A pressure-resistant and gas-tight containment building surrounding the reactor forms the ***outermost barrier***. According to Finnish safety requirements, the primary containment building is to be surrounding by another containment building cast of concrete (i.e. reactor building). This double protection forms the most important barrier for preventing radioactivity from spreading in the event of a severe accident. The space between the containment buildings can be maintained in a state of under-pressure in relation to outdoor air in all expected accident situations. As a result, any gases leaking from the inner containment building can be recovered and filtered in order to minimize gaseous emissions. The solid outer containment building also protects the inner containment building and reactor against external threats.

The nuclear power plant will be designed so that the containment building also endures severe accidents, including melting of the fuel core. The containment building will prevent the molten core and the majority

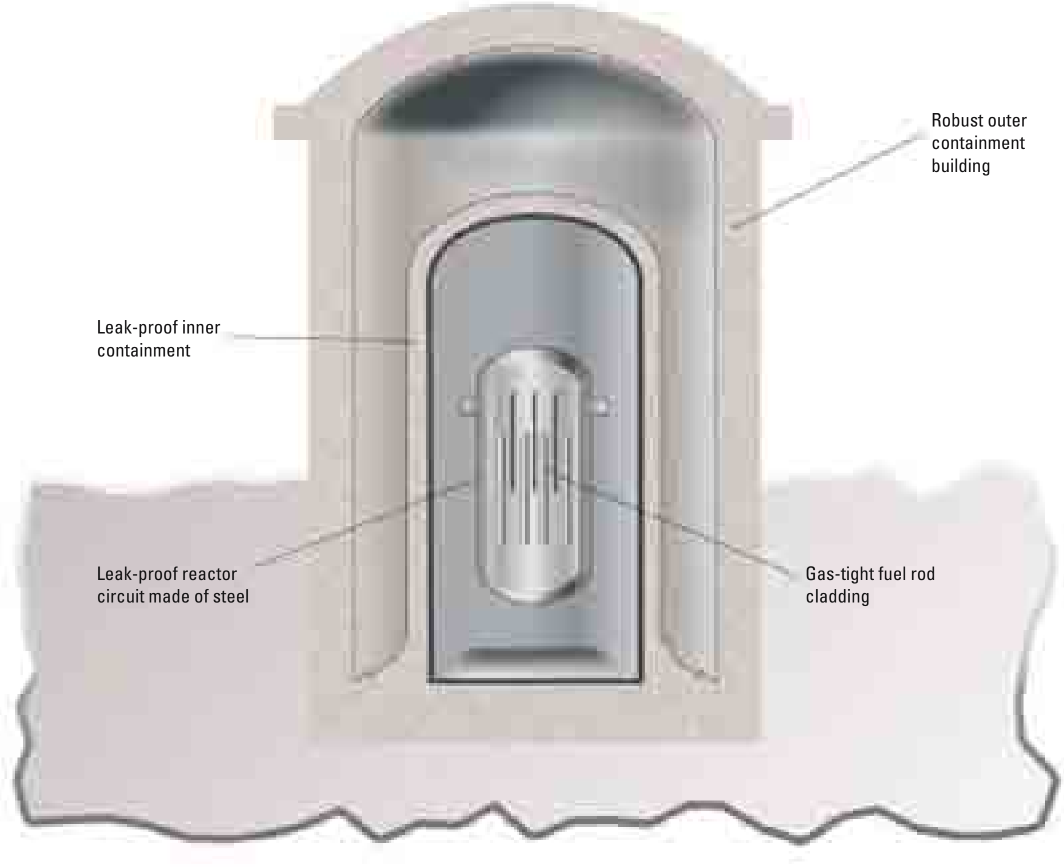


Figure 6-3. Spreading barriers for fuel radioactivity.

of gaseous radioactive substances from spreading into the environment. Outside the containment building, the radiation level will be at a safe and low level, even if radioactivity has been released inside the building.

The nuclear power plant will follow a high safety culture and developed quality assurance measures. The procedures required for inspecting the use and failures of the nuclear power plant and any accidents will have thorough instructions and they will be practiced regularly. Special attention will be paid to attentiveness and precision in connection with maintenance and repair work. The objective is to protect the plant from failures and employees from radiation. The Radiation and Nuclear Safety Authority will supervise personnel training and review the instructions. STUK will also supervise the nuclear power plant's safety management.

6.3 Implementation of nuclear safety requirements and principles in the design, construction and operation of a nuclear power plant

Fennovoima's nuclear power plant will be designed and constructed so that it meets the requirements set by legislation and the authorities. The design of the nuclear power plant will closely follow the safety principles and one of its central design criteria is preparation for different failure and accident situations, including the possibility of severe accidents caused by melting of the fuel core, as well as any threats caused by external factors.

The nuclear power plant's containment building and the surrounding outer containment building, or reactor building, will protect the reactor and safety systems from external threats, such as extreme weather conditions, different flying objects, explosions, burning and poisonous gases and intentional damaging. The nuclear power plant will be constructed so that it will endure a collision from an airliner without releasing any significant emissions into the environment. The design of buildings important for safety will take into account the collision force caused by the plane and the fire generated by its fuel.

The nuclear power plant's combined use in electricity and heat production does not have an impact on the plant's nuclear safety properties because the changes do not need to be targeted at the power plant's nuclear parts. If the need for adjusting the electrical or thermal power of a nuclear power plant operating in combined use has a significant impact on any malfunctions at the plant, e.g. by causing malfunction or failure types that do not occure in condenser use, they will be taken into account in the plant's safety design as dimensioning incidents similarly to other dimensioning incidents.

Table 6-1. Observed natural phenomena, extreme value predictions for the latter half of the present century.

		Simo	Pyhäjoki	Ruotsinpyhtää
Sea level (cm) (the figures for 2008 given in parentheses)	min.	-215 (-189)	-219 (-192)	-122 (-132)
	max.	+205 (+231)	+161 (+188)	+214 (+204)
Temperature, momentary	min.	-44.2	-42.8	-36.6
	max.	33.8	33.9	32.4
Temperature, 24 hrs	min.	-34.5	-35.3	-34.0
	max.	22.9	22.0	22.0
Rainfall (mm)	24 h	81.9	84.6	163.7
	7 days	138.3	126.7	175.5
Snow load (kg/m^2)		215.6	190.5	210.7
Wind velocity (m/sec.)	gust, 3 sec.	35.3	34.7	34.4
	average, 10 min.	31.4	31.2	27.4

The access of radioactive substances into the district heating network will be prevented by transferring heat from the turbine circuit to the district heating network using a closed and pure intermediate circuit so that the operating pressure in the intermediate circuit is greater than in the heat exchanger on the turbine side and the heat exchanger in the district heating network. Fennovoima has available long-term operating experience in the transfer of heat from the nuclear power plant to a nearby industrial plant's needs using such an intermediate circuit arrangement obtained at the Stade plant in Germany. In the event of a leak in the heat exchangers on the turbine side, it would be directed from the pure intermediate circuit towards the turbine.

According to assessments, combined production will not have other nuclear or radiation safety impacts.

The nuclear power plant's safety planning will take into account any natural phenomena occurring at the plant site, such as extreme weather conditions that may become more frequent or extreme due to the climate change. The design will also prepare for the increasing sea water temperature and rising sea levels caused by the climate change.

The location areas to be assessed have isostatic uplift and its consequences will be assessed when designing the nuclear power plant. However, the uplift is steady and it is not expected to cause any special requirements for the design of the nuclear power plant.

The design of the nuclear power plant will take into account extreme nature conditions and their estimates of occurrence. If required, the ground level of the nuclear power plant's location site will be raised sufficiently. The Finnish Institute of Marine Research has conducted a water level study, covering all of the alternative location municipalities for the nuclear power plant. The study is based on a comprehensive international literary review concerning changes in the ocean level during the next hundred years. In addition to the ocean level, the level of the Baltic Sea depends on changes in the total water volume in the Baltic Sea, isostatic uplift following the ice age and other weather and climate factors. (*Finnish Institute of Marine Research 2008a*). The Finnish Meteorological Institute has conducted a similar prognosis concerning the probability of occurrence of extreme temperatures, rainfall and wind speeds in these municipalities. The study is based on the best prognoses concerning global climate development, on the basis of which the occurrence of local weather conditions has been modeled. The confidence intervals of the prognosis for certain weather phenomena are rather great, because the observation material is obtained from a short period compared with the length of the prognosis horizon. (*Finnish Meteorological Institute 2008a*). The table (Table 6-1) presents prognoses concerning the studied natural phenomena at the end of the current century. The recurrence of the weather conditions is 1,000 years, which means that the reported value occurs once in a thousand years on average. The maximum and minimum values of water level are prognoses for 2075.

The design of the plant and its cooling systems will take into account any oil accidents in the sea area and the occurrence and impact of frazil ice and packed ice. The structures will be designed so that the formation of frazil ice or packed ice cannot cause an obstacle to the nuclear power plant's cooling. The nuclear power plant and the nuclear materials used will be protected from illegal actions, such as vandalism and sabotage. Threats caused by terrorism or other illegal actions will be mitigated by thorough and continuous security arrangements. They will supplement the protection provided by the sturdy structure and protection of sensitive sections required by the plant's basic safety planning.

The backgrounds of the personnel working continuously at the nuclear power plant or in outages will be checked and the employees' movement in the plant area will be restricted to areas necessary for working using

The impacts on landscape have been extensively studied. Boats in Ruotsinpyhtää, 2008.

access permits of different levels. When preparing for external threats, a situation where a threat is formed by a person or a group of people who work regularly or temporarily at the plant and have access permits will also be taken into account.

At this stage, Fennovoima will analyze three different nuclear power plant options. When applying for a decision-in-principle, STUK will prepare a preliminary safety assessment for the application, assessing how these options meet the nuclear safety requirements valid in Finland. At the decision-in-principle application stage, safety will be assessed at the principle level. Fennovoima will select the plant location and the type to be built after a favorable decision-in-principle. The detailed implementation of the safety solutions for the plant option selected will be described in great detail when Fennovoima applies for a construction permit for the nuclear power plant in accordance with the Nuclear Energy Act. The license holder and STUK will assess the implementation of the safety solutions throughout the project's construction period. The structures implemented and the results received from test operations will be assessed as a whole when Fennovoima applies for the operating permit in accordance with the Nuclear Energy Act.

Supervision of the use and safety of nuclear energy is the responsibility of STUK and the safety of the nuclear power plant will be controlled using different authority inspections. Inspections to be defined and recorded in the plant-specific operational inspection program by STUK will be performed at the nuclear power plant at regular intervals. In addition, the inspections required by the YVL Guide will be performed at the plant. In support of the supervision procedures, STUK is to be provided with regular reports and and reports on possible disturbance situations.

Radiation caused by the nuclear power plant to the residents of the surrounding areas, the health effects of radiation and the emergency and rescue operations related to the operation of the nuclear power plant are described in more detail in Section 8. Radiation control is described in Section 11.

Comments were invited regarding the EIA program in spring 2008. The first willow catkins in 2008.

The construction, operation and annual maintenance of the nuclear power plant have numerous impacts on entrepreneurship, service selection and the labor market in the location municipality, its surrounding economic area and Finland as a whole.

7 Scope of the environmental impact assessment, assessment methods and uncertainties in assessment

The functions inspected in this EIA procedure for environmental impacts are presented in Chapter 1 in the section describing the scope of the project's environmental impact assessment. Environmental impacts have been examined for each impact type in a separately defined area.

The scope of the environmental impact assessment for the examined functions, the assessment methods and materials used and uncertainties in assessment are presented in the following sections. The defined impact areas are presented in more detail in Chapter 8 in function impact assessment.

Projects that may cause joint impacts together with this project are described in Chapter 8 in the section discussing joint impacts. The project's joint impacts together with the current functions in the alternative locations are inspected as part of the environmental impact assessment.

7.1 Land use and the built environment

The project's impact on land use has been inspected at a local, municipal and regional level. Changes in land use have been assessed as consequences of construction work and other land use in the actual plant area and its immediate surroundings. The starting points have been regional plans prepared for the plant entity and preliminary town plan drafts in Simo and Pyhäjoki/Raahe were carried out along with the EIA procedure. The extent of the assessment of community structure impacts at a municipal level varies between municipalities. The extent of the inspected area has particularly been affected by the distance of the nearest village or settlement areas from the site location. At the regional structure level, the region where the project will be located has been inspected. Furthermore, the national land use objectives have been presented and their relationship with the project has been described.

The affected area of direct land use impacts caused by the alternative Pyhäjoki/Raahe location covers the Hanhikivi headland. Indirect impacts on regional and community structures have been assessed at a municipal level through changes in the starting points of land use in Pyhäjoki and Raahe and at a regional level as part of the regional structure of Northern Ostrobothnia. In practice, the affected area of changes in land use at a municipal level extends, in addition to the surroundings of the Hanhikivi headland, to the nearby village areas, the central settlement of Pyhäjoki municipality and the south-ern parts of Raahe center. Changes in regional structure have been assessed in the Raahe region.

In Kampuslandet and Gäddbergsö areas in Ruotsinpyhtää, direct land use impacts have been assessed in plant areas and their immediate surroundings and the areas of new planned connections (roads, power lines). The Ruotsinpyhtää option differs in land use from the Simo and Pyhäjoki options in that there already is a built nuclear power plant area nearby, and the planned plant will be located in its safety zone. The closest villages and settlements are located so far from the planned plant site that the project's impact on community structure has not been necessary to assess outside the probable safety zone. The Loviisa region has been assessed with regard to regional structure.

The area of direct land use impacts in the Simo location option covers the southern part of Karsikkoniemi where the actual plant operations are planned to be located. Furthermore, the direct land use impacts of power lines have been assessed. For community structure, areas south of the track located north of Highway 4 have been assessed as the affected area. These areas extend to the Hepola residential area in Kemi and the Maksniemi village in Simo. The entire Kemi-Tornio region has been taken into account in regional structure assessment, including the Norrbotten County and, in particular, the municipality of Haparanda in Sweden.

The project's impacts on land use have been assessed from the points of view of the current status of regional and community structure and land use planning. The current status of land use in the alternative site municipalities has been studied using maps, aerial photos, various registers, geoinformation, visits to the terrain and interviews. Other important sources of information have been valid and pending land use plans and related material. Furthermore, statements of authorities and feedback of other parties involved have played an important role in generating base information. Information has also been obtained through research concerning the areas related to the EIA procedure and technical planning.

In the impact assessment, any changes to current land use have been identified in the plant area and its immediate surroundings. In addition, indirect land use changes have been assessed in a wider regional and community structure. The assessment is based on the views of land use experts and authorities involved in the project. Moreover, the project's relationship to valid land use plans has been described, as well as the need to revise and prepare land use plans. In the Pyhäjoki/Raahe and Simo regions, a regional, master and town planning process has been pending which has supported the assessment of land use impacts significantly.

Any uncertainties in the assessment of land use impacts are particularly related to the implementation of land use in the long term. Direct impacts caused by the construction of the plant on land use in the location sites can be assessed reliably but indirect impacts on the wider regional and community structure will be realized in stages over decades. Furthermore, the changes will be affected by many other factors in society.

7.2 Construction of the nuclear power plant

The impact of ***the loading and unloading site, ship route, the construction of cooling water routes*** and dredging has been assessed on the basis of the information available from the environmental impact assessment for construction and nature surveys carried out in the areas. The estimate of the extent of the dredging and excavation required has been presented on the basis of technical planning prepared by the party responsible for the project.

The impact of ***transportation and commuter traffic during the construction stage*** has been assessed on the basis of the current traffic volumes and traffic volume estimates. Road improvements and new roads planned by the Road Administration have been taken into account in the assessment.

Impacts of traffic have been assessed along new planned roads and roads leading to the location sites. The impact of traffic emissions and noise has been assessed in the surroundings of these roads. Calculation methods for emissions are presented in the traffic emissions section in Chapter 3.

Traffic volumes during construction work have been assessed for the fourth or fifth year of construction when the number of employees is at its highest. The calculation methods for traffic volumes and the assumptions made are presented in the traffic volumes section in Chapter 3.

Environmental impacts caused by ***the construction of roads*** and the improvement of existing road connections have been assessed on the basis of information available on the environmental impact of the construction and use of roads, and surveys conducted in the plant's location sites.

The affected areas have been limited in the locations of new or improved roads and their immediate surroundings.

Environmental impacts caused by ***the construction of power lines*** have been assessed on the basis of information available on the environmental impact of the construction and use of power lines and surveys conducted in the plant's location sites.

The environmental impacts caused by the power line routes have been assessed up to the preliminary master plan border. The actual EIA procedure for the construction of power lines will be the responsibility of Fingrid Oy, the national grid company.

With regard to impacts during the construction of power lines, the impacts on land use, agriculture and forestry, habitation, the landscape and cultural heritage, interdependency between flora and fauna and the preservation of biodiversity and protection values in nature have been assessed. In addition, the impacts during the operating stage have been assessed as to people's health, living conditions and comfort and impacts on population.

The majority of the assessed environmental impacts comprise direct impacts and their affected area extends to a distance of about a hundred meters from the power line. These include the majority of impacts on nature and birds. Land use has generally been inspected at a distance of about 300 meters from a power line. Impacts on the landscape and cultural heritage have been assessed as entities formed by landscape and culture areas and in the local and remote landscape.

Impacts on people and society during the construction stage have mainly been assessed using similar methods as in the assessment of impacts during the operating stage. The project's construction and operating stage have been taken into account in the assessment of the project's regional economic and social impacts, which has included queries and group interviews for inhabitants. These methods and related uncertainties are described in greater detail in Chapter 7.10. Impacts on traffic and noise in the areas surrounding the location sites have also been taken into account in the impact assessment.

7.3 Radioactive emissions to the atmosphere

The assessment of radioactive emissions has been carried out on the basis of true emissions from existing plants and the design data concerning new pressurized and light water reactor plants. The assessments have followed the precautionary principle and the new nuclear power plant will fall below the emission values used in the assessment.

7.4 Water system and fishing industry

7.4.1 Extreme phenomena on the sea level

The assessment of average water level fluctuation and extreme water level values has been conducted by the Finnish Institute of Marine Research (*(Finnish Institute of Marine Research 2008a)* using a similar method as that used in the previous wider study on sea water level fluctuation (***Kahma et al. 2001***) ordered by the Radiation and Nuclear Safety Authority. The latest information on the ocean level and the impact of climate change has been included.

Changes in the average water level

The ocean level has increased throughout the 20th century. According to observations, the increase is becoming more rapid. This study has used a wide summary of scenarios published in scientific literature concerning the increase in ocean level (including the Intergovernmental Panel on Climate Change, IPCC, estimate).

Water level is being measured continuously using tide gauges, i.e. continuous measure-ment stations, in 13 locations on the Finnish coast. Observation material over 75–120 years is available from these locations, on the basis of which it is possible to calculate a scenario for the average water level. Scenarios for the inspected locations have been obtained by interpolating between the tide gauge locations in a linear manner. All inspected locations are, in relation to the tide gauges, located in places where linear interpolation can be considered to function reliably with regard to water level fluctuation. For isostatic uplift, any error caused by interpolation is approximately 0.1 mm/year which is insignificant compared to other uncertainties existing in the report.

Extreme water level values

Extreme water level values (maximum and minimum) have been inspected using probability distribution based on observations. The report presents extreme values to be reached in 2008 and 2075 with the probability of 10^{-3}.

Probability distributions have been calculated for extreme water level values in the tide gauge locations on the basis of observed monthly maximum and minimum values. These distributions were interpolated to obtain distributions for the inspected locations. Because there is only observation material over a period of 80–104 years

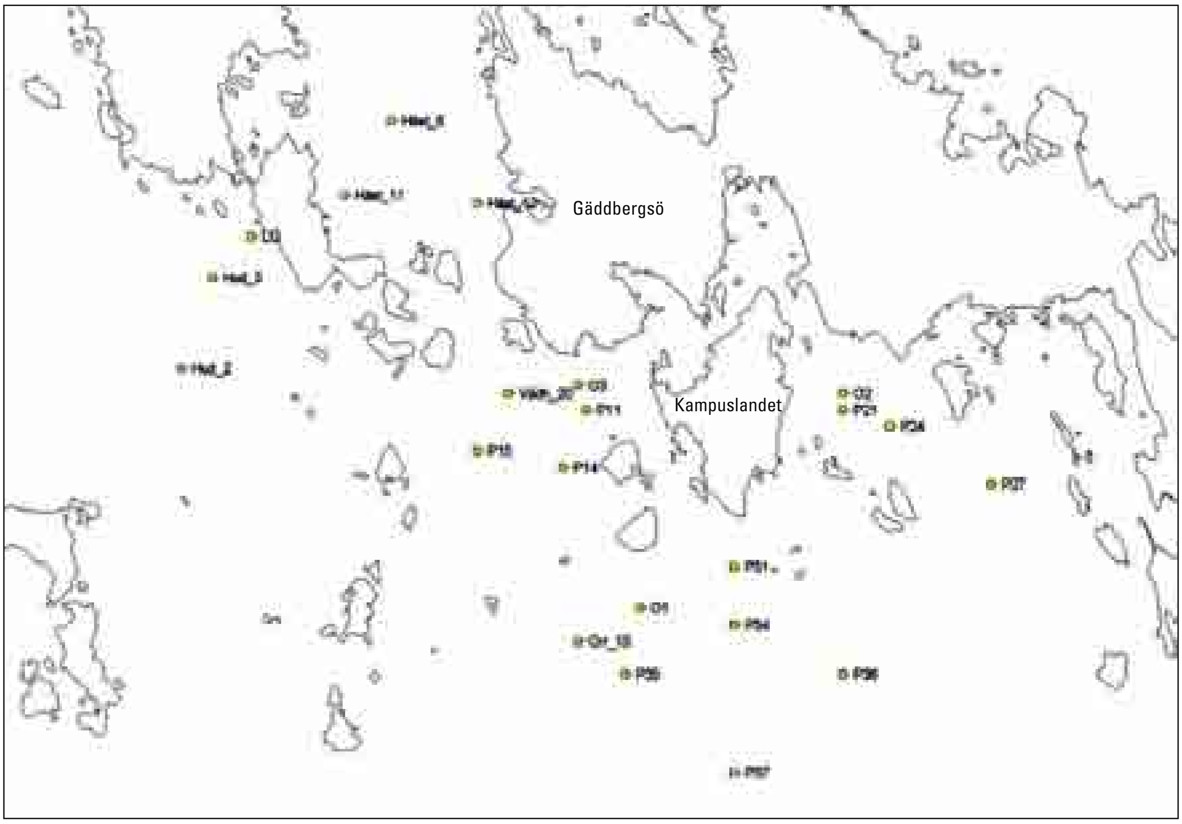


Figure 7-1. The location of HERTTA measurement points and time sequence points in the surrounding area off Gäddbergsö and Kampuslandet.

depending on the location, water level values that are rarer than the probability level of 10^{-2} must be assessed through extrapolation. An exponential distribution which has been stated to be well-suited for extrapolating water level distributions (*Kahma et al. 2001*) has been used for extrapolating the distributions.

7.4.2 Cooling water modeling

The impact of thermal load caused by cooling waters on water temperatures has been assessed using a 3D flow model by Ympäristövaikutusten Arviointi Oy. *(YVA Oy 2008a, YVA Oy 2008b, YVA Oy 2008c)* The impact of the location of the planned power plant unit's cooling water intake and discharge site on water temperatures in alternative cooling water intake sites has been inspected.

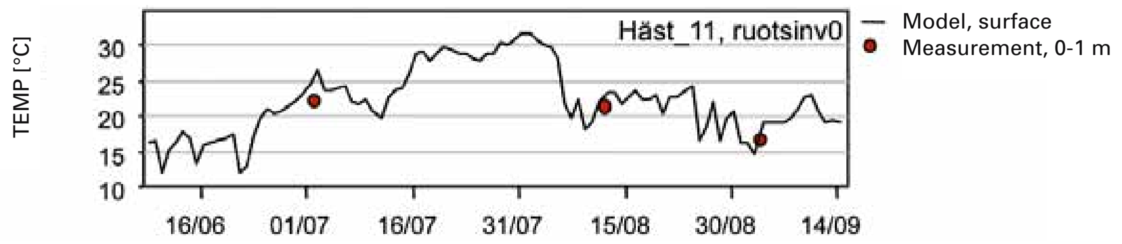
Model calculations were performed using YVA Oy's three-dimensional flow model which is a baroclinic model suitable for water areas and based on hydrostatic Navier-Stokes equations (*Koponen et al. 2008*). By using the selected calculation methods, the aim has been to represent flows that correspond to the real situation as well as possible within the limits set by current modeling knowledge and calculation power.

The 2003 summer period has been used in the model calculations. The selection criterion was warm July when the measured water temperature was the highest during 2002–2006. Ice conditions were modeled on the basis of the temperatures in January and February in ice winter 2002/2003. According to the Finnish Institute of Marine Research, the ice winter 2002/2003 was an average winter when inspecting the area of ice. Wind, temperature and humidity data measured at the Finnish Meteorological Institute's weather stations close to the power plant was used as condition information.

The calculated model results have been compared to the measured temperatures. The comparisons were mainly conducted using the 2003 measurements that have been obtained from the Finnish Environmental Institute's Hertta database. The material in the Hertta database has been measured at water quality monitoring points about once a month, at the most frequent intervals, but typically more rarely. The number of monitor-ing points and the measurement frequency vary between municipalities. The location of the monitoring points in Ruotsinpyhtää is presented as an example (Figure 7-1).

For comparing the measured and calculated temperatures, the model has been used to calculate the 2003 summer period. Generally, the surface temperatures calculated at the measurement points corresponded to the observations relatively well. Differences to real measured temperatures were an average of ±1–1.5 centigrades depending on the municipality. A comparison of the measured and modeled temperatures at two points off Ruotsinpyhtää is presented as an example (Figure 7-2).

When modeling climate change impacts, the impact of climate change during summer was estimated by adding



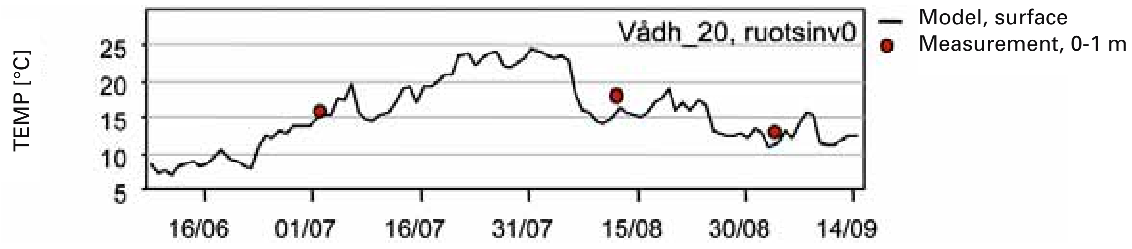


Figure 7-2. Calculated (line) and measured (dots) water temperature values on the sur-face and at a depth of 10 m in measurement points Vådholm_20 and Hästholm_11.

1.35 centigrades to the air temperature, boundary values of water temperature and the initial value in the layer of 0–20 meters. The increase in temperature is the average of monthly temperature increases estimated for May–September in 2050 (variation 1.2–1.5°C). The temperature increase was calculated on the basis of the Finnish Meteorological Institute's estimate on the impact of climate change on temperatures in the 21st century (*Jylhä et al. 2004, the Finnish Meteorological Institute 2008b*).

As reference data in ice modeling, ice charts of the Finnish Institute of Marine Institute's ice service over the ice winter of 2002/2003 have been used *(Finnish Institute of Marine Research 2008b*). The ice charts are not very accurate and, as a result, the comparison can only be regarded as indicative. The model generated slightly less ice in the Bothnian Bay and a little more in Ruotsinpyhtää compared to the real situation.

In ice calculation, the model simulates heat exchange and the formation and melting of ice in the water surface layer, but it does not take into account the migration of ice or packed ice. As a result, in areas and over periods where ice movement is significant the model cannot represent the real ice situation.

7.4.3 Ecology, fish stocks and the fishing industry

The description of the water system's current status has been performed on the basis of currently available materials (including observation obligations, environmental administration's Hertta database). Impact assessment for the project has been carried out as an expert assessment.

Impacts have been inspected based on the results from cooling water modeling in the affected area indicated by the modeling. Impact assessment has utilized wide observation and research data collected over several decades concerning the impact of power plants' cooling waters in Finland (Loviisa and Olkiluoto) and abroad (such as Forsmark and Oskarshamn in Sweden) and research data on the living environment requirements for species.

7.5 Soil, bedrock and groundwater

The current status of the soil and bedrock and related environmental impacts in the areas of the alternative location sites for the nuclear power plants have been assessed using preliminary constructability studies and literary reviews performed by Fennovoima Oy. For the constructability studies, terrain inspections and ground surveys have been conducted with the aim of identifying the general features, topography and earthquake potential of the bedrock in the target sites. In addition, geological bedrock mapping has been performed during the inspections for mapping bedrock cleavage and cleavage features.

Groundwater impacts have been assessed on the basis of information obtained from the environmental administration's environmental data management system (HERTTA). The power plant's location relative to groundwater areas has been identified and any risks caused by construction work and operations on groundwater have been assessed on the basis of experience in and available reports of similar operations.

The environmental impact on soil, bedrock and groundwater at the nuclear power plant's construction stage is presented in Chapter 8.2 and at the operating stage in Chapter 8.5.

7.6 Flora, fauna and natural biodiversity

The observed area for impact on nature covers the surrounding areas of the nuclear power plant's location site at a radius of about one kilometer. In total, the survey area covers about four square kilometers. In addition, the survey covered all power lines and roads leading away from the plant area up to the preliminary master plan border and other action areas located outside the plant area, such as the harbor and intake and discharge areas for cooling water, have been inspected.

Nature surveys *(Pöyry Environment Oy 2008a, Pöyry Environment Oy 2008b, Pöyry Environment Oy 2008c)* include nature mapping in the areas, the project's nature impact assessment and consideration for the need of Natura 2000 assessment. Nature surveys compile available information about the area's nature, including literature, information about protected areas and materials for the register of endangered species. The information has been supplemented in terrain surveys during Summer and Spring 2008. In addition, the area's maps and new oblique aerial photos have been used as background material.

The principles of nature survey have been to identify the characteristics of nature and valuable nature sites in the area. Vegetation in the area has not been modeled and detailed species mapping has not been performed in the area, apart from a few species. As part of nature survey, the occurrence of the Siberian flying squirrel has been identified in the target areas in April–May 2008. Potential living environments for the species in the inspected areas were studied by identifying Siberian flying squirrel's droppings and suitable nest holes. The Siberian flying squirrel survey represents the status in the inspected area over the inspection period with regard to the species. The survey results have taken into account the most central potential living environments for the species.

The aim of the bird survey has been to achieve the most appropriate accuracy considering project planning. It is possible to identify areas or living environments with a significant bird population on the basis of observing species and by studying the suitability of living environments. Terrain observations have been made during the most favorable time, season and weather conditions considering mapping calculations. On the basis of the observations and living environment studies made, it is possible to form a representation of the area's bird population at a general level and the most important values for the bird population that are sufficient for project planning. Linear calculation was used as the bird stock calculation method in Pyhäjoki and Simo. In Ruotsinpyhtää, the bird stock surveys were conducted with the focus on shore forests, water areas, damp areas and grown forests. Felling areas and young sapling stands were partially crossed. The method was selected because of the biodiversity in the area. The bird stock surveys were conducted as several inventories during May–June 2008.

The impacts of projects and plans directed at Natura areas or their surroundings are to be assessed appropriately (*Nature Conservation Act, December 20, 1996/1096)*. With regard to the Natura 2000 network areas located close to the project areas, a Natura assessment review has been conducted. The review inspects the project's impact on habitat types and species that comprise conservation criteria for the Natura area. If the review states that the project will probably reduce the natural values used as conservation criteria for the Natura area significantly, an accurate Natura assessment will be prepared at a later stage.

7.7 Landscape and cultural environment

The assessment of impacts on the landscape and cultural environment *(Pöyry Environment 2008d)* has been based on previous reports, map and aerial photo surveys, geoinformation analyses, visits to the terrain in May 2008 and the project's preliminary plan material. In the description of the areas' current status, the basic landscape factors of each location site and their surrounding areas have been identified and valuable targets in the landscape and/or cultural environment known on the basis of available source material have been briefly listed. The impacts have been assessed in relation to the location sites alternatives' current status. However, the assessment has, where applicable, taken into account future projects that will significantly alter the landscape (any changes in land use, new traffic routes, wind power plants or equivalent) and that do not depend on the possible construction of the nuclear power plant. The assessment has utilized the oblique aerial photos and photomontages prepared for the project in Spring and Summer 2008.

In order to assess landscape and, in particular, visual impacts, three zones have been defined where the nuclear power plant's impacts on the landscape have different significance. The definition of the distance zones has been based on available reports of the impacts of tall structures of different types (power line columns, wind power plants, towers) when inspected at various distances and has taken into account the project's na-ture by slightly increasing the distances from the values calculated on the basis of previous reports.

Depending on the nature and limitation of the landscape status, the following distance zones have been used in this assessment:

- Zone 1: "dominant zone", distance from the power plant is about 0–3 kilometers – the power plant is a dominant element in all types of areas.
- Zone 2: "nearby area", distance from the power plant is about 3–6 kilometers – the power plant is visible in the environment but its size or distance may

The EIA process studied the changes in landscape brought about by the nuclear power plant. Historical industrial milieu in Ruotsinpyhtää, 2008.

be difficult to identify.

– Zone 3: "distant area", distance from the power plant is more than 6 kilometers – the power plant is visible but other landscape elements reduce its dominance as the distance increases. Structures are part of the distant landscape. If observed at a sufficient distance, the structures blend in the horizon.

The dominant zone (0–3 kilometers) has been emphasized in the impact assessment. The nearby area (3–6 kilometers) has been inspected at a more general level but the inspection has become more accurate if the power plant can cause significant impacts on a target located in the nearby area. If an impact has been regarded as clearly significant, a general review has been performed in the distant area and any observations have been entered in the assessment text.

Reports related to landscape impacts caused by tall structures, such as towers and wind power plants, have been studied for providing a background for the assessment. The conclusions of the inspections can also be applied to the assessment of the nuclear power plant's landscape and visual impacts, where applicable.

The project's plans will be specified and supplemented in the future. This may have some impact on how objects are visible when viewing from specific observation points or how the power plant's immediate surroundings will be changed. During assessment work, it was not possible or purposeful to examine all possible visibility axes from single observation points towards the plant area or prepare accurate assessments of the plant area's relation to its immediate surroundings because of the generality of planning.

7.8 Traffic and safety

The impact of transportation and commuter traffic has been assessed on the basis of the current traffic volumes and traffic volume estimates. Road improvements and new roads planned by the Road Administration have been taken into account in the assessment. Impacts of traffic have been assessed along new roads and roads leading to the location sites. In addition, the inspection includes traffic volumes in nearby main roads. The calculation methods for traffic volumes and the assumptions made are presented in the traffic volumes section in Chapter 3.

The impact of traffic emissions and noise has been assessed in the surroundings of these roads. Emission volumes have been illustrated by comparing them to the total traffic emissions in the areas surrounding the alternative location sites. Calculation methods for emissions are presented in the traffic emissions section in Chapter 3.

7.9 Noise

Noise impacts caused by the construction of the power plant alternatives have been assessed based on the calculation performed using a noise model built on the basis of the preliminary locations of power plant functions. *(Pöyry Energy Oy 2008a)* Noise caused by traffic towards the power plant area has been modeled using a common Nordic road noise model.

The observed area for noise impacts extends to the environment of the inspected noise sources at distances where noise values fall below the guideline values set for road noise.

The model calculates the progress of noise in a three-dimensional environment. The model takes into account the roughness of the ground, reflections from buildings and the acoustic impact of soil in the spreading of noise. The impact of forests and softer soil has been taken into account using limited ground absorption areas. A hard soil has generally been defined for industrial areas and water and road surfaces for simulating the reflection effect for sound. Noise sources can be defined as point, line or pattern sources.

Noise sources during construction included in the model include the rock crushing plant and related bucket loaders and the batching plant. In addition to individual noise sources, noise during construction has been modeled as an area source so that it covers the area of buildings of two SWR units which is the largest of the inspected options.

Noise sources during operations include unit generator transformers, the steam turbine and generator, blowers in the turbine house, the sea water pumping station, backup generator units, the gas turbine unit and traffic towards the plant area. The sound volume levels of the sound sources are based on estimated values and values measured from similar components.

Road traffic volumes have been estimated for noise calculation according to normal use and use during construction so that they correspond to the maximum volumes (2 x SWR plant) and driving speeds of 60–80 km/h. With regard to noise caused by traffic, the bridge to be built on Kampuslandet island in Ruotsinpyhtää has been included in the model using a specific bridge element.

The spreading of noise has been calculated so that environmental conditions are favorable for noise spreading. For example, there is a light fair wind from the noise source towards each calculation point.

The farther the noise source is, the more significant the impact of annual weather fluctuation and wind direction is for the true sound level in the area. As a result, the uncertainty of the calculation increases the longer the distance to the noise source is. Typically, the uncertainty is about ± 4 dB at a distance of one kilometer.

7.10 People and society

The nuclear power plant's impact on people and society has been inspected through an assessment of regional economic impacts where the project's impact during construction and operations has been taken into account. (*Pöyry Energy Oy 2008b*). The project's social impact assessment has been performed on the basis of a resident survey and interest group interviews *(Pöyry Environment Oy 2008e, Pöyry Environment Oy 2008f, Pöyry Environment Oy 2008g)*. Furthermore, impacts on people's living conditions, comfort and recreation have been assessed based on the different expert assessments prepared for the project's environmental impacts, such as impact on the water system.

The impact assessment has been supported by the National Research and Development Center for Welfare and Health's (Stakes) manual entitled "Assessment of Impact on People" *(STAKES 2008)* and the guidelines of the Ministry of Social Affairs and Health concerning environmental impact assessment for assessing impacts on people's health, living conditions and comfort (*Ministry of Social Affairs and Health 1999*).

7.10.1 Assessment of regional economic impacts

Regional economic inspection is based on the regional economic scientific approach. The starting point is that the nuclear power plant is a large building project and, if implemented, a significant regional employer. The construction, operation and annual maintenance of the nuclear power plant have numerous impacts on entrepreneurship, service selection and the labor market in the location municipality, its surrounding economic area and Finland as a whole. These factors are reflected on regional migration, population structure and population development that will have an impact on the housing and property market. The location municipality will collect property tax for the nuclear power plant starting from the construction stage and its amount will be highest when the plant is completed. Increased municipal tax income, improved employment and increased regional income and consumption will also benefit the surrounding economic areas. These will have an effect on state subsidies received by municipalities and the demand for different services.

Employment impact has been inspected separately at the construction and operating stages. Both direct and indirect employment impacts have been inspected in both stages. Direct employment impacts refer to design and construction work required by the investment as implemented directly by the builder, contractors, subcontractors and service suppliers. In addition to direct impacts, the investment will create a long delivery chain for intermediate products. Intermediate products refer to the building materials and suppliers required by the investment, as well as transportation services, subcontracting and other services needed by the investment. The production of intermediate products re-quires that products and services are acquired further from the next level. This will create a chain of indirect cascading and employment impacts. Both direct and indirect employment impacts will create salary income to be used for consumption. Increased consumption can be seen in the operations of shops and other companies and in the use of labor force. Increased consumption will increase the number of people employed indirectly through the investment.

The assessment of the project's direct and indirect employment impacts has utilized the 2005 work input tables published by Statistics Finland. Investment data and employment impacts serve to assess the amount of property and municipal tax. In this report, corporation tax impacts and employment impacts of increased consumption have only been assessed at a qualitative level. In addition to the actual plant investment, this report also inspects the employment impacts of connected projects (such as the harbor and power lines).

The analysis of the current status of the inspected economic areas has only used public data sources, such as statistics published by Statistics Finland and the Ministry of Employment and the Economy.

Initial information and assumptions

The employment and economic impacts have been inspected in cases of one and two units. The total domestic content of the acquisitions is estimated at 35–45% (Table 7-1). The investment's very preliminary cost in case of one unit is estimated at EUR 4,000 million (investment A) and in case of two units at EUR 6,000 million (investment B). The total investment consists of several acquisitions made by Fennovoima. The investments include all of the project stages from design to commissioning. Connected projects are presented separately in this report.

The investments' cost structure is estimated as follows:

- Machinery and equipment, including installation work (share of the total investment is 55%)
- Construction work including excavation and plant construction (35%)
- Project, services and other costs (15%)

The total domestic content of the acquisitions is estimated at 35–45%.

Definition of economic areas

The assessment of regional economic impacts has mainly been carried out to the scale of economic areas, but some of the results are also presented for Finland as a whole and the location municipality. For example, property tax is only targeted directly at the location municipality. Division based on sub-regions has been used in the definition of the economic areas as much as possible. In some cases, it has been useful to inspect more municipalities because of their close location or if they share a common border.

The Raahe economic area defined for the Pyhäjoki option includes Pyhäjoki, Alavieska, Kalajoki, Merijärvi, Oulainen, Raahe, Siikajoki and Vihanti (Figure 7-3). The Loviisa economic area defined for the Ruotsinpyhtää option includes Ruotsinpyhtää, Lapinjärvi, Liljendal, Loviisa, Pernaja and Pyhtää (Figure 7-4). The Kemi-Tornio economic area defined for the Simo option includes Simo, Ii, Kemi, Keminmaa, Tervola and Tornio (Figure 7-5).

Assessment methods for employment impacts

The project's employment impacts have been inspected during the construction and operating stages. The inspections have been carried out for the entire country of Finland, or at the economic area level. The investment's employment impact at the national level is assumed to be the same regardless of the plant's future location.

Table 7-1. Initial data and assumptions in the assessment of regional economic impacts.

	Investment A	Investment B
Project duration, years	6	8
Regular employees, person work years/year	300	400
External services, person work years/year	100	100
Outage duration, weeks	1–3	2–6
Employees in the outage, people	500	500
Property taxation value, € million	150	200
Average income, €/year	35,000	35,000
Domestic content, %	35–45	35–45

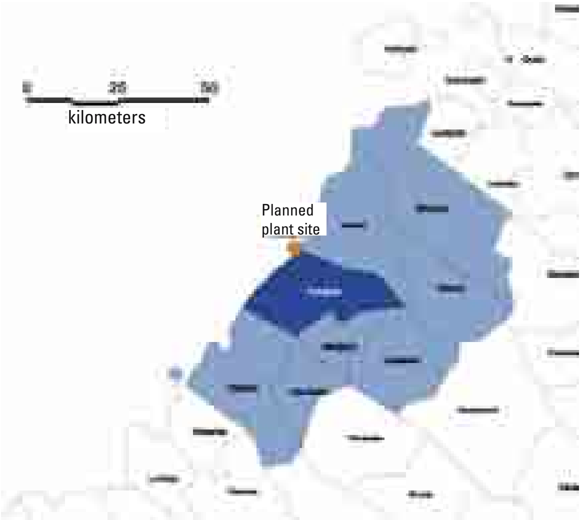


Figure 7-3. Raahe economic area defined for the Pyhäjoki option in the regional economic examination.

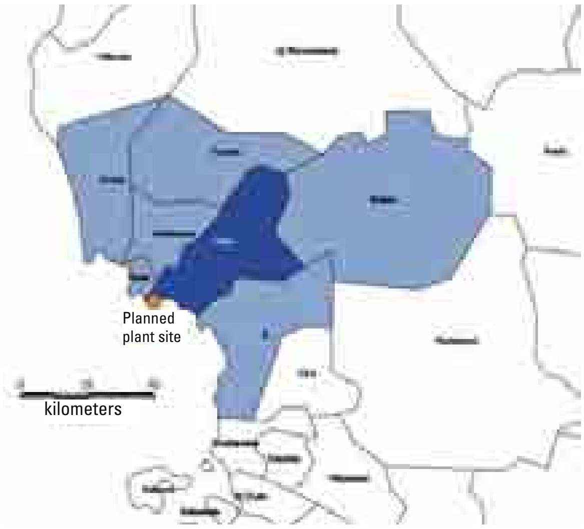


Figure 7-5. Kemi-Tornio economic area defined for the Simo option in the regional economic examination.

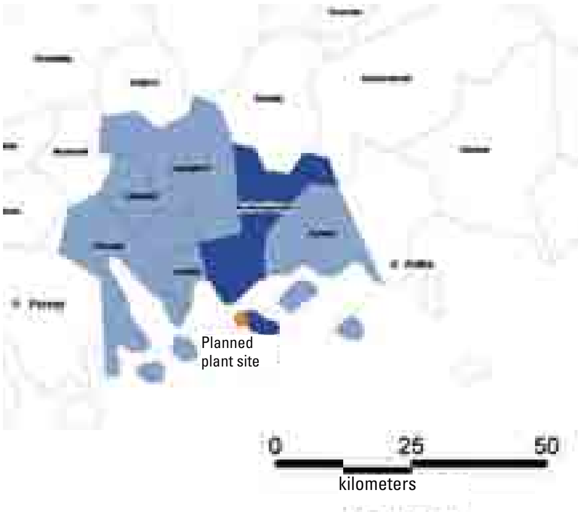


Figure 7-4. Loviisa economic area defined for the Ruotsinpyhtää option in the regional economic examination.

Employment impacts during the project's construction stage have been examined for machinery and equipment acquisitions and installation, building engineering work and other services related to the construction of the power plant. The assessment of the employment impacts is based on the content of domestic work in the project and the work input factors published by Statistics Finland.

On the basis of previous experience and reports, about 20 percent of the project's direct and indirect employment impacts targeted at Finland during the construction stage could be allocated in the location municipality and its surrounding economic area. The employment impact has been stated to mainly involve construction work and services required at the work site. The share is limited by the special competence required in certain tasks and the limited availability of competent labor within the economic areas. The need for local labor is divided over the entire construction period but the early stages are more emphasized. At the final stages, the emphasis will be placed on installation of machinery and equipment where the domestic content is lower. In this report, variation of 20–25% has been used as the employment impact allocated in the economic areas depending on the location municipality, and it is fully targeted at construction work and the services required in the site project.

Employment impacts during operations are based on information available on the operations of existing plants. The employment impacts during operations in the economic areas depend on how many of the area's residents will be employed at the power plant and how many employees will move permanently to the economic area. This report assumes that 85% of regular employees and external service providers will settle permanently in the economic area, in which case the employment impact at the operating stage will largely be targeted at the region in question. The estimate of the number of employees to settle in the economic area is the same in every location municipality and corresponds to the distribution realized in the case of the current Loviisa nuclear power plant.

Assessment methods for tax impacts

The investment will have an impact on the municipalities' economy particularly through property and income taxes. The municipal council can separately prescribe the tax percentage to be applied to the power plant and its buildings and structures. The maximum property tax for a nuclear power plant prescribed by law is 2.50%. A nuclear power plant building's taxation value is the replacement value less 2.50% annual age deduction. However, the taxation value will always be at least 40% of the replacement value.

The evaluation of property tax is based on the property's assumed value in cases of investment A and investment B. For investment A, the estimated value of the property upon its completion is EUR 150 million and, for two reactors in investment B, EUR 200 million.

The calculation of the tax income impact at the construction stage is based on the project's employment impacts. Tax is accumulated directly and indirectly from those employed. The employees' annual gross income at the construction and operating stages is estimated to amount to EUR 35,000. The municipal tax rate used for all location mu-nicipalities is 20% and the net tax rate after deductions is estimated to be 16% (80% of the municipal tax rate).

Corporate tax comprises income tax to be paid by limited companies and other corporations and it amounts to 26% of the corporation's taxable income. The corporation's taxable income is calculated as a difference between income subject to tax and deductible expenses. All companies pay corporate tax on their earnings.

Profit from corporate tax is divided between the state (76%), municipality (about 22%) and the Evangelic Lutheran Church and the Orthodox Church (about 2%). Corporate tax is divided in the relation of municipal-specific number of personnel in the corporation's offices.

The share of municipalities in corporate tax income has been 22.03% since 2004.

Assessment methods for other regional economic impacts

The assessment of impacts related to the property market, population number and population structure is based on previous reports and information available on existing plants.

Application of the state balancing system

According to the definition of Statistics Finland, state subsidy is, on the basis of the Act on Central Government Transfers to Local Governments (December 20, 1996/1147) and the Decree on Central Government Transfers to Local Governments (December 30, 1996/1271), an income balancing system prescribed for the division of expenditure between the State of Finland and municipalities, and its purpose is to balance the financial differences in the income base, cost structure and service needs of municipalities. State subsidies are calculated and determined on the basis of the age structure of a municipality's population or the number of students in education and unit costs of different services.

On the basis of annual taxation, the state subsidies are balanced, i.e. tax revenue balancing is carried out. A municipality's calculated tax revenues are compared to the balancing limit and, on the basis of the comparison, the municipality's state subsidies are balanced through an increase or a deduction. The balancing limit is 91.86% of all of the state's calculated tax revenue divided by the state's population. In 2008, the limit is EUR 2,680.43 per inhabitant. The balancing deduction for the part that exceeds the balancing limit is 37%. If a municipality's calculated tax revenue falls below the balancing limit, the municipality will obtain a balancing increase in its state subsidy and it is the difference between the balancing limit and the municipality's calculated tax revenue per each inhabitant. If a municipality's calculated tax revenue exceeds the balancing limit, the municipality will obtain a balancing deduction in its state subsidy and it is 37% from the difference between the balancing limit and the municipality's calculated tax revenue per each inhabitant. Increase in tax revenue will always reduce the municipality's subsidy received from the state and the state will distribute the savings to poorer municipalities. (*The Association of Finnish Local and Regional Authorities 2008a, the Association of Finnish Local and Regional Authorities 2008b*)

In the assessment of economic impacts, the effect of the balancing system has been assessed against property tax revenue received by municipalities. Property tax paid on the nuclear power plant has two parts, one of which is under the state balancing system and the other is outside it. The part of property tax which is under the state balancing system is 0.75%. The rest of the property tax revenue produced by the nuclear power plant is outside the state balancing system and remains in the municipality in full. If the highest allowed property tax percentage (2.50%) is used in the nuclear power plant's taxation, the municipality will always receive a share of at least 70% of the increased property tax revenue.

Uncertainties in the assessment

The initial data and assumptions used in the assessment of economic impacts are based on implemented projects and other reports where they have been proven to be reliable. The most significant uncertainty in the initial data is related to the amount of the total investment which is based on very preliminary estimates in this report.

Furthermore, the methods are the same that have been used in other similar regional economic studies. The initial data and the results and conclusions obtained based on the data can be estimated to be correct.

The assessment of the project's economic impacts includes notable uncertainties. This is a future project, in which it is impossible to make accurate predictions. The final economic impacts depend on economic cycles, the number of unemployed people and the availability of the labor force at the time. Municipalities and economic areas can also have an influence on how extensive employment impacts there will be in the area.

7.10.2 Social impact assessment

The affected area of impacts on people cannot be defined as a single geographic area. For example, changes in the landscape are mainly experienced in the immediate surroundings of the planned power plant site, but employment impacts can concern the entire region. The observed area of impacts has been defined fairly widely in this report: at the microlevel, the observed area covers the immediate surroundings of the nuclear power plant site in each alternative location municipality (an average radius of 5–10 km from the new nuclear power plant site presented in the EIA programme) and, at the macrolevel, it covers the subregion of each alternative municipality.

Materials

In order to carry out the project's social impact assessment, a number of data sources and methods have been used to achieve a reliable result (Figure 7-6). The aim of the assessment was to present views on the nuclear power plant project's impacts during its design, construction and operating stages, and to take comprehensively into account any factors that cause impacts on people. Another objective was to present any changes caused by the project or plan to people's quality of living or the area's development and resulting impacts. The meaning and significance of the changes were assessed for different operators and groups of people.

Furthermore, ecological, landscape or health impacts include social impacts. Changes in the landscape will have an impact on people's living conditions. Social impact assessment (SIA) pays attention to the social significance of ecological and landscape impacts. As a result, other environmental impacts are also important data sources in social impact assessment.

For assessing the impacts on people and recognizing the interest groups, the opinions on the environmental impact assessment programme, related newspaper articles and Internet discussions were examined. By analyzing the material, it was possible to generate a comprehensive view of the discussion themes and points of view related to the topic.

Methods

In order to support social impact assessment, group interviews were organized in all of the alternative municipalities. Their purpose was to identify the opinions of residents living close to the project *(Pöyry Environment Oy 2008e, Pöyry Environment Oy 2008f, Pöyry Environment Oy 2008g)* and parties operating in the project's immediate surroundings on the project. The interviews served to collect experience-based information on the local parties' living environment. Thus, it was possible to supplement the information available from previous reports, investments and various registers.
In addition, small group events served to deepen and specify the information obtained through the resident survey conducted in connection with the EIA procedure concerning impacts on people and society.

Those invited to the group interviews belonged mainly to the project's monitoring group. The interviewees were first contacted by telephone in order to agree upon an interview date, after which all of those invited were

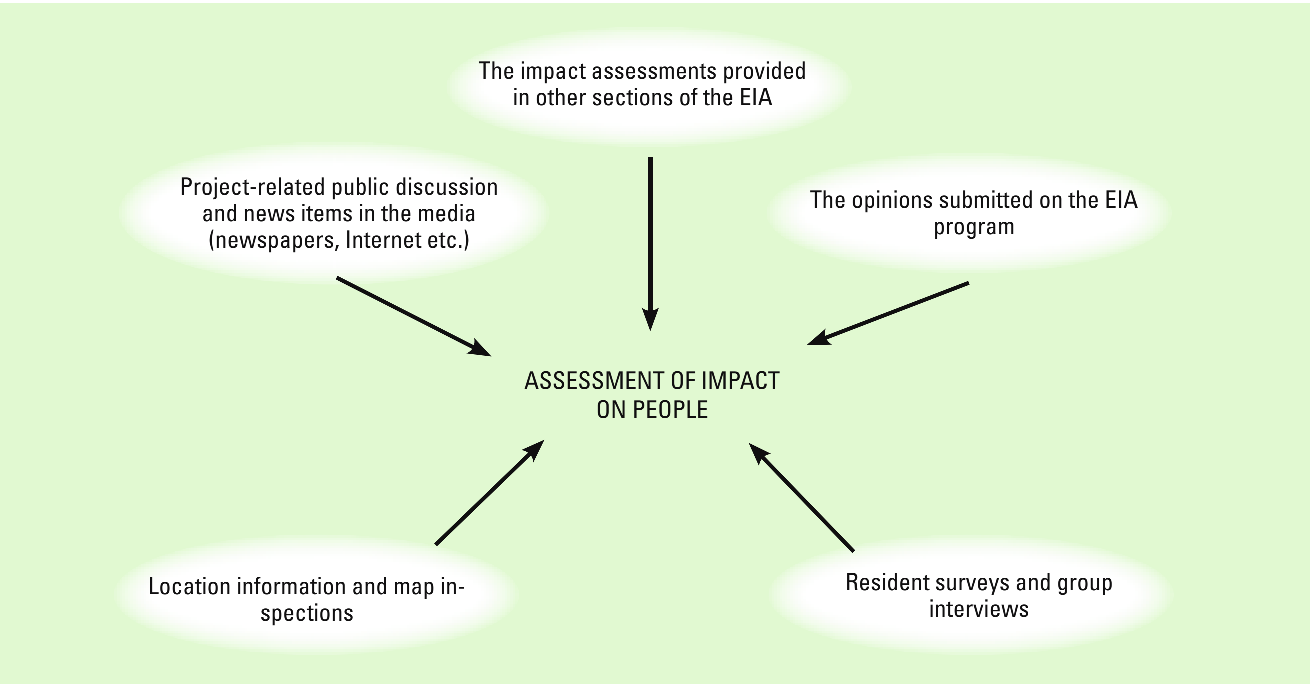


Figure 7-6. Material used in the assessment of impacts on people.

provided with information about the interview and discussion themes by post or e-mail. The size of the groups interviewed varied from three to thirteen people. An average of six to eight people were included in each event. In order to facilitate participation, the interviews were held as close to the invited parties as possible. The majority of those invited came to the group interview.

The group interviews were carried out as free-format theme interviews. The events were held in two languages in the affected area of Ruotsinpyhtää. At the beginning of the events, the representative of the company responsible for the project presented the project background briefly and responded to any questions raised. Then, the representative left the event and the group interview was conducted as a free-format, semi-structured theme interview where the interviewer steered the discussion on the basis of the interview structure prepared in advance and sent to the interviewees. The interviewees were provided with the possibility to share their opinions and impacts they felt important. The interviews took two to three hours. The quotations presented in reporting are not word-for-word quotes. The information used in the interviews on the design status was based on the issues presented in the EIA programme that the representatives of the company responsible for the project supplemented in their project presentations.

When inspecting the group interview results, it should be noted that the opinions and views of the interviewees do not necessarily represent the general opinions of residents and operators in the planned nuclear power plant's immediate surroundings. The opinions of a larger group of residents on the impacts of the new nuclear power plant were identified through a resident survey organized in Spring 2008.

There was a survey made among the people living near each of the alternative locations, sent to people either living in the sampling area or owning a holiday home there. A Swedish language questionnaire was also sent in bilingual areas. The survey produced information concerning large groups of people. It served to identify people's ideas of impacts of the nuclear power plant project on the living conditions and comfort of inhabitants and holiday residents and to obtain information about local conditions and issues felt by the inhabitants to be important for supporting the social impact assessment. The resident survey was organized in March–April 2008.

The sample for the survey included all those living within a five kilometer radius of the plant, both permanent and holiday residents. There was also a randomized sampling including 10% of those living within a radius of 5-20 kilometers of the plant, both permanent and holiday residents. One person of age was selected from each household. The age and gender distribution for the sampling was selected according to natural distribution. Addresses were selected from the population register by Itella TGM Oy. The sampling quantities and response percentages are presented below on a municipality-specific basis (Table 7-2).

Uncertainties in the assessment

Different individuals and population groups feel the new nuclear power plant project's impacts differently. It is extremely challenging to organize a fully comprehensive method of participation. This report has aimed at interviewing parties in each municipality that have been able to provide information and opinions on the areas surrounding the planned nuclear power plant and a wider region. The resident survey's response percentage was relatively high in each municipality and, as a result, a comprehensive view of the impacts experienced for the project can be generated. It is very challenging to assess the meaning and significance of changes in the social environment for different parties and groups of people because of the diversity of individuals and population groups and the range of the impacts experienced.

It is difficult to produce a complete assessment of the project's indirect social impacts because of the generality of the design data and the very long time span of the nuclear power plant's design, construction and operating stages. The objective has been to produce as versatile and local experience-based material on the project's social impacts as possible to support decision-making and further planning.

Table 7-2. Sampling quantities and response percentages per municipality for resident surveys.

Municipality	Sampling quantity	Response percentage
Pyhäjoki	589	52.8
Ruotsinpyhtää	948	33.3
Simo	1648	29.6

7.10.3 The health impact

The radiation dose caused by radioactive emissions during the nuclear power plant's operations has been assessed on the basis of the emissions of the current nuclear power plants in Finland. Health impacts caused by radiation have been assessed on the basis of a radiation dose for an individual belonging to the most exposed group of population in the surrounding areas of the existing power plants. The project's other health impacts have been assessed by comparing the plant's impacts with the guideline and limit values.

7.11 Chemicals

Chemicals used at power plants, their handling and storage arrangements and the management of chemical accident risks have been described on the basis of information available on similar plants and the obligations set by environmental and chemical legislation.

7.12 Waste

This EIA report has assessed the environmental impact arising from the handling and storage of regular, hazardous and operating waste and spent nuclear fuel produced at the nuclear power plant. The environmental impact of the disposal of spent nuclear fuel has only been described roughly, because a separate EIA procedure will be prepared later for the final disposal and related transportation of nuclear fuel.

Regular and hazardous waste

The volume, quality and handling of regular and hazardous waste has been described and their environmental impact has been assessed, according to the information available and the preliminary inspection project conducted during the project.

Operating waste

The volume and quality of radioactive operating waste and the environmental impact of waste handling, storage and final disposal have been assessed based on a report of handling and disposal alternatives for waste *(Platom Oy 2008)* and other research data and reports.

Spent nuclear fuel

The impact assessment and report are based on the recent reviews prepared in Finland and other countries, mainly including available research data about Sweden that can be applied to Finnish conditions.

7.13 Decommissioning of the power plant

This EIA report describes the decommissioning of the power plant and resulting environmental impacts. The description of the environmental impacts is based on the experience of Fennovoima's technical partner, E.ON, and Pöyry Energy, as well as on material on nuclear power plants' decommissioning projects. The environmental impacts of decommisioning the new nuclear power plant will be evaluated in a separate EIA procedure.

7.14 Irregular and accident situations

Nuclear power plant incidents and accidents can be categorized using the international INES scale into categories 0–7 which illustrates the severity of nuclear power plant incidents and which is described in more detail in Chapter 8.15. Categories 1–3 describe incidents that have decreased safety and categories 4–7 represent accidents. In order to assess impacts caused by a nuclear power plant accident, the spreading of radioactive emissions caused by a serious reactor accident (INES 6) have been modeled as an example case, as well as the resulting fallout and radiation dose for the population. Using the modeling results, the environmental impacts caused by an accident of Category 4 on the INES scale have also been assessed.

In order to assess the impact of an accident, a situation has been inspected where emission in the environment starts six hours after the start of the accident and lasts an hour.

According to the limit value set by the Government Decision (395/1991), the caesium-137 emission caused by an INES 6 accident is 100 TBq. The emission of other nuclides has been calculated on the basis of the relationship between the nuclides and caesium-137 in nuclear fuel considering that, depending on the nuclide, the release from the fuel may vary from 0.1 to 100 percent. The release portions used are based on experiments and results obtained through calculated models. The emission of radioactive iodine-131 is estimated to be 1,000 TBq. The model includes such a number of nuclides that corre-sponds to more than 90 percent of the radiation dose caused. As iodine-131 equivalent, the emission corresponds to a total of 30,000 TBq, i.e. the accident can be classified as being Category 6 or 7 on the INES scale (Chapter 8.16.1).

The spreading calculation of radioactive emissions is based on the Gaussian spreading model and its versions suitable for short and long distances. The model assumes that wind direction or speed will not change during spreading. The spreading calculation does not depend on the accident site or the prevailing wind direction. The spreading of a radioactive emission has been modeled at a distance of 1,000 km from the nuclear power plant. The dose calculation also extends to this distance.

Because the accident is serious, it is likely that the emission rather takes place through the damage to the power plant building than through the exhaust air shaft in a controlled manner. When released, the emission contains thermal energy which increases its release level even higher. As a result, the emission is expected to be released at a height of 100 m.

On the basis of weather information available from the location sites, typical weather conditions and disadvantageous weather conditions considering the impact of the accident have been defined for the assessment. Rain is a central weather factor for impacts. The radioactive cloud generated by the emission may travel long distances in dry weather. While traveling, some of the radioactive substances fall to the ground as a result of gravity (i.e. fallout). When it is raining, radioactive substances fall down more efficiently depending on the amount and force of rain.

The impacts of the accident have been assessed in a situation where radioactivity spreads in the location areas under the most typical weather conditions and without rain. In addition, the impacts have been assessed in a situation with the most disadvantageous weather conditions where it has been noted that rain may occur at any distance from the plant at the worst possible time for the emission cloud. The methods and work content have been discussed with the Radiation and Nuclear Safety Authority's experts at the work design stage and the report draft stage. Methods in accordance with the German standards (*Strahlenschutzkommission 2003*) have been used in the dose calculations. The methods are used in German safety assessments related to the licensing process for nuclear power plants. The method is roughly similar to methods used in other countries. In reality, the radiation doses caused by a serious accident are most likely smaller than the results given by the model because the calculation method and the assumptions selected overestimate the doses.

The radiation dose caused by a radioactive emission has been calculated separately for 1–2 year old children and adults, because the generation and impact of radiation expo-sure is different for the population groups.

Radiation exposure takes into account external radiation, i.e. radiation caused by the emission cloud and fallout, as well as activity entering the body through respiration and nutrition. The calculation of the radiation dose accumulated through nutrition takes into account the contamination of plants used directly as nourishment (including the fallout and radioactive substances migrating to the plant from contaminated soil through roots) and the radiation dose accumulated through different food chains.

People are not expected to change their habits as a consequence of an accident. As a result, the model is slightly more conservative, i.e. the impacts are overestimated.

Nutrition or feed produced at a distance of under two kilometers from the power plant is not expected to be used. Farther away, the assumption is that all nutrition is produced locally for the area where it is consumed. Because the consumption of nutrition produced only locally is not realistic, this assumption causes the method to overestimate the radiation doses at a distance of more than two kilometers. Control groups of different ages have different eating habits in the inspection. The typical Finnish diet has been taken into account. In addition, the breathing capacity differs between children and adults.

People are not expected to protect themselves in any way; instead, they are expected to stay outdoors around the clock as the radiation cloud travels over them and be exposed to the radiation caused by fallout without using any protection. This would not be the case in reality and, as a result, the resulting radiation doses are overestimates.

7.15 Production chain and transportation of nuclear fuel

The description of the impacts is based on E.ON's expertise in fuel procurement and supplier audits, information obtained from different suppliers in the fuel chain, generally available information and information produced by nuclear energy producer organi-zations and different fuel chain operators.

7.16 Fennovoima shareholders' possibilities for energy saving

A report of Fennovoima shareholders' energy-efficiency actions was carried out in May–June 2008 *(Fennovoima Oy 2008)*. The report identified the shareholders' energy savings and efficiency.

The report analyzed quantitative and qualitative information about the owners' energy efficiency activities. Questions were prepared so that they included already completed and future measures. The questions were also used to identify the methods of the shareholders' energy saving and efficiency activities. The questions were prepared so that all shareholders, regardless of the business field, were able to respond to them.

The environmental impacts on the aquatic environment are also assessed. Sea view in Simo, 2008.

The nuclear power plant's most significant impact on the site's soil, bedrock and groundwater will be caused at the plant's construction stage.

8 Environmental impact assessment for the project

8.1 Land use and the built environment

8.1.1 Pyhäjoki, Hanhikivi

8.1.1.1 Current land use

The immediate surroundings of the Hanhikivi headland are sparsely populated. The closest urban area with a town plan is the center of Pyhäjoki. There are no permanent settlements on the Hanhikivi headland. Primary forms of land use include forestry and outdoor activities. Holiday homes are located on the southwest coast of the headland. A public beach is also located there. The northeast coast is mainly in its natural state. Hanhikivi, a large erratic boulder, which is classified as a historical monument is located at the tip of the headland, on the border of Pyhäjoki and Raahe.

Approximately 11,300 people live in a radius of 20 kilometers and this area includes the Pyhäjoki settlement and part of the Raahe urban area. Village areas in the surroundings include Parhalahti, Piehinki and Yppäri. The seaside areas contain a number of holiday homes. There are approximately 370,000 people living within a hundred kilometer radius of the planned nuclear power plant area. This area covers the Oulu region.

There are no industrial operations in the Hanhikivi headland area or its surroundings. Jobs are located in urban areas. In addition, there are no large cultivated areas close to the planned site.

The Parhalahti area contains some twenty active farms, half of which are plant cultivation farms. In addition, there are a few animal farms. The area has a total cultivation area of about 600 hectares. About 280 hectares covers grain cultivation and 230 hectares covers grass cultivation. Furthermore, there are about 60 hectares of natural shore pastures in Maunus south of Hanhikivi.

The majority of the fundamental services and retail shops in the region are located in the Pyhäjoki central settlement and the Raahe town center. Pyhäjoki, Yppäri, Pirttikoski and Parhalahti village, as well as the Piehinki village centre in Raahe, have lower comprehensive schools.

Highway 8 runs east of the Hanhikivi headland, at a distance of approximately 5 kilometers. There is a private road from the Parhalahti village to the Hanhikivi headland along the southwest coast of the headland. The Tankokarinnokka fishing port can be reached through the road, as well as the holiday homes located on the southwest and west coasts of the headland.

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

The nearest significant port is located in Raahe. Plans have been made to make the cur-rently 8.0 meters deep route of the Port of Raahe 10.0 meters deep in 2007–2008 (*Port of Raahe 2007*). The sea route leading south from the port towards Kvarken runs at a distance of approximately 15 kilometers from Hanhikivi.

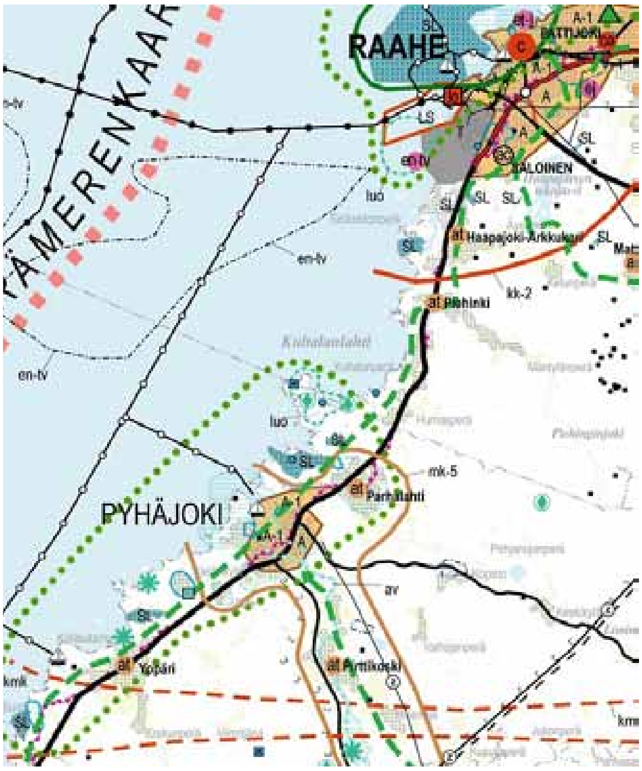


Figure 8-1. An extract of the Oulu region's regional plan.

The nearest airport is located in Oulu, some 100 kilometers from Pyhäjoki.

8.1.1.2 Planning situation

The Northern Ostrobothnian Regional Land Use Plan was ratified in the Ministry of the Environment on February 17, 2005 and became legally valid after the Supreme Administrative Court's decision on August 25, 2006. The Hanhikivi area emphasizes natural and cultural values and the development of recreation (Figure 8-1). The Hanhikivi area has been marked as a particularly important area in terms of biodiversity due to its habitat types and species on the isostatic uplift coast. The headland contains nationally valuable rock areas for nature and landscape protection and regionally valuable traditional biotope sites, and a nature conservation and Natura area is located on its southeast and south side. The area is included in the natural multipurpose area marking which covers the Pyhäjoki coast and which indicates areas that include valuable nature sites to be developed for recreation. Hanhikivi is a nationally significant historical site and the old Parhalahti fishing coast is part of national cultural environment. The green belt marking along the coast passes through the headland. Furthermore, the development zone marking in the Bothnian Bay applies to the entire coastal area. The Parhalahti village has been indicated as a village with a strong operating base. The sea area off Pyhäjoki-Raahe contains a large reservation for a wind power plant area.

On April 7, 2008, the Regional Council of Oulu Region decided to launch preparations for a Regional Land Use Plan for the nuclear power plant project. The participation and assessment scheme for the Regional Land Use Plan is on public display from August 4 to August 27, 2008.

A legally effective comprehensive shore Local Master Plan is in progress in Pyhäjoki. The comprehensive shore Local Master Plan proposal has been on public display in Spring 2008 with regard to the shoreline in Pohjankylä, Etelänkylä and Yppäri. Investigation for the nuclear power plant caused changes to the planning schedule and excluded the Parhalahti shore from the comprehensive shore planning.

The Parhalahti village area has a legally effective component Local Master Plan in effect. The old Parhalahti component Local Master Plan without legal effect and approved on December 16, 2008 is still valid for small parts of the Parhalahti shoreline. In other parts of the shoreline area, the old Pyhäjoki coast comprehensive shore plan without legal effect is in effect.

The small Mustaniemi area is located at the south end of the Hanhikivi headland which has a valid comprehensive shore Local Detailed Plan.

For Raahe, land use in the Hanhikivi headland area is prescribed by the Regional Land Use Plan, the Raahe Local Master Plan approved by the town council in 1979, III zone and the component shore Local Master Plan for the south coast area of Raahe which will be revised in 2009.

The comprehensive shore Local Master Plan area in the south coast area of Raahe includes valid Tyvelänranta and Piitana shore Local Detailed Plans.

Other component Local Master Plans located in the nearby areas include the Piehinki component Local Master Plan immediately north of the nuclear power plant's component Local Master Plan area and the Raahe gold mine's legally effective component Local Master Plan which became pending in 2007 and covers a large area east of the nuclear power plant. The component Local Master Plan for the gold mine has required a large-scale environmental impact assessment and the results completed in April 2008. The revision of the Haapajoki-Arkkukari component Local Master Plan became pending in 2007.

For community structure reasons, it is not useful to indicate construction intended for permanent residence in the nuclear power plant's nearby areas in Raahe. The revision of the comprehensive shore Local Master Plan of the south coast area in Raahe will become pending in 2009 because the area involves construction pressure for all-year holiday homes.

The municipality of Pyhäjoki and the town of Raahe have initiated Local Master Plan and Local Detailed Plan for the Hanhikivi area at the beginning of 2008. By Summer 2008, planning had proceeded from the initial stage to the preparation stage, and preliminary draft plans have already been drawn up. The participation and assessment scheme for the component Local Master Plans and Local Detailed Plans has been placed on public display on June 30, 2008.

8.1.1.3 Impacts on land use

On the Hanhikivi headland, the construction of the nuclear power plant will alter land use at the actual plant site and its surroundings. The actual plant site will be built and fenced, because of which routes in the headland will change. The purpose of use in the majority of the headland will change. Currently, the actual plant area does not have any specific land use so the change will not be significant. Some of the holiday residences on the southwest and west coast will be removed and the southwest and west coast cannot be used for recreational purposes. Instead, land use on the northwest coast which is a significant area for nature protection and recreation will mainly remain unchanged. Hanhikivi can still be accessed but the access direction will change. The new road connection planned for the plant will not cause any significant changes in land use in the area.

The power line leading to the plant will restrict land use on a strip 80–120 meters wide depending on the column type. Apart from regular fences, no structures or devices can be installed between the column structures and at a distance of less than three meters. Ditches or other excavation cannot be made or rights of way cannot be established at a distance of less than three meters from the column structures. Trees cannot be grown or maintain buildings or other structures taller than two meters in the power line clearing and buildings cannot be built in the immediate vicinity of the power line clearing. Furthermore, any activities that may cause danger to the use and maintenance of the power lines cannot be engaged in in the power line clearing or its immediate vicinity. The power line will be built up to the current line located at a distance of about 20 kilometers. The power line needs to be indicated normatively in the regional plan throughout its length. In the Local Master Plan, the location should be specified in the Hanhikivi headland area.

The construction of the power plant will have an impact on the municipalities' community structure by restricting land use in the plant's safety zone and by enabling new construction in settlements and villages and along roads. There will be a restriction or delimitation of building activities in an area starting from the northern edge of the Parhalahti village and extending towards the Hanhikivi headland, concerning the construction of new homes and other structures related to the community functions of inhabitation, such as hospitals, day-care centers and schools. Holiday housing will continue to be possible, as well as outdoor activities, recreation, agriculture and forestry. More detailed limitation of the safety zone will be defined in master planning for the area. The plant will not restrict land use outside the safety zone. The construction of the plant will change the bases of land use outside the safety zone, particularly in the villages and settlements of Raahe and Pyhäjoki, by providing new land use opportunities for building workplace and residential areas and services.

The significance of the Raahe region as a strong industrial region will become stronger, in which case the conditions for developing land use will improve.

8.1.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

8.1.2.1 Current land use

Two sites in Ruotsinpyhtää have been planned for the power plant, northern Gäddbergsö and southern Kampuslandet island.

Land use in the surroundings of the planned plant sites mainly includes forestry-dominated areas. The immediate and more distant surroundings of both alternatives include holiday homes located on the coast. There are a few single all-year houses in the southern part of Gäddbergsö. Tallbacka village is located opposite to Kampuslandet in the northeast.

Some 11,250 people live inside a radius of 20 kilometers from Kampuslandet and about 11,900 people within the same radius from Gäddbergsö. Parts of the municipalities of Ruotsinpyhtää, Pyhtää, Pernaja and Lapinjärvi and the town of Loviisa are located inside this area. There are approximately 1,700,000 people living within a hundred kilometer radius of Kampuslandet. This area covers the Helsinki Metropolitan Area.

There are about ten active farms in the south part of Ruotsinpyhtää, south of Highway 7. Two of these are cattle farms and the rest are plant cultivation farms. The area has a total cultivation area of about 500 hectares.

The majority of the environment's fundamental services and retail stores are located in the municipalities' settlement and village areas at least ten kilometers from the power plant site.

The Gäddbergsö site can be accessed by road from Highway 7 through the junction east of the town of Loviisa and the continuing Saaristotie road. There is no road connection to Kampuslandet.

The nearest railroad leads from the Loviisa Valko Harbor to the city of Lahti. This railway section is only used by freight traffic. The nearest passenger train station is in Kotka, some 55 kilometers away from the Kampuslandet area by road.

The nearest airport is Helsinki-Vantaa, approximately 100 kilometers away by road. There are two harbors in the nearby municipalities: Valko in Loviisa and Isnäs in Pernaja. Additionally, there are harbors in Kotka and Hamina.

Figure 8-2. An extract of the regional plan approved in the Regional Council of Itä-Uusimaa on November 12, 2007.

8.1.2.2 Planning situation

On November 12, 2007, the Assembly of the Regional Council of Itä-Uusimaa approved the new total Regional Land Use Plan for the region (Figure 8-2). A complaint has been filed concerning the approval decision on the Regional Land Use Plan and, as a result, the plan is not yet valid. Part of the southern shores of Gäddbergsö and Kampuslandet are listed as being valuable island scenes in the Regional Land Use Plan. A valuable geologic formation is indicated on the southwest tip of Gäddbergsö (a rock area). The safety zone of the Hästholmen nuclear power plant in Loviisa limits Gäddbergsö and part of Kampuslandet inside the zone.

The Regional Council is launching regional planning in stages in 2009, during which it will be possible to investigate the land use needs of the new nuclear power plant. Alternatively, the Regional Council has considered launching the previous regional planning in stages for the nuclear power plant's land use solutions during 2008.

In the valid Vahterpää-Gäddbergsö master plan, the area contains reservations for holiday home areas and agriculture- and forestry-dominant areas. The area does not have a Local Detailed Plan. Kampuslandet does not have valid Local Master Plan or Local Detailed Plans. The municipality of Ruotsinpyhtää will, upon the completion of the EIA report, decide if it will start planning in the area.

8.1.2.3 Impacts on land use

In the Gäddbergsö and Kampuslandet areas, the construction of the nuclear power plant will alter land use at the actual plant site and its surroundings. The actual plant site will be built and fenced, because of which routes in the areas will change. The purpose of use of the plant areas will change. Currently, the actual planned plant areas do not have any specific land use so the changes will not be significant. In both site areas, it will mainly be possible to preserve the current holiday home areas, at least the buildings located more than two kilometers from the plant. In the Gäddbergsö option, a few holiday homes will be removed for the planned harbor quay. The use of the areas for recreation or outdoor activities will be restricted.

The planned road connection to the nuclear power plant in the Gäddbergsö option will not cause any significant changes in land use in the area because it will mainly follow the outlines of the existing road. A new road, including bridges, will be required for Kampuslandet from the Reimarsintie road. The road route will not be in conflict with current land use. Connections to the Kampuslandet holiday homes will be improved.

The power line leading to the plant will restrict land use on a strip 80–120 meters wide depending on the column type. Apart from regular fences, no structures or devices can be installed between the column structures and at a distance of less than 3 meters. Ditches or other excavation cannot be made or rights of way cannot be established at a distance of less than 3 meters from the column structures. Trees cannot be grown or maintain buildings or other structures taller than 2 meters in the power line clearing and buildings cannot be built in the immediate vicinity of the power line clearing. Furthermore, any activities that may cause danger to the use and maintenance of the power lines cannot be engaged in the power line clearing or its immediate vicinity. The power line needs to be indicated normatively in the regional plan throughout its length. In the master plant, the location should be specified in the master plan area.

The construction of the power plant will have an impact on the municipalities' community structure by restricting land use in the plant's safety zone and by enabling new construction in settlements and villages and along roads. A large part of the new nuclear plant's safety zone is already included inside the safety zone of the Hästholmen plant, thereby the impacts limiting land use less will be significant than in a completely new site.

The safety zone and related land use restrictions will however extend to the Tallbacka, Ekebo, Reimars and Bullers areas. The extent of the safety zone and related restrictions will be defined in connection with master planning for the area. Residential and holiday housing to the current scale will continue to be possible, as well as outdoor activities, recreation, agriculture and forestry. The plant will not restrict land use outside the safety zone. The construction of the plant will not specifically change the bases of land use outside the safety zone, but there may be new land use opportunities in villages and set-tlements for building workplace and residential areas and services.

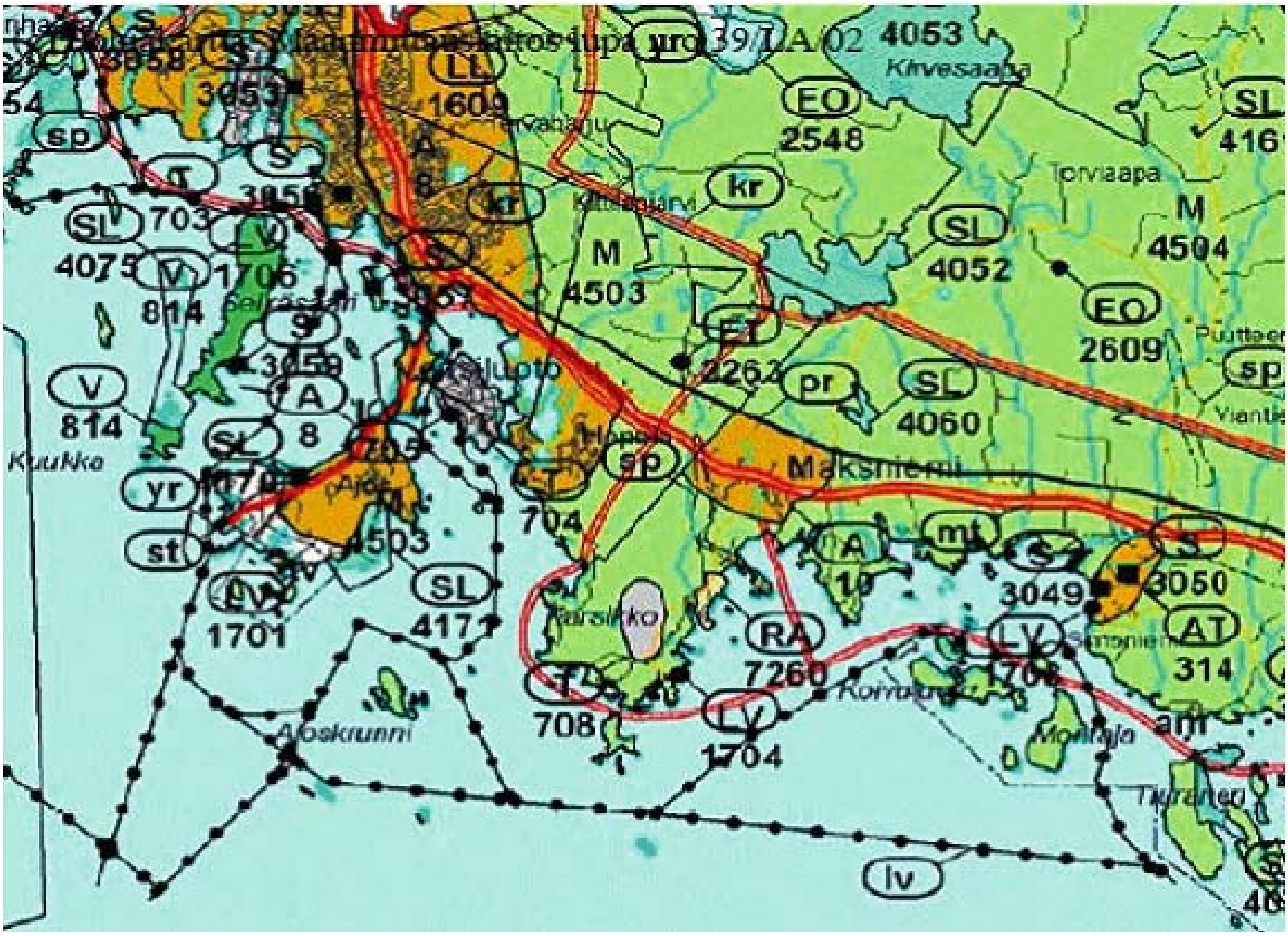
The construction of the plant in Ruotsinpyhtää will strengthen the position of the Loviisa region as a center for energy production and may increase the appeal of the region and conditions for developing land use, in particular, for business operations that will receive synergy benefits from the nuclear power plant.

8.1.3 Simo, Karsikkoniemi

8.1.3.1 Current land use

Karsikkoniemi contains individual all-year houses south of Hepola and Maksniemi and close to the northeast tip of the fishing port. Primary forms of land use include forestry and outdoor activities. There is a sheep farm in

Figure 8-3. An extract of the Western Lapland regional plan.



Maksniemi and its area is about 20 hectares. There are many holiday homes on the coast of the headland and on the nearby islands. The central parts of the headland are uninhabited and in natural state in many parts.

There are approximately 31,100 people living within a twenty kilometer radius of the power plant site. The city of Kemi is located inside this area. There are approximately 290,000 people living within a hundred kilometer radius of the planned nuclear power plant site.

The majority of the fundamental services and retail shops in the nearby areas are located in the centers of the municipality of Simo and the city of Kemi and in Hepola and Maksniemi. The Simo center is located along Highway 4 and the Karsikontie leading to Karsikko and the fishing port is directly connected to the highway.

The nearest railroad runs between Oulu and Tornio. The nearest railway station is located in Kemi, approximately 15 kilometers from Karsikko by road. The nearest airport is Kemi-Tornio, approximately 20 kilometers from Karsikko.

The nearest boat harbor is located in the Karsikko area. The nearest significant import/export port is the Port of Kemi, 25 to 30 kilometers from the Karsikko area.

The Karsikkoniemi site is located in the area of the observed airspace of the Kemi-Tornio airport. There are flight paths in the immediate vicinity of the site. The flight limitations required by the nuclear power plant will be identified in connection with area planning.

8.1.3.2 Planning situation

The Western Lapland Regional Land Use Plan ratified in 2003 is in effect in Karsikkoniemi. The plan indicates a residential area (A) in the Karsikkoniemi area in Maksniemi in the municipality of Simo and in the Hepola area in the city of Kemi (Figure 8-3). In addition, the plan indicates an area reservation for industrial operations in the middle of Kar-sikkoniemi where it is possible to place large-scale industry. There is also a connection between the area and the Karsikkoniemi harbor area. The Maksniemi fishing port with regional importance is located on the southeast coast of Karsikkoniemi. A reservation for the Leuannokka holiday residential area of 0.4 square kilometers is reserved in the eastern part of the headland. The Maksniemi groundwater area of class I is located south of the Maksniemi area. A reservation for a snowmobile route is indicated around Karsikkoniemi.

On June 16, 2005, the Ministry of the Environment ratified the regional wind power plan for Lapland's sea and coastal areas (Figure 8-4). In areas suitable for wind power production (tv), the plan cancels the area reservations for wind power production indi-cated in the Western Lapland regional plan.

At the beginning of 2008, the Regional Council of

Figure 8-4. An extract of the regional wind power plan for Lapland's sea and coast areas.

Lapland started to prepare the Regional Nuclear Power Plan for the Kemi-Tornio region. In Summer 2008, the process had proceeded to the preparation stage and a preliminary draft plan is being made.

The Local Master Plan for Karsikkoniemi in Simo has been approved on May 7, 2007, but, on May 9, 2008, the municipal council of Simo has, due to the revision of the Local Master Plan, cancelled the decision made on August 20, 2007 through which the Local Master Plan was set to enter into force. The Local Master Plan mainly indicates the shores of the headland's southern part as holiday residence areas. Residential areas for small houses are reserved for the northeast part of Karsikkoniemi. The undeveloped areas of Laitakari are indicated as recreational areas. In other respects, the undeveloped shore areas are indicated as agricultural and forestry areas of special environmental value. The inner areas of the headland are also marked as agricultural and forestry areas. There are areas marked as having particular importance in terms of biodiversity in the Karsikkoniemi Local Master Plan, such as the shore meadows along the shore of Sauvalaisenperä and Papinkari, the Röyttänhiekka dune and sandy shore area, the Laitakari block field, the Munakallio rock and the Teponlahti shore, which is important in terms of bird stock. Furthermore, the Local Master Plan indicates Lake Karsikkojärvi located in the inner parts of Karsikkoniemi, as being very valuable for biodiversity because of its overgrown open bog shores created as a result of isostatic uplift.

Several component Local Master Plan and Local Detailed Plan are in effect or pending in the Karsikkoniemi area and its surroundings.

The municipality of Simo and the city of Kemi have initiated local master and local detailed planning for the Karsikkoniemi area and the planned nuclear power plant at the beginning of 2008. In Summer 2008, planning had proceeded to the preparation stage, and preliminary draft plans are being drawn up. The participation and assessment scheme will be placed on public display in fall 2008.

8.1.3.3 Impacts on land use

In Karsikkoniemi, the construction of the nuclear power plant will alter land use at the actual plant site and its surroundings. The actual plant site will be built and fenced, because of which routes in the headland will change. The area's purpose of use will be changed in south parts of the headland. Currently, the actual plant area does not have any active land use so the change will not be significant. Holiday residences on the south coast will be removed in the area between the fishing port and the harbor quay to be built on the west coast to serve the power plant. Otherwise, land use in Karsikkoniemi will largely remain unchanged.

The new unbuilt residential areas indicated in previous plans cannot be implemented to the extent indicated in the plans. The current Karsikontie road can be used as the road connection to the plant. New roads must only be built at the actual plant site. In addition, it may be necessary to prepare for building new road connections for current land use and any rescue routes. The construction of the connections will not have any significant impact on land use.

The power line leading to the plant will restrict land use on a strip 80–120 meters wide depending on the column type. Apart from regular fences, no structures or devices can be installed between the column structures and at a distance of less than 3 meters. Ditches or other excavation cannot be made or rights of way cannot be established at a distance of less than 3 meters from the column structures. Trees cannot be grown or maintain buildings or other structures taller than 2 meters in the power line clearing and buildings cannot be built in the immediate vicinity of the power line clearing. Furthermore, any activities that may cause danger to the use and maintenance of the power lines cannot be engaged in the power line clearing or its immediate vicinity. The power line will be built up to the current line located at a distance of about 20 kilometers. The power line needs to be indicated normatively in the regional plan throughout its length. In the master plant, the location should be specified in the Karsikkoniemi area. At the same time, it is useful to investigate whether the power lines of the planned wind power parks can be connected to the same corridors.

The construction of the power plant will have an impact on the community structure of the municipality of Simo and the city of Kemi by restricting land use in the plant's safety zone and by enabling new construction in settlements and villages and along roads. Building activities would be forbidden or limited to the South of the Hepola and Maksniemi villages concerning the building of new homes and other structures related to the social functions of inhabitation such as hospitals, day-care centers and schools. Holiday housing will continue to be possible, as well as outdoor activities, recreation, agriculture and forestry. More detailed limitation of the safety zone will be defined in master planning for the area. The plant will not restrict land use outside the safety zone. The construction of the plant will change the bases of land use outside the safety zone, particularly in the Simo and Kemi settlements, by providing new land use opportunities for building workplace and residential areas and services. The construction of the plant will have a significant impact on the entire Kemi-Tornio region, including the Norrbotten County and, in particular, the municipality of Haparanda. The significance of the region as a strong industrial region will become stronger, in which case the conditions for developing land use will improve.

8.1.4 Content and significance of national land use objectives

National land use objectives are part of the control system for land use in accordance with the Land Use and Building Act. They are decided upon by the Government. The objectives may apply to issues that have:

- international or otherwise larger than regional significance for regional structure, area use or the traffic and energy network;
- a significant impact on cultural or natural heritage at a national level; or
- a nationally significant impact on ecological sustainability, the economy of regional structure or the avoidance of significant environmental damage.

The state authorities must, in their actions, take into account the national land use objectives and promote their fulfilment. The state authorities must also assess the impacts of their actions considering the national land use objectives.

The application of the national land use objectives must be ensured in regional planning and other land use planning so that their fulfilment is supported. The national land use objectives are divided into six entities:

- Functional regional structure
- Recovering community structure and the quality of the living environment
- Cultural and natural heritage, recreation and natural resources
- Functional connection networks and energy management
- Special issues in the Helsinki region
- Special areas as natural and cultural environments

The project's planning process is guided by the general and special objectives.

8.2 Construction of the nuclear power plant

8.2.1 Impacts of the power plant's construction work

8.2.1.1 Earth-moving, soil, bedrock and groundwater

The nuclear power plant's most significant impact on the site's soil, bedrock and groundwater will be caused at the plant's construction stage. Before starting construction work, the geological conditions of the selected site, such as soil structure and flow directions and pressure of groundwater, will be identified in order to prevent and reduce the impacts during construction. Construction work will be planned so that there will be as few adverse impacts as possible.

For the bearing capacity of soil, the location areas are mainly rock, moraine and sand areas with good building qualities. In addition to the preliminary building quality studies prepared at the pre-planning stage, more detailed base studies, such as bedrock sample drilling, will be conducted at the sites, through which the power plant and the required bedrock structures can be designed reliably.

During the construction stage, there will be blasting, excavation and rock crushing work at the power plant site for the roads required and the power plant and other buildings. For low and medium level waste, four separate caves have been preliminarily planned at a depth of 30–100 meters, depending on the geological properties of the final disposal area. A joint access tunnel will also be built for the caves. During construction, all earth-moving, excavation and dredging masses are to be utilized on the site in different landfills and landscaping work. Due to the low elevation in Pyhäjoki, approximately more land masses will be required for landfills. Chapter 3.5.3 includes estimates on the volumes of land masses created in the construction of the nuclear power plant.

The foundation waters and rain waters drained from the construction site will contain more solids and possibly oil and nitrogen compounds than waters normally drained from tarmac-covered yards. The quality and volume of water drained to the sea from the construction site will be monitored. Any conduction of waste water to sewers will be agreed upon with the location municipality's waterworks and sewage system.

There are no important groundwater areas or other areas suited for the acquisition of groundwater in the nuclear power plant's alternative sites or their immediate vicinity. However, the existence of bedrock groundwater must be taken into account because of underground construction work to be performed at the site. During excavation work, bedrock groundwater will flow into the excavated spaces. The water conductivity of bedrock is based on the number of holes inside the bedrock. Generally, groundwater flows are smaller in bedrock than in soil. Rock excavation will primarily have an impact on bedrock groundwater and further on soil groundwater. The impact on groundwater can be prevented through sealing the bedrock before excavation, if required.

8.2.1.2 Flora and fauna

At the construction stage, the reconstruction of roads and buildings in the area will cause local damage (noise, vibration, emissions from machines) to the fauna and, in places, the original habitats will be changed permanently (permanent changes caused by the project are inspected in a separate Chapter 8.6 concerning the impacts on flora, fauna and natural sites). The most significant changes during construction are targeted at the bird stock in the areas. Damage caused by construction will affect the behavior of birds and may damage their nesting.

In Pyhäjoki, the areas that will change the most considering the nuclear power plant unit are located in areas in the inner parts of Hanhikivi where the most sig-

The environmental impacts on flora are also assessed. Flowing water in Ruotsinpyhtää, 2008.

nificant sites for birds or other animals in the inspected area not located. The impact during the con-struction of the power lines will be targeted at the Hietakarinlahti area which is one of the most important areas for the bird stocks in the inspected area.

The impact during the construction of the harbor quay will mainly be targeted at the Siikalahti area located on the west and northwest side of Hanhikivi which is not a regionally important site considering the bird stock.

In Ruotsinpyhtää, the areas to be changed the most are located in the inner parts of Gäddbergsö or Kampuslandet where there are no significant sites considering the bird stock. The area's bird stocks can also otherwise be regarded as fairly ordinary.

In Simo, the areas to be changed the most are located in the inner parts of Karsikko where there are no significant sites considering the bird stocks or other animals, apart from the Karsikkojärvi lake. The impact of the construction of cooling water routes will, in the base intake option, be targeted at Laitakari and Korppikarinnokka that are sites with a notable bird stocks.

The impacts during construction will be reduced by scheduling earth-moving and construction work outside birds' nesting periods, if possible, in which case the adverse im-pact caused by construction work will be smaller. In areas that are very important for migratory birds, construction work will be scheduled outside the busiest spring and fall migration seasons.

8.2.1.3 Landscape

In addition to the actual construction site, impacts during construction work will be caused by heavy traffic required by the transport of large building parts and its requirements, new road connections and the improvement of current roads. High cranes will be visible in the landscape from far away. Some of the buildings, fields, and traffic connections will only be implemented for the period of construction and will be landscaped when they are no longer needed.

8.2.1.4 Noise

Noise impacts caused by traffic from and to the construction site are assessed through noise modeling.

The noisiest stage during the construction of the nuclear power plant will be the first years of construction when functions that cause significant noise include the rock crushing plant, batching plant and bucket chargers.

Noise during construction may, in some cases, include shock waves, particularly in the reactor building's construction site. Noise caused by the rock crushing plant will be directed away from the most noise-sensitive areas using noise barriers to be built of rocks around the crushing plant.

Traffic during construction will vary greatly with regard to traffic frequency and the actual noise status will differ from the average sound levels obtained as a result of calculations based on an even traffic flow. The momentary passing noise level and daily average sound level caused by traffic noise can be affected using speed limits, in which case the reduction of the default speed of 60 km/h in the assessed traffic situation during the nuclear power plant's construction to 40 km/h will reduce the noise level in properties close to the road (by about 4 dB and, in the event of 50 km/h, by about 2 dB).

The guideline values for noise are described in Chapter 8.9 concerning noise impacts during the nuclear power plant's operations.

Pyhäjoki

The current noise status at the location site in the Hanhikivi headland is described in Chapter 8.9.

During the noisiest construction stage, the average sound level, LAeq, in the holiday home area located in the Hanhikivi headland area will be 45–50 dB(A) (the average sound level is a calculated sound level where sound with varying volume is changed mathematically into steady sound; the A-emphasis, db(A), serves to emphazise such sound frequencies to which the human ear is the most sensitive) (Figure 8-5). The 40 dB(A) zone caused by noise from road traffic towards the plant will extend to a distance of slightly less than 800 m from the road and the 45 dB(A) zone will extend to a dis-tance of 400 m on both sides of the road.

According to noise modeling results, the noise caused by the construction of the nuclear power plant in the surrounding areas of the Hanhikivi headland site will cause that the daytime guideline value of 45 dB(A) for holiday home areas will be exceeded during the noisiest construction stage in some 15 holiday homes currently located in the area. Some of the holiday homes located on the northwest coast and the holiday homes on the west coast of the headland will probably be removed as the plant project proceeds. Traffic noise during construction work will cause the daytime guideline values to be exceeded in about 10 holiday homes located in the immediate vicinity of the road.

Ruotsinpyhtää, Kampuslandet and Gäddbergsö

The current noise status at the location site in Kampuslandet and Gäddbergsö is described in Chapter 8.9.

During the noisiest construction stage of the nuclear power plant on Kampuslandet is-land, the average sound level, LAeq will be 47–50 dB(A) in the closest holiday homes currently located in the northeast part of the island at a distance of one kilometer from the con-

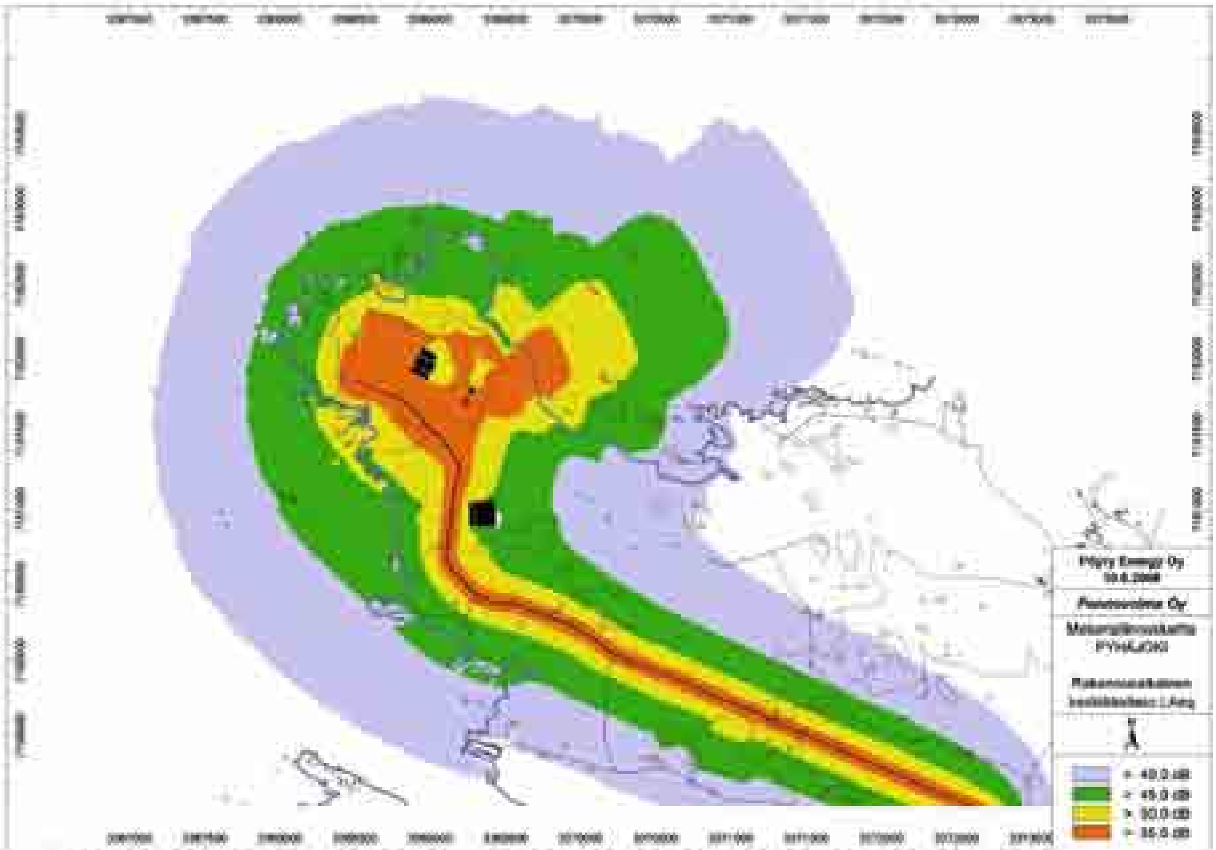


Figure 8-5. The maximum noise status during the construction of the nuclear power plant at the Hanhikivi headland site (the rock crushing plant, batching plant and the contractor's facilities are marked in the figure).

Figure 8-6. The maximum noise status during the construction of the nuclear power plant at the Kampusland Island site. (The rock crushing plant, batching plant and the contractor's facilities are marked in the figure.)

struction site (Figure 8-6). The average sound level will be 40–45 dB(A) in holiday homes located slightly farther at a distance of more than one kilometer from the construction site. The 40 dB(A) zone caused by noise from road traffic towards the plant will extend to a distance of slightly about 700–740 m from the road and the 45 dB(A) zone will extend to a distance of 380 m on both sides of the road.

During the noisiest construction stage of the nuclear power plant on Gäddbergsö headland, the average sound level, LAeq will be 50-55 dB(A) in the closest holiday homes currently located at a distance of a few of hundred meters from the construction site (Figure 8-7). The average sound level will be 45-50 dB(A) in holiday homes located slightly farther at a distance of about one kilometer from the construction site. The 40–45 dB(A) zones are located south and southeast of the construction site at a distance of slightly more than one kilometer and on the northeast side at a distance of two kilometers from the construction site.

According to calculations, the 40 dB(A) zone caused by noise from road traffic towards the plant will extend to a distance of slightly about 700–750 m from the road and the 45 dB(A) zone will extend to a distance of 380 m on both sides of the road. According to calculations, the 45 dB(A) noise zone will extend to a fairly large area, covering the Marskärrsbotten bay northwest of Gäddbergsö, partly because of traffic noise and partly because of the construction site.

According to noise modeling results, the noise caused by the construction of the nuclear power plant in the surrounding areas of the Kampuslandet island site will cause that the daytime guideline value of 45 dB(A) for holiday home areas will be exceeded during the noisiest construction stage in some 20 holiday homes located at a distance of one kilometer from the construction site. Traffic during construction will cause the guideline value to be exceeded in 20 properties located close to the road.

In the surrounding areas of the Gäddbergsö headland site, the daytime guideline value of 45 dB(A) for holiday homes will be exceeded in less than 20 holiday homes located at a radius of one kilometer from the construction site. Traffic during construction will cause the guideline value to be exceeded in 30 properties located close to the road.

Simo, Karsikkoniemi

The current noise status at the location site in Karsikkoniemi is described in Chapter 8.9.

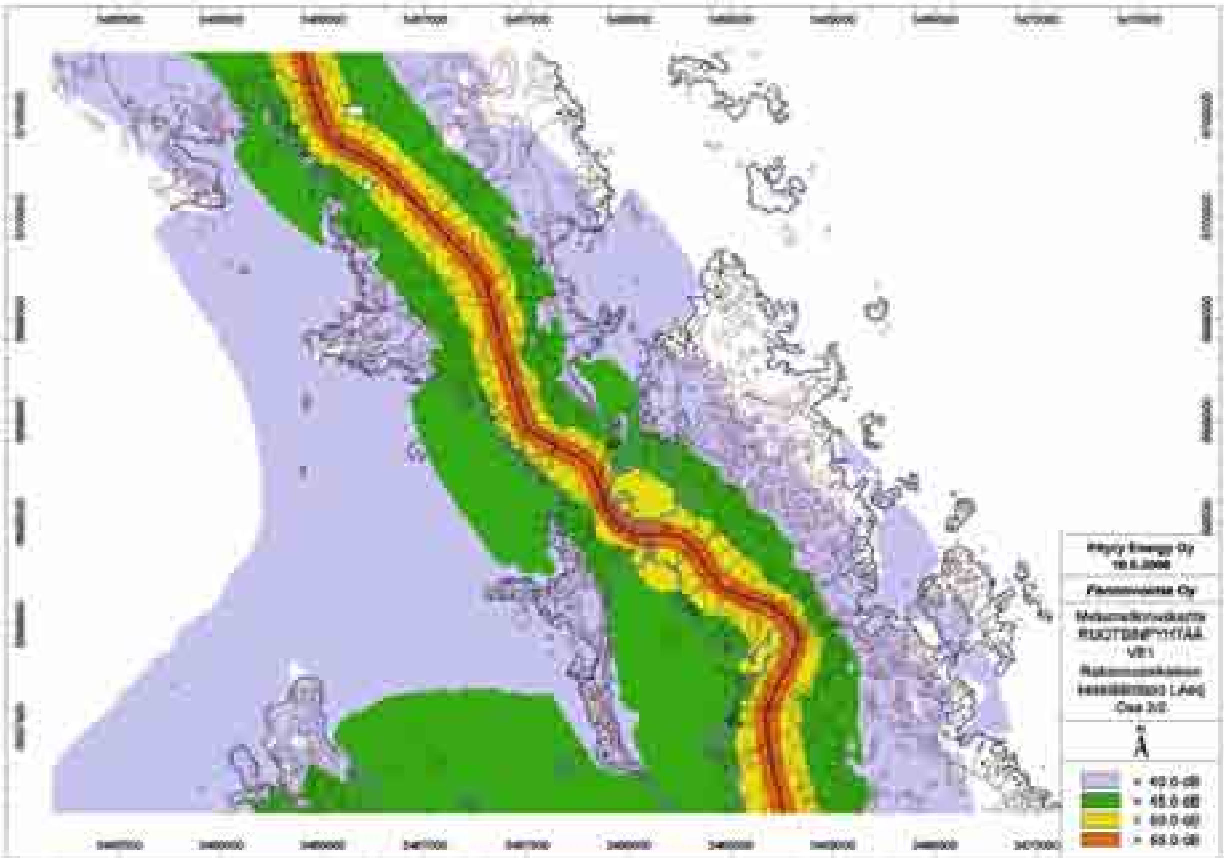
During the noisiest construction stage, the average sound level, LAeq will be approximately 50 dB(A) in the closest holiday homes currently located at a distance of a few of hundred meters from the construction site (Figure 8-8). In other properties located in the Karsikkoniemi area, the average sound level will be 40–49 dB(A). According to calculations, the 40 dB(A) zone caused by road traffic noise will extend to a distance of 750 m on both sides of the road.

According to noise modeling results, the noise caused by the construction of the nuclear power plant in the surrounding areas of the Karsikkoniemi site will cause that the daytime guideline value of 45 dB(A) for holiday home areas will be exceeded during the noisiest construction stage in a few dozen holiday homes located on the south and west coast of the headland. The holiday homes located on the south coast of Karsikkoniemi will probably be removed as the nuclear power plant project proceeds.

Traffic noise during construction will not cause the daytime guideline value to be exceeded in holiday homes.

8.2.1.5 Impact of dust on air quality

Earth-moving work, traffic at the site and certain functions such as rock crushing, will generate dust during the construction of the nuclear power plant. Dust sources are generally located at a low level, in which case dust cannot spread far and the impact on air quality will mainly be limited to the construction site.



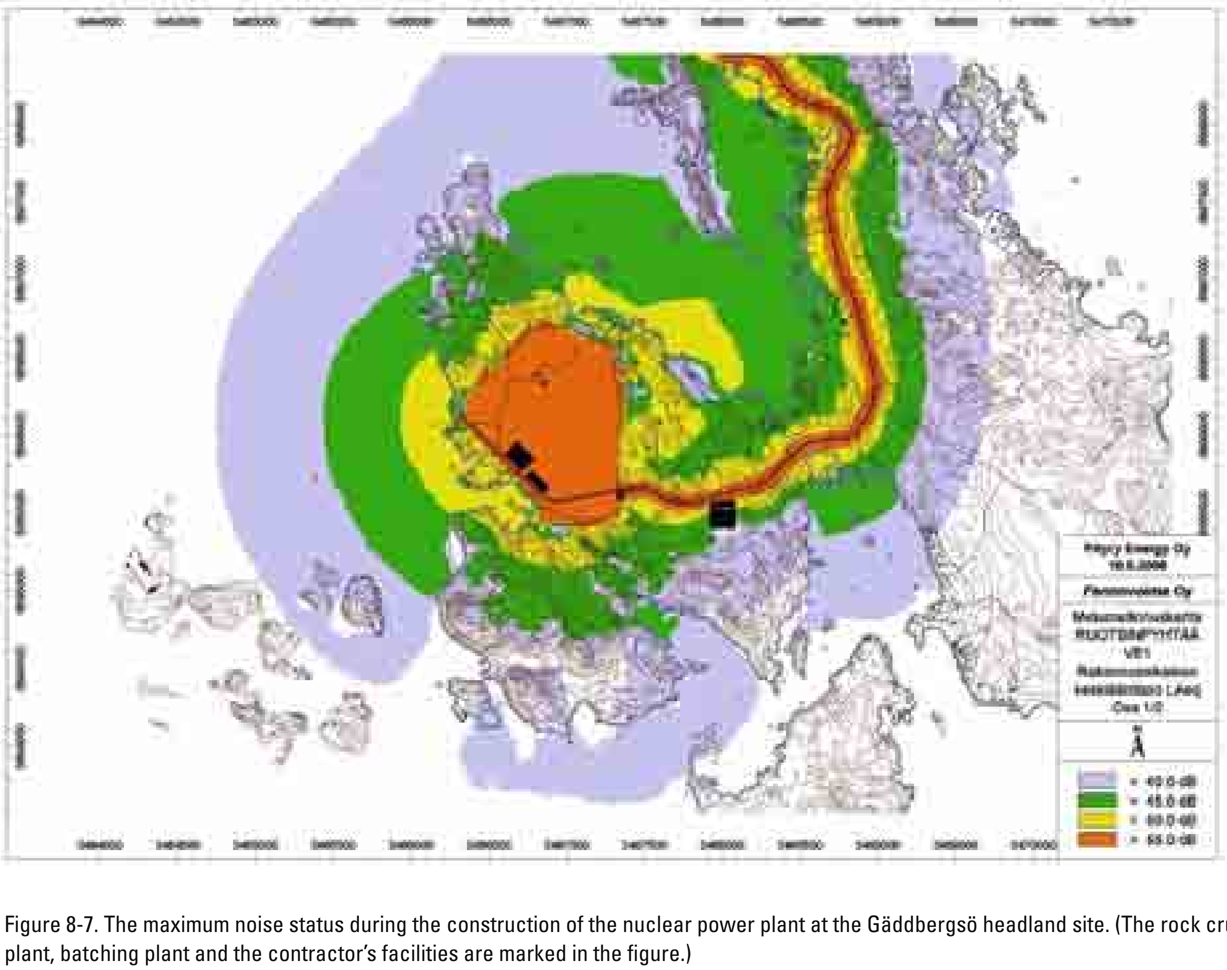


Figure 8-7. The maximum noise status during the construction of the nuclear power plant at the Gäddbergsö headland site. (The rock crushing plant, batching plant and the contractor's facilities are marked in the figure.)

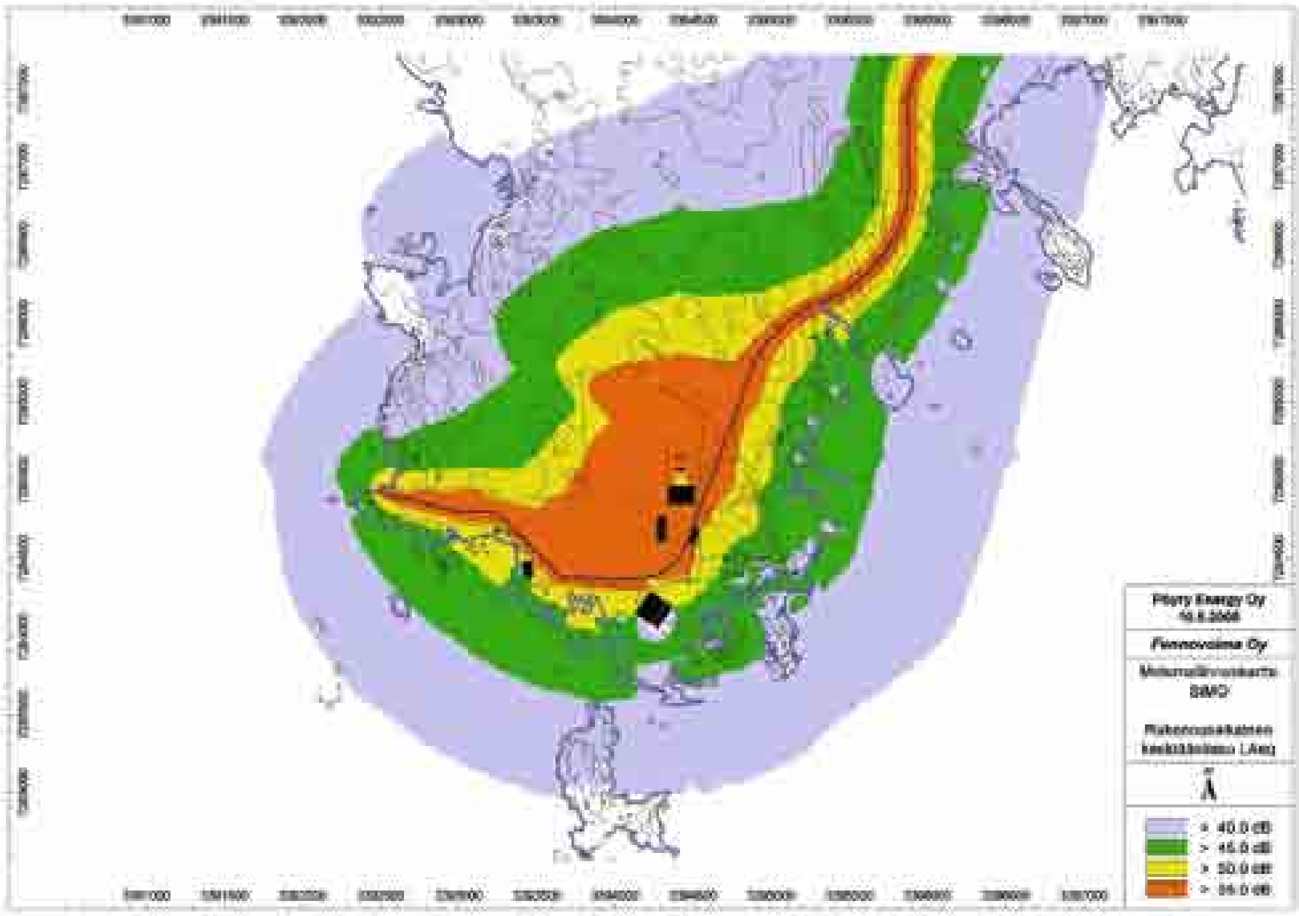


Figure 8-8. The maximum noise status during the construction of the nuclear power plant at the Karsikkoniemi site. (The rock crushing plant, batching plant and the contractor's facilities are marked in the figure.)

8.2.2 Building of the navigation channel and harbor quay

The construction of the loading and unloading station and the navigation channel to be built in the plant area or its vicinity is described in the land and water construction section in Chapter 3.

The construction of the navigation channel and harbor quay will require dredging in the water area. The impact of dredging is described at a general level because the composition of the sea bottom sedimentary deposit in the project areas has not been studied. The impact of water construction will be investigated in more detail at the project's licensing stage as required by the Water Act.

The impact of dredging will mainly depend on the quality of the sedimentary deposit to be dredged and the extent of dredging (an assessment of dredging and excavation mass can be found in Chapter 3). Sea bottom sedimentary deposit will be removed from the dredging area, which will remove flora and fauna from the treatment area. Direct impacts of dredging work carried out in the outer area (navigation channel) will only be caused on sea bottom animals, which will be recovered to the level preceding dredging in a few years.

Indirect impacts of dredging include temporarily muddy water (due to the increased volume of solids) and an increase in nutrient content. Muddy water and the increase in nutrient content will be more pronounced when dredging sedimentary deposit which includes a high volume of organic substances (such as mud or sludge bottom). When dredging sedimentary deposit which consists mainly of mineral substances (such as sand and gravel bottom), the impact on water quality will be more minimal. By selecting the dredging method according to the sedimentary deposit and by using other purposeful methods (such as silt curtain protection), the impact on water quality can be reduced significantly.

Temporarily muddy water and correspondingly increased sedimentation may have adverse impacts on animals in the coastal zone, including fry and spawn. Noise and vibration caused by construction work may temporarily drive fish and birds off the area. Furthermore, basic production may, if other conditions are favorable, increase slightly close to the dredging area as a consequence of nutrients released from the sedimentary deposit. However, the impacts will be temporary and local. In addition to the extent of dredging and the composition of the sedimentary deposit, the size of the muddy water area will depend on the prevailing streams. Muddy water can generally be observed at a distance of 100–200 m from the dredging area.

The chemical content of sedimentary deposits to be dredged, i.e. the content of any detrimental elements, will be determined as required by the Water Act. If any content of detrimental elements which exceeds the limit value is observed in the dredging areas, dredging work will be carried out using the best possible technology available for preventing the detrimental elements from spreading into the environment.

The sedimentary deposit masses created in dredging are to be used in excavation work in the plant area or banked in a suitable sea area depending on their volume and quality. If any content of detrimental elements which exceeds the limit value is observed in the masses, they will be treated as required by the Environmental Protection Act.

Dredging will be completed in a year, if possible. It will also be scheduled so that it will not cause any significant damage to nesting bird stock or spawning fish areas. If required, muddying water can also be observed using water quality meters operating in real-time, in which case dredging work can be stopped if the content of detrimental elements increases excessively close to any sensitive areas.

The impacts on water quality caused by dredging will be temporary and local, and they have been assessed to minor on the basis of information available.

8.2.3 Building cooling water structures

The construction of cooling water structures is described in the land and water construction section in Chapter 3.

In the shore intake options, impacts will mainly be caused by dredging in front of the intake site. The impact of dredging can be assumed to correspond to the aforementioned impacts of the navigation channel and harbor quay. Other impacts caused by the construction of the shore intake option, such as any excavation and other construction work, will correspond to those caused by the navigation channel and harbor quay.

The bottom intake option will require a cooling water

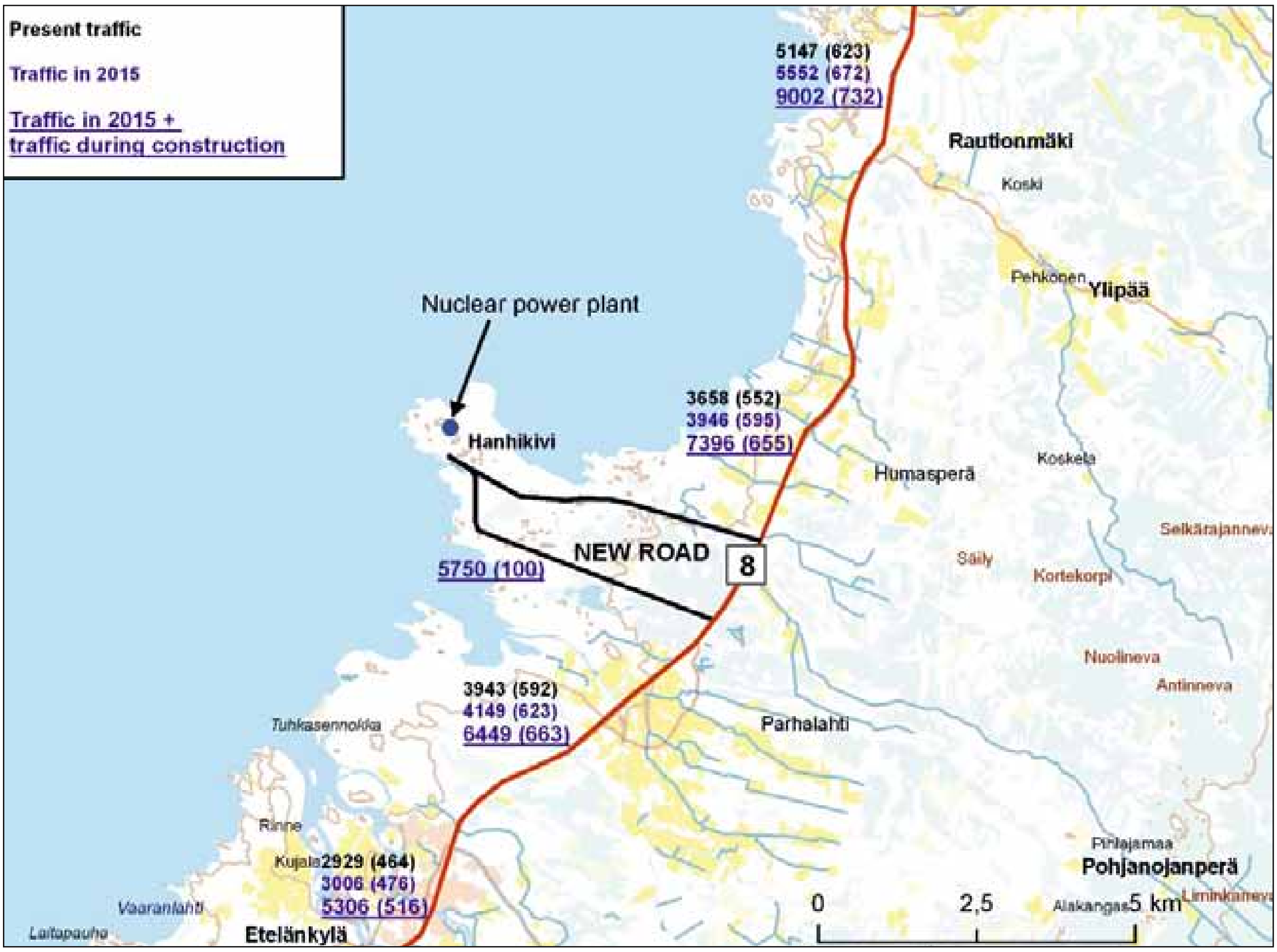


Figure 8-9. Current traffic volume in Pyhäjoki and Raahe on weekdays, traffic volume in 2015 according to the Road Administration's growth forecast and the change in 2015 traf-fic volume caused by the construction of the nuclear power plant. The share of heavy traffic is presented in parentheses..

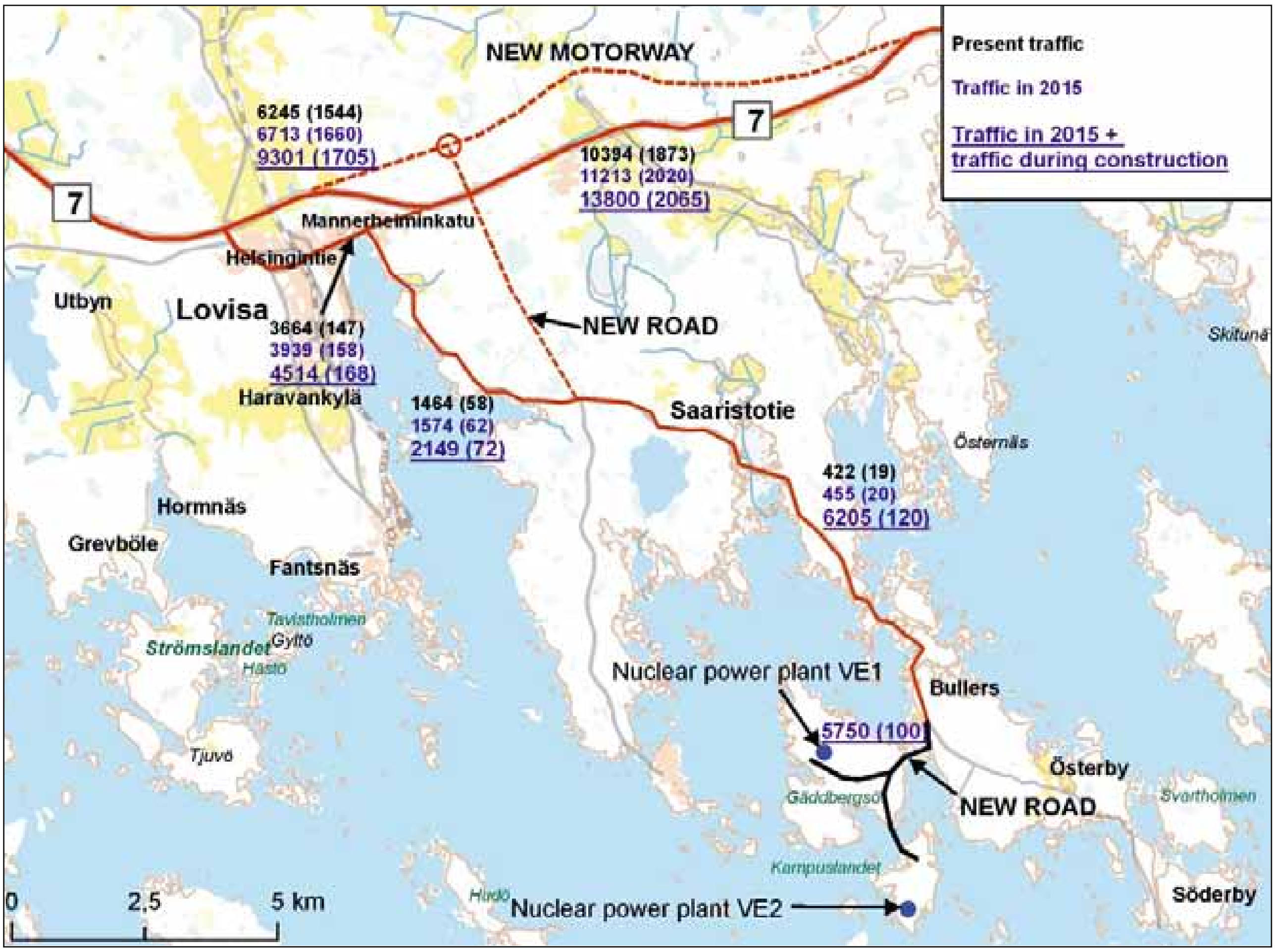


Figure 8-10. Current traffic volume in Ruotsinpyhtää and Loviisa on weekdays, traffic volume in 2015 according to the Road Administration's growth forecast and the change in 2015 traffic volume caused by the construction of the nuclear power plant. The volume of heavy traffic is presented in parentheses.

tunnel to be built below the sea bottom from the plant to the water intake site. Excavation work for the tunnel will be carried out below the sea bottom and, as a result, it has been assessed not to cause any adverse impacts because of good sound and vibration insulation of the ground layer below the sea bottom. The transportation of rock waste from the tunnel to the power plant area will be performed using trucks. This will slightly increase heavy traffic in the plant area. The majority of rock waste is to be used in various filling work in the power plant area; thus, traffic has been assessed not to increase significantly outside the plant area.

The construction of the intake structures for the intake option to be built at the sea bottom may require dredging work in the structures' location area. The impact of dredging will correspond to those caused by the navigation channel and harbor quay.

8.2.4 Impacts of transportation and commuter traffic

The traffic flow caused by the nuclear power plant and the principles of calculation are presented in Chapter 3.11. The traffic routes, current status of traffic and any known new roads and road improvements are presented in the traffic and safety section in Chapter 8.

The following presents the impacts of traffic flows during construction work in the case of two nuclear power plant units on the fourth or fifth year of construction when the traffic flow will be at its highest level. The map.presented for each alternative site illustrates the impact of the traffic flow resulting from the construction of the nuclear power plant on traffic on roads leading to the location site. The map shows three figures: current total traffic volume on weekdays, traffic volume in 2015 according to the Road Administration's growth forecast and the impact of changes to the 2015 traffic volume caused by the nuclear power plant. The share of heavy traffic is presented separately.

The increase in traffic is notable in all options. However, traffic will only be especially frequent in the fourth or fifth year of construction. As a result, any adverse traffic impacts will only cover this limited period.

8.2.4.1 Pyhäjoki

On weekdays, traffic will increase by about 4,350 vehicles a day on Highway 8 north of the Hanhikivi headland (Figure 8-9) and by 2,300 vehicles south of the headland. The increase on the north side of the Hanhikivi headland will nearly double the traffic volume on the highway. On the south side, the increase will be smaller, approximately 50–70%. Heavy transportation will increase by 40–60 vehicles a day, i.e. a maximum of 10% of heavy traffic on the highway in 2015. If any passing lane is in use on the south side of Raahe during the construction of the nuclear power plant, traffic will flow more smoothly compared to the current situation.

8.2.4.2 Ruotsinpyhtää

On weekdays, traffic will increase by some 2,600 vehicles a day on Highway 7 and the motorway, i.e. there will be an increase of 20–40% depending on the road (Figure 8-10). Heavy transportation will increase by 45 vehicles a day, i.e. less than 5%. If implemented, the planned motorway will improve the flow and safety of traffic in the area. The traffic volume on the Saaristotie road from the Atomitie road to Reimars will in-crease significantly, being about 15 times greater. The high traffic volume may reduce safety on the Saaristotie road.

The inspection includes the assumption that the planned motorway and the road running from the motorway junction (an extension of the Atomitie road leading to the Saaristotie road) will be available. If the motorway and the Atomitie road extension are not implemented, the Saaristotie road will be accessed from the highway through the Mannerheiminkatu and Helsingintie roads. This would increase the traffic volume during the construction of the nuclear power plant on the Mannerheiminkatu and Helsingintie roads significantly. The traffic volume at the beginning of the Saaristotie road, along which Fortum's nuclear power plant traffic is led to Hästholmen, would increase significantly.

8.2.4.3 Simo

On weekdays, traffic will increase by about 4,000 vehicles a day on Highway 4 north of Karsikkoniemi and by 1,700 vehicles a day on the south side (Figure 8-11). On the north side of Karsikkoniemi, the increase in the traf-

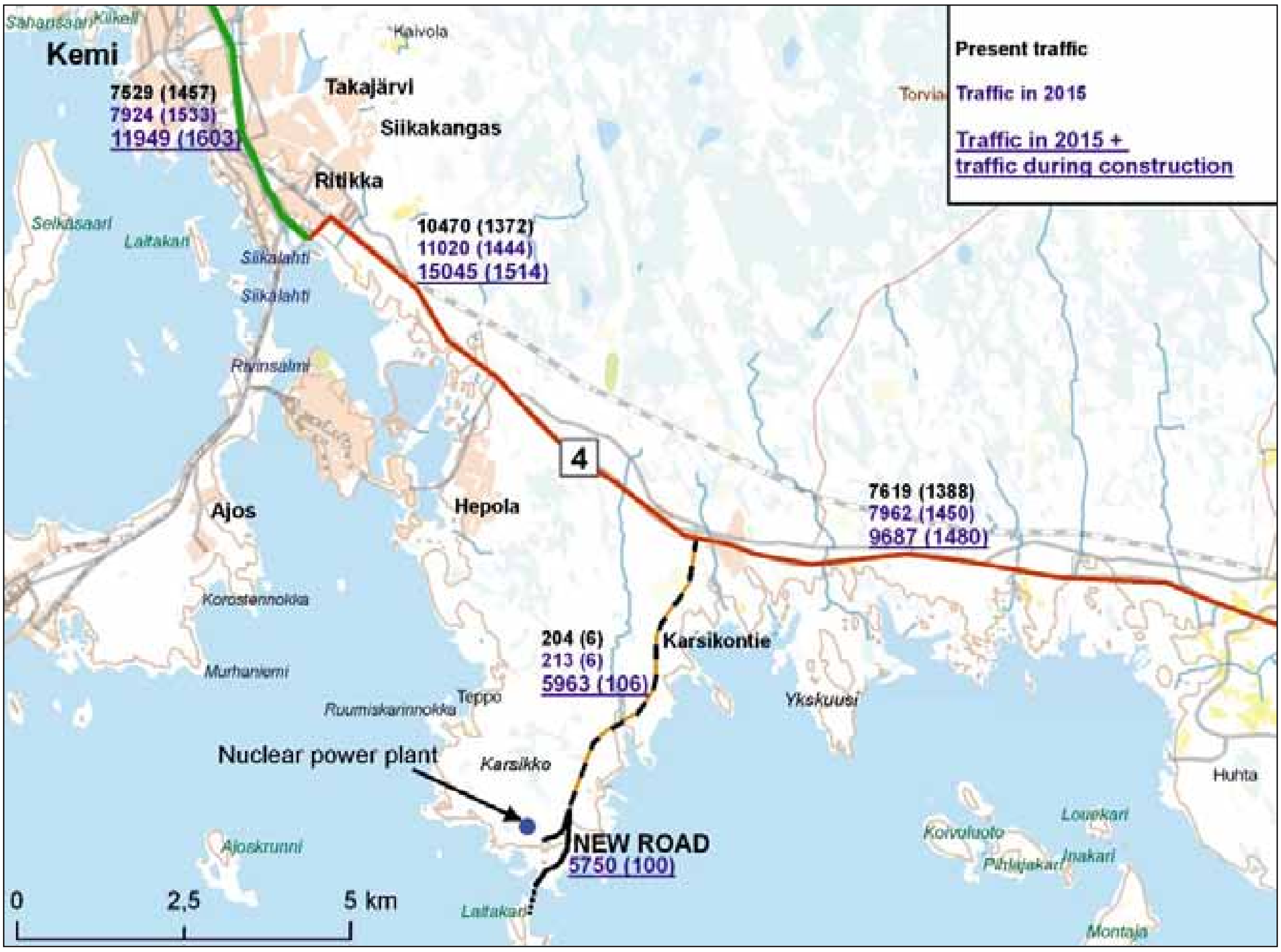


Figure 8-11. Current traffic volume in Simo and Kemi on weekdays, traffic volume in 2015 according to the Road Administration's growth forecast and the change in 2015 traffic volume caused by the construction of the nuclear power plant. The volume of heavy traffic is presented in parentheses.

fic volume on the highway will be 50% compared to the traffic volume without the nuclear power plant, whereas the increase will be about 20% on the south side. Heavy transportation will increase by 5% on the north side and by 2% on the south side. The increase in traffic volume will be significant particularly on the north side of Karsikkoniemi. Upon completion, the new motorway starting from the Karsikontie junction will improve the flow and safety of traffic.

8.2.5 Impact of traffic emissions on air quality

The emissions of transportation and commuter traffic for the nuclear power plant and the criteria for calculation are presented in Chapter 3.13.2. The attached table (Table 8-1) presents the municipal-specific total traffic emissions at the location sites in 2006 and their forecast for 2015 when the construction of the nuclear power plant will be in progress. In addition, the average emissions from traffic (a two unit plant) during the construction of the nuclear power plant are presented for reference. For each location option, traffic emissions in those municipalities where the nuclear power plant's traffic mostly flows have been inspected.

In the Pyhäjoki option, nitrogen oxide (NO_x) and carbon monoxide emissions (CO) will increase by 20% and particle and carbon dioxide emissions will increase by 15% compared to the total traffic emissions in the area (Pyhäjoki and Raahe) in 2015. Sulfur dioxide emissions (SO_2) will be very low.

In the Ruotsinpyhtää option, nitrogen oxide (NO_x) emissions will increase by 50%, carbon monoxide emissions (CO) by 20% and particle and carbon dioxide emissions by 15% compared to the total traffic emissions in the area (Ruotsinpyhtää and Loviisa) in 2015. Sulfur dioxide emissions (SO_2) will be very low.

In the Simo option, nitrogen oxide and carbon monoxide emissions will increase by 20% and particle and carbon dioxide emissions by 12% compared to the total traffic emissions in the area (Simo and Kemi) in 2015. Sulfur dioxide emissions will be very low.

Traffic during construction will increase emissions significantly in all of the alternatives. However, traffic will only be especially busy during the fourth or fifth year of construction. In other construction years, traffic volumes and emissions will be considerably lower. Construction-related traffic emissions are not estimated to have any significant long-term impacts on air quality in the areas surrounding the alternative location sites.

8.2.6 Impacts of building roads

The location of the new roads or improved existing roads required by the project is described in Chapter 3. Corresponding nature surveys have been conducted for the planned routes as for the plant area. Impacts on nature caused by the construction of roads are assessed in more detail in the flora, fauna and biodiversity sections in Chapter 8.

Construction and repair work related to road con-

Table 8-1. The nuclear power plant's average traffic emissions and the total traffic emissions in the surrounding areas of the location options in 2006 and 2015 (tons a year).

		CO	NO_x	PM	SO_2	CO_2
Nuclear power plant's average traffic emissions during construction (t/a):		228	54	2	0.24	6,925
Traffic emissions at location sites in 2006 and 2015 (t/a):						
PYHÄJOKI	2006					
	Pyhäjoki	217	59	3	0.07	12,425
	Raahe	743	176	9	0.24	42,173
	2015					
	Pyhäjoki	223	60	3	0.08	12,751
	Raahe	801	190	10	0.26	45,494
RUOTSINPYHTÄÄ	2006					
	Ruotsinpyhtää	211	65	3	0.08	13,447
	Loviisa	226	61	3	0.08	14,196
	2015					
	Ruotsinpyhtää	228	70	3	0.09	14,506
	Loviisa	243	66	3	0.09	15,261
SIMO	2006					
	Simo	343	116	5	0.14	23,305
	Kemi	682	162	8	0.22	38,770
	2015					
	Simo	358	121	5	0.14	24,353
	Kemi	718	170	9	0.24	40,806

nections will be carried out at the same time as construction work at the power plant site. They can also be scheduled to be performed before the actual power plant work. Roads will be placed and designed so that they will cause as little environmental impact as possible. The most significant environmental impacts caused by the construction and use of roads include impacts on land use, air quality and the comfort of people, soil, bedrock, natural resources, surface and groundwater, flora, fauna and the landscape. The construction of roads will also cause adverse impacts through noise and vibration.

The following presents local environmental impacts caused by the construction of roads in the nuclear power plant's alternative sites.

8.2.6.1 Pyhäjoki, Hanhikivi

The new road of less than 5 km to be built to the plant area from Highway 8 will not be located in nature conservation areas or their immediate vicinity. However, the construction of the new road may cause local damage to animals and, in some places, the original living environments will change permanently. Furthermore, the transportation of land masses will cause local changes in the living environment. The areas that will be changed are located in the inner parts of Hanhikivi where significant sites for birds or other animals are not located.

There is no housing near the planned road so the construction of the road will not cause disturbance to inhabitants. The road project will not cause any significant changes in land use in the area.

8.2.6.2 Ruotsinpyhtää, Kampuslandet ja Gäddbergsö

The construction of the nuclear power plant will require that the Saaristotie road is repaired at a 7.4 km stretch and one of the bridges on it is reinforced. In the Gäddbergsö option, about 2.5 kilometers of new road must be built from the Reimarsintie road. In the Kampuslandet option, some 3.5 kilometers of new road must be built, and a 220-meter bridge has to be built from Gäddbergsö to Kampuslandet.

The planned road connections to the nuclear power plant will not cause any significant changes in land use in the area because they will mainly follow the outlines of the existing road. In the Kampuslandet option, the landscape of the area will change because of the bridge connecting Kampuslandet and Gäddbergsö. Connections to holiday homes in Kampuslandet will improve because of the new bridge and road connection.

However, the repair of the road network in the area may cause local damage to wildlife and, in some places, the original living environments will change permanently. Furthermore, the transportation of land masses will cause local changes in the living environment. The repair of the current road will cause temporary damage and disturbance to users of the road and homes by the road.

8.2.6.3 Simo, Karsikkoniemi

The Karsikontie road must be widened along less than 5 km. In addition, a new road leading from the Karsikontie road to the plant area must be built. The new road will lead from the Karsikko area to Niemennokka which contains rocky and rough terrain.

In addition to the new road connection, it may be necessary to prepare for building new road connections for current land use and any rescue routes. An embankment road will possibly be built on the Laitakari island for the purpose of building and maintaining the cooling water structures.

The construction of the connections will not have any significant impact on land use. The new road to be built on Laitakari and the related embankment or bridge will change the landscape at the tip of the headland.

The repair of the current road will cause temporary damage and disturbance to users of the road and homes by the road. For animals, the repair of the current road will not cause any major difference compared with the current situation. The construction of the new sections to Laitakari and the future plant area will cause local damage to animals.

8.2.7 Impacts of building power lines

In order to connect the nuclear power plant to the national grid, two 400 kV and a 110 kV power lines will be required. The power lines are usually built using guyed towers; steel towers for 400 kV lines and wooden towers for 110 kV lines. Non-guyed towers, i.e. freely standing towers, are also built but their use is more general in town areas. The construction of power lines will be scheduled to take place in the latter half of the nuclear power plant's construction stage.

Depending on the tower solution, the power line route will be a terrain corridor approximately 80–120 meters wide. Restrictions will be set for land owners regarding the free use of land areas and trees in the corridor. Buildings cannot be located inside the terrain corridor and there cannot be any forestry in the area. The growth height of trees will also be restricted in the border zones of the corridor so that falling trees will not extend to the power line.

Many functions, such as agriculture, are possible as long as the restrictions set are seen to with regard to certain structures (e.g. ditches can only be built and structures or equipment installed at a distance of at least three meters from the towers). Damage caused to field areas will mainly result in a minor loss of cultivated area and restricted movement of farming machines close to the towers. It is possible that drains are damaged dur-

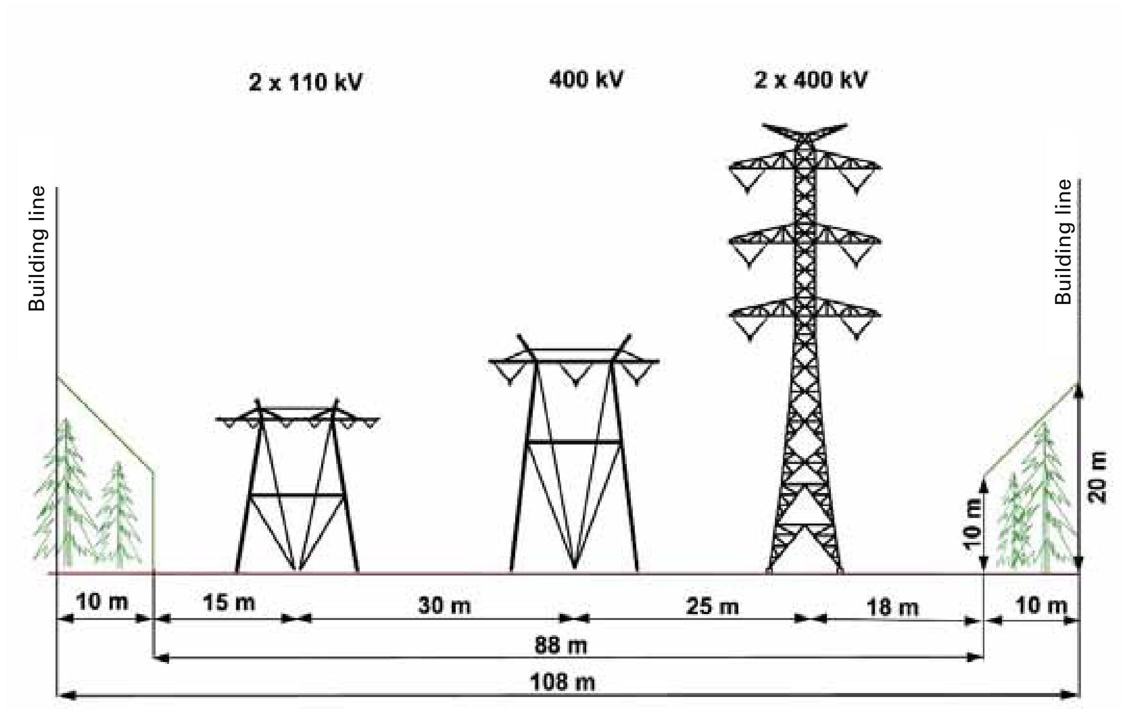


Figure 8-12. A diagrammatic plan of the possible tower solution and cable area.

ing construction. Adverse impacts will be reduced using different tower types and through their placement.

Land use restrictions are discussed in more detail in the land use impact section in Chapter 8. Financial compensation will be paid to land owners for restrictions according to the Act on the Redemption of Immoveable Property and Special Rights. (*Fingrid Oyj 2008*)

Damage caused by the transportation of machinery and equipment and the installation of cables will be assessed and noted in design particularly in relation to wear-sensitive terrain. Waste volumes created during construction (e.g. packaging materials and wire strips) will be very low. They will be handled appropriately without causing any damage to the environment. Noise during construction will be created by building machinery and blasting connections when extending cables. (*Fingrid Oyj 2008, Fingrid Oyj 2007*)

The construction of a transmission line of more than 15 kilometers and of more than 220 kV requires an EIA procedure. In this project, the impacts of power lines have been assessed up to the preliminary master plan border, i.e. 3–5 kilometres from the location sites, but this section will be included in the EIA procedure to be prepared for power lines in the selected location municipality.

The following presents environmental impacts caused by the construction of power lines in the nuclear power plant's alternative sites. Impacts on nature caused by the construction of power lines and impacts during operations, such as any impacts of electric and magnetic fields and the risks of colliding birds, are assessed in the health and natural impact section in Chapter 8. The location of the power line routes in the environment of the location sites is presented on maps in Chapter 3.

8.2.7.1 Pyhäjoki, Hanhikivi

The new power line route will be built up to the current power line located at a distance of about 20 kilometers. The accurate connection point will be identified later as design becomes more specific.

The power line route will mostly run in forest and swamp areas. There are no nature conservation areas in or near the route, but it crosses over the Hietakarinlahti area which is fully in its natural state and has a significant bird stock.

The construction of the power line may cause damage to bird stock in the area during nesting and migration periods. Adverse impacts can be reduced by starting work be-tween August and April, if possible. In addition, more detailed design and location of the power line route must take into account the importance of the Hietakarinlahti bird stocks and the location of territories of nesting species with significant conservation value.

8.2.7.2 Ruotsinpyhtää, Kampuslandet ja Gäddbergsö

The new power line route will be built up to the current power line located at a distance of about 15 kilometers. The accurate connection point will be identified later as design becomes more specific.

There are no nature conservation areas in the immediate vicinity of the power line route. The route will mainly be placed in thinned forests along roads or on old fields. In the northern part, the route crosses over water in two places.

The construction of the power line route on the island will slightly alter the shore areas in the north parts of Kampuslandet. The changes will mainly involve the landscape. In addition, the power line route will significantly change the landscape when placed in the narrow cape north of the Bullers farm and when running through the Taasianjoki river valley and along the valuable cultural landscape area.

The power line route across Gäddbergsö will change the shore areas at the southern part, in particular, as the areas will become treeless. Along the route, there are two historical monuments on the east side of Gäddbergsö (historical stone structures). Any impacts on the monuments are to be identified as design becomes more specific.

8.2.7.3 Simo, Karsikkoniemi

The new power line route will be built up to the current power line located at a distance of about 20 kilometers. The accurate connection point will be identified later as design becomes more specific, when the power line route's connection to the historical monuments located at the north part of Karsikkoniemi will be revised.

The power line route will mainly run from the plant towards northeast through forested swamp and ridge areas on the west side of the Marostenmäki residential area.

The supplementary information for the EIA program of WPD Finland Oy's wind power plant project presents electrical transmission Alternative 1 as touching the shore, tentatively, in the municipality of Simo, northwest of Karsikkoniemi by Lallinperä (*WPD Finland Oy 2008*). Fennovoima and WPD are planning power line routes connected to their nuclear power plant and wind power plant projects in cooperation. The power lines will be placed in the same corridor, whenever possible.

The construction of the power line may cause damage to bird stock in the area during nesting and migration periods. Adverse impacts can be reduced by starting work between August and April, if possible. In addition, more detailed design and location of the power line route must take into account the importance of the Karsikkojärvi bird stocks and the location of territories of nesting species with significant conservation value.

8.2.8 Impacts of the construction stage on people and society

8.2.8.1 Impact on regional economy

The nuclear power plant is a very large building project and, if implemented, a significant regional employer. The construction, operation and annual maintenance of the nuclear power plant have numerous impacts on entrepreneurship, service selection and labor market in the location municipality, its surrounding economic area and Finland as a whole. These factors are reflected on regional migration, population structure and population development that will have an impact on the housing and property market. The project's impact on regional structure and economy and employment are discussed in more detail in Chapter 8.10 covering the construction and operating periods.

8.2.8.2 Impact on comfort, recreation and living conditions

Constructing a nuclear power plant is a large project. The construction period that covers six to eight years has significant social impacts on the location municipality and surrounding areas. A lot of people will move to the area for the construction period and some of the employees will arrive from abroad. At the construction stage, demand for houses will increase and services will probable increase in the area. It is important that the availability of the housing, healthcare and education services required is ensured.

Increased traffic and noise caused by construction work may have an impact on the comfort of residents in the nearby area, but the impact will only be local. Traffic volumes caused by construction work will reach their peak in the fourth or fifth year of construction. The distribution of the traffic volumes to different routes in each municipality is assessed above. Noise impacts will be limited to the immediate vicinity of the construction site and traffic routes. Water construction work will cause muddy water, which may reduce comfort in nearby beaches and shores of holiday homes. The con-struction site will be clearly distinguishable in the local landscape through the new traffic connections.

The variety of cultures and languages brought to the area along foreign employees at the construction stage will provide the region's municipalities, entrepreneurs and residents with opportunities for internationalization. Any cultural clashes and disturbances can be prevented by familiarizing foreign employees with Finnish culture and practices and by organizing sufficient and different leisure-time activities.

8.2.8.3 Opinions of residents and nearby operators

The opinions of residents and operators surrounding the location sites on the project's impacts during construction and operations have been identified using a resident survey and interest group interviews. In the responses to the resident survey, the employment impacts during construction were regarded as significant in all municipalities. The construction of the nuclear power plant was considered to have an impact on comfort in the area in all municipalities. The impacts brought up by the Pyhäjoki residents as the most significant during the construction stage were those on land use and landscape, employment and traffic. The responses in Ruotsinpyhtää raised the impacts of traffic and land use, the construction of power lines and the impact on the feeling of safety. The residents of Simo regarded the most important environmental impacts during construction to be impacts on land use and landscape, the water system and employment. The results of the resident survey and interest group interviews are described in more detail in Chapter 8.10.

8.3 Atmospheric emissions

8.3.1 Current air quality and weather conditions

8.3.1.1 Pyhäjoki, Hanhikivi

Weather conditions

The Hanhikivi headland is located on the coast of the Bothnian Bay. The winter is long in the Bothnian Bay area, and the temperature is relatively low for most of the year. The location of the Bothnian Bay in the western part of a large mainland area and also close to the Atlantic Ocean causes the climate to vary between marine climate and continental climate, depending on the prevailing winds.

In the Oulu Airport measurement point, the average annual temperature was 2.4 °C in 1971–2000. The average rainfall was 447 mm a year. (*Finnish Meteorological Institute 2002*)

The vicinity of different climate zones causes winds to be variable in the Bothnian Bay region, especially in the winter. In summer, southerly and southwesterly winds prevail. Northerly winds are also common in the winter. Usually, the winds are moderate. (*Bothnian Bay Life 2007*)

Air quality

The quality of air is not monitored in the Pyhäjoki municipality, as there is no industry significant for the quality of air in the area, and there is no measured data for the region available. The nearest place where the quality of air is monitored is in the town of Raahe where Rautaruukki's steelworks are located. The town of Raahe monitors the impact of industry and traffic on the air quality within the frameworks of an extensive air quality monitoring program.

The quality of air can be considered to be good in the Hanhikivi headland area, since there are no activities causing significant emissions in the immediate surroundings.

8.3.1.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

Weather conditions

The Kampuslandet and Gäddbergsö area is located on the coast of the Gulf of Finland. The sea makes the climate milder and evens out temperature differences between different seasons. Because of the vicinity of the sea, winds are stronger than in inland areas.

In 1971–2000, the average annual temperature in Ruotsinpyhtää was 4.6 °C. The average rainfall was 707 mm a year. (*Finnish Meteorological Institute 2002*)

Air quality

According to the Uusimaa Regional Environment Center's air quality monitoring (*Kousa et al. 2007*), the air quality is, on average, good in Ruotsinpyhtää, since there are no significant industrial sources or energy production plants in the municipality, and, additionally, the emission densities of even the busiest roads are relatively low.

The concentration of nitrogen dioxide and inhaled particles is, most likely, clearly below the limit values. However, there may be occasional high particle concentrations in areas with a lot of small-scale wood combustion. (*Kousa et al. 2007*)

In the 2004 bioindicator monitoring, the condition of hypogymnia physodes corresponded to the average level in Uusimaa and Itä-Uusimaa. The occurrence of lichen species was slightly greater than on average. The hypogymnia physodes was healthy in the surroundings of Myllykylä and slightly damaged elsewhere in Ruotsinpyhtää. (*Kousa et al. 2007*)

8.3.1.3 Simo, Karsikkoniemi

Weather conditions

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

The average annual temperature at Kemi-Tornio Airport was 1.2 °C in 1971–2000. The average rainfall was 513 mm a year. (*Finnish Meteorological Institute 2002*)

The vicinity of different climate zones causes winds to be variable in the Bothnian Bay region, especially in the winter. In summer, southerly and southwesterly winds prevail. Northerly winds are also common in the winter. Usually, the winds are moderate. (*Bothnian Bay Life 2007*)

Air quality

Air quality is good in the Kemi-Keminmaa region based on conducted measurements and bioindicator monitoring. Air quality monitoring has been conducted as joint monitoring since the beginning of the 1990s.

		CO	NO_x	PM	SO_2	CO_2
Nuclear power plant's average traffic emissions during operation (t/a):		29	8	0.3	0.03	1,015
Traffic emissions at location sites in 2006 and 2020 (t/a):						
PYHÄJOKI	2006					
	Pyhäjoki	217	59	3	0.07	12,425
	Raahe	743	176	9	0.24	42,173
	2020					
	Pyhäjoki	226	61	3	0.08	12,932
	Raahe	834	197	10	0.27	47,339
RUOTSINPYHTÄÄ	2006					
	Ruotsinpyhtää	211	65	3	0.08	13,447
	Loviisa	226	61	3	0.08	14,196
	2020					
	Ruotsinpyhtää	237	73	3	0.09	15,094
	Loviisa	252	68	3	0.09	15,853
SIMO	2006					
	Simo	343	116	5	0.14	23,305
	Kemi	682	162	8	0.22	38,770
	2020					
	Simo	367	124	6	0.15	24,936
	Kemi	738	175	9	0.24	41,936

Table 8-2. The nuclear power plant's traffic emissions and the total traffic emissions in the surrounding areas of the site options in 2006 and 2020 (tons a year).

The environmental impacts of the Kemi pulp and paper industry's flue gas emissions have decreased since the beginning of the 1990s. Based on the 1999–2003 air quality measurements, sulfur dioxide is at a level where it no longer constitutes an air protection problem.

Considering that Karsikkoniemi is located relatively far from emission sources and settlements, it can be assessed that air quality is good in the region.

8.3.2 Impact of radioactive emissions

The assessment of the maximum amount of radioactive emissions released in the air from the nuclear power plant planned by Fennovoima in different plant options and the treatment methods used for emissions are presented in Chapter 3.12.1.

The tight limit values set for nuclear power plant emissions and emission supervision guarantee that the emissions of modern nuclear power plants are very small and their radiation impact on the environment is extremely small compared with the impact of ra-dioactive substances existing normally in nature. For example, the emissions of the existing Finnish nuclear power plants have amounted to less than one per cent of the limit values set (see Chapter 3.12.1) and the results of environmental supervision performed by the Radiation and Nuclear Safety Authority indicate that the impact of emissions from plants on the environment and people have been insignificant (*STUK 2008b*).

Fennovoima's nuclear power plant will be designed so that its radioactive emissions will securely fall below the limit values set and, as a result, the impact of emissions on the environment and people will be insignificant.

8.3.3 Impact of other emissions

8.3.3.1 Impact of emissions from emergency power and heat generation

The power plant's other emissions, i.e. emissions from the generation of emergency power and heat, are presented in Chapter 3.13.1. The emission volumes are very small and they have no significant impact of the air quality of the alternative sites.

8.3.3.2 Impact of transportation emissions

Transportation emissions usually constitute a significant factor affecting air quality, particularly in urban areas. Traffic exhaust emissions are released into the atmosphere at a low level and they do not mix in the air as efficiently as emissions from energy production plants that are conducted out of the plants through a tall chimney. In addition to exhaust emissions, traffic causes indirect emissions, such as particles off the road.

Emissions from transportation and commuter traffic related to the nuclear power plant and their calculation criteria are presented in Chapter 3.13.2. The emission volumes are similar in all options because their average transportation distances are nearly identical.

The attached table (Table 8-2) presents the total traffic emissions in the nearby areas of the site options in 2006 and predictions for 2020. In addition, the table includes average traffic emissions caused by nuclear power plants (a two unit plant). For each site option, traffic emissions in those municipalities where the nuclear power plant's traffic mostly flows have been inspected.

Carbon monoxide (CO), nitrogen oxides (NO_x), particles (PM) and carbon dioxide (CO_2) would be increased due to the nuclear power plant's traffic by less than 10% of the total traffic emissions in the areas in all of the options. The relative increase in sulfur dioxide emissions (SO_2) would be 11% in the Pyhäjoki and Simo options and about 20% in the Ruotsinpyhtää option, but the tonnage would be very small.

Impacts of traffic emissions will be very local and their impact on air quality will depend, in addition to the emission volumes, on the traffic routes used and current traffic volumes. In all of the options, traffic to the plant runs mostly along highways or motorways. The traffic volumes on these roads are fairly high, and the nuclear power plant's traffic will not cause a significant change in the volumes and, as a result, in traffic emissions and air quality.

The nuclear power plant's traffic emissions can be assessed to have an impact on air quality mostly along smaller, less operated roads leading to the nuclear power plant. Because air quality in all of the site options is assessed to be good, traffic emissions most likely will not have an adverse impact on air quality.

The content of impurities caused by traffic will decrease as the distance to the side of the road increases. As a result, the impact of emissions on people's health depends on the location of housing compared to roads. Impacts on health are discussed in more detail in the section concerning impacts on people.

8.4 Water system and fishing industry

8.4.1 General information

This section presents general information about water systems, fish stocks and the project's impacts for providing background for municipality-specific impact assessments.

Biological impacts of cooling water

Central impacts of cooling water result from the effect that accelerates biological functions because of an increase in the temperature. As a consequence, the growth and decomposition of organisms speed up if the conditions are otherwise favorable. Cooling water causes the growth period to become longer. As a result of these factors, typical impacts observed at cooling water discharge sites include faster growth of certain plankton, plant and animal species and accelerated decomposition. At a general level, the impacts can be compared to eutrophication.

Adaptation of fish to different temperatures and impact on migration behavior

Fish can roughly be divided into cold and warm water species (*Alabaster & Lloyd 1980*). Cold water species include all of our salmonidae, ide, burbot and bullheads. Warm water species include the majority of cyprinids, zander, European perch, northern pike and ruffe. For cold water species, the optimum temperature for mature fish for growth is 12–19 centigrades and the lethal temperature is less than 28 centigrades (*Alabaster & Lloyd 1980*). For warm water species, the optimum temperature is more than 19 centrigrades and the lethal temperature is more than 28 centrigrades, and even more than 30 centigrades for certain species. Fish can endure quick temperature changes poorly. Fries are more sensitive than mature fish and rapid changes of 1.5–3.0 centigrades are damaging (Svobodá et al. 1993).

A winter-spawning burbot usually spawns in January–February at a depth of less than 3 m (*Lehtonen 1989*). The spawning period depends on the water temperature, and spawning generally takes place when the water temperature is at its coldest, the optimum tem-perature being 0–3 centigrades (*Evropeitseva 1947*). For the spawn to evolve, the opti-mum water temperature is 4 centigrades (*Jäger et al. 1981*).

Changes in the water temperature may change the moment of spawning and have an impact on the development rate of spawn. If the water is too warm, fries could hatch out before a sufficient volume of their most important source of nutrition, i.e. zooplankton, has developed. By contrast, an appropriate increase in the temperature may improve the living conditions of spring-spawning fish species. If the water temperature exceeds the optimum temperature of fish, they will reduce swimming and nutrition intake. Longer exposure to high temperatures will cause stress and expose fish to diseases. The immune system of fish is the most efficient in water of about 15 centigrades (*Svobodá et al. 1993*).

Fish have a sensitive temperature sense and they actively seek a suitable temperature; thus, they can usually avoid discharge areas for cooling water if the temperature rises too high. According to studies conducted in several countries, warm cooling water has not been found to have an impact on the rising behavior of fish *(Langford 1990)*. According to the studies, there will be no significant adverse impact on rising behavior when warm cooling ware does not directly prevent fish from accessing rivers. This could take place in a situation where the entire water area in front of a river from the surface to the bottom is warmed up to a temperature that is actively avoided by fish.

Fish parasites

A high water temperature and extended warm season expose fish to different parasite infections and diseases, which has been proven at fish farms. However, the situation in sea areas cannot be directly compared with farm conditions. As far as is known, parasite studies concerning the discharge areas of Finnish power plants have not been published (*Fagerholm, H., Åbo Academi, verbal information*). Swedish studies have not found any differences between the occurrence of parasites in a warming area and the reference area (*Höglund & Thulin 1988, Sandström & Svensson 1990*).

Gas bubble disease in fish

As water temperature increases, the volume of gas dissolving in water decreases. A supersaturated state may occur in water where excessive nitrogen or oxygen contained by water generates bubbles. With regard to oxygen, supersaturation occurs also naturally, particularly in euthropic waters during the maximum production of phytoplankton. As fish move from cold water to warm supersaturated water, bubbles may generate in the fish's interstitial fluid, damaging the fish or causing death. Gas bubble disease may occur in the immediate vicinity of the discharge site for cooling water.

Fish can avoid supersaturated water to some extent (*Langford 1990*). Furthermore, the swimming depth of fish, i.e. environmental pressure, has an impact on the release of gas. The gas bubble disease may cause mortality to a significant extent in discharge sites where the natural migration route of fish runs through a shallow, significantly warming water area. No damage has been observed in discharge sites of Finnish power plants.

Fish driven to the power plant along cooling water

The cooling water intake site has a great significance on the number of fish driven along cooling water. The number of small fish, in particular, is greater close to the shore than in deep sea areas. In the two Olkiluoto plant units, cooling waters carry along 1.5–7 tons of fish a year (*Teollisuuden Voima Oy 2006*). In Neste Oil Corporation's Porvoo refin-ery where water intake is 30 m^3/s, cooling water taken in carries along 39–56 tons of fish a year (*Neste Oil Corporation 2006*). Fish can be prevented from being driven into the cooling water intake system through different technical measures.

Alien species

The North-American polychaete has spreaded into the Baltic Sea from North-American deltas through ballast water. It was first observed in the Baltic Sea in 1985, in the Gulf of Finland in 1990 and in the Bothnian Bay in 1996 (*Finnish Institute of Marine Research 2008a*). Currently, it has spread throughout Finnish sea areas up to Tornio. It has largely changed the species structure at soft sea bottoms and it occurs as the dominant species in some places. The species endures a relatively low oxygen content.

Cordylophora caspia arrived at the Baltic Sea at the beginning of the 19th century through the ballast waters of ships. The species originates from the Caspian Sea but it has spread efficiently to brackish water areas around the world. One of the reasons it thrives is its large tolerance to salt content and temperature fluctuations. It can endure temperatures from -10 (in resting form) to +35 centigrades and reproduce between 10 and 28 centigrades. It can also always endure fresh water up to salinity of 35‰ and re-produce in salt content of 0.2–20‰ (*Tyler-Walters & Pizzolla 2007*). Cordylophora caspia has been observed to generate large plant stands in the cooling water system at the Olkiluoto nuclear power plant. However, the plant stands do not have an impact on the plant's safety or electricity production. The plant stands can be prevented by rinsing the cooling water routes with chlorine. The residual concentration caused by chlorination in the cooling water conducted into the sea is low and it is assessed not to cause pollution in the environment.

Mnemiopsis leidyi originates from the American east coast, from where it has spread to several regions through ballast water of ships. Similar to many alien species, it can adapt to numerous environments because is can endure large variation in salt and oxygen content and in temperature. It thrives in salt content of 2–38 ‰ and temperatures of 2–32 centigrades, and endures low oxygen content (*Purcell et al. 2001*). It is androgynous and can reproduce by splitting, enabling the species to reproduce very rapidly under suitable conditions. Mnemiopsis leidyi preys efficiently on zooplankton, fish spawn and fries. After spreading into the Black Sea, the species reduce the European anchovy stock rapidly and caused changes in other levels of the ecosystem. The species was first observed in the eastern Baltic Sea in 2006. In August 2007, it was observed in the northern Baltic Sea and it exists elsewhere in the Baltic Sea apart from the Bothnian Bay. The species can also reproduce and winter in the Baltic Sea (*Lehtiniemi et al. 2007*). The species has been observed to thrive in deep bottom areas in the Baltic Sea (at a depth of more than 50 m) below the salinity metalimnion. It has not been observed in the Baltic Sea in salt content of less than 5%. The volume of zooplankton in the northern Baltic Sea is thought to be the central factor limiting it from becoming abundant.

Alien species in the Baltic Sea also include the zebra mussel and dark false mussel that belong to the species of zebra mussel. The zebra mussel originates from the Black Sea and Caspian Sea region. Its optimum salt content is said to be less than 1‰, but it is also observed in conditions with a higher salt content (*Kilgour et al. 1994*). The species was observed on the Finnish coast in 1995 and it currently exists in places on the shoreline. In favorable conditions, it can grow rapidly and has caused problems in the world by thriving in abundance in cooling water channels of power plants (*Kauppila & Bäck*

The EIA process has studied the impacts on landscape brought about by the nuclear power plant project. Boat in a sea view in Simo, 2008.

2001). However, it exists only locally on the Finnish coast and has not caused problems of any similar extent. The occurrence of the zebra mussel is limited by the temperature because, in order to reproduce, it requires the average water temperature to increase to more than 12 centigrades in summer (*Orlova 2002*).

Dark false mussel is a brackish water species and its optimum salt content is said to be 1.4–12.7‰. The occurrence of the species in relation to salt content overlaps that of the zebra mussel particularly in areas where the salt content is 0.2–3.0‰. The original range of the dark false mussel is the Gulf of Mexico in North America. The species was first observed in the northern Baltic Sea in 2003 in Loviisa nuclear power plant's cooling water discharge area where it exists in tight communities. The dark false mussel is originally from the border of subtropical and temperate zones and its occurrence and spreading in the Baltic Sea is possibly limited by the temperature. Furthermore, it has not been observed to be able to reproduce outside the affected area of cooling waters. As far as is known, the zebra mussel and dark false mussel do not exist in the Bothnian Bay.

Special features of the Bothnian Bay

Special features of the Bothnian Bay region include shallowness and low salt content which is approximately 0.2–0.4%. Similarly to the Baltic Sea in general, the salt content increases towards the south. The low salt content results from the high volume of fresh water conducted through rivers and the shallowness of Kvarken, which reduces the flow of water with higher salt content to the Bothnian Bay. The impact of low salt content can be seen as vertical stratification which is weaker in the Bothnian Bay than in the Baltic Sea. Because of weak stratification, the Bothnian Bay does not have oxygen depletion which is typical to the actual Baltic Sea because water columns are also mixed at the bottom during spring and fall cycles. However, the oxygen status in deep sea areas has decreased slightly over the recent years (*Olsonen 2008*). The Bothnian Bay is low in nutrients but, because of rivers, there is plenty of humus. The nutrient content of the Bothnian Bay has remained at the same level over the recent years (*Olsonen 2008*). Unlike the other basins of the Baltic Sea, a typical feature of the Bothnian Bay is its phosphorus-limited basic production. However, production close to the shore may also be nitrogen-limited as a result of rivers and any waste water. There are not as many species as in the actual Baltic Sea and they consist of brackish and fresh water species. Because of low salt content, there are fewer marine species than in the actual Baltic Sea. (*Kronholm et al. 2005*).

Classification of the ecological status of surface waters
The preliminary classification based on the ecological and chemical status of surface waters in accordance with the EU Water Framework Directive was implemented in Finland for the first time in 2008. Deviating from the previous water quality classification, the emphasis of the ecological classification is placed on water biology and on how human activities have affected the biological state. (*Environmental Administration 2008a*)

Surface waters are classified into five categories: excellent, good, satisfactory, adequate and poor. The classification has mainly been performed on the basis of monitoring results from 2000–2007. Preliminary water classification has been performed by regional environment centers. The final classification will be completed at the end of 2009 at the latest and will be reported to the EU at the beginning of 2010.

8.4.2 Pyhäjoki, Hanhikivi

8.4.2.1 Current state of waters

The regular monitoring programme for water quality and biological state implemented closest to the Hanhikivi headland is the obligatory monitoring programme off the coast of Raahe. The sea area off Raahe is burdened by wastewater from Rautaruuki Oyj's Raahe steel plant and wastewater processed in the town of Raahe (*Pöyry Environment Oy 2007a)*.

Other regular monitoring points for water quality include the OUVY-1 station off Pyhäjoki belonging to the monitoring of coastal water quality conducted by the North Ostrobothnia Regional Environment Center and the OUVY-2 station off Raahe that repre-sent the outer coastal zone. The rr-8 monitoring station which previously was included in regular monitoring is outside the coastal area defined by the Water Framework Direc-tive and, as a result, samples have not been taken from the station since 2006. The quality of sea water has been monitored regularly since the 1970s (*Environmental Administration's Hertta database*).

The state of the sea area surrounding the Hanhikivi headland is described based on the obligatory monitoring off Raahe and the water observations included in the Hertta database. In order for the observations to represent the state of the sea area surrounding the Hanhikivi headland as well as possible, the nearest coastal points clearly belonging to the scope of rivers and wastewater have been left outside the assessment. The assessment utilizes other research data available concerning the area's water ecosystem and the impact of cooling waters.

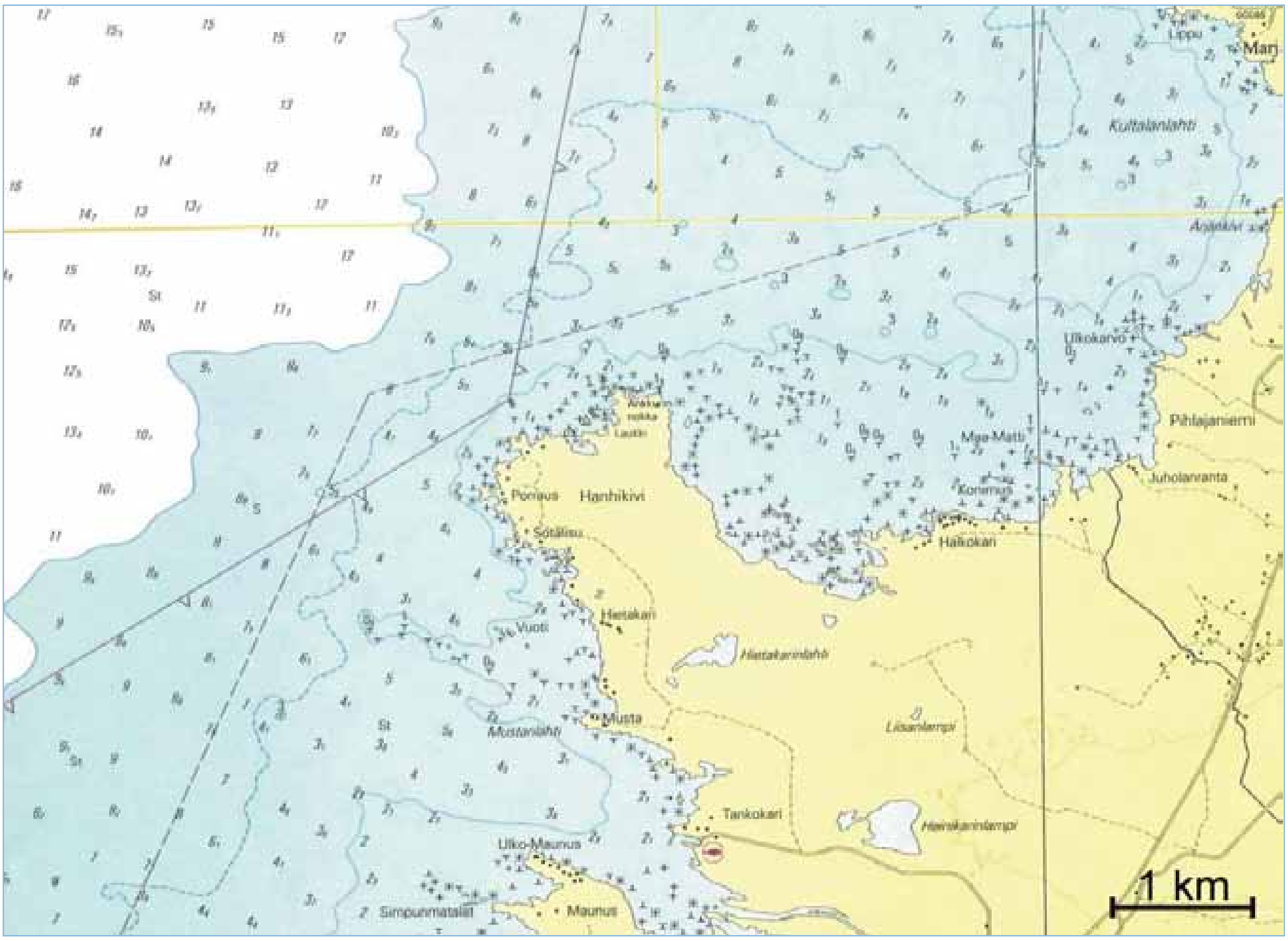


Figure 8-13. Extract from the nautical chart of the Hanhikivi headland area.

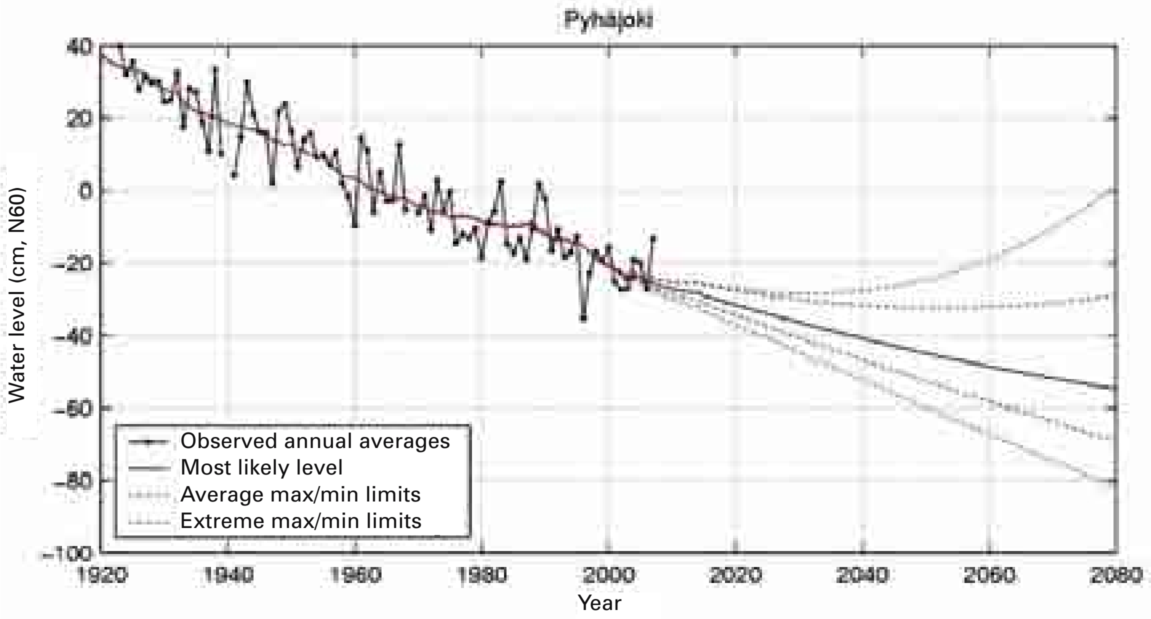


Figure 8-14. Interpolated annual averages and average water level scenario in Pyhäjoki, values interpolated linearly from the values calculated for the Raahe and Jakobstad observation sites. *(Finnish Institute of Marine Research 2008a)*

General description

Hanhikivi is located on the coast of the Bothnian Bay between Pyhäjoki and Raahe. Viewed from the coastal level, Hanhikivi is a headland some 4 km long and slightly more than 1 km wide (Figure 8-13). The coast is very open by Hanhikivi and the sea opens directly in front of the headland. Furthermore, there are only a few small islands and islets close to the headland. The coastal zone surrounding the headland is very shallow and rocky. Particularly the bay on the northeast side of the headland is shallow, consisting of a water area which is only a meter deep up to a distance of 1 km from the shore. The water area deepens more quickly from the headland's northwest tip towards the open sea, and the depth is more than 10 m at a distance of 1 km from the shore.

The most significant of the rivers flowing near the Hanhikivi area is the Pyhäjoki river (average flow rate 29 m^3/s). It discharges itself into the southwest side of the Hanhikivi cape at a distance of 6 km from the headland. No significant rivers flow on the northeast side. As a result, the impact of river waters on the sea area is smaller in the Hanhikivi headland than in the majority of the north-eastern coast of the Bothnian Bay. Because of the openness of the shore, water changes efficiently in the area, and the risk of eutrophication in the shore areas in Pyhäjoki is rather small *(Henriksson & Myllyvirta 2006)*.

Currents

In the Bothnian Bay, currents are mainly caused by winds and, therefore, their direction and strengths vary greatly (*Kronholm et al. 2005*). The main current flows towards north along the Finnish coast and towards south along the Swedish coast. For southerly winds prevailing off Hanhikivi, the main current flows from south to north.

A large volume of water flows between the Bothnian Bay and the Bothnian Sea. There is mainly low-saline surface water flowing out and more salinic water of the Bothnian Sea flowing in. In the short term, the relationship between these water masses is fairly constant. In the long term, the relationship may change which will lead to changes in the salt content in the Bothnian Bay. (*Kronholm et al. 2005*)

Average water level and water level extremes

This section presents the average fluctuation in water level and water level extremes in the project area, based on the report of the Finnish Institute of Marine Research ordered by the company responsible for the project (*Finnish Istitute of Marine Research 2008 a*). The level is presented in the N60 system.

The continuous water level measurement sites closest to Hanhikivi and used in the survey are located in Raahe (distance approximately 18 kilometers) and Jakobstad (distance approximately 120 kilometers). Both stations have provided observations since 1922.

Isostatic uplift on the coast of the Bothnian Bay will continue to be quicker than the increase in the sea level according to the most probable scenario (Figure 8-14). In Pyhäjoki, the water level will most likely continue to decrease in relation to the ground. According to the most likely estimate, the sea level in Pyhäjoki will decrease by 27 cm from the current level by 2075.

The most significant factors affecting short-term water

Table 8-3. Sea level extremes in 2008 and 2075 corresponding to the level of probability of 10^{-3} events/year.

	Highest sea level (cm)	Uncertainty limits	Lowest sea level (cm)	Uncertainty limits
In 2008	+188	–	-192	–
In 2075	+161	+140 – +210	-219	-240 – -170

level fluctuation on the coast of Finland are wind, fluctuation in atmospheric pressure and the to-and-fro oscillation of the water level of the Baltic Sea *(seiche effect)*. The impact of tide is small, only a few cm. Short-term water level fluctuation is the highest in the remotest corners of the Gulf of Bothnia and the Gulf of Finland.

Probability distributions were calculated for extreme water level values on the basis of observed monthly maximum and minimum values. The water level values calculated from the distributions correspond to the level of probability of 10^{-3} events/year, or one event per a thousand years as estimated currently. The highest sea level in 2075 in Pyhäjoki is likely to be approximately 27 cm lower than in 2008 (Table 8-3). As a result of the decrease in the average water level, also the lowest extremes will decrease. The lowest sea level in 2075 is likely to be 27 cm lower than in 2008

Ice conditions

Because of the cold climate and low salt content, the Bothnian Bay usually freezes over every year. Ice typically starts to generate at the beginning of November and the Bothnian Bay is usually free of ice at the beginning of May.

The formation of pack ice is a typical phenomenon in the Bothnian Bay region. Winds and currents shape the ice particularly in the outer archipelago and on the open sea. Different sizes of ice floes form ice barriers. The barriers can be very high, in which case they will also extend below the water surface. Ice has been found to scrape the sea bottom up to a depth of 28 m. Generally, the impact only extends a few meters. (*Kronholm et al. 2005*)

Water quality

The quality of water off Hanhikivi is mainly affected by the general state of the Bothnian Bay because wastewater is not conducted to the area and the impact of rivers is generally small. The impact of river water, particularly the nearby Pyhäjoki river, can be seen in the quality of water in the coastal area as the runoff is great particularly in spring. The cost off Hanhikivi is open, and water variation is at a good level because of the mixing effect of winds and currents and its quality remains close to that of the outer sea area.

The total phosphorus content off Hanhikivi has typically varied between 5 and 15 µg/l in 1990–2007 (the average is 6 µg/l), depending on the season and sampling site. In the nearest sites off Raahe, the phosphorus content has been higher than farther away because of the impact of wastewater. The content has decreased slightly over the inspected period. The total content of nitrogen has typically varied between 200 and 350 µg/l (the average is 300 µg/l). No clear direction has been found in the nitrogen content over the inspected period. The content of nutrients has typically been at the same level in all aqueous layers. The nutrient content is typical for rough waters. Production has varied from nitrogen- to phosphorus-limitation, being more often phosphorus-limited in sites close to the coast. The oxygen status of the sea area off Hanhikivi remains at a good level throughout the year because of the roughness and mixing of water, and there is no oxygen depletion.

The salt content of sea water in Hanhikivi has been an average of 3‰, which is clearly higher than in northern areas of the Bothnian Bay. Near the shore the salt content can be clearly lower, particularly if the Pyhäjoki flow is at a high level.

Water transparency is rather low near the shore varying between 1.5 and 3 m depending on basic production linked with the season and the volume of humus conducted by river waters. In areas located farther from the coast, water transparency can be significantly higher, up to 7–8 m in the fall.

The monitoring sites for water quality off Hanhikivi are located about 5–15 km from the mainland, in the outer coast area and in the open sea. Near the coast, the content of nutrients and humus is most likely a little higher than that presented above and the salt content is probably a little lower. However, the results from the outer sea area can be considered to represent water quality near the coast fairly well, because water changes off Hanhikivi well. The impact of fresh water from the Pyhäjoki river which has a higher content of nutrients and humus can be seen clearly in the water quality in the sea area southwest of Hanhikivi, particularly during spring floods. In spring and during seasons with low winds, the border between river water and sea water can be rather striking in the sea area and clearly observable visually because of the color of the water.

In typification in accordance with the ecological state of surface waters, the sea area off Hanhikivi belongs to inner coastal waters of the Bothnian Bay. According to the ecological classification for water status drawn up by environmental authorities, the state of the sea area off Hanhikivi is good.

Phytoplankton and zooplankton

Because of the short vegetation period, basic production in the Bothnian Bay is low compared to the other basins of the Baltic Sea. The volume of phytoplankton can be measured using the chlorophyll content, i.e. leaf green content. The chlorophyll content measured near Hanhikivi show fairly large variation, which relates to normal variation between the sampling dates. The chlorophyll content is increased significantly if the sampling is performed at the same time as diatom thrives strongly, which is emphasized if there are only a few sampling times. The chlorophyll content has, on average, been at the level typical for slightly eutrophic waters.

The sea area off Hanhikivi has not been included in national blue-green algae monitoring. The nutrient content is low in the area and water variation is good. As a result, it is assessed that there are not any inflorescence masses of blue-green algae.

No zooplankton studies have been conducted close to the Hanhikivi region; thus, species are described roughly on the basis of general features in the Bothnian Bay. A typical feature of zooplankton communities in the Bothnian Bay, as of other species, is the abundance of fresh water species and a low number of total species. Similarly to the phytoplankton community, the zooplankton community changes fairly regularly during a year. For the majority of the year, the community is dominated by copepods (*Kronholm et al. 2005*). When water is at its warmest at the end of summer, there are lots of daphnia. They are common in coastal waters where they can easily be the dominant group of zooplankton. During the warm season, there are also plenty of rotifers. According to the latest national monitoring, the average zooplankton mass in the Bothnian Bay is growing (*Olsonen 2008*).

Aquatic vegetation and macroalgae

Underwater vegetation off Hanhikivi has not been mapped. The occurrence of aquatic vegetation and macroalgae is affected by geographic position and prevailing weather conditions. Aquatic vegetation in the Hanhikivi headland is described roughly on the basis of the weather conditions and general information about the Bothnian Bay region (*Kronholm et al. 2005, Leinikki & Oulasvirta 1995*).

In the open shores off the headland, the bottom is rocky because of waves and currents. On hard rock bottoms, species mostly consist of macroalgae that can attach themselves to the rock surfaces. These include annual filamentous green algae, such as cladophora glomerata. Cladophora glomerata generally appears in the coastal zone of the Bothnian Bay as a dominant species up to a depth of 2.5–3 m. Below this limit, the dominant species up to the alga limit is often another filamentous green alga, i.e. cladophora aegagropila. Only a few species of marine red algae exist in the area, such as ceramium tenuicorne. Because of the low salt content in Hanhikivi, focus vesiculosus is missing from the species of the sea area.

The generation of organic matter in sheltered bays changes the quality of the bottom. Vascular plants are often dominant in soft bottoms. Vegetation in the Bothnian Bay is dominated at the water level by eleocharis acicularis and potamogeton berchtoldii and, in sand bottom areas, by chara aspera and zannichellia palustris. In deeper waters, common species include potamogeton perfoliatus and potamogeton vaginatus. The appearance depth for vegetation is regulated by the amount of light. Water in the Bothnian Bay area is dark as a result of humus, because of which the lower limit for vegetation runs generally at less than 5 m near the shore.

Bottom fauna

The volume and composition of bottom fauna have been monitored off Raahe as part of the region's obligatory monitoring related to the fishing industry since the end of the 1970s.

The dominant group among the region's bottom fauna is lumbriculus variegates which is typical in soft bottoms. Small groups of monoporeia affinis which is fairly demanding with regard to the quality of water have appeared in the area throughout the inspected period. The species which usually thrives farther away from the coastal zone has been observed in small groups and the number of observed individuals has largely remained stable. The appearance of caridina japonica and corophium volutator has been regular, but the density has been small. A small density of saduria entomon which endures a small load of wastewater has appeared regularly. No significant changes have taken place in the composition of the bottom fauna over the recent years, and the species have remained the same. (*PSV- Maa- ja Vesi Oy 2005*)

Typically, the rocky bottoms in the Bothnian Bay have large communities of cordylophora caspia. The species appears on plant surfaces and on hard bottoms. (*Leinikki & Oulasvirta 1995*)

Sedimentary deposit

No research has been conducted off the Hanhikivi headland concerning the composition or chemical properties of sedimentary deposit. However, the content of detrimental elements is estimated to be fairly low. Polluted sedimentary deposits are typical in areas close to ports, industrial wastewater or other similar operations. Wastewater has not been conducted off Hanhikivi. As a result, the sedimentary deposit is assessed to be clean.

Fish and fishing industry

A total of 216 fishermen fished in the sea area off the mouth of Pyhäjoki river (south of the mouth of Pyhäjoki river approximately 4 km from Hanhikivi) in 2003 mainly using fishing nets (*Juntunen et al. 2004*). A small amount of trap fishing is carried out in the sea area and lampern hunting in the mouth of Pyhäjoki river. Fishing at sea mainly took place in the early summer and fall. The average fishing season was about one month. The total haul, excluding trap fishing, was 14 tons, of which common whitefish represented 60% and coregonus albula, Baltic herring and northern pike represented 10% each. The fisher-specific haul in the mouth of Pyhäjoki river was 63 kg.

According to the fishing survey (*Pöyry Environment Oy 2007a*) conducted in the sea area off Raahe north of Hanhikivi (Pattijoki-Raahe-Saloinen-Piehinki), less than 200 households performed domestic fishing in the sea area in 2006, and 37 fishermen were engaged professional fishing. The professional fishermen mostly carried out net and trap fishing. The emphasis of fishing was placed on net fishing.

Professional fishermen used 41 large traps and coarse-meshed nets. The professional fishermen used slightly less than 7,000 fishing nets, half of which were fine-meshed small whitefish nets (mesh size 27–33 mm) and half large whitefish nets (mesh size 35–60 mm). Trap fishing was mainly carried out in June–August and net fishing in summer and fall. Winter fishing using nets was carried out by one-fourth of professional fishermen. The most popular forms of fishing for domestic fishermen included net fishing, casting rod fishing and trolling. Domestic fishermen used 24 large traps and about 4,500 fishing nets, of which more than 60% were coarse-meshed whitefish nets (35–60 mm). Domestic fishermen's net fishing was mainly carried out in the open water season. Winter fishing using nets was carried out by one-fourth of net fishermen.

The total haul off Raahe was 76 tons in 2006, of which small whitefish (coregonus widegreni) represented 29%, large whitefish (coregonus lavaretus) 24%, European perch 20% and Baltic herring 13%. Salmon and trout represented only 2–3% each. The significance of other fish was minor. The most important fish for professional fishermen were whitefish, European perch and Baltic herring, and whitefish and European perch for domestic fishermen. The share of professional fishermen of the total haul was nearly 70%. The household-specific haul for domestic fishermen was 133 kg, and 1,385 kg for professional fishermen.

Fishing in the sea area is mostly damaged by slime buildup in traps.

Trap fishing is performed in areas surrounding Hanhikivi (at a radius of 5 km from Hanhikivi) by five fishermen, some of whom are in the professional fisherman register (*Perämeren kalatalousyhteisöjen liitto / Union of fishing industries in the Bothnian Bay, verbal information*). The nearest trap sites are on the north side of Hanhikivi close to the planned discharge site for cooling water. About 12 traps are used. Active net fishing is carried out in the area, focusing on catching whitefish. The area north of Hanhikivi is the most significant fishing area. About 20 fishermen perform professional net fishing. Winter net fishing is rare in the area. Domestic fishing is mainly carried out in the area using nets.

The shallow shoals in the Hanhikivi environment are important spawning areas for whitefish. The migration route of coregonus lavaretus rising from the south passes partly in front of Hanhikivi. The main migration route of salmon runs farther out at sea. As a result, the salmon haul caught off Pyhäjoki and Raahe is fairly small. Parhalahti south of Hanhikivi is particularly rich in salmon and the bay also contains grayling, at least some of which spawns on the surface of Liminkaoja which runs to Parhalahti. In addition, sea-spawning grayling may also appear in the area. Lampern also rises to Liminkaoja and is caught from the ditch for domestic purposes.

8.4.2.2 The impact of wastewater

The project will create social and process wastewater. Some of wastewater will be treated in the plant area and some can be conducted to be treated in a municipal water treatment plant. The project's wastewater load (wastewater fractions, volumes, load and treatment) is described in more detail in Chapter 3.9 Wastewater.

If a separate water treatment plant is built in the plant area, the eutrophication of the sea area may increase locally in the immediate vicinity of the discharge site caused by the impact of nutrient load. However, the nutrient load caused by the project is assessed to be so small that it will not have an impact on the general status of the Hanhikivi area or the Bothnian Bay.

Salt created in neutralizing process wastewater is the same salt contained by sea water naturally. Thus, neutralization water will not have an impact on the water quality in the sea area. Furthermore, boron used in certain plant types appears naturally in sea water. It belongs to necessary microelements but is toxic in large concentrations. However, the wastewater conducted in the sea contains so small concentrations of boron that it will not cause any adverse impacts on the water environment.

8.4.2.3 The impact of cooling waters on sea water temperature

The impact of thermal load caused by the power plant on sea water temperatures was assessed through model inspections carried out by Suomen Ympäristövaikutusten Arviointi Oy. The modeling methods and assessment of

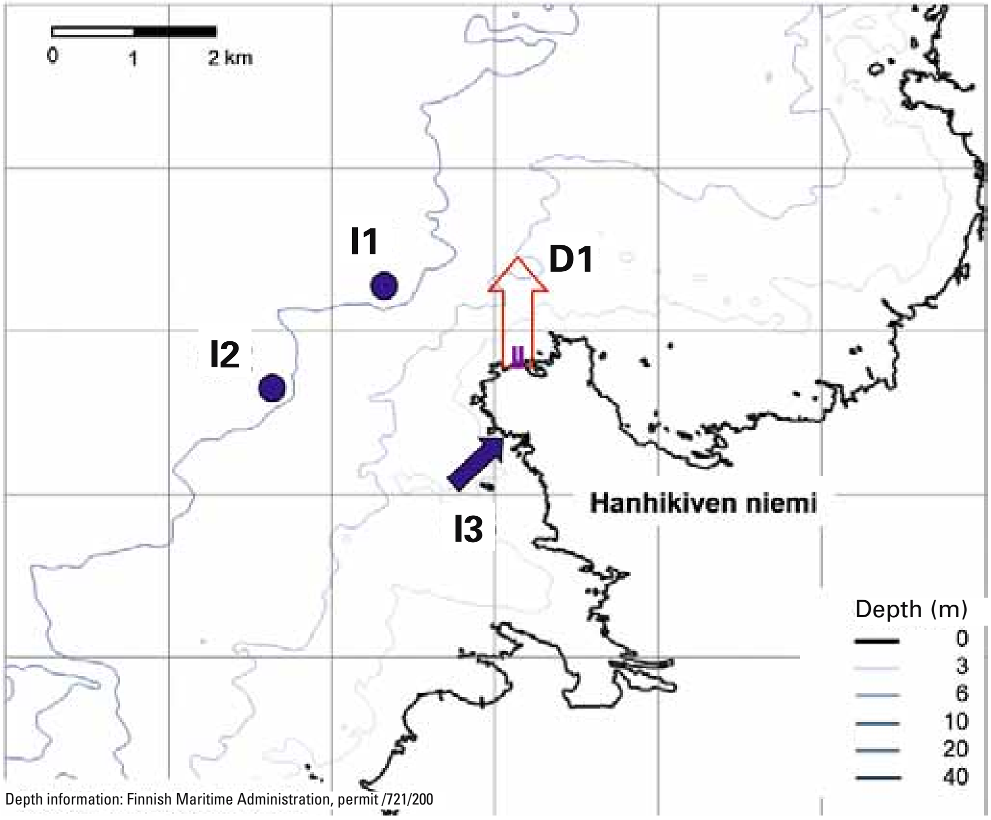


Figure 8-15. Alternative cooling water intake and discharge locations.

Table 8-4. A description of the intake and discharge arrangements.

I1, intake 1	intake from the bottom at the depth of 10 m
I2, intake 2	intake from the bottom at the depth of 10 m
I3, intake 3	intake channel at the surface level, direction from southwest
D1, discharge 1	discharge channel at the surface level, direction to north

the accuracy are presented in Chapter 7.

Cooling water warms up by about 12 centigrades as it flows through the power plant. The temperature of the sea water used as cooling water is about 20 centigrades at maximum in summer. At the mouth of the discharge site for cooling water, the temperature may be about 32 centigrades at maximum.

The alternative intake and discharge sites for cooling water are presented on the map (Figure 8-15). Three different intake sites and one discharge option were inspected in the modeling (Table 8-4). Only one discharge site option was inspected in Pyhäjoki because the other options considered at the model selection stage were assessed to have less favorable environmental impacts. The discharge site option west of Hanhikivi was left outside the inspection because its impact was assessed to be partly targeted at the Natura 2000 area. The option on the east side was abandoned because its impact would have been targeted at the area containing protected shore meadows.

The impact of cooling water on the state of the sea area off Hanhikivi has been inspected using three combinations of intake and discharge sites. The inspected options are:

A. Bottom intake I1 on the southwest side, discharge D1 to north
B. Bottom intake I2 on the west side, discharge D1 to north
C. Shore intake I3 on the southeast side, discharge D1 to north

Each of the intake and discharge option combinations (A–C) is modeled for two different electric output options:

Option 1: a power plant with electric power of 1,800 MW
Option 2: a power plant with electric power of 2,500 MW (two power plant units)

In addition, the model has been used to calculate the zero option, i.e. a situation without any thermal load caused by cooling water.

The warming effect of cooling waters has been studied at different depths. Frozen sea in Pyhäjoki, 2008.

Average temperature increase in different aqueous layers
The warming-up impact of the power plant's cooling waters at different depths was assessed using the average temperature fields in June (1 June 2003 – 1 July 2003). The average temperature in June for the zero option in the layer of 0–1 m was about 12 centigrades. Temperature increases are calculated by reducing the zero option's reference field from the result field of each alternative calculation. For all options, temperature increase is presented in the layer of 0–1 m (Figure 8-16). Temperature increase in the layer of 2–3 m is presented as an example for Option C2, because the options did not much differ from one another (Figure 8-17). In addition, the impact of different option combinations (A–C) on temperature increase has been inspected as areas in deeper layers (more than 3 m) (Figure 8-18).

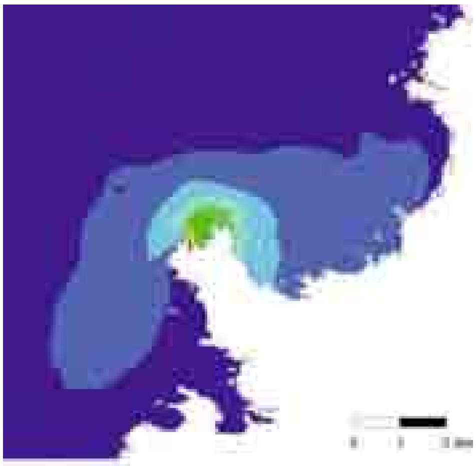
In the surface layer, the area which warms up by more than one centigrade was 23 km^2 at maximum in Option A2. Smaller heat increase areas were in Option B for both power options. The temperature increase is smaller in Option C2 than in Option A2, even though cooling water is taken from closer to the surface. The reason is that northern winds prevail in June and the current along the coast runs mainly to south. This gen-erates upwelling near the coast, rising cold water below cooling water. Then, cooling water mixes with the risen water and cools down. Intake I1 is in the route of the cold bottom current and reduces the volume of cold water rising from the bottom to the discharge site, causing the discharge water to cool down more slowly. In Option B, the warmed-up area is smaller than in Options A and C, because the intake (I2) is not in the route of the bottom current and does not cause a similar phenomenon. The phenomenon is mainly connected to northerly winds.

In the surface layer, an average temperature increase of more than five centigrades is limited to the nearby areas of the cooling water discharge site, being less than 0.75 km^2 in all of the inspected options. The largest increase in temperature is in Option C where intake water is taken from the surface, being warmer than water taken from the bottom. The smallest area to warm-up is in Option B (see previous paragraph).

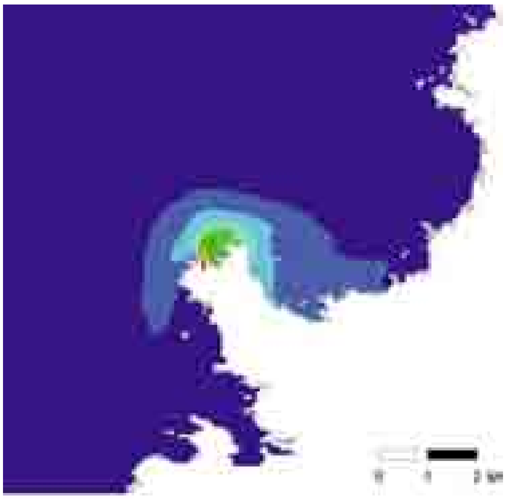
In deeper layers, the temperature increases only slightly and has not increased by more than one centigrade in any of the options at the depth of more than 9 m in an area of more than 0.05 km^2. Water warms up only a little at depths of more than 3 m in all of the inspected options.

Average temperature increase in different wind conditions
Typical spreading of heated cooling water was estimated under different wind conditions by calculating increases in temperature over two tenday periods in July 2007, 6–16 July (north wind) and 19–29 July (south wind), and over the whole of July. In the former period, winds

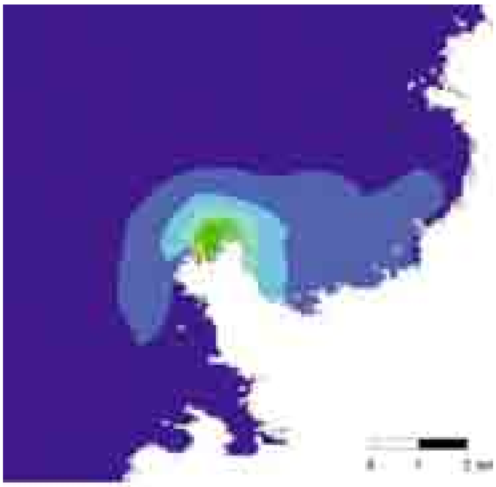
A1, 0–1 m layer



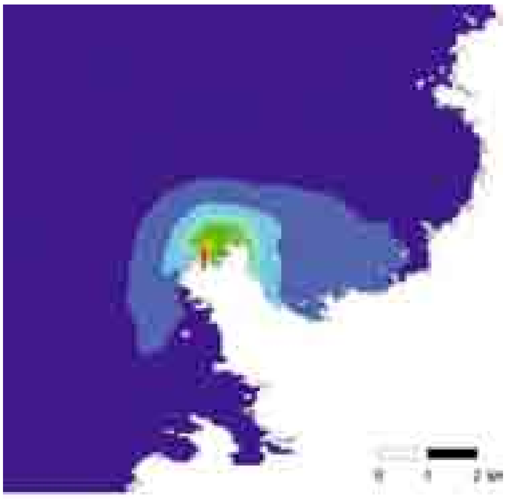
A2, 0–1 m layer



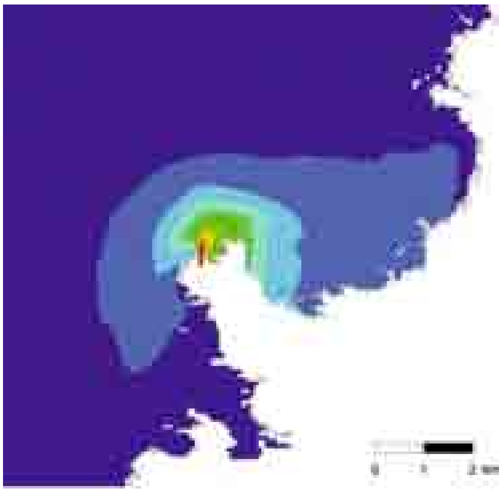
B1, 0–1 m layer



B2, 0–1 m layer



C1, 0–1 m layer



C2, 0–1 m layer

Figure 8-16. Temperature increase compared to the zero option in the aqueous layer of 0–1 m as an average June value in Options A1 and A2, B1 and B2 and C1 and C2.

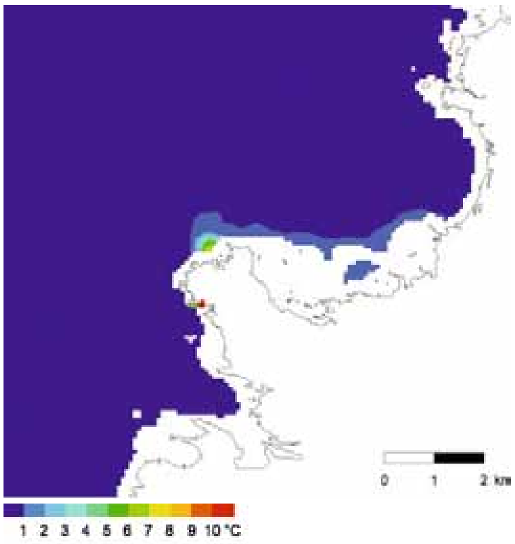


Figure 8-17. Temperature increase compared to the zero option in the aqueous layer of 2–3 m as an average June value in Option C2. The white areas are less than 2 m deep.

were mainly directed from the north and east and, in the latter period, from the south and southwest. The impact of wind direction is illustrated in one option (C) (Figure 8-19), because the difference between intake sites can mainly be seen in the size of the area warmed up.

For southerly winds, heat tends to accumulate in Kultalahti on the northeast side of Hanhikivi, in which case the area which warms up by more than one centigrade is rather large compared with the event of northerly wind. However, warm water mixes well with the current running along the coast and circles to the coast through the open sea.

For northerly winds, there is upwelling on the coast, i.e. a phenomenon where wind pushes warm surface water to the open sea and cold water rises from the bottom to the surface layer. In these conditions, the power plant's cooling water mixes efficiently with the rising cold water, and thermal increase areas are clearly smaller than in the event of southerly winds.

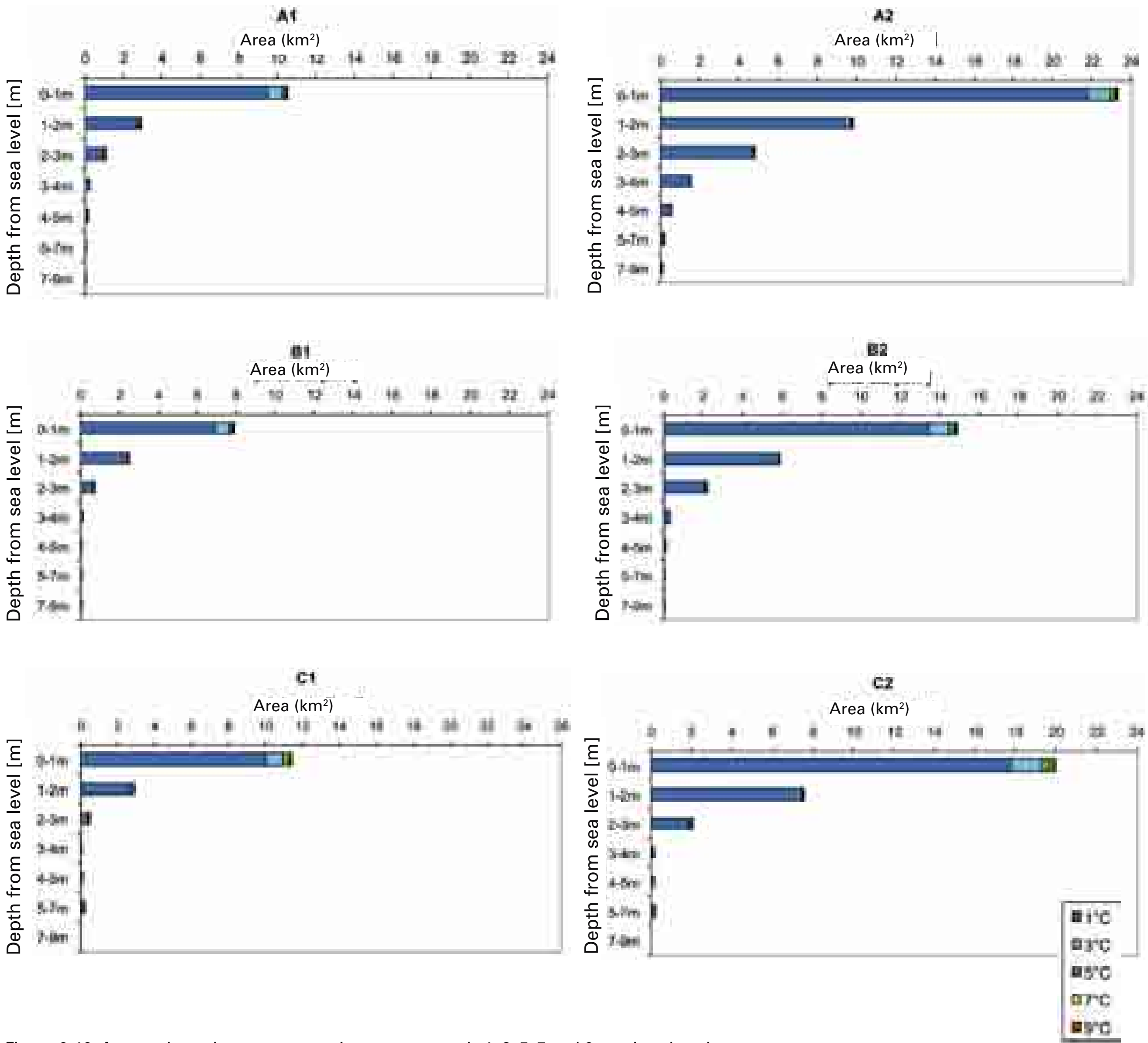


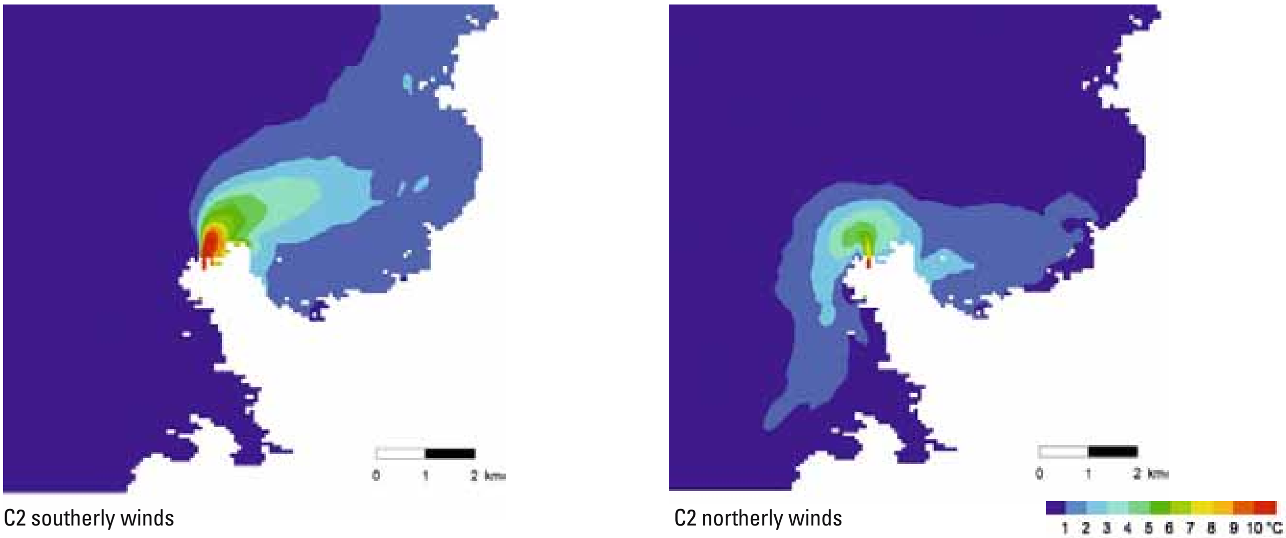
Figure 8-18. Areas where the temperature increase exceeds 1, 3, 5, 7 and 9 centigrades, June average.

Calculated as a July average, the area which warms up by more than two centrigrades is less than 17 km² in all of the options and, in all of the options with two units, less than 10 km² (Figure 8-20). The smallest areas with a temperature increase of more than one centigrade were in Option B and the largest in Option C. This is caused by the lower water temperature at the intake site (I2) in Option B compared with the shore intake (I3) in Option C. The difference between the electric power options can be seen in the size of the area warming-up which is nearly 50% larger in the option with two units.

8.4.2.4 The impact of cooling waters on the ice conditions

The project's impact on the sea area's ice status was inspected in a situation at the be-ginning of February under ice winter 2002–2003 conditions. With regard to the extent of the ice coating, the 2002–2003 ice winter was average (*Finnish Institute of Marine Research 2008cw*). It was unusual in that the winter started earlier than on average and lasted longer than on average. Freezing started in the north of the Bothnian Bay at the end of October, i.e. two weeks earlier than on average. The beginning of December was cold, and freezing took place quickly. The Bothnian Bay was covered with ice in the mid-December, i.e. a month earlier than normal. At the end of May, ice first started to break up in the south of the Bothnian Bay about a week later than normal and, finally, in the north of the Bothnian Bay on May 28, i.e. at the normal time. The ice winter lasted about three weeks longer than normal in the Bothnian Bay. (*Kalliosaari 2003*)

According to calculations, the current close to the surface in the Bothnian Bay during winter runs along the shore circling counter-clockwise, mainly to north on the Finnish coast and to south on the Swedish coast.



C2 southerly winds

C2 northerly winds

Figure 8-19. Average warm-up in the surface layer in July 2003 considering option C2 in southerly and northerly winds.

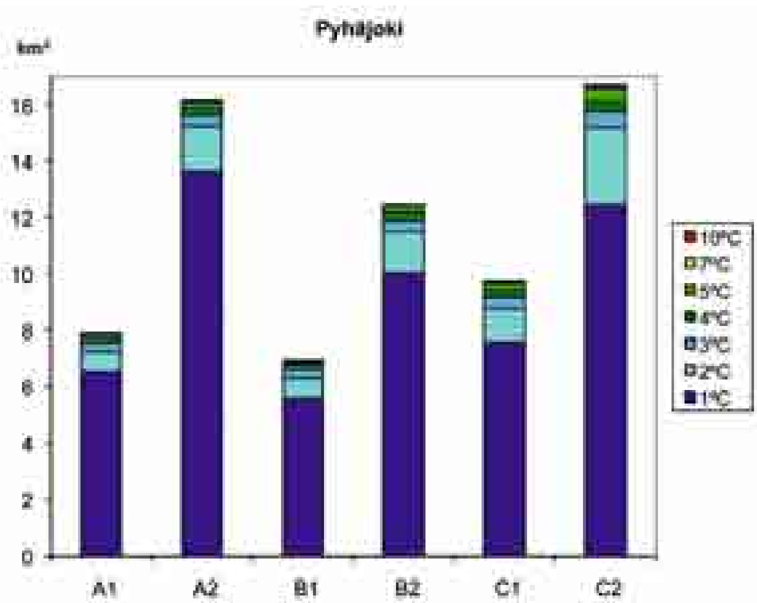
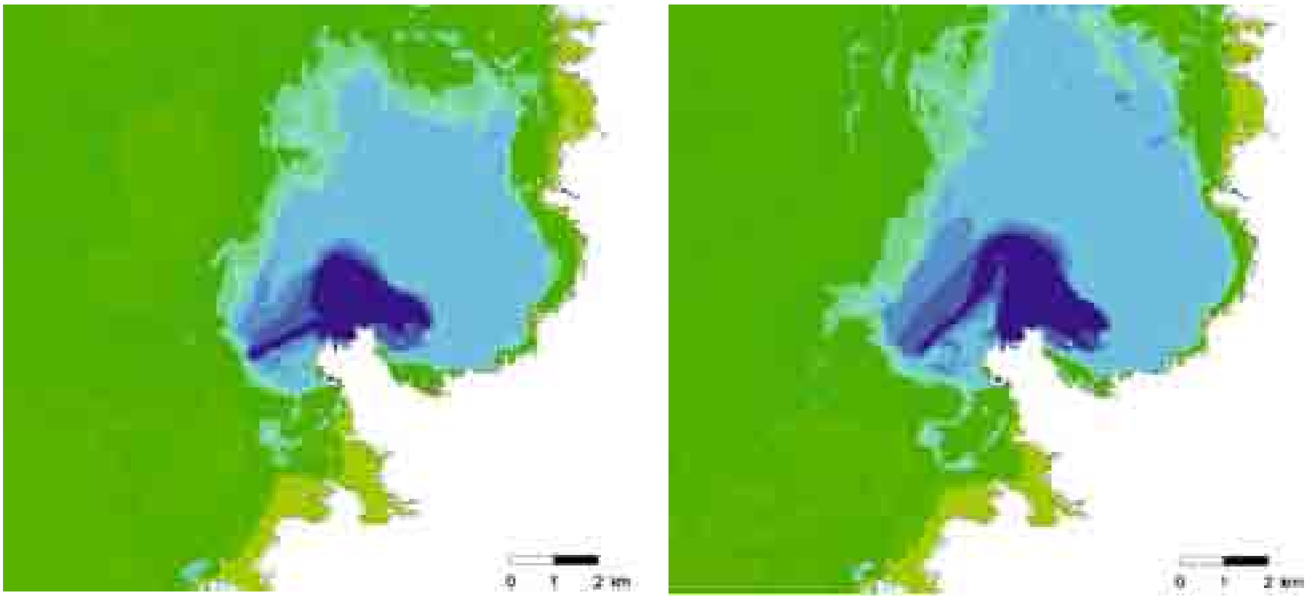


Figure 8-20. Areas where the surface layer warms up by 1–10 centigrades as a July average.



Ice condition in the option C1 | Ice condition in the option C2

Figure 8-21. The impact of cooling waters on the project area's ice status at the beginning of February.

The current off Pyhäjoki follows the main current, but the shallow coast areas cause bends and whirls in the current.

In winter, the thermal load of cooling water keeps the discharge site unfrozen and causes ice to thin out mainly to the north and east of Hanhikivi (Figure 8-21). The unfrozen area or thin ice area (thickness less than 10 cm) is about 8 km² for the 1,800 MW power plant option (1) and about 12 km2 for the 2,500 MW power plant option (2).

Differences between the unfrozen and thin ice areas are minor in Options A and B. In Option B, the areas are, however, slightly smaller (apart from Option A1 where the thin ice area is smaller than in option B1 by 0.2 km²). In Option C, the unfrozen and thin ice areas are a little larger compared to Options A and B, particularly in the option with two units (10–20%).

Table 8-5. Areas of open sea or thin ice (less than 10 cm) in the different options in modeling throughout February (2003). The area of thin ice encompasses that of unfrozen water as well.

Option	Unfrozen water (km²)	Thin ice (km²)
A1	3.5	7.8
A2	5	10.9
B1	3.7	8
B2	4.7	10
C1	4	8.2
C2	5.2	12.2

8.4.2.5 The impact of cooling waters on water quality and ecology

Water quality

The quality of cooling water will not change as it flows through the power plant, apart from the increase in temperature. However, there may be differences in water quality between the intake and discharge site. As a result, the impact on the discharge site depends on the water quality at the intake site. Water quality in the sea area off Hanhikivi is very similar at the intake and discharge sites. The content of nutrients off the coast is typically a little higher than in the outer sea area, so the conduction of water from the open sea to the shore may improve water quality in some cases. In the event of Hanhikivi, this is assessed not to have an impact on the water quality at the discharge site because water mixes efficiently.

Heated cooling water may, in certain conditions, strengthen natural heat layers in summer, in which case exposure to oxygen depletion near the bottom increases. However, there are not any basins exposed to oxygen depletion off Hanhikivi or areas where water mixes poorly. Furthermore, there is not any organic matter load in the area; thus, the project is assessed not to have an impact on the oxygen content of hypolimnion.

The impact of cooling waters on the water quality at the discharge site is assessed to be minor in all of the inspected intake and discharge options.

Phytoplankton and zooplankton

Research conducted in cooling water areas has shown thermal load to increase basic production in the discharge areas (e.g. *Mattila & Ilus 2006, Snoeijs 1988,* *Langford 1990*). In the Bothnian Bay, the production of phytoplankton is particularly limited by the short open sea period. Warm cooling waters will extend the open sea period and vegetation period and, as a result, the annual production of phytoplankton increases in the discharge area. The impact of warm water accelerating decomposition may speed up the circle of nutrients between producing and decomposing entities; thus, increasing the production of phytoplankton in the discharge area. However, increase in production has been observed to be limited to the warmed-up water area in the studied warm water discharge areas.

Phytoplankton species have also been found to change as a consequence of warm water (*Sandström & Svensson 1990*). This may result from the direct and indirect impacts of thermal load. The optimum temperature for phytoplankton varies between different species and groups of species. According to Hawkes (1969), the optimum temperatures usually vary between 15 and 25 centigrades for diatoms and between 30 and 40 centigrades for blue-green algae. For diatoms and dinophyta that favor cold water, typical spring inflorescence will take place earlier in the warmed-up area. Blue-green algae are often known to become more abundant in warm waters and their quantities have been observed to increase in cooling water discharge areas (*Kirkkala & Turkki 2005, Sandström & Svensson 1990*). Inflorescent masses for blue-green algae are the most typical in eutrophic sea areas particularly in late summer when nitrogen acts as a nutrient limiting growth. However, infloscent masses for blue-green masses do not much exist because of the area's low content of nutrients and phosphorus-limited properties. The probability of increased inflorescence for blue-green algae in the sea area off Hanhikivi is also decreased by the openness of the area.

The thermal stress of cooling waters is assessed to increase annual production of phytoplankton in the discharge area. There may also be changes in species and annual abundance ratios. However, the project's impacts in relation to the phytoplankton community in the Bothnian Bay area is assessed to be insignificant and limited only to the warmed-up area. The project is assessed not to increase the amount of inflorescence for blue-green algae.

The impact of cooling water on zooplankton has been studied in Finland and abroad (e.g. *Langford 1990, Sandström & Svensson 1990*). However, research has not shown any significant changes in the areas' zooplankton communities. As a result, the project is assessed not to have any adverse impact on the zooplankton community.

Aquatic vegetation and macroalgae

Cooling water will be conducted to the sea through a channel where the water flow speed at the mouth of the channel will be 1 m/s. The flow causes the fine-grained sedimentary deposit at the bottom of the front of the discharge area to drift away at a distance of a few hundred meters. Vegetation will change in this area and filamentous algae will replace rooting water plants.

A more significant impact which changes vegetation will, however, be accelerated growth in the warmed-up water area. The development observed through research is largely similar to eutrophication. Species will be more one-sided and production will increase. Filamentous algae which typically become more abundant in discharge areas (such as cladophora glomerata) and a few vascular plants which tolerate thermal load well (such as potamogeton pectinatus and myriophyllum spicatum) will become more abundant, whereas other species will decline.

The lack of impact of ice which detaches vegetation may be seen as changes in species in the vegetation of the coastal zone in the area which remains unfrozen in winter. In the unfrozen areas, perennial species such as phragmites, may take over space from other species. This may also be seen as accelerated erosion in shallow shore meadows in the affected area.

Increased production will also increase the amount of organic matter and decomposition, which will consume oxygen in the aqueous layer close to the bottom. In the Hanhikivi headland area, water changes efficiently and the oxygen status close to the bottom will not be deteriorate as a result.

The project is assessed to increase the total production of aquatic vegetation and change the composition of species by increasing the growth of filamentous algae in the warming area. These impacts are assessed to extend to the area where the average temperature increase will be at least one centigrade. The project is assessed not to have impacts on vegetation in a larger area.

Bottom fauna

As stated above, erosion caused by the discharge flow of cooling water will change the quality of the sea bottom in front of the discharge point. In this area, species typical for soft sea bottoms, such as monoporeia affinis and larvae, will be replaced by hard bottom species, such as cordylophora lacustris. However, this impact will be limited to a very small area in front of the discharge area.

The impacts of cooling water on bottom fauna are mainly indirect and mostly due to changes in primary production. The increased quantity of organic matter favors species that benefit from eutrophication. For example, larvae of chironomus plumosus which is a typical species in euthophic waters may become abundant in the affected area, whereas monoporeia affinis which favors cold waters will not probably thrive in the area.

The project's impact on bottom fauna communities is assessed to be minor and local. The project will not have an impact on bottom fauna so that it could affect the fish stock which uses bottom fauna as nutrition.

Alien species

Marenzelleria viridis also appears off Raahe. Because of the project, it may reproduce locally in the area affected by cooling waters. However, marenzelleria viridis has been found to reproduce in the entire Baltic Sea area and the thermal load of cooling waters is assessed not to have an impact on the species becoming more common in the Bothnian Bay.

Mnemiopsis leidyi has not been found in the Bothnian Bay. Its spreading is most likely limited by the small volume of zooplankton and the salt content, combined with other environmental factors, such as coldness. The warming impact of cooling waters is directed at the shore areas and the surface layer, whereas the meniopsis leidyi exists in deep waters in the Baltic Sea. Warm cooling waters have not been found to have much impact on zooplankton communities. As a result, the project is seen not to have such impact on the appearance of the mnemiopsis leidyi that could be distinguished from general changes in the state of the Baltic Sea.

Alien species in the Baltic Sea also include the zebra mussel and dark false mussel that belong to the species of zebra mussel. Neither of the species are known to appear in the Bothian Bay area. The discharge of the power plant's cooling waters could create suitable conditions for zebra mussels in the area which warms up. However, the coldness of the Bothnian Bay restricts zebra mussels from thriving outside the warmed-up area, i.e. the cooling water intake area or the Bothnian Bay in general. The dark false mussel is probably restricted from thriving in the area by the low salt content. It should be noted that these and other bivalvia can be prevented mechanically or chemically and, as a result, they will not cause any impacts on safety or production at power plants.

8.4.2.6 Impacts on fish and fishing industry

Fish stocks

Slight temperature increase in the water system, particularly if it involves increase in eutrophication, will basically favor spring-spawning fish species at the expense of more demanding fall-spawning fish. In summer, the temperature of surface water will, occasionally, increase to about 30 centigrades up to a distance of 1.5 km from the discharge area because of cooling waters depending on the weather, which will, in practice, drive fish away from the area. In summer, the surface layer (0–1 m) of the sea will increase by more than 3 centigrades in a maximum area of 2 km^2 and by more than 5 centigrades in a maximum area of less than 1 km^2. Such local warming up of surface water is assessed not to have a wide adverse impact on the area's fish stocks because the deeper aqueous layers are cooler and fish can actively seek suitable temperatures. In summer, the area affected by cooling waters will be suitable for spring-spawning warm water species but, in winter, the area will also tempt cold water species, such as whitefish and trout.

The shallow shoals in the Hanhikivi environment are important spawning areas for whitefish. The damaging warming up of hypolimnion caused by cooling waters in the spawning areas of the aforementioned fish will be limited near the discharge area and it will not have a significant impact on these fish stocks. The increased temperature may have an adverse impact on the reproduction of burbot in the immediate vicinity of the discharge area, but it will not have a significant impact on the burbot stock in the area. The burbot stock in the sea area between Raahe and Pyhäjoki are not particularly strong and burbot fishing is relatively rare in the area.

The migration route of coregonus lavaretus passes off Hanhikivi. The main migration route of salmon runs farther out at sea. According to the model inspection, the significant warming up of the surface water will, in summer, be restricted to the area north of Hanhikivi and Kultalanlahti bay in the average wind situation. Significant warming may also occur west of Hanhikivi under suitable wind and current conditions. Salmon usually migrates in the surface layer a few meters deep. Warming will be minor at a depth of more than 2 m in all of the options. The local warming up of surface water is assessed not to have a significant impact on the migration behavior of fish migrating north, but coregonus lavaretus will most likely appear less in the shore area north of Hanhikivi which is a traditional whitefish fishing area.

A suitable increase in temperature may advance the spawning season of fish and speed up the development of spawn and the growth at the fry and mature stages, which may have positive impacts on the stocks of spring-spawning fish. For example, advanced spawning has been found among the Baltic herring and European perch in cooling water discharge areas in Sweden (*Neuman & Andersson 1990*). Evidence of advanced spawning of the Baltic herring has been found off the Olkiluoto power plant in the Bothnian Sea (*Vahteri 2000*). At the Olkiluoto power plant in the 1990s, the growth speed of the European perch was found to be slightly improved in the cooling water discharge area compared to the surrounding sea area (*Oy Vesi-Hydro Ab 1995*), but, in 2006, differences in the growth of the European perch were small in different areas and improved growth could not be found in the discharge area *(Ramboll Finland Oy 2007*).

Increased temperature will have different impacts on fish stocks. Taking into account the size of the water area which will warm-up significantly and the mobility of fish and their ability to actively seek suitable temperatures, cooling waters will not cause significant or wide damage to the fish stocks in the Hanhikivi headland area. However, the increase in the temperature and its consequences will favor spring-spawning fish species in the long term, such as northern pike, European perch, carp bream and roach.

Fish driven to the power plant along cooling water
Fish driven to the plant off Hanhikivi would mainly include Baltic herring in the bottom intake option and it could be driven to the plant to a significant extent during spawning season in spring. In the shore intake options, fish would mainly include spring-spawning fish, such as roach, European perch and ruffe.

The access of fish to the plant can be reduced by installing barrier bets in front of the intake channel during the spawning season in spring or using different repellents (reduced impacts are described in Chapter 10).

The volume of fish driven to the plant is assessed not to have a significant impact on the fish stock in the sea area.

Fishing
Fishing is currently carried out in the sea area off Hanhikivi using traps and nets. In summer, the slight eutrophication of the sea area increases the growth of algae, causing slime buildup and increased cleaning needs in traps and reduced fishing efficiency. The damage caused by cooling waters to fishing will mainly be limited to an area north of Hanhikivi at a distance of about 2 km and to Kultalanlahti bay. Whitefish will problably appear less frequently in the shore areas north of Hanhikivi that are important whitefish fishing areas. For fishing, the different cooling water intake options do not have a sig-nificant difference.

The project will not have an impact on the reproduction of seals because seal reproduction areas are not located in the affected area of cooling water. The project is also assessed not to have an impact on the seal stocks or the appearance of seals in the area.

The most concrete impact of cooling waters on fishing will occur in winter when unfrozen areas and thin ice will restrict ice fishing. In winter, net fishing off Hanhikivi is rather rare. As the possibilities for ice fishing reduce, the possibilities for long-term open sea fishing and winter fishing in the open sea will improve. The unfrozen area will lure cold water species, such as whitefish and trout.

In summer, salmonidae that favor cold water will avoid the area clearly affected by cooling waters and prevailing fish species will include spring-spawning fish and those that prefer warm water. This may cause fishing distances to become longer in summer with regard to, for example, whitefish. Cooling waters and their resulting impacts will not have an impact on fish quality.

8.4.2.7 Comparing the impact of the intake and discharge options for cooling water
Intake sites I1 and I2 will be located farther out in the sea area where water will be taken near the bottom. In summer, the temperature of intake water will be slightly higher in Option C (I3) than in Option B (I2). This is mainly caused by the location of the intake site in Option C on the shore of a shallow bay, in which case a large volume of warm surface water will be taken in, particularly in southerly winds. In northerly winds, there will also be recirculation in Option C from the discharge site to the intake site, which may temporarily increase the temperature of intake water by several centigrades. The warmed-up area will be about 25–35% higher in Option C than in Option B. The temperature difference in intake water between shore and bottom intake will be smaller in fall, winter and spring than the estimate presented here.

In Option A, the location of the bottom intake (I1) will cause changes in the currents near the bottom, which, particularly in northerly winds, will cause cold water to mix less efficiently with cooling water. As a result, the location of the bottom intake (I2) in option B is better.

The area of the warmed-up water area will increase in the option of two units because of its greater cooling water volume and thermal load. The impacts are assessed to be similar in both of the options, but the project's affected area is roughly 50% greater in the option of two units.

Water quality will be failrly similar in all cooling water intake sites and depths, and the intake site will not have a significant impact on water quality.

The only major difference between the environmental impacts caused by the options is the size of the affected area, which, in summer, is about 25–35% smaller in Option B (bottom intake I2) than in Option C (shore intake). In the bottom intake option (I1 and I2), the quantity of fish driven to the plant will be smaller than in the shore intake option.

8.4.3 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

8.4.3.1 Current state of waters
The quality and biologic state of water off Kampuslandet and Gäddbergsö is monitored as a part of the cooling and waste water monitoring program of the Loviisa power plant. In addition to the monitoring of sea water temperature and quality, the monitoring program also includes biological monitoring surveys, such as the monitoring surveys of primary production, phytoplankton, bottom fauna, and aquatic vegetation (*Fortum Power and Heat Oy 2008a*). In 2007, Kymijoen vesi ja ympäristö ry carried out the biological monitoring surveys. (*Mattila 2008*)

The sea area off the Loviisa power plant is one of the best-known sites in Finland due to decades of water monitoring. The water monitoring sites cover the surrounding areas of Kampuslandet and Gäddbergsö, so the results of the monitoring can be presumed to represent the current state of the area well, and to be representative of the possible consequences of the project. The impact assessment makes use of also other available research information on the impact of cooling water on waters both in Finland and abroad.

General description and hydrologic data

The island of Kampuslandet and the Gäddbergsö headland are located at the edge of the inland archipelago zone of the coast of the Gulf of Finland (Figure 8-22). Due to the impact of the archipelago and narrow straits, the area is characterized by relatively large basins with little turnover of water due to the rather shallow sills.

The bays of Klobbfjärden and Hästholmsfjärden are located to the north and east of Gäddbergsö. These basins, separated by the mainland and archipelago, are rather shallow, mostly under ten meters deep. Due to the impact of the narrow straits, water turnover with the outer sea area is limited. Klobbfjärden is connected to the delta of the western branch of the Taasianjoki and Kymijoki rivers via the narrow strait of Jomal-sundet in the northeast, while Hästholmsfjärden is connected to the outer sea area through the southern straits. The sill depth to Hästholmsfjärden is approximately 8 meters. The cooling waters of the Loviisa power plant are drained to Hästholmsfjärden. Gäddbergsö is separated from Kampuslandet by a rather shallow strait under a kilometer wide.

Surrounded by a few small islands and islets, Vådholmsfjärden is located to the south of Gäddbergsö and west of Kampuslandet. The Vådholmsfjärden water area is demarcated by several quite small islands and islets. The sill depth of Vådholmsfjärden is approximately 18 meters, and its water turnover is higher than that of the more confined Hästholmsfjärden. Orrengrundsfjärden is located to the south of Kampuslandet and Vådholmsfjärden. Here, the coast grows rapidly deeper to more than twenty meters, and the area is directly connected to the outer sea area.

Kymijoki empties into the sea off Ruotsinpyhtää, as does the considerably smaller Taasianjoki river. The mean discharge of the western branch of Kymijoki is approximately 150 m^3/s and that of Taasiajoki approximately 4 m^3/s. The western branch empties into Ahvenkoskenlahti, located to the east of Loviisa. Taasianjoki empties into Kullanlahti, from which the water goes further via Ahvenkoskenlahti to the sea. River water is

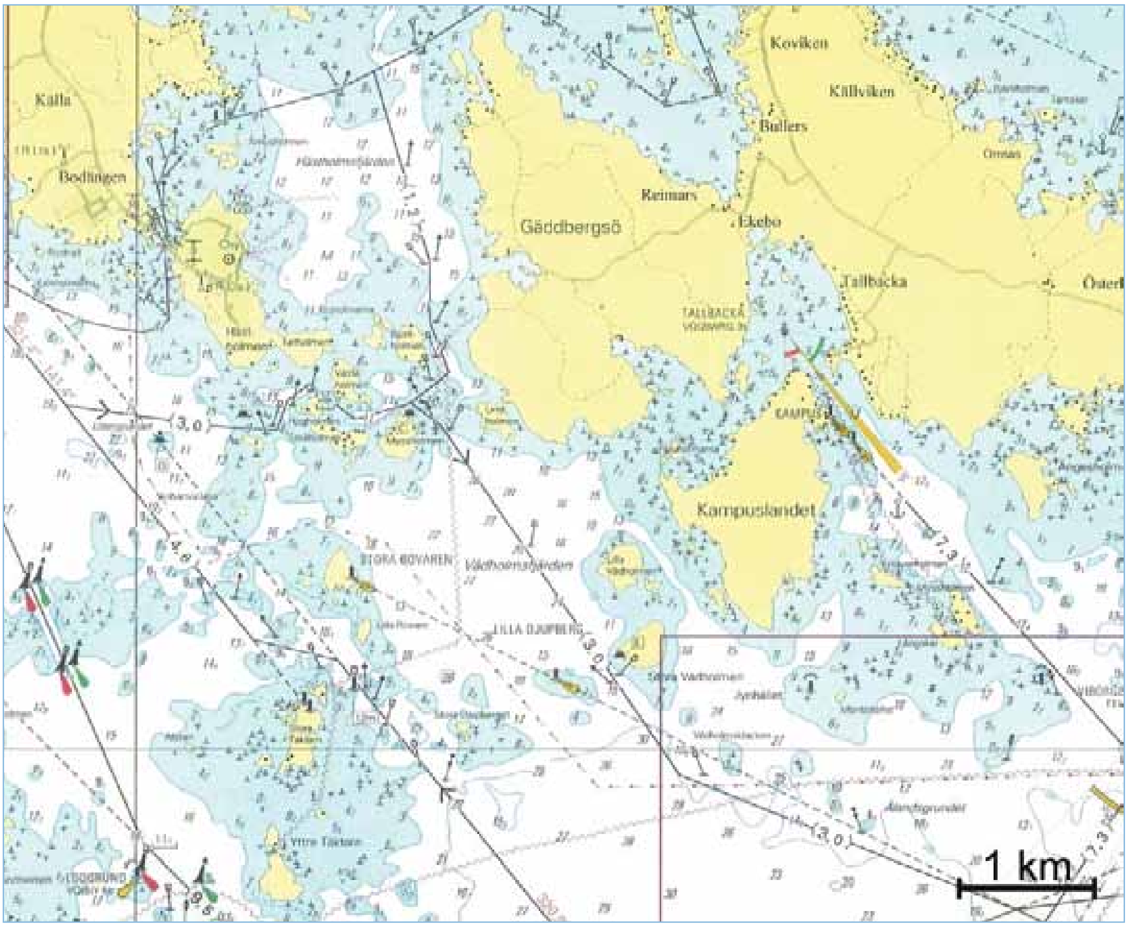


Figure 8-22. Extract from the nautical chart of the Kampuslandet-Gäddbergsö area.

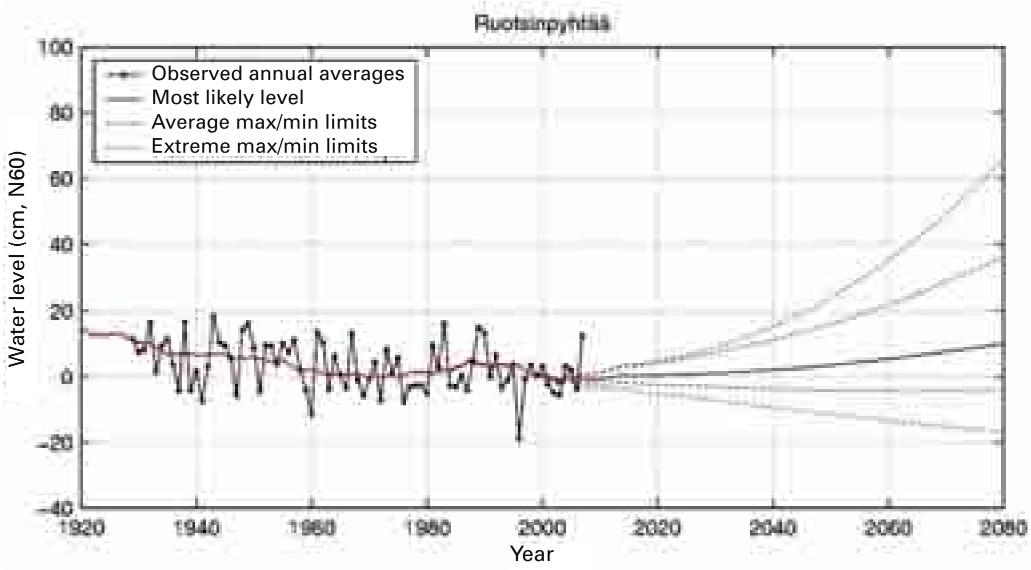


Figure 8-23. Interpolated annual averages and average water level scenario in Ruotsinpyhtää, values interpolated linearly from the values calculated for the Helsinki and Hamina observation sites. *(Finnish Institute of Marine Research 2008a)*

the primary source of loads in the area. That the eutrophicating impact of the nutrients and organic matters comes from river water can be seen in the quality of water throughout the project area. The area's eutrophication is also affected by ineffectively changing water in basins, which increases load within the water system (the release of nutrients back into the cycle as a result of oxygen depletion) and the area's sensitivity to eutrophication *(Henriksson & Myllyvirta 2006)*.

Average water level and water level extremes

This section presents the average fluctuation in water level and water level extremes in the project area, based on the report of the Finnish Institute of Marine Research (*Johansson et al. 2008*).

In Ruotsinpyhtää, Gäddbergsö and Kampuslandet are located so close to each other that water level fluctuations are very similar. Therefore, they have been reviewed as a single location. The closest continuous water level measurement sites used in the survey are located in Helsinki (distance approximately 80 kilometers) and Hamina (distance approximately 50 kilometers). There are observations available from Helsinki since 1904 and from Hamina since 1928.

On the coast of the Gulf of Finland, land uplift is weaker than at the Gulf of Bothnia, and the average water level is expected to begin to rise in the near future. According to the most likely scenario, water level will rise by approximately 10cm by 2075 (Figure 8-23).

The most significant factors affecting short-term water level fluctuation on the coast of Finland are wind, fluctuation in atmospheric pressure and the to-and-fro oscillation of the water level of the Baltic Sea (*seiche effect*). The impact of tide is small, only a few cm. Short-term water level fluctuation is the highest in the remotest corners of the Gulf of Bothnia and the Gulf of Finland.

Probability distributions were calculated for extreme water level values on the basis of observed monthly maximum and minimum values. The water level values calculated from the distributions correspond to the level of probability of 10-3 events/year, or one event per a thousand years as estimated currently. The highest sea level in 2075 in Ruotsinpyhtää is likely to be approximately 10cm higher than in 2008 (Table 8-6). As a result of the rise of the average water level, also the lowest extremes will rise. The lowest sea level in 2075 in Ruotsinpyhtää is likely to be approximately 10cm higher than in 2008.

Ice conditions

In addition to the general ice conditions of the Gulf of Finland, the cooling waters of the Loviisa power plant have an impact on the ice conditions in the project area. The eastern parts of the Gulf of Finland freeze every year, but during temperate winters, the entire Gulf of

Table 8-6. Sea level extremes in 2008 and 2075 corresponding to the level of probability of once per a thousand years.

	Highest sea level (cm)	Uncertainty limits	**Lowest sea level (cm)**	Uncertainty limits
In 2008	+204	–	-192	–
In 2075	+214	+190 – +260	-132	-140 – -80

Finland freezes only partially. In the Gulf of Finland, freezing typically begins during October-November.

The impact of the Loviisa power plant on ice conditions is particularly evident in Hästholmsfjärden. In average winters, the area is mostly ice-covered for a short time, but the ice remains weak, particularly off the power plant and in narrow straits (*Fortum Power and Heat Oy 2008b*). In certain conditions, the cooling water plunges under the fresh surface water and may travel long distances to the west before submerging e.g. near shallows, weakening the ice. According to local residents, this happens, for instance, in the areas to the north of the island of Hudö.

Water quality

The most significant factors affecting the water quality off Kampuslandet and Gäddbergsö is the load from the rivers emptying into the area, and the general state of the Gulf of Finland. Further away, load is caused by the waste waters from the Loviisa power plant waste water treatment plant and the water conducted off Loviisa from the waste water treatment plant of the town of Loviisa.

The total phosphorus content of the area during the 2007 growth period were at the same level or slightly lower than in 2006. In surface water, the content was slightly lower than the average content of the 1990s (varying between 19 and 43 millionths per liter, µg/l) and close to the bottom at the level of the 1990s (varying between 24 and 638 µg/l). The total nitrogen content, on the other hand, has decreased from the levels of the 1980s and 1990s. In 2007, surface water nitrogen content varied between 333 and 678 µg/l and that of water close to the bottom between 41 and 1,918 µg/l. In addition to external nutrient load, high nutrient concentrations close to the bottom are caused by internal load, i.e. release of sedimented nutrients back into circulation due to a poor oxygen situation.

Because of the limited water turnover and general eutrophication caused by the bottom sills, the oxygen situation of the water close to the bottom has been relatively poor in the area, particularly at deep locations. In 2007, the oxygen content of sea water was on a par with recent decades. In August-September, the Hästholmsfjärden and Orrengrundsfjärden deeps were oxygen-free or low-oxygen. Based on the results from recent years, one may state that the state of the bottom has deteriorated further in the Hästholmsfjärden area. The probability of oxygen depletion is increased by the strong stratification, increased by the warm cooling waters drained to the area in Hästholmsfjärden. In 2007, surface water was generally supersaturated in regard to oxygen, which is a sign of the area's high primary production, i.e. eutrophication.

In 2007, the salinity of surface water varied between 4.11‰ and 4.33‰ on average, which is roughly the same as in the previous year. The average salinity of water close to the bottom (4.37‰ to 5.11‰) was less than during the 1980s and 1990s on average. The area's salinity is affected by the volume of fresh river water coming to the area, as well as the fluctuation in the salinity of the Gulf of Finland and the Baltic Sea in general. Due to the impact of river water, there is high seasonal fluctuation in the salinity of the area. The impact of river water is particularly evident in the winter and spring, when sweet river water, which is lighter than sea water, decreases the salinity of surface water. Salinity is increased, on the other hand, by bottom water rising to the surface layers.

Sight depth has remained at the level of the 1990s and 1980s averages in the area. In general, sight depth improves when moving from the archipelago towards the outer sea area. In 2007, sight depth varied between 1.1 meters in Klobbfjärden and 5.2 meters in Orregrundsfjärden. In particular, sight depth is impaired by river water driven to the area in the spring; its impact can be seen the most in Klobbfjärden and Hästholmsfjärden.

According to the classification of the ecological state of waters carried out by the environmental authorities in 2008, the ecological state of Klobbfjärden and Hästholmsfjärden is poor. The state of other surrounding area has been classified as satisfactory.

Phytoplankton and zooplankton

According to a study carried out in 2005, the area's phytoplankton mainly consisted of diatoms, dinoflagellates and blue-green algae (*Mattila and Ilus 2006*). These dominant species are typical of the Gulf of Finland. Typically, spring bloom is dominated by dinoflagellates. The quantity of blue-green algae increased from June and was at a peak in July, August and September. The quantity of blue-green algae has been observed to have increased throughout the eastern parts of the Gulf of Finland during the 1990s (*Kauppila and Bäck 2001*).

Based on the chlorophyll a results, the monitoring area can be considered distinctly eutrophicated. The annual primary production survey values for 2007 clearly exceeded those of 2005 and 2006. In the Gulf of Finland, primary production has been on the rise from the 1970s due to the general eutrophication development of the sea area. The chlorophyla contents measured in the Gulf of Finland have more than doubled during this time (*Olson 2008*). Similar development can also be seen in the monitored area. In Hästholmsfjärden, growth in the quantity of primary production has been seen to increase at a rate faster than the grown sea area.

No regular zooplankton monitoring has been carried out in the area in recent years. No impacts on zooplankton have been observed in studies conducted in the cooling water impact area.

Aquatic vegetation and macroalgae

The aquatic vegetation of the area has been monitored with the help of vegetation lines from the 1970s (*Mattila & Ilus 2006)*. The type of bottom has a significant impact on the thriving of vegetation. In the project area, the shores are typically hardpan, comprising of rocks and rocky areas or gravel. There are relatively few soft or sandy bottoms in the area.

The impact of the Loviisa power plant is evident in the vegetation of Hästholmsfjärden. Aquatic vegetation has eutrophicated clearly during the operation of the plant. The vegetation has also been observed to have become less diversified, as has the increase of hornwort, which favors eutrophication. Red algae and bladder wrack have decreased at the monitored lines. In sheltered warm cooling water impact areas, the number reeds has been observed to increase. The general eutrophication development of the sea area has also contributed to the increase in vegetation. Changes observed in the vegetation have been the most significant in the area that remains completely unfrozen due to the pro-longed growth period.

Bottom fauna

The dominant species among the region's bottom fauna are chironomid larvae and lumbriculus variegates. There are few species at most observation sites, apart from the area off the cooling water discharge area. In this area, the conditions are favorable for several bottom fauna species due to the impact of the warm cooling water. In 2007, Baltic telling and mud snail were observed in the area, as well as the alien species North-American polychaete and dark false mussel, which have spread to the Baltic Sea after the end of the 1980s.

In 2007, the state of bottom fauna was weak in Vådholmsfjärden and very weak in the Orrengrundsfjärden deep, as in previous years. The decline in bottom fauna is typical of the development of recent decades throughout the Gulf of Finland. The state of bottom fauna has been poor in recent years in the Gulf of Finland both in the deep bottoms of the open sea and the areas close to the coast (*Haahti & Kangas 2006*).

The cooling water discharge site has been seen to offer a favorable growth site for various new alien species. The most recent newcomers are *Gammarus tigrinus*, discovered in Hästholmsfjärden, and dark false mussel. The dark false mussel colony is very dense in the vicinity of the cooling water discharge site, and dense colonies are found throughout Hästholmsfjärden. In 2005, the species was also found in the Pernajan-saaristo archipelago. (*Mattila & Ilus 2006*)

Sedimentary deposit

No research has been conducted in the immediate vicinity of the project area concerning the composition or chemical properties of sedimentary deposit. However, no such industrial, port or other activity is practiced in the area that would be estimated to have had significant effects on the quality of sedimentary deposit.

Fish and fishing

Fishing and fish in the project area are monitored by way of fishery monitoring, which is among the commitments of the Loviisa power plant. Professional fishing is monitored in an area extending approximately 15 km to the west of the project area and household and recreational fishing in a smaller area, extending within approximately 5 km of the project area.

In 2005, a total of seven professional fishermen fished in the vicinity of the project area (*Ramboll Finland Oy 2006*). Of the professional fishermen, four were full-time fishermen and three part-time. Of them, three fished only in the open water season, the others also during the ice season.

The professional fishermen had approximately 205 nets for scaled fish and three Baltic herring nets in use. Most of the professional fishermen have mainly fished using nets. There is also some salmon fishing in the sea area using salmon hooks or fyke nets. The professional fishermen had four salmon hooks, three shore fyke nets and five bait hooks in use. The most important catch species for professional fishermen were pike-perch, pike, salmon and perch. The household-specific haul was approximately 1,770 kg.

There is a total of six spots for fyke net fishing by professional fishermen in the waters close to Gäddbergsö and Kampuslandet. Of these, two are located in Vådholmsfjärden, one at Moritshället, which is within a striking distance of the southern tip of Kampuslandet, and one at Långskär, to the southeast of Kampuslandet. In addition, there are two spots for fyke net fishing off Lehtinen and Boistö, located four km to the southeast of Kampuslandet.

Household and recreational fishing was performed by approximately 2,000 people in 2005. The most popular fishing equipment were net, casting rod, and rod and line. Recreational fishing was clearly more popular during the summer months, with July being the busiest (80% of those who fish fished). Only 10% to 15% or the household and recreational fishermen fished during the winter months. The most important species were pike (30%), perch (20%) and pike-perch (13%). The household-specific haul was approximately 40 kg. (*Ramboll Finland Oy 2006*)

Fishing in the sea area is damaged by unstable ice conditions, seals and slime buildup in traps.

The fish species of the eastern parts of the Gulf of Finland are typical brackish water species. The salinity of the eastern parts of the Gulf of Finland is so low (approx. 4–7 ‰) that most freshwater species prosper in the area (*Metsähallitus 2007*). Based on the catch data, the fish of the project area can be considered typical of the coastal area of Eastern Gulf of Finland. Of freshwater species, e.g. pike, perch and several roaches are seen in the area. Of sea species, e.g. turbot and smelt are found. Of the small species not present in catch data, e.g. lump-sucker, three-spined stickleback and stone loach, which are typical coastal species, are very likely to be found in the area. With regard to salmonids, e.g. salmon, sea trout, common and valaam whitefish, as well as eel and lampern are found in Eastern Gulf of Finland (*Metsähallitus 2007*).

The coastal areas of the islands, islets and rocks of Eastern Gulf of Finland are important feeding areas for sea trouts and whitefish. Mainly two whitefish species are found in Eastern Gulf of Finland, namely the river-spawning common whitefish and the sea-spawning valaam whitefish (*Koivurinta & Vähänäkki 2004*). Several species breed in submerged shallows and ridges. Turbot, valaam whitefish and Baltic herring, for in-stance, breed in gravel shallows. Several small-sized species breed in the coastal zone, and in addition to this, the coastal zone is an important growth and feeding area for the fry and adults of several fish species. (*Metsähallitus 2007*)

8.4.3.2 Impact of wastewater

The project will create social and process wastewater. Some wastewater will be treated in the plant area and some can be conducted to be treated in a municipal water treatment plant. The project's wastewater load (wastewater fractions, volumes, load and treatment) is described in more detail in Chapter 3.9 on wastewater.

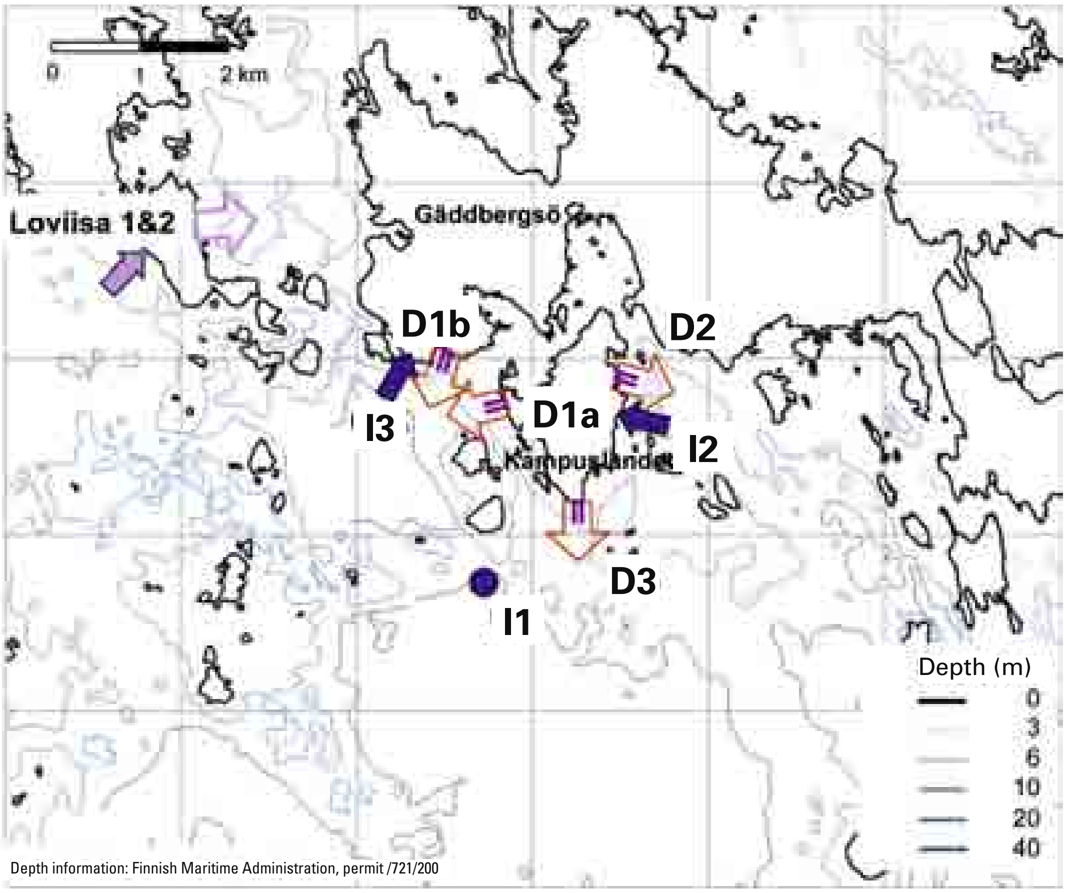


Figure 8-24. Alternative cooling water intake and discharge locations. The blue arrows show shore intakes, the red circle intake from the bottom (tunnel) and the red arrows show the discharge sites. The purple arrow indicates the Loviisa plant intake and discharge location.

Table 8-7. A description of the intake and discharge arrangements.

I1, intake 1	intake at a depth of 15 meters from the bottom, direction from the south
I2, intake 2	intake channel at a depth of approximately 10 m, direc-tion from the east-southeast
I3, intake 3	intake channel at a depth of approximately 10 m, direc-tion from the southwest
D1, discharge 1a	discharge channel at the surface level, direction to the west
D1, discharge 1b	discharge channel at the surface level, direction to the south
D2, discharge 2	discharge channel at the surface level, direction to the east
D3, discharge 3	discharge channel at the surface level, direction to the south
Loviisa 1 and 2, intake/discharge	Loviisa 1 and 2 intake channel at the surface level, dis-charge at the surface

The nutrient load caused by the project is assessed to be so small that it cannot be estimated to have a detrimental impact on the general status of the sea area, regardless of whether it is discharged into the sea through a separate treatment plant or through the town of Loviisa treatment plant further away.

Salt created in neutralizing process wastewater is the same salt contained by sea water naturally. Thus, neutralization water will not have an impact on the water quality in the sea area. Furthermore, boron used in certain plant types appears naturally in sea water. It belongs to necessary microelements but is toxic in large concentrations. However, the wastewater conducted in the sea contains so small concentrations of boron that it will not cause any adverse impacts on the water ecosystem.

8.4.3.3 Impact of cooling waters on sea water temperature

The impact of thermal stress caused by the power plant on sea water temperatures was assessed through mathematical dispersion modeling.

The thermal impact of the cooling waters discharged from the Loviisa 1 and 2 power plant units to Hästholmsfjärden has been taken into account in the current state of the modeling. The combined impacts of Fennovoima's unit and the planned third Loviisa unit have been assessed in Chapter 8 in the section on combined impacts with other projects.

Cooling water warms up by about 10 to 12 centigrades as it flows through the power plant. The temperature of the sea water used as cooling water is about 20 centigrades at maximum in summer. At the mouth of the discharge site for cooling water, the temperature may be about 32 centigrades at maximum. Approximately 500 meters from the cooling water discharge site, the temperature has fallen by approximately 1 to 2 centrigrades

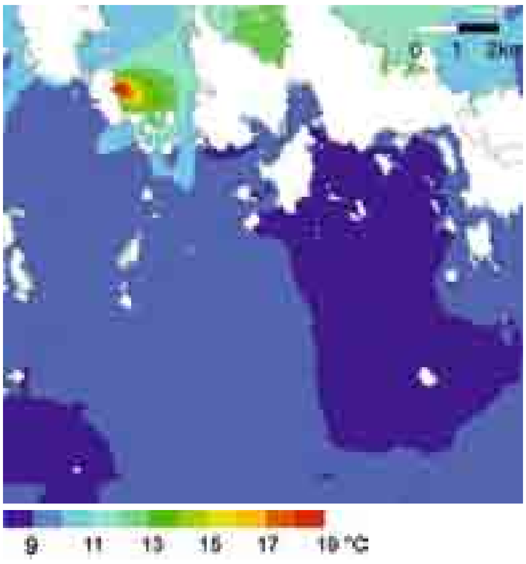


Figure 8-25. Temperature in the surface layer in the current situation (Loviisa 1 and 2 in operation) in June.

Table 8-8. Combinations used in the modeling. All alternatives assume Loviisa 1 and 2 units to be in operation

Alternative	Electric output, [MW]	Intake	Discharge
V0	Loviisa 1 & 2	-	-
A1	1800	I1	D1b
A2	2500	I1	D1b
B1	1800	I1	D2
B2	2500	I1	D2
C1	1800	I1	D3
C2	2500	I1	D3
D1	1800	I2	D1a
D2	2500	I2	D1a
E1	1800	I2	D3
E2	2500	I2	D3
F1	1800	I3	D2
F2	2500	I3	D2
G1	1800	I3	D3
G2	2500	I3	D3

from this.

The alternative intake and discharge sites for cooling water surveyed in the modeling are presented on the map (Figure 8-24). Three different intake sites and four discharge options were inspected in the modeling (Table 8-7).

Intake 1 is an intake from the bottom option in which the cooling water is conducted to the plant via a submarine tunnel. Intakes 2 and 3 are shore intake options in which the cooling water is taken at a depth of approximately 10 meters.

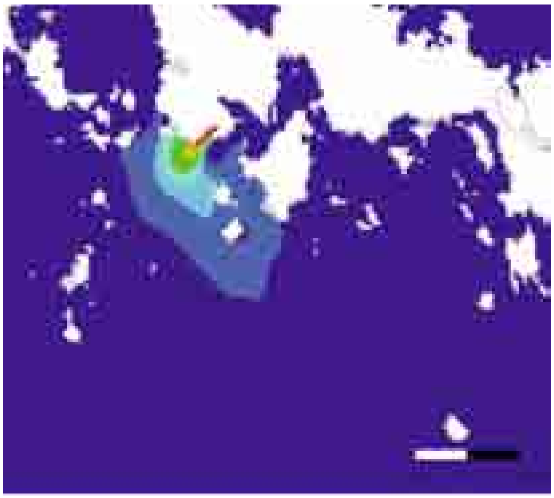
In discharge site location Options D1a and D1b, the cooling water is discharged via a channel to Vådholmsfjärden. The differences between these adjacent discharge site locations are minor, and therefore they are considered a single location in the text (D1). In Option D2, the cooling water is discharged to the east of Kampuslandet and in Option D3 to the south of Kampuslandet, in the direction of Orrengrundsfjärden.

The impact of cooling water on the state of the sea area off the project area has been inspected using seven combinations of intake and discharge sites (Table 8-8). Each combination of options has been modeled for two different two different electric power options (1,800 MW and 2,500 MW). In addition to these, the zero option, i.e. the current situation (V0), has been calculated, including the thermal load of the existing Loviisa 1 and 2 units.

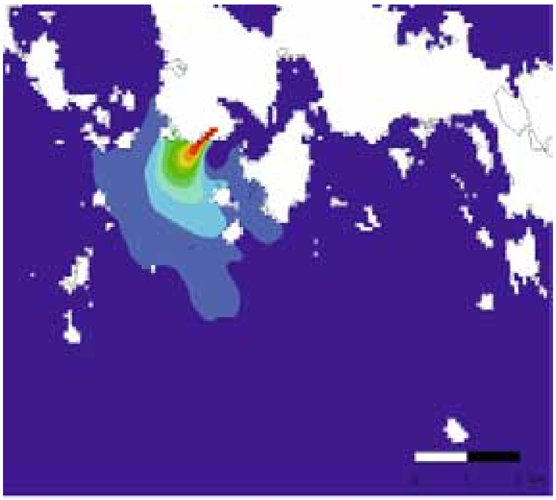
Average temperature increase in different aqueous layers

The warming-up impact of the power plant's cooling waters at different depths was as-sessed using the average temperature fields in June (1 June 2003 – 1 July 2003).

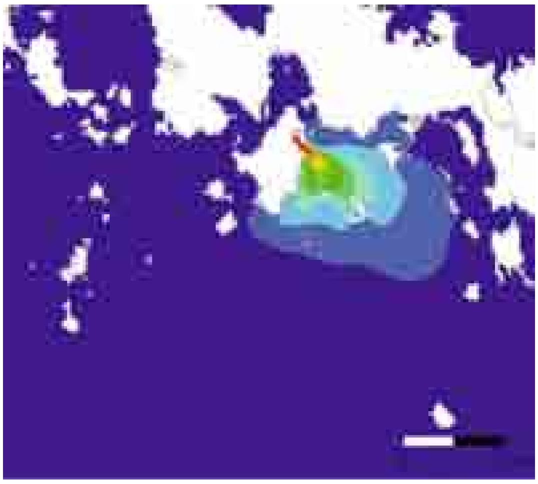
The average temperature field of the comparison cal-



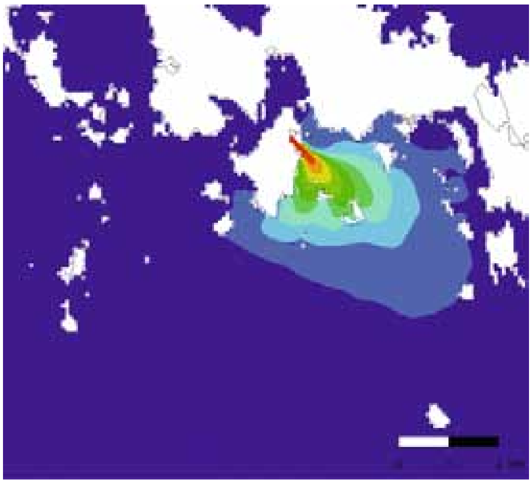
Discharge 1, 1 unit



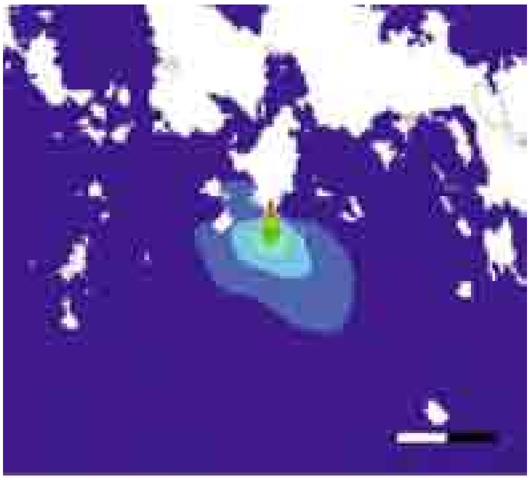
Discharge 1, 2 units



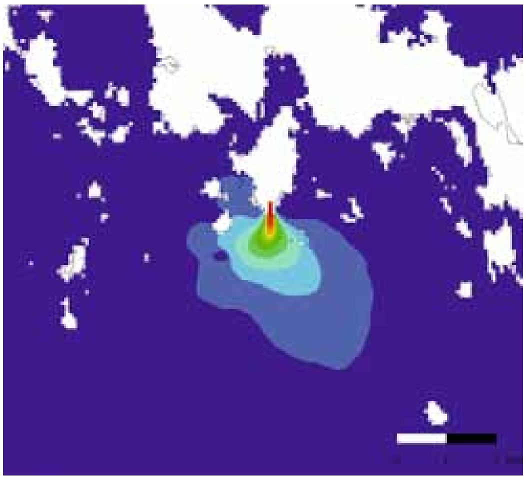
Discharge 2, 1 unit



Discharge 2, 2 units



Discharge 3, 1 unit



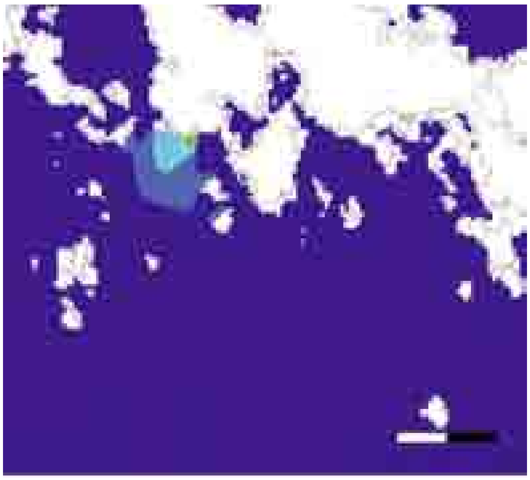
Discharge 3, 2 units

Figure 8-26. Temperature increase compared to the zero option in the surface layer (0–1 m) as an average June value in discharge site Options D1, D2 and D3.

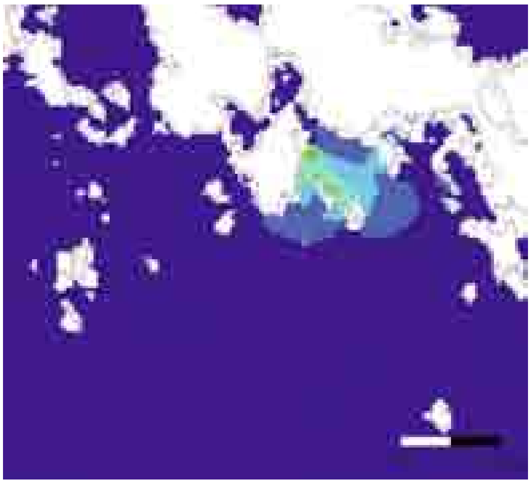
culation (i.e. the current situation, V0) show the impact of the Loviisa 1 and 2 units (Figure 8-25). The intake flow rate of the Loviisa units and increase in temperature were assessed on the basis of the power plant's technical specifications available for the public, so they might not necessarily be completely equal to actual usage. The increases in temperature caused by the Fennovoima plant have been calculated by deducting the current situation from the results of each option calculation. Temperature increase in the layer of 0–1 m is presented as dispersion graphs for all the discharge sites (D1–3) and the intake site I1 in both power plant options (Figure 8-26). Temperature increase in the layer of 2–3 m is presented in the case of two units for the different discharge site location options (D1–3) (Figure 8-27). In addition, the impact of different intake and discharge site location option combinations (A–G) on temperature increase has been inspected as areas in deeper layers (more than 3 m) (Figure 8-28).

In the surface layer, the area which warms up by more than one centigrade was at maximum in Discharge Option D2 (approximately 18 km^2). This is due to the shallow-ness of the discharge area and poorer mixing of water compared to Options D1 and D3. Of the discharge options, D3 is the most beneficial in terms of the water area that will be heated with nearly all option combinations.

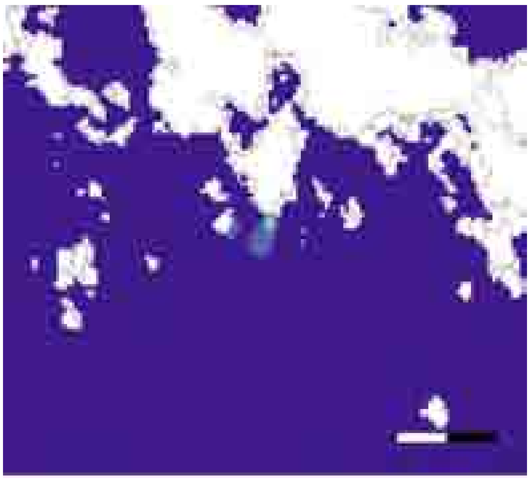
In June, Intake Options I1 and I2 are nearly as good. Intake I2 is slightly better with the 1800 MW power plant unit, but the differences level off with the larger power plant unit. Intake I3 causes larger areas that will be heated than either of Intake Sites I1 and I2, which is



Discharge 1, 2 units

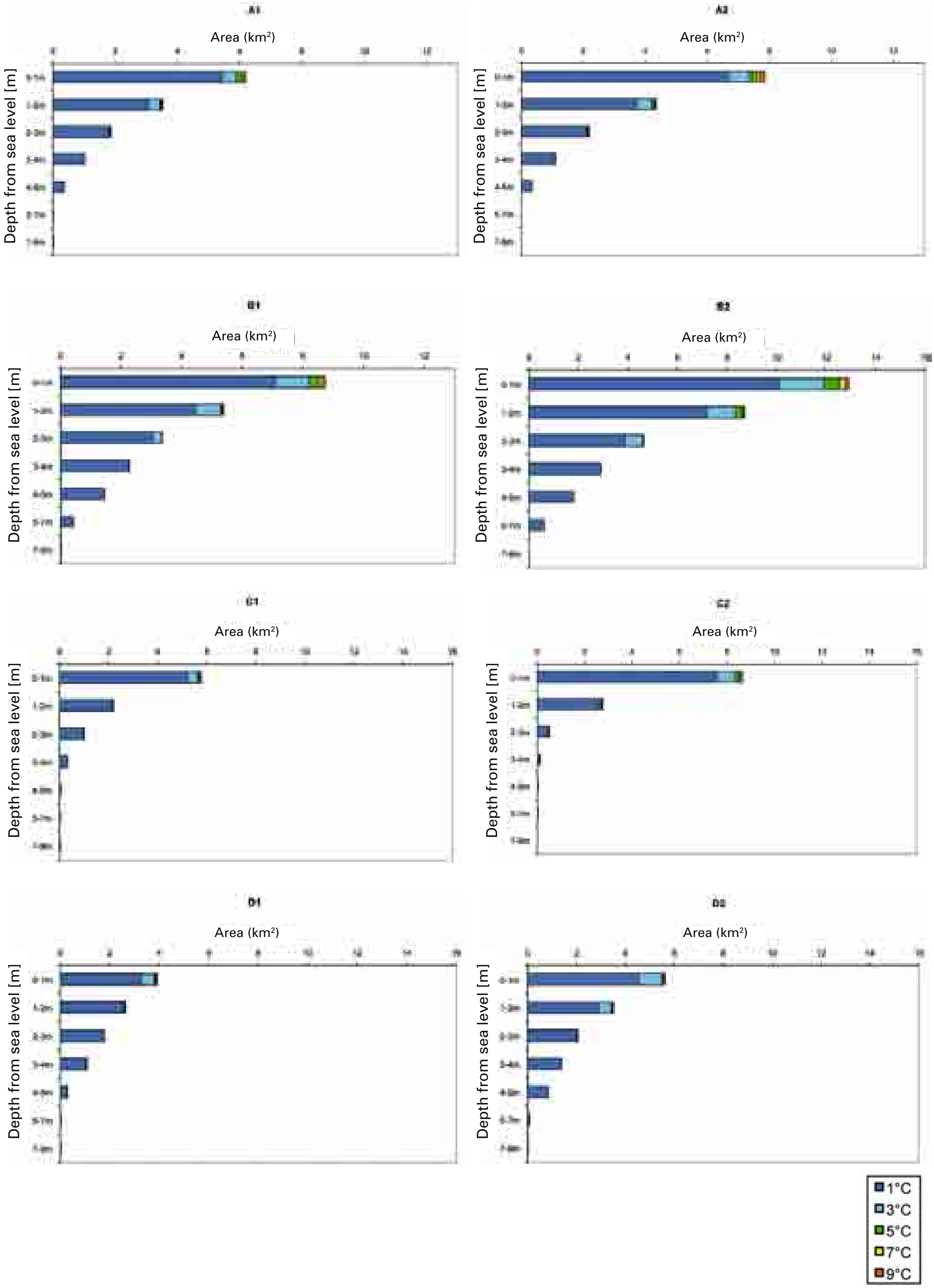


Discharge 2, 2 units



Discharge 3, 2 units

Figure 8-27. Temperature increase compared to the zero option at a depth of 2–3 m as an average June value in discharge site Options D1, D2 and D3 in the case of two power plant units.



Area (km²)
Depth from sea level [m]
1°C
3°C
5°C
7°C
9°C

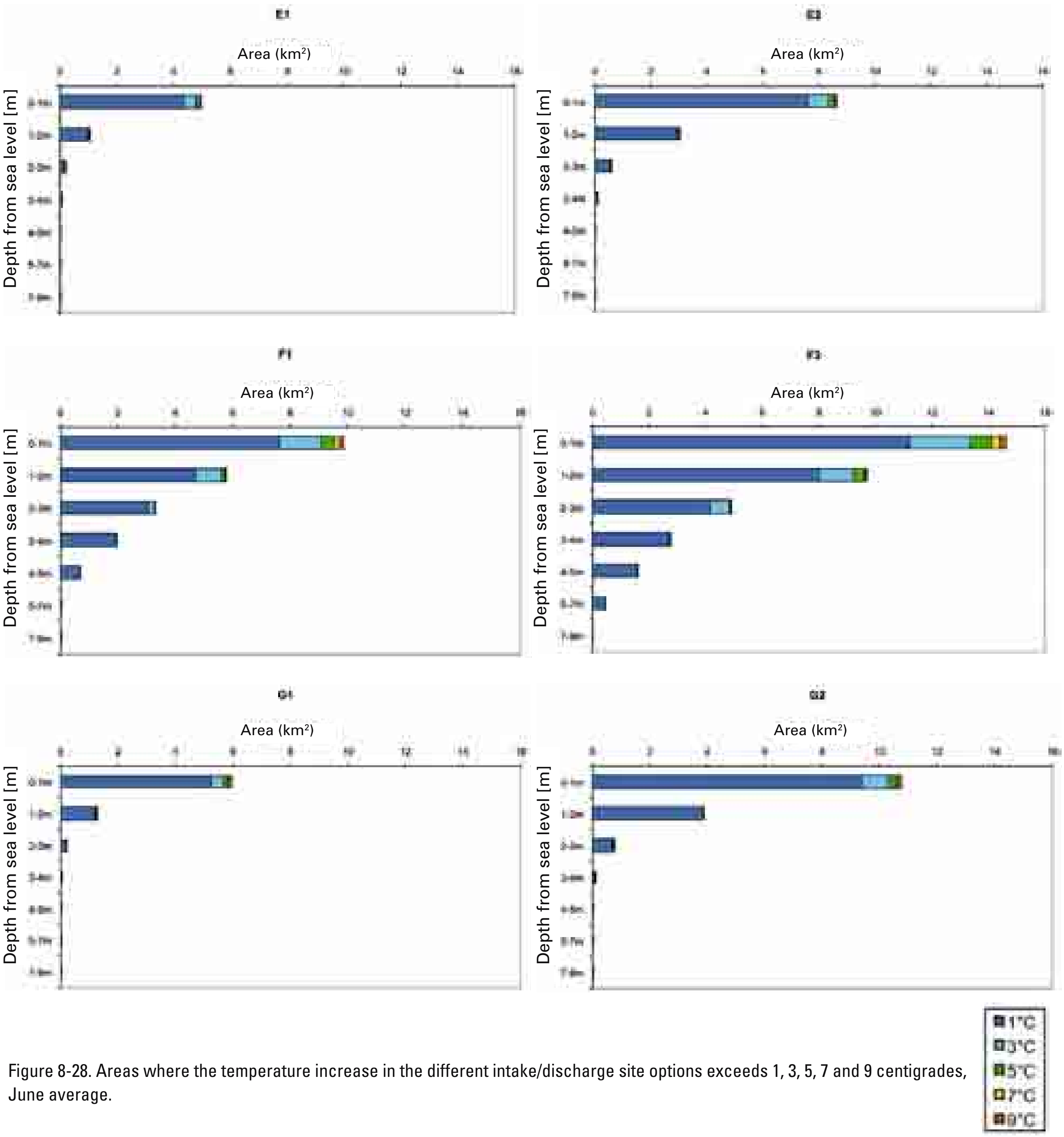


Figure 8-28. Areas where the temperature increase in the different intake/discharge site options exceeds 1, 3, 5, 7 and 9 centigrades, June average.

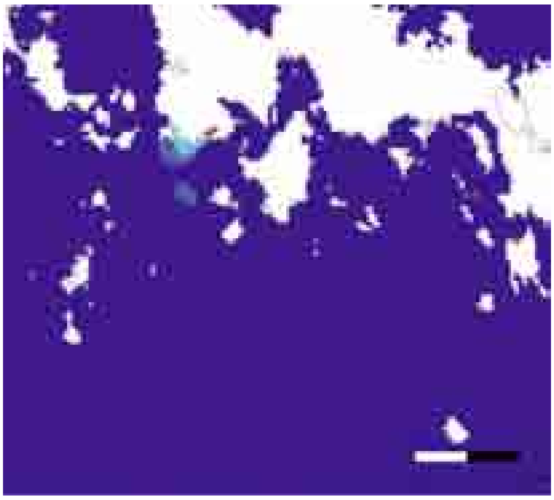
due to the higher temperature of the input water.

*In the surface layer, an average temperature increase of more than five centigrades*is limited to the nearby areas of the cooling water discharge site, being less than 1.3 km^2 in all of the inspected options. The lowest temperatures are achieved in discharge site Options D1 and D3. With Discharge Option D2, the areas where temperature will increase are larger than with the other options due to the shallowness of the area. This is particularly evident in Option F in which the cooling water is taken from the surface at Vådholmsfjärden.

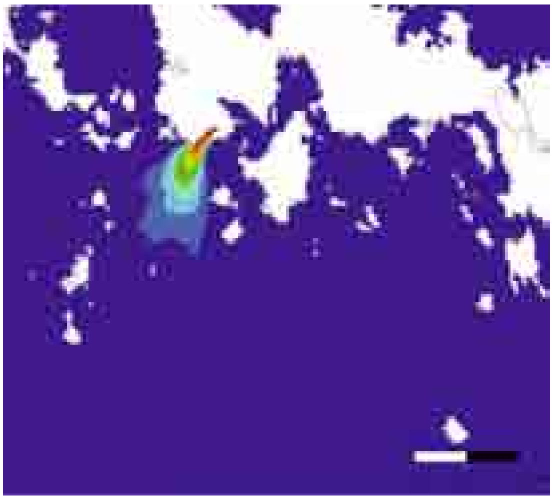
In deeper layers, the temperature increases only slightly and has not increased by more than one centigrade in any of the options at the depth of more than 9 m in an area of more than 0.05 km^2. The smallest areas where temperature will increase are achieved in Option D3, in which the discharge area is deep and water mixes well. The largest areas are achieved in Option D2, in which the discharge area is shallow and consequently mixing is weaker.

Average temperature increase in different wind conditions

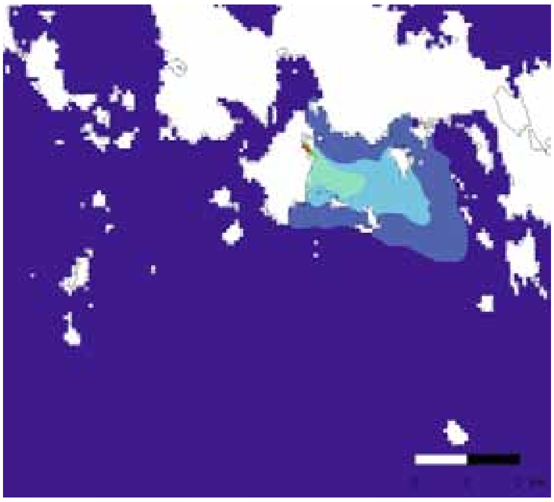
The warming-up impact of the power plant's cooling waters was estimated under different wind conditions by calculating increases in temperature over two five-day



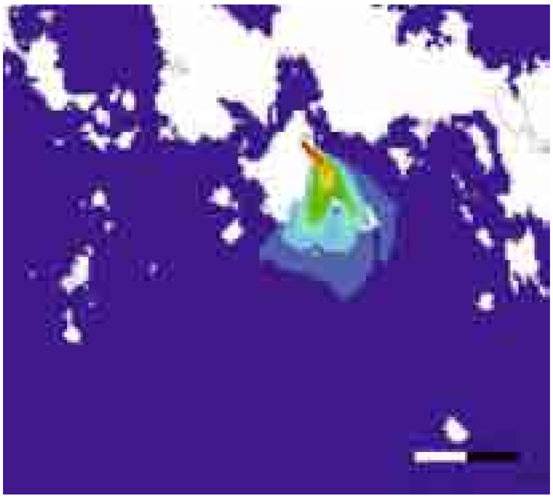
Discharge 1, *southerly winds*



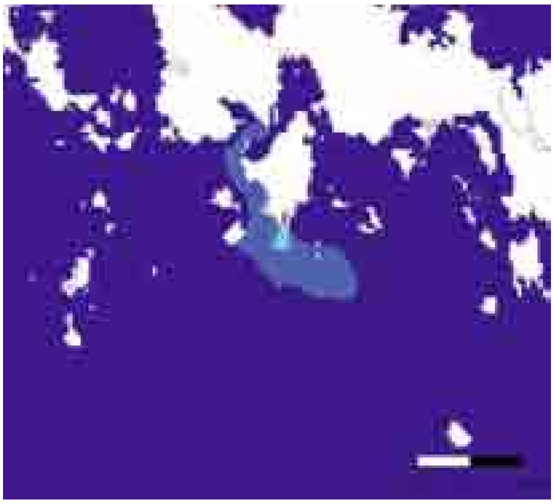
Discharge 1, *northerly winds*



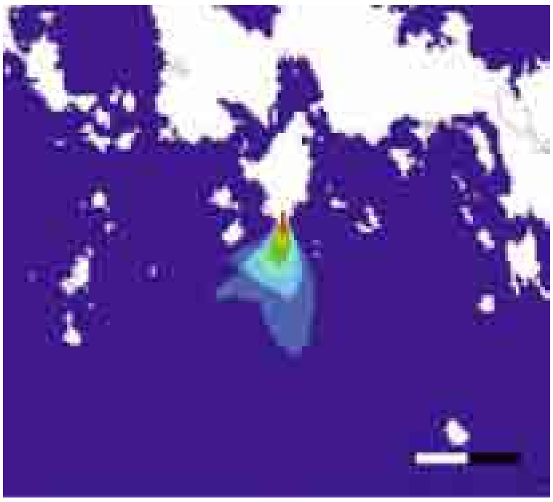
Discharge 2, *southerly winds*



Discharge 2, *northerly winds*



Discharge 3, *southerly winds*



Discharge 3, *northerly winds*

Figure 8-29. Warm-up with southerly and northerly winds in the surface layer in July 2003 in discharge site location Options D1, D2 and D3.

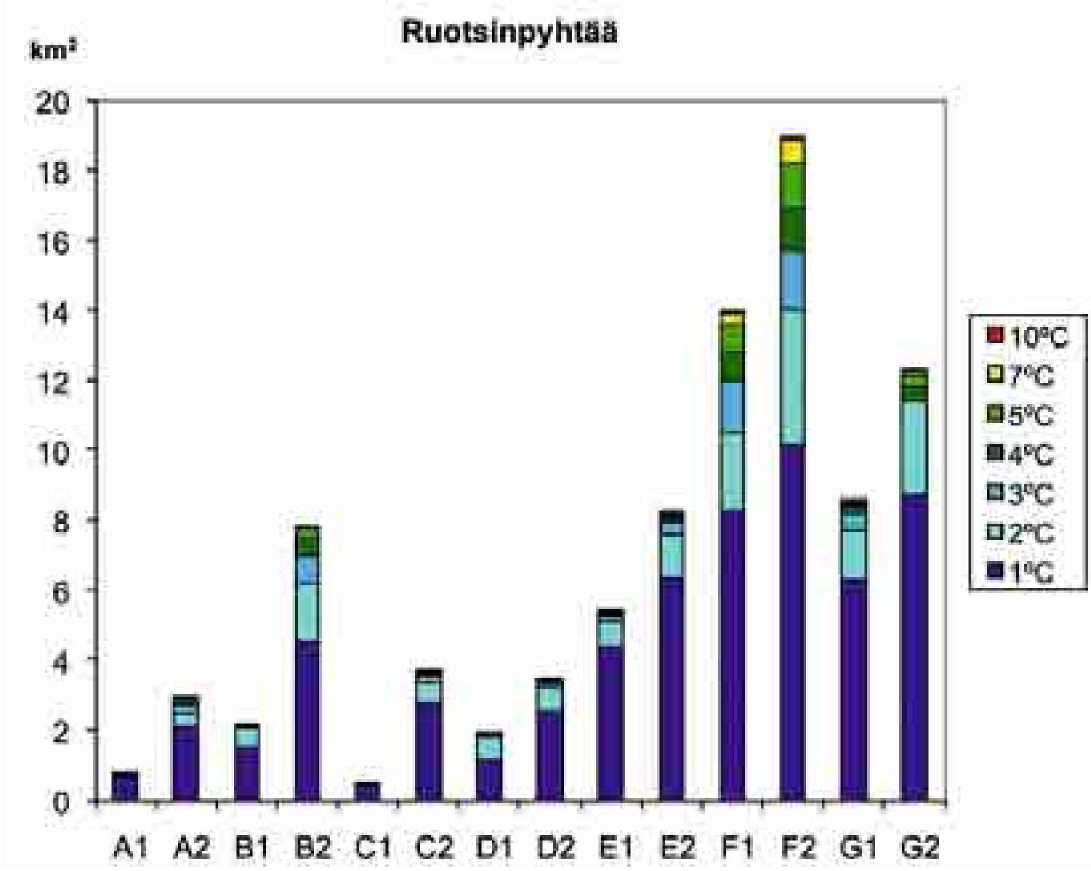


Figure 8-30. Areas where the surface layer warms up by 1–10 centigrades as a July average.

periods in July 2007, 6–11 July (northerly wind) and 21–26 July (southerly wind), and over the whole of July. In the former period, winds were mainly directed from the north and moderate or fresh (average speed 6.9 m/s) and, in the latter period, from the south and moderate or light (average 3.8 m/s). The impact of wind conditions on the dispersion of temperature has been examined among the different discharge site location options (Figure 8-29). In addition, the size of the area that will be heated as July averages has been compared among all the different option combinations (A–G) (Figure 8-30).

For southerly winds, discharge water is mixed with the warm surface water. However, the intake water is cool because of the water's temperature layers. As a result, the temperature difference between the discharge and surface water is small, particularly for Intake I1. The extent of mixing depends on the mixing of the water in the area close to the discharge site, which is the faster the more open the area close to the discharge site is. The smallest areas that will be heated are achieved with Discharge D3 and Intake I1 and the largest with Discharge D2 and Intake I3.

For northerly winds, there is welling and the coastal waters are warmed up. As a result, the temperature difference between the surface and discharge water is greater than with southerly winds. Discarge water from all of the discharge sites travels to the open sea through the surface current and mixes with the cool welling water, in which case cooling takes place quickly. Differences between different discharge options are smaller than with southerly winds.

In July, the effect of the intake site location on the area that will be heated is more significant than that of the discharge site. The smallest area that will be heated is achieved with intake from the bottom (I1) in all the assessed combinations of options. The area that will be heated in the bottom intake options varies by approximately 2–4 km² with one unit and 6–9 km² with two units. With shore intakes (I2 and I3), the area that will be heated varies by 7–18 km² and 11–25 km² with two units. The smallest area is achieved with the Discharge D3 (Option C) to the south of Kampuslandet. In terms of the area that will be heated, the Vådholmsfjärden Intake Option (I3) is the worst, as the cooling waters of the current Loviisa power plants have a heating effect on it. The largest area is achieved in the option combination F (I--D2) in which the effects of the warmer input water are emphasized in the shallow discharge area.

8.4.3.4 Impact of cooling waters on ice conditions

In the winter, heated cooling water keeps the water open in the area close to the discharge site, and it also causes thinning of the ice over a broader area to the south and southeast of the discharge sites (Figure 8-31). In the winter, the flow of cooling water is bidirectional according to the model calculations: close to the surface, the heated cooling water mainly flows to the west and southeast in the beginning, but deeper, starting at approximately 10 meters, the water flows also east and northwest with the current.

The areas of open water remain small, amounting to 3.7–5.2 km^2 with the 1,800 MW power plant unit at the beginning of February and 4.5–5.3 km^2 with the larger 2,500 MW power plant option (Table 8-9).

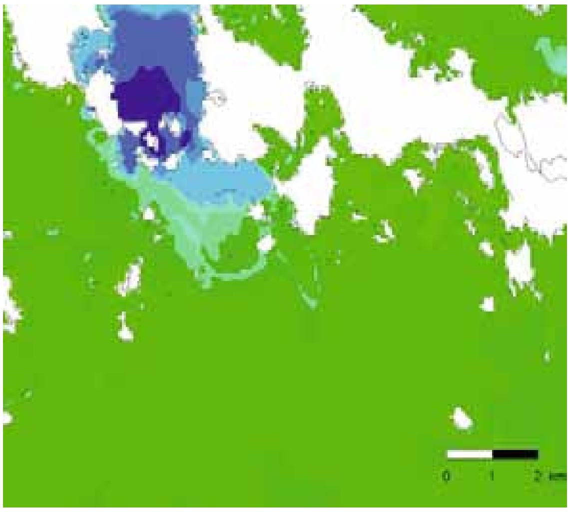
The area of thin ice (less than 10 cm) increases from the zero-option value with one power plant unit from two- to fourfold compared to the thin ice area caused by the current Loviisa units in the nearby area, amounting to a maximum of 24.5 km^2. With the higher power plant power, the area increases three- to fivefold, amounting to a maximum of 30.7 km^2.

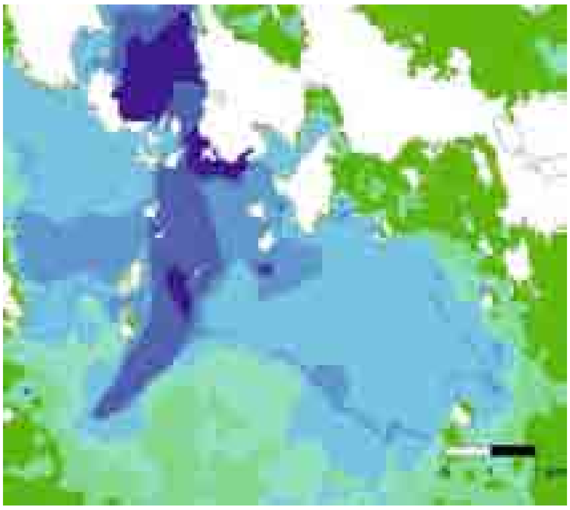
8.4.3.5 The impact of cooling waters on water quality and ecology

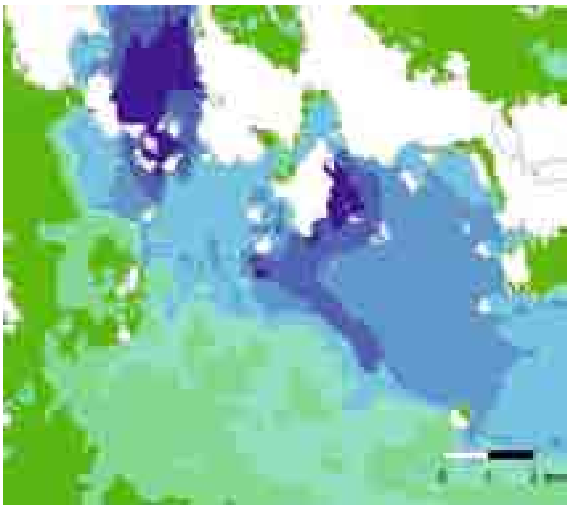
Water quality

The quality of cooling water will not change as it flows through the power plant, apart from the increase in temperature. However, there may be differences in water quality between the intake and discharge site. As a result, the impact on the discharge site depends on the water quality at the intake site.

In all the intake options (including shore intake), the cooling water is planned to be taken from the aqueous layer close to the bottom. The nutrient content of water close to the bottom is higher than of surface water in the area, so the nutrient content of surface water is likely to increase initially with all the discharge site location options as a result of the impact of cooling waters. This is the most evident in the intake from the bottom option in Orrengrundsfjärden (I1), in which the nutrient content close to the bottom is higher than in different intake ar-


Ice conditions in zero-option


Ice conditions, discharge 1


Ice conditions, discharge 2

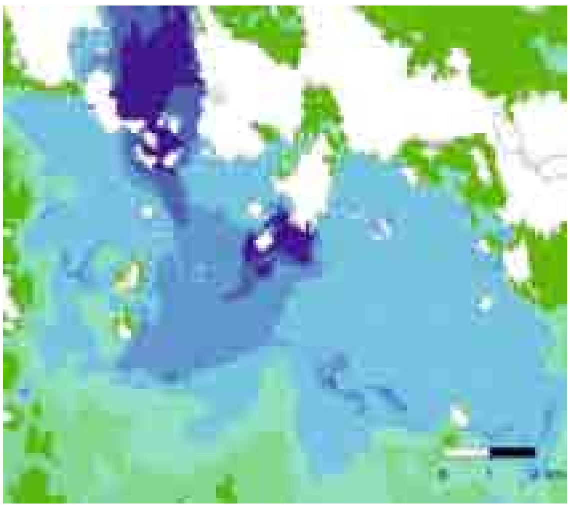

Ice conditions, discharge 3

Figure 8-31. Impact of cooling waters on the ice conditions of the project area in the situation at the beginning of February with the two-unit option at all the discharge site location options.

Table 8-9. Areas of open sea or weak ice (less than 10 cm) in the different alternatives in the modeling throughout February (2003). The area of weak ice includes that of unfrozen water as well. The V0 situation is the current situation with the Loviisa 1 and 2 units in operation.

Option	Unfrozen water (km^2)	Thin ice (km^2)
V0	1.8	6.4
A1	4.6	20.0
A2	4.5	25.8
B1	3.7	18.8
B2	4.8	30.7
C1	4.0	18.0
C2	5.1	21.0
D1	5.1	14.0
D2	5.3	15.1
E1	5.2	20.3
E2	5.0	24.1
F1	4.5	16.9
F2	5.1	21.5
G1	4.2	21.1
G2	4.9	21.2

eas and no surface water mixes with the input water, as in shore intakes. However, the impact is likely to be short-lived, spanning over a few months, as taking the cooling water from the aqueous layers close to the bottom improves the turnover of water and thereby the oxygen situation in it, decreasing nutrient content of intake water.

If the salinity of water at the intake site exceeds the salinity of the discharge site clearly, the area is frozen and there is an abundance of freshwater in the surface, the heated cooling water might "submerge" under the fresh surface layer due to being heavier. In this case, cooling is slower and the total area that will be heated higher. This phenomenon is mainly an option when taking water from the intake from the bottom option (I1), in which the salinity of the water close to the bottom has been slightly (approximately 1‰) higher than the salinity of surface water on average in the 2000s. However, as it has been planned for the plant to use a discharge method that efficiently mixes the discharge area and because the discharge area is more open and therefore better mixed, it is unclear if this submerging effect will be present in the first place.

Heated cooling water may, in certain conditions, strengthen natural heat layers in summer, in which case exposure to oxygen depletion near the bottom increases. There are low-oxygen deeps in all the planned discharge area options at the moment. Warm cooling water may expand these areas or prolong the winter-time oxygen depletion, if the water changing impact of cooling water intake does not reach theses depths.

Phytoplankton and zooplankton

Research conducted in cooling water areas has shown thermal stress to increase basic production in the discharge areas (e.g. *Mattila & Ilus 2006, Snoeijs 1988, Langford 1990*). Warm cooling waters will extend the vegetation period and speed up the metabolism of organisms. The discharge area is already eutrophic, and primary production has been observed to increase faster than the general eutrophication development in the nearby Loviisa power plant impact area. Based on this, warm cooling waters can be expected to increase primary production in the cooling water discharge area of the new power plant.

The primary production-accelerating impacts of cooling water are estimated to extend to an area in which water temperature in the surface layer is more than one centigrade above normal for the most of the time. The size of this area depends mainly on the power option examined. The extent of the affected area is also dependent on the differences between the intake and discharge options. In intake from the bottom (I3), the water is approximately 2–5 centigrades cooler than water in the discharge area in June, which decreases the size of the area that will be heated.

The location of the discharge sites has an effect on the size of the area that will be heated, and therefore also the increase in the production of phytoplankton. The smallest affect area can be found in Discharge D3 to the south of Kampuslandet as a result of good water turnover.

Blue-green algae are often known to become more abundant in warm waters and their quantities have been observed to increase in cooling water discharge areas *(Kirkkala & Turkki 2005, Sandström & Svensson 1990)*. Inflorescent masses for blue-green algae are the most typical in eutrophic sea areas particularly in late summer when nitrogen acts as a nutrient limiting growth. Inflorescence of blue-green algae has increased in the area affected by the warm waters of the Loviisa power plant. The amount of inflorescence of blue-green algae may also be increased in the affected area of the new power plant's cooling water. According to assessments, the project will not have detrimental impacts on the zooplankton community.

The thermal load of cooling waters is assessed to increase primary production in the discharge area. There may also be changes in species and annual abundance ratios. However, the project's impacts are assessed to be local and minor with regard to the state of the Gulf of Finland as a whole. Apart from the size of the affected area, the impacts of the different options are considered to be similar in general.

Aquatic vegetation and macroalgae

Cooling water will be conducted to the sea through a channel where the water flow speed at the mouth of the channel will be 1 m/s. The flow causes the fine-grained sedimentary deposit at the bottom of the front of the discharge area to drift away at a distance of approximately a few hundred meters. In the area close to this discharge channel, vegetation will likely consist mainly of filamentous algae.

The most significant impact which changes vegetation will, however, be accelerated growth in the warmed-up water area. The development observed in vegetation is largely similar to eutrophication. Species in the cooling water discharge areas have been observed to become more less diverse and production will increase.

Red algae and several bladder wracks are estimated to be likely to regress permanently in the warmed-up area. The quantity of filamentous algae, on the other hand, is likely to increase. The number of species of vascular plants that thrive in soft bottoms, may decrease as a result of eutrophication, but the biomasses increase due to the accelerated growth of few species that tolerate the thermal load well. In shallow and protected areas, mainly reed areas comprised of phragmites, are likely to become more dense and expand.

Increased production will also increase the amount of organic matter and decomposition, which can deteriorate the oxygen situation in the aqueous layer close to the bottom. This may intensify to some extent the occasional oxygen depletion already present in all the discharge area options.

The project is assessed to increase the total production of aquatic vegetation and change the composition of species by increasing the growth of filamentous algae in the area. These impacts are assessed to extend to the area where the temperature increase will be at least one centigrade. The project is not estimated to have an impact on vegetation on a wider scale, or on the vegetation of the Gulf of Finland in general.

Bottom fauna

As mentioned above, erosion of the area off the discharge area is changing the quality of the bottom in the area. In this area, the bottom fauna species will change.

The impacts of cooling waters on bottom fauna area mainly indirect, and mostly due to changes in primary production. The increased quantity of organic matter favors species that benefit from eutrophication. For example, larvae of chironomus plumosus or lumbriculus variegates which are typical species in euthophic waters may become abundant at the soft bottoms in the affected area. The warm oxygenous bottoms close to the discharge area offer good conditions for several other species as well. However, in deeps, oxygen depletion may worsen and cause a decline in bottom fauna.

The project's impact on bottom fauna communities is assessed to be local, and is not considered to differ significantly from the impact of the general eutrophication of the Gulf of Finland coast. The project is not considered to reduce bottom fauna so that it could affect the fish stock which uses bottom fauna as nutrition.

Alien species

It has been noted that the cooling waters of the Loviisa power plant provide a favorable living environment for several alien species. In particular, the dark false mussel occurs in the area as dense communities. Other alien species found in the area include *Gammarus tigrinus* and North-American polychaete.

The location of the project area in the vicinity of the Loviisa power plant and unrestricted mobility of the fauna make it possible for these alien species to spread also to the area affected by the cooling waters of the new power plant. It should be noted that bivalvia and other organisms growing in cooling water passages can be prevented mechanically or chemically and, as a result, they will not cause any impacts on safety or production at power plants. So far, Mnemiopsis leidyi has been found in the deeps of the open parts of the Baltic Sea. The impacts of cooling waters, on the other hand, are on the vicinity of the coast and the surface layer. Spreading of Mnemiopsis leidyi to the project area cannot be considered very probable.

8.4.3.6 Impacts on fish and fishing industry

Fish stocks

Slight temperature increase in the water system, particularly if it involves increase in eutrophication, will basically favor spring-spawning fish species at the expense of more demanding fall-spawning fish. In summer, the temperature of surface water will, occasionally, increase to about 30 centigrades up to a distance of 1.5 km from the discharge area because of cooling waters depending on the weather, which will, in practice, drive fish away from the area. In summer, the surface layer (0–1 meters) of the sea will increase by more than 3 centigrades in a maximum area of approximately 3 km^2 and by more than 5 centigrades in a maximum area of 1 km^2. The local warming up of surface water is assessed not to have a significant adverse impact on the area's fish stocks because the deeper aqueous layers are cooler and fish can actively seek suitable temperatures. Warm water species thrive in the area in summer. In Hästholmsfjärden, the unfrozen sea area has been observed to attract also cold water species in the winter, such as sea trout and whitefish.

Seashore areas and shallows are spawning areas for several species, such as whitefish. Due to the impact of cooling waters, hypolimnion will warm up in the vicinity of the discharge area, which might worsen the conditions in the spawning areas. In the area affected by the cooling waters, close to the coast, there are no longer whitefish spawning areas, according to local fishermen. Off the project area, the spawning areas of valaam whitefish

(Coregonus widegreni) are located along the coasts and shallows of the islands and islets of the outer sea area. Any spawning areas of the Baltic herring have not been identified in the affected area of cooling water. However, there are spawning areas of the Baltic herring in the shallow areas of the outer sea area. The warming up of the aqueous layer deeper than a few meters caused by the cooling waters is limited to the vicinity of the discharge area, and it is not assessed to have a significant impact on the spawning areas. The increased temperature may also have an adverse impact on the reproduction of burbot in the discharge area, but due to the relatively small size of the area, it is not estimated to have a significant impact on the burbot stocks in the area.

According to local fishermen, the migration route of common whitefish, salmon and sea trout at least partly passes in front of Kampuslandet to the south of the island. At most (in the case of two power plant units), the surface layer warming up due to the impact of cooling waters extends in the southern discharge option (D3) to approximately two kilometers to the south of Kampuslandet, i.e. at least partially to the assumed route of migratory fish. In Discharge Option D2, the area affected by cooling waters is mainly limited to the east of Kampuslandet, and in Option D1 to Vådholmsfjärden, but the area warming up by more than one centigrade may in both options extend to the migration route. Warming will be minor at a depth of more than 2 m in all of the options. Local warming up of surface water is assessed not to have a significant impact on the migration behavior of fish, but migratory fish will most likely appear less often in the shore area off Kampuslandet.

A suitable increase in temperature may advance the spawning season of fish and speed up the development of spawn and the growth at the fry and mature stages, which may have positive impacts on the stocks of spring-spawning fish. These impacts are assessed to be similar with all the plant location options (a more specific description can be found in the section on the impact on fish in Pyhäjoki).

For the most part, the project's impacts can be compared to the impacts of the present Loviisa power plant. In the area affected by warm cooling waters, the conditions favor spring-spawning fish species, such as pike, perch and bream. Compared to the Hästholmsfjärden discharge area of the existing Loviisa power plant, discharge of the cooling waters from Fennovoima's power plants would take place in a more open sea area, where the impacts would likely be smaller. Of the discharge options, D3 would probably be the best in terms of fish stock, as in it the cooling waters will be conducted directly to a deeper and more open sea area and the impacts on the coastal zones remain smaller. The openness of the sea area also facilitates better mixing, meaning that the area that will warm up will remain smaller than with the other options. On the other hand, the impacts of Option D3 would more obviously affect the assumed route of migratory fish species than the other discharge site location options. In Discharge Options D1 and D2, the impacts affect shallow coastal areas more widely, and the areas that will warm up are larger.

Fish driven to the power plant along cooling water

In Ruotsinpyhtää, the fish driven to the plant would mainly include Baltic herring and smelt. In the intake from the bottom option, the number of fish is estimated to be lower than in the shore intake. The access of fish to the plant can be reduced by installing barrier nets in front of the intake channel during the spawning season in spring or using various technical repellents (reduced impacts are described in Chapter 10).

The volume of fish driven to the plant is assessed not to have a detrimental impact on the fish stock in the sea area.

Fishing

Fishing is currently carried out in the sea area off the project area using traps and nets. The sea area is rather eutrophic, which already now increases slime build-up and cleaning needs in traps and reduces fishing efficiency. In Option D1, the damage caused by cooling waters to fishing is likely to be mainly limited to Vådholmsfjärden, in Options D2 and D3 to the east and south of Kampuslandet to Orrengrundsfjärden. The impacts are likely to be slightly higher in Options D1 and D2 where the impacts of cooling waters would affect a more extensive and shallow area.

Also, migratory fish will most likely appear less in these areas.

The impacts on fyke net fishing would likely to be rather similar in all the alternative discharge sites, as there are spots for fyke net fishing close to all the discharge sites. For fishing, the different cooling water intake options do not have a significant difference.

The project will not have an impact on the reproduction of seals because seal reproduction areas are not located in the affected area of cooling water. The project is also assessed not to have an impact on the seal stocks or the appearance of seals in the area.

During the winter season, the more extensive unfrozen areas and thin ice will restrict ice fishing. As the possibilities for ice fishing reduce, the possibilities for fishing in the open sea will improve. Unfrozen areas have been reported to lure cold water species, such as whitefish and trout in the winter.

Due to the impact of the cooling waters from the existing power plant and the temperate winters of recent years, ice conditions in the area are unstable. Because of the project, the area of thin ice would expand approximately 9–25 square kilometers on the current area.

The fluctuations in the sea water level are recorded as part of the EIA process. Quay in Simo, 2008.

The impact would mainly affect Vådholmsfjärden and Orrengrundsfjärden.

In summer, the impact area of the cooling water is dominated by spring-spawning fish species that favor warm water and are often of less value in terms of fishing. Salmonidae, which are cold water species, avoid the area in the summer due to the high temperatures. This may cause fishing distances to become somewhat longer with regard to, for example, whitefish. Cooling waters and their resulting impacts will not have an impact on fish quality.

8.4.3.7 Comparing the intake and discharge options for cooling water

The impacts of the cooling water intake sites on waters mainly differ with respect to the area that will warm up. In the cooling water bottom intake Option I1, the water coming to the plant is cooler than surface water in the summer, which means that the area that will warm up will be smaller than with the shore intake options according to nearly every option combination review. In terms of area, shore intake (I2) to the east of Kampuslandet is the second-best option. In Vådholmsfjärden (I3), located to the south of Gäddbergsö, the intake water is warmer due to the impact of the cooling waters from the Loviisa power plant. Quality of water mainly differs between bottom and shore intakes. Water close to the bottom contains more nutrients than the surface layer, which is why primary production could initially increase more in Option I1 than in the shore intake options. On the other hand, the lower intake water temperature decreases the affected area. In the bottom intake option, the number of fish driven to the plant along cooling water is estimated to be smaller than with the shore intake options.

Of the assessed options, discharge Site D3 (to the south of Kampuslandet) is the best based on nearly all the option combination reviews in terms of the area that will be heated. With this option, the warming effect of the cooling water mainly affects a deeper water area, so changes in the more delicate coastal zone can be estimated to be smaller than in the other options. Of the options reviewed, its impacts most obviously extend to the assumed route of migratory fish. This is not expected to have an impact on migratory behavior, but there might be damage caused to fishing in the sea area off Kampuslandet. On the other hand, the other two assessed options probably have similar effects as well. Of the assessed options, discharge Site D2 (to the east of Kampuslandet) is the worst in terms of the area that will warm up. The impacts affect a shallow area where water turnover is poor compared to the other options. The impacts on the coastal zone are larger than with the other options, and growth in primary production is likely to be slightly higher. Discharge Site (D1) is directed to Vådholmsfjärden, which is a relatively open sea area. With regard to the area that will be heated it is better than Option D2 but worse than Option

D3 with nearly all of the assessed option combinations. Its location close to Hästholmsfjärden, the discharge area of cooling waters from the Loviisa power plant, is seen in the winter as the ice of the Hästholmsfjärden straits and Vådholmsfjärden remained thin.

8.4.4 Simo, Karsikkoniemi

8.4.4.1 The current state of the waters

The quality and biological state of water off Karsikkoniemi is monitored as a part of the obligatory monitoring program off Kemi. The obligatory monitoring program off Kemi is being carried out by order of Oy Metsä-Botnia Ab's Kemi plant, Stora Enso Oyj's Veitsiluoto plants and Kemin Vesi Oy. Of these, Stora Enso Oyj's Veitsiluoto plants are located closest to the project area, approximately 5 km away. The Lapland Environment Centre also has water quality monitoring sites off Karsikko.

The state of the water area surrounding Karsikkoniemi is described based on the water observations from the obligatory monitoring program off Kemi and the Hertta database. The observation sites have been selected so as to represent the state of the area close to Karsikko and the outer sea area. Observations from the mouth of Kemijoki have been omitted from the data, as there water quality differs from the Karsikko area due to the higher impact of waste and river water. The assessment also makes use of other research data on the water ecosystem of the area and the impacts of cooling waters both in Finland and abroad.

General description and hydrologic data

Karsikkoniemi is located at the bottom of the Bothnian Bay. The archipelago of the mouth of Simojoki opens to the southeast of the cape with the island of Ajos to the west of the cape. The island of Laitakari is located off Karsikko, as are smaller islands and islets (Figure 8-32). However, the coast is, as is typical of the Bothnian Bay, mainly open and the open sea opens directly to the south of the cape. Karsikko is surrounded by shoaly shallows with a depth of less than 5 meters for the most part. The bays to the east and west of the cape are in general rather shallow (less than 10 meters). To the south of the shallows, approximately 2 kilometers from the coast, the depths exceed 10 meters and the area is freely connected to the actual water column of the Bothnian Bay. In Karsikko, the conditions for coastal eutrophication are more

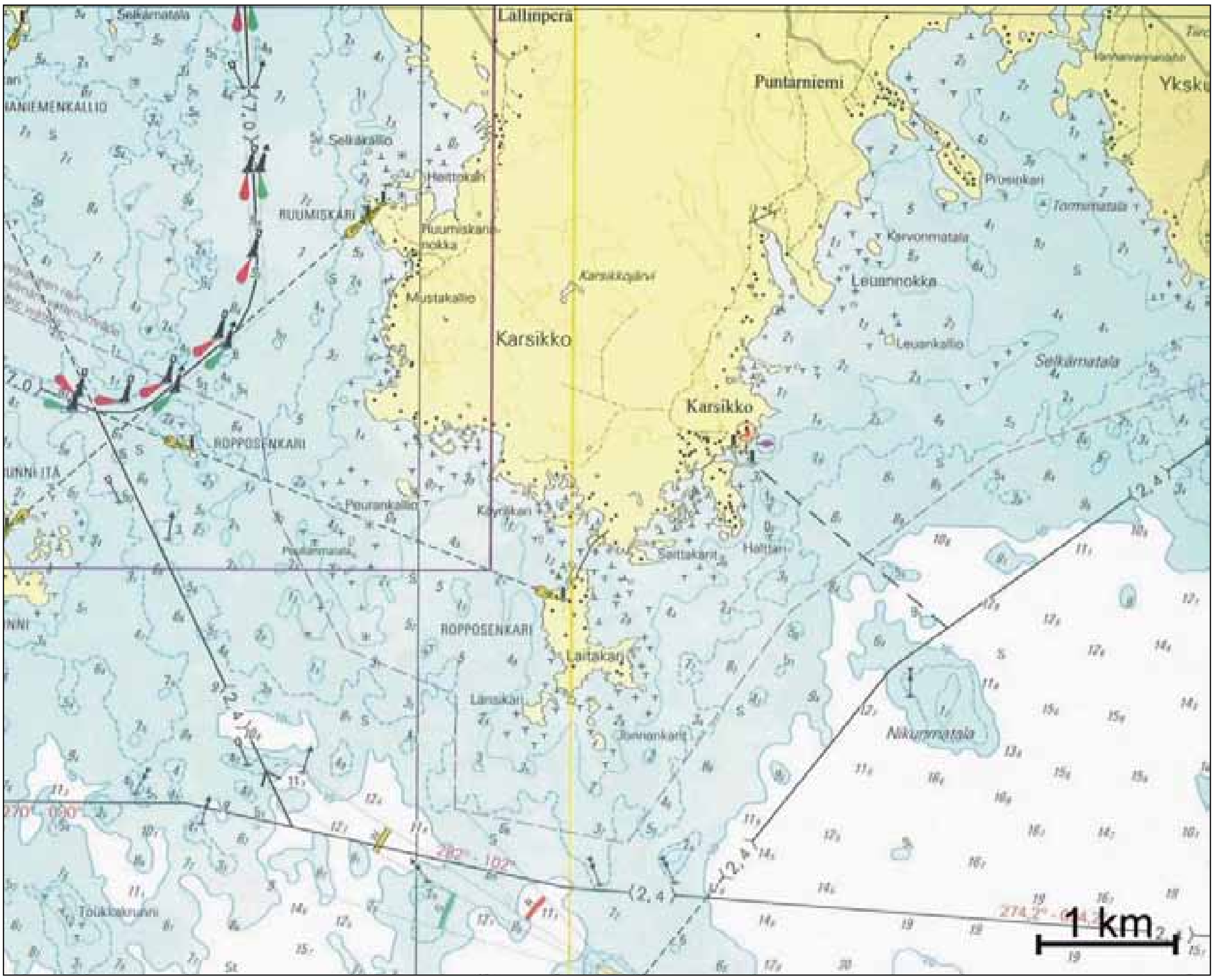


Figure 8-32. Extract from the nautical chart of the Karsikkoniemi area.

minor than in the island areas of the Gulf of Finland because of flat bottom surfaces and efficiently changing water *(Henriksson & Myllyvirta 2006)*. The route leading to the Veitsiluoto Port is located to the west of Karsikko.

Two large rivers empty into the area close to Karsikkoniemi. Simojoki empties into approximately 15 kilometers to the east; its mean discharge is 45 m^3/s, and Kemijoki empties into slightly over 15 kilometers to the west; its mean discharge is 581 m^3/s (Korhonen 2007). The rivers carry fresh, more humus- and nutrient-containing water into the area.

Currents

In the Bothnian Bay, currents are mainly caused by winds and, therefore, their direction and strengths vary greatly *(Kronholm et al. 2005)*. The main current flows towards north along the Finnish coast and towards south along the Swedish coast. The main current direction off Karsikko is from southeast to northwest.A large volume of water flows between the Bothnian Bay and the Bothnian Sea. There is mainly low-saline surface water flowing out and more salinic water of the Bothnian Sea flowing in. In the short term, the relationship between these water masses is fairly constant. In the long term, the relationship may change which will lead to changes in the salt content in the Bothnian Bay. *(Kronholm et al. 2005)*

Average water level and water level extremes

This section presents the average fluctuation in water level and water level extremes in the project area, based on the report of the Finnish Institute of Marine Research ordered by the company responsible for the project *(FinnishInstitute of Marine Research 2008 a)*.

The continuous water level measurement sites closest to Karsikkoniemi and used in the survey are located in Kemi (Ajos) (distance approximately 9 kilometers) and Oulu (distance approximately 75 kilometers). Both stations have provided observations since 1922.

Isostatic uplift on the coast of the Bothnian Bay will continue to be quicker than the increase in the sea level (Figure 8-33). In Simo, the water level will most likely continue to decrease in relation to the ground, by approximately 26 cm from the current level by 2075 (Table 8-10). As a result of the decrease in the average water level, also the lowest extremes will decrease. The lowest sea level in 2075 is likely to be 26 cm lower than in 2008.

The most significant factors affecting short-term water level fluctuation on the coast of Finland are wind, fluctuation in atmospheric pressure and the to-and-fro oscillation of the water level of the Baltic Sea *(seiche effect)*. The impact of tide is small, only a few cm. Short-term water level fluctuation is the highest in the remotest corners of the Gulf of Bothnia and the Gulf of Finland.

Ice conditions

Because of the cold climate and low salt content, the Bothnian Bay usually freezes over every year. Ice typically starts to generate at the beginning of November and the Bothnian Bay is usually free of ice at the beginning of May.

The formation of pack ice is a typical phenomenon in the Bothnian Bay region. Winds and currents shape the ice particularly in the outer archipelago and on the open sea. Different sizes of ice floes form ice barriers. The barriers can be very high, in which case they will also extend below the water surface. Ice has been found to scrape the sea bottom up to a depth of 28 m. Generally, the impact extends only a few meters. *(Kronholm et al. 2005)*. The formation and accumulation of pack-ice walls varies greatly from year to year.

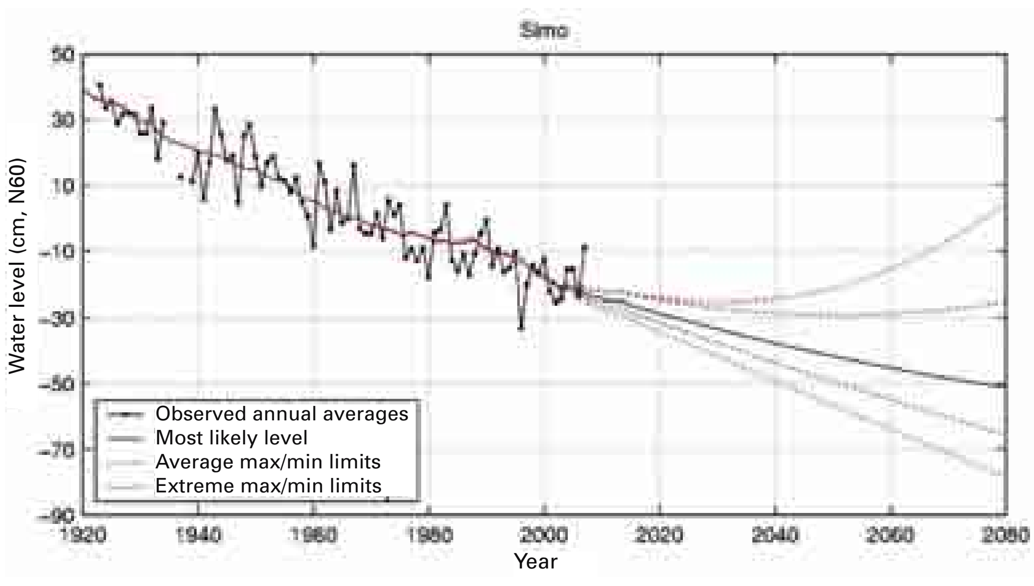


Figure 8-33. Interpolated annual averages and average water level scenario in Simo, values interpolated linearly from the values calculated for the Kemi and Oulu observation sites. *(Finnish Institute of Marine Research 2008a)*.

Table 8-10. Sea level extremes in Simo in 2008 and 2075 corresponding to the level of probability of once per a thousand years.

	Highest sea level (cm)	Uncertainty limits	**Lowest sea level (cm)**	Uncertainty limits
In 2008	+231	–	-189	–
In 2075	+205	+180 – +250	-215	-240 – -170

Water quality

The impacts of river water and nearby area's wastewater discharge sites can be seen in the nutrient content off Karsikkoniemi, particularly in the bay of Veitsiluoto between Karsikko and Ajos.

During the period between 1990 and 2007, the total phosphorus content has typically varied between 5 and 30 µg/l (average approximately 15 µg/l), and a slight decrease can be seen in it. During this decade, the content has mainly been under 20 µg/l, being slightly lower on average to the east of Karsikko than to the west. The total nitrogen content has remained at roughly the same level during the comparison period across all sites, varying typically between 250 and 450 µg/l (average approximately 330 µg/l). The nutrient content is at its peak during the spring and early summer due to the impact of river water, and at those times the content may temporarily be even considerably higher than presented above. The impact of river water is also particularly evident in the spring, with the nutrient content being higher in the surface water than in the water close to the bottom. In the outer area, the limiting nutrient has mostly been phosphorus, and closer to the coast also nitrogen. *(Pöyry Environment Oy 2008, Environmental Administration's Map Service 2008)*

The oxygen situation of the water close to the bottom in the sea area off Karsikko is mostly good or satisfactory, as is typical of the Bothnian Bay, and no actual oxygen depletion occurs. Also, there have been no obvious changes in the situation between 1990 and 2007.

The salinity of water at the open sea observation sites has varied between 0.2‰ and 3.2‰ in the 2000s *(Environmental Administration's Map Service 2008)*. Due to the impact of river water, at times the surface layer consists mainly exclusively of fresh water. The salinity is typically lowest close to the surface and highest close to the bottom because of the impact of river water. A high humus content and low water transparency (usually approximately 1 to 2 meters) are typical of the sea area off Karsikko, varying significantly based on the quantity of seepage water.

The quality of water of Kemi has improved with more efficient waste water treatment *(Pöyry Environment Oy 2007b)*. The positive impacts are evident off Karsikko as well, particularly in the bay of Veitsiluoto, in the form of lower phosphorus content.

In typification in accordance with the ecological state of surface waters, the sea area off Karsikko belongs to inner coastal waters of the Bothnian Bay. In acccordance with the typification according to the ecological state of water, the state of the sea area off Karsikko is satisfactory. The state is damaged by river and waste water. The state of the outer coastal area, on the other hand, is good.

Phytoplankton and zooplankton

Because of the short vegetation period, basic production in the Bothnian Bay is low compared to the other basins of the Baltic Sea. The volume of phytoplankton can be measured using the chlorophyll content, i.e. leaf green content. The average content has decreased in the bay of Veitsiluoto during the comparison period 1990–2007. The chlorophyll content off Karsikko has mainly been typical of slightly eutrophic waters and of rough waters outside the coast. *(Pöyry Environment Oy 2007)*

Mass bloomings of blue-green algae typically occur in eutrophic waters, particularly during the warm periods late in the summer. Mass bloomings are, however, typical mainly in the Baltic Sea proper, where blue-green algae have a competitive edge over the other algae in the summer when the ratio of available inorganic nitrogen to phosphorus is low (*Larsson et al. 2001, Lignell et al.2003*). In the Bothnian Bay, mass blooming does not occur in the same way, e.g. because of the area's low content of nutrients and phosphorus-limited properties. In national blue-green algae monitoring, blue-green al-gae was not observed at the outer sea area site closest to Karsikkoniemi (*Environmental Administration 2008a*). Close to the coast, particularly in areas loaded by waste water, blue-green algae may occur at times, however. At the Kemi boat harbor, which is included in the monitoring, slight amounts of blue-green algae were observed during the first half of July. The Kemi boat harbor is located in an area with a higher load than the area off Karsikko.

No zooplankton studies have been conducted close to the Karsikko region; thus, species are described roughly on the basis of general features in the Bothnian Bay. A typical feature of zooplankton communities in the Bothnian Bay, as of other species, is the abundance of fresh water species, and a low number of total species. Similarly to the phytoplankton community, the zooplankton community changes fairly regularly during a year. For the majority of the year, the community is dominated by copepods (*Kronholm et al. 2005*). When water is at its warmest at the end of summer, there are lots of daphnia.

They are common in coastal waters where they can easily be the dominant group of zooplankton. In addition, during the warm season, rotifers are often abundant. According to the latest national monitoring, the average zooplankton mass in the Bothnian Bay is growing (*Olsonen 2008*).

Aquatic vegetation and macroalgae

Underwater vegetation of the area off Karsikkoniemi has not been mapped. The occurrence of aquatic vegetation and macroalgae is affected by geographic position and prevailing weather conditions. Aquatic vegetation is described roughly on the basis of the ambient conditions and general information about the Bothnian Bay region (*Kronholm et al. 2005, Leinikki & Oulasvirta 1995*).

In the open shores off the headland, the bottom is rocky because of waves and currents. In hard rock bottoms, species mostly consist of macroalgae that can attach themselves to the rock surfaces. These include annual filamentous green algae, such as *cladophora glomerata*. Cladophora glomerata generally appears in the coastal zone of the Bothnian Bay as a dominant species up to a depth of 2.5–3 m. Below this limit, the dominant spe-cies up to the alga limit is often another filamentous green alga, i.e. *cladophora aegagropila*. Only a few species of marine red algae exist in the area, such as ceramium tenuicorne. Because of the low salinity, focus vesiculosus is missing from the species of the area.

The generation of organic matter in sheltered bays changes the quality of the bottom. Vascular plants are often dominant in soft bottoms. Vegetation in the Bothnian Bay is dominated at the water level by *eleocharis acicularis* and *potamogeton berchtoldii* and, in sand bottom areas, by *chara aspera* and *zannichellia palustris*. In deeper waters, common species include *potamogeton perfoliatus* and *potamogeton vaginatus*. The appearance depth for vegetation is regulated by the amount of light. Water in the Bothnian Bay area is dark as a result of humus, because of which the lower limit for vegetation runs generally at less than 5 m near the shore.

Bottom fauna

Bottom fauna in the area off Karsikkoniemi is monitored regularly as a part of the monitoring of the water area off Kemi. In the Bay of Veitsiluoto at a depth of 4–5 meters, and in the outer sea area at a depth of approximately 10–18 meters, communities of soft sea bottoms are dominant. The dominant group among the region's bottom fauna is lumbriculus variegates, which was found relatively the most particularly in deeper ar-eas. Close to the coast, the frequency score of larvae of *chironomus plumosus* was the highest. e.g. larvae of chironomus plumosus, which tolerate eutrophic waters well, occur in the Bay of Veitsiluoto, which is affected by waste water. However, they have not been observed in outer areas at all, and their quantities have been on the decline in the 2000s also in the Bay of Veitsiluoto, probably due to changes in water quality. *Monoporeia affinis* was observed both in the Bay of Veitsiluoto and the outer areas. It is a typical species especially in deeper mud bottoms; yet in 2006 it was the most frequent in samples from Veitsiluoto. *Saduria entomon* was also observed in the outer area. (*Pöyry Environment Oy 2007b*)

Typically, the rocky bottoms in the Bothnian Bay have large communities of *cordylophora caspia*. The species appears on plant surfaces and on hard bottoms. (*Leinikki & Oulasvirta 1995*)

Sedimentary deposit

Detrimental elements have accumulated in the sea bottom sedimentary deposit of the Bay of Veitsiluoto between Karsikko and Ajos over the years as a result of releases from the area's industrial operations. Content of detrimental elements in the sedimentary deposit is typically the highest in the vicinity of the Port of Ajos and the bay of Veitsiluoto, decreasing with distance from the coast.

A sedimentary deposit survey carried out in connection with the environmental impact assessment of the Ajos deep-water harbor examined the chemical spoiling of the sedimentary deposit of the immediate vicinity of the port (*SCC Viatek 2002*). Concentrations of PAH compounds, oil hydrocarbons and PCDD/F compounds, lead and mercury that exceeded level 1 (roughly corresponds to the natural content of the environment) were observed in the sedimentary deposit samples in many places. No exceedings of level 2, i.e. dredging masses classified as spoiled, were observed in the sedimentary deposit survey with regard to any of the measured detrimental elements. Based on the survey, the topmost sedimentary layer, approximately half a meter thick, of the dredging area is contaminated, i.e. between levels 1 and 2. The sedimentary deposit samples were mainly taken from the dock basin, so the concentrations of detrimental elements are likely to be higher than in the actual sea area.

The occurrence of organic chlorine compounds in the sedimentary deposit is examined as a part of the obligatory monitoring program off Kemi. Chlorine was abandoned in the production of pulp in the early 1990s. The quantity of chlorine compounds in the sedimentary deposit has been decreasing since 1997 and approaching the level of natural concentration. (*Pöyry Environment Oy 2007b*)

Fish and fishing

The latest report on fishing in the sea area off Kemi and Simo was made in 2006 (*Pöyry Environment Oy 2007b)*. With regard to domestic fishermen, the report covers those who have bought fishing licenses from the Kemi recreational fishermen's associations and the joint Simo water areas. The data do not include fishermen who are not members in recreational fishermen's associations. As for professional fishing, the data include the professional fishermen fishing off Kemi and Simo included in the T&E Centre registry.

Slightly under 400 households performed domestic fishing in the area off Kemi and Simo in 2006, and 38 fishermen were engaged in professional fishing. The professional fishermen mostly carried out fyke net and net fishing. The focus of fishing was clearly on fyke net fishing. Four trawling teams performed trawling on a small scale. The professional fishermen used approximately 150 fyke nets and catches, of these three out of four were coarse-meshed salmon or whitefish catches. The professional fishermen used approximately 1,600 fishing nets, more than 80% of which were coarse-meshed whitefish nets (mesh size 36–50 mm). Fyke net fishing was mainly carried out in June–August and net fishing in September–October. Winter fishing using nets was carried out by one-fifth of professional fishermen. The most popular forms of fishing for domestic fishermen included trolling, casting rod fishing and ice fishing, which were practiced by more than half of the fishermen. Slightly under a half of the fishermen performed net fishing. The domestic fishermen used approximately 2,200 fishing nets, slightly under 80% of which were coarse-meshed whitefish nets (mesh size 35–55 mm). Net fishing was mainly carried out in the open water season. Winter fishing using nets was carried out by slightly under a third of net fishermen.

The total haul off Kemi-Simo, excluding trawling, was approximately 150 tons in 2006, of which vendace accounted for 27%, salmon for 20%, whitefish for 18% and European perch for 15%. The most important fish for professional fishermen were salmon, whitefish, vendace and European perch, and European perch, pike, whitefish and vendace for domestic fishermen. Professional fishermen accounted for three quarters of the total haul. Of the total haul of the most important fish, i.e. salmon, whitefish and vendace, professional fishermen accounted for even more, more than 90%. The household-specific haul for domestic fishermen was 93 kg, and 3,030 kg for professional fishermen. The trawl haul amounted to approximately 18 tons in 2006, of which vendace accounted for more than 70%.

Fishing in the sea area is mostly damaged by seals and slime buildup in traps.

Fyke net fishing is performed in areas surrounding Karsikko, at a radius of approximately 5 km from it, by seven fishermen, four of whom are in the professional fisherman register. The closest spots for fyke net fishing are on the east shore of Karsikko, next to the planned cooling water intake site and to the south of Laitakari. About 30 fyke nets are used. Net fishing is rather insignificant to professional fishermen in the area. Domestic fishing is mainly carried out in the area using nets.

The shallow shoals in the Karsikko environment are important spawning areas for valaam whitefish, vendace and Baltic herring. The migration route of salmon and common whitefish rising from the south passes partly in front of Karsikko. The Röyttä and Haltari catch sites on the eastern shore of Karsikko have historically been known as the best salmon catch sites in Finland.

According to net fishing experiments in the Bay of Veitsiluoto and Ajoskrunni, approximately 3–4 km from the planned cooling water discharge sites, the most common fish species have been roach and perch, which together accounted for more than 80% of the total biomass in 2004–2006. In addition to them, some whitefish, vendace, Baltic herring, pike, carp bream, dace, bleak and ruff has been found in the catches (*Pöyry Environment Oy 2007b*).

8.4.4.2 Impact of wastewater

The project will create social and process wastewater. Some of wastewater will be treated in the plant area and some can be conducted for treatment in a municipal water treatment plant. The project's wastewater load (wastewater fractions, volumes, load and treatment) is described in more detail in Chapter 3 in the section on wastewater.

The nutrient load caused by the project is so small that it cannot be estimated to have a detrimental impact on the general status of the Karsikkoniemi sea area or the state of the Bothnian Bay in general.

Salt created in neutralizing process wastewater is the same salt contained by sea water naturally. Thus, neutralization water will not have an impact on the water quality in the sea area. Furthermore, boron used in certain plant types appears naturally in sea water. It belongs to necessary microelements but is toxic in large concentrations. However, the wastewater conducted in the sea contains so small concentrations of boron that it will not cause any adverse impacts on the water ecosystem.

8.4.4.3 Impact of cooling waters on sea water temperature

The impact of thermal load caused by the power plant on sea water temperatures were assessed through model inspections.

The alternative intake and discharge sites for cooling water are presented on the map (Figure 8-34). Three different intake sites and two different discharge options were inspected in the modeling (Table 8-11).

The impact of cooling water on the state of the Simo sea area has been inspected using three combinations of intake and discharge sites. The inspected options are:

A. Shore intake I1 from the east side, discharge D1 to the southwest
B. Shore intake I2 from the southeast side, discharge D2 to the west

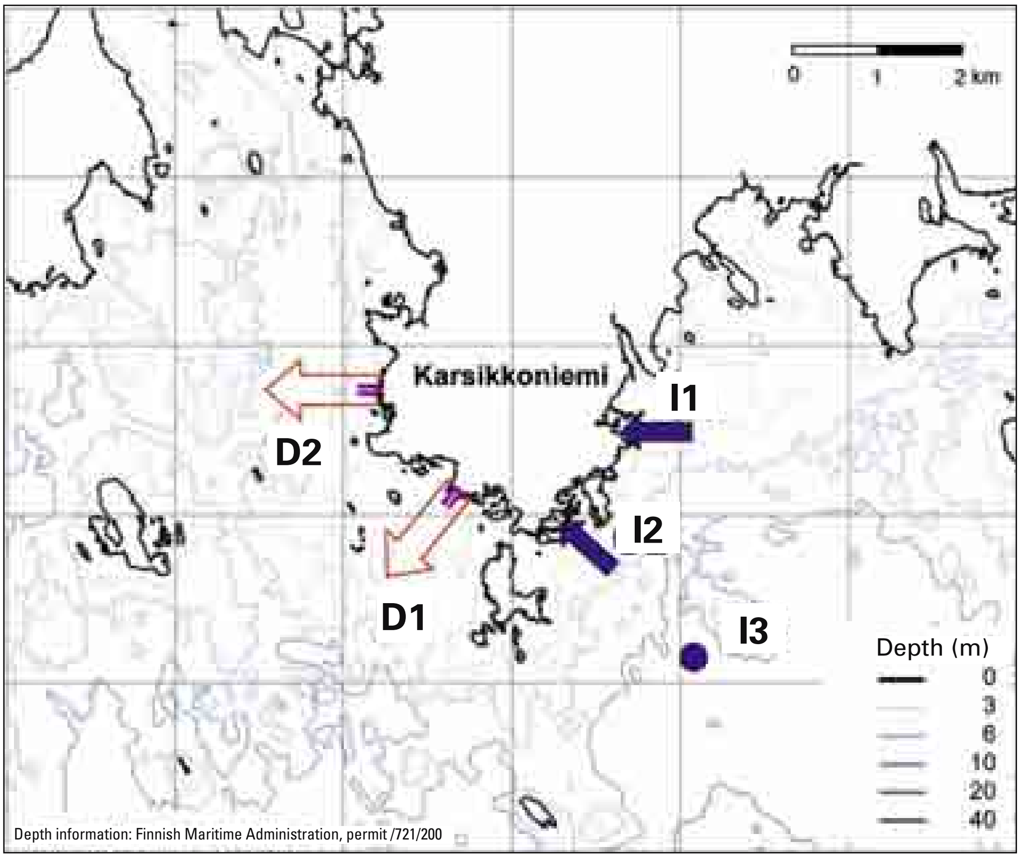


Figure 8-34. Alternative cooling water intake and discharge locations.

Table 8-11. A description of the intake and discharge arrangements.

I1, intake 1	intake channel at the surface level, direction from the east
I2, intake 2	intake channel at the surface level, direction from the southeast
I3, intake 3	intake from the bottom at the depth of 10 m
D1, discharge 1	discharge channel at the surface level, direction to the southwest
D2, discharge 2	discharge channel at the surface level, direction to the west

C. Bottom intake I3 from the southeast side, discharge D2 to the west

Each of the intake and discharge option combinations (A–C) is modeled for two different electric power options:
Option 1: a power plant with electric power of 1,800 MW
Option 2: a power plant with electric power of 2,500 MW (2 units)

In addition, the model has been used to calculate the zero option (V0), i.e. a situation without any thermal stress caused by cooling water.

Average temperature increase in different aqueous layers
The warming impact of the power plant unit's cooling waters at different depths was assessed using the average temperature fields in June (1 June 2003 – 1 July 2003). The average temperature in June for the zero option in the layer of 0–1 m was about 11 centigrades. Temperature increases are calculated by reducing the zero option's reference field from the result field of each alternative calculation. For all options, temperature in-crease is presented in the layer of 0–1 m (Figure 8-35). For Options A2 and B2, temperature increase is presented in the layer of 2–3 meters as an example, showing well the difference between the discharge sites (D1 and D2) (Figure 8-36).

In the surface layer, the area which warms up by more than one centigrade was at maximum, 40 km^2, in Option A2. With Option B, the areas where temperature will increase are smaller than with Option A, which is a result of the stronger current of water in the area of the Option B discharge site (D1) and the shallowness of the discharge area in Option A (D2). With Option C (I3), the areas where temperature will increase are smaller than with option A, mainly due to the cooler input water.

In the surface layer, an average temperature increase of more than five centigrades is limited to the nearby areas of the cooling water discharge site, being less than 2 km^2 in all of the options. The largest area is achieved with Option B, when the area in front of the discharge

The impacts of cooling water have been modeled for each alternative location. Shore view in Ruotsinpyhtää, 2008.

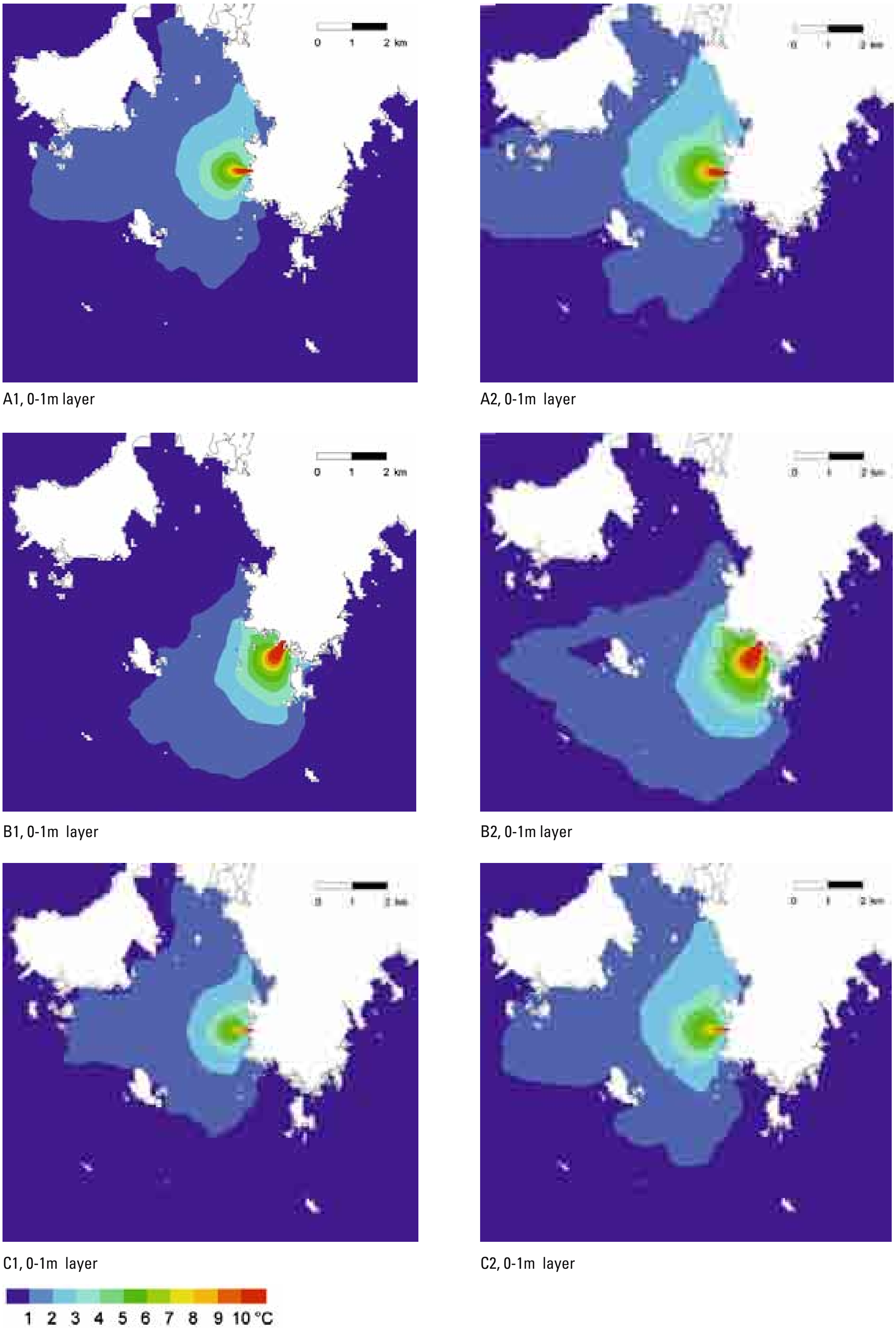


Figure 8-35 Temperature increase compared to the zero option in the aqueous layer of 0–1 m as an average June value in Options A1&2, B1&2 and C1&2.

channel is shallow, preventing mixing into deeper aqueous layers at the mouth of the discharge channel. Option C provides the smallest area, which is mainly due to the cooler input water.

In deeper layers, the temperature increases only slightly (Figure 8-37), by 1–3 centigrades for the most part. The temperature does not increase by more than one centigrade in any of the options at the depth of more than 9 m in an area of more than 0.05 km^2. In Option B (D1), the increase is less than in Options A and C (D2) due to good mixing of the cooling water.

Average temperature increase in different wind conditions
Typical spreading of cooling water was estimated under different wind conditions by calculating increases in temperature over two ten-day periods in July 2003, 6–16 July (northerly wind) and 19–29 July (southerly wind), and over the whole of July. In the former period, winds were mainly directed from the north and east and, in the latter period, from the south and southwest. In the former period, winds were mainly directed from the north and east and, in the latter period, from the south and southwest. The impact of wind direction is presented ere with both discharge site options with the calculation Options A (D2) and B (D1). In Option C (D2), the area warmed remains slightly smaller than in Option A.

For southerly winds, in Option A the cooling water tends to accumulate in the Bay of Veitsiluoto between Ajos and Karsikkoniemi. In this case, the size of the sea area that will be heated is rather large, because the heated water cannot mix with the current running along the coast. During longer south wind periods, warm water begins to accumulate also in depth, which slows cooling down. In Option B, the areas of temperature in-crease remain smaller in south wind conditions.

For northerly wind, there is upwelling off Simo, i.e. wind pushes warm surface water to the open sea and cold bottom water rises from the bottom to the surface layer. In these conditions, the heated cooling water mixes efficiently with the rising cold water, and thermal increase areas are clearly smaller in all options than in the event of south wind. In Option C, water closer to the bottom is still one or two centigrades colder than water in Options A and B, resulting in a further decrease in the affected area.

Calculated as a July average, the area which warms up by more than two centrigrades is less than 25 km^2 in all of the options and, in all of the options with two units, less than 20 km^2 (Figure 8-39). The smallest areas with a temperature increase of more than one centigrade are in Option B and the largest in Option A.

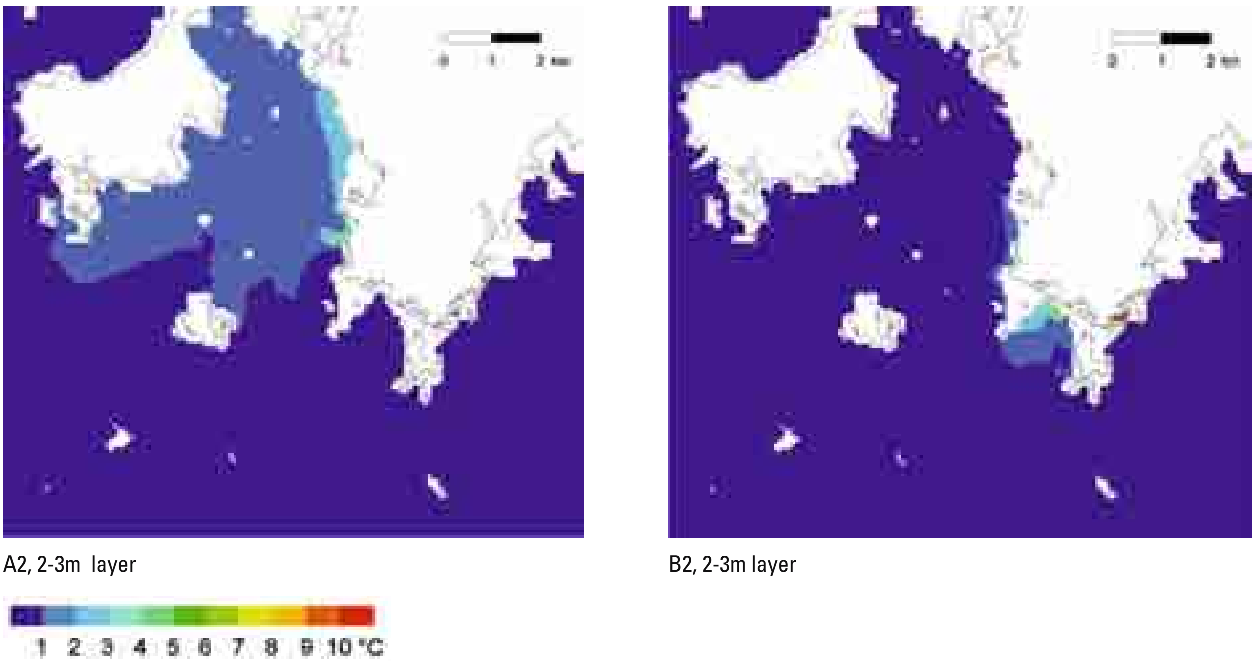


Figure 8-36. Temperature increase compared to the zero option in the aqueous layer of 2–3 m as an average June value in Options A2 and B2.

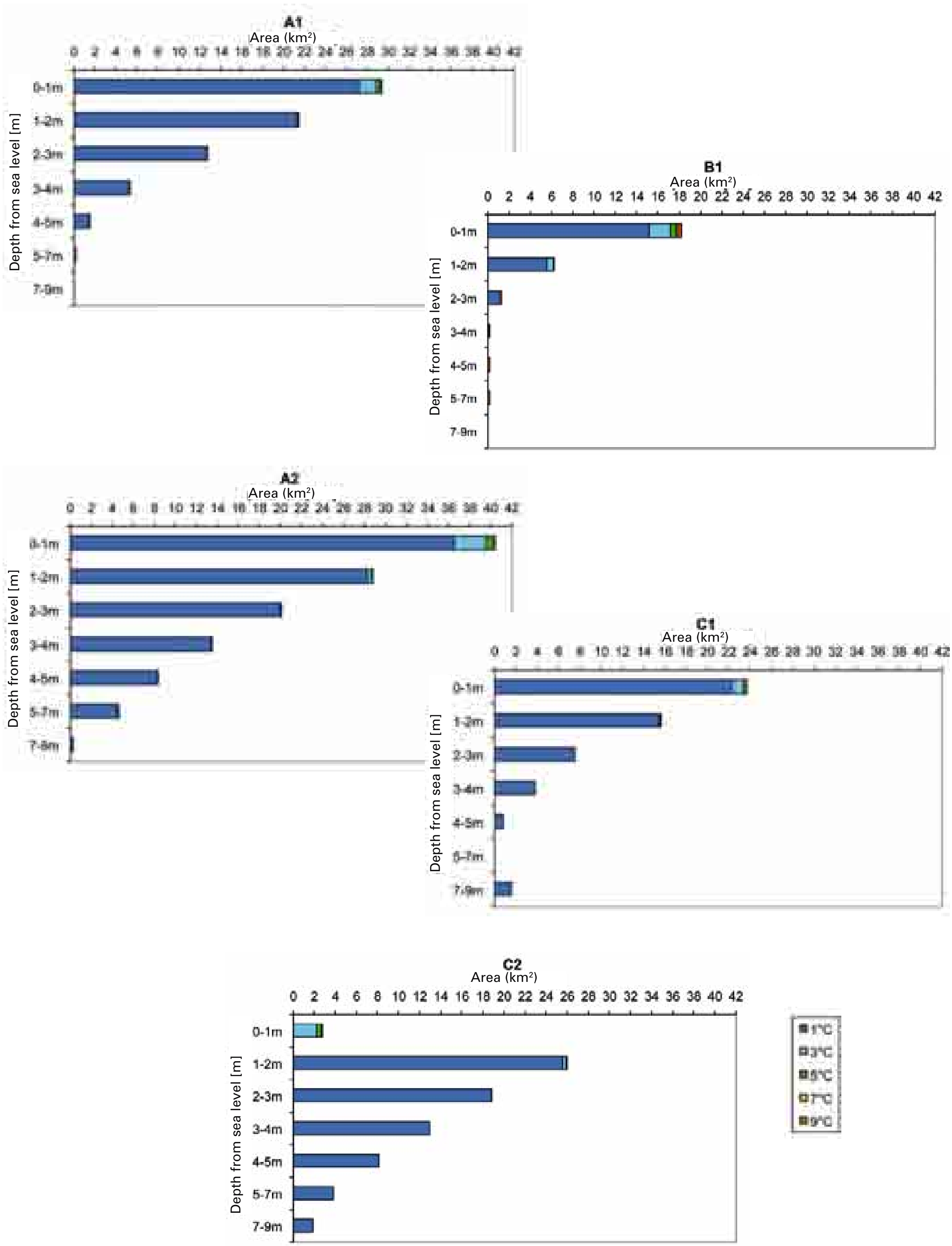
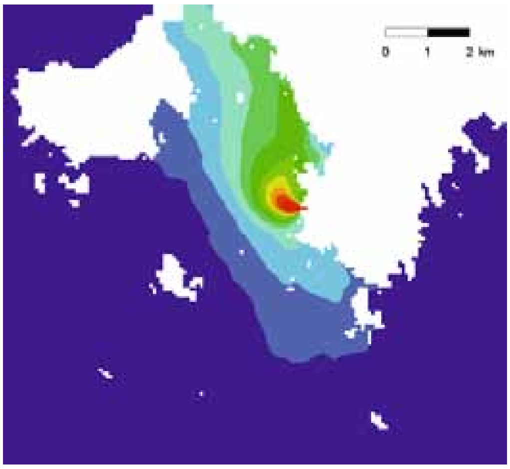
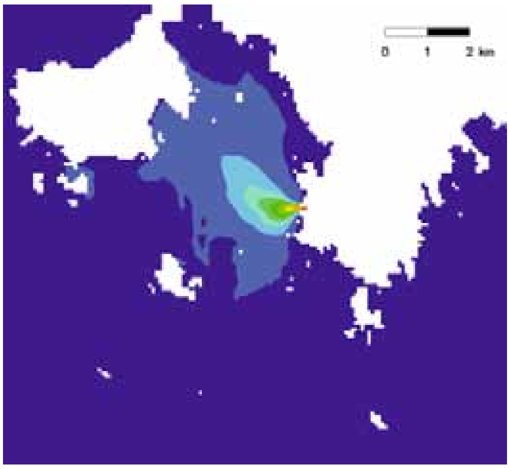


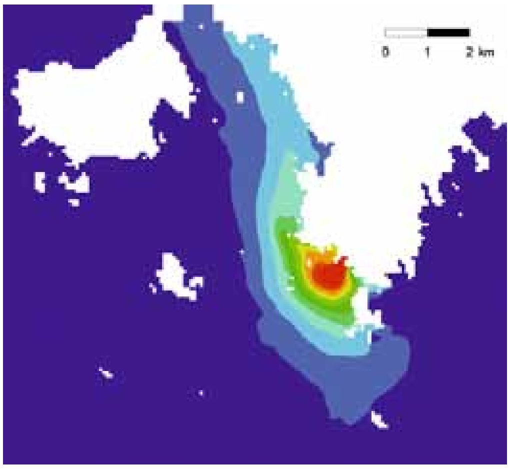
Figure 8-37. Areas where the temperature increase exceeds 1–10 centigrades, June average.



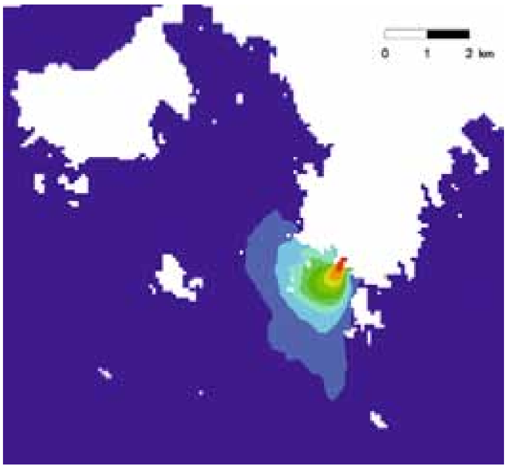
A2 surface, *southerly winds*



A2 surface, *northerly winds*



B2 surface, *southerly winds*



B2 surface, *northerly winds*

Figure 8-38. Average warm-up in the surface layer in July 2003 considering Options A2 and B2 in northerly and southerly winds.

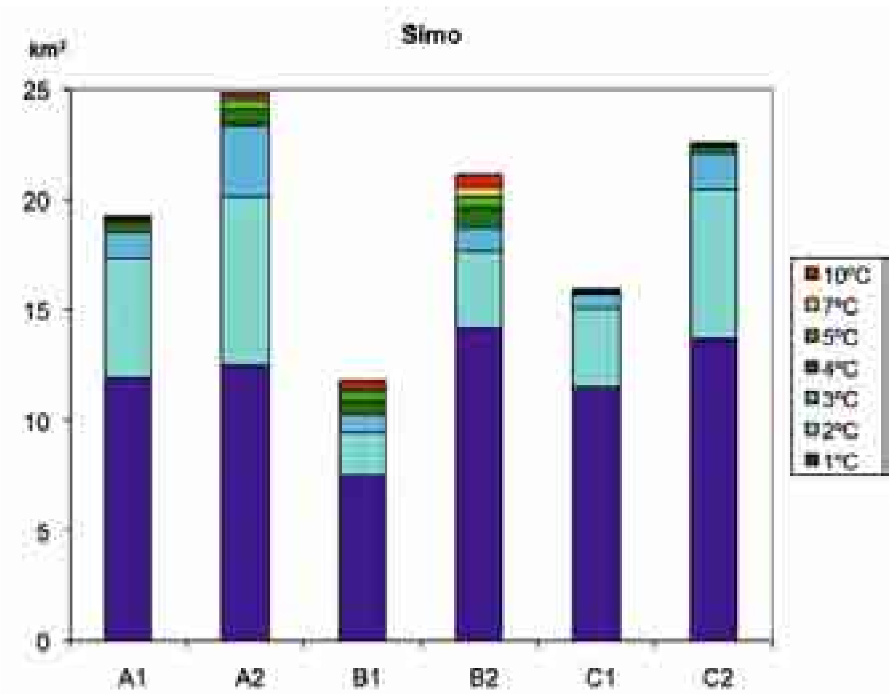


Figure 8-39. Areas where the temperature increase exceeds 1–10 centigrades, July average.

8.4.4.4 The impact of cooling waters on ice conditions

The project's impact on the sea area's ice status was inspected in a situation at the be-ginning of January and February under ice winter 2002–2003 conditions. With regard to the extent of the ice coating, the 2002–2003 icewinter was average (*Finnish Institute of Marine Research 2008c*). It was irregular that the winter started earlier than on average and lasted approximately three weeks longer than on average. (*Kalliosaari 2003*)

The current close to the surface in the Bothnian Bay during winter runs along the shore circling counter-clockwise, mainly to the north on the Finnish coast and to the south on the Swedish coast. The circulation is caused by fresh water conducted through rivers, variation in sea level and differences in salinity in Kvarken. In the area between Hailuoto and Kemi, the current is varied and turbulent due to the shallowness of the bot-tom. In deeper areas, however, the direction of current conforms to the above.

The water area that remains unfrozen in the winter centers in the vicinity of the discharge site (Figure 8-40). The area of thin ice is located mainly between Ajos and Karsikkoniemi and southwards from Karsikkoniemi. In Option C, the warmed water mainly stays between Karsikkoniemi and Ajos, while in the other options it tends to move south more. The difference is likely to be due to differences in salinity and temperatures between the shore and bottom intakes and their impact on the flow mass from Kemijoki. The size of the unfrozen and thin ice areas with the 1,800 MW power plant option (1) amounts to approximately 7–8.5 km² and with the larger 2,500 MW power plant option (2) to approximately 9–12.5 km² (Table 8-12). The smallest area of thin ice is achieved in Option C, in Options A and B the areas are nearly the same size.

Table 8-12. Areas of open sea or thin ice (less than 10 cm) in the different options in modeling throughout February (2003). The area of thin ice encompasses that of unfrozen water as well.

Option	Unfrozen water (km^2)	Thin ice (km^2)
A1	4.6	8.6
A2	5.7	12.6
B1	4.5	8.4
B2	5.8	12.4
C1	3.5	7.3
C2	4.8	9

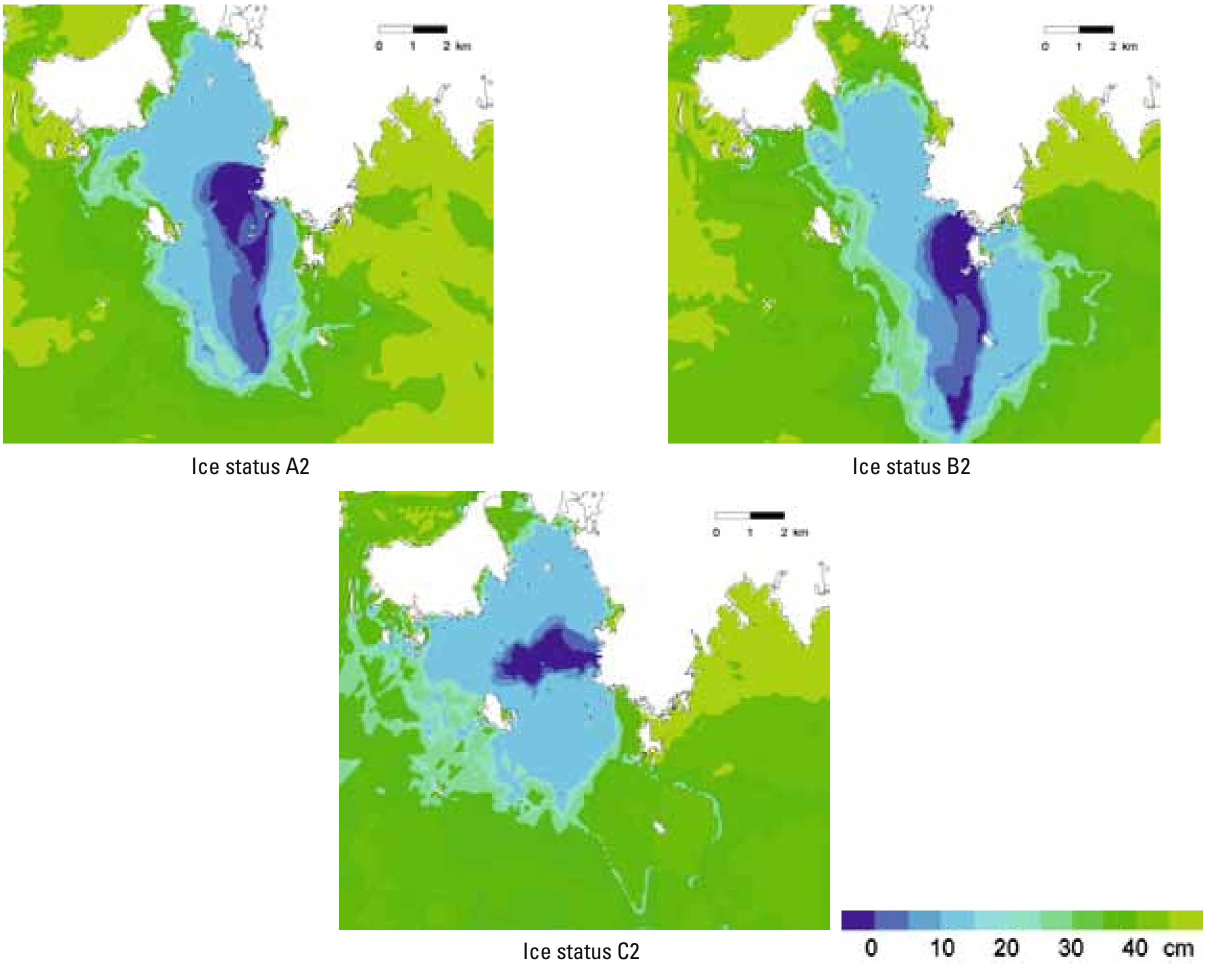


Figure 8-40. The impact of cooling waters on the project area's ice status at the beginning of February.

8.4.4.5 The impact of cooling waters on water quality and ecology

Water quality

The quality of cooling water will not change as it flows through the power plant, apart from the increase in temperature. Therefore, the quality of cooling water depends on the quality of water at the intake site. If cooling water is taken from the east side of Karsikkoniemi, its quality is nearly the same as that of the discharge area. In the bottom intake option, water is taken from further away in the sea area close to the bottom, where the content of nutrients is slightly lower than in surface water on average. Conducting water from the east side of Karsikkoniemi or deeper from the bottom may have a slight positive impact on the quality of water at the discharge area. Due to the impact of cooling water, also upwelling, or cooler bottom water rising to the surface layer, may be stronger than normal in certain winds. However, the impact of these factors on water quality at the discharge site is likely to be minor, as the differences in water quality are small.

There are no deeps favorable for the emergence of oxygen depletion in the sea area off Karsikko, with a naturally poor water turnover and abundant accumulation of organic matter. Weakening of oxygen situation in hypolimnion has not been observed in the Bay of Veitsiluoto or elsewhere in the vicinity of the discharge site, even during stratification periods. The project is not considered to have an impact on the oxygen situation in the area.

The impact of cooling waters on the water quality at the discharge site is assessed to be minor in all of the inspected intake and discharge options.

Phytoplankton and zooplankton

In the Bothnian Bay, the production of phytoplankton is particularly limited by the short open sea period. Warm cooling waters will extend the open sea period and vegetation period and, as a result, the annual production of phytoplankton increases in the discharge area. The impact of warm water accelerating decomposition may speed up the circle of nutrients between producing and decomposing entities; thus, increasing the production of phytoplankton in the discharge area. However, an increase in production has been observed to be limited to the warmed-up water area in the studied warm water discharge areas.

There are few mass bloomings of blue-green algae because of the area's low content of nutrients and phosphorus-limited properties. In the Bay of Veitsiluoto, water quality is poorer than the general quality of water in the Bothnian Bay, and production is nitrogen-limited at times. Temperature increase may increase the probability of the occurrence of blue-green algae in the Bay of Veitsiluoto, where water turnover is limited, especially in southerly winds. However, this is not estimated to result in a significant increase in mass blooms of blue-green algae, e.g. due to the limited content of nutrients in the water.

The thermal stress of cooling waters is assessed to increase annual production of phytoplankton in the discharge area. The impacts on phytoplankton production are likely to be higher in discharge site Option D2 (Options A and C) than in discharge site Option D1 (Option B), because the warmed-up water area is more strongly directed to the Bay of Veitsiluoto, which has a higher content of nutrients than the more open sea area. The bottom of the Bay of Veitsiluoto in particular is already more eutrophic than the general level of the area. According to assessments, the project will not have detrimental impacts on the zooplankton community.

Aquatic vegetation and macroalgae

Cooling water will be conducted to the sea through a channel where the water flow speed at the mouth of the channel will be 1 m/s. The flow causes the fine-grained sedimentary deposit at the bottom of the front of the discharge area to drift away at a distance of approximately a few hundred meters. Vegetation will change in this area and filamentous algae will replace rooting water plants.

A more significant impact which changes vegetation will, however, be accelerated growth in the warmed-up water area. The development observed through research is largely similar to eutrophication. Species will be more less diverse and production will increase. Filamentous algae, which typically become more abundant in discharge areas, such as *cladophora glomerata*, and a few vascular plants which endure thermal stress well (such as *potamogeton pectinatus* and *myriophyllum spicatum*) will become more abundant, whereas other species will decline. Eutrophication intensifies the impact of the thermal load on vegetation. However, the quality of water has improved in the area in recent years, and it is not considered to change significantly because of the project or the general development of the Bothnian Bay area.

The lack of impact of ice which detaches vegetation may be seen as changes in species in the vegetation of the coastal zone. In the unfrozen area, perennial species, such as phragmites, may take over space from other species. The unfrozen area, however, remains rather small in the Karsikkoniemi region, so the impact is estimated to be minor and limited to the vicinity of the discharge channel.

The project is assessed to increase the total production of aquatic vegetation and change the composition of species by increasing the growth of filamentous algae in the area. These impacts are assessed to extend to the area where the temperature increase will be at least one centigrade. The project is not estimated to have an impact on vegetation on a wider scale, or on the vegetation of the Bothnian Bay in general. Of the options, A and C (Discharge Site 2) are likely to result in clearer impacts on the growth of filamentous algae and aquatic vegetation, as the affected area is the more clearly sheltered Bay of Veitsiluoto than the relatively open water area to the south of Karsikkoniemi.

Bottom fauna

As mentioned above, erosion of the area off the discharge area is changing the quality of the bottom in the area. In this area, species typical for soft sea bottoms, such as monoporeia affinis and larvae, will be replaced by hard bottom species, such as cordylophora lacustris. However, this impact will be limited to a very small area in front of the discharge area.

The impacts of cooling water on bottom fauna are mainly indirect and mostly due to changes in primary production. Thermal load has been found to increase the instability of bottom fauna communities. The increased quantity of organic matter favors species that benefit from eutrophication. For example, the number of larvae of chironomus plumosus may increase and the number of monoporeia affinis decrease in the affected area.

The project's impact on bottom fauna communities is assessed to be minor and local. The project is not considered to reduce bottom fauna so that it could affect the fish stock which uses bottom fauna as nutrition.

Alien species

The North-American polychaete is currently seen off Karsikkoniemi. Because of the project, it may reproduce locally in the area affected by cooling waters. However, the North-American polychaete has been found to become more widespread in the entire Baltic Sea area and the discharge of cooling waters is not assessed to have an impact on the species becoming more common in the Bothnian Bay in general.

Mnemiopsis leidyi has not been found in the Bothnian Bay. Its spreading is most likely limited by the small volume of zooplankton and the salt content, combined with other environmental factors, such as coldness. The warming impact of cooling waters is directed at the shore areas and the surface layer, whereas the meniopsis leidyi exists in deep waters in the Baltic Sea. Therefore, the discharge of cooling water is not expected to promote the spread of meniopsis leidyi to the affected area.

Alien species in the Baltic Sea also include the zebra mussel and dark false mussel that belong to the species of zebra mussel. Neither of the species are known to appear in the Bothian Bay area. The discharge of the power plant's cooling waters could create suitable conditions for zebra mussels in the area which warms up. However, the coldness of the Bothnian Bay restricts zebra mussels from thriving outside the warmed-up area, i.e. the cooling water intake area or the Bothnian Bay in general. The dark false mussel is probably restricted from thriving in the area by the low salt content.

Sedimentary deposit

Concentrations of detrimental elements that represent pollution have been observed in the sedimentary deposit in the bottom of the Bay of Veitsiluoto and the area close to the port of Ajos. Yet the quality of the sedimentary deposit in the sea area off Karsikkoniemi has not been studied, and there it is likely to be better than in the abovementioned areas.

Sedimentary deposit is washed away from the area close to the front of the discharge channel due to the flow. However, this area is rather limited, and it is located directly in the vicinity of Karsikkoniemi in an area where the concentrations of detrimental elements are estimated to be low. Otherwise, the project is not estimated to be connected with changes in flows that would result in the sedimentary deposit coming out.

The warming effect of cooling water mainly affects surface layers, and apart from the immediate vicinity of the discharge site, it will not have a direct impact on the sedimentary deposit. Indirectly, the increase in primary production caused by cooling waters is estimated to result in increased sedimentation and thereby the "dilution" of the concentrations of detrimental elements in the sedimentary deposit.

The project is not considered to cause any detrimental elements stored in the sedimentary deposit to return to the water column or biological circulation.

8.4.4.6 Impacts on fish and fishing industry

Fish stocks

A slight temperature increase in the water system, particularly if it involves an increase in eutrophication, will basically favor spring-spawning fish species of little value at the expense of more demanding fall-spawning fish. In summer, the temperature of surface water will, occasionally, increase to about 30 centigrades in the immediate vicinity of the discharge area because of cooling waters depending on the weather, which will, in practice, drive fish away from the area. In summer, the surface layer (0–1 m) of the sea will increase by more than 3 centigrades in a maximum area of 4 km^2 and by more than 5 centigrades in a maximum area of less than 2 km^2. However, local warming up of surface water is not assessed to have an adverse impact on the area's fish stocks because the deeper aqueous layers are cooler and fish can actively seek suitable temperatures. In summer, the area affected by cooling waters will be suitable for spring-spawning warm water species but, in winter, the area will also tempt cold water species, such as white-fish and trout.

The shallow shoals in the Karsikkoniemi environment are important spawning areas for valaam whitefish, vendace and Baltic herring. The damaging warming of deeper aqueous layers caused by cooling waters in the spawning areas of the aforementioned fish will be limited near the discharge area, and it is not expected to have a damaging impact on these fish stocks. The increased temperature may have an adverse impact on the reproduction of burbot in the immediate vicinity of the discharge area, but it is not estimated to have a detrimental impact on the burbot stocks in the area. The burbot stocks in the sea area off Kemi-Simo are currently rather weak, and its spawning ability has been impaired.

The migration route of salmon and common whitefish partly passes in front of Karsikkoniemi. According to the model inspection, the significant warming up of the surface water will, in summer, be restricted from the area to the west of Laitakari to the Bay of Veitsiluoto in the average wind situation, depending on the discharge site option. Warming of a few centigrades may also occur south of Laitakari under particular wind and current conditions. Salmon usually migrates in the surface layer a few meters deep. Warming will be minor at a depth of more than 2 m in all of the options.

The warming of surface water in the area west of Laitakari and the Bay of Veitsiluoto is not expected to impact the migration behavior of migratory fish rising to Simojoki or lampern. The cooling water discharge area is located nearly 20 kilometers from the mouth of the River Simojoki. The migration route of migratory fish continued from Karsikkoniemi toward north on the south side of Laitakari and Ajoskrunni, and is therefore located to the south of the warmed area. Any migration north of Ajoskrunni through the mouth of the Bay of Veitsiluoto is likely to be insignificant. Therefore, the warming of surface water in the area west of Laitakari and the Bay of Veitsiluoto is not considered to have a significant impact on the migratory behavior of salmon and common whitefish migrating past Karsikkoniemi. For migratory fish, a better discharge option is the discharge situated on the Bay of Veitsiluoto side (D2), in which the surface water would not be significantly warmed in the area south of Laitakari-Ajoskrunni.

A suitable increase in temperature may advance the spawning season of fish and speed up the development of spawn and the growth at the fry and mature stages, which may have positive impacts on the stocks of spring-spawning fish (described in more detail in connection with Pyhäjoki).

Increased temperature will have different impacts on fish stocks. Taking into account the size of the water area which will warm-up significantly and the mobility of fish and their ability to actively seek suitable temperatures, cooling waters will not cause significant or wide damage to the fish stock in the area. However, the increase in the temperature and its consequences will favor spring-spawning fish species in the long term, such as northern pike, European perch, carp bream and roach.

Fish driven to the power plant along cooling water

Fish driven to the plant off Karsikkoniemi would mainly include Baltic herring in the bottom intake option, and it could be driven to the plant to a significant extent during spawning season in spring. In the shore intake options, fish would mainly include spring-spawning fish of little value, such as roach, European perch and ruffe. The access of fish to the plant can be reduced by installing barrier nets in front of the intake channel during the spawning season in spring or using various technical barriers. The volume of fish driven to the plant is assessed not to have a detrimental impact on the fish stock in the sea area.

Fishing

Fishing is currently carried out in the sea area off Karsikko, mainly using fyke nets. In summer, the growth of algae increases in the warmed area, causing slime build-up and increased cleaning needs in traps and reduced fishing efficiency of the fyke nets. Significant damage to fyke net fishing caused by cooling water is limited to the south and west of Laitakari and the catch sites in Ajoskrunni. As far as professional fishing is concerned, discharge on the Bay of Veitsiluoto side is the better discharge option (D2), concentrating the temperature impact on the bay of Veitsiluoto and its mouth, where the closest spots for fyke net fishing are on the south shore of Ajos and Ajoskrunni.

The project will not have an impact on the reproduction of seals because seal reproduction areas are not located in the affected area of cooling water. The project is also assessed not to have an impact on the seal stocks or the appearance of seals in the area.

The most concrete impact of cooling waters on fishing will occur in winter when unfrozen areas and thin ice will restrict ice fishing. In winter, net fishing off Karsikko is rather rare. As the possibilities for ice fishing reduce, the possibilities for long-term open sea fishing and winter fishing in the open sea will improve. The unfrozen area will lure cold water species, such as whitefish and trout.

In summer, salmonidae that favor cold water will avoid the area clearly affected by cooling waters and prevailing fish species will include spring-spawning fish of little value and those that prefer warm water. This may cause fishing distances to become longer in summer with regard to, for example, whitefish. Cooling waters and their resulting impacts will not have an impact on fish quality.

8.4.4.7 Comparing the intake and discharge options for cooling water

Of the cooling water intake sites, shore intakes (I1 and I2) are so similar in terms of conditions (water quality, temperature) that they are not considered to differ. The water quality of the intake from the bottom (I3) is also close to the water quality of the shore and the discharge area. However, water temperature varies to some extent, particularly during summer months, being two centigrades lower than the temperature of shore intake water on average. With the bottom intake option, the warmed sea area that remains approximately 1–2 km^2 smaller during summer months. The bottom intake temperature advantage is significant mainly during a one-month period in early summer when the water is clearly stratified but the metalimnion is still at a depth of less than 10 meters. There is no significant difference between bottom intake and shore intake in the fall, winter and spring.

In discharge site D2, the impacts most clearly affect the Bay of Veitsiluoto, which warms up, especially when south wind packs water to the bay. In discharge site D1, the impacts are the most obvious in the sea area to the south of Karsikkoniemi. In discharge Option D2, warming up may at times, due to long south wind periods, extend to a wider area and deeper aqueous layers. The sheltered and eutrophic nature of the Bay of Veitsiluoto compared to the area of the southernmost tip of Cape Karsikko may also emphasize the primary production-increasing impact of cooling water. With regard to impacts on the water system, Option D1 is therefore slightly better than Option D2. On the other hand, in Option D2 the impacts affect a more limited area that is already changed by human activity. In Option D1, the most significant impacts affect an area where the impact of human activity has been smaller.

As far as professional fishing is concerned, discharge on the Bay of Veitsiluoto side is the better discharge option (D2), concentrating the detrimental impact on the Bay of Veitsiluoto and its mouth, where the closest spots for fyke net fishing are on the southern shore of Ajos and Ajoskrunni. D2 is also a better discharge option with regard to migratory fish according to the safety principle, as in this case the surface water does not warm up significantly in the area to the south of Laitakari-Ajoskrunni.

8.4.5 Impacts on currents

The impacts of cooling water intake and discharge on currents in the sea area were assessed as a part of the cooling water modeling.

The flow of cooling water is approximately 1 m/s at the surface at the mouth of the discharge channel. The flow rate decreases rapidly with distance, and approximately half a kilometer from the mouth of the discharge site it is only approximately 0.05 m/s. In deeper aqueous layers, flow rates are smaller than this.

At the mouth of the intake channel or bottom intake structure, the flow rate of cooling water is approximately 0.2–0.3 m/s. Further away from the intake or in upper aqueous layers, changes in flow rate are minimal.

The impacts of cooling water intake and discharge on flow rates are considered to be minor.

8.4.6 Impacts of climate change on warming up of the sea area

In the climate change assessment, changes in June water temperature were calculated for the surface layer and the layer of 2–3 meters. The graphs have been calculated by the calculation for 2003 from the result field of the climate change assessment calculation, providing the estimated water temperature increase during 2003–2050. The results of climate change impact calculation were very similar at all the assessed localities and with all the intake and discharge options, so temperature change in the Pyhäjoki B2 (bottom intake I2, discharge D1) option combination is presented here as an example (Figure 8-41).

In the surface layer, water temperature will increase by approximately 0.7–1.5 centi-grades at all localities In the deeper layers close to the coast, temperature will increase at all localities by approximately 0.6–1.5 centigrades in the 9–11 m layer. In Ruotsinpyhtää, temperature increase is approximately 0.5–0.6 centigrades at a depth of 20–25 meters.

In all the localities, the water temperature increase predicted by the calculation is slightly lower than the increase in air temperature. This is mainly due to upwelling, which occurs at the assessed localities mainly during north wind. Here, deeper cold water mixes with the surface water and cools it down, in which case the surface water cannot warm up as much as in a situation without upwelling.

8.4.7 The impact of radioactive water emissions

The assessment of the maximum amount of radioactive emissions released into the water system from the nuclear power plant planned by Fennovoima in different plant options and the treatment methods used for emissions are presented in Chapter 3.12.2.

The tight limit values set for nuclear power plant emissions and emission supervision guarantee that the emissions of modern nuclear power plants are very small and their radiation effect on the environment is extremely small compared with the impact of radioactive substances existing normally in nature. For example, the tritium emissions of existing Finnish nuclear power plants have been about 10 percent and the other emissions well below one percent of the set emission limits (see Chapter 3.12.2). The sea water samples taken annually from the nuclear power plant areas have contained tritium originating from power plants but there have rarely been other radioactive substances from power plant emissions. Similarly, fish have only randomly been observed to contain small signs of local emissions. *(STUK 2008b)* The tritium content in sea water has mainly been natural and tritium originating from nuclear weapon tests. The content of tritium from nuclear power plants in sea water decreases to an insignificant level close to the plants.

Radioactive substances released into the water system enter food chains or sink to the bottom. In examina-

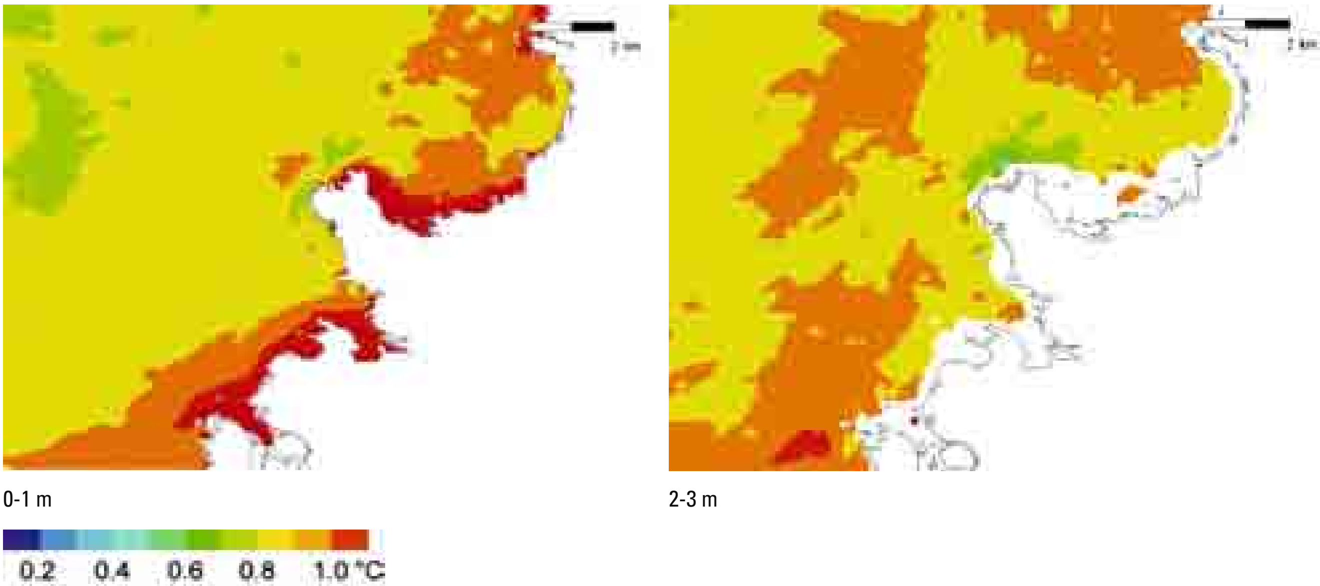


Figure 8-41. Water temperature increase by 2050 compared to the situation of 2003 in the surface layer and at a depth of 2–3 m (Pyhäjoki as an example).

tions performed in the sea areas of the existing Finnish power plants, radioactive substances have been observed in fish, algae and other water plants, benthic organisms and sedimenting elements. The observed content of radioactive substances originating from nuclear power plants has been smaller than the content of natural radioactive substances in the observed areas. The behavior and impact of radioactive substances are controlled by their biological, chemical and physical characteristics, such as half-life.

Fennovoima's nuclear power plant will be designed so that its radioactive emissions fall below the set limit values. The plant's radioactive emissions will not have any adverse impact on the environment or people.

8.5 Soil, bedrock and groundwater

8.5.1 Current state of soil, bedrock and groundwater

8.5.1.1 Pyhäjoki, Hanhikivi

Soil and bedrock

Three kilometers long and one kilometer wide, the Hanhikivi headland is located on the east coast of the Bothnian Bay. The headland is comprised of monolithic bedrock. In terms of topography, the area is very even; relief is small in the area. Wide rock headlands rise to less than five meters from sea level. The rock headlands are bare or covered by very thin strata. Of topsoil types, moraine is the most common. Glaciated rock can be seen, for instance, in the rock headlands of the west shore of the headland. There are also wide bare sands on the west coast. The coastal zone is young land, mostly exposed from under the sea 100–300 years ago. Land-uplift continues in the Gulf of Bothnia. The new coast line forms based on the properties of bedrock, soil and local environment.

In terms of rock type ratios, the area is part of the Ostrobothnia schist belt. The area's bedrock comprises of conglomerate schist which differs geologically from the rest of the surroundings, containing mainly micaceous schist and gneiss. In addition to acidic gneiss, the bedrock also contains alkaline rock types. The schist fragment size varies from the fines of the sand to basketball-sized blocks. The largest blocks are evenly dis-tributed in the fines.

Conglomerate extends under the sea. At the mainland side, the headland's conglomerate deposits are limited to gabbro and diorite deposits (so-called intrusive rock, or coarse-grained igneous rock). Rock types of the eastern part of the headland are mainly comprised of quartz-feldspar schist. The Hanhikivi area has been classified as a valuable bedrock area in terms of natural and landscape conservation.

For the bearing capacity of soil, the coastal area is mainly comprised of rock, moraine and sand areas with good building qualities. The bedrock is mainly firm, but in places the varying properties of the soil binders and blocks deteriorate the firmness of the bedrock. In addition, there are fissures sparingly, mainly long and straight, in the bed rock. (*Elminen et al. 2007*)

Seismology

Finnish bedrock is among the most seismically stable areas in the world. However, there is rock stress in the Finnish bedrock, and its eruption may cause mild earthquakes. The rock stress is caused by the expansion of the North Atlantic ridge; the Eurasian and North American crustal plates separate by approximately 2 cm per year. Land-uplift may cause earthquakes in the Gulf of Bothnia area.

There are approximately 15–30 earthquakes in Finland every year, ranging between 1 and 4 on the Richter scale. The strongest recorded earthquake took place in Alajärvi in 1979 (approximately 3.8). Nearly half of all earthquakes observed in Finland took place in the Kuusamo region. (*University of Helsinki 2008*) The Hanhikivi headland is a part of a seismically low-active area. The largest earthquake observed in the vicinity (2.7) was measure approximately 10 kilometers to the northeast of Hanhikivi (*Elminen et al. 2007*).

Groundwater

Groundwater is present nearly everywhere in Finland. Its recharge is the most abundant in areas where the bedrock is comprised of gravel and sand formations which conduct water well. The distance of groundwater level from the surface of the earth varies from approximately one to more than 30 meters. Generally, groundwater level is approximately 2–5 meters deep underground. In moraine-covered areas, groundwater level is approximately at a depth of 1–2 meters. Groundwater areas are classified into three categories based on their usability and need for conservation; Category I includes groundwater catchment areas important for water supply, Category II groundwater catchment areas suitable for water supply and Category III other groundwater catchment areas. (*Environmental Administration 2008a*).

There are no classified groundwater catchment areas in the power plant location area in the Hanhikivi headland, and the area are no significant areas in terms of community water supply. The closest groundwater catchment areas, Haapakoski and Kopisto, are located approximately 10 kilometers away from the plant area to the south and southeast. There are six groundwater catchment areas located fully or mostly in the area of the Pyhäjoki municipality; of these, Kopisto and Kötinkangas are important for groundwater supply. The Kopisto groundwater catchment area is the only active water intake site in Pyhäjoki. The water intake plant at the Kötinkangas groundwater catchment area is not operational due to the excessive iron content of the water.

The Kopisto groundwater catchment area is a heterogenous formation with coarse sand and rocky gravel in its central part. Washed out moraine occurs in significant amounts, particularly in the western part of the area. The thickness of soil layers is small and the materials are relatively weakly sorted. The soil's water permeability is rather weak. The natural main flow direction of groundwater is toward the northwest. The groundwater is soft and slightly acidic. Excessive loading of the area with water intake is avoided so as to not increase the iron content of the water. (*Environmental Administration's Map Service 2008)*)

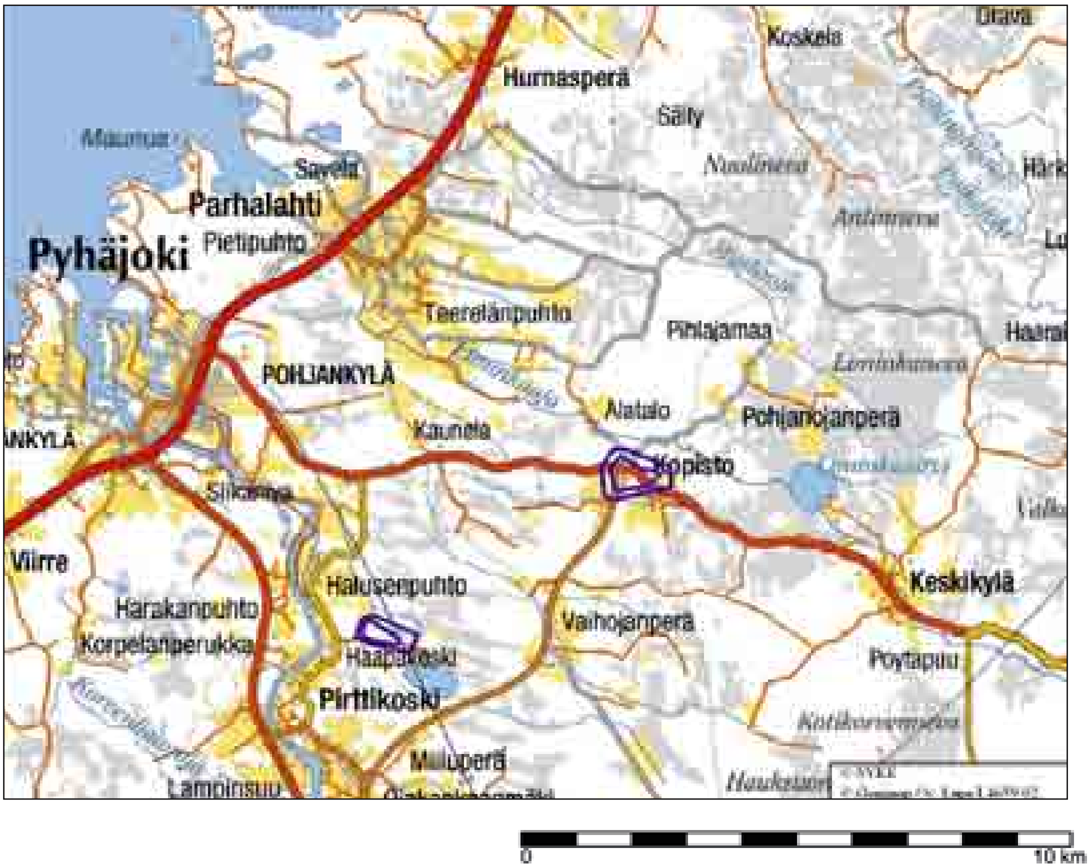


Figure 8-42. Groundwater catchment areas closest to the power plant site.

8.5.1.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

Soil and bedrock

Kampuslandet is a rocky, rather rugged island approximately 2 kilometers long and 1.5 kilometers wide in the Gulf of Finland, in the Ruotsinpyhtää archipelago. In terms of topography, the island is uneven. Most of the ground surface is 5–10 meters above sea level. Several open bedrock areas rise up to approximately 20 meters above sea level. The areas in between the open bedrock areas are comprised of more fragmented rock covered by a thin humus layer. The island and its surrounding waters have an abundance of sizeable erratic blocks, with rocks and rocky areas comprising of smaller stones in the terrain. In between the erratic blocks, rocky areas and rocks there are swampy, moist depressions.

The island's rock material is homogenous. The main rock type is rapakivi granite. The main minerals are feldspar (70% to 80%) and quartz (18% to 28%). The most common soil types are moraine and clay. In terms of building qualities, the rock represents typical Finnish granite rock. The rock exposures are mainly intact, the rock is mass structural and has few cracks. In the surrounding archipelago, low north-south rocky islets are common.

Kampuslandet is located in the edge and roof parts of the Wiborg rapakivi massif, i.e. close to the contact of rapakivi and older bedrock. Hollows, which originated in the bedrock crystallization phase (here, approximately 1.65 billion years ago), occur at times in such areas. There are several small hollows in the northeastern and eastern shores of Kampuslandet. There are hollows of above normal size in the Högberget area, but even larger ones have been encountered in southeast Finland. (*Elminen 2008*)

Gäddbergsö is a headland approximately 3 kilometers long and approximately 2.5 kilometers wide. Its terrain properties are for the most type similar to the Kampuslandet area. The headland is rocky and blocky, and there are also intact rock exposures. At the exposures, the rock is mass structural and has few or sparse cracks, fragile in terms of rock type based on the composition of main minerals. The soil in the headland is moraine. Gäddbergsö has good building qualities. In addition to the rock exposures, good availability of fine aggregate is an advantage. Disadvantages are mainly connected with the high crushing costs of the sizeable erratic blocks. In the regional plan approved by the Assembly of the Regional Council of Itä-Uusimaa on November 12, 2007, a rock area valuable in terms of nature and landscape protection has been pointed out in the southwest tip of Gäddbergsö (Kasaberget). (*Pohjatekniikka Oy 2007*)

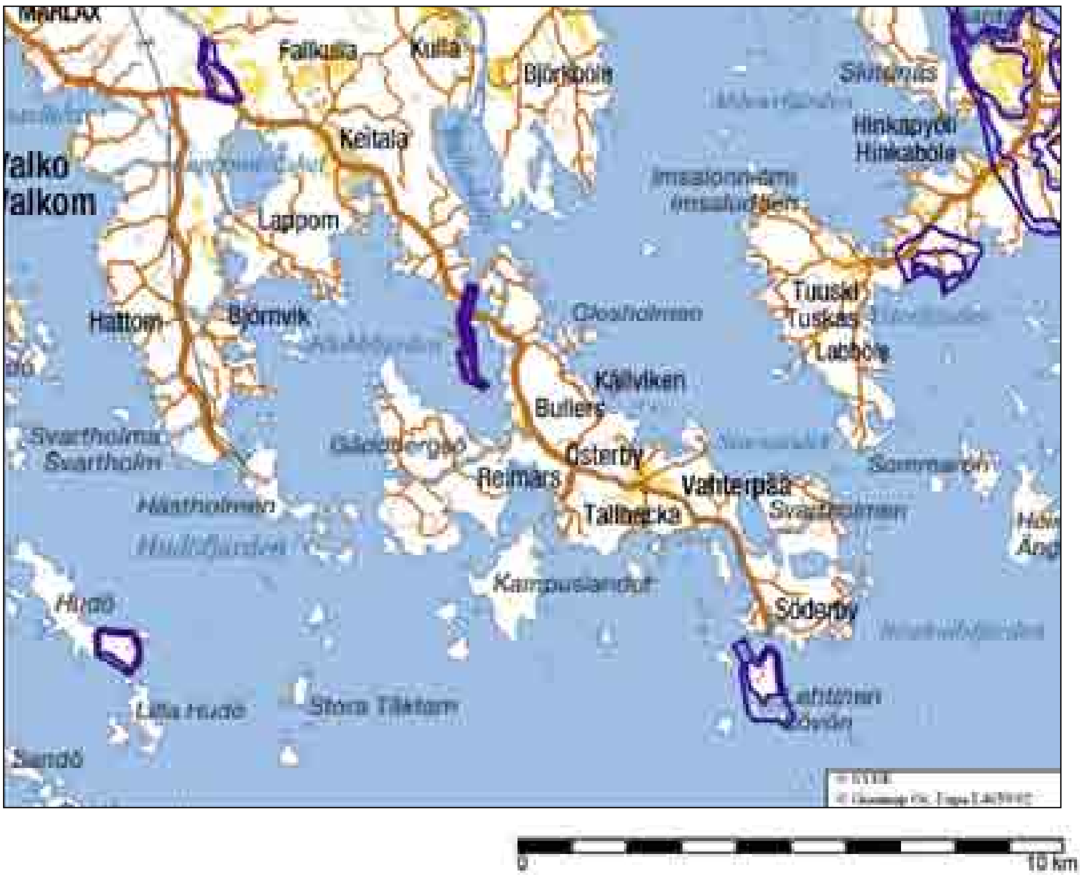


Figure 8-43. Groundwater catchment areas closest to the power plant site.

Seismology

In terms of earthquakes, Ruotsinpyhtää is located in a very stable area. The magnitude of earthquakes observed in the area has been less than 3 on the Richter scale. (*Pohjatekniikka Oy 2007*)

Groundwater

There are 13 classified groundwater catchment areas in the Ruotsinpyhtää region; of these, three are groundwater catchment areas important for water supply (Petjärvi, Kunkinkaankylä and Tesjoki). However, there are no groundwater catchment areas important for water supply or suitable for it in the vicinity of the nuclear power plant location area. The nearest groundwater catchment area, Jomalsundet (Category III), is located to the north of Gäddbergsö approximately a kilometer from the power plant (Figure 8-43). The area is comprised of a narrow, well-defined ridge whose rock material is stratified sand and gravel formation. Even though the total yield of the area is only satisfactory, the groundwater formation is locally important in terms of water supply. Sea water can be absorbed into the area in connection with groundwater intake due to the permeable shoreline. (*Environmental Administration's Map Service 2008)*

8.5.1.3 Simo, Karsikkoniemi

Soil and bedrock

Some 6 kilometers wide, Karsikkoniemi is located on the coast of the Bothnian Bay, in the southwest corner of the municipality of Simo. The southwesternmost parts of the headland are located in the area of the city of Kemi. The island of Laitakari is located to the south of Karsikkoniemi, approximately 200 meters off the mainland. The Simo area's bedrock is a part of the Archean granite gneiss complex of Pudasjärvi, over 2.5 billion years old. There are rocky patches in various places, the vastest of them, e.g. in Laitakari and Mustakallio on the western edge of Karsikko. The majority of rock types in the area are abyssal rock types of varied composition and outlook. The main rock types in the area are Archeic granite gneiss and metadiabase by general name. With regard to engineering geology, the rock types are unweathered and mainly medium-grained. The rock has an abundance of cracks in the surface on average. The bedrock is well-exposed in the western parts of Karsikko and Laitakari. Elsewhere, exposure is weak or nonexistent, and the bedrock is covered by rather thick soil layers. (*Härmä et al. 2007*)

Seismology

With respect to Finnish conditions, the Simo region is located in a seismically active area. There have been several earthquakes of a magnitude of more than 4 on the Rich-

Figure 8-44. Groundwater catchment areas closest to the power plant site.

ter scale in the area close to Simo, outside the borders of Finland. The magnitude of the largest observed earthquake (Bothnian Bay earthquake in 1882) is estimated as 4.9. Its center was immediately to the west of the Simo area. (*Härmä et al. 2007*)

Groundwater

There are nine groundwater catchment areas important for water supply and two areas suitable for it in the municipality of Simo. However, there are no groundwater catchment areas important for water supply or suitable for it in the nuclear power plant location area. The groundwater catchment areas important for water supply that are closest to the power plant site are Maksniemi and Ajos. Groundwater catchment areas classified as other groundwater catchment areas (Category III) are found, for instance, Ykskuusi and Holstinharju (Figure 8-44).

The Maksniemi groundwater catchment area is located at the root of Karsikkoniemi, approximately 2 kilometers from the power plant's location site. The area comprises of a ridge block running almost exactly from north to south, covered by a moraine bed of large rocks 1.5–2 meters thick. There are thick sand and gravel layers under the moraine. Groundwater level is in sight in places. Groundwater recharges well in the area (approximately 400 m^3/d), and the part of the ridge under moraine is of high water permeability. There are silts and moraine with a lower water permeability in the edge areas. The main flow direction of groundwater is toward the sea. The quality of groundwater is good. The Ajos groundwater catchment area is located on the other side of the bay than the power plant site, and is a part of the municipality of Kemi. (*Environmental Administration's Map Service 2008*)

8.5.2 Impacts on the ground, bedrock and groundwater

There are no important groundwater areas or other areas suited for the acquisition of groundwater in the nuclear power plant's alternative sites or their immediate vicinity. For the bearing capacity of soil, the location areas are mainly rock, moraine and sand areas with good building qualities. The risks of pollution of groundwater and soil arising from the operation of the nuclear power plant are minimized by way of structural solutions and sewage arrangements of process discharge and waste water.

Underground external structures are cast of waterproof concrete. Waste water from the plant area's unmonitored premises (non-radiation controlled premises) are conducted through a floor drain system to the plant area's sewer system and thereby to the waste water treatment plant. Waste water is conducted through oil separators if it is possible for oil to be released from their generation areas to the water. Chemicals are stored in a container intended for each chemical type and labeled appropriately. In the event of leaks, all premises containing chemical tanks or storage facilities are drained to protective pools, slurry and oil separation wells and neutralization pools. Storage and handling of fuel oil and chemical makes use of tight protective structures and sewer protection so that in the eventuality of any malfunctions, chemicals released into the shielding pool or floor can be collected. Rain and foundation waters and water otherwise carried to the surfaces of the area are collected in a managed way and conducted so that they will not cause a contamination risk to groundwater or soil. Waste water from the controlled area (radiation controlled premises) is pumped to a liquid waste treatment system located in the nuclear power plant area.

Groundwater infiltrates the final disposal caves and tunnels for low- and medium-level waste during their use depending on the size of the space, compactness of the surrounding rock, groundwater level and compaction procedures carried out during the excavation. This does not have a detrimental impact on the quality or quantity of the surrounding groundwater, as water accumulating in the foundations of the final disposal premises and their tunnels are collected using separate leak collection systems and conducted to waste water treatment. Water quality, including radioactivity, is monitored by way of sampling.

The structures and equipment of a nuclear power plant are designed to be earthquake-proof. Earthquakes and their impacts are monitored during the operation of the nuclear power plant. This ensures that earthquakes do not risk the safety of the plant.

In Simo, Highway 4 and the road leading to Karsikkoniemi run across the Maksniemi groundwater area. The construction and operations of the power plant will cause only a minor amount of chemical or oil transportation, and the project will not cause any need for particular protection measures for groundwater.

8.6 Flora, fauna and ecological values

8.6.1 Pyhäjoki, Hanhikivi

8.6.1.1 Current status of the environment

Flora

The Hanhikivi area is a young, low-lying land-uplift coast seashore. The area is characterized by humid, low-lying shore meadows and shallow bays that are overgrowing. The more extensive seashore meadows at the eastern and northern part of the headland consist mainly of low-growing Baltic rush, grass and sedge meadows, and the species growing there include, for example, slimstem reedgrass, creeping bent, marsh pea, tufted loosestrife, elder-leaved valerian, sea arrowgrass, cowbane, Mackenzie sedge, chaffy sedge and marsh lousewort. Some of the meadows are reed, spikesedge or cane meadows dominated by reed beds or sea club-rush and common spike-rush at the water's edge. There are also greater sedge meadows in the Ankkurinnokka area.

The Hietakarinlahti Bay in the middle of the headland is surrounded by low-growing Baltic rush, grass and sedge shore meadows as well as reed, spikesedge and cane shore meadows. There are tall-growing common reeds in the area.

The western shore of Hanhikivi headland is a land-uplift coast with a sandy bottom. There is one larger sandy shore in the Hietalahti area. This shore has also been marked as a public bathing beach. There are no specific dunes on the sandy shore as described in the Nature Conservation Act habitat types, and the area is almost overgrown. Tea-leaved willow and common reed grow on the shore, for example.

The shore meadows on the west side of the headland are relatively narrow and will soon turn into shrubbery or seashore forests. Yellow flag iris grows in some places, along other typical shore plants. Some of the shores are limited by cliffs; there are cliffs also on the northern shores of Hanhikivi headland. Mossy stonecrop grows on the cliffs, for example. There is buckthorn in Hanhikivi headland's shore areas as well.

There are 'fladas' and 'kluvs', topographies characteristic of a land-uplift coast seashore, in the seashore area. The characteristics of such areas may only be changed by virtue of a permit as specified in the Water Act. There are fladas in the Hanhikivi headland area at, for example, the bottom of Siikalahti bay and Lipinlahti bay. Areas classified as kluvs include, for example, Hietakarinlahti bay, Heinikarinlampi pond and smaller Rovastinperukka pond (*Suunnittelukeskus Oy, 2007*).

Succession of the flora, i.e. gradual changing of the population of a specific location, continues at the mainland side of the seashore meadow as a belt of tea-leaved willows. The tea-leaved willow shrubbery gradually becomes more dense, changing into deciduous groves consisting of grey alder, birch and rowan. There are groves dominated by meadowsweet in the area. The dominating tree species in these areas is grey alder. The shrub layer includes tea-leaved willow, red currant and raspberry. Common species of the field layer, i.e. the ground level layer, include meadowsweet, tufted hairgrass, elder-leaved valerian, marsh cinquefoil and woodland angelica. Some of the seashore forests are grey alder and downy birch groves dominated by wood millet. In addition to wood millet, the field layer includes woodland angelica, chickweed wintergreen, red campion and stone bramble, for example. There are some shore forests dominated by Lapland cornel and grasses, with downy birch as the dominating tree species. The shrub layer includes rowan, raspberry, juniper and small spruces.

The succession of the flora in the middle of Hanhikivi headland continues to spruce forests and fairly dry peaty pine forests. There are some rocky and stony areas covered by reindeer lichen, and the forest is almost wilderness in some places. Some of the spruce corps are dense managed forests.

When going from the shore inland, the forests turn mainly into fairly dry peaty pine forests. There are also some mixed forest areas. The forests are managed forests at different stages of their development. Furthermore, there are several areas with forest ditches closer to trunk road 8.

Five endangered or otherwise protected vascular plants grow in the Hanhikivi area: Artemisia campestris subsp. bottnica, Siberian primrose, fourleaf mare's-tail, leathery grapefern and Fries' pondweed. The most endangered of these are Artemisia campestris subsp. bottnica, Siberian primrose and fourleaf mare's-tail, which are three of the species listed in Annex IV of the Habitats Directive. Furthermore, Artemisia campestris subsp. bottnica is a species to be primarily protected by virtue of the Nature Conservation Act.

Avifauna

Hanhikivi, and especially the Parhalahti bay area to the south of Hanhikivi, are the most important bird migration monitoring sites in the Raahe region, particularly in the spring (*Hauru et al, 1996*). Plenty of bird species, especially large ones, annually migrate through the area. These include, for example, cormorant, swan, goose and curlew. A large number of small birds also migrate through the Hanhikivi area.

Coves in the Hanhikivi area, Hietakarinlahti bay and Heinikarinlahti bay are major migratory bird resting and feeding places (*Hauru et al, 1996*). Heinikarinlahti bay is approximately a kilometer from the area under review. The Takaranta area, a migratory bird resting area of national significance located to the northeast of Hanhikivi, gathers an especially large number of resting and feeding birds (*Surnia ry, 2008*). During the autumn migration of swan, Takaranta is the most important gathering area for the species. The shores of Hanhikivi headland house a large number of feeding ringed plovers, golden plovers, broad-billed sandpipers, dunlins and Temminck's stints as well as some occasional bar-tailed godwits and black-bellied plovers. A sea area at the tip of Hanhikivi headland remains unfrozen many winters, and waterfowl can be seen there even in the middle of winter.

A large variety of birds nest in the Hanhikivi area (*Surnia ry, 2008; Hauru at al, 1996*). All dabbling duck species of Finland, except for gadwall, nest in the area or in its immediate vicinity. The most plentiful nesting species of the Hanhikivi area include black-headed gull, goldeneye, teal, Eurasian wigeon, mallard, graylag, coot and horned grebe. Other species which regularly nest in the area but are less numerous include garganey, little gull, spotted crake, hobby, marsh harrier, northern harrier, red-necked phalarope, Temminck's stint and lesser spotted woodpecker. There are also long-tailed tits in the Hanhikivi area. The most common wader species are curlew and common redshank. The most plentiful gull species are black-headed gull and common tern. Plenty of waterfowl and gulls nest at Hietakarinlampi pond. For example, a black-headed gull colony of approximately 20 to 30 couples nests in the area. Some little gulls also regularly nest close to them. The colony has become clearly smaller in the past two decades.

Hietakarinlahti bay and the extensive seashore meadow area to the north of it form a significant avifauna habitat entity. Several waterfowl and shore birds, such as teal, mallard, curlew, common redshank and common greenshank, occur at Hietakarinlahti bay. Swans nest at the easternmost corner of Hietakarinlahti bay. Approximately ten black-headed gull couples and three little gull couples have been spotted in the area. There were in estimate several dozens of Anseriformes broods in the northern part of Hietakarinlahti bay, the most plentiful of them being Eurasian wigeon, teal and goldeneye. Several tufted duck and northern pintail broods were also observed in the area. Some parts of Hietakarinlahti bay's shores are surrounded by a dense common reed zone, and sedge warblers and marsh harriers nest there, among other birds.

Waterfowl and waders have also been observed to the west of Hanhikivi headland in the small, lush ponds of the Hietakari and Siikalahti area. The species nesting there include, for example, curlew, common greenshank, Eurasian wigeon and goldeneye.

The shore areas of Hanhikivi are a separate avifauna entity. The most common species nesting in the shore areas include, for example, tufted duck, graylag, curlew, common redshank, Eurasian oystercatcher, common tern and black-headed gull.

Avifauna in the inner parts of Hanhikivi headland mainly consists of forest species. The most common ones are common forest species willow warbler and finch. Robin and siskin, species typical for coniferous forests, are also common here, however. The bird species in the areas governed by deciduous trees in the inner parts of the headland include several species typical for deciduous forests, such as garden warbler, wood warbler and blackbird.

The avifauna of Liisanlampi pond, situated along the planned power line route, consists of waders and some waterfowl species. During a visit at Liisanlampi, a crane's nest, a common greenshank, an Eurasian wigeon, a teal and a sedge warbler were observed. The other bird species along the planned power line route and road area mostly include typical species for coniferous forests, such as finch, robin, siskin, song-thrush and tree pipit. There are also some species typical for swamps, such as wood sandpiper, meadow pipit and yellow wagtail.

No large diurnal birds of prey have been observed in the assessment area or its immediate vicinity (*Ollila, written statement on 13 June 2008*). Osprey have been observed irregularly feeding in the Hanhikivi area. The species nests outside of the assessment area, however, and no more specific information on its location is available.

According to the observation data and a calculation made in the terrain as a part of the EIA process, a total of nine species included in the EU Birds Directive Annex I nest in the Hanhikivi area. Thirteen species included in the international Finnish special liability species nest in the area. Four species classified as endangered and four species classified as nearly endangered in the national Finnish classification nest in the Hanhikivi assessment area. The black-tailed godwit, a species classified as highly endangered, is found in the Hanhikivi 10 x 10 km map area but the existing information shows that the nesting areas of the species are outside the assessment area to the south of Hanhikivi in the Maunus and Kultalahti areas (*Surnia ry, 2008*).

Other animal species

Siberian flying squirrel

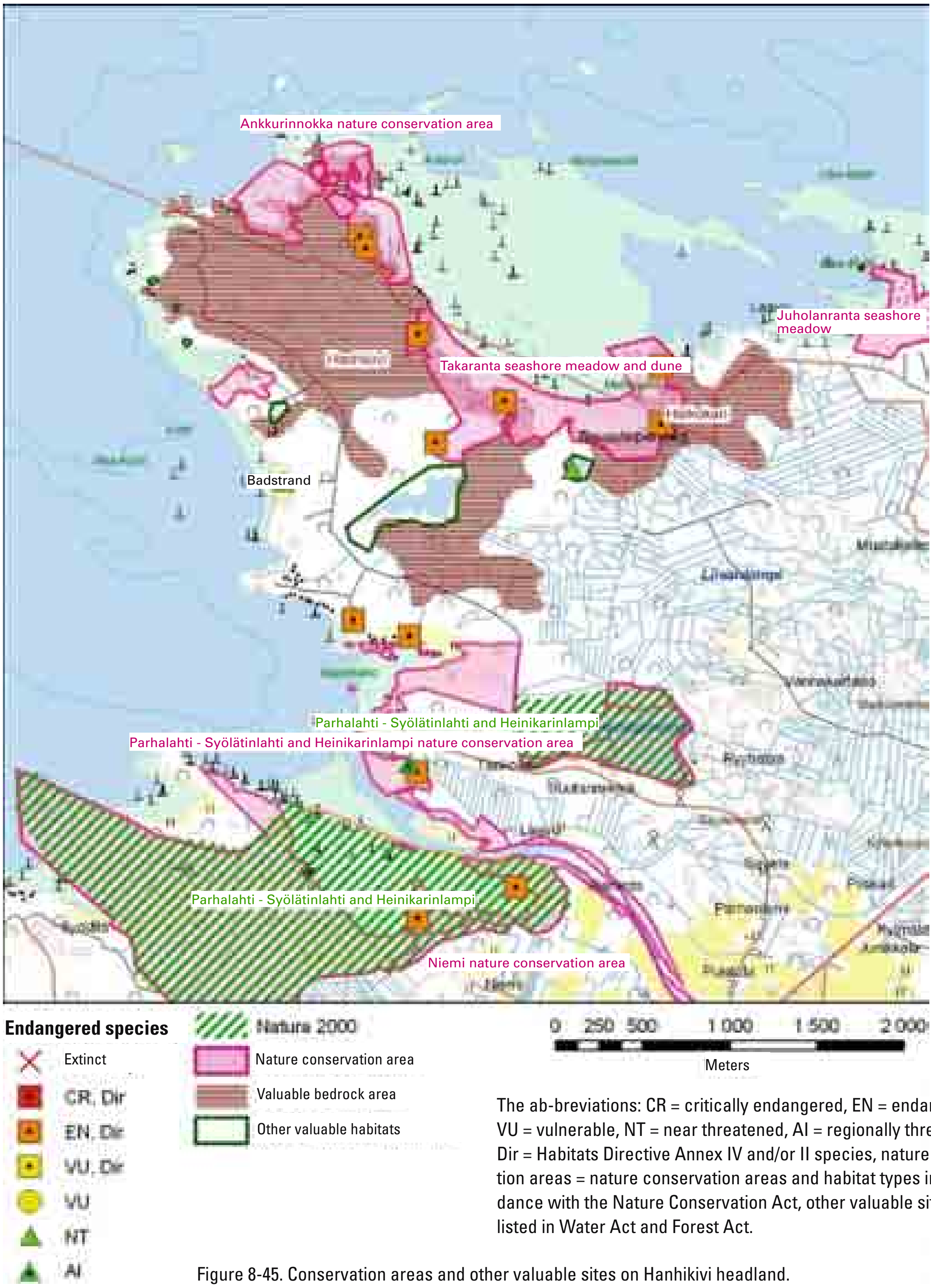
Information on the occurrence of Siberian flying squirrel was obtained from a variety of environmental databases. According to the information obtained, the species does not occur in the Pyhäjoki assessment area. The closest Siberian flying squirrel observation included in the environmental administration's data is approximately seven kilometers from the assessment area.

Potential Siberian flying squirrel habitats were surveyed and signs of occurrence of the species were sought in connection with the EIA procedure. Siberian flying squirrel favors fairly old mixed forests dominated by spruce where the other tree species are most often aspen, alder and birch. There are small forest areas like this in the Hanhikivi area in, for example, the middle parts of Hanhikivi headland and along a path leading to the Hanhikivi erratic boulder. No feces suggesting the occurrence of Siberian flying squirrel was observed in connection with the terrain survey even in the potential habitats.

Moor frog

Moor frog occurs almost throughout Finland. The northernmost known observation area is Ivalo. However, there are fewer moor frogs in northernmost Finland than in southern Finland, whereas in Central Finland and the province of Oulu, moor frog is sometimes even more common than the common frog. The observation database of the Finnish Museum of Natural History does not include any moor frog observations made in Pyhäjoki or the neighboring municipalities.

There are small relictions, ditches and ponds, suitable



The ab-breviations: CR = critically endangered, EN = endangered, VU = vulnerable, NT = near threatened, AI = regionally threatened, Dir = Habitats Directive Annex IV and/or II species, nature conservation areas = nature conservation areas and habitat types in accordance with the Nature Conservation Act, other valuable sites = sites listed in Water Act and Forest Act.

Figure 8-45. Conservation areas and other valuable sites on Hanhikivi headland.

breeding places for the moor frog, in the assessment area, for example in the shore areas of Hietakarinlahti and Hanhikivi. No valid observations of the species in the assessment area have been made, however.

Bats

No bats have been observed in the Hanhikivi area *(Finnish Chiropterological Society,*). The habitat structure of the area corresponds to the habitat requirements of Northern serotine bat, for example. There are no caves or more extensive rocky areas that could be used as bat hibernation sites in the assessment area.

Other animal species

The other land animals of the Hanhikivi area include typical forest species living in variable habitats, such as elk, mountain hare and squirrel. Roe-deer have also been observed in the area.

Conservation areas and other valuable sites

Nature conservation areas

There is a nature conservation area, Ankkurinnokka, consisting of four different sectors at the northernmost point of the Hanhikivi headland, on lands of the municipality of Raahe (Figure 8-45). There is also a nature conservation area consisting of several sec-tors, Parhalahti-Syölätinlahti and Heinikarinlampi conservation area, on either side of Parhalahti bay to the south of Hanhikivi. Furthermore, there are three more nature conservation areas around Heinikarinlampi pond: Hanhimaa nature conservation area, Ojala nature conservation area and Pikkukallio nature conservation area. There is also a nature conservation area called Niemi to the south of Parhalahti bay.

Natura 2000 network areas

The Parhalahti-Syölätinlahti and Heinikarinlampi Natura area is located in the lands of the Pyhäjoki municipality, a little less than two kilometers south of the assessment area.

Habitat types of the Nature Conservation Act

There are several habitat types listed in Chapter 29 of the Nature Conservation Act in the Hanhikivi headland area. The Hanhikivi area habitat types are: Eastern meadow of Hanhikivi (seashore meadow), northwesterly Hanhikivi meadow (seashore meadow), northern Hanhikivi meadow (seashore meadow), Siikalahti (seashore meadow) and Takaranta (seashore meadow and dune). Furthermore, Juholanranta seashore meadow is approximately 2.5 kilometers from the Hanhikivi headland on the lands of the municipality of Raahe.

Valuable habitats referred to in the Water Act and the Forest Act

There are some habitats important for the biodiversity of forest nature as described in the Forest Act and some sites listed in the Water Act in the Hanhikivi area. Most of these sites are fladas or kluvs which cannot be changed in any way without a permit as specified in the Water Act.

Sites significant for avifauna

Some parts of the assessment area are located in the Hietakarinlahti-Takaranta bird area of national significance (FINIBA) (*Birdlife Finland, 2008*) (Figure 8-46) The criterion species for the area is swan. There are especially many swans in the area during migration. The Takaranta area is an area of national significance as a migratory bird gathering area.

The most significant sites for birds in the assessment area include Hietakarinlahti bay and the reed beds surrounding it, a seashore meadow to the north of Hietakarinlahti bay and the Takaranta area. The Hanhikivi assessment area is an area with a representative overall avifauna; more species and couples than normal nest in the area due to the versatile biotope structure. In addition, several migratory birds migrate through and rest and feed in the Hanhikivi area

Figure 8-46. The Hietakarinlahti-Takaranta bird area of national significance (FINIBA area).

Nationally valuable bedrock areas

The Hanhikivi headland, consisting mostly of bedrock covered by moraine, has been classified as a nationally valuable bedrock area in terms of nature and landscape conservation. The Hanhikivi area is highly significant from the geological and scenic viewpoint (*Husa et al, 2001*). Halkokari bedrock area is located to the east of the assessment area.

Other sites

The Hanhikivi area is included in a pilot project of the METSO Forest Biodiversity Program for Southern Finland, 'Merestä metsäksi' (From Sea to Forest). The pilot project is active in the shore areas of Northern Ostrobothnia. The objectives of the project include, for example, gathering information on the status of succession forests and ecological values and voluntary ensuring of biodiversity in the area. The valuable areas of Hanhikivi represent land-uplift coast succession forests. Approximately 150 hectares of land have been protected by means of ecological value trade in the Hanhikivi area (*Ruokanen, 2007*).

8.6.1.2 Impacts on nature sites

Flora

The current vegetation would be removed from the nuclear power plant area and the areas in which adjacent buildings would be built. Vegetation would also be removed from the new road line. Trees would be removed from the power line route and the power line clearing would be kept open. The planned power line route would go over the Hietakarinlahti bay that is in its natural state. The surroundings of the Hanhikivi headland would be transformed from a versatile natural environment into an industrial area.

The Hanhikivi headland area would change and the nature of the area would become so fragmented that the area's significance as a model of uninterrupted succession development would clearly deteriorate.

Three plant species included in the Habitats Directive Annex IV have been observed in the assessment area: Artemisia campestris subsp. bottnica, fourleaf mare's-tail and Siberian primrose. No specific location data on the occurrence of the Habitats Directive Annex IV species which is also a species to be primarily protected by virtue of the Nature Conservation Act, Artemisia campestris subsp. bottnica, is available. The location of the species must be checked during the more specific design stage of the power line route and road arrangements. The occurrences of the species can probably be retained by means of proper design (such as proper placement of pylons).

There are several occurrences of Siberian primrose and fourleaf mare's-tail in the Hanhikivi area. The occurrences are concentrated on the eastern shore of the headland; several occurrences of Siberian primrose have also been observed in the surroundings of Parhalahti bay and to the north of Parhalahti bay. If the habitats of the species outside the construction areas are retained, the occurrence of the species in the area would not deteriorate. Thermal impacts from cooling water may influence the shores of the area, however. The thermal impacts might locally increase plant production and decrease the cleaning effects of ice on the shores. This may lead to increased overgrowing of open shore meadows and alluvial shores, and such overgrowing may decrease the habitats available for Siberian primrose and fourleaf mare's tail, if the water temperature increases permanently by several degrees. In addition to the overgrowing of shores, the scarce fourleaf mare's-tail is susceptible to eutrophication.

Impacts on other noteworthy plant species

Occurrences of two near threatened species have also been observed on the Hanhikivi headland. Fries' pondweed has been observed at Rovastinperukka pond and leathery grapefern in the sand of the Hietalahti public bathing beach. These occurrences are not located in the action areas and when assessed based on the currently available plans, the project should not affect the occurrences. The leathery grapefern occurrence was not found during a site visit despite searches. It seemed like an unlikely habitat for the species, and the sandy shore is being overgrown by reed beds.

Impacts on fauna

Avifauna

The plant unit of the planned power plant would be in an area where the avifauna mainly consists of forest species. Of the EU Birds Directive species, hazel hen and black grouse would experience the worst losses of habitat. Structures connected with the power plant area should not be placed in the Hietakarinlahti bay area close by, because the avifauna of the bay area is noteworthy.

The planned power line route travels over the north end of Hietakarinlahti bay to the east. The nesting of species significant from the nature conservation viewpoint in Hietakarinlahti bay and on the seashore meadows to the north of the bay would be disturbed during the construction of the power plant unit (whooper swan, marsh harrier, crane, wood sandpiper, common tern and Arctic tern among the species included in the Directive). If the power line is constructed between October and April, the nesting of these species would not be disturbed by the construction project.

There are a large number of tundra swan, graylag and swan, among other bird species, in the Hanhikivi area during the migration seasons. The power line route would travel transversely to the main migration direction, and thus it would increase the risk of collisions especially in open areas and areas favored by birds. The most important area among these is the Hietakarinlahti bay area. Marking the power line route with bird warning spheres would reduce the risk of collisions.

The habitat structure of Siikalahti bay area would permanently change if the planned quay is erected. This area is not especially valuable with regard to avifauna.

In the area where the cooling waters affect the nature, there is an area of approximately a couple of square kilometers that would also remain unfrozen in the winter. The area is close to the tip of Hanhikivi headland and continue from there to the Takaranta area. The unfrozen water area could be used as a resting and feeding area by, for example, migrating waterfowl. It is also possible that some of the migrating species would remain in the unfrozen water area for longer than normal. The thermal impact could improve the feeding conditions of species feeding on fish, such as common tern and Arctic tern, and the nesting season of waterfowl and shore birds might start earlier in the cooling water impact area. The timing of the nesting season will also depend on other environmental conditions in the area, however.

Other animal species

The impacts on other land animals during construction would include changing habitats and increased disturbances due to construction works. These impacts would not be significant from the viewpoint of the other animal species, however, because substituting habitats would be retained outside the developed areas around Rovastinperukka, for example. The power plant area and the road arrangements for it may hinder the move-ments of elk and deer at Hanhikivi headland's tip, for example.

Conservation areas

The nuclear power plant and the adjoining structures would be positioned in a manner avoiding conservation areas. The project would deteriorate the conditions in the valuable Hanhikivi bedrock area if buildings are placed in this area.

The thermal impacts from the cooling waters may influence the shores of the area: plant growth may increase and the cleaning effects of ice on the shores may decrease. This could lead to increased overgrowth of open shore meadows and alluvial shores. The impacts would be concentrated on shores where the sea water temperature would change by several decrees Celsius and where the increase in temperature would be relatively permanent. These impacts may deteriorate the state of the protected seashore meadows.

8.6.1.3 Natura assessment review

The following measures connected with the project may cause detrimental impacts:

- Warming of sea water due to cooling water and consequent eutrophication
- Birds' risk of colliding with power lines
- Noise during construction

In the following chapters, the impacts of these measures on the area's Natura values will be assessed.

Reviewed Natura 2000 areas

Parhalahti-Syölätinlahti and Heinikarinlampi Natura area

The Parhakari-Syölätinlahti and Heinikarinlampi Natura area is a little less than two kilometers to the south of the planned nuclear power plant site. The entire area is on the lands of the municipality of Pyhäjoki. The Natura area is protected by virtue of the Habitats Directive as an SCI area and by virtue of the Birds Directive as an SPA area. The following Habitats Directive habitats have been assigned as the Natura area conser-vation criteria (prioritized habitats, i.e. habitats of especial significance in bold):

- *Perennial plants on rocky shores*
- ***Boreal seaside meadows of the Baltic Sea***
- *Gradually changing swamps and seaside swamps*

The habitats which the cooling water may influence are given in italics.

Of the Habitats Directive Annex II species, Primula nutans var. jokelae grows in the Natura area. Of the bird species in the Birds Directive Annex I, common tern, crane, whooper swan, wood sandpiper, horned grebe, tundra swan, hazelhen, marsh harrier, ruff, smew and red-necked phalarope have been observed in the area (*North Ostrobothnia Regional Environment Centre, 2008*).

Assessment on the need for a Natura assessment

The Parhalahti-Syölätinlahti area is rocky, low-lying land-uplift coast seashore. The Heinikarinlampi pond is a former bay that has been separated from the sea.

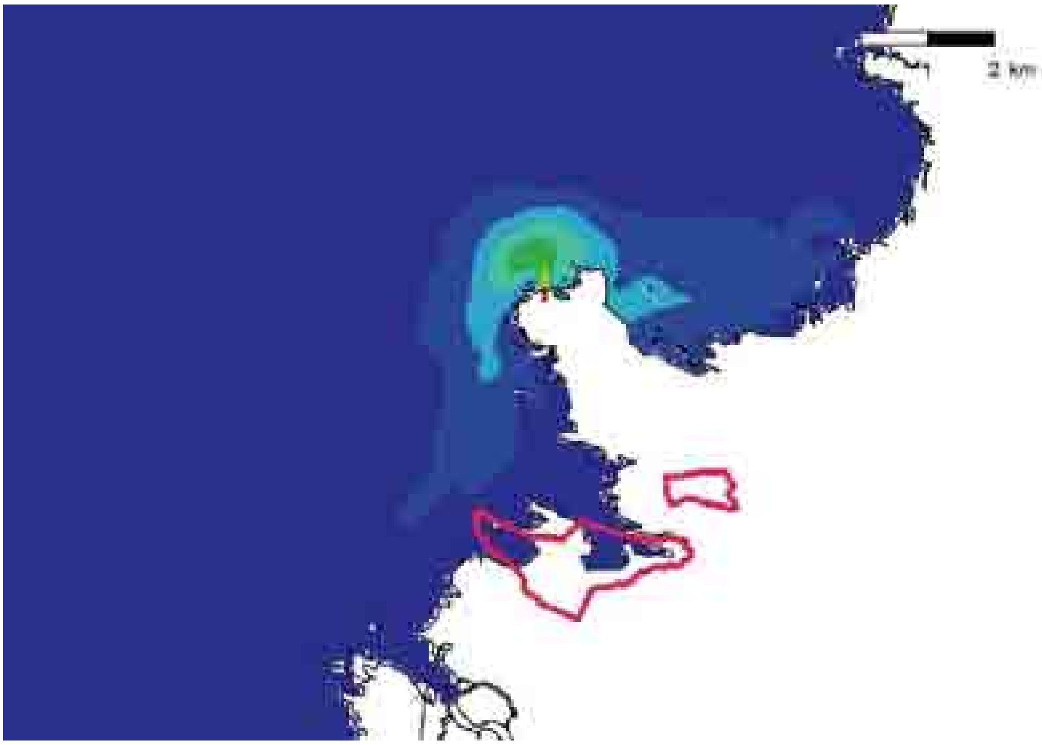


Figure 8-47. Temperature impacts caused by a two-unit power plant in the sea area in the ease of northerly wind. The borders of the Natura 2000 area have been marked on the map in red.

The Maunus seashore meadow is located in between Syölätinlahti bay and Parhalahti bay. It is the only seaside meadow that has remained open. The meadow's flora mostly consists of creeping bent, slimstem reedgrass and saltmarsh rush. Red fescue grows in drier places. There are also Mackenzie sedge, common spike rush and common mare's-tail populations and common club-rush and reed beds at the water's edge. The area is a bird wetland of national significance (*North Ostrobothnia Regional Environment Centre, 2008*).

The impacts of cooling water on the sea water temperature have been modeled for several seasons by using various alternatives and a variety of wind speeds. The impacts have been assessed taking into account the so-called maximum situation where heating also occurs to the west of the headland (in case of northerly winds) (Figure 8-47). Based on the modeling, the thermal impacts of the nuclear power plant's cooling waters would not extend to the Natura 2000 area and thus the thermal energy should not have any significant deteriorating impacts on the Natura area's conservation principles.

The power line route would be more than 200 meters from the Natura 2000 area in a foliage-covered (forested) environment. The Natura 2000 area is not a major bird resting area during migration or a major nesting area. Thus, the power line should neither significantly increase the bird collision risk nor reduce the Natura 2000 area's significance as a nesting and resting environment for the bird species included as the conservation criteria.

Noise during construction may cause intermittent disturbance for the avifauna but the construction work would take place so far away from the Natura 2000 area that the noise should not have any major deteriorating impacts on the bird species included as the conservation criteria.

Based on the information given above, an actual Natura assessment as laid down in the Nature Conservation Act is not deemed necessary because the project is not estimated to have any major deteriorating impacts on the Natura 2000 area's conservation criteria.

8.6.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

8.6.2.1 Current status of the environment

The assessment area is a typical shoreline for the Kymenlaakso region: there are many rocky areas, pine is the dominating tree species and most of the forests are managed forests.

Flora

The Gäddbergsö forests are characterized by their young age. Most forests are sapling stands, young wet peaty forests dominated by pine or fairly dry peaty forests. Trees on the shores are mixed deciduous trees; black alder is common. There are some spruce stands and mixed spruce forests. Most of these are managed forest areas and the impacts of forest management actions can be clearly seen. There are some old mixed forests dominated by spruce, such as to the south of Sandviksgerget and in the Marskärret, Vedaskärret, Hallonkärret ja Poromaren areas. The dominant vegetation type is wet peaty forest. There are fairly dry peaty forests and even barren peaty forests in rocky areas and on the slopes of cliffs.

Fairly small seaside groves and grove-like peaty forests are common in shore areas. Most of the seaside groves are of the so-called red campion type, although there are some shore areas dominated by wood millet as well. There are hardly any seashore meadows; the narrow, meadow-like shores are rocky shores with patches of shore plants growing on them. More extensive sites that can be classified as seashore meadows occur on the eastern shore of Bredviksbergen-Kinnasudden. The shores of most coves have overgrown with reed beds or are at least partially covered by reed bed belts.

Bedrock areas are also common on the shores. The most significant bedrock area is Kasaberget, classified as a bedrock area of national significance. Kasaberget consists of extensive open bedrock areas, some of them showing extensive segmented surfaces and 'steps'. The middle part of the bedrock area consists of sparse, stunted fairly old pines and patches of partly moist depressions dominated by sprigs (heather). The bedrock area of national significance also includes areas outside the open bedrock area. These are pine sapling stands.

There are only a few wetlands and even those few are small. Most of them have also been ditched. The wetlands are bogs dominated by large sprigs; some small swamp combinations also occur. Several brooks flow towards the seashore, most of them cleared. Most of the brooks originate in small wetlands created in a rock depression.

Extensive tree felling has occurred in the areas to the north of Hallonkärret, to the west of Bredvik and to the north of Kaamossen.

The nature at ***Kampuslandet*** is less versatile. The forests at Kampuslandet are also fairly young and sapling stands are common there. Pine stands and mixed forests dominated by pine are by far the most common. Extensive felling has been done in the middle part of the island and there is a generous amount of thinning waste in the young forests in the other parts of the island as well.

Some of the shore areas are more prominent than those at Gäddbergsö. Kampuslandet includes more extensive meadow-like shores with more versatile species. The shores are less dominated by reed beds and there are also some small sandy coves. There are less seashore groves, however.

There are no actual water systems on Kampuslandet. There are some peat-covered areas, fairly small bogs or combinations of bogs and marshes that have been formed in small depressions.

Of endangered and protected plant species, marsh spurge is fairly common on the shores of Kampuslandet as fairly small populations typical for this species. Marsh spurge is protected in entire Finland. It only occurs at the southern coast of the country; it is most common in the Kymenlaakso area. Marsh spurge grows only in some places on the shores of Gäddbergsö, mainly on the southern shores and to the south of Reimars, in the Ytterstranden area.

Protected lesser butterfly orchid grows in Gäddbergsö in semi-open peaty forest dominated by aspen to the south of Dyvik. The habitat is typical for the species: wet peaty forest where trees grow fairly sparsely and where gooseneck moss if common, for example.

Lady's bedstraw, a near threatened species in Finland, grows in some places on the headlands of Hemängen's fields. Lady's bedstraw is a nearly endangered species mainly because it easily hybridizes with white bedstraw. Lady's bedstraw is fairly common in the Ruotsinpyhtää-Pyhtää area along old roads, close to meadow areas and at the edges of yards.

Avifauna and other animal species

Avifauna

The 64 bird species observed in the area are common for a land area where most of the forest are dominated by coniferous trees, typical for rugged rocky shores and typical for an inland archipelago area, except for some exceptions. A total of nine species listed in Birds Directive Annex I were observed. Of these, barnacle goose, black grouse, common tern, Arctic tern, black woodpecker and red-backed shrike probably nest in the pro-ject area. An observation of a flying whooper swan was made and a Caspian tern was observed foraging in the area. An osprey probably nests in one of the nearby islands; there are no osprey nests in the assessment area. Red-backed shrike's habitats include felling clearings slowly growing over with bushes (an observation in the bushes of a felling area in Kampuslandet) and grouse is fairly common in the area as a whole.

Siberian flying squirrel

No observations of Siberian flying squirrels were made in the assessment area or along the power line route. There are a couple of potential habitats offering nutrition and suitable nesting places on Gäddbergsö. These are old spruce stands where aspen grows in groups or small groups of aspen grow along ditches or brooks. Such areas are small, however, and cannot offer enough food for the species. Most of the area consists of rocky pine forests, shore areas dominated by pine or alder or managed forests, which are not suitable habitats for the species. Since the forests are managed, there are only a few hollow trees.

Bats

The area's suitability for bats was assessed based on the habitat types. There are suitable feeding sites for Daubenton's bat, a species favoring shore areas, especially in sheltered coves with black alders growing on their shores. It is likely that Northern serotine bat, a species occurring in entire Finland, occurs also in this area. The species is quite common in southern Finland There may be places suitable as day-time hiding places for the bat in the cliffs and rocky areas of Kasaberget and Kampuslandet's southern tip.

Other animal species

There is a moderate elk population in the area. In addition, foxes and brown hare were observed in the area, for example.

Conservation areas and other valuable sites

Nature conservation areas

There are no nature conservation areas in the assessment area (Figure 8 48). The closest nature conservation areas are approximately three kilometers to the northwest and southwest. There are no nature conservation areas up to the preliminary master plan border or in the immediate vicinity of the power line route.

Natura 2000 network areas

There are no Natura 2000 network areas in the assessment area. The closest Natura area (the Pernajanlahti bays and Pernajansaaristo archipelago sea conservation area) is at its closest approximately 1.5 kilometers south of Kampuslandet. The Vahterpää fladas Natura 2000 area is located approximately five kilometers east of the project area. The Kullafjärden bird wetland is located approximately 800 meters from the preliminary power line route. This area is also a part of the national bird wetland protection program.

Habitat types of the Nature Conservation Act

There is one littleleaf linden population on Gäddbergsö in the ditched Lillängen area that has apparently previously been a pasture. A cleared ditch runs through the area. The site is a potential Nature Conservation Act habitat type. However, it is not very representative as a habitat because, for example, there are only a dozen lindens.

Valuable habitats referred to in the Forest Act

There is a small bog-marsh combination at the northernmost tip of Gäddbergsö. This can be included in one of the valuable habitats listed in the Forest Act (bogs with few trees) (Figure 8-49). The marsh was created in a rock depression surrounded by young, densely forested peaty pine forests. The edges of the swap are bog dominated by large sprigs, whereas the middle part is

Figure 8-48 Nature conservation areas close to Gäddbergsö and Kampuslandet.

treeless marsh. Dominant species include bottle sedge, slender sedge, cotton grass and cranberry. There are small swampy depressions in their natural state also in other parts of the Gäddbergsö area. These are bogs, however, and are thus not of the type referred to in the Forest Act.

Kasaberget in Gäddbergsö can also be classified as a valuable habitat listed in the Forest Act. A bedrock area to the south of Dyviksbergen and the Lillängsberget area are partially open bedrock areas but their natural state has been somewhat altered due to forest machines, and thus these sites are not classified as habitats listed in the Forest Act.

The bedrock area at the southern tip of Kampuslandet is a bedrock area of low productivity referred to in the Forest Act. Unlike the bedrock in Kasaberget, the bedrock here is more clearly ‘step-like’. There are dry grasslands on top of the bedrock, whereas Kasaberget is mainly bare rock or rock covered by lichen.

Hallonbärget brook meadow is located at the base of a brook around the road leading to Gäddbergsö. There is an abundant ostrich fern population along the brook. Other species worth mentioning include spring aspect

Figure 8-49. Valuable habitats close to Gäddbergsö and Kampuslandet. Other valuable habitats = habitats laid down in the Water Act and Forest Act.

species wood anemone and hepatica as well as fingered sedge and common ladyfern.

Seaside groves are common in the entire area, although some of them are small. The seaside groves are dominated by red campion. Wild chervil, meadowsweet and plants of the Calamagrostis family alternate as the other dominant species. The seaside groves are not deemed valuable habitats as referred to in the Forest Act because they do not clearly stand out from their surroundings, and because they are common and typical for shore areas in the entire coast.

Rocky areas are common in the entire area but they are not areas of low productivity as referred to in Chapter 10 of the Forest Act. Instead, they are mainly wet peaty spruce/pine forests.

Brook habitats specified in the Water Act

The base of a brook in the northern part of Bölsängen has remained in its natural state. The top part of the brook and the part to the south of the road have been partially cleared. Lindholmslägden brook is in its natural state from the edge of a swamp area to the seashore.

The top part of the brook flows in an area that has been cleared open. The bottom part of the brook spreads into obscure beds in a wet seashore forest dominated by black alder. There is a small spring outbreak on Marskärret.

Nationally valuable bedrock areas

Kasaberget is a nationally valuable bedrock area.

Other sites

A large number of hardwood trees grow in the Reimars village area. They are limited to yard areas or their immediate surroundings, however. These are probably originally planted trees. The species occurring there include, for example, linden, ash and maple.

Poromaren at the northern part of Gäddbergsö has been partially thinned. The flood meadow-type environment includes sparsely growing large birches and alders. The flood meadow area is dominated great grasses; the dominant species include plants of the Calamagrostis family, meadowsweet and raspberry. The floor meadow characteristics of the area can be seen in the fact that yellow loosestrife and swamp horsetail grow there, for example. The area has been ditched. Some of the surrounding forests have been thinned, and there are some excessively dense fairly young spruce stands.

The seashore area west of Marskärret in Gäddbergsö is a representative old mixed spruce forest of a type that is hardly found elsewhere. The value of the area is increased by the fact that there are some springs, the area is dominated by large ferns and there are sturdy aspen stands. There is also a moderate number of decaying trees.

A wet depression with its inherent tree species has been left undisturbed between felled areas in the middle part of Kampuslandet. Large numbers of black alders grow in the entire wetland. The site has suffered from the surrounding felling activity, however.

The best representative seashore meadow of the assessment area is located in the northern part of Kampuslandet's western side. There are a clearly separated spikesedge zone and a clearly separated sedge zone which gradually changes into great grasses in the meadow. The top part of the meadow has turned into reed beds. There are also other small seashore meadows on Kampuslandet. Based on their vegetation, these can be clas-sified more as rocky shore meadows than seashore meadows, however.

There are seashore meadows on the eastern shore of Gäddbergsö in the Kinnäsudden area. These are dominated by great grasses and sedge. The herbaceous species occurring there include, for example, valerian, marsh marigold, cinquefoil and meadowsweet. Some of the meadows have partially turned into reed beds.

8.6.2.2 Impacts on nature sites

Flora

In the Kampuslandet location alternative, the nature of the island would be turned into developed areas especially at the southern part of the island where the actual power plant area would be placed. Furthermore, the infrastructure required by the power plant would change the island into a developed area.

Most of the natural characteristics of the island are common for the area, and the forests in the area are highly managed. Forests in the shore areas are mainly in their natural state. Functions are mainly located in forestry-dominated areas, because of which the project's impacts on biodiversity would remain low at the regional level. The changes would naturally be clear locally on the island, although the areas not to be developed are a fairly good representation of the general nature characteristics of the entire island. The bedrock area at the south tip of the island would probably no longer be retained in its natural state. No rare or endangered species have been observed in the bedrock area. The most significant ecological values of the area are focused on the shores in which no major constructions would be erected in the course of the project.

The project would not destroy any sites listed in the Nature Conservation Act or Water Act. The power line route to the island would somewhat change the shore areas at the north part of Kampuslandet but these changes would be mostly scenic. Structures placed in the shore areas might destroy some local marsh spurge populations. The species is quite common on the shores, however, and thus the construction work would not cause any major detrimental impacts at the population level.

The power line route across Gäddbergsö would change the shore areas at the southern part of Gäddbergsö in particular: these areas would become treeless. No major changes would occur in the meadow-like areas. There are some representative seashore groves dominated by alder along the Gäddbergsö power line route. Their characteristics would clearly change. The construction of the power line will change the natural state of the united entity formed by seashore groves and meadows on the east shore. Habitats of marsh spurge growing on the shores would not be deteriorated because the species grows in open terrain. Similar seashore groves would be retained in the northern parts of Gäddbergsö, however.

In the Gäddbergsö location alternative, the actual power plant area would be placed in the middle of Gäddbergsö Island where the forests have been felled or are young homogenous pine stands. The construction project might change the nature of the Böllsängen brook due to changes in the catchment area even though the brook itself would remain outside the actual developed area. The rest of the power plant area does not exhibit any special ecological values.

The power line route on Gäddbergsö would also be located in managed forests where the trees are young and homogenous. To the south of Reimars village, the power line would be placed in a grove-like seashore alder stand. Felling the trees would clearly change the area's characteristics. The alder stand has already partially changed due to dredging, for example. The power line would go over a bay overgrown by reed beds to the south of Ekebo. The shores of the bay are partially meadow-like and changing into seashore alder stands.

The other infrastructure elements required by the power plant would also change the area's natural conditions. When placing the infrastructure elements, the most major habitats, i.e. Kasaberget and the representative old seashore forest area in Marrskärret, should be retained whenever possible. The Poromaren area and a small linden stand in the Lillängen wetland should also be retained.

If these sites could be kept outside the developed area, the impacts on biodiversity would be fairly minor as a whole, since there are similar habitats in many places close by. The middle parts of Gäddbergsö are not significant for biodiversity due to the fact that they are effectively utilized managed forests.

The discharge of cooling water might cause some eutrophication in the shore areas. The shallow shores of Gäddbergsö are already mostly overgrown by reed beds. There are not as much reed beds on the rocky shores and on shores susceptible to the power of the sea, and the cooling water would probably not cause any major changes in these areas.

Avifauna

The observed bird species can mostly be deemed regular species for coastal and inland archipelago areas. The area does not include any habitat entities of major significance to bird species.

Sheltered bays overgrown by reed beds offer habitats different from the prevailing rugged rocky shores and cliffs but not even these create any significant entities due to their fragmented nature. The most significant bays in Gäddbergsö are off Boslängen and off the south side of Ekebo. There is a bay which provides a sheltered environment off Lillängsviken in Kampuslandet. The east shore contains a few smaller sheltered bays that may have an impact on water birds. In the forested area, areas deviating from the regular felled forests, sapling stands and managed forests mainly include more grove-like and more lush areas in wet depressions and on wet shores. These make the avifauna more versatile. Most of the lush habitats and shores would remain outside the developed area, and thus no major disadvantages would occur to the birds in these habitats.

Barnacle goose can be deemed the most valuable species nesting in the assessment area. The project would probably not deteriorate the species' opportunities to utilize the area. Some of the forest species habitats would be destroyed by buildings, but as a whole, the change cannot be deemed in any way significant for the area's avifauna.

The shores of the area are currently rugged rocky shores or cliffs. These shores offer nesting places mainly for common waterfowl and seaside bird species, and based on the birdlife survey done, there are no actual lush habitats significant for the avifauna. Neither would any major changes that would significantly harm the birdlife in the entire area occur in the shore areas as a whole.

Other fixed structures aside from actual buildings (bridges, roads) would probably cause some disturbance to the birdlife due to increased traffic. If implemented, the power lines would create a greater risk of collisions especially for species which are not adept in dodging power lines. The plan does not include any long stretches of airborne power lines over the sea or power lines in open sites significant for the birdlife, however. The risk of collisions can be reduced by, for example, adding bird warning spheres on the power lines and by choosing optimal power line locations. The cooling water that would reduce the ice coating and also the eutrophication might offer better preconditions for resting during migration for some bird species.

Noise during construction would probably disturb at least the most sensitive bird species. This would probably only cause them to move away from the construction areas, however.

8.6.2.3 Natura assessment review

The following measures connected with the project may cause detrimental impacts:

- Warming of sea water due to cooling water and consequent eutrophication
- Birds' risk of colliding with power lines
- Noise during construction

The nuclear power plant building or the other buildings are not deemed to significantly increase the risk of bird collisions because there would only be separate and fairly large buildings. The potential plant area is located approximately 1.5 kilometers from the closest Natura 2000 area, it has not been deemed to increase the risk of collisions, and thus the assessment is that the structures of the power plant area would not cause any significant harm for the bird species occurring in the Natura 2000 areas.

Reviewed Natura 2000 areas

The closest Natura 2000 area (the Pernajanlahti bays and Pernajansaaristo archipelago sea conservation area) is at its closest approximately 1.5 kilometers south of the project area, at sea. The Vahterpää fladas Natura 2000 area is located approximately five kilometers east of the project area. The Kullafjärden bird wetland is located approximately 800 meters from the preliminary power line route. This area is also a part of the national bird wetland protection program.

Pernajanlahti bays and Pernajansaaristo archipelago sea conservation area, FI0100078

The area is protected by virtue of the Habitats Directive and the Birds Directive (an SCI and SPA area). The surface area is approximately 65,760 hectares. The following habi-tat types that serve as the conservation basis occur in the area:

- ***Coastal lagoons***
- *Shallows*
- *Annual plants on banks*
- *Perennial plants on rocky shores*
- *Cliffs*
- *Ridge islands*
- *Islets and islands*
- ***Seashore meadows***
- *Sandy shores*
- Brackish water bays (only at the Pernajanlahti bays)
- Great grasses
- Hardwood stands
- Groves
- Forested swamps

The habitats which the sea water temperature may influence are given in italics. The assessment was focused on these habitat types. So-called terrestrial habitats have not been separately specified in the assessment because the changes in seawater temperature are not deemed to cause an impact on habitats located on land, since these are not susceptible to the impacts of sea water. There are no brackish water bays in the project impact area.

Of the Habitats Directive Annex II species, grey seal occurs in the area.

Of the Birds Directive Annex I species, bittern, tundra swan, whooper swan, smew, European honey-buzzard, hazelhen, spotted crake, corn crake, crane, ruff, wood sand-piper, Caspian tern, common tern, great horned owl, European nightjar, black woodpecker, barred warbler, red-backed shrike, ortolan bunting, marsh harrier, Arctic tern and three endangered species occur in the area.

Vahterpää fladas, FI0100083

The area is protected by virtue of the Habitats Directive (an SCI area). The surface area is approximately 104 hectares. The area consists of two fladas, a kluv lake and seashore areas. The fladas are mostly in their natural state and the shores are undeveloped.

The following habitat types that serve as the conservation basis occur in the area:

- ***Coastal lagoons***
- *Perennial plants on rocky shores*
- ***Seashore meadows***
- Gradually changing swamps and seaside swamps
- Groves

Kullafjärden bird wetland, FI0100081

The area is protected by virtue of the Habitats Directive and the Birds Directive (an SCI and SPA area). The surface area is approximately 185 hectares. Kullafjärden, also called Tessjöfjärden, is a bird wetland of the Taasianjoki River delta. The shallow and lush bay includes extensive aquatic vegetation zones, of which common reed forms the largest. Yellow water lily is also common in the area. Water areas that are more than one meter deep include mainly lakeshore bulrush. The delta's aquatic and seashore flora is versatile. There is an open water area in

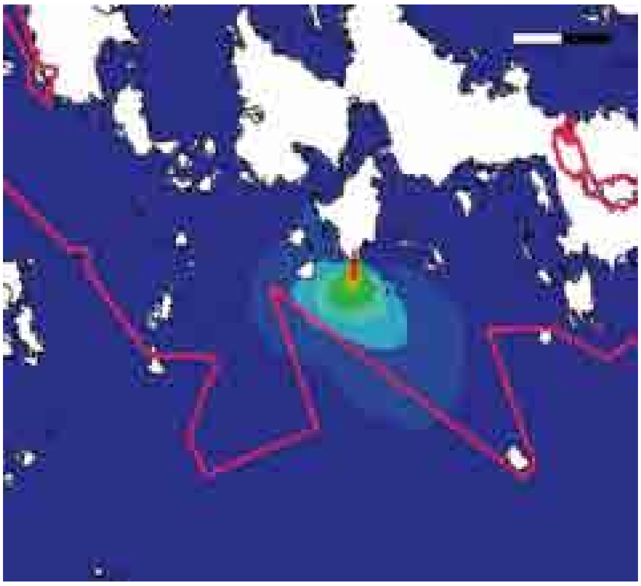


Figure 8-50A. Temperature impacts caused by a two-unit power plant area in the sea area if the discharge site were as close to the Natura 2000 area as possible. The borders of the Natura 2000 areas have been marked on the map in red (the Pernajanlahti bays and Pernaja archipelago area are to the south of the border).

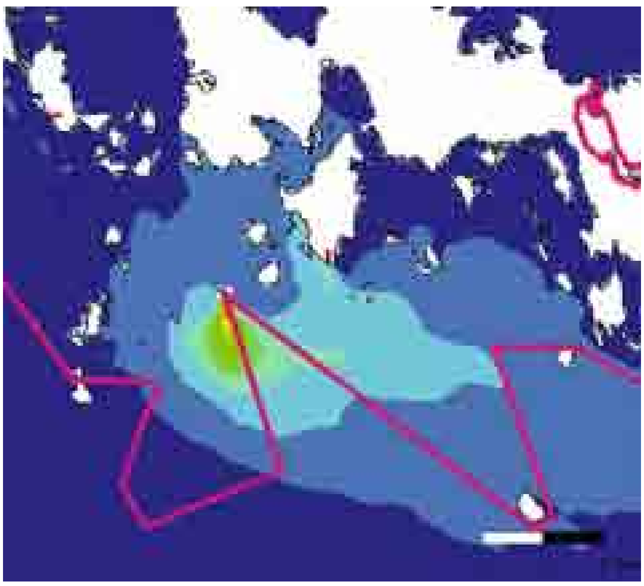


Figure 8-50B. Joint temperature impacts caused by Loviisa 3 and the Fennovoima project in the sea area if the discharge site were as close to the Natura 2000 area as possible. The borders of the Natura 2000 areas have been marked on the map in red (the Pernajanlahti bays and Pernaja archipelago area are to the south of the border).

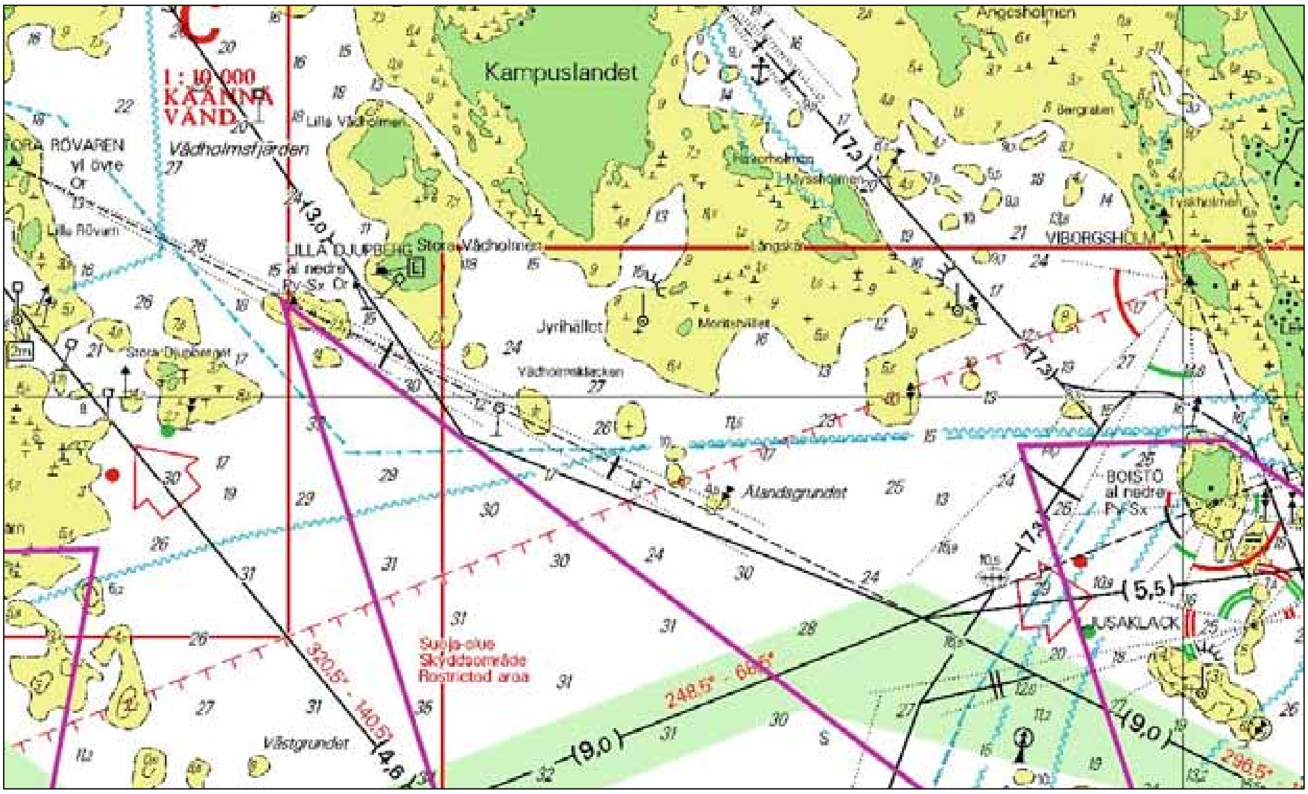


Figure 8-51. An excerpt from a nautical chart of the coastal area. The borders of the Natura 2000 area have been marked on the map in purple (the area is to the south of the border).

average approximately two meters deep at the southern part of the bay.

The following habitat types that serve as the conservation basis occur in the area:

- **Flood plains**
- Great grasses
- Gradually changing swamps and seaside swamps
- River deltas

Of the Birds Directive (Annex I) species, bittern, wood sandpiper, whooper swan, ruff, smew, spotted crake, red-backed shrike and marsh harrier occur in the area. Other species worth mentioning include the migratory bird species grey heron, garganey, northern pintail and common redshank.

Assessment on the need for a Natura assessment

Pernajanlahti bays and Pernajansaaristo archipelago sea conservation area

The Natura 2000 area in question is located to the south of the project area, at sea. At its closest, the Natura 2000 area is as a wedge-like border to the south of Kampuslandet.

Impact of the Fennovoima project

Here, studied mechanisms that may harm the Natura 2000 area include warming of sea water. The power lines would be directed away from the Natura 2000 area and the parts of the Natura 2000 area closest to the project area are not major migratory bird resting areas. Thus, the risk of birds colliding with power lines would not increase. Noise during construction would not extend to the Natura 2000 area that is fairly far away.

The impacts of cooling water on the sea water temperature have been modeled for several seasons by using various alternatives and a variety of wind speeds. The impacts have been assessed taking into account the so-called maximum situation where the cooling water discharge site is at the tip of Kampuslandet Island and the warming is directed to the south. The power plant's maximum capacity will be 2,500 MW. The sea water temperature at the northern edge of the Natura 2000 area would increase by approximately one degree Celsius.

This part of the Natura 2000 area consists of water areas and one small rock. The rock can be classified as the habitat type 'islets and islands' which is not a so-called prioritized habitat type. The surrounding sea area is mainly a minimum of 30 meters deep and no underwater ridges have been observed in this sea area. The morphology above the surrounding area's water does not suggest the occurrence underwater sand-banks in the cooling water impact area (Figure 8-51). Thus, the only habitat type occurring in the affected area is 'islets and rocks' where the most central protection criterion concerns the bird stocks.

The temperature increase would be limited to a small part of the Natura 2000 area and the impacts would be merely intermittent. The sea area in front of Kampuslandet is open and almost free from islands, and there are no gradations in the sea floor that would decrease the water turnover rate close to the discharge site. Thus, possible eutrophication due to the increase in temperature would be minor, the increase in temperature would not cause any major eutrophication and it would thus not decrease biodiversity of the Natura 2000 area's aquatic plants.

The thermal impact of the nuclear power plant's cooling waters might impact the habitats of waterfowl in the area affected by the cooling waters. The size of the thermal impact zone will depend on the capacity of the power plant, and the impacts would be clearest in the immediate vicinity of the discharge site. In the area affected by the cooling waters, there would be an area that remains unfrozen also in the winter. Waterfowl could use this area for resting and feeding.

The thermal impact of the nuclear power plant's cooling waters might impact the habitats of waterfowl in the area affected by the cooling waters. The size of the thermal impact zone will depend on the capacity of the power plant, and the impacts would be clearest in the immediate vicinity of the discharge site. In the area affected by the cooling waters, there would be an area that remains unfrozen also in the winter. Waterfowl could use this area for resting and feeding.

The thermal impacts of the cooling waters could locally increase plant production and decrease the cleaning effects of ice on the shores. This could lead to increased overgrowth of open shore meadows and alluvial shores, and these may further affect birds. On the other hand, an increase of aquatic plant on the shores would improve the habitats of waterfowl, for example.

The unfrozen water area could be used as a resting and feeding area by, for example, migrating waterfowl. It is also possible that some of the migrating species would remain in the unfrozen water area longer than normal. The thermal impact could improve the feeding conditions of species feeding on fish, and the nesting season of waterfowl and shore birds might start earlier in the cooling water impact area. The timing of the nesting season will also depend on other environmental conditions in the area, however. The project is not deemed to deteriorate the habitats of bird species included as the Natura 2000 area's conservation criteria.

The Fennovoima project is assessed not to require the actual Natura assessment because its impact will not be significant on any habitat type or species.

Joint impact of Loviisa 3 and the Fennovoima project

The joint impact of Loviisa 3 and the Fennovoima project on the sea water temperature in the maximum situation on the Natura area is presented in Figure (Figure 8-50B). The joint impact of the Loviisa 3 nuclear power plant and the Fennovoima project on the Natura 2000 area, increasing the temperature by more than one degree centigrade will mainly be limited in the same sea area as the single impact of the Fennovoima project. The area is mainly 30 meters deep and there are no other habitat types apart from the islets and rocks habitat type.

The temperature impact of about one centigrade will extend widely to Natura area towards east with regard to joint impacts. The majority of the affected area in the Natura area comprises an open sea area. However, the area contains some islands and several islets where the habitat types are not known. In this area, 'islets and rocks' represents the Natura habitat types. The majority of the sea area is more than 30 meters deep and there are no underwater habitat types.

On the basis of the aforementioned and following the precautionary principle, the actual Natura assessment should be prepared if both of the Loviisa 3 and Fennovoima projects will be implemented, because of the plants' assessed joint impacts and the lack of knowledge concerning the islets and shallow areas located in the area of joint impacts.

Vahterpää fladas

The Natura 2000 area in question is located approximately five kilometers from the project area and there is no direct connection between the cooling water discharge area and the Natura 2000 area. The increase in temperature would not extend to the Natura 2000 area.

Due to the distance, the project would not influence the conservation criteria of the Natura 2000 area and a Natura assessment as laid down in the Nature Conservation Act is not deemed necessary.

Kullafjärden bird wetland

The area is located at a distance of approximately five kilometers from the project area. Thus, noise would not cause any harm in the area. The increase in sea water temperature due to cooling waters would not extend to the Natura 2000 area or even to its adjacent areas. Thus, the activities mentioned above connected with the project would not have any detrimental impacts on the Natura 2000 area in question.

A potential power line route is located approximately 800 meters from the southern border of the Natura 2000 area. Species occurring in the area mainly include species favoring reed beds and lush bird wetlands, such as marsh harrier, bittern and little crake. The power line may increase the risk of collision with birds in places where the Vahterpää road crosses the strait. The risk can be reduced by, for example, installing bird warning spheres. A lower voltage power line of the regular electricity grid already passes the strait. Such power lines have been observed to pose a greater collision risk than high-voltage lines. An accurate assessment of the impact of power lines on birds can be prepared in connection with the power line designs and the EIA when more detailed information about the location and structures of the power line will be available.

The project is not deemed to cause any major adverse impacts on the conservation criteria of the Natura 2000 area, and a Natura assessment as laid down in the Nature Conservation Act is not deemed necessary. With regard to the power lines, the need assessment will be prepared alongside the power line's environmental impact assessment.

8.6.3 Simo, Karsikkoniemi

8.6.3.1 Current status of the environment

Flora

The vegetation of the shores of Simo and the archipelago is very diverse in terms of species as well as vegetation types. Factors making the area versatile include, for example, fast land uplift, zonality of vegetation, the brackish water of the Bothnian Bay and cultural biotopes. The shores of Karsikkoniemi headland are succession shores typical of the Bothnian Bay land-uplift coast. The vegetation transforms from seashore meadow via reed beds and decidous forests dominated by grey alder and birch into dry peaty forests dominated by coniferous trees (*Seitap, 2006*).

Most of the Karsikkoniemi area seashore meadows are narrow and rocky. The most extensive seashore meadows have been classified as habitat types protected by virtue of the Nature Conservation Act. The seashore meadows mainly include low-growing Baltic rush, grass and sedge. The dominant species of the meadows are slimstem reedgrass and also Boreal bog sedge in some places. There are only a few reed, spikesedge and cane shore meadows and seashore meadows dominated by greater segde. Reed beds are small, in particular. The common grasses growing on the seashore meadows include, for example, elder-leaved valerian, tufted loosestrife, bird vetch, garden heliotrope, marsh cinquefoil, silverweed, grass of Parnassus, and also Primula nutans var. jokelae and southern adder-stongue in some places. Buckthorn is especially common on the shores of Karsikkoniemi.

There are sandy shores in the Röyni area, for example. The species of this area include, for example, sea sandwort, sand ryegrass and double bladder campion. There are no specific dune formations in the area, however. There are also some rocky shores at Kar-sikkoniemi.

The seashore meadows on the mainland side gradually change into willow bushes and seashore groves. Extensive deciduous forest areas dominated by birch can be found in the southern parts of the Karsikkoniemi headland and the Laitakari island, for example. In addition to birch, grey alder, rowan and aspen are common in the forests. The field layer of the seaside birch stands consists of grasses, stone bramble, Arctic bramble, woodland angelica and Lapland cornel, for example. Meadowsweet is especially com-mon in the wetter forests; actual Filipendula-type alder stands are very few, however. For instance, the heath forests with deciduous trees in the southern part of the headland alternate with mainly willow-growing wetland depressions.

The shores of the Karsikkoniemi headland rise fairly rapidly into peaty forests; the actual seashore zone is quite narrow in most places. Forests in the area are in forestry use. The age of the forest types varies. There are plenty of fairly old spruce stands but also plenty of felled areas and sapling stands. For instance, the forests along Paanuniementie road are largely managed.

Most of the forests at Karsikkoniemi are wet peaty forests (of the lingonberry-blueberry type) with spruce as the dominant tree species. Some pines and downy birches grow among the spruces. Wetter sites include swamp forests. The middle part of the headland and the areas where the soil is rocky or sandy include more rugged and drier pine forests (*of the crowberry-blueberry type and the blueberry-heather-lichen type*). There is an extensive sand field, Röyttänhiekka, along the Kitiniementie road. Pine, juniper, bearberry, reindeer lichen, reindeer moss and cup lichen grow there. There are some open sandy spots in the area. The area is highly susceptible to abrasion.

There are several small patches of wetland surrounded by forests at the tip of the Kar-sikkoniemi headland. Most of these are marshes dominated by greater sedge, some are flood meadow-type marshes. The vegetation includes, for example, bottle sedge, slender sedge, Scandinavian small-reed, swamp horsetail and marsh cinquefoil. There are also small morasses in the area; the species growing there are demanding, such as marsh or-chids. Almost none of the wetlands at the headland have been ditched.

The most important marsh is the open marsh surrounding Lake Karsikkojärvi, which is the result of closing up of the lake. The marsh is slightly irregular in nature. To the south of the lake, the marsh is sedge marsh dominated by slender sedge, the shores of Lake Karsikkojärvi are dense lake reed beds and the north side of Lake Karsikkojärvi includes morasses. Morass species are represented in the area by, for example, broad-leaved cottongrass, star campylium moss, Scorpidium cossoni and tomentypnum moss.

The planned cooling water discharge site at Prusinperä is rocky seashore. European water plantain, common mare's-tail, great badderwort and mamillate spikerush, for example, grow in the rock depressions. Other dominant species include purple loosestrife and meadowsweet. The rocky shore is followed by a tea-leaved willow zone where sweet-gale is very common. The rocky, peaty pine forest that comes after the willow zone has been felled in this part of the area.

The power line route zone begins at a morass area surrounding the Ahvenlahti bay. Demanding morass species growing in the area include, for example, scorpidium moss, star campylium moss, livid sedge, flatleaf bladderwort, flecked early marsh orchid and sphagnum. The vegetation changes mainly into drier peaty forest to the north of the Ahvenlahti bay. The terrain at Pirttirakka, a turning point of the power line route, is very rocky and rough peaty forest with boggy longitudinal swamp formations. Both sides of the Lahdenohja brook are covered by lush groves which also include longitudinal patches of grove-like swamp forests where there are springs. The edges of the brook are covered by spinulose woodfern. The power line route area to the north of trunk road 4 is a pine sapling stand.

The road route from trunk route 4 to the end of the Karsikkoniemi headland mainly goes along the current road. The roadsides are mainly bushy areas including sapling stands and birch; there are also some wet peaty spruce forests. There are lush birch stands on either side of the Lahdenohja brook. There is a small swamp to the west of the road at the Röyttänlampi pond.

The new road route goes from the Karsikkoniemi area to Niemennokka. The Niemennokka headland is rocky and rough terrain. Plants growing in the grooves between the seaside rocks include, for example, purple loosestrife, greater yellow-rattle, goldenrod, round-leaved wintergreen, elder-leaved valerian and meadowsweet. Buckthorn is abundant in the entire area. There are several holiday homes at the seashore in the road route area.

Endangered and noteworthy plant species

The following endangered and near threatened vascular plants occur in the Karsikkoniemi and Laitakari areas of Simo:

Figure 8-52. Nature conservation areas, Natura areas and other valuable sites at Karsikkoniemi and in the adjacent areas.

Name	Status	Directive's Annex IV species
Artemisia campestris subsp. bottnica	extremely endangered, CR	✔
Siberian primrose	highly endangered, EN	✔
Fairy slipper	vulnerable, VU	✔
Flecked early marsh orchid	vulnerable, VU	
Hudson bay sedge	vulnerable, VU	
Early marsh orchid	near threatened, NT	
Water pygmweed	near threatened, NT	

Regionally threatened (AI) vascular plants in the area that are still viable in entire Finland include black alder, livid sedge, bog orchid, buckthorn, yellow flag, beach pea, southern adderstongue, common butterwort, angular Solomon's seal and threadleaf crowfoot.

Of the endangered species observed in the Karsikkoniemi area, the most endangered are Siberian primrose, *Artemisia campestris subsp. bottnica* and fairy slipper, which are three of the Habitats Directive Annex IV species (in maps, abbreviation Dir). Furthermore, *Artemisia campestris subsp. bottnica* is a species to be primarily protected by virtue of the Nature Conservation Act. However, its distribution has been classified as irregular. A previously observed occurrence of grove sandwort, a Habitats Directive Annex IV species, was interpreted eradicated in 2006. Location data regarding occurrences of angular Solomon's seal, Hudson bay sedge, yellow flag and threadleaf crowfoot are inaccurate.

Avifauna and other animal species

The birdlife at Karsikkoniemi is versatile due to the versatile habitat structure of the area. The avifauna in the headland's inner parts mainly consists of species common for deciduous and mixed forests. There are also swamp and wetland species around Lake Karsikkojärvi. Most of the species at the seashore are waterfowl and gulls; the seashore birdlife also includes clearly maritime species. Open islands in front of the Karsikkoniemi headland are important bird nesting areas. During the migration season, a large number of, for example, tundra swan and crane travel over the Karsikkoniemi headland.

Bird species in the Karsikkoniemi area have been calculated in 1996, 2004 and 2008, for example. In 2004, a total of 43 bird species were observed in the Karsikkoniemi area; in 2008, a total of 48 species were observed. According to the national bird atlas observation database, a total of 115 bird species have been observed in the 10 x 10 km bird observation area of Karsikkoniemi. 61 of these were confirmed to nest in the area. The 10 x 10 km area extends over the Karsikkoniemi headland and the Maksniemi headland, and all the way to Hepola, and thus all the species mentioned in the database have not necessarily been observed at Karsikkoniemi.

In the 2008 survey and according to the bird atlas information, 13 species included in the EU Birds Directive Annex I without doubt nest in the area. Two species classified as endangered and eight species classified as nearly endangered in the national Finnish classification nest in the Karsikkoniemi assessment area.

Avifauna in the inner parts of the Karsikkoniemi headland mainly consists of forest species. Most of the old meadows in the area have reverted to forest, and the species nesting in these areas are typical deciduous forest species, such as blue tit. Lake Karsikkojärvi and the swamp surrounding it that is almost in its natural state form an entity of their own. Several waterfowl species nest on the lake and in its surroundings. The other forests in the inner parts of Karsikkoniemi are mostly managed, and felling has been performed in several areas. This is also reflected in the area's birdlife. In areas where there are still old trees left, also species typical for old forests nest, such as black woodpecker.

The bird species in the seashore areas of Karsikkoniemi are typical for Gulf of Bothnia seashores. The most important islands and islets for the birdlife in front of Karsikkoniemi are Laitakari, Länsikari, Junnankarit and Peurankallio. Laitakari has a uniform birch stand and the island's birdlife includes waterfowl, seashore species and also several species typical for deciduous and mixed forests. A colony of gulls and terns nest at Länsikari. A colony of herring gulls nests at Peurankallio. In addition to herring gulls, common terns and Arctic terns, several waders and waterfowl species nest in the Junnankari area. Waders and waterfowl also occur on the shores of Karsikkoniemi, in Röyni and the Heittokari-Kotakari-Teponlahti area in particular. The latter is also a resting and feeding area for birds of the *Anseriformes* family.

Siberian flying squirrel

Siberian flying squirrel has not been observed in the Karsikkoniemi area. Based on terrain survey results, one can also state that Siberian flying squirrel does not occur in the assessment area.

Moor frog

There are several small relictions, ditches and ponds, suitable breeding places for the moor frog, in the Karsikkoniemi area, around Lake Karsikkojärvi and at the south end of the Karsikkoniemi headland, for example. Alluvial ponds and bays close to the sea-shore are also suitable breeding places for the species.

According to the observation database of the Finnish Museum of Natural History, the closest moor frog observations have been made in Järppi, approximately 10 kilometers north of Karsikko.

Bats

No bats have been observed in the Karsikkoniemi area. The biotope structure of the area corresponds to the habitat requirements of Northern serotine bat, for example. There are no caves or more extensive rocky areas that could be used as bat hibernation sites in the assessment area.

Other animal species

The land animals of Karsikkoniemi include typical forest species, such as elk, mountain hare and squirrel. Roe-deer have also been observed in the area. No consistent surveys of invertebrates in the area have been made (*Seitap Oy, 2006*).

Conservation areas and other valuable sites

Nature conservation areas

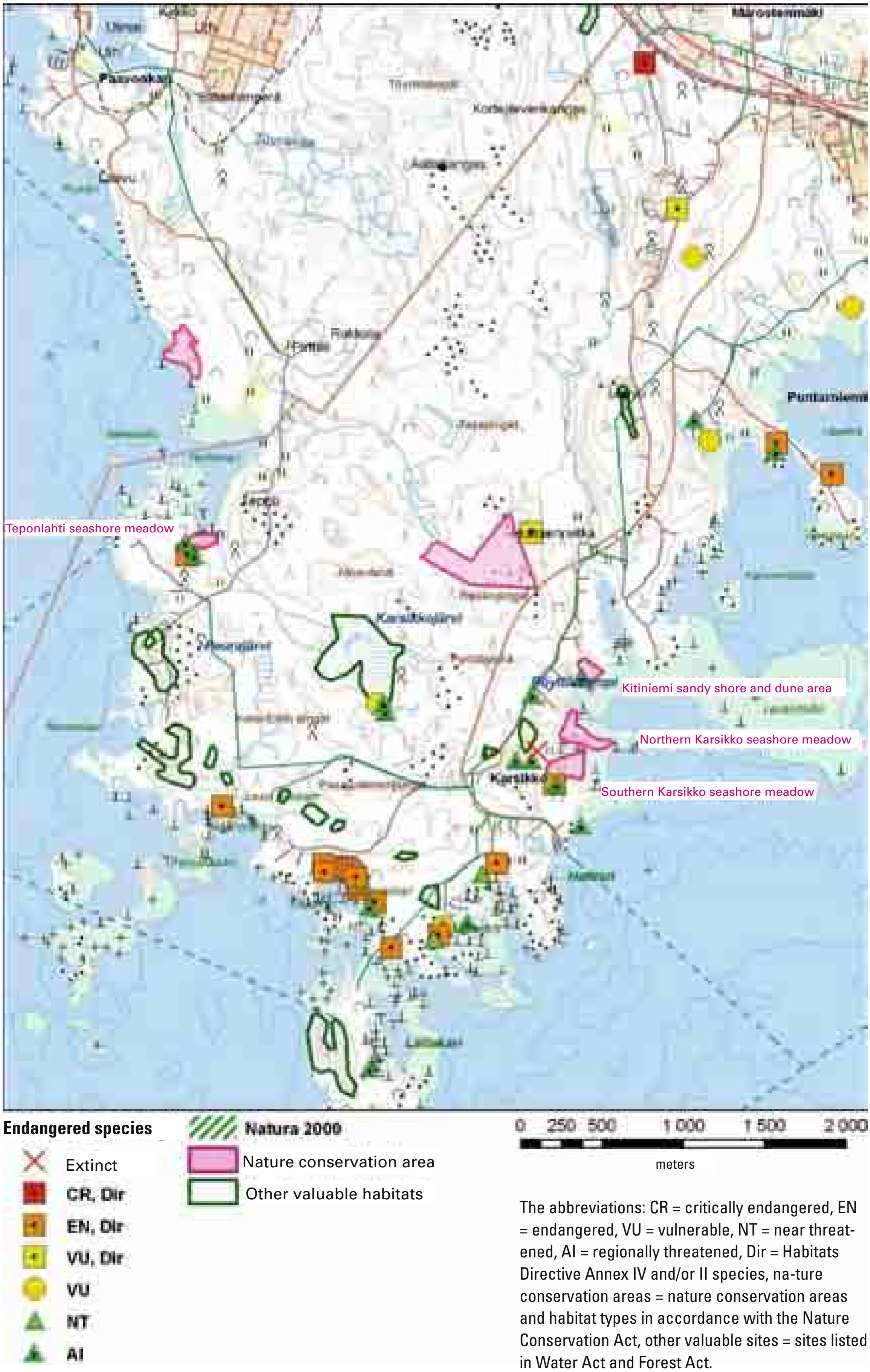
There are several private nature conservation areas at the Ajos headland, at their closest approximately 3.5 kilometers from the assessment area: The Lautiosaari nature conservation area, the Inakari nature conservation area, the Murhaniemi nature conservation areas 1 and 2, and Ajos morass (Figure 8-52). Furthermore, the Iso Ruonaoja brook meadow, the Mäkelä nature conservation area and the Länsi-Ervasti nature conservation area are within a range of approximately eight kilometers of the area.

Natura 2000 network areas

There are no Natura 2000 network areas in the Karsikkoniemi area. The closest Natura network sites are included in the Bothnian Bay islands Natura area. The closest Natura area is located in Kemi at the Ajos headland, approximately 3.5 kilometers from the as-sessment area. The Bothnian Sea national park, which is also a part of the Natura network, is approximately 10 kilometers away in front of the Karsikkoniemi headland.

Habitat types of the Nature Conservation Act

The Lapland Environment Centre has identified three habitat types protected by virtue of the Nature Conservation Act in the Karsikkoniemi area (Figure 8-53). The two-hectare sandy shore and dune area of Kitiniemi is located on the eastern shore of the Karsikkoniemi headland, approximately one kilometer north of the fishing harbor. The Teponlahti seaside meadow is located on the western shore of Karsikkoniemi, to the north of Ruumiskarinnokka. Northern and southern Karsikkoniemi seashore meadow are located on the eastern shore of the Karsikkoniemi headland. Several habitats protected by virtue of the Nature Conservation Act have also been limited at Ykskuusi, ap-proximately four kilometers east of Karsikkoniemi: The Tiironhiekka seashore meadow, the Tiironhiekka sandy shore and the southern Tiironhiekka seashore meadow.



The abbreviations: CR = critically endangered, EN = endangered, VU = vulnerable, NT = near threat-ened, AI = regionally threatened, Dir = Habitats Directive Annex IV and/or II species, na-ture conservation areas = nature conservation areas and habitat types in accordance with the Nature Conservation Act, other valuable sites = sites listed in Water Act and Forest Act.

Figure 8-53. Conservation areas and other valuable sites at Karsikkoniemi.

__Other nature sites__

There are several habitats important for the biodiversity of forest nature as described in the Forest Act in the Karsikkoniemi area. These include, for example, small sandy areas in their natural state or almost in their natural state, cliffs, rocks and rocky areas, the surroundings of small ponds and brooks and seashore flood meadows.

__Sites significant for avifauna__

There are no birdlife areas deemed to be of national (FINIBA) or international (IBA) significance in the assessment area. The most important bird areas in the assessment area include Lake Karsikkojärvi and its surroundings, and the islands and islets in front of the Karsikkoniemi headland. The most important islands are Länsikari, Laitakari, Junnankarit and Peurankallio. The Korppikarinnokka area to the north of Laitakari is also a site valuable for the local birdlife. The Röyni-Keppimatala area to the east of the Karsikkoniemi headland and the Kotakari bay to the west of the headland are important waterfowl nesting and resting areas.

8.6.3.2 Impacts on nature sites

The surroundings of the Karsikkoniemi headland would be transformed from a natural environment into an industrial area. In addition to regular nature, some sites important for biodiversity would be eradicated in the area, such as habitats listed in the Forest Act.

There would be no direct or indirect detrimental impacts to nature conservation areas because none of them are located in the areas to be developed.

Some of the habitats listed as especially important in the Forest Act would probably change due to the construction project. These are mainly small swamp areas and rocky areas. The power line route would change the surroundings of Lake Karsikkojärvi by opening a treeless corridor there. The birdlife would be disturbed during the power line construction period. This disturbance could be alleviated by scheduling construction activities to take place outside the nesting season.

Impacts on Habitats Directive Annex IV species and primarily protected species

Three plant species included in the Habitats Directive Annex IV have been observed in the assessment area: *Artemisia campestris subsp. bottnica*, fairy slipper and Siberian primrose. The fairy slipper occurrence is in an area where no construction measures would take place in accordance with the plans currently available.

No specific location data are available on the occurrence of the Habitats Directive Annex IV species which is also a species to be primarily protected by virtue of the Nature Conservation Act, *Artemisia campestris subsp. bottnica*. The occurrence is probably right next to trunk road 4 or close to the road. The location of the species must be checked during the more specific design stage of the power line route and road arrangements. The occurrence of the species can probably be retained by means of proper planning.

There are several occurrences of the Habitats Directive Annex IV species Siberian primrose in the Karsikkoniemi seashore meadows. There may even be more occurrences than included in the map because the terrain survey did not cover the shores of summer homes. No direct impacts would be directed to the occurrences of the species if no structures were constructed in the areas where the species occurs.

The thermal impacts of cooling water might influence the shores of the area and thus the vitality of Siberian primrose. The thermal impacts might locally increase plant production and decrease the cleaning effects of ice on the shores. This could lead to increased overgrowing of open shore meadows and alluvial shores in those areas where the temperature would clearly and permanently increase. When implementing discharge site P1, the occurrence in the area must be avoided if possible.

Impacts on other noteworthy plant species

There are plenty of occurrences of endangered and otherwise noteworthy plant species at Karsikkoniemi headland. These species include species that are endangered nationally and regionally, and also protected species (such as flecked early marsh orchid). Many of the occurrences of noteworthy species, especially of those species that occur in the seashore zone, are located in the planned plant area. For example, occurrences of flecked early marsh orchid and early marsh orchid have been observed at seashores and in small wetlands. The location data for some species is inaccurate and thus the impacts on these species cannot be assessed in more detail.

Occurrences in areas where power plant buildings and areas would be constructed would probably be eradicated. However, if these areas are taken into account when designing the site, most of the occurrences, especially those on shores and close to shores, could probably be retained.

Impacts on fauna

The areas which would change the most are located in the inner parts of the Karsikkoniemi headland where there are no significant sites considering the avifauna or other animals, except for the Lake Karsikkojärvi, and in the Laitakari and Korppikarinnokka area which are significant for the avifauna. The quay construction impacts would mainly occur at Prusinperä which is not a site with exceptionally representative birdlife.

The impacts on other land animals during construction would include changing habitats and increased disturbances due to construction works. These impacts would not be significant from the viewpoint of the other animal species, however, because substituting habitats would be retained also in the Karsikkoniemi area. The power plant area and the road arrangements for it could make hinder the movements of elk and deer at the Karsikkoniemi headland's southern parts.

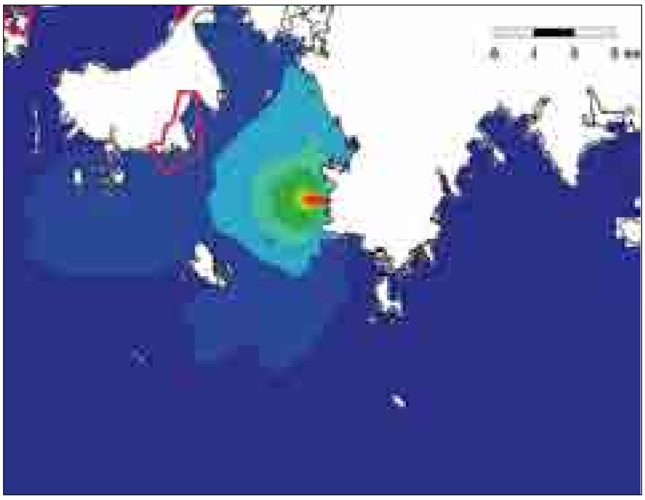
The planned power line route travels on the east side of Lake Karsikkojärvi, partially above the lake, to the north. The nesting of species significant from the nature conservation viewpoint at the lake and in its surroundings would be temporarily disturbed during the construction of the power plant unit (whooper swan, osprey and crane among the species included in the Directive). One current nesting site of osprey is located in the planned power line route areas, and if the planned power line is constructed, this nesting site will be destroyed.

Waterfowl and seashore bird couples nesting at Lake Karsikkojärvi would probably decrease due to the increased level of disturbance and the changes in the habitat during the construction period. Of the Birds Directive species, these impacts refer to whooper swan, crane and wood sandpiper in particular.

The disturbances caused by construction would influence the behavior of birds, and the earth-moving and construction works would permanently change the habitat structure in some parts of Laitakari. The gull colony of Länsikari would mainly be only influenced by the increased disturbance from the construction activities, however. In the Laitakari area, grouse, little gull, common tern and Arctic tern among the Directive species would in particular be subjected to the impacts.

Impacts on Birds Directive Annex I species

The collision risk caused by the power line route is the highest for larger species. Such species included in the Directive and found in the Karsikkoniemi area are whooper swan, crane and wood grouse. The collision risk would be more pronounced during migratory seasons when a large number of geese, for example, occur in the Karsikkoniemi area from time to time.



Kuva 8-54. Temperature impacts caused by a two-unit power plant area in the sea area if the discharge site were as close to the Natura 2000 area as possible. The borders of the Natura 2000 area have been marked on the map in red.

The thermal impact from the nuclear power plant's cooling waters could locally influence the habitats of waterfowl in the area affected by the cooling waters. In the area affected by the cooling waters, there would be an approximate area of a couple of square kilometers that would remain unfrozen also in the winter. Waterfowl could use this area for resting and feeding. The thermal impact could improve the feeding conditions of species feeding on fish, such as common tern and Arctic tern, and the nesting season of waterfowl and shore birds might start earlier in the cooling water impact area. The timing of the nesting season will also depend on other environmental conditions in the area, however.

The nuclear power plant and the adjoining structures would be positioned in a manner avoiding conservation areas and valuable sites whenever possible. According to the preliminary design data, the plant area would not extend to any protected areas, except for the Karsikkoniemi field, which is a heritage landscape.

8.6.3.3 Natura assessment review

The following measures connected with the project may cause detrimental impacts:

- Warming of sea water due to cooling water and consequent eutrophication
- Birds' risk of colliding with power lines
- Noise during construction

In the following chapters, the impacts of these measures on the area's Natura values will be assessed.

Reviewed Natura 2000 areas

Bothnian Bay islands Natura area (FI1300302)

The Bothnian Bay islands Natura area (a total of 7,136 hectares) consists of islands, islets and shallows in front of Kemi, Tornio, Simo, Kuivaniemi, Ii, Haukiputaa, Oulu, Oulunsalo and Hailuoto. The Natura area is protected by virtue of the Habitats Directive as an SCI area and by virtue of the Birds Directive as an SPA area. The Habitats Directive habitats listed below have been assigned as the Natura area conservation criteria (The prioritized habitats, i.e. habitats of especial significance are given in bold). The habitats which the sea water temperature may influence are given in italics.

- *Underwater sand-banks*
- River deltas
- ***Coastal lagoons***
- *Perennial plants on rocky shores*
- *Boreal islets and islands of the Baltic Sea*
- ***Boreal seaside meadows of the Baltic Sea***
- *Boreal sandy shores of the Baltic Sea including perennial herbaceous plants*
- Migrating *Ammophila arenaria* (European beachgrass)

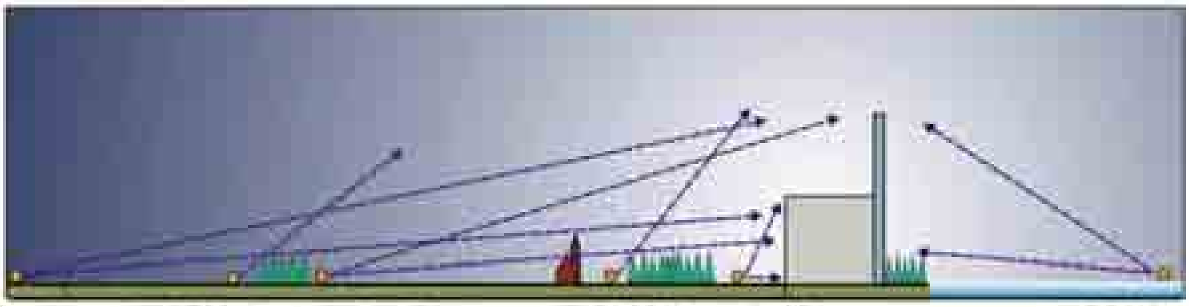


Figure 8-55. Examples of landscape impacts caused by the nuclear power plant.

dunes or 'white dunes'
- **Fixed seashore dunes covered by grasses ('grey dunes')**
- Dry Calluna and Empetrum nigrum moors/dunes
- **Dry and wet Fennoscandic meadows including plenty of different species**
- **Land uplift coast's primary succession stage forests in their natural state**
- Boreal groves
- Fennoscandian pasturage and pastures cleared by means of burn-beating

Of the Habitats Directive Annex II species, smartweed, fourleaf mare's-tail, grove sandwort, Wallenberg's water plantain (a prioritized species) and Siberian primrose occur in the Natura area. Of the Birds Directive Annex I species, Steller's eider, merlin, northern hawk owl, dunlin, red-throated loon, common tern, golden plover, bittern, black-throated diver, crane, Arctic tern, whooper swan, wood sandpiper, spotted crake, European honey-buzzard, horned grebe, black woodpecker, tundra swan, red-backed shrike, little gull, little tern, marsh harrier, bluethroat, Caspian tern, northern harrier, ruff, short-eared owl, grouse, smew, red-necked phalarope and six endangered species occur in the Natura area.

Assessment on the need for a Natura assessment
<u>Bothnian Bay islands Natura area</u>

Karsikon alueeseen nähden läheisin Perämeren saarten The closest border of the Bothnian Bay islands Natura area to the Karsikko area is located at Ajos headland, a little over three kilometers from the assessment area.

The impacts of cooling water on the sea water temperature have been modeled for several seasons by using various alternatives and a variety of wind speeds. The impacts have been assessed taking into account the so-called maximum scenario where the cooling water discharge site is on the western site of Karsikkoniemi headland and the warming is directed to Veitsiluodonlahti bay between Karsikkoniemi headland and Ajos headland. The power plant's capacity during the maximum scenario will be 2,500 MW.

In the area affected by the cooling waters, there would be an area that remains unfrozen also in the winter. Waterfowl could use this area for resting and feeding. Based on the water impact assessment, the unfrozen area would extend to a distance of approximately five kilometers from the discharge site. The unfrozen water area could be used as a resting and feeding area by, for example, migrating waterfowl. It is also possible that some of the migrating species would remain in the unfrozen water area longer than normal. The thermal impact could improve the feeding conditions of species feeding on fish, and the nesting season of waterfowl and shore birds might start earlier in the cooling water impact area. The timing of the nesting season will also depend on other environmental conditions in the area, however.

The thermal impacts of the cooling waters could locally increase plant production and decrease the cleaning effects of ice on the shores. This could lead to increased over-growth of open shore meadows and alluvial shores. On the other hand, an increase of aquatic plant on the shores would improve the habitats of waterfowl, for example.

The power plant cooling water impact zone would extend to the shores of one of the Natura area's parts. The increase in temperature would be minor and sporadic, however, and the modeling does not suggest that the project would have any major influence in the area's ice cover. Based on the cooling water modeling, the unfrozen area would not extend to the Natura area. The Ajos site in the Natura area does not have any underwater habitat types. The shores are grassy in many places. Furthermore, the only larger seaside meadow has become largely grassy. The area's rocky shores habitat type has regular vegetation and it cannot be regarded as particularly dominant. Merkkikari represents the 'islets and islands' habitat type. The underwater parts of the islet are rocky and nearly

Pictures of landscapes are part of the EIA procedure. A farm in Pyhäjoki, 2008.

without any vegetation. The Merkkikari values mainly concern the bird stocks and the project is not deemed to have an impact on the bird stock values..

Based on the information given above, an actual Natura assessment as laid down in the Nature Conservation Act is not deemed necessary because the project is not estimated to have any major deteriorating impacts on the Natura 2000 area's conservation criteria.

8.7 Landscape and cultural environment

The landscape is an entity comprising inorganic and organic nature and areas of different types resulting from the impact of human activity the factors of which include bedrock and soil, vegetation, climate conditions, and signs of human activity. Immaterial factors are also linked to the landscape. Regional history, human experiences, hopes, appreciation, and attitudes influence how the landscape is perceived. Assessments of the same landscape or the significance of landscape impacts caused by a new project can differ noticeably from each other. The importance of subjective factors in relation to the perception of landscape impacts is emphasized in a project such as a nuclear power station that inspires strong feelings.

Landscape impact comprises changes in the structure, characteristics, and quality of the landscape. Visual impacts are one subset of landscape impacts. The significance of a adverse landscape impact can be reduced by harmful factors already present in the area, such as smoke, noise, or odors. (*Weckman 2006*)

Implementation of the nuclear power plant will cause direct landscape impacts as a result of the plant area buildings, water intake and disposal as well as structures related to electricity transmission and new or improved traffic connections to the area. The highest structure in the plant area will be the vent stack, rising approximately 120 meters higher than the surroundings. The height of the reactor and turbine buildings will be approximately 60 meters. The other buildings and structures will be lower. The nuclear power plant will be linked to the national grid. The impact of power lines is handled in this assessment at a general level with regard to the nuclear power plant's immediate surroundings because the impact of power lines will be specified as the design proceeds. Both visible and underwater and underground structures will be associated with water intake. The plant's warm cooling water will be released into the sea and during the winter this will cause a melt area of varying size at the water disposal site. A cloud of fog can form above this area on calm, subzero days.

In addition to the construction site, impacts during construction work will be caused by heavy traffic required by the transport of large building parts and its requirements (e.g. about 100 meters long quay), new road connections and the improvement of current roads. High cranes will be visible in the landscape from far away. Some of the buildings, fields, and traffic connections will only be implemented for the period of construction and will undergo landscaping when no longer needed.

The nuclear power plant may cause extensive visual impacts due to its large size and location. Long, broad visibility axles towards the nuclear power plant extend from many directions via the open sea area if there are no elements, such as trees or structures, to cut off the view near the observation point. Views of the plant from open fields, swamp areas, felling areas, road routes, or other open areas orientated towards the plant can stretch very far.

In addition, the nuclear power plant may cause changes in the landscape hierarchy, for example, by "subordinating" the landmarks of the environment built earlier (church towers or similar structures) or changing the nature of the landscape from a natural or cultural environment to that of a power plant. In the dark, the lighting of the plant area and new traffic connections and the glow from that lighting can have an impact on the nature of the landscape (Figure 8-55).

8.7.1 Pyhäjoki, Hanhikivi

8.7.1.1 Current landscape and cultural environment

The coastal zone in the Pyhäjoki region is very even with alternating natural landscape sections and small-scale built areas. The area has no archipelago zone. Hanhikivi headland is mainly a natural area, although felling has altered the landscape to a certain degree. The terrain is very even and low-lying. With the exception of a few uplifts, the height the headland and surrounding areas is less than 2.5 meters above sea level. (*Northern Ostrobothnia regional plan, Environmental Administration's Environmental Information System 2008*)

In addition to forested natural areas, the shores of the Hanhikivi headland have some holiday homes, shore meadows, a boat harbor, and a sandy shore. The northern shore is unbuilt and has extensive shallows lying off it. The nearest areas of permanent housing, the villages of Pietipuhto and Parhalahti, are located about 5 kilometers southeast of the headland. Construction in the area of the villages is confined to an open valley used for cultivation, the open landscape of which faces towards the northwest and the Hanhikivi headland. In addition to natural landscape sections, the coastal zone in the Hanhikivi headland environment has holiday homes and meadows.

With the exception of sea views from the shores, the views in the Hanhikivi headland area are mainly limited because dense vegetation effectively cuts off the views inside the area. Open views within the headland and towards the power plant area mainly extend via suitably orientated open bog or swamp areas, direct road routes and open shore areas. From outside the area, open, unrestricted views towards Hanhikivi headland ex-tend in every direction from the sea, because there are no islands to cut off the view. The headlands and shores in the surrounding area also have open views towards the headland stretching into the open sea.

Valuable sites in the landscape and cultural environment

This section lists the sites of value that, on the basis of

Figure 8-56. Photomontage: The nuclear power plant in the Hanhikivi headland. There are two power plant units in the figure. The figure for a single power plant unit option is presented in Chapter 1.4.1, which addresses location alternatives.

Figure 8-57. Photomontage: The nuclear power plant in the Hanhikivi headland viewed from the sea.

map information and field visits, may be impacted by construction of the power plant. By character or location, the other sites of value in the area are such that there will be no impacts or the impacts will be so slight that they are insignificant with regard to retaining the value of the sites.

- The Hanhikivi historical monument is a nationally significant monument (*National Board of Antiquities 2001*).
- In the Northern Ostrobothnia regional plan, Hanhikivi headland is marked as containing a traditional rural landscape/traditional biotope of national/regional importance. A road or route designated as important in terms of cultural-historical background or landscape runs through the village of Parhalahti. In the plan, Hanhikivi headland is marked as part of a multiple-use natural area. (*Council of Oulu Region 2005*)
- A nationally significant culture historical environment, the Parhalahti fishing shore (*Built Cultural Environment*)
- A traditional rural biotope, the Takaranta seashore meadow, runs from the northern side of the Hanhikivi headland to the base of the headland *(Environmental Administration's Map Service 2008)*

8.7.1.2 Impacts on the landscape and cultural environment

The nuclear power plant will be located on a clearly distinguishable headland that reaches out into the open landscape of the sea and can be identified as a natural environmental entity in the remote landscape. The plant surroundings differ significantly from the environment in terms of size and character, thus creating a new landmark that dominates an extensive area of the landscape and changes its character, hierarchy and the uniformity of the natural environment. However, when viewed from the sea at a sufficient distance, the large open water surface and outline of the continental coast in the background lend support to the large structure as the smaller features disappear (Figure 8-56 and Figure 8-57).

From closer, views from the broader area of permanent housing (Pietipuhto and Parhalahti) extend toward the power plant due to the orientation of the open landscape of the cultivation area. The plant structures will be visible and clearly distinguishable from be-hind the edge of the forest. As a result of the distance (over 4 kilometers), the power plant is unlikely to cause significant changes in the character and hierarchy of the land-scape in the village area. Visibility axles from other continental directions towards the power plant extend through suitably orientated fields, clear felling areas, the road network, and open swamp areas. In forested areas, vegetation close to the observation point effectively cuts off the views.

With regard to holiday homes, the most significant changes will occur in the main visibility axles extending toward the sea from the holiday homes located on the northern shores of the Maunus and Syölatti areas located south of the Hanhikivi headland, and in views from certain other holiday homes for which the main direction of the view faces the plant area. Due to the characteristics and types of environment in the region, as well as the size and nature of the project, the impacts of the project on the sea landscape will most likely be perceived as adverse.

Local impacts on the landscape in the power plant construction area will be significant when the current forested natural area becomes a large-scale built environment. In addition to the plant area, landscape impacts will be caused by the power plant accommodation area and the new road connection to the power plant area. The current buildings in the plant area will be removed from use or their purpose will be changed. The new quay will differ from the existing construction of the coastal zone in terms of its size and characteristics, but it will blend in with the power plant environment in the future. The forest areas restricted because of the power line route will be the site of a new open power line corridor that, depending on the tower solution, will be approximately 80-120 meters wide. The power line route will run towards east from the Hanhikivi area and will be connected to the national grid at a distance of about 20 kilometers from the nuclear power plant. Fingrid Oyj will define the route if the project advances in Pyhäjoki.

The structures related to water intake will be located invisibly underwater in the open sea or on the shore, in which case a quay-like concrete structure will be visible. A channel structure that is about 50 meters long and 30 meters wide will be built on the north shore of the Hanhikivi headland for water discharge. The structure will be bordered by embankments of about 10 meters in width. Due to the impact of warm water, the sea in front of the discharge site will remain open in the winter in an area of varying size. A cloud of fog can form above the unfrozen area on calm, subzero days.

In the dark, the plant lighting will stand out in an area that is otherwise nearly completely dark. The glow may also be visible from afar. The importance of the plant as a new landmark in the region may be emphasized in the dark.

Impacts on sites of value

The implementation of the power plant will significantly change the character of the surroundings of the nationally valuable historical Hanhikivi antiquity, and may have impacts on accessibility to the stone. The stone's status in relation to the built environment will depend on the more detailed design.

The highest structures of the power plant are likely to be visible behind the trees from the nationally valuable Parhalahti fishing harbor and the regionally valuable village, but buildings and vegetation will quite effectively cut off views to the plant. However, due to the distance (3–4 kilometers), the visual impacts are unlikely to significantly detract from the value of the area. The status of the regionally important Takaranta seashore meadow will change when the power plant replaces the existing low-lying natural area near the meadow. Views from the Maunus shore meadow and its position in the landscape will change.

The Northern Ostrobothnia regional plan designates Hanhikivi headland as part of a multiple-use natural area. Implementation of the nuclear power plant will reduce the opportunities for recreational use in the area and cause significant impacts on the landscape entity of the area.

The plant will not cause significant impacts on other valuable landscape and/or cultural environment sites in the region.

8.7.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

8.7.2.1 Current landscape and cultural environment

The landscape in Ruotsinpyytää is subtle due to the broken nature of the soil, bedrock and sea bays, the varied features of the archipelago, and the diversity of business in the area. The built environments in the region's shore and archipelago area range from large industrial and power plant surroundings to small-scale holiday homes. (*Landscape working group report I.*)

The Gäddbergsö and Kampuslandet options are located in the area of an archipelago landscape formed by the natural environment, holiday homes and small-scale cultural environments. The existing nuclear power plant located on the western side of Gäddbergsö is an important landmark in the area. Both of the site options are part of the inner archipelago zone where islands are large and forested. The landcape in the Gäddbergsö site is limited by the mainland coast and the large islands of the inner archipelago. Kampuslandet borders on the open outer archipelago and open sea zone in the south.

Gäddbergsö and Kampuslandet are mainly natural areas, although extensive fellings have altered the landscape in places. The terrain in the location sites is varied and rocky in terms of topography. The height of the terrain in the power plant construction area on Gäddbergsö range from 0–35 meters above sea level. The highest spot on the island is Kasaberget, which is clearly distinguishable in the landscape and reaches 42.5 meters above sea level. The highest part of Kampuslandet is Högberget, the summit of which is 27.5 meters above sea level.

Both Gäddbergsö and Kampuslandet have holiday homes, and Gäddbergsö also has some permanent housing, traditional buildings and some small field/meadow areas. For the most part, the areas are natural and are also perceived as such in the remote landscape. There are a lot of holiday homes on the shores in the vicinity of the location sites. The headland on the eastern side of the islands also has some permanent housing, the Tallbacka village that is most visible in the landscape, and a few old farms. The area designated as suitable for wind power production in the Itä-Uusimaa regional plan (2007) is important in terms of landscape. The existing nuclear power plant located on the western side of Gäddbergsö is an important landmark in the area.

The views on the islands are mainly limited due to the trees and lack of open areas. Open views towards the islands extend from the surrounding shore areas and the open sea. The islands in the area partially block open sea views from the south to Gäddbergsö. Located on the edge of the outer archipelago zone, Kampuslandet is visible in an extensive area. Viewed from the north, Gäddbergsö dominates the landscape and blocks views towards Kampuslandet

Valuable sites in the landscape and cultural environment

This section lists the sites of value that, on the basis of map information and field visits, may be impacted by construction of the power plant. Other valuable sites in the region are such with regard to their character or location that there will not be any adverse impact on their values.

– Gäddbergsö's Kasaberget is a valuable geological formation (*Regional Council of Itä-Uusimaa 2007*)
– Some of the Gäddbergsö and Kampuslandet shores, the Tallbacka area, and smaller islands near Kampuslandet are regionally important areas with regard to the cultural environment or landscape Some of the islands and headlands and a small area in the northern part of Gäddbergsö are reserved in the regional plan as environmentally significant areas primarily used for agriculture and forestry (*Regional Council of Itä-Uusimaa 2007*)
– There is a historical monument in the Bullers area along the new power line route (stone structures from the historical period) (*Environmental Administration's Map Service 2008, Built Cultural Environment)*
– There are buildings close to the both alternative power plant sites that are included in the inventory of culture historical sites prepared for the component master plan in the area (*Inventory of Culture Historical Sites 1999*).

8.7.2.2 Impacts on the landscape and cultural environment

Gäddbergsö

The Gäddbergsö site option is located in the same inner archipelago and continental coastal landscape as the existing Loviisa nuclear power plant. The new nuclear power plant will expand and reinforce the landscape impact of the heavily built power plant environment in Hästholmsfjärden and Klobbfjärden. In the Klobbfjärden landscape the new power plant site will change the character, hierarchy and views of the landscape. When examined broadly, the new power plant will continue the industrial zone that interlocks with the natural areas, cultural environments and holiday homes located on the headlands and islands in the mainland shore and inner archipelago zones of the Loviisa region. Kasaberget and the other forested ridges in the area provide a certain amount of scale support for the large structure (Figure 8-58 and Figure 8-59).

Figure 8-58. Photomontage: The nuclear power plant in the Gäddbergsö headland. There are two power plant units in the figure. The figure for a single power plant unit option is presented in Chapter 1.4.1, which addresses location alternatives.

Figure 8-59. Photomontage: The nuclear power plant in the Gäddbergsö headland viewed from the sea.

The only real views towards the power plant will be from the sea and the shores. The highest power plant structures may be visible in places from behind the edge of the forest, for example, to roads, field or meadow areas, yards, and clear felling areas as well as open or lightly forested bedrock areas that face the power plant.

The environment near the permanent housing and holiday houses in the immediate surroundings of the Gäddbergsö site and its status in the landscape entity will change significantly as a result of plant construction, even though there may be no direct line of sight to the power plant and the main views from the yards of the buildings towards the sea will remain unchanged. The main visibility axles toward the sea will change significantly from the north in the direction of Klobbfjärden, where there is a lot of holiday housing on the shores. Due to the limitation and orientation of the landscape, the bay and its shore areas are completely within the plant's dominant zone. The views from the south will also change significantly in places, but this will be partially obstructed by the forested ridges on the southern side of the nuclear power plant. Due to the characteristics and types of environment in the region, as well as the size and nature of the project, the impacts of the project on the sea landscape as viewed from the holiday homes are perceived as adverse. On the other hand, a nuclear power plant is already part of the sea view from many holiday homes in the Klobbfjärden area. The new power plant next to the current plant will significantly increase the dominance of power plant buidings in the area which, together with new power lines, will change the character of the area's landscape entity.

The local impacts on the landscape will be significant because the current forested natural areas of the archipelago will become a built environment with large buildings, fields, new traffic connections, power lines, accommodation areas, and other structures. The current buildings in the plant area will be removed from use or their purpose will be changed. Implementation of large structures in an area with varying terrain forms may require extensive modification of the terrain. The harbour will change the present character of the shore, but will later blend in with the power plant's built zone.

As a result of the new power line route, the present closed forest areas will be the site of a new open power line corridor that, depending on the tower solution, will be approximately 80–120 meters wide. The new power plant corridor will be a dominant element and change the landscape significantly when running through the narrow isthmus of the Reimars area and the Bullers area that include traditional buildings, and when being located in the narrow isthmus north of Bullers in its direction. The power line route will run towards north and will be connected to the national grid at a distance of about 15 kilometers from the nuclear power plant. Fingrid Oyj will define the route if the project advances in Ruotsinpyhtää.

Water intake and discharge on the rather steep and rocky shores do not require large embankments, but will be visible as concrete structures in the shore zone. Due to the impact of warm water, the sea in front of the discharge site will remain open in the winter in an area of varying size. A cloud of fog can form above the unfrozen area on calm, subzero days.

In the dark, the power plant lighting will be visible in an area that is otherwise almost completely dark and its glow may be visible to great distances. When viewed from the north, the existing and new power plants will dominate a landscape that is otherwise almost completely dark. The significance of the plant as a new regional landmark may be emphasised in the dark in both the Gäddbergsö and Kampuslandet alternatives.

Kampuslandet

Kampuslandet is located on the outer edge of the inner archipelage, bordering on the open outer archipelago and open sea zone in the south. The area has long, open visibility axles from the sea. The power plant will create a new landmark that dominates a landscape that, in terms of its character and size, is mainly perceived as a natural area and an archipelago environment entity shaped by small-scale cultural environments. The character and views of the landscape will change significantly in the area. In the dark, the dominant position of the lighted power plant in the landscape may be emphasized.

As small-scale elements gradually disappear when viewed from an increasing distance from the open sea, the nuclear power plant will no longer clearly dominate the individual elements of its surroundings, but will receive scale support from the extensive open sea zone and the inner archipelago and silhouette of the continental coastline in the background. In certain places, remote views may exist in which the new power plant and Loviisa's existing power plant and the Valko plant area structures can be seen. When examined broadly, the new power plant continues the industrial zone that inter-locks with the natural areas and holiday homes located on the headlands and islands of the Loviisa region (Figure 8-60 and Figure 8-61). With the exception of open water ar-eas, there are only a few open areas near the power plant, meaning that the only views towards the power plant are from the sea and the shores. The highest power plant structures may be visible in places from behind the edge of the forest, for example, from roads, field or meadow areas, yards, and clear felling areas as well as lightly forested bedrock areas that face the power plant.

The immediate surroundings of the holiday homes located in the north of Kampuslandet and their position in the landscape entity will change significantly, even through the main views from the yard areas of the buildings towards the sea in the north will mainly remain unchanged. The main visibility axles towards the sea will change significantly from the homes and holiday homes located in the east on the Tallbacka shore, in the north on the southern shore of Gäddbergsö, and on the small islands around Kampuslandet. The impact on the sea landscape extending from the homes and holiday homes will probably be perceived as adverse. The sea views from the

Figure 8-60. Photomontage: The nuclear power plant on Kampuslandet Island. There are two power plant units in the figure. The figure for a single power plant unit option is presented in Chapter 1.4.1, which addresses location alternatives.

Figure 8-61. Photomontage: The nuclear power plant on Kampuslandet Island viewed from the sea.

holiday homes on the shores of Klobbfjärden in the north also face the power plant area, but Gäddbergsö will partially block the structures from view. From this direction the structures are unlikely to clearly dominate the landscape because the distance to the power plant is several kilometers.

The local impacts on the landscape in the power plant area will be significant. The present rocky insular forest of varying terrain will be transformed into a built-up environment of large scale with its buildings, fields, new traffic connections, power lines and other structures. The current buildings in the plant area will be removed from use or their purpose will be changed.

The new road, its connecting bridge and the new power lines will run parallel through the open landscape in the strait between Kampuslandet and Gäddbergsö, changing the character of the landscape status and sea views in the area significantly. As a result of the new power line route, the present closed forest areas will be the site of a new open power line corridor that, depending on the tower solution, will be approximately 80–120 meters wide. The new power plant corridor will be a dominant element and change the landscape significantly when running through the narrow isthmus of the Reimars area and the Bullers area that include traditional buildings, and when being located in the narrow isthmus north of Bullers in its direction. The power line route will run towards north and will be connected to the national grid at a distance of about 15 kilometers from the nuclear power plant. Fingrid Oyj will define the route if the project advances in Ruotsinpyhtää.

Water intake and discharge can be seen in the coastal zone as concrete structures. Due to the impact of warm water, the sea in front of the discharge site will remain open in the winter in an area of varying size. A cloud of fog can form above the unfrozen area on calm, subzero days. The power plant harbour will differ significantly from the present character of the shore, but if implemented the plant will blend in with its built zone.

Impacts on sites of value (Gäddbergsö and Kampuslandet)

In both alternatives the construction of a nuclear power plant in the landscape detracts from the status of Kasaberget as a focal point of the regional landscape.

The Kampuslandet option will cause significant impacts on the environment of the cultural environment or landscape entities with regional importance indicated in the regional plan (e.g. the Tallbacka village, islands surrounding Kampuslandet), as well as on the character, image and position of the landscape in the landscape entity. The Gäddbergsö alternative will also change the views from the above-mentioned sites of value, and will also have impact on the status of the areas in the landscape entity. The Bullers historical monument is located in the area of the new, preliminarily planned, power line route. Any related impacts must be identified and studied as the power line planning proceeds.

There are traditional buildings in the immediate surroundings or the plant area of both site options that area included in the cultural environment inventory prepared alongside the area's master plan (*Inventory of Culture Historical Sites 1999*). The Gäddbergsö option may have impact on the following sites included in the inventory: Björkboda, Bullers, Bullers folkskola, Reimars, Vannäs and Lugnet. The Kampuslandet option may have impact on the following sites: Bullers, Bullers folkskola, Reimars, Stenbacka, Käldas, Österudd and Lugnet.

The plant will not cause significant impacts on other valuable landscape and/or cultural environment sites in the region.

8.7.3 Simo, Karsikko

8.7.3.1 Current landscape and cultural environment

Karsikkoniemi is located on an even land-uplift zone at the bottom of the Bothnian Bay, many parts of which are built. The built environments range from large industrial, power plant and harbor environments to small-scale holiday homes. Karsikkoniemi is part of a chain of coastal headlands and islands. The headland is directly connected to the open sea zone without an archipelago zone in between.

The shores of Karsikkoniemi follow the built zone. Although the majority of construction in the area is holiday homes, there is also some permanent housing. The southeast section of the headland is the site of the Karsikko fishing harbor and the former Karsikko fishing village. The other parts of the headland are primarily natural areas that have been modified by felling. Laitakari island lies immediately south of the headland and is the site of some holiday homes. The nearest large areas of settlement (Hepola, Marostenmäki, Maksniemi) are located approximately 4-5 kilometers from the plant area. The islands and headlands located west of Karsikkoniemi in the Kemi-Tornio area have heavy industry, harbor operations and wind power plants, the structures of which are visible in the landscape from afar. The Lapland sea and coastal area regional land use plan (2005) for wind power designates three areas where it is possible to build wind power plants in the Karsikko environment.

The height differences of the terrain in the plant area range between 0-8 meters above sea level. The terrain rises fairly evenly towards the north, and the highest points on the southern side of Trunk Road 4 are about 20 meters above sea level. The Marostenmäki-Kirnuvaara ridge and related Puntarniemi area forms an entity that can be distinguished in the landscape (the highest point is 17.5 meters above sea level).

With the exception of sea views extending from the shores, the views in the Karsikko area are mainly limited because of vegetation and structures. Longer views within the area are mainly via clear felling areas, road routes, power line clearings, a few small fields and meadows and sparsely forested or treeless swamps.

Open views from outside the area towards Karsikkoniemi extend from the sea and surrounding shore areas because there are no islands to cut off the views. As a result of the terrain and forest clearings, views from Trunk Road 4 also extend towards the plant area in places.

Valuable sites in the landscape and cultural environment

This section lists the sites of value that, on the basis of map information and field visits, may be impacted by construction of the power plant. Other valuable sites in the region are such with regard to their character or location that there will not be any adverse impact on their values based on their preliminary inspections.

- The former fishing village of Karsikko located in the southeastern part of Karsikkoniemi is a nationally important cultural historical environment The same fishing village environment includes a building assessment site and a built heritage man-agement assistance site. The area also has a traditional rural biotope, the Karsikko field. *(Environmental Administration's Map Service 2008, Built Cultural Environment*)
- There are several built heritage and antiquity sites in the vicinity of the power plant (*(Environmental Administration's Map Service 2008*)
- The cultural landscape at the mouth of Simojoki river is a nationally important landscape The western edge of the area comes within five kilometers of the location of the power plant at its nearest point (*Environmental Administration's Environmental Information System 2008, Landscape working group report II*)

8.7.3.2 Impacts on the landscape and cultural environment

The natural area of the headland will change dramatically into a built power plant environment. The large power plant will differ significantly from the rest of the dominant zone's environment in terms of character and size, thus forming a landmark that from the sea will be distinguishable in an area that is perceived in the remote landscape as a natural area or holiday home zone. From the sea, there are very few elements to cut off the views. Views from the shores of the surrounding headlands and islands extend towards the power plant (Figure 8-62 and Figure 8-63).

The significance of the landscape impact from each observation point will depend on the distance and the dominance of the plant in the visibility sector. The position of Karsikko in the wider landscape entity is affected by the industrial, harbor and power plant areas in the Kemi-Tornio shore areas. The gentle terrain in the region will provide little scale support for the large building but, on the other hand, the terrain is large-scale continental coast, meaning that the power plant will be seen against a silhouette that includes the forested continental coast and industrial structures as well as the extensive open water surface.

The character and dimensions of the power plant structures will clearly differ from the other construction in the zone of dominance. However, when examined in a broader sense, the power plant will continue the chain of large harbor and industrial areas and wind power plant areas located on the islands and the headland, thus extending the landscape impact of the “industrial zone” in a more easterly direction. On the western side of Karsikkoniemi, the landscape in the landscape space surrounding Ajos already includes heavy structures (a plant, wind power plants, power lines, a harbor). By character, the eastern side of Karsikkoniemi is a natural area and a zone of small-scale housing and holiday homes. When examined from this direction, Karsikkoniemi serves as a kind of buffer before the Ajos and Veitsiluoto industrial zone; although industrial or power plant structures are visible on the horizon they are part of the remote landscape.

The new power plant would make the strongly built human activity zone part of the landscape east of Karsikko.

In terms of homes and holiday homes, there will be significant impacts on the main visibility axles towards the sea in the zone of dominance from the directions of Puntarniemi and Laitakari. Although the distance to the power plant is 4.5 kilometers, the sea views from the western shore of Ykskuusi will change significantly because the shore faces directly towards the plant area. The views from the homes and holiday homes in the Ajos, Ajoskrunni and Koivuluoto shore areas will also change. Due to the region’s characterstics and the project’s scale and character, the project’s impact on the sea landscape opening from the houses and holiday homes will probably be perceived as adverse, event though the landscape on the west of Karsikko is already characterized by industrial structures.

The views within Karsikkoniemi towards the power plant extend through open areas (open felling areas, roads facing the power plant area, open meadows and swamps, power line corridors or similar). The views to the power plant will also extend from the upper floors of newer residential buildings in the northern part of Karsikkoniemi and from Trunk Road 4 in places.

In the dark, the power plant lighting will stand out from other lighted sites in a relatively dark area. The glow may be visible from afar. Due to the presence of other similar sites, the impact in the landscape on the western side of Karsikkoniemi is not as significant as that on the eastern side, where the power plant will clearly stand out as a single lighted site in an environment that is otherwise nearly dark.

The local impacts of construction on the landscape will be significant if the current forested natural area, which has been modified by major felling, becomes a large-scale built environment. The new road connection to be built to Laitakari and the related embankment or bridge will

Figure 8-62. Photomontage: The nuclear power plant in Karsikkoniemi. There are two power plant units in the figure. The figure for a single power plant unit option is presented in Chapter 1.4.1, which addresses location alternatives.

Figure 8-63. Photomontage: The nuclear power plant in Karsikkoniemi viewed from the sea.

change the small-scale and low-lying shore landscape at the tip of the headland to a certain degree.

A quay will be built in the Prusinperä area on the western shore of Karsikkoniemi. A channel structure that is about 50 meters long and 30 meters wide will be built north of the quay for water discharge purposes. The structure will be bordered by embankments that are about 10 meters wide. The structures related to water intake will be located invisibly underwater in the open sea or on the shore, in which case a quay-like concrete structure will be visible. Due to the impact of warm water, the sea in front of the discharge site will remain open in the winter in an area of varying size. A fog cloud can form above this area on calm, subzero days. The character of the shore zone will change, but the landscape impacts of the structures located on the shore will not be significant in the future when the power plant dominates the landscape of the headland.

The route of the new power line corridor will, according to preliminary plans, run mainly through the forested swamp and ridge areas towards north and will be connected to the national grid at a distance of 20 kilometers from the nuclear power plant. Fingrid Oyj will define the route if the project proceeds in Simo. The current closed forest areas will be the site of a new open power line corridor that, depending on the tower solution, will be approximately 80-120 meters wide.

Impact on valuable sites

Implementation of the power plant will not cause direct impacts on the nationally important former fishing village area in Karsikko. The status of the village will change significantly when the adjacent natural area becomes a large-scale power plant environment. The hierarchy of the landscape and the character of the area will change as the nuclear power plant dominates the headland landscape.

The views from the nationally important landscape area at the mouth of Simojoki river to the west and Karsikko will change in places. However, the landscape impact of the nuclear power plant cannot be considered to be of significant harm in terms of value due to its distance from the area (approximately five kilometers at its nearest point).

In the more detailed planning of power lines, the relationship to the antiquities in the northern part of Karsikkoniemi must be examined.

8.8 Traffic and safety

The traffic flow caused by the nuclear power plant and the principles of calculation are presented in Chapter 3.11. The following section assesses the impacts that traffic during the nuclear power plant operations will have on traffic. Traffic volumes during annual maintenance will be larger than normal, thereby increasing the traffic volumes on the roads to the power plant. Annual maintenance usually lasts from one to two months, so its possible adverse effects on traffic only last for this limited period. Furthermore, annual maintenance usually takes place in the summer when other traffic on the main routes is less than at other times of the year.

8.8.1 Impacts on traffic in the Pyhäjoki alternative

Current state of traffic and plans

The traffic connection to the Pyhäjoki location will run along Trunk Road 8 (E8) and a diverging road to be built for the nuclear power plant.

No significant improvement plans have been made for Trunk Road 8 at Pyhäjoki. The long-term plan of the Road Administration's Oulu Road Region (*Oulu Road Region 2002*) presents the construction of a passing lane on Trunk Road 8 south of Raahe. A light traffic route is planned for the Pyhäjoki–Parhalahti section of Trunk Road 8 (*Oulu Road Region 2008*).

Impacts on traffic and safety

Approximately 60% of the nuclear power plant traffic volumes is expected to come from the north and 40% from the south in accordance with the distribution of population in the Raahe economical area.

The attached map (Figure 8-64) illustrates the impact that traffic caused by nuclear power plant operations will have on the traffic on roads leading to the location site. The map shows three figures: current traffic volumes on weekdays, traffic volumes in 2030 according to the Road Administration's growth forecast (Road Administration 2007) and the changes in 2030 traffic volumes caused by the nuclear power plant. The volume of heavy traffic is presented in parentheses.

Nuclear power plant traffic will only have a minor effect on traffic volumes on Highway 8. Overall traffic volumes on the trunk road near the intersection leading to the nuclear power plant will increase by approximately 7–10% and heavy traffic volumes by about 2–4%.

Nuclear power plant traffic will not have a significant impact on trunk road traffic safety. The possible construction of a new passing lane south of Raahe will improve traffic flow. The new light traffic route will also ensure the safety of light traffic.

The new road to be built from the trunk road to the nuclear power plant will be designed to be suitable for the use of traffic required by the power plant. The intersection from the trunk road will be designed to be safe and smooth by means of preselection lanes and speed limits.

8.8.2 Impacts on traffic in the Ruotsinpyhtää alternative

Current state of traffic and plans

The traffic connection to the Ruotsinpyhtää location will run along Trunk Road 7. The trunk road has two junctions to Saaristotie road leading to the tip of the Vahterpää headland: an eastern junction via Mannerheimintie road and a western junction via Helsingintie road. A new road to be built for the new nuclear power plant will diverge from Saaristotie road at Reimars, leading to Gädd-

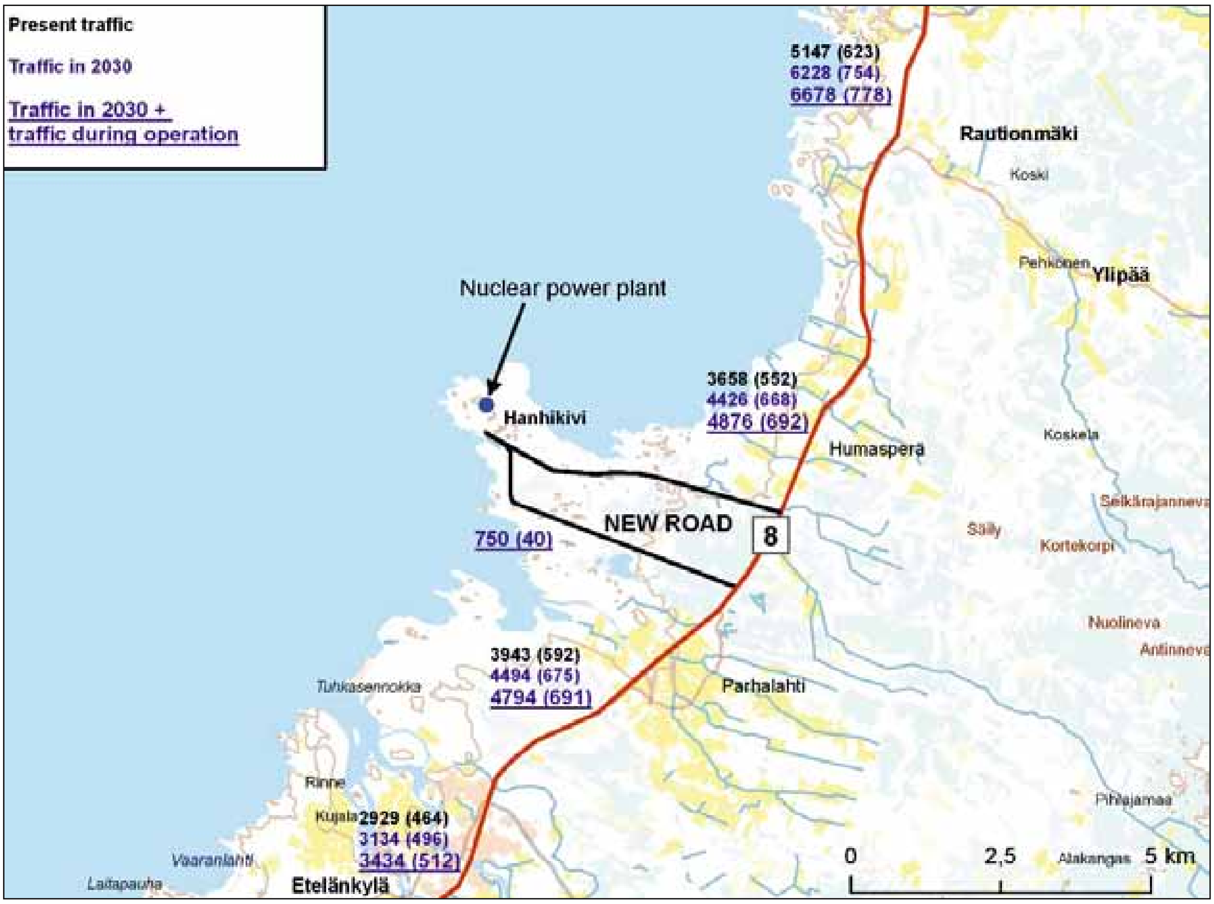
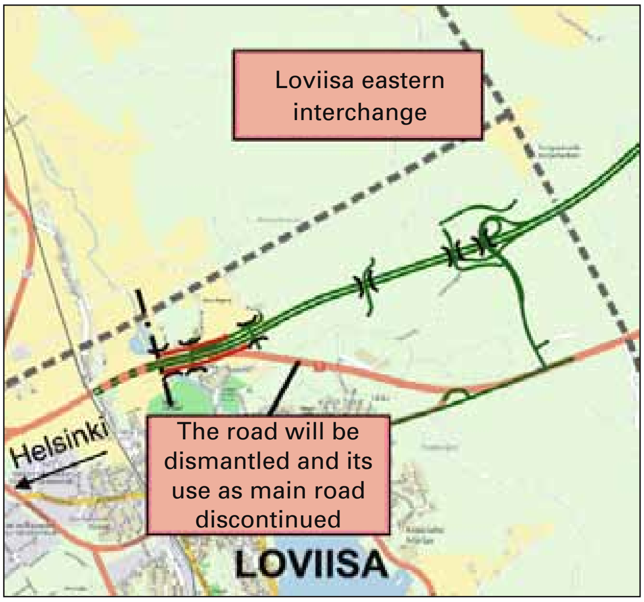


Figure 8-64. Current traffic volumes on weekdays near the Pyhäjoki location, traffic volumes in 2030 according to the Road Administration's growth forecast and change in 2030 traffic volumes caused by the nuclear power plant. The volume of heavy traffic is presented in parentheses.

Figure 8-65. Koskenkylä–Loviisa–Kotka motorway interchange at the boundary of Loviisa and Ruotsinpyhtää *(Kaakkois-Suomi Road Region 2008).*



bergsö headland and onward to Kam-puslandet island.

In 2007, the Kaakkois-Suomi Road Region compiled a general plan for upgrading the Koskenkylä-Loviisa-Kotka section of Trunk Road 7 to a motorway. The Road Administration's aim is to build the road in 2009-2011. The project would comprise upgrading the current trunk road to a motorway from Koskenkylä to Loviisa (17 kilometers) and construction of a motorway from Loviisa to Kotka (39 kilometers). An interchange pro-viding a connection to Mannerheiminkatu road is shown at the boundary of Loviisa and Ruotsinpyhtää (Figure 8-65). (*Kaakkois-Suomi Road Region 2008*)

A new road connection from the planned motorway to Saaristotie road, an extension of Atomitie road, is shown in the component master plan for the northern part of Loviisa and the Tesjoki areas of Ruotsinpyhtää The route of the Atomitie road extension from the planning area in the Loviisa and Ruotsinpyhtää component master plan to the existing Atomitie road is shown in the proposal for Loviisa's shoreline component master plan on 3 May 2008. The municipalities' joint component master plan has been approved in the City Planning Committee and delivered to the Ministry of the Environment for confirmation (*City of Loviisa 2008*).

Impacts on traffic and safety

Approximately 45% of traffic to the nuclear power plant is expected to come from the east, 45% from the west and the remaining 10% from Loviisa. The estimate is based on the distribution of population in the Loviisa economical area.

The attached map (Figure 8-66) illustrates the impact that traffic caused by nuclear power plant operations will have on the traffic on roads leading to the location

Figure 8-66. Current traffic volumes in Ruotsinpyhtää and Loviisa on weekdays, traffic volumes in 2030 according to the Road Administration's growth forecast and the change in 2030 traffic volumes caused by the nuclear power plant.

site. During assessment, it has been assumed that the new motorway and interchange to the extension of Atomitie road are in use, in which case there is a connection from the motorway to Saaristotie road via the Atomitie road extension. The map shows three figures: current traffic volumes on weekdays, traffic volumes in 2030 according to the Road Administration's growth forecast and the change in 2030 traffic volumes caused by the nuclear power plant. The volume of heavy traffic volumes is presented in parentheses.

Nuclear power plant traffic will only have a minor effect on Trunk Road 7 or motorway traffic volumes. The maximum increase in total traffic volume on the trunk road or motorway will be approximately 5% and about 1% for heavy traffic. If the Atomitie road extension is realized, traffic volumes at the start of Saaristotie road and on the Helsingintie and Mannerheiminkatu roads will increase slightly because only the personnel living in downtown Loviisa will use that route to reach the plant. This will cause a 2.5-fold increase the traffic volume at the other end of Saaristotie road from Atomitie road to Reimars.

The new motorway will improve traffic flow and safety and the nuclear power plant traffic would barely affect the situation. The traffic conditions on Saaristotie road from Atomitie road will change significantly and traffic safety may decrease. The new road and its intersection from Saaristotie road to the nuclear power plant will be built in a smooth and safe manner.

8.8.3 Impacts on traffic in the Simo alternative

Current state of traffic and plans

The traffic connection to the Simo location runs along

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Figure 8-67. The improvement plant for Trunk Road 4 at Kemi (Lapland Road Region 2008).

Trunk Road 4, turning onto Karsikontie road, which leads to Karsikkoniemi.

The Lapland Road Region will upgrade Trunk Road 4 at Kemi in 2007–2010 (Figure 8-67). The road section being upgraded begins at Maksniemi in Simo and ends at the Kemi-Tornio motorway in Keminmaa. The road section that begins at Karsikontie road on the southern boundary of Kemi and ends near the Ajos interchange will be upgraded to a divided four-lane road. The existing trunk road north of the Ajos junction will be upgraded to a motorway. A game fence and noise protection will be built on some road sections. (*Lapland Road Region 2008*)

Impacts on traffic and safety

Approximately 70% of the nuclear power plant traffic volume is expected to come from the north and 30% from the south in accordance with the distribution of population in the Kemi-Tornio economic area. The attached map (Figure 8-68) illustrates the impact that traffic caused by nuclear power plant operations will have on the traffic on roads leading to the location. The map shows three figures: current traffic volumes on week-days, traffic volumes in 2030 according to the Road Administration's growth forecast and the change in 2030 traffic volumes caused by the nuclear power plant. The volume of heavy traffic is presented in parentheses.

Nuclear power plant traffic will only have a minor effect on Trunk Road 4 traffic volumes. The total volume of traffic on the trunk road will increase by approximately 3-6% and heavy traffic by about 2-4%.

The new motorway will improve traffic flow and safety and the nuclear power plant traffic would barely affect the situation. The volumes of traffic on Karsikontie road will change significantly and traffic safety may decrease. However, the road will be improved to make it suitable for the nuclear power plant traffic, in which case safety and traffic flow will be taken into consideration.

8.9 Noise

Noise impacts during construction of the nuclear power plant are described in section 8.2.1.4, which addresses the impacts of construction. The following sections assess noise impacts from the power plant area in the operating phase of the nuclear power plant and those caused by traffic to the power plant in the alternative nuclear power plant locations on the basis of the noise modeling.

Equipment and functions causing noise during the operating phase include unit generator transformers, the steam turbine and generator, blowers in the turbine house, the sea water pumping station, backup generator units, the gas turbine unit and traffic towards the plant area. The largest noise impact occurs in the immediate vicinity of the turbine hall and transformer.

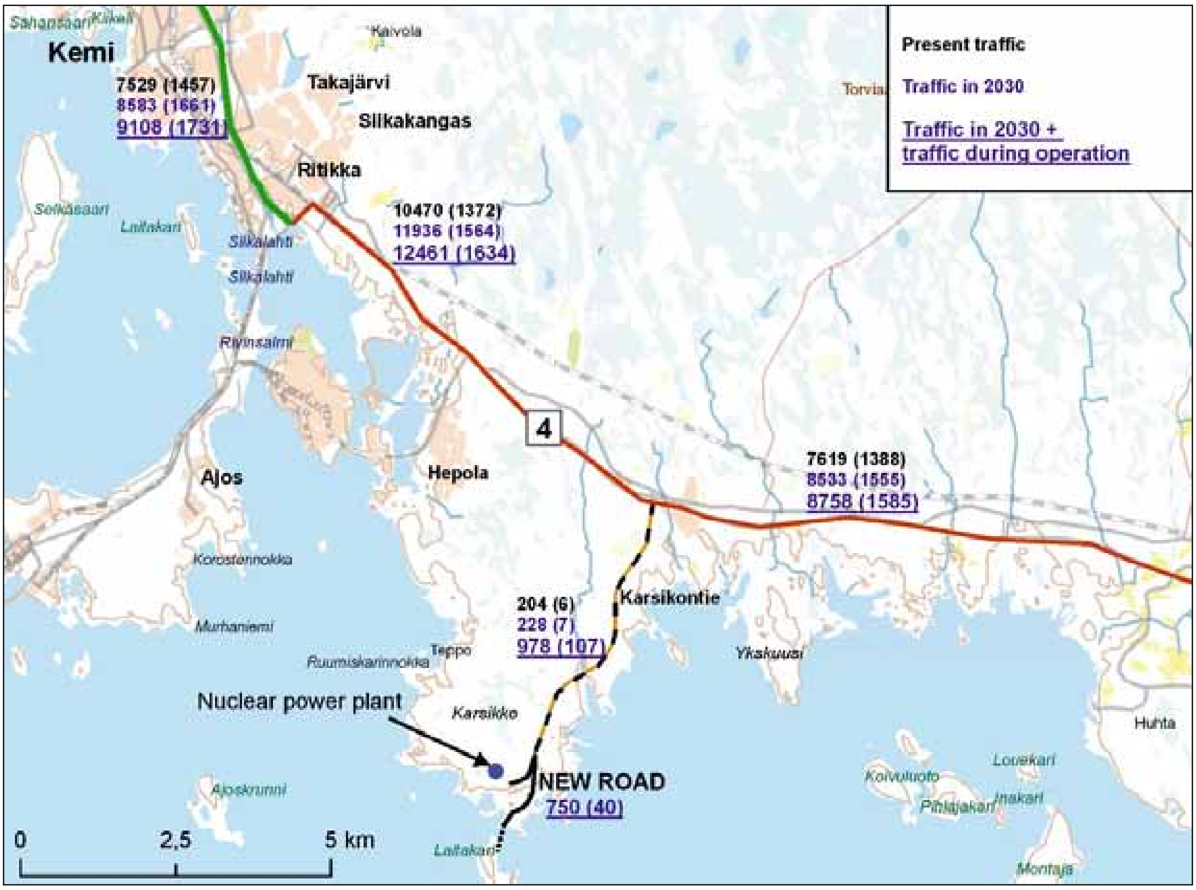


Figure 8-68. Current traffic volumes in Simo and Kemi on weekdays, traffic volume in 2030 according to the Road Administration's growth forecast and the change in 2030 traf-fic volume caused by the nuclear power plant.

8.9.1. Noise impact and the Government's guidelines

The unit of sound volume is decibel (dB). Examples of different decibel levels are listed below:

auditory threshold	**0 dB**
leaves	10 dB
wristwatch ticking	20 dB
whisper	30-40 dB
office	50-60 dB
restaurant, department store	60 dB
busy street	80 dB
passing truck	yli 90 dB
rock concert	100-120 dB
pain threshold	130 dB
jet plane	140 dB

The weighted decibel scale dB(A) takes into account that the human ear hears different frequencies differently. In accordance with section 9 of the Noise Prevention Act 382/87) passed on 3 April 1987, the Government has decided on outdoor guideline values for the A-weighted equivalent sound level (L_{Aeq}). The guideline in residential areas, recreational areas in settlements and in the immediate vicinity of settlements and areas serving care or educational institutes is that the noise level may not exceed the daytime (7 am – 10 pm) guideline of the A-weighted equivalent sound level (L_{Aeq}) of 55 dB or the night-time (10 pm – 7 am) guideline of 50 dB. The nighttime guideline value in new areas is 45 dB. In areas used for holiday homes, the A-weighted average sound level L_{Aeq} guideline values are 45 dB(A) in the daytime and 40 dB(A) at night. However, the general guideline values for housing areas can be applied to areas used for holiday homes in settlements. The nighttimetime guideline value is not applied in nature conservation areas that are not normally used for outdoor activities or nature observations at night.

8.9.2 Pyhäjoki, Hanhikivi

8.9.2.1 Current noise situation

There are some holiday homes in the vicinity of the nuclear power plant planned for Hanhikivi headland, primarily near the shore on both sides of the headland At present, there is no activity that causes significant noise.

The location near the sea is quite favorable in terms of spreading noise and, in particular, the spreading of noise along the water surface helps to spread low frequencies quite far in calm weather.

8.9.2.2 Noise impacts

In the case of a single 1,800 megawatt unit (Figure 8-69), the average sound level L_{Aeq} during continuous basic operation of the nuclear power plant will be 45-47 dB(A) in holiday homes located on the western shore of the headland. The average sound level in holiday homes now located on the southwest and northeast shores of the headland will be approximately 40 dB (A). The 40 dB (A) sound zone caused by road traffic to the plant stretches for about 180 meters from the road on both sides.

In the case of two 1,250-megawatt units (Figure 8-70), the average sound level L_{Aeq} caused by continuous operation of the nuclear power plant will be 46–51 dB(A) in holiday homes now located on the western shore of the headland about half a kilometer from the power plant buildings. The average sound level will be 40–45 dB(A) in holiday homes located slightly farther away at a distance of approximately one kilometer from the construction site. The impact of traffic noise is the same as in the case of a single 1,800-megawatt unit.

In the case of a single power plant unit, the night-time guideline value of 40 dB (A) will be exceeded in about 15 holiday homes located in the vicinity of the location. The daytime guideline value of 45 dB (A) will be exceeded in a few holiday homes. Noise levels in the majority of the current holiday homes in the environment will remain below the guideline value. In the case of two power plant units, the night-time guideline value of 40 dB (A) will be exceeded in about 20 holiday homes and the daytime guideline value of 45 dB (A) in about 10 holiday homes. Some of the holiday homes located on the northwest coast and the holiday homes on the west coast of the headland will probably be removed as the plant project proceeds.

The noise caused by traffic to the plant will not have significant impacts because there are no holiday homes in the area.

In addition to the noise resulting from continuous basic operation of the nuclear power plant, test use of the plant's backup power systems will occasionally cause noise. In such cases, the daytime guideline value of 45 dB (A) for the nearest holiday home areas will

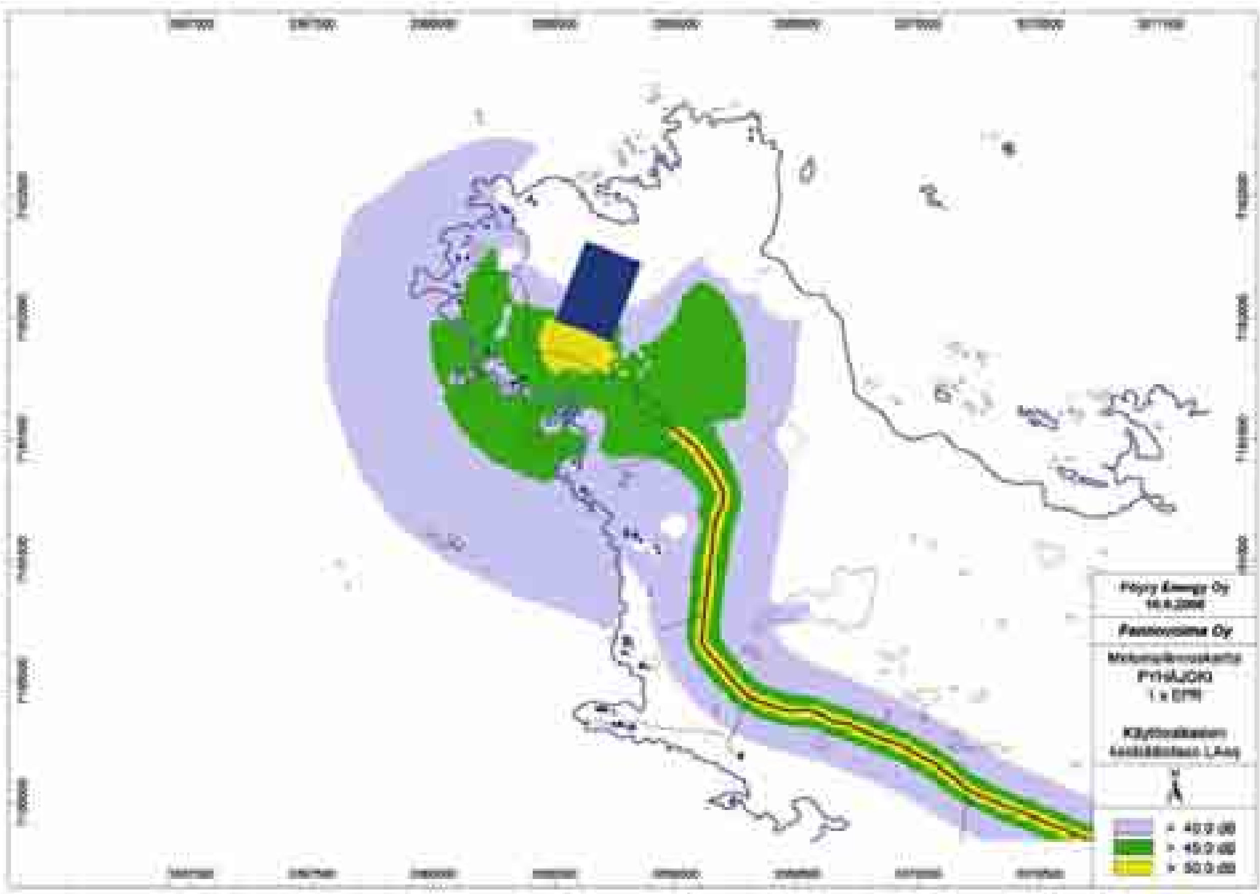


Figure 8-69. Noise caused by nuclear power plant operations (one 1,800 megawatt unit) in the vicinity of the Hanhikivi headland location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

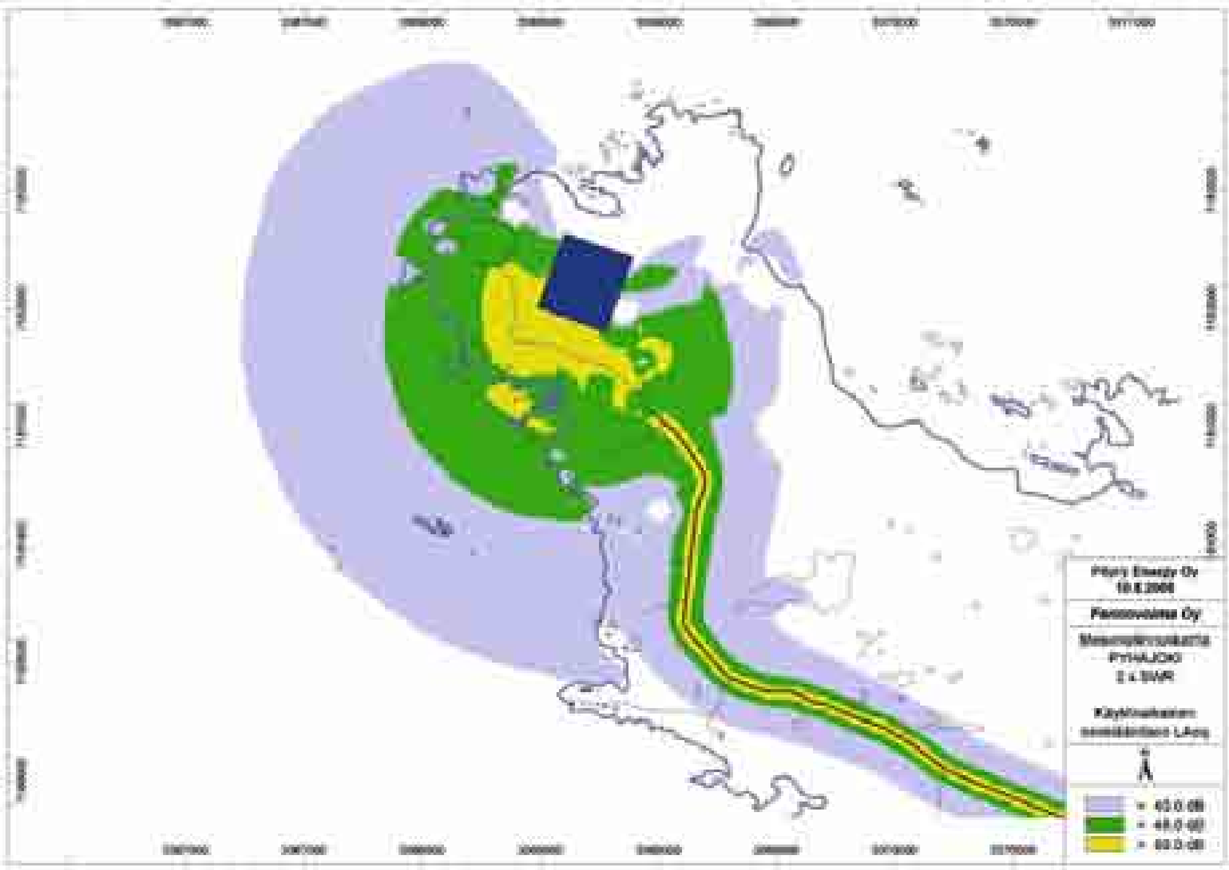


Figure 8-70. Noise caused by nuclear power plant operations (two 1,250-megawatt units) in the vicinity of the Hanhikivi headland location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

be exceeded in holiday homes. However, the backup power plant test use time only lasts for a few hours each year and happens during the daytime, meaning that the noise impacts related to these situations will not be very significant.

8.9.3 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

8.9.3.1 Current noise situation

The majority of holiday homes on Kampuslandet are in the northern part of the island. Most of the holiday homes in the vicinity of the Gäddbergsö location are near the shore on both sides of the headland.

There are currently no functions causing significant noise in the vicinity of the planned power plant locations.

The archipelago conditions in the vicinity of the Kampuslandet and Gäddbergsö locations are favorable with regard to the spreading of noise, and in particular the spreading of noise along the water surface helps to spread low frequencies quite far from the plant in calm weather.

8.9.3.2 Noise impacts

Kampuslandet

In the case of a single 1,800-megawatt unit (Figure 8-71), the average sound level L_{Aeq} during continuous basic operation of the nuclear power plant will be approximately 40–42 dB(A) in the holiday homes located on the northeast shore of the island within one kilometer of the nuclear power plant buildings. The 40 dB(A) zone caused by road traffic noise will extend to an average distance of 180 meters on both sides of the road.

In the case of two 1,250-megawatt unit (Figure 8-72), the average sound level L_{Aeq} during continuous basic operation of the nuclear power plant will be approximately 43-45 dB(A) in holiday homes located on the northeast shore of the island within one kilometer of the nuclear power plant buildings. The impact of traffic noise is the same as in the case of a single 1,800-megawatt unit.

Gäddbergsö

In the case of a 1,800-megawatt unit, the average sound level L_{Aeq} will be approximately 40 dB(A) in the closest holiday homes located a few hundred meters from the power plant buildings (Figure 7-73). The 40 dB(A) zone caused by road traffic noise will extend to an average distance of 180 meters on both sides of the road.

In the case of two 1,250-megawatt unit, the average sound level LAeq will be approximately 40 dB(A) in the closest holiday homes located a few hundred me-

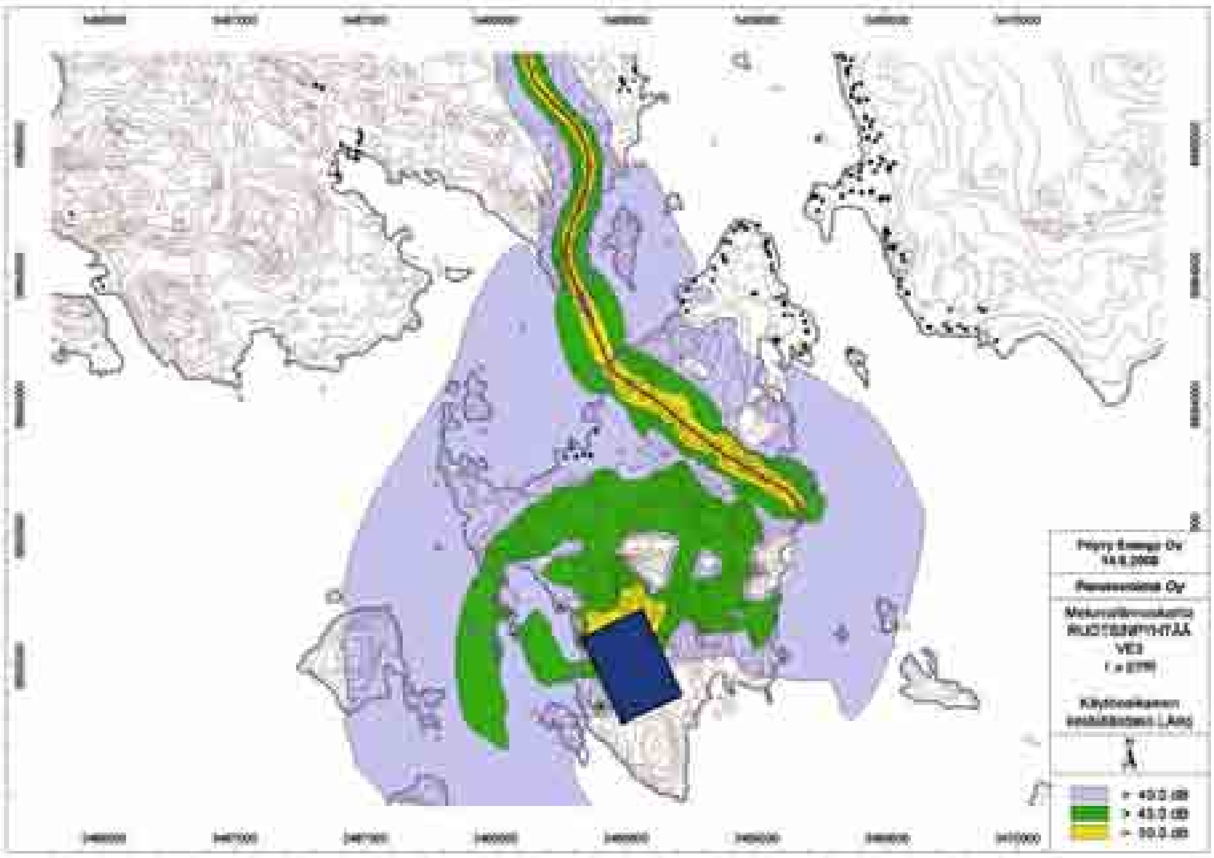


Figure 8-71. Noise caused by nuclear power plant operations (one 1,800 megawatt unit) in the vicinity of the Kampuslandet Island location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

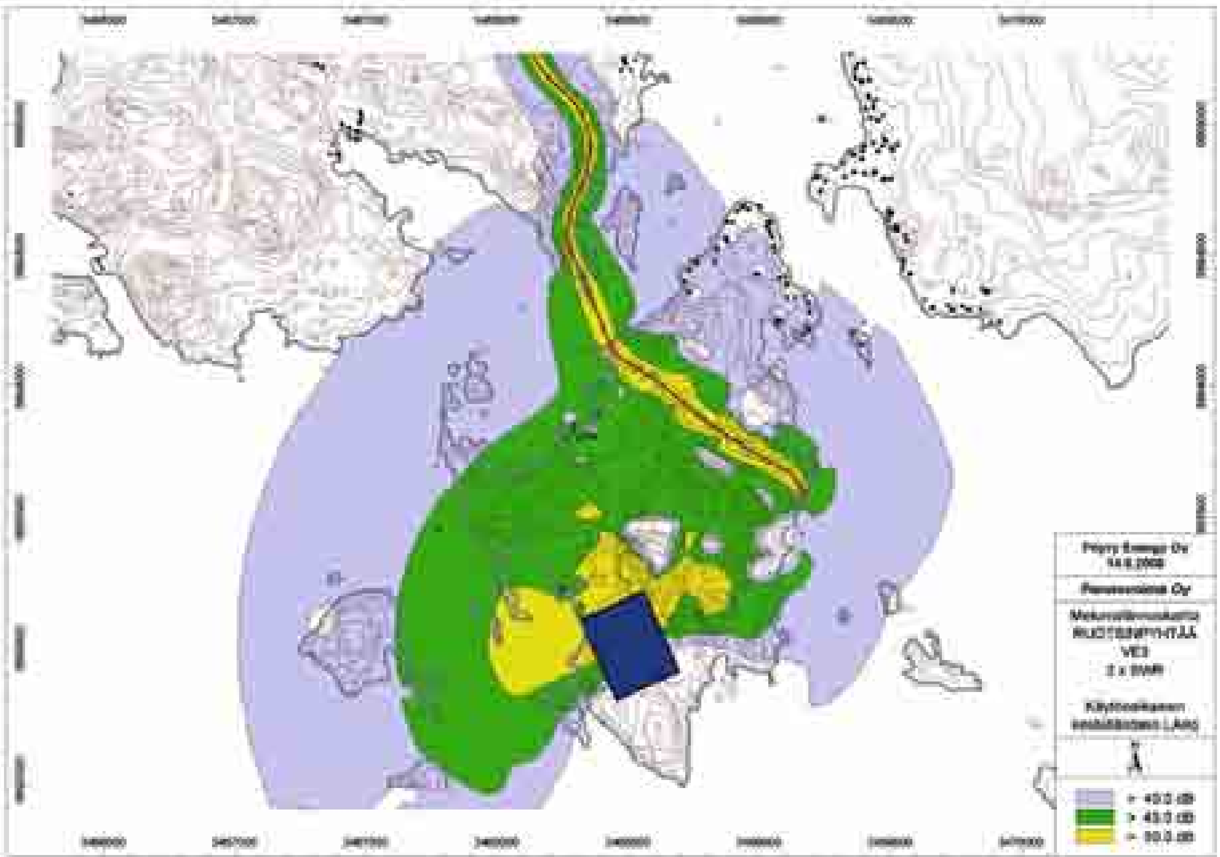


Figure 8-72. Noise caused by nuclear power plant operations (two 1,250-megawatt units) in the vicinity of the Kampuslandet island location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

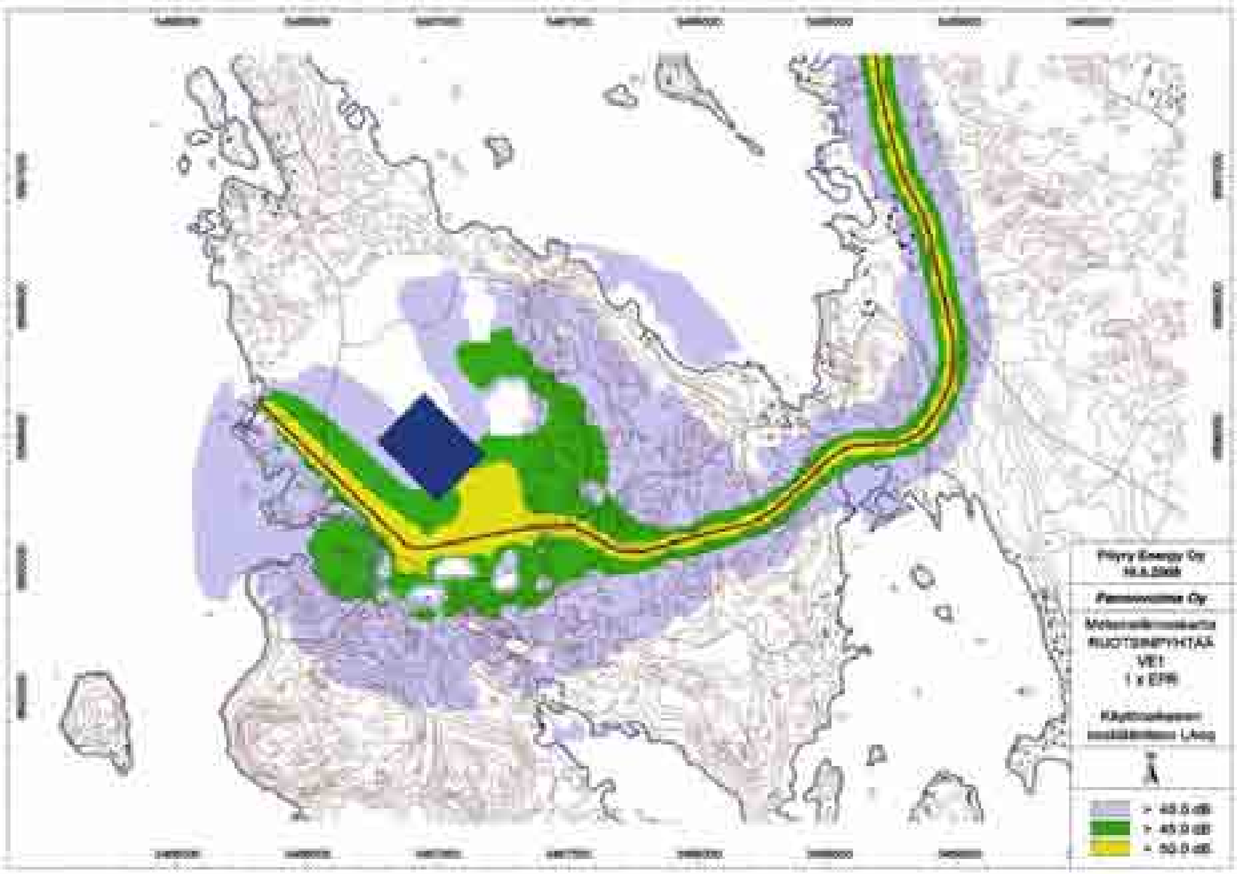


Figure 8-73. Noise caused by nuclear power plant operations (one 1,800-megawatt unit) in the vicinity of the Gäddbergsö headland location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

ters from the power plant buildings LAeq is approximately 40–45 dB(A) (Figure 8-74). The 40 dB(A) zone will extend to an average distance of 180 meters on both sides of the road.

In the case of a single power plant unit in the Kampuslandet location, the nighttime guideline value of 40 dB (A) will exceeded in about 5 holiday homes now located in the vicinity of the location. In the case of two power plant units, the nighttime guideline value of 40 dB (A) will be exceeded in about 10 holiday homes. The noise caused by road traffic towards the plant will not have a significant impact.

In the case of a single power plant unit in the vicinity of the Gäddbergsö location, the night-time guideline value of 40 dB (A) will be exceeded in only a few holiday homes. Noise levels at other holiday homes in the vicinity will remain below the guidance level. In the case of two power plant units, the night-time guideline value will be exceeded in only a few holiday homes. Noise levels in the majority of the current holiday homes in the environment will remain below the guideline value. Traffic noise will not have any significant impact. In addition to the noise resulting from continuous basic operation of the nuclear power plant, test use of the plant's backup power systems will occasionally cause noise. In such cases, the daytime guideline value of 45 dB (A) for the nearest holiday home areas will be exceeded in holiday homes. However, the backup power plant test use time only lasts for a few hours each year and happens during the daytime, meaning that the noise impacts related to these situations will not be very significant.

8.9.4 Simo, Karsikkoniemi

8.9.4.1 Current noise situation

In the Karsikkoniemi area, there are settlements in the northern parts of the area and on the sea shore, especially in the eastern part of the headland. There are mainly holiday homes in the vicinity of the shoreline. At this time, there are no functions causing significant noise in the vicinity of the power plant area.

The terrain in the vicinity of the Karsikkoniemi location does not have any features that particularly facilitate or hinder the spreading of noise, and the spreading of noise to noise-sensitive holiday homes mainly takes place along the ground, which is covered by trees and undergrowth.

8.9.4.2 Noise impacts

In the case of a single 1,800-megawatt unit (Figure 8-75), the average sound level L_{Aeq} during continuous basic operation of the nuclear power plant is approximately 40 dB(A) in the nearest holiday homes located within half a kilometer of the nuclear power plant buildings. The 40 dB(A) zone caused by noise from traffic

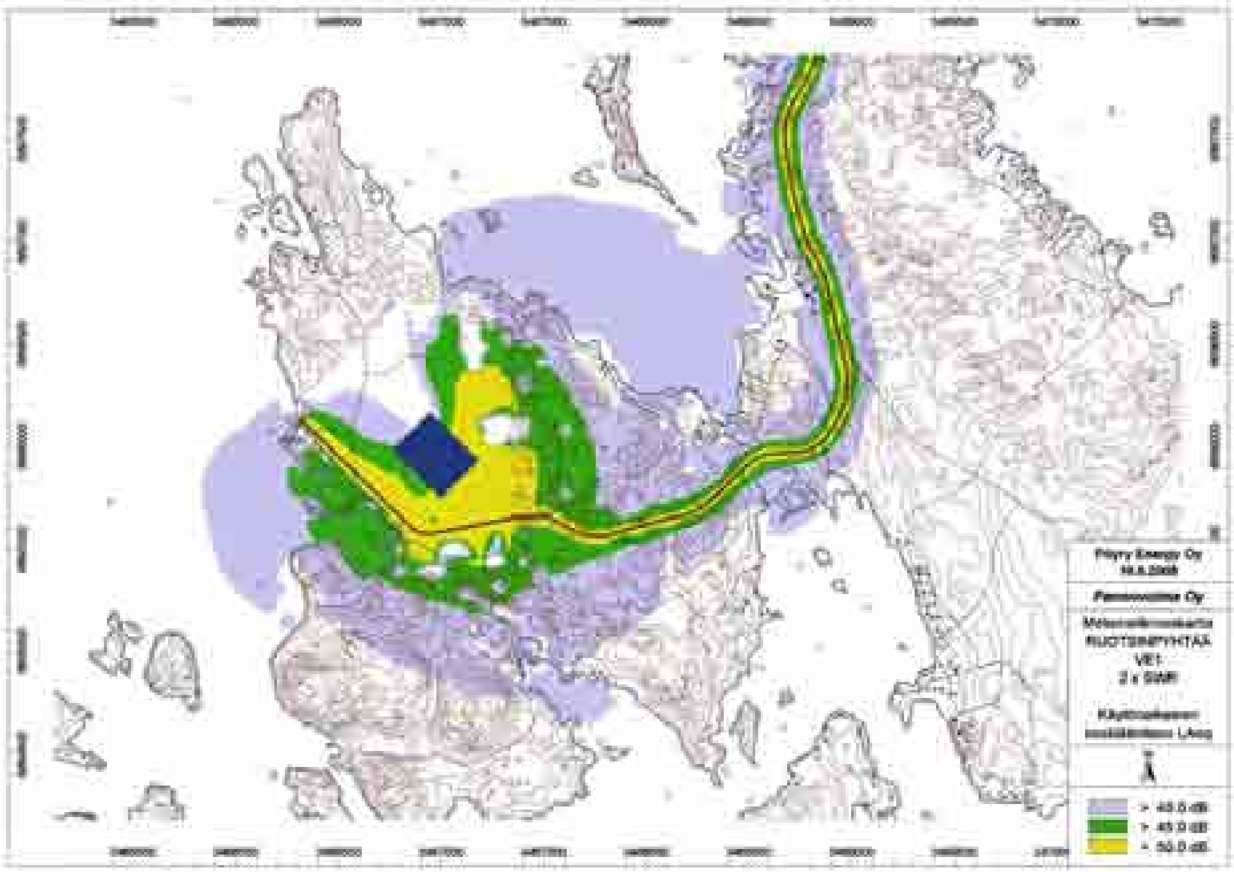


Figure 8-74. Noise caused by nuclear power plant operations (two 1,250-megawatt units) in the vicinity of the Gäddbergsö headland location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

to the plant will extend to an average distance of 180 meters on both sides of the road.

In the case of two 1,250-megawatt units (Figure 8-76), the average sound level LAeq during continuous basic operation of the nuclear power plant will be about 43 dB(A) in the nearest holiday homes located about one kilometer from the power plant buildings on the eastern and western sides of the power plant area. The noise levels in the holiday homes located a little farther from the power plant buildings and on the southernmost shores of the headland will be less than 40 dB. The impact of noise from traffic is the same as in the case of a single 1,800-megawatt unit.

In the case of a single power plant unit, the night-time guideline value of 40 dB (A) will exceeded in a few holiday homes now located in the vicinity of the location. In the case of two power plant units, the nighttime guideline value of 40 dB (A) will be exceeded in about 10 holiday homes. Noise levels in the majority of the current holiday homes in the environment will remain below the guideline value. The holiday homes located on the south coast of Karsikkoniemi will probably be removed as the nuclear power plant project proceeds. Traffic noise will not have any significant impacts.

In addition to the noise resulting from continuous basic operation of the nuclear power plant, test use of the plant's backup power systems will occasionally cause noise. In such cases, the daytime guideline value of 45 dB (A) for the nearest holiday home areas will be exceeded in holiday homes. However, the backup power plant test use time only lasts for a few hours each year and happens during the daytime, meaning that the noise impacts related to these situations will not be very significant.

8.10 Impacts on people and the society

This chapter assesses the impacts of the nuclear power station project on people and the society in the various alternative locations. The chapter estimates the impacts of the pro-ject on the regional structure, economy and employment both in all of Finland in general and regionally, considering each alternative location. In addition, the impacts of the project are assessed as to people's living conditions, comfort, recreation possibilities and health. The methods used for studying impacts on people and society are presented in Chapter 7.

8.10.1 People and communities nearby

8.10.1.1 Pyhäjoki, Hanhikivi

The immediate surroundings of the Hanhikivi location are sparsely populated. About 140 people live permanently within a five kilometer radius of the location. (Figure 8-77) The nearest village is Parhalahti (a little more than 4,000 inhabitants), located at a distance of

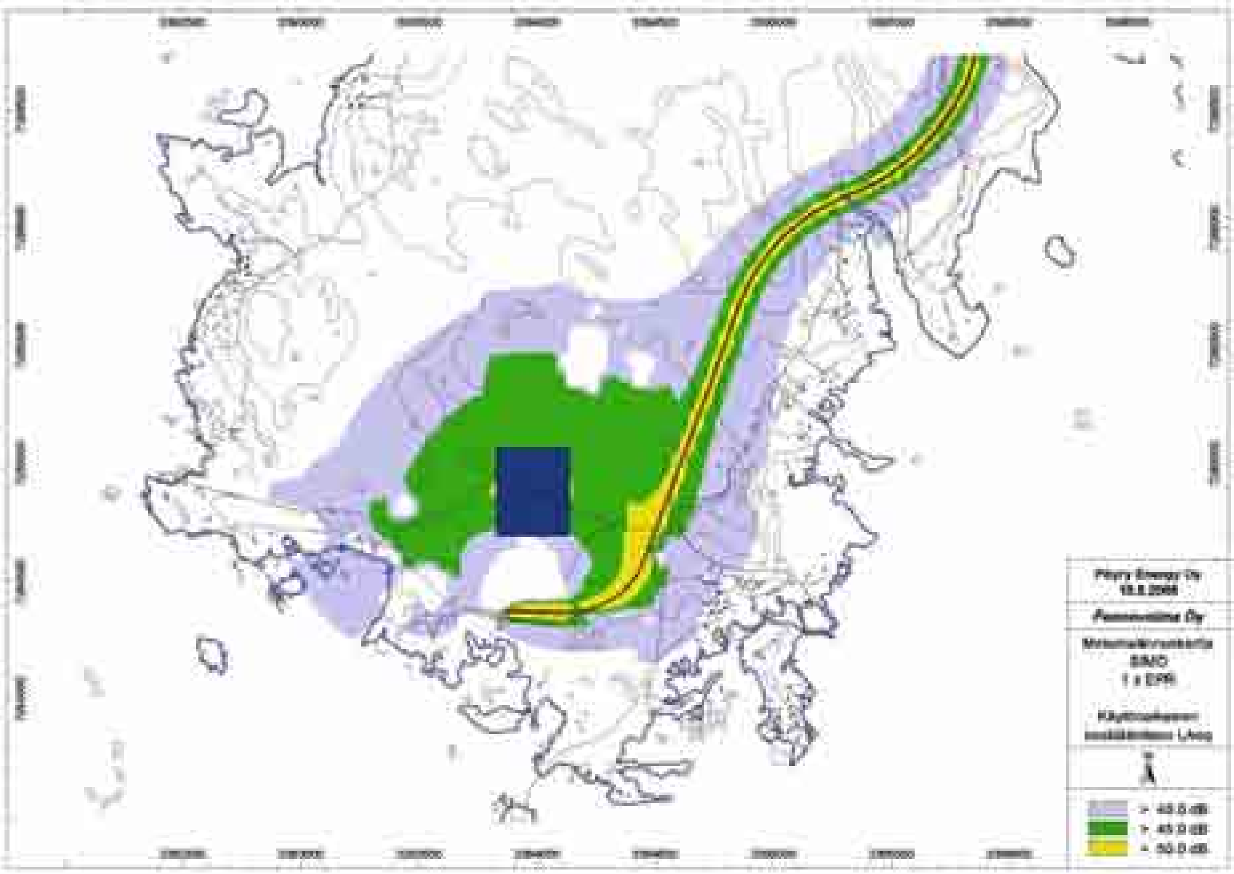


Figure 8-75. Noise caused by nuclear power plant operations (one 1,800-megawatt unit) in the vicinity of the Karsikkoniemi location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

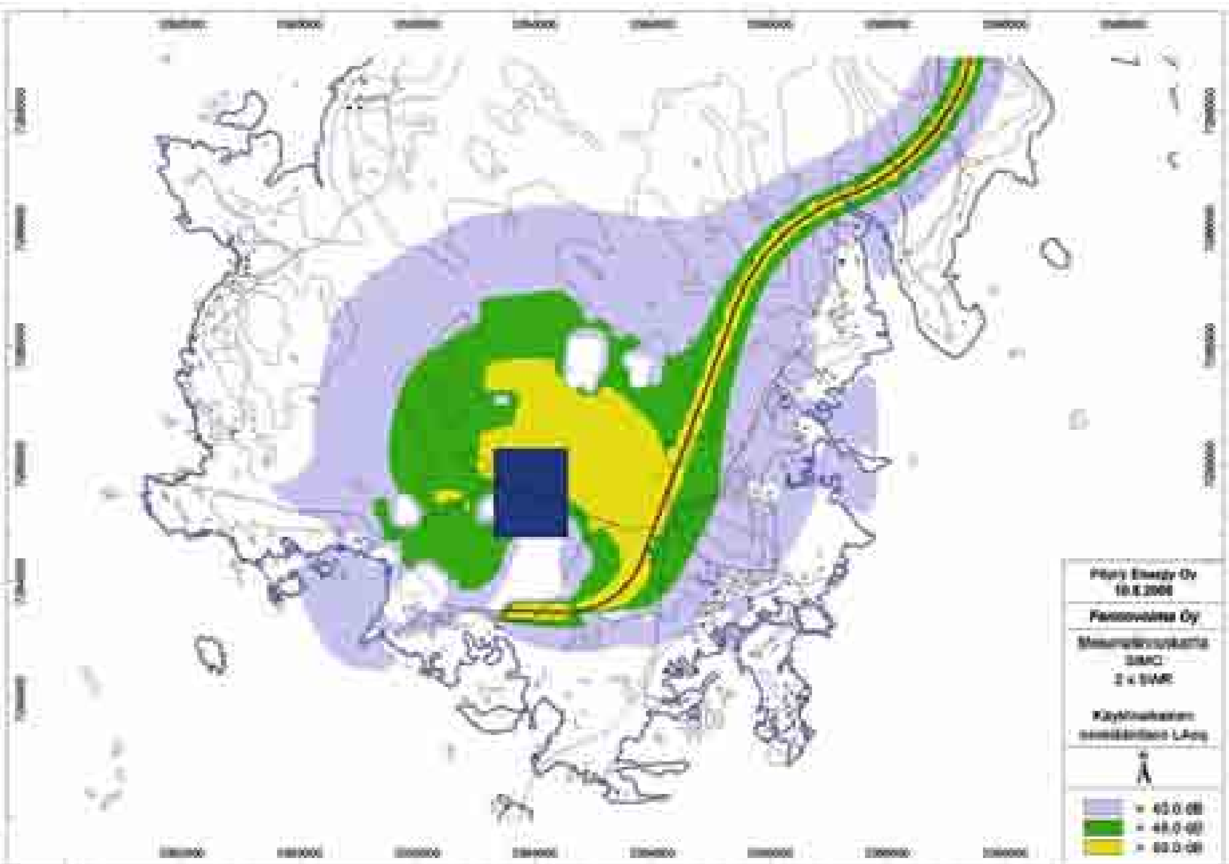


Figure 8-76. Noise caused by nuclear power plant operations (two 1,250-megawatt units) in the vicinity of the Karsikkoniemi location. (The location of the power plant units is presented in the figure as a black box in the case of both one and two power plant units.)

about six kilometers. The central locality of the Pyhäjoki municipality and the center of Raahe are both within this area. The development of the population in the Pyhäjoki municipality and the economic area of Raahe economic area are exam-ined in the chapter dealing with regional structures.

There are approximately 370,000 people living within a hundred kilometer radius of the power plant site. Of these, a significant number lives in the Oulu region. The largest population centers in the area are Oulu, Kokkola, Raahe, Ylivieska, Kiiminki, Haukipudas, Kempele, Nivala, Oulunsalo and Kalajoki.

The Pyhäjoki coast is almost entirely a holiday home area. There are fewer holiday homes in the Hanhikivi area than elsewhere in the Pyhäjoki shore areas, and on the headland itself, they are located on the west coast while the east coast is largely reserved for nature conservation. There are some 20 holiday homes in the Hanhikivi headland area. Within a twenty kilometer radius, there are a few hundred of them.

The schools, day-care centers, heath centers, service homes and bathing beaches near the Hanhikivi area are shown in the following figure. (Figure 8-78). There are four schools within the radius of one kilometer, the nearest of them being the village school of Parhalahti. The nearest bathing beach is located on the west bank of the headland.

8.10.1.2 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

The immediate surroundings of Kampuslandet in Ruotsinpyhtää and Gäddbergsön are sparsely populated. About 70 people live permanently within a five kilometer radius of the two locations (Figure 8-79 and Figure 8-80). Within a twenty kilometer radius of Kampuslandet, there are 11,250 permanent inhabitants. There are slightly more permanent inhabitants at the same distance of Gäddbergsö, 11,900. Within a twenty kilometer radius, there are the centers of Loviisa, Valko, Tesjoki, the villages of Ruotsinpyhtää and Pyhtää, and Purola. The development of the population in the municipality of Ruotsinpyhtää and the economic area of Loviisa is discussed in the chapter dealing with regional structures.

There are approximately 1,700,000 people living within a hundred kilometer radius of Kampuslandet and

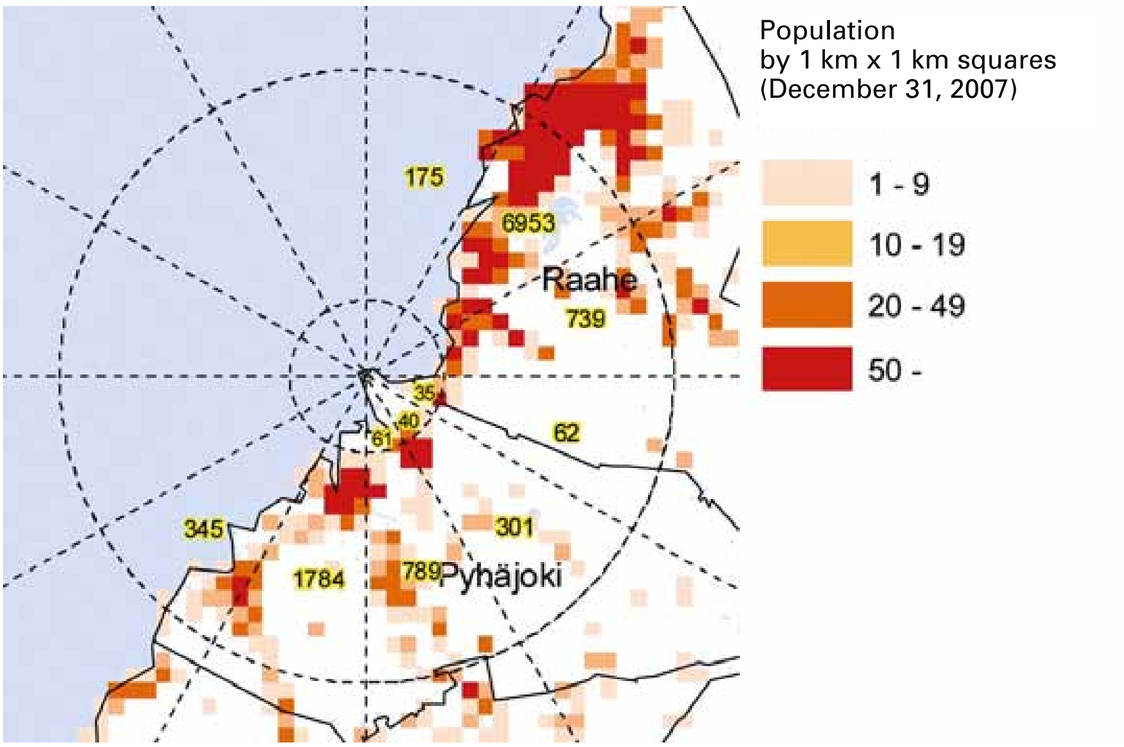


Figure 8-77. Population distribution in the Pyhäjoki Hanhikivi area within radii of five and twenty kilometers, year 2007.

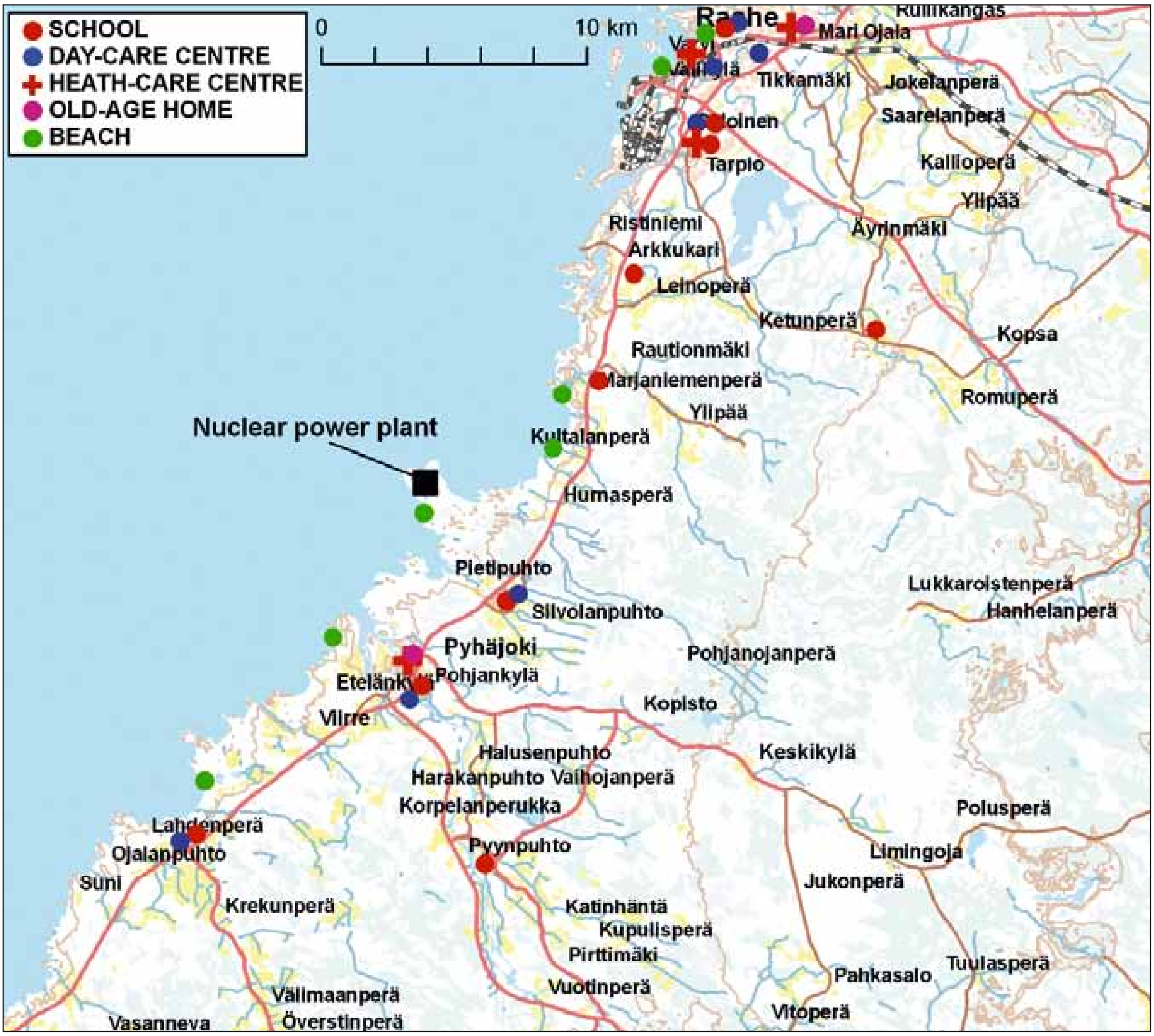


Figure 8-78. The daycare centers, schools, health centers, service homes, and bathing beaches close to Hanhikivi.

Gäddbergsö. The area encompasses almost all of the metropolitan area where most of this population lives. Other major population centers in the area include Porvoo, Kotka, Kouvola, Kuusankoski, Lahti, Orimattila, Hyvinkää, Mäntsälä, Järvenpää, Kerava and Tuusula.

There are holiday homes in the northern parts of Kampuslandet and some in the Gäddbergsö area. There are holiday homes on the shores of islands surrounding the site as well. In addition, there is an almost uninterrupted chain of holiday homes on the shores of Klobbfjärden. There are almost two hundred holiday homes within a distance of five kilometers from the Gäddbergsö headland. In summer, the population of the vicinity multiplies. At a distance of twenty kilometers, the number of holiday homes is more than one thousand.

The schools, day-care centers, heath centers, service homes and bathing beaches near the Kampuslandet and Gäddbergsö areas are shown in the following figure (Figure 8-81). The nearest school and day-care center are located in the Valko area. In the central urban area of Loviisa, there are several schools, day-care centers, service homes and the nearest health center. The Loviisa nuclear power plant is located to the east of Gäddbergsö at a distance of less than five kilometers.

8.10.1.3 Simo, Karsikkoniemi

The immediate surroundings of the Karsikkoniemi location are sparsely populated. The nearest populated areas are located at the base of the headland. About 1,250 people live permanently within a five kilometer radius of the location (Figure 8-82). The nearest populated areas are parts of the town of Kemi, i.e. Hepola (1,400 inhabitants), Rytikari (800 inhabitants) and Ajos (400

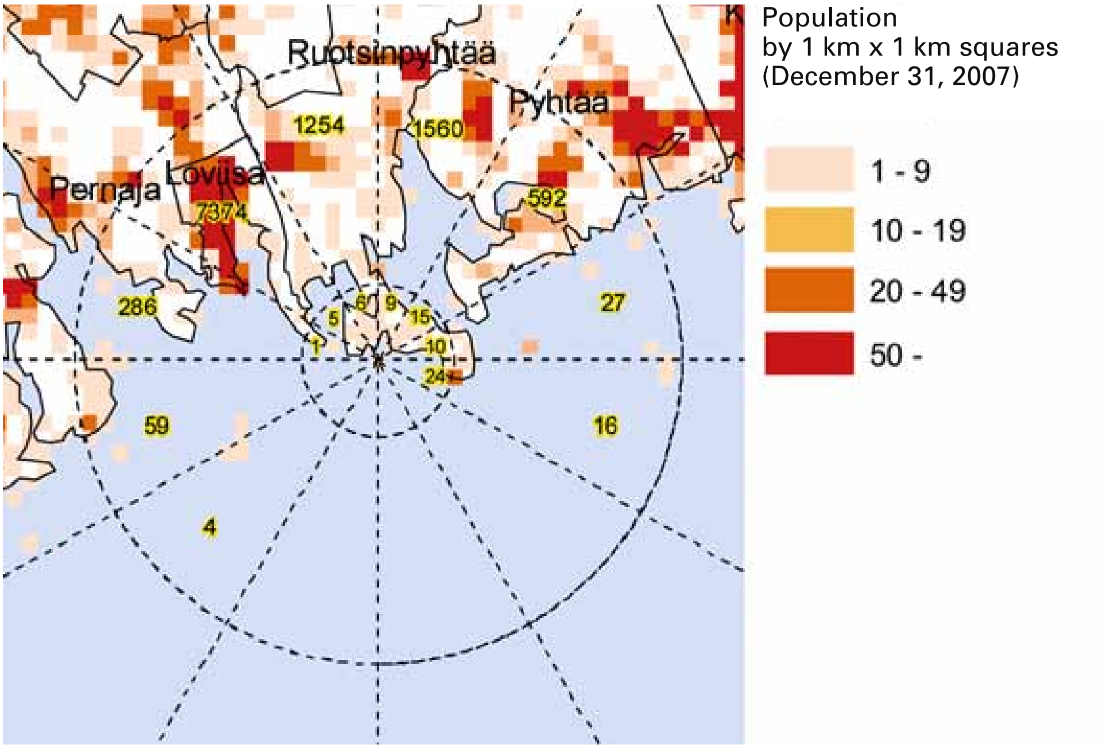


Figure 8-79. Population distribution in the Ruotsinpyhtää Kampuslandet area within a radius of five kilometers and twenty kilometers, year 2007.

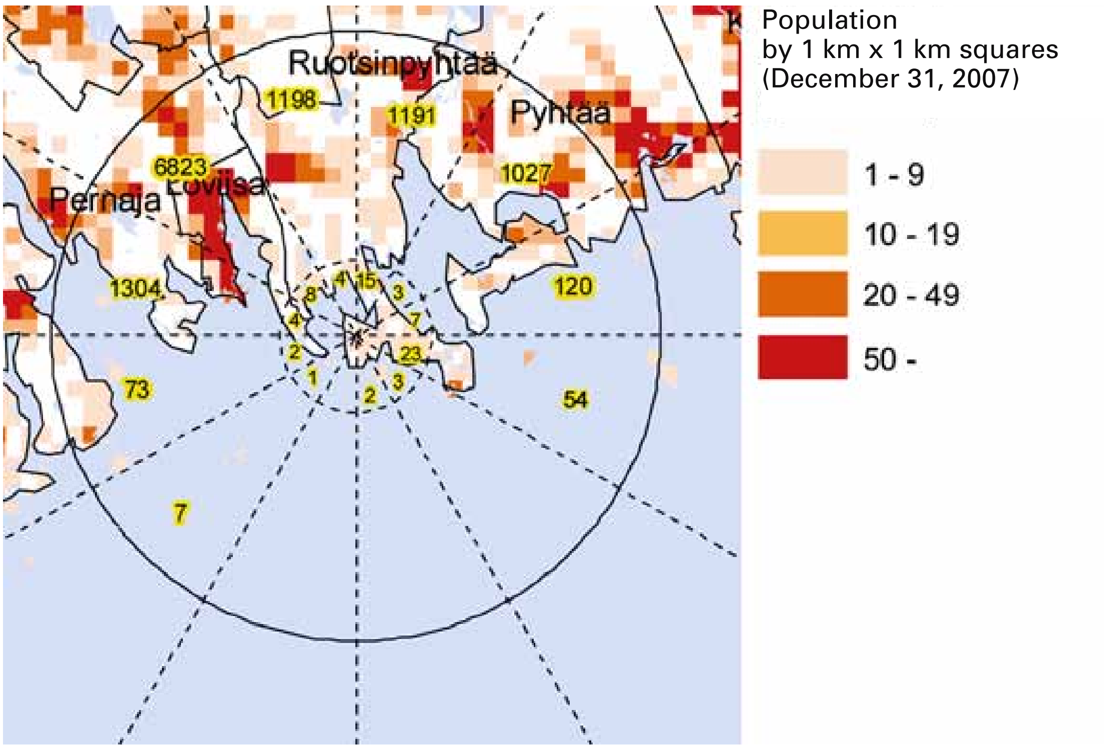


Figure 8-80. Distribution of population in the area of Ruotsinpyhtää Gäddbergsö within a radius of five kilometers and twenty kilometers, year 2007.

inhabitants), and the village of Maksniemi (slightly less than 1,000 inhabitants) located in the neighboring municipality of Simo. There are 31,100 regular inhabitants within a twenty kilometer radius. In addition to the residential areas mentioned above, the center of the town of Kemi is located inside this area. The development of the population in the municipality of Simo and the economic area of Kemi-Tornio is discussed in the chapter dealing with regional structures.

There are approximately 290,000 people living within

Figure 8-81. The day-care centers, schools, the health center, service homes and bathing beaches near Kampuslandet and Gäddbergsö.

a hundred kilometer radius of the site. Of these, a significant number live in the Oulu region. Other larger population centers in the area include Haukipudas, Oulunsalo, Kempele and Tornio. Haparanda in Sweden is also located within one hundred kilometers of the site.

In the Karsikkoniemi area, there are settlements in the northern parts of the area and the sea shore, especially the eastern part of the headland. There are mainly holiday homes in the vicinity of the shore. There are a few dozen holiday homes within a five kilometer radius of the site. The interior parts of Karsikkoniemi are mainly uninhabited. Within a twenty kilometer radius, there are a few hundred holiday homes.

The schools, day-care centers, hospitals, health centers, service homes and bathing beaches near the Karsikkoniemi area are shown in the following figure (Figure 8-83). The nearest schools and day-care centers are located in the Hepola and Maksniemi areas. In the central urban area of Kemi, there are several schools, day-care centers, a service home and the nearest hospital.

The Karsikkoniemi location is within the area of the controlled airspace of the Kemi-Tornio airport. There are no-fly zones with four kilometer radiuses around the present Finnish nuclear power stations, reaching up to the height of 6,500 feet or 2,000 meters (Government decree 929/2006). The no-fly zones have been set in order to make the surveillance of the plant site area easier. The no-fly zone of the new nuclear power plant will be defined in a way that will not interfere with the operation of the Kemi-Tornio airport.

The impacts of the project on the road network were also studied. Road leading through a village in Simo, 2008.

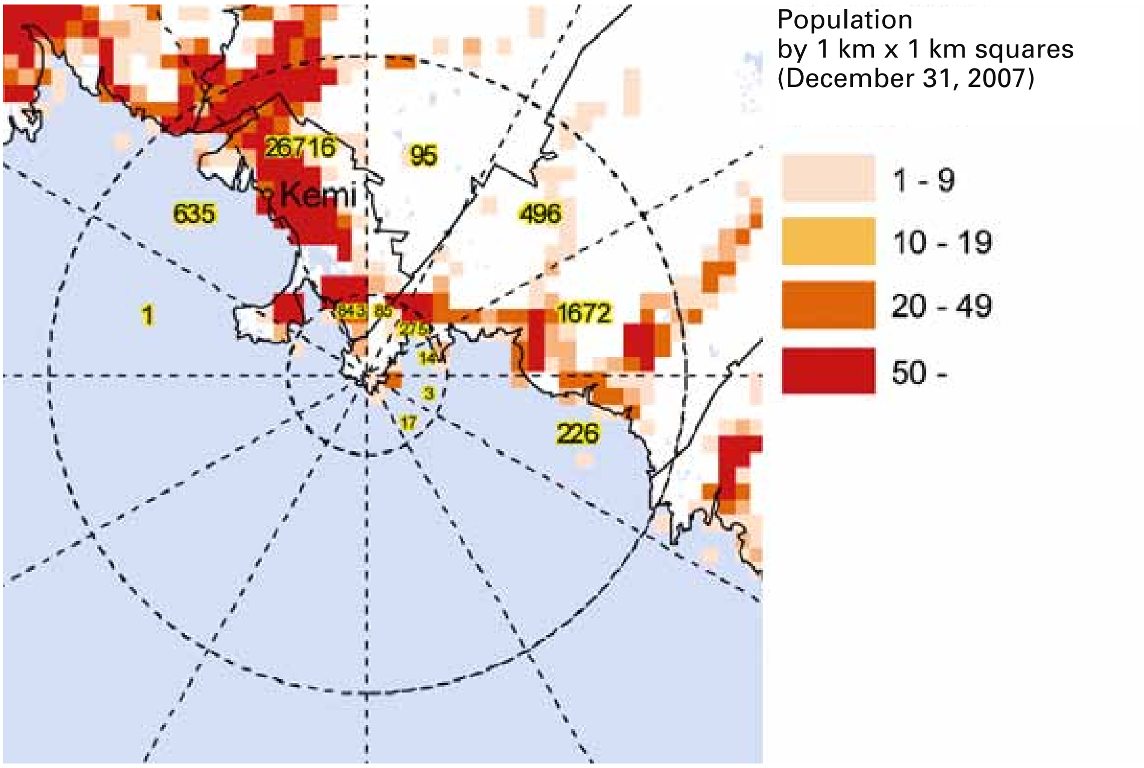


Figure 8-82. Population distribution in the Simo Karsikkoniemi area at a radius of five kilometers and twenty kilometers.

Figure 8-83. The day-care centers, schools, hospitals, health centers, service homes and bathing beaches near Karsikkoniemi.

8.10.2 Regional structure, economy and employment

8.10.2.1 Overall economic impacts

Economic impacts of the investment

In the assessment of the regional economic impacts of the nuclear power plant, the investment costs in case of one unit (investment A) are estimated at EUR 4,000 million, and in case of two units (investment B) at EUR 6,000 million. The division of the investment into different lots and the degree of domestic origin of each part depend on the final plant solution and delivery method. The regional economic impacts of the investments were calculated using assumed domestic origin percentages of 35% and 45% (Table 8-13 and Table 8-14). In case of investment A, the economic impact upon Finland is calculated at EUR 1,400–1,800 million depending on the degree of domestic origin.

In case of investment B, the economic impact upon

Finland is estimated to be 1.5 times that of investment A, in other words, EUR 2,100–2,700 million. The same domestic content distributions have been used for both investment options.

Employment-related impacts in Finland during the construction phase

In case of one unit and the degree of domestic origin at 35%, the impact on employment in Finland is estimated at 20,000 man-years (Table 8-15). Evenly distributed over six years, the impact on employment is 3,200-3,300 man-years per year.

In case of investment A and the degree of domestic origin at 45%, the impact on employment in Finland is estimated at 25,000 man-years (Table 8-16). Evenly distributed over six years, the impact on employment is 4,200 man-years per year.

In case of investment B and the degree of domestic origin at 35%, the impact on employment in Finland is estimated at 29,000 man-years (Table 8-17). Evenly distributed over eight years, the impact on employment is 3,600-3,700 man-years per year.

In case of investment B and the degree of domestic origin at 45%, the impact on employment in Finland is estimated at 38,000 man-years (Table 8-18). Evenly distributed over eight years, the impact on employment is 4,700-4,800 man-years per year.

In practice, the annual distribution of the employment-related impacts depends on the phase of the construction work. Tasks relating to building technology especially tend to concentrate at the beginning of a construction project.

A part of the wages and daily allowances of those participating in the project either directly or indirectly is necessarily spent on the consumption of various ser-

Table 8-13. Distribution of economic impact upon Finland in investment cases A and B with the degree of domestic origin at 35%.

Degree of domestic origin 35%	% Share of total investment		% Degree of domestic origin		% Domestic share of investment		Domestic share of investment, M€	
	A	B	A	B	A	B	A	B
Machinery and equipment	55	55	20	20	11	11	440	660
Construction work	30	30	50	50	15	15	600	900
Project-related and other services	15	15	60	60	9	9	360	540
Total	100	100			35	35	1,400	2,100

Table 8-14. Distribution of economic impact upon Finland in investment cases A and B with the degree of domestic origin at 45%.

Degree of domestic origin 45 %	% Share of total investment		% Degree of domestic origin		% Domestic share of investment		Domestic share of investment, M€	
	A	B	A	B	A	B	A	B
Machinery and equipment	55	55	26	26	14	14	566	849
Construction work	30	30	64	64	19	19	771	1,157
Project-related and other services	15	15	77	77	12	12	463	694
Total	100	100			45	45	1,800	2,700

Table 8-15. Employment-related impacts in Finland during the construction phase in investment case A with the degree of domestic origin at 35%.

Investment A, 35%	Direct impact, man-years	Indirect impact, man-years	Total impact, man-years
Machinery and equipment	2,200	2,200	4,400
Construction work	4,800	3,600	8,400
Project-related and other services	4,680	2,160	6,840
Total	11,680	7,960	19,640

Table 8-16. Employment-related impacts in Finland during the construction phase in investment case A with the degree of domestic origin at 45%.

Investment A, 45 %	Direct impact, man-years	Indirect impact, man-years	Total impact, man-years
Machinery and equipment	2,828	2,828	5,656
Construction work	6,172	4,629	10,801
Project-related and other services	6,017	2,777	8,794
Total	15,017	10,234	25,251

Table 8-17. Employment-related impacts in Finland during the construction phase in investment case B with the degree of domestic origin at 35%.

Investment B, 35%	Direct impact, man-years	Indirect impact, man-years	Total impact, man-years
Machinery and equipment	3,300	3,300	6,600
Construction work	7,200	5,400	12,600
Project-related and other services	7,020	3,240	10,260
Total	17,520	11,940	29,460

Table 8-18. Employment-related impacts in Finland during the construction phase in investment case B with the degree of domestic origin at 45%.

Investment B, 45 %	Direct impact, man-years	Indirect impact, man-years	Total impact, man-years
Machinery and equipment	4,243	4,243	8,486
Construction work	9,257	6,943	16,200
Project-related and other services	9,026	4,166	13,191
Total	22,526	15,351	37,877

vices and products, creating new jobs. It is noteworthy, however, that even though consumption grows in the location itself and in the surrounding economic area, the goods consumed are mainly manufactured outside the economic area. This means that the impact on employment takes place mainly in the location of manufacture and further, in the locations where the raw materials for the products in question are produced. Certain services such as accommodation services are produced mainly locally, but groceries and their raw ma-terials are generally produced outside the economic area.

Foreign workers also spend at least a part of their wages in Finland. Part of the foreign personnel stationed in Finland take their families along, as was seen during the con-struction of Olkiluoto 3. As to the demand of public services like education, social welfare and health services, their employment-related impacts take place in the plant's location and in the surrounding economic area. Especially employees stationed for long periods increase the demand for public services during the construction phase.

In investment case A, the number of workers peaks in 2–3 years from the beginning of construction work when there are about 3,500 workers on site. In investment case B, the exact time when the total number of workers peaks — to about 4,700–4,800 — depends on the order in which the construction of the plant's units is started. It is estimated that the peak is reached about three years after the beginning of the construction work, provided the latter unit is began two years after the first one. There are both domestic and foreign workers included in the total number of workers on site.

Employment-related impacts in Finland during the construction phase

The plant is estimated to employ 400 people full-time in case A. About 300 of these people are directly involved with the operation of the plant and 100 with external services. External services required directly at the plant include cleaning, security, plant rescue operations, catering and transportation. In investment case B, the plant is estimated to employ about 500 people. About 100 of these are employed in external services.

During the commissioning phase, there is dedicated staff for commissioning activities on site in addition to the permanent staff. During annual maintenance in case of one unit, there are 500 extra temporary jobs created at the plant for 1–3 weeks (10–30 man-years). In case of two units, the annual maintenance is expected to employ the same number of people but the time span involved is doubled (2–6 weeks, 20–60 man-years). The same employees are expected to take part in both maintenance operations. The work force participating in an annual maintenance operation comes mainly from outside the economic area.

In addition to direct employment opportunities, the plant creates indirect employment opportunities in the operating phase through intermediate goods chains and increases in consumption. In the operation, maintenance and service operations of the plant, different goods and materials are needed that have an effect beneficial to employment. Some of these are produced in Finland, some abroad. As in the construction phase, all increases in employment and people's purchasing power increase, in turn, the consumer demand for private services, which creates more employment opportunities still. The consumer demand for private services is distributed within the economic area according to where people live, but the employment-related impacts are carried via the intermediate goods chains to all of Finland and abroad as well. The permanent plant staff with their families consume public services, too, thereby increasing the demand for educational and healthcare services. In addition, new residents increase the demand for recreation services. If no service resources are available, these sectors must employ new work force.

Jobs are created through investments made on the infrastructure as well. Municipalities must take care of building the public utility works for new residents. In addition, there may be a need to build new day-care centers, schools or leisure centers, which also will have an effect on employment. There will be new jobs in housing production especially in the beginning of the operating phase when some of the new residents moving in into the area either build a house or have one built. The employment-related impacts of the construction work extend to all of Finland.

If the project of Fennovoima is implemented, it may have significant impacts on employment through the owners' investments as well. The cascade effects of these investments may be regionally very significant. Outokumpu Oy, for example, has emphasized the significance of this Fennovoima project regarding its own investments.

Impacts on municipal economy

The revenue of the municipality in which the plant is located will grow significantly due to the property tax, municipal tax and corporate tax. All of the economic area will benefit from the increase of the municipal and corporate taxes, but the revenue from the property tax will remain mainly in the plant's location. Property taxes, in particular, will be very significant for the municipality. Annual revenue from property taxes will provide the municipality, in comparison to others, with a good margin and good room to maneuver in planning its economy and future. The municipality will be able to use the increased revenue to enhance the quality and quantity of services enjoyed by the present residents as well. If the municipality so wishes, it is possible to use the expanded revenue base for decreasing the municipal tax rate, too, which will also benefit the inhabitants.

In addition to pulling in increased revenues, the municipality where the plant is located and other municipalities nearby must invest in service production and the building of infrastructure for new and existing residents. New properties and also the nuclear power plant must have public utility services built for them. As the number of residents in the municipality grows, more services must be produced to keep the service level experienced by the existing residents from decreasing. In addition, the municipalities in the economic area may need to invest in day-care centers, schools and leisure services as early as during the construction phase.

Permanent employees moving in into the economic area will settle in the area of several municipalities so that the increase in service demand in a single municipality is not necessarily very extensive. It is noteworthy that the locations examined and their economic areas have experienced a decline of population in the recent years, so there may be free capacity for service production.

When assessing the net economic impacts of the investment upon the locations and economic areas involved in the operating phase, the following items of income must be noted:

- revenue from property taxes to the municipality where the plant is located (nuclear power plant, new homes, new business premises and other buildings)
- revenue from municipal taxes to the municipalities in the economic area (new tax payers, decreased unemployment rate)
- revenue from corporate taxes
- revenue from those employed indirectly by the private and public sectors

All revenue impacts the tax equalization performed under the state subsidy system, the calculated revenue decreasing the subsidy due the municipality.

As to expenditure, the following investments may come up and must be noted:

- investments in public utility services and infrastructure
- building new day-care centers, schools and other real estate property
- increasing the supply of public services and recreation services (personnel for schools, day-care centers, healthcare, social welfare).

Investments on infrastructure and real estate are typically depreciated on an extended schedule, and with long-term financing arrangements, the financial burden of investments should not grow too large on a year-to-year basis. Investments and expenditures are distributed on a wide area according to, for example, where people live.

In order to assess the economic impacts in more detail at the level of a single municipality, it would be necessary to have information concerning the distribution of residents and municipal revenue in the municipality of the plant and the surrounding economic area. Such detailed information, however, is not available, and the distribution of population is therefore assessed at the level of economic area. As to the impacts upon a single municipality it can be said that in magnitude, the financial benefits of the project surpass by far the expenditure required by investments and other expenses in all of the locations studied.

Economic and employment-related impacts on the economic areas

Employment-related impacts

It has been estimated that 20–25% of the employment-related impacts in Finland during the construction phase of the project will be created in the economic areas themselves. For investment A, this means 3,000–4,000 man-years depending on the degree of domestic origin. At an annual level, the employment effect of the project would be 500–800 man-years.

For investment B, the employment effect during the construction phase would be 4,000–6,500 man-years depending on the degree of domestic origin. This calculation assumes that all those participating in the project in the economic area are involved also in investment case A; in other words, in investment case B also, there are 500–800 man-year's worth of people employed annually, and the employment-related impact in the larger investment case is larger through the longer duration of the project only. The rest of the employment-related impacts in Finland will be created outside the economic area.

The employment-related impacts in the use-phase have been estimated at 340–425 man-years in all of the economic areas studied depending on whether investment A or B is examined. The estimate includes all those who are directly employed, meaning the permanent staff of the plant and the providers of the required external services like cleaning, security and catering.

The employment-related impacts concerning the inputs of intermediate products have been estimated to ensue outside the economic area. During the operating phase, there will be indirect employment opportunities created in the economic area through growing consumption and the businesses picking up. The workers moving permanently into the economic area with their families will need both public and private services. The demand for public services such as healthcare and education will also increase.

In addition to the permanent staff, workers participating in annual maintenance operations will create seasonal demand for accommodation and catering services. It is possible that there is a need to employ temporary work force at that time.

Fish breeding is not practised in Pyhäjoki and Simo within the affected area of cooling water. In Ruotsinpyhtää, there are two fish hatcheries near the cooling water discharge sites west of Gäddbergsö. If the cooling water discharge is directed towards Vådholmsfjärden (Discharge D1), the temperature of the surface water may increase by one centigrade near the fish hatcheries. The temperature increase will speed up the growth of fish and have a positive impact on fish breeding. However, the temperature increase will be so small that there probably will not be any observable impact.

The nuclear power plant project may have direct negative effects on professional fishermen who might use their fyke nets in the immediate vicinity of the plant site. They may have to move some of the fishing gear somewhere else.

Tax-related impacts

If the property tax percentage is assumed to be 2.50%, the property taxes for the completed plant will accumulate to EUR 3.8–5.0 million at an annual level in the different locations studied. After this, the amount of property taxes depends on, for example, how the replacement value of the property develops. When the impact of the state subsidy system is taken into account, the net benefit from the annual property taxes for the plant's location municipalities amounts to 70–80%.

Revenue from property taxes is also created for the plant's location municipality and the economic area as a whole because the people moving in will build new homes or have them built. Also, the building of new business premises will increase the property tax accumulation when business picks up.

The impacts of income taxation will reach wider than those of property taxation because they depend on the places of residence of the workers. Revenue from municipal taxes will be increased both in the construction phase and operating phase.

In investment case A, the municipal taxes in the different economic areas are estimated to accumulate to EUR 17–27 million during the construction phase depending on the degree of domestic origin. This would mean EUR 2.8–4.5 million annually, provided the municipal taxes would accumulate evenly during the construction phase. In investment case B, the municipal taxes in the different economic areas are estimated to accumulate to EUR 23–37 million during the construction phase, meaning EUR 2.8–4.5 million annually. In investment case B, the greater revenue accrual is due to the longer du-ration of the construction phase and the greater total employment-related impact.

The construction of a nuclear power plant creates social impacts and affects the regional economy. Morning coffee in a Finnish home, 2008.

The municipal revenue in the operating phase is estimated to be the same in all the locations studied, because the number of operating personnel and external employees is the same and 85% of the employees are expected to live permanently in the economic area. In the operating phase, the municipal taxes in the economic area are estimated to accu-mulate to EUR 1.9–2.4 million depending on whether we are looking at investment A or B. The rest of the impacts will be created outside the economic area depending on the municipalities in which the workers live. The final tax accumulation will depend on the size of the investment, the number of operating personnel and their pay level. In addition, investments will create indirect employment opportunities in the private and public sectors, increasing the revenue accrued in the economic area.

Fennovoima operates on the Mankala principle, meaning non-profit operation. Therefore, it does not pay corporate taxes in any significant amount. The revenue from corporate taxes will, however, increase due to the increases in the turnover and profit of the businesses in the Raahe economic area. Revenue from corporate taxes is created through businesses involved directly in the project and through indirect impacts. Reve-nue from corporate taxes is also created when the profits of the owners of Fennovoima possibly increase. If the nuclear power plant improves the owners' financial results, the taxes and corporate taxes paid by them will also increase.

The housing market and living

In the construction phase, there will be a demand for short-term temporary housing near the construction site and a demand for accommodation further away in regional population centers. An installation mechanic on a few week's assignment is likely to appreci-ate short commuting distances and practicality, choosing accommodation nearby. A worker stationed for a year or two, maybe with his or her family along, is likely to appreciate comfort in housing. In his or her case, accommodation further way is the most likely option.

The largest number of people simultaneously working at the nuclear power plant construction site is about 3,500 people in case of investment A and 4,700–4,800 in case of investment B. These numbers are so large that the required accommodation will necessarily include nearby accommodation, barracks adjacent to population centers, rented accommodation in the near vicinity and accommodation further away in the nearest larger cities.

Nearby accommodation, which often means conglomerations of barracks, has an alternative in rented housing nearby or communal living in units of 5–10 barracks adjacent to population centers. If barracks are concentrated on one large area, there may be disorderly behavior and other problems due to insufficient opportunities for recreation, alcohol or the multicultural environment.

The size of the rental housing market in the different locations is reflected in the numbers of rented housing units. In Simo, there is a scarce supply of rental apartments, but in the town of Kemi, the supply is more abundant. In 2006, there were about 4,000 units of rented housing in Kemi. The situation in Pyhäjoki is similar to that in Simo, making it necessary to turn there to the rental home market in Raahe. In 2006, there were slightly less than 3,000 units of rented housing in Raahe. In case of Ruotsinpyhtää, the town of Loviisa offers some rental apartments. In 2006, there were about 1,300 units of rented housing there. As to the more northern location alternatives, it is possible to have some of the employees live in Oulu, for example, with vehicle pools to transport people to the construction site. In case of Ruotsinpyhtää, these alternatives would include Porvoo, Kotka and the metropolitan area in addition to Loviisa. An increased demand in the rental market may be reflected as increases in the local rental rates.

During the operating phase, and depending on the size of the plant, there would be 400–500 full-time employees operating the plant and working in the external services. Of these employees, 340–425 (85%) are expected to stay permanently in the economic area. If all these employees are assumed to move in from elsewhere, this would mean a demand for about 400 new apartments or houses in the economic area. According to statistics, it can be estimated that the demand would be roughly distributed among 200 houses and 200 row houses or apartments in multistory buildings. If there are vacant abodes in the area, it is not necessary to build all these, but on the other hand, the municipalities might wish to entice new residents by providing houses and seaside lots. In practice, some of the employees of the plant would be original inhabitants already living in the economic area. This would decrease the demand for housing. During the start-up phase of the plant, there will also be a demand for rented housing. The workers with their families may first move in to the area and only then start looking for a place of their own.

The demand for housing plots and homes may cause the prices on the housing market to go up slightly, but on the other hand, the prices in the economic areas examined here are clearly lower than the national average, and there is plenty of land available for zoning. The real estate market can be estimated to revive somewhat due to the project. The construction phase, on the other hand, may have a depreciating effect on the prices of the nearby holiday homes.

Population and its structure

The nuclear power plant has impacts on the numbers and structure of the population in both the location itself and the surrounding economic area. This is due to the increase in the employment opportunities and improved overall employment. The relation between the number of employment opportunities and migration depends on several factors. If the employment situation in the economic area is good to begin with and there is only little trained workforce unemployed or outside the active workforce, new employment opportunities will cause active migration and an increase in population. The educational and age structures in the economic areas play a role in how the areas are able to respond to an increased demand for labor. In all of the economic areas studied here, the supply of appropriately trained workforce is insufficient, meaning that new workforce must move in into the economic area from outside.

In addition to the population structure and the employment opportunities offered by the nuclear power plant, there are other factors that impact the volume of migration and population growth. These factors include, for example, the comfort of the living environment, communications, prices of property and housing, service levels and employment opportunities for spouses. Especially families with children may consider the quantity and quality of health, day-care and educational services very significant.

If it were assumed that all the 400–500 employees required in the operating phase moved in from outside the economic area and 85% of them remained in the area, this would mean, calculated by an average family size of 2.1 persons, about 700–900 new inhabitants for the area. In the economic area of Loviisa, 900 new inhabitants correspond to almost 4% of the present population; whereas the relative increase in population is smaller in the economic areas adjacent to Raahe and Kemi-Tornio. In practice, at least some of the employees of the plant would be original inhabitants currently unem-ployed or outside the active workforce, which would decrease the above estimate concerning the growth of the population base.

The population moving into the region of the plant would be better educated and younger than average. The plant would offer employment opportunities for those graduating from local polytechnics and universities in the nearby areas, enabling them to remain in the region working there. In case of every location and economic area studied here, the population base would be extended and the age structure would grow younger.

Structure of industry, demand for services

There will be new demand created for the building and metal sectors and for service production in the construction phase of the project. The significance of these sectors will increase in the structure of the regional industry. The importance of service production within the industrial structure will grow as well. There will be a demand created for services required directly by the building site (cleaning, catering, security, transportation) and indirectly (commerce, accommodation, restaurant business). The demand for public services and recreation services will increase during the construction phase.

In the operating phase, new permanent staff will move in into the area with their families and create demand for the production of public services. Young families will create demand for educational and day-care services. All of the alternative locations and re-gions have experienced loss of population in the recent years, so there is some free capacity available. In addition, the municipalities must invest in public services. The increased population and buying power spur the industry in the economic area. This is seen in commerce and in the catering business, for example.

The significance of tourist industry may increase if a visitor center is established at the plant as was done in Eurajoki. There are 12,000–15,000 visitors annually to Olkiluoto in Eurajoki. Tourism also makes the commerce, accommodation and restaurant business more significant in the structure of the regional business life.

Associated projects

Associated projects refer to the investments into infrastructure that are related to the nuclear power plant project and are required by the operation of the plant. These include, for example, connecting the power lines into the national grid, constructing the cooling water tunnels and the investments in the dock area.

The magnitude of the associated projects is estimated at EUR 70 million. There are no significant differences between the locations. The employment-related impacts of these investments can be roughly examined using work contribution coefficients. If the degree of domestic origin in the projects is assumed to be 90%, the total employment-related impact in Finland during the construction time will be about 900 man-years. This impact will be distributed among the economic area and the rest of Finland according to, for example, the availability of trained workforce. There is a great demand for building and earth-moving work associated with the additional projects, and there may be good local resources available to respond to the demand.

The calculations are indicative only, but they show the magnitude of the financial impacts related to the directly associated projects. The employment effect of the associated projects in case of one unit forms about 3–5% of the total employment-related impacts calculated for the project. In case of two units, the relative share is smaller.

8.10.2.2 Pyhäjoki, Hanhikivi

Present state in the economic area - population, structure of industry, labor market and municipal economy

Population

The permanent population of Pyhäjoki is about 3,500 and in the economic area of Raahe, which spans eight municipalities, it is about 56,000 (Table 8-19). In the early 1980's, the population was about 53,600, after which it grew steadily until the early 1990's. Then, in all the municipalities, the number of inhabitants started to decline. In the past few years, however, the decline has leveled off and the population has actually increased in Kalajoki, for example.

The population of Pyhäjoki has declined by a few dozen annually throughout the 2000's. The greatest population center in the economic area is the city of Raahe with about 22,400 inhabitants in 2006. The distance from Pyhäjoki to Oulu is about 100km, and the number of inhabitants there is about 130,000. The distance to Kokkola is about the same, and the number of

Table 8-19. Average population in the Raahe economic area in different years (*Statistics Finland 2008*).

	1985	1990	1995	2000	2006
Pyhäjoki	3,691	3,747	3,876	3,645	3,454
Alavieska	3,044	3,061	3,068	2,965	2,841
Kalajoki	9,150	9,357	9,455	9,143	9,238
Merijärvi	1,416	1,469	1,435	1,384	1,269
Oulainen	8,220	8,276	8,455	8,235	8,094
Raahe	24,334	24,190	23,919	23,242	22,404
Siikajoki (*	6,426	6,560	6,538	6,115	5,818
Vihanti	4,005	3,892	3,828	3,596	3,305
Total	60,285	60,550	60,571	58,324	56,421

*The table uses the municipal structure of 2007, in other words, the municipalities of Siikajoki and Ruukki are presented as one municipality, Siikajoki (this is the case in the following tables and fig-ures as well).)

Table 8-20. Population forecast for the Raahe economic area (*Statistics Finland 2008*).

	2010	2020	2030	2040
Pyhäjoki	3,288	3,083	2,961	2,831
Alavieska	2,756	2,637	2,589	2,540
Kalajoki	9,364	9,684	9,893	9,905
Merijärvi	1,217	1,194	1,188	1,167
Oulainen	7,973	7,856	7,849	7,755
Raahe	22,247	22,196	22,012	21,554
Siikajoki	5,868	6,074	6,220	6,268
Vihanti	3,138	2,940	2,850	2,759
Total	55,851	55,664	55,562	54,779

Table 8-21. Population structure in the Raahe economic area in 2006 (*Statistics Finland 2008*).

2006	0–14 years, %	15–64 years, %	over 64 years, %
Pyhäjoki	18,5	62,1	19,4
Alavieska	21,6	59,2	19,2
Kalajoki	19,9	63,5	16,6
Merijärvi	23,9	57,8	18,2
Oulainen	20,6	62,1	17,3
Raahe	19,0	68,2	12,8
Siikajoki	22,1	62,1	15,8
Vihanti	18,3	60,7	21,0
Economic area	19,9	64,4	15,7
All of the country	17,2	66,6	16,2

inhabitants there is about 37,000.

According to population forecasts, the number of inhabitants in the Raahe economic area will decline somewhat by the year 2040 (Table 8-20). In Pyhäjoki, the estimated population decline by 2040 is about 620 people, or just under 20%. The population of Raahe is also estimated to decline some.

In 2006, the number of people over 64 years of age in the Raahe economic area was slightly below the national average (Table 8-21). In Finland, the average percentage of those over 64 was 16.2%, and in the economic area under consideration here, the percentage was 15.7%. Especially in Raahe, the relative share of those over 64 was only 12.8%. In this economic area, 19.9% of the population was under 15 in age whereas the average in Finland was 17.2%. In other words, the population in the Raahe economic area is slightly younger than the national average.

In the Raahe economic area in 2006, 61% of the population held a degree higher than the basic comprehensive school certificate. The corresponding figure for all of Finland is about 64% (Table 8-22). The population in Raahe, Kalajoki and Oulainen is some-what higher educated compared to the other municipalities in the economic area, which shows, for example, in the higher portion of people with tertiary level degrees.

In Pyhäjoki, it is common to live in some form of housing that the residents own; the portion of detached houses of all of the housing stock is almost 80%. In 2006, there were only 238 units of rented housing in Pyhäjoki. In Raahe, the number of rented homes was about 2,900 in 2006. Altogether, there were slightly less than 5,400 rented housing units in the economic area (Table 8-23). The home building activity in the region is concentrated in Raahe and Kalajoki. The past few years have been a busy time in building, but the situation is leveling off.

Structure of industry

The structure of industry in the Raahe economic area has been characterized by the strong position of heavy industry, which shows in the number of jobs in mining and manufacturing (Figure 8-84). It is noteworthy that in this structure of industry, the em-ployment opportu-

Table 8-22. Educational structure of the population in the Raahe economic area in 2006 (*Statistics Finland 2008*).

2006	Graduated, %	Medium-level degree, %	High-level degree, %
Pyhäjoki	59.4	44.2	15.2
Alavieska	57.1	43.6	13.4
Kalajoki	60.3	43.0	17.3
Merijärvi	47.2	38.1	9.1
Oulainen	60.5	41.0	19.5
Raahe	64.9	44.1	20,8
Siikajoki	57.5	43.1	14.5
Vihanti	53.6	41.4	12.2
Economic area	61.0	43.1	18.0
All of the country	64.1	38.3	25.8

Table 8-23. Distribution of housing units per ownership type in the Raahe economic area in 2006 (*Statistics Finland 2008*).

Economic area 2006	Units of rented housing	Number of people
Total	23,604	55,556
Owner apartment	17,687	45,871
Rental home	5,386	8,721
Right-of-occupancy home	0	0
Other possessory relation or relation not known	531	964

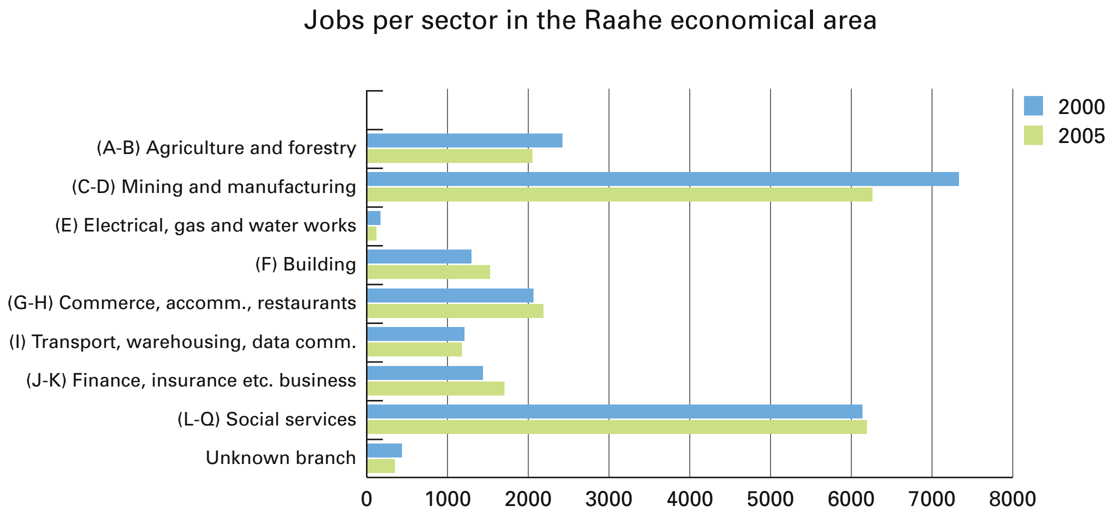


Figure 8-84. Jobs per sector in the Raahe economic area in 2000 and 2005 *(Statistics Finland 2008).*

nities in mining and manufacturing have declined significantly in the Raahe economic area over the past five years, showing a loss of 1,000 jobs in the sector. New employment opportunities are created in this industry, however, with ventures such as the Laivakangas gold mine project. The structure of industry is slowly diversifying, and new jobs are created in the commercial and service sectors as well.

The business locations in the economic area were concentrated in Raahe and Kalajoki. Altogether, there were about 2,500 business locations in the economic area in 2006 (Table 8-24).

The significance of social services as a regional employer within the structure of industry is of the same

Table 8-24. Numbers of business locations, turnover and personnel in the Raahe economic area (*Statistics Finland 2008*).

2006	Business locations	Turnover, M€	Personnel
Pyhäjoki	146	49	326
Alavieska	108	53	413
Kalajoki	582	366	2,243
Merijärvi	38	8	74
Oulainen	343	282	1,481
Raahe	892	1,409	7,701
Siikajoki	266	87	628
Vihanti	145	58	350
Total	2,520	2,313	13,216

magnitude as that of the mining and manufacturing sector. There are over 6,000 jobs in the field. There is a high school in Pyhäjoki, but the rest of the intermediate grade schools in the area are located in Raahe. The Raahe School of Engineering and Business, operating under the Oulu University of Applied Sciences, is also located in Raahe. From the point of view of Pyhäjoki, the closest hospital is located in the city of Raahe.

Investments in private services and especially in the field of commerce have increased in the region. The more versatile commercial services are concentrated in the cities of Raahe and Kalajoki.

According to the Finnish Game and Fisheries Research Institute (2007), in 2006 there were 69 professional fishermen registered in the sea area under the T&E Center for Lapland, in which the Raahe region sea area also belongs, with 26 of the fishermen getting over 30% of their total income from fishing. The number of fishing vessels was 88 in total. In Pyhäjoki, the main catch for the fishing industry is whitefish. The importance of salmon as catch grows only after the Haukipudas and Ii villages going northward along the coast In terms of catch in 2006, the share of the Bothnian Bay of the total catch from the Bothnian Bay, Bothnian Sea, Archipelago Sea and Gulf of Finland together was about 3.5%.

Agriculture in the Raahe economic area is concentrated in the Siikajoki municipality. In 2005, there were slightly over 2,000 jobs in agriculture and forestry in the economic area.

Employment and work

The distribution of industries in the Raahe economic area shows the great significance of mining and manufacturing in the role of local employer, as this sector employs about 6,000 people. The social services sector employed about the same number of people. Altogether, there were a little over 21,500 jobs in the economic area in 2005.

In 2005, Raahe and Oulainen were more than self-sufficient as to jobs, in other words, they had more employment opportunities than they had people employed. Kalajoki was close to self-sufficiency as regards jobs, too. A third of Pyhäjoki inhabitants commute to some other municipality. About 250–300 workers commute daily between Raahe and Oulu, one direction or the other. In 2005, the self-sufficiency rate of the Raahe economic area was about 100%.

At the end of 2007, there were about 2,400 unemployed job seekers in the Raahe economic area. Of the unemployed, almost half lived in the city of Raahe. The unemployment rates in the municipalities in the region were near the Finnish average, which was 8.2%. At the end of 2007, the unemployment rate in Raahe was a touch over 10% and in Pyhäjoki it was 8.1% The unemployment rate in the municipalities of the economic area averaged 8.9%. (*The Ministry of Employment and the Economy 2008*)

Municipal economy

In 2006, the financial situation of the municipalities in the Raahe economic area was a little weaker than average. The annual margin was positive in some municipalities, but however, the annual margins of the municipalities in the economic area were lower than the average in Finnish municipalities (EUR 327/inhabitant). The revenue from taxes was EUR 2,969 per inhabitant in Raahe, which is somewhat higher than the national average (EUR 2,874/inhabitant). In the rest of the municipalities, the revenue was less than this. In the economic area, the loan stock per inhabitant is quite high, especially so in Raahe where it is over EUR 4,000 per inhabitant while the national average is EUR 1,464 per inhabitant. In 2006, the revenue from taxes in Pyhäjoki was EUR 2,207 per inhabitant, the annual margin EUR 266 per inhabitant, and the loan stock EUR 2,327 per inhabitant. In 2006, the surplus in Pyhäjoki was about EUR 0.5 million, and there was a cumulative surplus of EUR 5.8 million. In 2006, the surplus of the city of Raahe was about EUR 8.4 million, but there was a cumulative deficit of EUR 8.6 million accrued earlier.

In 2006, the municipal tax was clearly the most signifi-

Table 8-25. The revenues and state subsidies of the municipalities in the Raahe economic area in 2006 (*Statistics Finland, 2008*).

2006	Income tax, M€	Property tax, M€	Share of corporate tax, M€	State subsidies, M€	Total, M€
Pyhäjoki	7.0	0.3	0.2	6.5	14.1
Alavieska	5.0	0.2	0.3	5.9	11.3
Kalajoki	17.0	0.9	1.2	13.8	33.0
Merijärvi	1.8	0.1	0.2	3.1	5.2
Oulainen	16.8	0.8	1.2	15.1	34.0
Raahe	56.9	2.0	7.6	19.5	86.0
Siikajoki	10.8	0.5	0.6	12.4	24.4
Vihanti	6.2	0.2	0.3	7.1	13.8
Total	121.6	5.1	11.7	83.5	221.8

cant source of revenue for every municipality in the Raahe economic area (Table 8 25). State subsidies played an important role, too, and in case of Pyhäjoki for example, the state subsidy was almost as high as the total revenue.

At the moment, the municipal tax rates in all the municipalities in the economic area are higher than the national average. In 2008, the municipal tax rates in the economic area average at about 19.8% while the national average is 18.6%. (*The Association of Finnish Local and Regional Authorities, 2008c*)

In 2003, the municipality of Pattijoki merged with the city of Raahe. At the beginning of 2007, Ruukki and Siikajoki merged. The latest planned merger is that of Kalajoki and Himanka at the beginning of 2010. This is the first ever Finnish municipal merger across province boundaries, and there will be about 12,500 inhabitants in the new city of Kalajoki. *(The Association of Finnish Local and Regional Authorities, 2008c)*

8.10.2.3 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

Present state in the economic area – population, structure of industry, labor market and municipal economy

Population

In the municipality of Ruotsinpyhtää, there are about 2,900 permanent residents, and in all of the economic area, there are almost 24,000 of them (Table 8-26). Most of the people live in the city of Loviisa and the municipality of Pyhtää. In 2006, the population of Loviisa averaged at 7,400 and that of Pyhtää at 5,100.

In 1985, the average number of inhabitants in the economic area was about 26,000. After that, there has been a decline due to natural reduction and migration out. There has been an increase in population in Pernaja only. In recent years, the decline of the population in the economic area has stopped, and in Ruotsinpyhtää, for example, there has been a slight increase. Urban areas close to Ruotsinpyhtää include cities like Kotka (about 55,000 inhabitants) and Porvoo (about 48,000 inhabitants). In addition, the metropolitan area with a population of over a million is at a distance of less than a hundred kilometers (Helsinki, Espoo and Vantaa).

According to population forecasts, the number of inhabitants in the economic area will grow by 10% by the year 2040 (Table 8-27). The estimated population growth in Loviisa and Ruotsinpyhtää is about 10% as well.

The population in the Loviisa economic area is slightly older than the national average. In 2006 in this economic area, 19.9% of the population was over 64 in age whereas the average in Finland was 16.2% (Table 8-28). The

Table 8-26. Average population in the Loviisa economic area in different years (*Statistics Finland 2008*).

	1985	1990	1995	2000	2006
Ruotsinpyhtää	3,394	3,354	3,268	3,020	2,917
Lapinjärvi	3,409	3,317	3,189	3,035	2,941
Liljendal	1,423	1,537	1,507	1,462	1,453
Loviisa	8,727	8,447	7,847	7,604	7,387
Pernaja	3,653	3,642	3,811	3,792	3,960
Pyhtää	5,375	5,453	5,455	5,265	5,140
Total	25,981	25,749	25,076	24,176	23,797

Table 8-27. Population forecast for the Loviisa economic area (*Statistics Finland 2008*).

	2010	2020	2030	2040
Ruotsinpyhtää	2,962	3,099	3,215	3,255
Lapinjärvi	2,963	3,051	3,172	3,236
Liljendal	1,416	1,394	1,412	1,420
Loviisa	7,421	7,651	7,929	8,025
Pernaja	4,229	4,683	5,028	5,244
Pyhtää	5,152	5,180	5,202	5,127
Total	24,143	25,058	25,958	26,307

Table 8-28. Population structure in the Loviisa economic area in 2006 (*Statistics Finland 2008*).

2006	0-14 years, %	15-64 years, %	over 64 years, %
Ruotsinpyhtää	15.8	64.7	19.5
Lapinjärvi	15.7	62.1	22.2
Liljendal	17.0	63.8	19.3
Loviisa	14.6	64.0	21.5
Pernaja	18.9	63.6	17.5
Pyhtää	17.4	64.0	18.6
Economic area	16.3	63.8	19.9
All of the country	17.2	66.6	16.2

Table 8-29. Educational structure in the Loviisa economic area in 2006 (*Statistics Finland 2008*).

2006	graduated, %	with medium-level degree, %	with higher level degree, %
Ruotsinpyhtää	53.7	36.4	17.3
Lapinjärvi	52.8	38.2	14.6
Liljendal	54.6	37.7	16.9
Loviisa	55.7	32.9	22.9
Pernaja	54.9	35.1	19.8
Pyhtää	60.1	39.3	20.8
Economic area	55.8	36.0	19.9
All of the country	64.1	38.3	25.8

share of those over 64 was the greatest in Lapinjärvi and Loviisa (about 22%).

In 2006 in this economic area, 15.8% of the population was under 15 in age whereas the average in Finland was 17.2%. Only in Pernaja the share of those under 15 was clearly over that of the national average. The aging of population poses a threat to the Loviisa economic area in the future, as the number of the elderly increases and the relative share of the young declines.

In 2006 in the Loviisa economic area, about 56% of the population held a degree higher than the basic comprehensive school certificate, which is clearly lower than average in Finland (Table 8-29). The low number of people with educational certificates is explained, at least partly, by the great share of the elderly in the population.

In Ruotsinpyhtää, it is relatively common to live in a form of housing that the residents own, and the share of domestic houses is about 75% of all the homes there. In 2006, there were a little over 250 units of rented housing, and about 15% of the population of the municipality lived in them. In Loviisa, living is more urban, and the number of rented housing units was about 1,300 in 2006. In all of the economic area, the number of rented housing units was about 2,500 (Table 8-30). In the Loviisa economic area, building projects focus on domestic houses and residential apartment buildings.

Structure of industry

After social services, manufacturing is the second largest employer in the Loviisa economic area (Figure 8-85). The focus of the enterprise structure in the economic area is on small and medium-sized industry. The key sectors are formed by industries in energy, electricity, packaging, metal and plastics.

Table 8-30. Distribution of housing units per ownership type in the Loviisa economic area in 2006 (*Statistics Finland 2008*).

Economic area 2006	Housing units	Number of people
Total	10,942	23,469
Owner apartment	8,141	18,906
Rental home	2,555	4,127
Right-of-occupancy home	0	0
Other possessory relation or relation not known	246	436

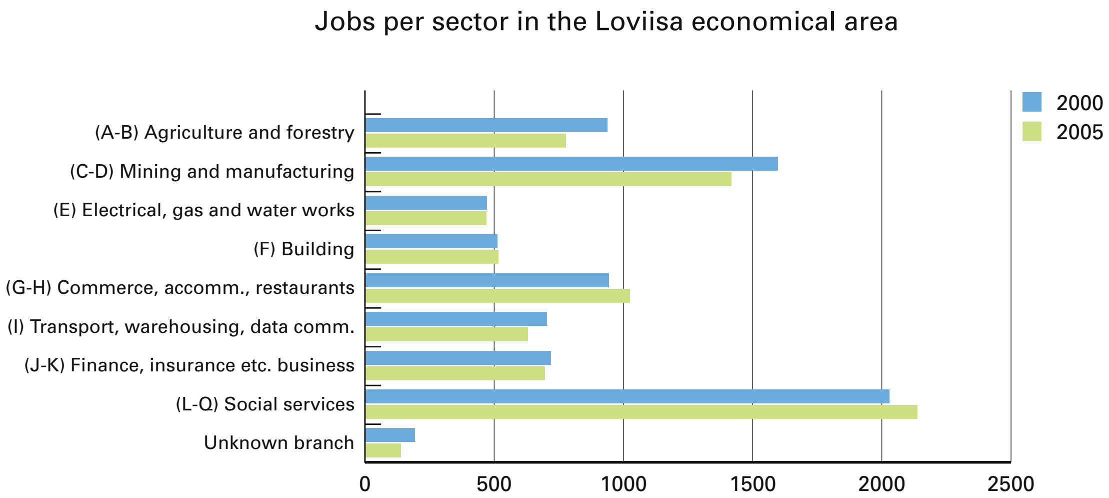


Figure 8-85. Jobs per sector in the Loviisa economic area in 2000 and 2005 (*Statistics Finland 2008*).

Table 8-31. Numbers of business locations, turnover and personnel in the Loviisa economic area (*Statistics Finland 2008*).

2006	Business locations	Turnover, M€	Personnel
Ruotsinpyhtää	149	73	465
Lapinjärvi	191	123	489
Liljendal	102	50	230
Loviisa	516	619	2,425
Pernaja	225	57	451
Pyhtää	250	90	530
Total	1,433	1,012	4,590

The locations of enterprises in the economic area are concentrated in Loviisa. One third of office locations and over half of personnel are located in the city of Loviisa. Altogether, there were about 1,400 business locations in the economic area in 2006 (Table 8-31).

Social services form the largest sector providing employment opportunities in the Loviisa economic area (Figure 8-85). This sector offers over 2000 jobs and has been experiencing a slight rise lately. Social and private services are concentrated in Loviisa. There are no intermediate-level educational institutions in Ruotsinpyhtää; they are located in Loviisa. In Loviisa, there are high-schools for both Finnish and Swedish-speaking students and a vocational school for Finnish-speaking students. The nearest polytechnics are found in Kotka and Porvoo. The nearest universities are located in Helsinki and Lappeenranta.

Healthcare in Ruotsinpyhtää is arranged through the Loviisa Healthcare District. Health center branch services can be found in the Ruukki and Tesjoki areas in Ruotsinpyhtää. The nearest hospital and health center are located in Loviisa.

According to the Finnish Game and Fisheries Research Institute (2006), there were 241 professional fishermen registered in the sea area under the T&E Center for Uusimaa in 2006, with 115 of the fishermen getting over 30% of their total income from fishing. The number of fishing vessels was 370, almost all of them small inshore fishing vessels. In terms of catch in 2006, the share of the Gulf of Finland of the total catch from the Bothnian Bay, Bothnian Sea, Archipelago Sea and Gulf of Finland together was about 5%.

Employment and work

The distribution of industries within the industrial structure of the economic area shows the importance of the role played by manufacturing. It employs over 1,800 workers. Social services are the largest sector offering employment (employing 2,800 people). All together in 2005, there were about 7,800 jobs in the economic area and 10,000 people were employed.

In addition to manufacturing, the city of Loviisa and the municipalities in the economic area play an important role as local employers. One must also note the increasing importance of commerce, accommodation services and the restaurant business in providing local employment. In 2000, this sector employed 1,200 people and in 2005, as many as 1,350 people.

Only the city of Loviisa in the Loviisa economic area is more than self-sufficient as to jobs. Over half of Pernaja and Pyhtää inhabitants, for example, commute to some other municipality to work. Many inhabitants of this region work outside the economic area, and the self-sufficiency ratio in jobs was a touch less than 80% in 2005. From Loviisa, people mainly commute to Kotka, Porvoo and the metropolitan area.

In the Loviisa economic area at the end of 2007, the share of the unemployed of the workforce was the same or lower than the national average. At the end of 2007, the number of unemployed job-seekers was less than 800, and the unemployment rate in the economic area averaged 6.5%. Most of the unemployed job-seekers lived in the city of Loviisa. (*The Ministry of Employment and the Economy 2008*)

Municipal economy

The financial situation of the municipalities in the Loviisa economic area was relatively good in 2006. The annual margin was positive in all the municipalities, and the loan stock per inhabitant was clearly lower than the national average except for Pyhtää and Loviisa. The economy of the city of Loviisa especially is on a solid basis in the light of the annual margin (EUR 887/inhabitant) and revenue from taxes (EUR 3,710/inhabitant). The property taxes from the present nuclear power plans impact Loviisa's revenue. In 2006, the deficit in Ruotsinpyhtää was about EUR 0.1 million, and there was a prior cumulative deficit of EUR 0.6 million. The surplus in Loviisa was EUR 4.4 million, and there was a prior cumulative surplus of EUR 2.9 million.

In 2006, the municipal tax was clearly the most significant source of revenue for every municipality (Table 8-32). State subsidies played an important role, too, and in case of Lapinjärvi for example, the state subsidy was as high as the total tax revenue. In 2006, the municipality of Ruotsinpyhtää was state-subsidized by EUR 2.6 million and the city of Loviisa by over EUR 10 million.

The municipal tax rates in the municipalities in the Loviisa economic area were slightly higher than the national average. The average municipal tax rate in the economic area in 2008 was 19.2% (*The Association of Finnish Local and Regional Authorities, 2008c*).

At the moment, there is a special task force set by the ministry working on the municipal restructuring of the Loviisa region (state of affairs 30 April 2008).

8.10.2.4 Simo, Karsikkoniemi

Present state in the economic area – population, structure of industry, labor market and municipal economy

Population

Table 8-32. The revenues and state subsidies of the municipalities in the Loviisa economic area in 2006 (*Statistics Finland, 2008*).

2006	Income tax M€	Property tax M€	Share of corporate tax , M€	State subsidies M€	Total M€
Ruotsinpyhtää	6.5	0.3	0.8	2.6	10.1
Lapinjärvi	5.6	0.2	0.4	6.3	12.4
Liljendal	2.8	0.1	0.4	1.6	5.0
Loviisa	19.5	3.3	4.6	10.5	37.9
Pernaja	8.8	0.5	0.5	4.0	13.8
Pyhtää	12.7	0.8	0.6	4.9	18.9
Total	55.8	5.2	7.2	29.8	98.1

In 2006, the permanent population of Simo was about 3,600, and in all of the Kemi-Tornio economic area it was about 70,000 (Table 8-33). Most of the people in the area under scrutiny here live in the cities of Kemi and Tornio. The population numbers of these cities have become increasingly similar in the recent years. In 2006, the population of Kemi averaged 22,800 and that of Tornio 22,300. The proximity of these two medium-sized cities makes the population base of Simo's economic area greater than the rest of the locations.

The population of all of the province of Lapland started a sharp decline after the recession in the 1990's, and in the end of 2007, the population of Lapland averaged 184,000. Almost one-third of the inhabitants of Finnish Lapland lived in the Kemi-Tornio economic area.

Larger urban centers relatively near Simo include Oulu at a distance of about 80 kilometers (about 130,000 inhabitants) and Rovaniemi a little further away (about 58,000 in-habitants). In addition, there are the border city of Haparanda (about 7200 inhabitants) adjacent to Tornio and the city of Luleå (about 73,000 inhabitants) in Sweden.

According to population forecasts, the number of inhabitants in the Kemi-Tornio economic area is expected to increase some in the next decades (Table 8-34). This is mainly due to the population growth expectations in Ii and Tornio. It is estimated that a growth of 30% will take place in Ii by 2040; in Tornio, the growth is expected to be more moderate. If the impact of Ii is disregarded, the population of the economic area is estimated to decline slightly from the current situation. It is estimated that the population of Simo will decline by 430 people

Table 8-33. Average population in the Kemi-Tornio economic area in different years (*Statistics Finland 2008*).

	1985	1990	1995	2000	2006
Simo	4,305	4,272	4,161	3,908	3,609
Ii (*	7,937	8,206	8,536	8,459	8,925
Kemi	26,483	25,470	24,816	23,828	22,801
Keminmaa	8,729	9,115	9,407	8,979	8,878
Tervola	4,487	4,205	4,106	3,924	3,669
Tornio	22,251	22,789	23,215	22,668	22,298
Total	74,190	74,055	74,240	71,765	70,179

* The table uses the 2007 municipal structure; the municipalities of Kuivaniemi and Ii have merged (this concerns the next tables and pictures as well)

Table 8-34. Population forecast for the Kemi-Tornio economic area (*Statistics Finland 2008*).

	2010	2020	2030	2040
Simo	3,484	3,340	3,254	3,177
Ii	9,585	10,820	11,513	11,844
Kemi	22,135	2,1281	20,928	20,546
Keminmaa	8,832	8,956	9,051	8,988
Tervola	3,519	3,269	3,161	3,092
Tornio	22,508	23,112	23,558	23,587
Total	70,063	70,778	71,465	71,234

Table 8-35. Population structure in the Kemi-Tornio economic area in 2006 (*Statistics Finland 2008*).

2006	0-14 years, %	15-64 years, %	over 64 years, %
Simo	17.3	63.4	19.3
Ii	23.0	61.1	15.8
Kemi	14.6	66.6	18.8
Keminmaa	19.2	66.3	14.5
Tervola	17.8	58.2	24.0
Tornio	18.9	66.4	14.7
Economic area	17.9	65.2	16.9
All of the country	17.2	66.6	16.2

by 2040, which is about 12% of the present population.

There are no significant differences between the population structure in the Kemi-Tornio economic area and the averages in the rest of Finland (Table 8-35). In the economic area, there are slightly more people over 64 but also some more people under 15 than in the country on average. In this economic area, 16.9% of the population was over 64 in age whereas the average in Finland was 16.2%. The share of population of those over 64 in Tornio, Keminmaa and Ii was less than average and in Kemi, Tervola and Simo more than average. In this economic area, 17.9% of the population was under 15 in age whereas the average in Finland was 17.2%. Only in Kemi the share of those under 15 was clearly under that of the national average.

In the Kemi-Tornio economic area in 2006, 63% of the population held a degree higher than the basic comprehensive school certificate. The corresponding figure for all of Finland was 64% (Table 8-36). The population in Kemi, Tornio and Keminmaa is some-what higher educated than in the smaller municipalities in the economic area.

In the municipality of Simo, almost 85% of the population lives in houses they own, which is typical of small municipalities. The rest of the inhabitants live in row houses and residential apartment buildings. In 2006, there were 245 units of rented housing in Simo, and only about 12% of the population of the municipality lived in them. The living in the cities of Kemi and Tornio is more urban than in the rest of the municipalities, as is shown by the prevalence of residential apartment buildings and rented homes. In 2006, the number of rented housing units in Kemi was about 4,000, which is almost half of their number in all of the economic area. In 2006 in Tornio, there were about 2,800 units of rented housing, whereas their number in all of the economic area was about 8,800 (Table 8-37).

<u>Structure of industry</u>

The Kemi-Tornio economic area is one of the most industrialized ones in Finland, which shows in the industrial structure of the area (Figure 8-86). The area produces about 90% of the export income of Lapland and about 8% of that of Finland. The manufacturing industry in the area is based on strong metal and forestry sectors and the related clusters. The Kemi-Tornio economic area carries weight as the commercial center of Lapland, with the recent investments strengthening this position. The commercial markets reach from Central Finland to northern Norway and north-eastern Russia.

In terms of business locations, most of the enterprises in the Kemi-Tornio economic area are located in Kemi and Tornio (Table 8-38). Altogether, there were about 3,300 business locations in the economic area in 2006, and the number of them increased by 180 in 2000-2005.

As to private services, those that have strengthened their positions within the structure of the industry in the Kemi-Tornio economic area include commerce, accommodation services and the restaurant business. The merger of the urban centers of Tornio and Haparanda

Table 8-36. Educational structure of the population in the Kemi-Tornio economic area in 2006 (*Statistics Finland 2008*).

2006	graduated, %	with medium-level degree, %	with higher level degree, %
Simo	58.0	40.8	17.2
Ii	60.3	42.6	17.7
Kemi	62.6	41.8	20.8
Keminmaa	66.4	41.4	24.9
Tervola	56.6	41.9	14.8
Tornio	64.1	43.2	20.9
Economic area	62.7	42.3	20.5
All of the country	64.1	38.3	25.8

Table 8-37. Distribution of housing units per ownership type in the Loviisa economic area ine 2006 (*Statistics Finland 2008*).

Economic area 2006	Housing units	Number of people
Total	31,731	70,163
Owner apartment	22,097	54,301
Rental home	8,814	14,402
Right-of-occupancy home	0	0
Other possessory relation or relation not known	820	1,460

Jobs per sector in the Kemi-Tornio economical area

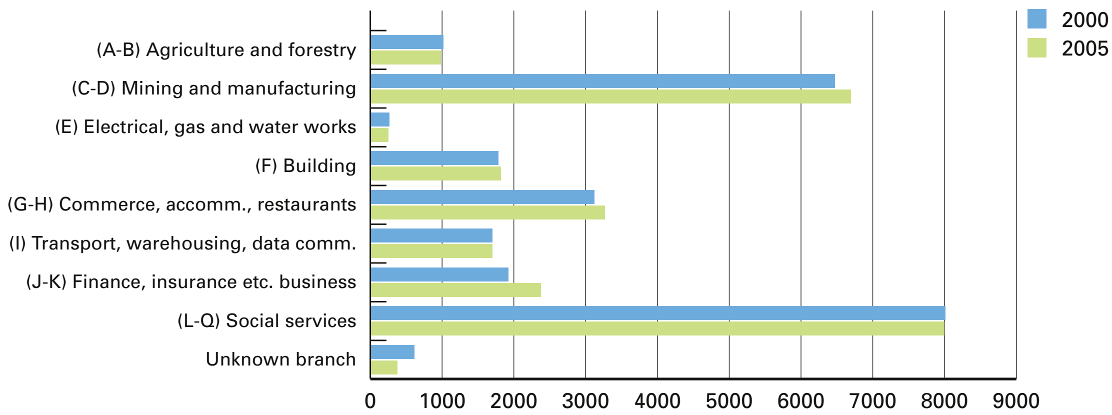


Figure 8-86. Jobs per sector in the Kemi-Tornio economic area in 2000 and 2005 (*Statistics Finland 2008*).

Taulukko 8-38. Numbers of business locations, turnover and personnel in the Kemi-Tornio economic area *(Statistics Finland 2008).*

2006	Business locations	Turnover, M€	Personnel
Simo	138	25	232
Ii	366	172	1,189
Kemi	1,006	1,919	6,150
Keminmaa	437	254	1,553
Tervola	166	59	340
Tornio	1,149	4,049	6,012
Total	3,262	6,480	15,476

involves significant commercial investments that also entice people to take shopping trips into the region, causing tourism to grow strongly. Tourism as a livelihood has increased in importance in the Kemi-Tornio area in the recent years. Shopping tourism to the urban center of Tornio-Haparanda has been rising strongly.

Social services form the largest sector providing employment in the industrial structure. These services include schools, education, health and social welfare. The sector provides about 8000 jobs. There is a high school in Simo, but the rest of the nearby intermediate schools in the area are located in Kemi. The Kemi-Tornio University of Applied Sciences and the Meri-Lappi Institute, a joint unit of the universities of Lapland and Oulu, both operate in Kemi and Tornio. The nearest universities are located in Oulu and Rovaniemi. The social and healthcare services are arranged by the Länsi-Pohja Healthcare District. The Länsi-Pohja central hospital is located in Kemi.

According to Finnish Game and Fisheries Research Institute (2006) there were 69 professional fishermen registered in the sea area under the T&E Center for Lapland in 2006, with 26 of the fishermen getting over 30% of their total income from fishing. The number of fishing vessels was 88, almost all of them small inshore fishing vessels. In the area surrounding Simo, the most important catch in the economic sense is salmon. The significance of fishing as a livelihood in all of the Bothnian Bay area has decreased. In terms of catch in 2006, the share of the Bothnian Bay of the total catch from the Bothnian Bay, Bothnian Sea, Archipelago Sea and Gulf of Finland together was about 3.5%.

In the Kemi-Tornio economic area, there is some agriculture, dairy farming and reindeer farming.

Employment and work

The sectoral distribution within the industrial structure of those employed in the Kemi-Tornio economic area shows the importance of mining and manufacturing (Figure 8-86). In 2005, the sector offered jobs for over 6,500 employees. The industrial employment opportunities exist mainly in the metal and forestry sectors. In terms of quantity, social services were the largest sector offering employment (employing 8,000 people). Altogether, there were about 25,500 jobs in the economic area in 2005.

Important regional employers, in addition to manufacturing, include the cities of Kemi and Tornio and the Länsi-Pohja Healthcare District. One must also note the importance of commerce, accommodation services and the restaurant business as providers of local employment. In 2005, this sector employed over 3,000 people, and the number has been rising in the recent years.

In 2005 in the Kemi-Tornio economic area, only the city of Kemi was more than self-sufficient as to jobs, in other words, there were 25% more jobs than people employed. The city of Tornio also offers many jobs in its area, but it is barely self-sufficient as regards them. According to a report by the Regional Council of Lapland (2008), over one third of Simo residents with employment commuted to the city of Kemi to work in 2005. In 2005, the self-sufficiency rate of the economic area was about 100%.

At the end of 2007, there were a little more than 4000 unemployed job-seekers in the Kemi-Tornio economic area. Most of the unemployed job-seekers lived either in the city of Kemi or Tornio. In 2007, the unemployment rate in the Kemi-Tornio economic area averaged 12.9%. (*The Ministry of Employment and the Economy 2008*)

Municipal economy

The municipalities in the Kemi-Tornio economic area have run more into debt and are in a weaker financial position than most municipalities in Finland. In 2006, the annual margins of the municipalities were negative except for Tervola and Simo. The municipal loan portfolio per inhabitant in the economic area under scrutiny here was EUR 2,209 per inhabitant. Revenue from taxes was below that of the national average except in Kemi. In 2006 in Simo, the annual margin was EUR 137, revenue EUR 2,89 and loan portfolio EUR 1,604 per inhabitant.

Of the municipalities in the Kemi-Tornio economic area, Kemi and Keminmaa are considered to be in crisis, in other words, their financial position is seen as particularly difficult. In 2006, the deficit of the city of Kemi was about EUR 6.2 million. There was a prior cumulative deficit of the same size. In 2006 in Simo, the fiscal year ended with a surplus of EUR 0.1 million, but there was, still, a cumulative deficit of about EUR 0.7 million.

In 2006, the municipal tax was clearly the most significant source of revenue for every municipality in the economic area (Table 8-39). State subsidies played an important role, too, and in case of Simo, for example, the state subsidy was almost as high as the total revenue.

In 2008, the municipal tax rates in all the municipalities in the Kemi-Tornio economic area are higher than the national average The average municipal tax rate in the economic area in 2008 is 20.3%.

Impacts in Sweden

Especially in the Simo location, the direct and indirect employment-related impacts of the project would reach Haparanda and the surrounding areas in Sweden due to the closeness of the national border, because an internal border in the EU does not form an obstacle to people's mobility, in practice. Even today, the cooperation between Tornio and Haparanda is extensive, and the city administrations communicate and interact on a regular basis. Many basic municipal services and recreational opportunities are shared. The training and recruiting of labor force is also planned jointly, at least in part. For practical reasons, the impacts upon Haparanda were not separately assessed quantitatively, but depending on the actions taken by the municipality (such as training and supplying workforce, supplying services, supplying housing), there may be significant benefits available for it. The possibility of some permanent staff settling in Haparanda or in Sweden should not be excluded, either. The distance between Haparanda and Maksniemi is only about 40 kilometers, and after the current road

Table 8-39. The revenues and state subsidies of the municipalities in the Raahe economic area in 2006 *(Statistics Finland 2008).*

2006	Income tax M€	Property tax M€	Share of corporate tax, M€	State subsidies M€	Total M€
Simo	8.0	0.3	0.2	6.7	15.3
Ii	16.8	1.6	0.8	17.7	36.9
Kemi	59.1	4.1	4.1	26.3	93.6
Keminmaa	21.4	2.3	1.0	9.4	34.2
Tervola	6.7	1.8	0.6	8.0	17.1
Tornio	52.5	4.0	2.2	23.2	81.9
Total	164.6	14.1	9.0	91.3	279

The impacts on traffic during the construction phase were studied as part of the EIA process. Road traffic in Finland, 2008.

construction project is finished, most of the way is freeway.

8.10.3 Living conditions, comfort and recreation

The impacts of the project on the living conditions, comfort and recreation of the people living nearby have been examined here both on the basis of expert assessments and the views of the inhabitants and other active players in the vicinity and region. The impacts based on expert assessments are presented in Chapter 8.10.3.1. The results from a survey conducted among the residents in the vicinities of all of the alternative locations are presented on a general level in Chapter 8.10.3.2. The answers to the survey conducted among residents and to the one conducted among interest groups are presented per location in Chapters from 8.10.3.3 to 8.10.3.5. A summary of the impacts upon the living conditions, comfort and leisure of the people is presented in Chapter 8.10.3.6.

8.10.3.1 Expert assessments

The nuclear power plant project impacts, for example, land use in the vicinity, the landscape and also, to a degree, fishing in the area. These impacts are dealt with per location in more detail in Chapters 8.1, 8.7 and 8.4.

The grounds of the nuclear power plant extend about a kilometer from the plant (Chapter 3). Because of the plant's extent, holiday homes need to be removed from the south-western shore of the Hanhikivi headland, and the shore in the area cannot be used for leisure purposes any more. In the Gäddbergsö alternative in Ruotsinpyhtää, some holiday homes need to be removed from the intended dock area, but other than that, it is possible to save the current holiday home areas in the vicinities of both of the locations in Ruotsinpyhtää. In the Simo alternative, the holiday homes on the southern shore of Karsikkoniemi need to be removed from between Kalasatama and the new harbor intended for the western shore to serve the plant; other than that, the land use in Karsikkoniemi can remain essentially as it currently is.

The security zone of the nuclear power plant extends about five kilometers from the plant, restricting the use of land in the area to a certain degree. In the Pyhäjoki alternative, there would be restrictions on building activities in an area starting from the northern edge of the Parhalahti village and extending towards the Hanhikivi

The impacts on people's recreation and comfort were also assessed taking into account the residents' views. Finns enjoying outdoor activities, 2008.

headland, concerning the building of new homes and other structures related to the social functions of inhabitation such as hospitals, day-care centers and schools. In the Ruotsinpyhtää alternative, most of the security zone of the nuclear power plant is already included in the security zone of the Hästholmen plant, thereby making the impacts of the restrictions on land use less significant than in Pyhäjoki or Simo. In the Simo alternative, there would be a restrictions on building activities to the South of the Hepola and Maksniemi villages concerning the building of new homes and other structures related to the social functions of inhabitation such as hospitals, day-care centers and schools.

The nuclear power plant operator must be able to control all operations on the plant's grounds, and moving around in the area would be prohibited or at least restricted. Otherwise, the normal operation of a nuclear power plant does not restrict moving or leisure activities in the vicinity except for the unfrozen stretches of water and those with weak ice covers.

The normal operation of a nuclear power plant has no radiation impacts on people's living conditions or their recreation opportunities in the vicinity. It is possible to move around in the vicinity of a nuclear power plant and pick and eat the berries and mushrooms safely. Eating fish is also safe. It is a part of the standard radiation control procedures in the vicinity of nuclear power plants that samples of soil and water are taken regularly (Chapter 11). The objects sampled for studying the soil in the environment include naturally growing berries, mushrooms and game as well as agricultural and horticultural products. The radiation monitoring conducted around Finnish nuclear power plants has not detected any radioactive materials originating from these plants in milk, grain, meat, mushrooms, berries, apples or the grass cattle grazes on. Other samples have shown minor, sporadic contents, but the samples in question have been so-called indicator samples (such as reindeer moss) that effectively accumulate radioactive materials. Objects sampled from the sea environment include pike, Baltic herring, perch and young salmon grown in the plants' cooling water. In fish, there have been only minor, sporadic signs of radioactive materials originating from nuclear plants. (*STUK 2008c*).

Should a severe accident happen, civil defense actions would be taken in the vicinity of the nuclear plant and the use of foodstuffs would be restricted. It must be born in mind, however, that the probability of a severe accident is minimal. The impacts of a severe accident are dealt with in more detail in Chapter 8.15. During the normal operation of a nuclear power plant, the protective zone (less than about 5 kilometers) and the emergency planning zone (5–20 kilometers) defined around it have no effect on the everyday life of the population (Chapter 8.15).

The most significant environmental impact of a nuclear power plant is caused by the cooling water. In the most concrete manner this is seen in the winter when unfrozen stretches of water and weak ice restrict activities that take place on ice for, for example, recreation. The impact of cooling water upon the ice conditions in the area is presented in Chapter 8.4. Because of winds, currents and differences between winters, the location and size of weak ice varies from year to year. Stretches of unfrozen water and weak ice will be appropriately marked so that people know to avoid them. It is not possible to use snowmobiles or other motor vehicles in these areas. The thickness of ice in areas where it is weak is under 10 cm, making it necessary to restrict even skiing and ice-fishing in the area. On the other hand, the possibilities for regular fishing in winter time are improved.

In Pyhäjoki, the cooling water keeps waters unfrozen or causes the nearby ice to thin out mainly to the north and east of Hanhikivi. There are no winter roads on ice or official snowmobile routes that people would be prevented from using.

In Ruotsinpyhtää, the warm cooling water can be lead into the sea in three alternative places. Depending on the alternative chosen, the main impacts will be experienced at Vådholmsfjärden, east of Kampuslandet, or at Orrengrundsfjärden, south of Kampuslandet. The Ruotsinpyhtää area experiences impacts caused by the cooling waters from the Loviisa nuclear power plant, too. The area that warms up because of them is mainly restricted to Häsholmsfjärden.

In Simo, the area of weakened ice is mainly located between Ajos and Karsikonniemi and southwards from Karsikonniemi. The unfrozen stretch of water and the area only covered by weak ice would prevent people from using the snowmobile route around Karsikkoniemi. The area of weakened ice does not stretch east of Karsikkoniemi onto the snowmobile route east of Puntarniemi, following the direction of the shoreline. There are no road routes on the frozen ice that people would be prevented from using.

On frosty mornings, there is fog over stretches of unfrozen water. However, the fog does not disturb maritime or road traffic.

8.10.3.2 Resident survey

There was a survey made among the people living near each of the alternative locations, sent to people either living in the sampling area or owning a holiday home there. The survey was intended to chart the opinions and views of the people living near the prospective nuclear power plant sites concerning, in particular, the impacts of the project upon their lives and sense of comfort. The sample for the survey included all those liv-ing within a five kilometer radius of the plant, both permanent residents and those with holiday homes there; there was also a randomized sampling including 10% of those living within a radius of 5–20 kilometers of the plant, both permanent residents and those with holiday homes there.

People in all the alternative locations assumed either a rather negative or neutral attitude towards the impacts of the project. Women tended to assume a more critical and negative view than men except for Ruotsinpyhtää where there was no significant difference of attitude between the genders. In all the alternative locations, people with holiday homes and those living in the immediate vicinity of the intended plant assumed an attitude more critical than those who were either permanent residents or lived further away.

People impacted by the Simo and Pyhäjoki alternatives were expected to benefit the most. In both of these alternatives, almost half of the respondents expected the construction of a nuclear power plant to be beneficial for the region. In Simo, a little over one-third of the respondents disagreed with the statement, and in Pyhäjoki, a little under a third. Men, permanent residents and respondents living further away from the plant deemed the benefits of the nuclear plant greater than the rest of the groups. In the survey concerning the Ruotsinpyhtää alternative, a little less than a third expected the construction of the nuclear power plant to benefit the region, while more than half of the respondents disagreed with the statement.

The majority of respondents in all the alternative locations felt that the project's impact on the comfort of their living area was negative. However, a noticeable part of respondents, i.e. about four people out of ten, believed the area could be comfortable even after the plant was built. Those living in the immediate vicinity and those with holiday homes felt more negative than the others about the comfort-related impacts.

In Pyhäjoki, about a third of the respondents expected the project to have a negative impact on the opportunities for recreation or hobbies. In other locations, the corresponding figure was about a half. In Pyhäjoki a half, in Ruotsinpyhtää a little less than a third, and in Simo a little over a third believed that the project had no impact on the opportunities for recreation or hobbies. People in all the alternative locations believed the negative impacts on recreation to concern fishing, boating, picking berries or other lines of outdoor life. People with holiday homes felt the impacts on recreation and hobbies to be negative more often than others. In none of the alternative locations did people believe the project to impact traffic and communications negatively to any significant extent.

The opinions regarding the impacts of the new nuclear power plant on how people wished to move out of their areas were unevenly divided. In all the alternative areas, the majority of the nearby residents and holiday home owners estimated the wish to move out to grow as the project progresses. Those living further away and the majority of permanent residents in all the locations believed the plant to have no impact on people's wish to move. In all locations, the project was expected to have a reducing effect on property prices near the nuclear power plant.

The employment-related impacts during the construction phase were seen to be great in all the locations. In all the locations, men had more positive expectations regarding the employment-related impacts of the construction phase than women. The employment-related impacts during the operating phase were not thought to be as significant as the those during the construction phase, but in all locations, men considered them more significant than women.

In all the alternative locations, the impacts on waterways and quality of water were seen as the most significant environmental impacts during normal use. In Pyhäjoki and Simo, people stressed the impacts on their sense of security, health and comfort. In Ruotsinpyhtää, these impacts were not considered as significant. There, people stressed, in addition to the impacts on waterways, the impacts on fishing and fishery, land use and the landscape. In addition in Pyhäjoki, people considered the employment-related impacts significant, and in Simo, the impacts on fishing and fishery.

People expressed their wish that safety would receive great attention when the new nuclear power plant is designed. In addition, they hoped that the workforce employed in the building of the plant would be Finnish, and as many people as possible from the nearby areas would be offered employment opportunities there. The advanced design should focus on minimizing the impacts on waterways and on the utiliziation of cooling water. In addition, they stressed the importance of paying attention to the local public opinion and solving the problems related to the treatment of spent nuclear fuel.

8.10.3.3 Pyhäjoki, Hanhikivi

Views of the actors in the surrounding areas

The nuclear power plant project has been deemed to introduce significant uncertainty into the development of the villages involved since it started. In Parhalahti, especially, people considered the possibilities for additional building and further development of the present properties considerably more difficult than earlier. They estimated that the planning phase had caused property prices and prices of building plots for holiday homes to decrease in the surrounding villages. For some individuals, the planning phase has caused emotional stress. Some of the interviewees felt their faith in the administra-tion and elected officials of the municipality weakened; some had lost it completely. Local people wished to see no long-term disputes created between different groups with differing views. There also was a suggestion of a referendum in connection of municipal elections.

'People in the alternative locations hang in a loose noose until the decision is made.'

'Development in the villages has been stalled; zoning should be on hold until the EIA is ready.'

'One doesn't feel like fixing the house or building like, say, a back-yard sauna.'

'A dark cloud spread out when this project was brought up.'

'The city fathers gave us a nightmare.'

'It would be ideal to be allowed to live in one's own home.'

There is a popular movement in Parhalahti opposing the nuclear power plant project, with about 140 members in mid-April 2008. The association meets at the village school, and there are 30–40 participants in the meetings.

The views as to the impacts of the project on the villages and the municipality of Pyhäjoki vary to a degree. Some people believed the municipality to become more active and the municipal economy to benefit significantly. However, a distinct majority among the actors interviewed in the surrounding area considered the project to be more harmful than beneficial for the municipality. People regarded the loss of the idyllic life in the village of Parhalahti as the most significant local drawback. They felt the village was too close to the nuclear plant and it would wither away because of the project. They were also wary that the sales possibilities for local agricultural products would become less favorable if the plant were built.

'Are there sufficient resources in the Pyhäjoki municipality to run a project like this? Will Raahe reap the benefits? Will Pyhäjoki become desolate – the rest of those who are able to move out will move out?'

'The Laivakangas mining project is about to be implemented. What are the combined impacts of the steel works, mine and nuclear power plant?'

The residents of the alternative locations have been given an opportunity to express their views on the project. A farm in Pyhäjoki, 2008.

‘We need more resources: police, healthcare, fire and rescue services.’

‘Pyhäjoki image is that of nature, how much would it suffer?’

‘We’ll get to close down our schools as there’ll be no new families with children moving in.’

‘The properties of those who want to move out should be redeemed at fair prices.’

The Hanhikivi headland itself, according to the interviewees, is an important recreational area for birdwatchers and hunters. The area is used by the locals for picking berries like buckthorn and Arctic bramble. The bathing beach of the Parhalahti people is located in the western part of the headland, and there are popular spots for fishing close to the headland. As to everyday exercise or fitness training, the value of the area is reduced by the lack of walking paths and other similar passages. There are unbuilt shores on the Hanhikivi headland, but as they are low-lying meadowlands and often protected, they are not very suitable for holiday homes.

People also felt the operational preconditions for camp centers in Raahe will deteriorate if the nuclear power plant is built. They were worried for, for example, what would happen to the good quality of swimming water at the bathing beaches.

Among the construction phase impacts, people considered these significant: increasing sense of insecurity, impacts of the building site traffic upon traffic safety and the living environment, loss of the village idyll, and loss of the Hanhikivi area and its natural state. Holiday home owners were seen to be trampled by the nuclear power plant and the associated operations and structures required by it.

Among the operating phase impacts, people would most often bring up these: restriction of opportunities to move around on the Hanhikivi headland, disturbance caused by the lighting of the plant, sense of insecurity caused by the accident risk, fear and worry concerning risks to one’s health due to radiation. During the discussion on radiation hazards, people referred to a German study according to which the prevalence of leukaemia in children has increased in the vicinity of nuclear power plants. All in all, the interviewees regarded a new nuclear power plant adjacent to the village to be a very strange proposition, unsuitable for the village idyll and peaceful country life.

Local and regional views of the project

At municipal and regional levels, the benefits from the nuclear power plant project were seen to be extensive.

Employment opportunities in the region have been in decline for the past few decades. The Raahe region is an industrialized subregion, and the regional self-sufficiency regarding employment is high. There is one large operator in the area with its related spin-off industries. In addition to these, mechanical wood processing plays an important role in providing jobs in the region. The development of the Pyhäjoki municipality has been closely linked to that of the Raahe region.

The impacts of the nuclear power plant on the local trade and industry were compared to those of Rautaruukki coming into the region. However, it was also brought up that the indirect benefits to the local and regional economy depend on the activity and skills of the local entrepreneurs. The construction phase will boost but also disturb the market. The building sector in the Raahe region is relatively minor today and the project would have a significant impact on the region.

The local Chamber of Commerce has estimated the property and income taxes brought by the project. According to these studies, the property taxes would ámount to about EUR 3.5 million annually in the Pyhäjoki municipality while the employment-related impacts such as income taxes would spread out to a more extensive commuting area. After the construction phase, the 400 or so new permanent jobs would mean about one thousand new permanent residents for the region. The steady revenue from taxes, extending to the commuting area, would amount to about EUR 4 million annually, according to the estimate by the Chamber of Commerce. New jobs would bring in highly edu-cated residents and increase the accumulation of income tax revenue. The population increase was believed to increase the demand for good housing plots, and building plot prices were expected to go up, in particular after the construction phase. The project would create jobs in the service sector as well, enhancing the local service structure and making the region more enticing. By and large, the Raahe region currently relies on one single industrial plant. The demand for services created by the new plant would facilitate the formation of a more extensive industrial base. A positive impact was seen in that the local cultural life would become livelier, also benefiting the present residents.

The interviewees considered the local resources to be ample for starting a building site for a nuclear power plant. However, the demand for workforce increases in the region just like elsewhere in Finland, and there would be an inevitable need for external recruiting. The region has experienced a similar surge of growth earlier, however, when the metal works were established there. Along with it came inhabitants, accommodation and catering services and businesses. There are vacant apartments and unused accommodation capacity available. The project was seen as an opportunity to cooperate on the Raahe-Kalajoki-Oulainen axis. The providers of health services, too, are well networked in the area.

The most concrete of the environmental impacts of the project was seen to be the local impact of cooling water on ice formation in the Hanhikivi area. The considerable threats mentally associated with nuclear power were understood, but on the other hand, the opposition's most pointed claims — such as that of half of the population wishing to move out — were called into question. The interviewees had faith in the newest technologies and the fact that the nuclear power sector takes all threats and risks related to operations extremely seriously. The nuclear power company was seen to invest in safety and comfort, and this was believed to have a positive effect on other players in the region as well.

The EIA was expected to present facts to fight off visions of threatening scenarios so that the unfruitful black-and-white discussion based on emotions could be ended. However, the importance of the Hanhikivi headland for the holiday home owners and residents of the nearby areas was understood.

Results from the survey conducted among residents

There were 589 survey forms in total sent out concerning the Pyhäjoki alternative, and 311 replies were received. The reply rate to this survey among residents was extremely high: more than one person in two (53%) sent in a reply. The response rate of those living nearby (within a five kilometer radius of the nuclear plant site) was higher, 88%, than that of those living further away (5–20 kilometer radius), 46%. Therefore, it can be said that the nuclear power plant project has stirred much interest. The residents have wished to express their views and take part in the EIA process.

The respondents were asked about the comfort of their present living area and their expectations of it after the nuclear plant was built.

Of all the respondents, 91% considered their present living area comfortable or very comfortable. Only 8% of the respondents considered the area they lived in either less than comfortable or uncomfortable (Figure 8-87). After the nuclear plant were built, 30% of all the respondents considered their living area either comfortable or very comfortable. Almost half of the respondents estimated their living area to be less than comfortable or uncomfortable after the nuclear plant were built. Women hed more negative expectations regarding the impacts on comfort than men (Figure 8-88). Holiday home owners felt that the impacts of building the nuclear plant on the comfort of the area would be clearly more negative than the permanent residents. The respondents living close to the intended plant felt the impacts on their comfort more to be more negative than the rest of the respondents.

A large share of the respondents considered the employment-related impacts of the construction phase of the nuclear plant either rather significant or very significant (Figure 8-89). 73% of all the respondents, 64% of the women and 79% of the men, considered the employment-related impacts of the construction phase either rather significant or very significant. A little less than a quarter of all the respondents, 31% of the women and 18% of the men, considered the employment-related impacts of the construction phase either rather insignificant or very insignificant.

The employment-related impacts of the operating phase were not considered significant as often as the construction-phase impacts. Almost half of the respondents estimated the operating phase impacts to be rather significant or very significant. There were differences of opinion between the genders. 61% of the men and 37% of the women considered the employment-related impacts in the operating phase either rather significant or very significant. 34% of the men and 45% of the women estimated them to be either rather insignificant or very insignificant (Figure 8-90). 18% of the women considered the employment-related impacts in the operating phase to be completely insignificant. The permanent residents considered the employment-related impacts in the operating phase more significant than the holiday home owners. Similarly, those who lived further away considered the employment-related impacts in the operating phase more significant than those who lived nearby.

The respondents were asked to name three most significant environmental impacts of the construction phase and three most significant environmental impacts of the operating phase. The most significant impacts of the construction phase were condidered to be those on land use and landscape, employment and traffic.

The impacts brought up as most significant for the operating phase were those on waterways and the quality of water, on sense of security and on health and comfort. In addition, some respondents answering an open-ended question on the issue expected the project to entice new residents to move into the area.

A little less than half of the respondents expected the project to have no impact on the opportunities for recreation and hobbies. Of all the respondents, one tenth expected the impacts to be positive whereas almost a third

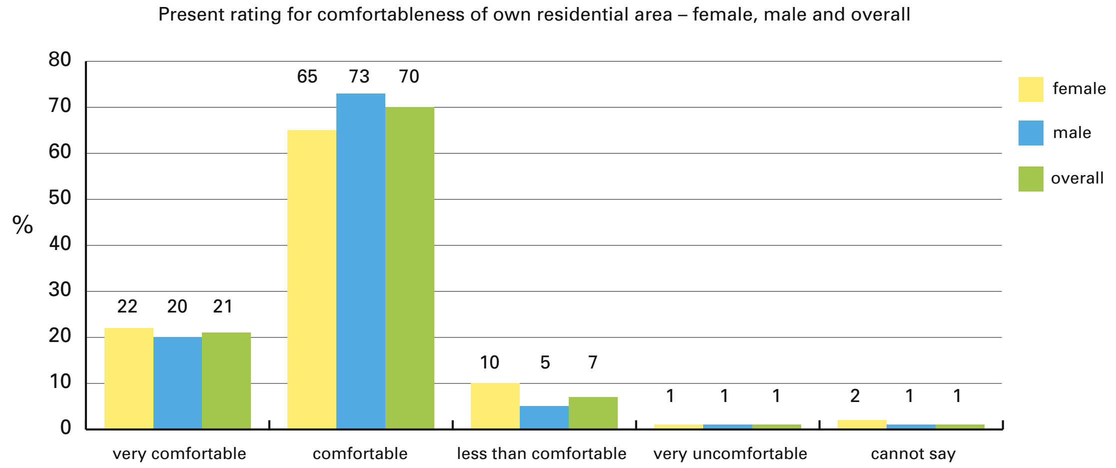


Figure 8-87. Views of respondents as to the current comfort of their living area (Pyhäjoki).

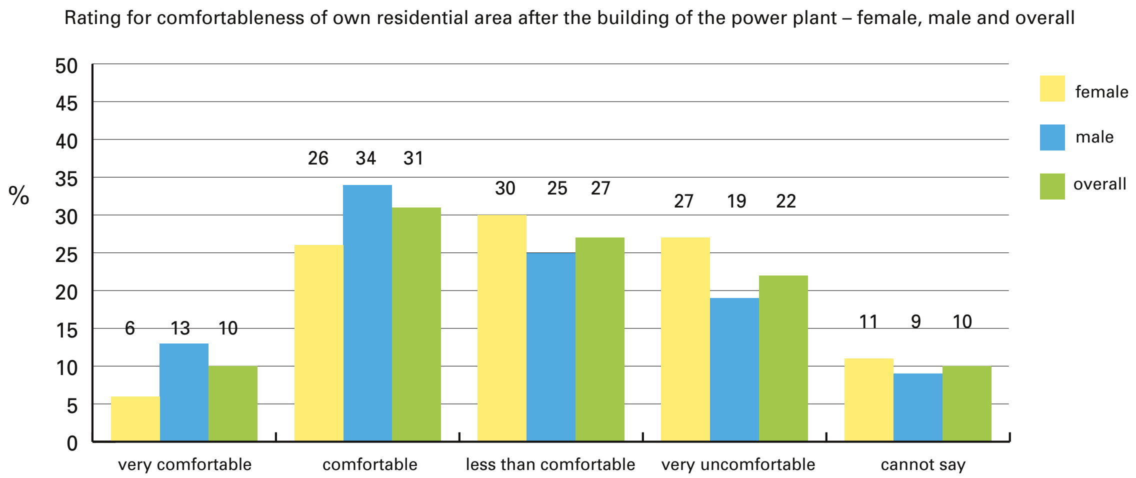


Figure 8-88. Views of respondents as to the comfort of their living area after the nuclear plant is built (Pyhäjoki).

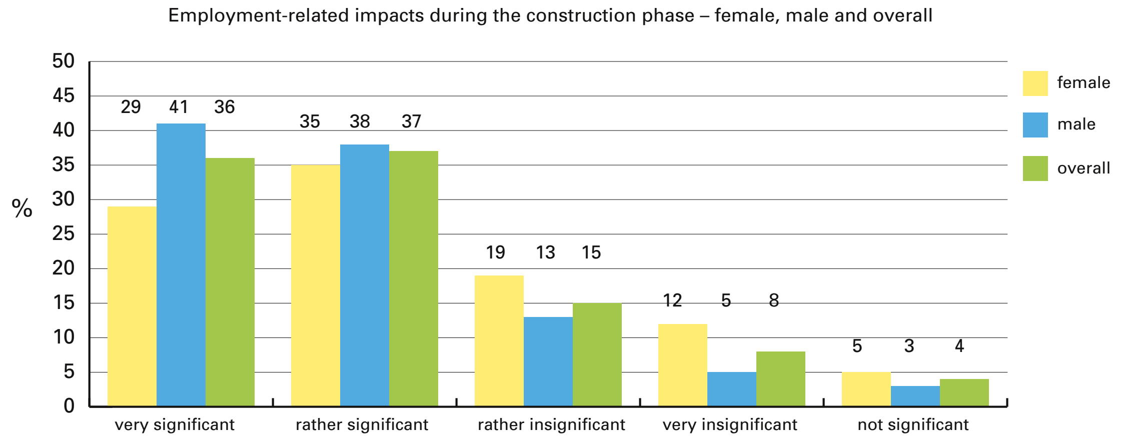


Figure 8-89. Employment-related impacts in construction phase, all respondents, men and women (Pyhäjoki).

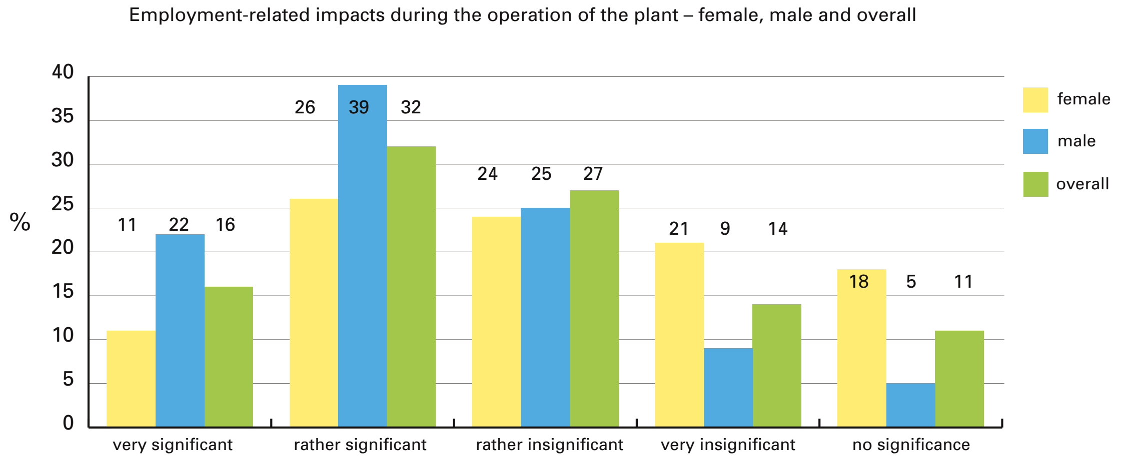


Figure 8-90. Employment-related impacts in operating phase, all respondents, men and women (Pyhäjoki).

of them estimated the impacts on opportunities for recreation and hobbies to be negative. Most often, impact was expected on fishing, boating, outdoors life, picking berries and hunting water fowl. The project was not generally seen to impact traffic connections or other passageways.

The impacts of the new nuclear power unit on how people wished to move out of their area were unevenly divided. About two thirds of the nearby residents and holiday home owners expected the wish to move out to increase if the project is implemented. A good half of those living further away and the same portion of permanent residents believed the plant to have no impact on people's wish to move. The holiday home owners and nearby residents, especially, believed the project to cause the values of the properties to deteriorate.

The resident survey presented the claim, 'I believe that the building of the nuclear power plant will benefit my area', and the respondents were asked to assess its truth value. The divergence among the different respondent groups was relatively large. Most of the men, permanent residents and those living further away agreed with the claim while holiday home owners and nearby residents disagreed. Over half of the men and the same portion of those living further away believed that the nuclear power plant would benefit their area. 41% of the women thought the project to benefit them, and 36% disagreed with the claim. A considerable part of the respondents was unable to determine what stand to take (Figure 8-91).

People expressed their wish that safety-related impacts would receive great attention when the new nuclear power plant is designed. In addition, people hoped that the workforce employed in the building of the plant would be Finnish, and that attention would be paid to the issues of emissions, radiation and the treatment of radioactive waste.

8.10.3.4 Ruotsinpyhtää, Kampuslandet and Gäddbergsö

Views of the actors in the surrounding areas

The nearby residents and actors held very critical views about the project, the EIA process and studies. The EIA

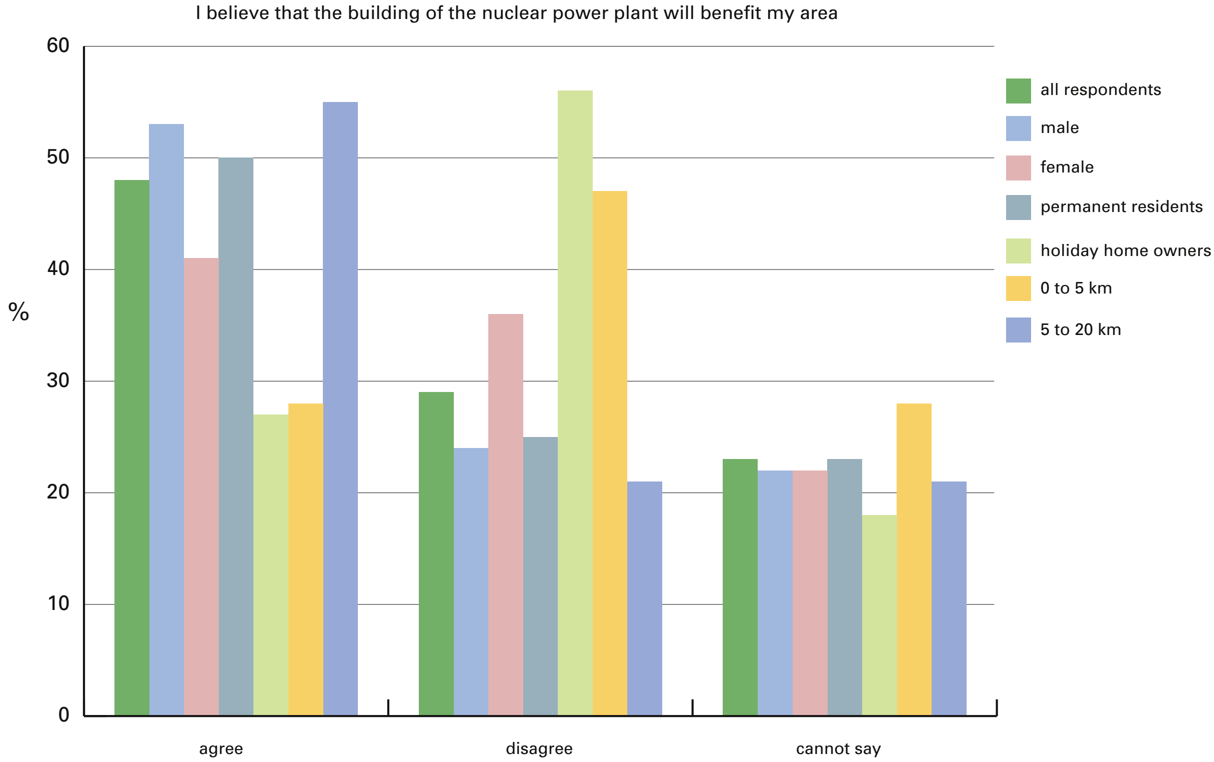


Figure 8-91. My view of the claim, 'I believe that building the nuclear power plant will benefit my area' (Pyhäjoki).

process was compared to a theatrical piece acted out too fast. Serious doubt was cast upon the true possibilities of the residents and other interest groups to exert real influence. People hoped that the information flow and dialogue with the party responsible for the project would be improved. The advancement of the project regardless of the local opposition was criticized. The basis for the assessment and monitoring of environmental impacts should be the understanding of the present state of the environment and especially the waterways in the area. When assessing radiation impacts, according to the interviewees, it would be necessary to note the recent studies in Germany which claim the risk of cancer to be increased in the vicinity of nuclear power plants. The assessment of impacts on waterways was criticized, too.

'How do we influence them to do sufficient flow modeling? This includes the usual ice conditions. It is not possible to do any reliable research in a few months. We have no basic information about the currents in this area and it is not possible to get it within this timeframe.'

'The models in Fortum's EIA are not valid, the currents really do not flow like that.'

As to the design phase impacts, the uncertainty of the future of the area was regarded as a significant negative impact. The project was considered to be less than optimally timed considering municipal decision-making and the ongoing discussion of municipal mergers.

'We're hanging in a loose noose as long as we don't know whether there will be a nuclear plant here or not.'

'Not knowing is worst.'

'The locals don't dare do the planned investments on building projects and extensions because of this uncertainty.'

As to the impacts of the construction phase, people thought that traffic safety on Saaristontie would deteriorate. Power lines and roads were expected to take up very much space on the islands. There was the fear that construction workers would cause disturbances and an increased risk of burglaries in the area.

The impact on waterways was brought up as one of the most important operating phase impacts. It was pointed out that the currents in the area flow from east to west extending the impact area to Loviisa, Pernaja and maybe even Pellinki. The interviewees were of the opinion that, if both of the nuclear projects under way in the area currently get implemented, the impacts on waterways will be visible very widely. There was the fear that cooling water would cause vegetation in narrow straits to overgrow and boats would have no more access. It was pointed out that there were five spots for fyke net fishing in the waters close to the nuclear power plant and it was expected that the fishing would stop in them if the project were to be implemented.

'It's necessary to measure for years to get correct flow data. There's been measuring equipment in one spot in Häsholmsfjärden. This tells us nothing of the sea as a whole; that would require 20–30 pieces of metering equipment.'

'It is particularly into the inner bays that the strongest currents flow.'

'The impacts of Hästholmen were estimated to be much smaller than they actually were.'

Similarly, the impacts of the nuclear power plant upon fish were considered to be considerable. The present Hästholmen plant was seen to have caused the share of coarse fish to multiply dramatically in the nearby waters.

'As much as maybe 20,000–25,000 kilos of fish gets sucked into the intake pipes in Hästholmen, including planted fish. There are ways available to help the fish bypass the plant.'

'The hunting club uses the area for fishing. If the water gets more spoiled, there will be no more fishing for recreation. The ice is weak as it is.'

Areas valuable from the point of view of the recreational use of waterways and the leisure of the residents and holiday home owners include Kampuslandet and more precisely, Kasaberget. In addition, it was pointed out that the route for traditional yachts goes between Kampuslandet and Gäddbergsö.

The implementation of the nuclear power plant was seen to change the social and cultural structures of the archipelago.

'We've hoped to have entrepreneurs and families with children moving in into the archipelago and we've taken a lot of trouble to make it happen. In the recent years, we've been very happy to have families move in, and there have been children born here — the 17th one was just born. This is probably the end to that development.'

'The municipality has been of the opinion that only minor enterprises that cause no disturbance are suitable for the archipelago, like the boat-building yard we got EU subsidies for. Is the municipality now going to betray the islanders?'

'The change is going to be too huge for the area; we are talking about a large industrial complex that does not suit the area.'

One of the interviewees considered the impacts of the nuclear power plant upon the local social life to be extremely negative:

'For generations, many people have held to the tradition that the family meet at their summer cabin in the summer or in the parents' place. If the project gets implemented, this will end and families will break up. Family relations and friendships, fishing and hunting teams, boat crews and all social life will be destroyed.'

All in all, the interviewees considered the location pointed out in the EIA program for Ruotsinpyhtää as very unfavorable from the point of view of nature and the people. Getting public utility services in the area was seen as an eventual positive impact; otherwise they thought the benefits would "escape" Ruotsinpyhtää. The project's impacts on waterways were considered a great problem.

Local and regional views of the project

The intended nuclear power plant location was seen to be one where the residents and holiday home owners had settled because of the unspoilt nature. There are old farms in the area as well, some of them founded as early as in the 1500's and 1600's. In practice, the islanders live their own lives far from everything. The service level in the designated area is modest. There are more than a hundred permanent residents, and the number is multiplied in summer when the holiday home owners come. Ruotsinpyhtää and Pyhtää can be described as dormitory communities with the municipal sector as the largest employer. In the Loviisa region, people's desires concerning moving were studied, and the report indicates that the present nuclear power plant had no significant effect one way or the other. The present residents have lived in the area for a long time and have appar-ently become accustomed to living in the neighborhood of a nuclear plant, no more considering it to pose a threat.

The close vicinity of the plant was considered wonderful as to its nature, but challeng-ing from the point of view of tourism, for example. The area borders on open sea, there is no archipelago to protect it, and the waters are rocky. The holiday home property prices in the area have been the highest in Finland, which is typical of Itä-Uusimaa. During recent years, there has not been much property for sale, and what there has been, has sold fast. The waters near the designated area are popular among recreational fishermen, and they come to the area from as far as Kymenlaakso and Päijät-Häme. There are a few professional fishermen in the area, too. Kasaberget was mentioned as a valuable destination for viewing the landscape, picking berries and collecting mushrooms.

As to the planning phase impacts, the effect of the nuclear plant project on the sales of the holiday home estates was brought up during the interview. After the EIA process started, the interviewees said, the real estate business had clearly slowed down.

The views of permanent residents and summer house dwellers on the nuclear power plant project were studied in the alternative locations. Mail boxes, Ruotsinpyhtää 2008.

As to the construction phase impacts, it was brought up during the discussion that there is a lack of sufficiently trained experts in the Loviisa area. People guessed that most of the builders would come from where the plant was ordered from. However, they hoped the project would help improve the employment situation in the Loviisa region. It would make the project more acceptable if it was definite that the employment-related impacts would be experienced in the region of the plant's location. The local subcontractors ought to be able to benefit from it as much as possible. People desired more information on housing, healthcare services and the responsibilities of arranging services for the family members of the staff. It was seen that the project might enable the commercial services to grow. During the construction phase, it would be necessary to ascertain that the local labor and service market would not overheat. When mapping out accommodation alternatives for workers, it would be sensible to clarify how the existing barracks on Hästholmen could be utilized.

If there were 3,000 people working on the nuclear construction site, the present population of Ruotsinpyhtää would be doubled. The interviewees were of the opinion that there will be potential builders for the nuclear power plant available from dockyards and the paper industry. The construction phase was expected to impact the local social and cultural life significantly, especially if the builders were foreign.

It was expected that permanent staff would prefer to settle in the nearby Loviisa area rather than Ruotsinpyhtää. Therefore, income tax was not thought to benefit Ruotsinpyhtää as such, but property taxes alone were considered considerable. From the point of view of the business life in the municipality, the project in total was seen in positive light except for the drawbacks perhaps experienced by the local fishing. Tourism was considered a future branch of industry upon which the project might impact both positively and negatively through image-building. The impacts on house prices in the region were expected to be small except for the immediate vicinity of the nuclear power plant.

As to the environmental impacts during the operating phase, the main attention focused on the impacts of cooling water. The cooling water intake and discharge locations should be chosen as far as possible from the shore in order to minimize the impacts. The waterways west of Hästholmen were thought to have suffered because of the present nuclear plant. It was brought up, for example, that the quality of water had deteriorated, the fish stock had undergone changes of species, and the conditions had become less favorable for ice-fishing. People explained that comb jellies (*ctenophores*) had been found by Hästholmen and shellfish now grew in the cooling water intake pipes. In addition, fish getting into the cooling water intake was seen to have caused major damage to the fish stock. The new nuclear power plant was thought to cause similar impacts, in particular west of the plant. In addition to the impacts on waterways, the impacts caused by light emanating from the plant were considered significant.

Results from the survey conducted among residents

There were 948 survey forms in total sent out concerning the Ruotsinpyhtää alternative, and 316 replies were received. The reply rate to this survey among residents was relatively high: a third (33%) of those who had been sent a survey form sent in a reply The response rate of those living nearby (within a five kilometer radius of the nuclear plant site) was a little higher, 35%, than that of those living further away (5–20 kilometer ra-dius), 33%. The respondents were asked about the comfort of their present living area and their expectations of it after the nuclear plant was built.

Of all the respondents, 88% considered their present living area comfortable or very comfortable. Only 9% of the respondents considered the area they lived in either less than comfortable or uncomfortable (Figure 8-92). After the nuclear plant were built, 36% of all the respondents considered their living area either comfortable or very comfortable. More than half of the respondents estimated their living area to be less than comfortable or very uncomfortable after the nuclear plant were built. Men felt the impacts on comfort to be more negative than women (Figure 8-93). Holiday home owners felt the impacts of building the nuclear plant on the comfort of the area to be clearly more negative than the permanent residents. The respondents living close to the in-tended plant felt the impacts on their comfort to be more negative than the rest of the respondents.

A large share of the respondents considered the employment-related impacts of construction phase of the nuclear plant either rather significant or very significant (Figure 8-94). 58% of all the respondents, 53% of the women and 61% of the men, considered the employment-related impacts of the construction phase either rather significant or very significant. About a third of all the respondents, 38% of the women and 29% of the men, considered the employment-related impacts of the construction phase either rather insignificant or very insignificant. 9% of the women and 10% of the men considered the employment-related impacts in the construction phase to be completely insignificant

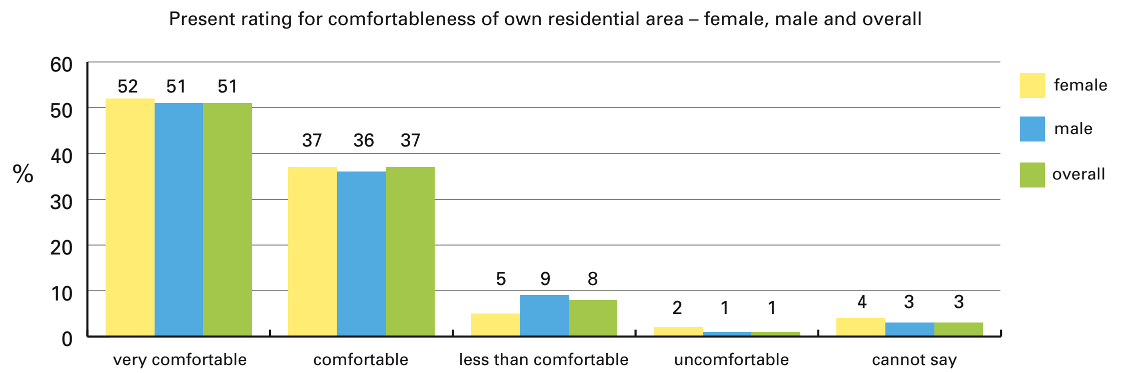


Figure 8-92. Views of respondents as to the comfort of their living area currently (Ruotsinpyhtää).

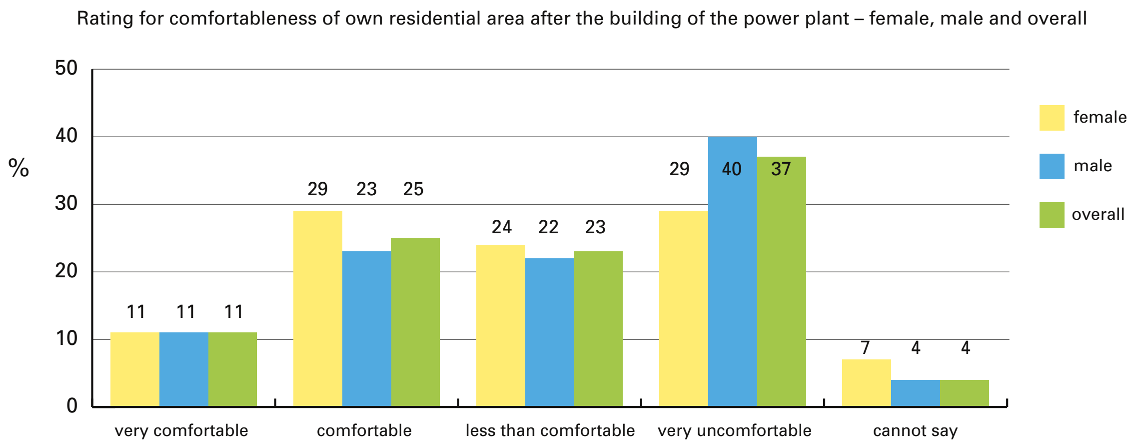


Figure 8-93. Views of respondents as to the comfort of their living area after the nuclear plant is built (Ruotsinpyhtää).

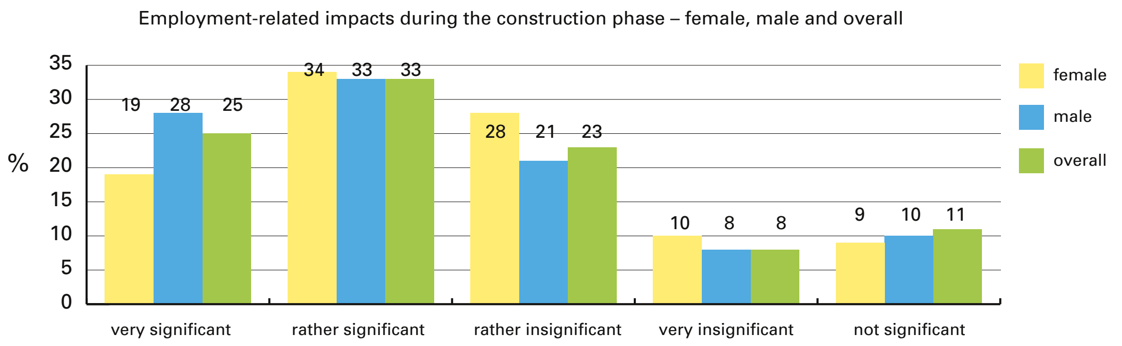


Figure 8-94. Employment-related impacts during the construction phase, all respondents, men and women (Ruotsinpyhtää).

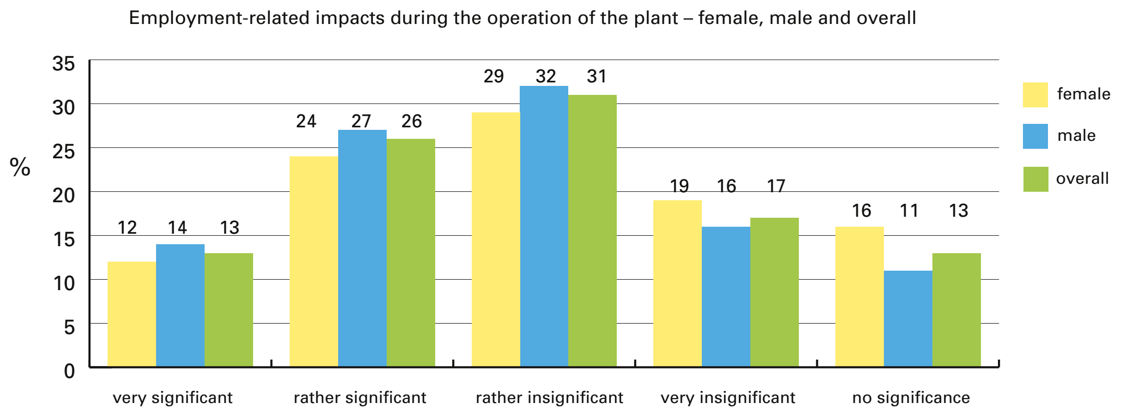


Figure 8-95. Employment-related impacts in operating phase, all respondents, men and women (Ruotsinpyhtää).

Holiday home owners considered the employment-related impacts in the construction phase somewhat less significant than the permanent residents did. Those living further away considered the employment-related impacts most significant.

The employment-related impacts of the operating phase were not considered significant as often as the construction-phase impacts. 39% of all the respondents estimated the operating phase impacts to be rather significant or very significant. There were small differences of view between the genders (Figure 8-95). The permanent residents considered the employment-related impacts in the operating phase more significant than the holiday home owners. Similarly, those who lived further away considered the employment-related impacts in the operating phase more significant than those who lived nearby.

The respondents were asked to name three most significant environmental impacts of the construction phase and three most significant environmental impacts of the operating phase. The impacts brought up as most significant for the construction phase were those on traffic, land use and landscape, impacts from building the required power lines, and impacts on people's sense of security.

The impacts brought up as most significant in the operating phase were those on water-ways and the quality of water, on fishing and fishery, and on land use and landscape.

A little less than a third of the respondents expected the project to have no impact on the possibilities for recreation and hobbies. Of all the respondents, about one in eight esti-mated the impacts to be positive, and a half expected the impacts on opportunities for recreation and hobbies to be negative. Most often, these impacts were expected to focus on fishing. In addition to fishing, the project was expected to impact boating and berry-picking negatively.

The opinions regarding the impacts of the new nuclear power plant on how people wished to move out of their areas were unevenly divided. About half of the nearby residents and holiday home owners expected the wish to move out to increase if the project were to be implemented. About half of the permanent residents and half of those living further away believed the plant to have no impact on people's wish to move. In general, people believed the project to cause deterioration in property values.

The resident survey presented the claim, 'I believe that the building of the nuclear power plant will benefit my area', and the respondents were asked to assess its truth value. There was some divergence among the different respondent groups as to the claim. Those most agreeing with the claim included permanent residents and those living further away while all the other groups clearly disagreed. The majority of those living further away also disagreed with the statement (Figure 8-96).

People stressed safety in the design of the new nuclear power plant unit and expressed their wish that minimizing the impacts on waterways and the utilization of cooling water would receive great attention.

8.10.3.5 Simo, Karsikkoniemi

Views of the actors in the surrounding areas

As to the impacts of the nuclear power plant project during the planning phase, the group interview session brought up the uncertainty felt by the nearby residents and holiday home owners. The impacts experienced in the planning phase were expected to be created mainly in the near vicinity of the plant. In the village of Simo, there were no significant impacts detected. Even though the project has got both proponents and opponents, it has not caused deterioration in neighborly relations. The opponents were seen as 'louder' than those who had assumed a neutral or positive attitude towards the project.

In the group interview session, it was pointed out that there are holiday homes within the bounds of the site presented in the EIA document. Holiday homes, sections of the Hepola residential area and the Maksniemi village are located inside the five-kilometer security zone. Particularly in Hepola, the question of security zone has caused concern among the residents. The people living in the vicinity of the intended plant would wish to have the matter resolved as soon as possible. It was said that property prices in the Hepola area had gone down because of the project and the area had become less enticing than before. In Kemi, the planning of the Satamakangas residential area has been stalled.

It was pointed out that the planned nuclear power plant project had prevented people from building on the lots they had earlier reserved in Karsikkoniemi. The investment opportunities of an entrepreneur in tourism, operating on the headland, have been also been thwarted.

The building of the nuclear power plant would significantly reduce the hunting grounds in Karsikkoniemi. The Karsikko area is especially important for moose hunting. The interviewees also thought that people's interest in picking berries and mushrooms in the headland would decrease. The southernmost areas of Karsikko and Laitakari with its surroundings are important bird sanctuaries, and this environmental value was estimated to suffer significantly if the nuclear power plant project were to be implemented there.

The closest school was estimated to be located within the security zone. The nuclear power plant project was thought to impact children's sense of security.

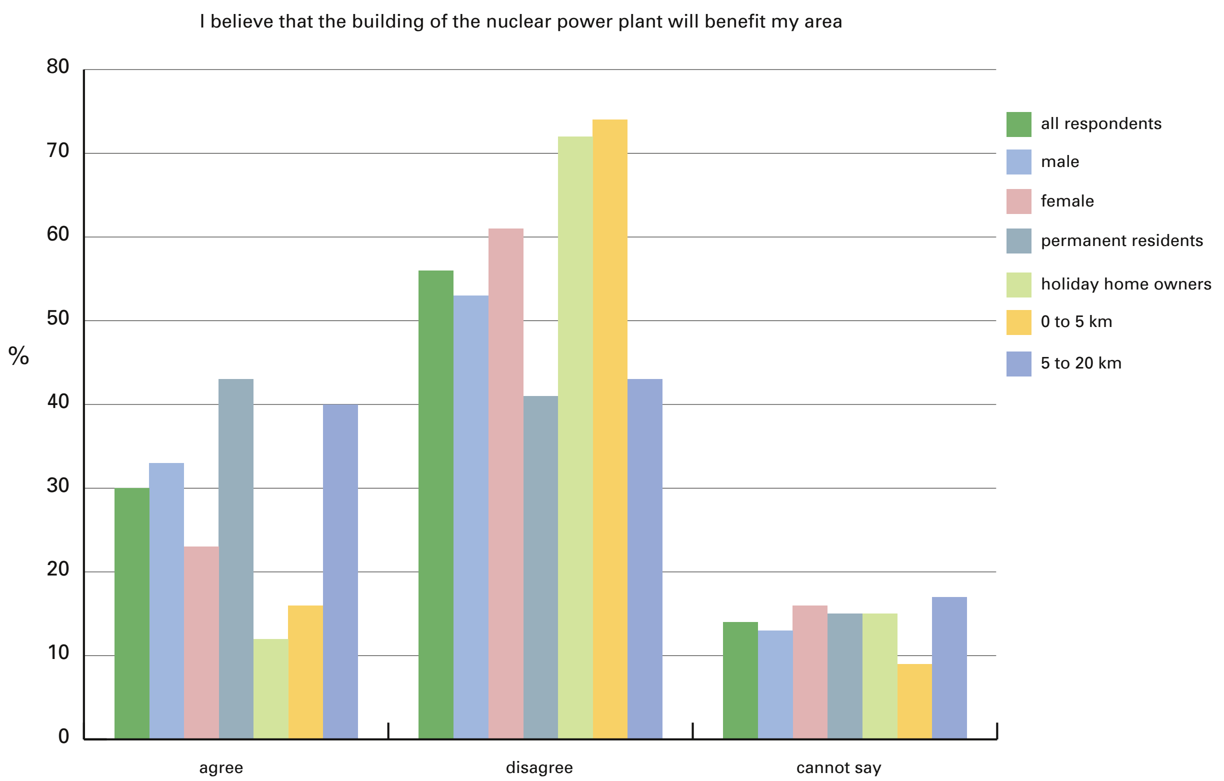


Figure 8-96. My view of the claim, 'I believe that the building of the nuclear power plant will benefit my area' (Ruotsinpyhtää).

The views of people living near the alternative locations were studied by conducting a resident survey. Landscape in Simo, 2008.

'How will children react to rescue and evacuation plans and practices?'

The interviewees with critical attitudes towards the project were worried about the long-term impacts upon the future generations. In the nearby area, there are residents who are concerned about the plant's impacts on their health. Spent nuclear fuel, in particular, is considered an environmental hazard. Some residents are concerned about the admonitions given and defects and delays seen during the construction of the new nuclear plant in Olkiluoto, considering them to have an adverse effect on the safety image of nuclear power. Those with critical attitudes towards the project doubted whether the party responsible for the project has sufficient insurance coverage for accidents that might happen. In addition, the opponents say, there are local polluters already.

A survey conducted by the association of single-family house owners of the Hepola area among its members (a third of the members replied) showed that three quarters of the respondents opposed the construction of a nuclear power plant in Karsikkoniemi. The plant was seen to be located too close to residential areas. The residents were worried about radiation and the risk of accidents. Increasing water temperatures were seen as a significant impact of the nuclear plant. In addition, the local residents were concerned about the final repository of spent nuclear fuel.

When the social impacts of the construction phase were discussed, the interviewees thought that by preparing in the right manner, local businesses and workers would get to benefit from the project. The nearby residents were, however, worried about the possible disturbances caused by a large group of workers. But some potential was also seen in an international group of builders:

'Cultures may collide at first, but there will be benefits, too. They'll teach more lan-guages in the local school - that'll enrich our culture.'

Some of the interviewees believed that the property prices in the vicinity would deteriorate, some thought house and property prices would eventually rise due to the increased demand. People believed that the building sector in Maksniemi would also be boosted.

'The nearby area will be more enticing for residents once people are used to the plant.'

There was the fear that the plant's cooling water would cause eutrophication in the nearby waters and entice warm-water fish to the traditional areas of migrating fish. Fish getting into the cooling water intake pipes was also thought to adversely impact the local fish stock. Two or three professional fishermen operate in the Karsikkoniemi area. People fear that the warming of seawater would drive catch away from the area, and in addition, the spots suitable for fishing by Karsikkoniemi and Laitakari were seen to be lost if the nuclear power plant were to be implemented here.

Unfrozen stretches of water were expected to cause fog when the temperatures drop well below freezing. The snow-mobiling conditions were expected to deteriorate.

The area of the intersection of Karsikkoniementie and highway No. 4 should be reconsidered as the nuclear power plant project proceeds.

The interviewees regarded the intensifying of business and the improvement of municipal economy as the positive impacts of the nuclear power plant project. On the other hand, the project was expected to cause expenses for the municipality as well. The interviewees wished to know who is ultimately responsible for the costs of setting up the services required in the construction phase and building the public utility services. However, property and income taxes were considered significant benefits to be drawn from the project. The project was estimated to diversify the local labor market and in-crease the need for education. The young in the region were seen to benefit from the additional employment opportunities. The project was also seen as an opportunity to strengthen the position of the regional polytechnic. Failure to implement the nuclear power plant project was expected to lead to the region withering.

Those who held positive attitudes towards the nuclear power plant project had faith in domestic nuclear expertise and considered it important that the energy needs of Finland are satisfied by domestic production.

'No need to fear everything in advance. There are more causes to the end of the world, nuclear power is not the only monster.'

Nuclear power would safeguard the future of the regional manufacturing industry and support mining projects in progress in Lapland. According to the interviewees, nuclear power does not exclude the development of other energy forms in any way.

Local and regional views on the project

The regional development forecasts concerning northern Finland and Sea-Lapland have been relatively pessimistic, but during recent years, there have been positive developments in tourism, mining, and the type of manufacturing industry that requires high-level expertise.

The impacts of the nuclear power plant upon the development of the regional industries and municipalities were considered particularly positive. The impacts on regional economy were estimated along the same lines as in the Raahe region. The nuclear power plant was seen to suit the area perfectly, because the industrial investments in the area require additional energy. In addition, the mining projects in Northern Finland and the development of mountain-side ski resorts were estimated to increase the need for power in the future.

The nuclear power plant project would diversify and strengthen the energetic image of Sea-Lapland. The area would form a power center generating energy from many different sources. In the Kemi-Tornio area, there is wood processing and metal industry that require high levels of expertise. The interviewees believed the nuclear power station to suit the operating environment of the regional business life well and the educational institutions in the area to have sufficient skills and resources to include nuclear power-related subjects in their curriculums. In this way, the young people of the region could be educated and employed and thereby benefit from the project.

The impacts of the project's implementation upon the population structure of the region were estimated to be especially positive, because the current dependency ratio in the region is unfavorable and the forecasts are bleak. However, the local players were invited to become active so that the region and all of the commuting area would benefit from the project as much as possible. It was also seen that inter-municipal cooperation was required. People did not believe that the project could be implemented using domestic labor only because competitive tendering is required and there is a lack of domestic resources.

'The needs of expertise in the area change if the project is implemented in the region; the educational institutes should be ready for it.'

'The municipalities and businesses need to be alert, otherwise the construction-phase jobs go elsewhere.'

The regional resources to implement the project were considered good. In addition, people thought that the decision-making process would take a long time, allowing the regional players time to set up the required services. The vacant abodes in the region could be utilized to arrange the housing services. It was estimated that there were currently about 200 of those in Kemi. Globalization would happen naturally due to the closeness of the national border. Setting up public transport was considered necessary. If the project were to be implemented, it would create a need to recruit building inspectors and inspectors of safety at work. There is a regional fire and rescue service operating in the area, and it has experience of large industrial plants. However, solving the questions of safety and security will strain the public officials and create costs that should be shared between the municipalities and the party responsible for the project. The public rescue services would also need to recruit new people. Personnel is needed for educating and training the residents. The party responsible for the project and public authorities need to prepare civil defense plans and arrange information sessions and drills. All oil transport to Northern Finland takes place through the Ajos harbor close to Karsikko, which causes the need to be prepared for hazards involving oil.

The concrete negative impacts of the implementation of the project were seen to concentrate on the fishing and tourism industries in Karsikkoniemi together with the residents and holiday home owners in the area. The impacts on waterways should be minimized by taking and discharging the cooling water as far as possible from the areas important for fishing. Modeling the impacts on waterways was considered challenging because the currents in the area, according to the interviewees, are unpredictable. The nuclear power plant was expected, in addition, to undermine the public image and sales of fish caught in the waters near Karsikkoniemi for many years to come. The fishermen are worried about the impacts of the construction phase as well, because according to them, the fish moved elsewhere for the time the Ajos windmills were under construction.

'The holiday home owners and fishermen who feel they suffer ought to be taken good care of and they should be well compensated.'

Results from the survey conducted among residents

There were 1,648 survey forms in total sent out concerning the Simo alternative, and 487 replies were received. The reply rate to this survey among residents was reasonable: about three people in ten (30%) of those who had been sent a survey form sent in a reply The response rate of those living nearby (within a five kilometer radius of the nu-clear plant site) was higher, 38%, than that of those living further away (5–20 kilometer radius), 27%.

The respondents were asked about the comfort of their present living area and their expectations regarding it after the nuclear plant was built. Of all the respondents, 91% considered their present living area comfortable or very comfortable. Only 9% of the respondents considered the area they lived in either less than comfortable or uncomfort-able (Figure 8-97). After the nuclear plant were built, 41% of all the respondents considered their living area either comfortable or very comfortable. Half of the respondents estimated their living area to be less than comfortable or uncomfortable after the nuclear plant were built. Women had more negative thoughts regarding the impacts on comfort than men (Figure 8-98). Holiday home owners felt that the impacts of building the nuclear plant on the comfort of the area would be clearly more negative than the permanent residents. The respondents living close to the intended plant felt that the impacts on their comfort would be negative than the rest of the respondents.

A large share of the respondents considered the employment-related impacts of con-struction phase of the nuclear plant either rather significant or very significant (Figure 8-99). 65% of all the respondents, 55% of the women and 72% of the men, considered the employment-related impacts of the construction phase either rather significant or very significant. A little less than a third of all the respondents, 36% of the women and 25% of the men, considered the employment-related impacts of the construction phase either rather insignificant or very insignificant. 9% of the women considered the em-ployment-related impacts in the construction phase to be completely insignificant This view was held by 3% of the male respondents.

Holiday home owners considered the employment-related impacts in the construction phase somewhat less significant than the permanent residents did. Those

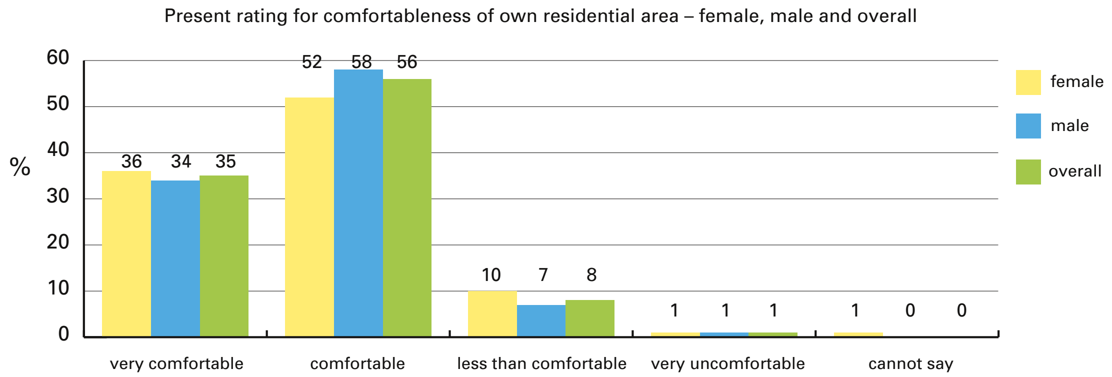


Figure 8-97. Views of respondents as to the comfort of their living area currently

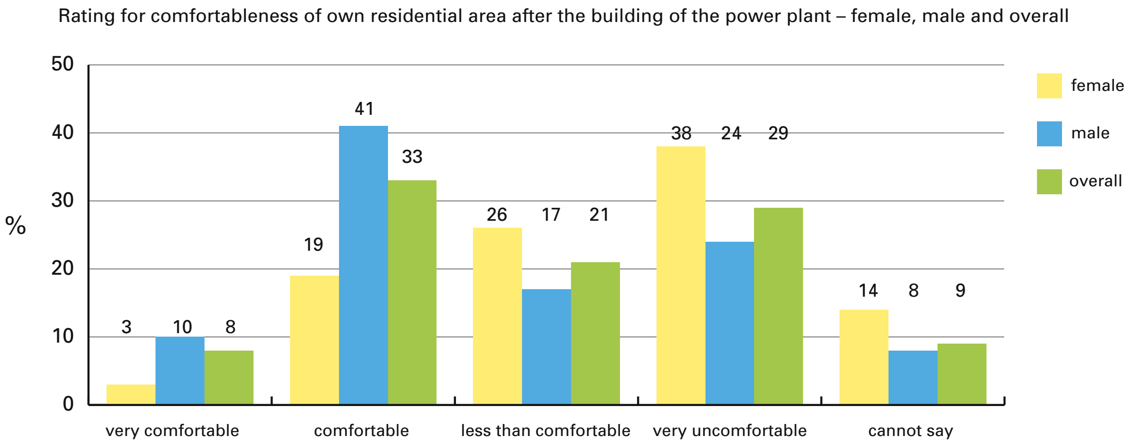


Figure 8-98. Views of respondents as to the comfort of their living area after the nuclear plant is built (Simo).

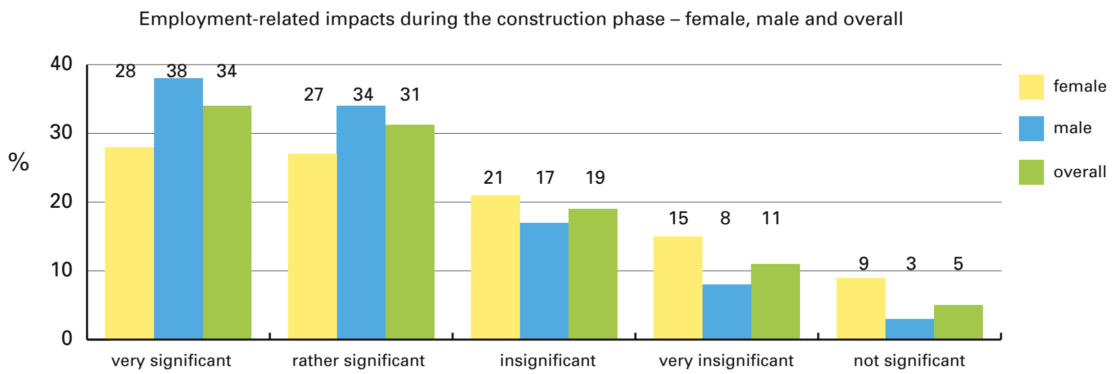


Figure 8- 99. Employment-related impacts during the construction phase, all respondents, men and women (Simo).

living further away considered the employment-related impacts most significant.

The employment-related impacts of the operating phase were not considered significant as often as the construction-phase impacts. Almost half of the respondents estimated the operating phase impacts to be rather significant or very significant. There were differences of view between the genders. 48% of the men and 37% of the women considered the employment-related impacts in the operating phase either rather significant or very significant. 46% of the men and 55% of the women estimated them to be either rather insignificant or very insignificant (Figure 8-100). The permanent residents considered the employment-related impacts in the operating phase more significant than the holiday home owners. Those who lived further away considered the employment-related impacts in the operating phase more significant than those who lived nearby.

The respondents were asked to name the three most significant environmental impacts of the construction phase and the three most significant environmental impacts of the operating phase. The impacts brought up as most significant in the construction phase were those on land use and landscape, on waterways and the quality of water, and on employment.

The impacts brought up as most significant for the operating phase were those on waterways and the quality of water, on health and comfort, on sense of security and on fishing and fishery.

A fair third of the respondents estimated the project to have no impact on the possibilities for recreation and hobbies. Of all the respondents, about one in ten estimated the impacts to be positive, and almost half of the respondents estimated the impacts on possibilities for recreation and hobbies to be negative. Most often, these impacts were expected to focus on fishing, berry-picking and boating. In addition to these, the project was expected to adversely affect outdoor activities. People with holiday homes believed the impacts on recreation and hobbies to be negative more often than others did. The project was not generally seen to impact traffic connections or other passageways.

The impacts of the new nuclear power unit on how people wished to move out of their area were unevenly

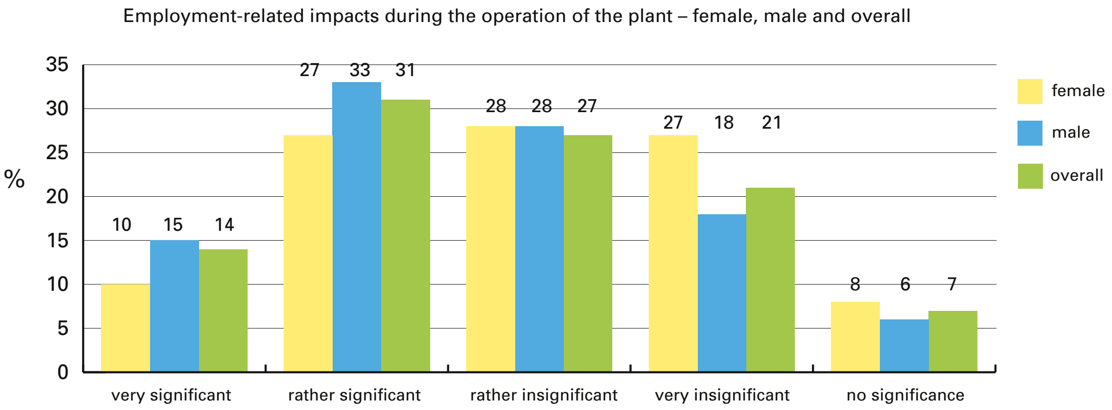


Figure 8-100. Employment-related impacts during the operating phase, all respondents, men and women (Simo).

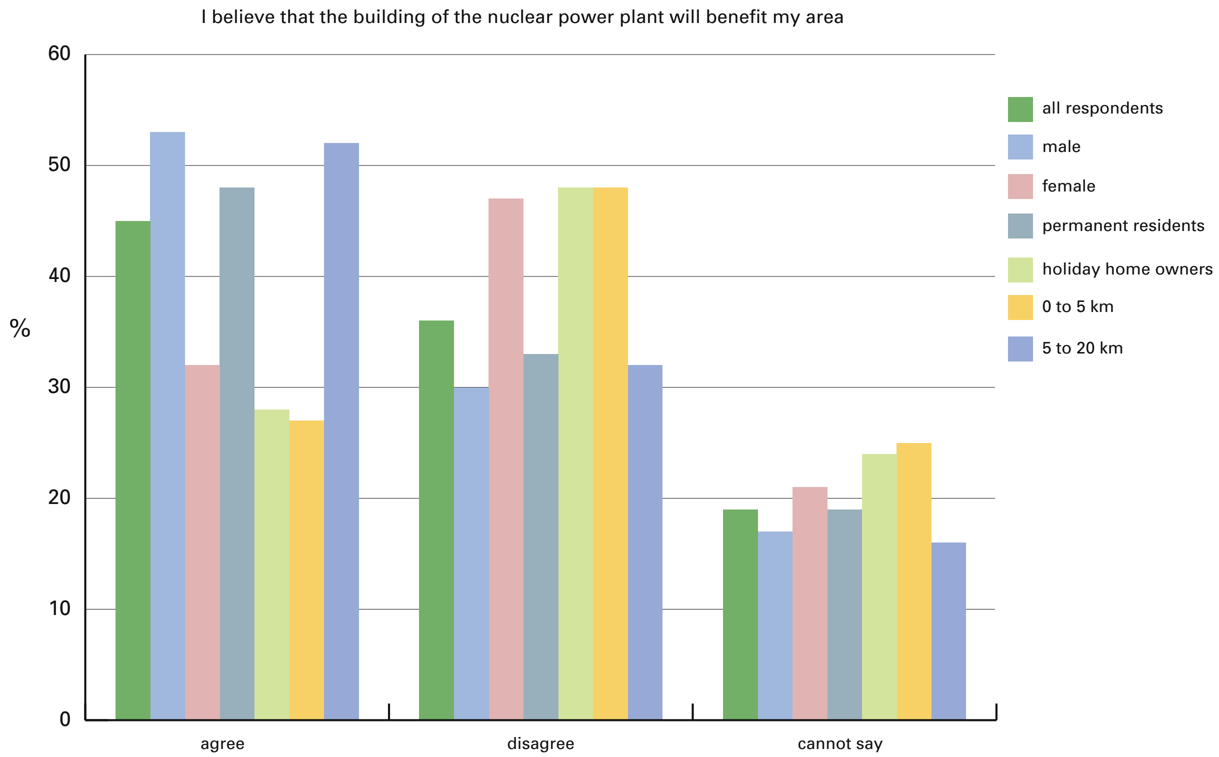


Figure 8-101. My view of the claim, 'I believe that the building of the nuclear power plant will benefit my area' (Simo)

divided. About half of the nearby residents and holiday home owners estimated the wish to move out to increase if the project were to be implemented. About half of the permanent residents and half of those living further away believed the plant to have no impact on people's wish to move. People believed the project to cause property prices to deteriorate.

The resident survey presented the claim, 'I believe that the building of the nuclear power plant will benefit my area', and the respondents were asked to assess its truth value. The divergence among the different respondent groups was relatively large. Most of the men, permanent residents and those living further away agreed with the claim while women, holiday home owners and nearby residents disagreed. Over half of the men and over half of those living further away believed that the nuclear power plant would benefit their area (Figure 8-101).

People expressed their wish that the residents' views, the living environment and the plant's safety and security would receive great attention when the new nuclear power plant is designed.

8.10.3.6 Summary of the assessment

Nuclear power and especially the new nuclear power plant project on new locations has raised a lively debate in local papers and the internet, heavily charged ideologically, politically, economically and ecologically. The strength of the views is most probably caused by the issues of safety, security and risks associated with nuclear power as well as the uncertainties regarding spent nuclear fuel and its treatment.

Seen as a whole, the views concerning the new nuclear power plant vary from one end of the scale to the other; thinking in terms of black and white, the nuclear power plant is considered either a jackpot for the area and region or a deathblow for the vicinity of the intended site (Figure 8-102). The social impacts expected during the planning phase in the alternative locations for the plant include the formation of groups favoring or oppos-ing the project.

Those in favor of the nuclear power plant consider the plant to create well-being based on the intensification of regional economy. The plant is considered to create very high annual revenue from property taxes for the municipality in question and revenue from income taxes due to new jobs for all of the region. Some of those opposing the nuclear power plant oppose electricity generated by nuclear power as such, some do not oppose nuclear power itself but do not wish to see a nuclear power plant in their own locality.

The opponents of the project consider the project unsuitable for the locality, justifying this with environmental values, closeness of inhabitation or the risks generally associated with the operation of nuclear power plants. The project has received the most opposition in the immediate vicinity of the alternative sites. Women and holiday home owners assume attitudes more critical than others. Communities opposing the project have been created in every alternative location. Those in favor of the project and those with neutral attitudes have not formed similar fronts. The opponents have, in addition, opened up web pages and petitions to allow the signatories to express the critical stands they have assumed towards the project. By mid-May, 2008, the petitions opposing the Pyhäjoki, Simo and Ruotsinpyhtää alternatives had about 2000 signatories. The petitions created by those in favor have been less extensive.

On the basis of the analysis of the materials used in assessing the social impacts, it is possible to roughly subdivide the impacts of the nuclear plant into three categories (Figure 8-103).

The most important negative social impacts of the planned nuclear power plant include the concerns, fear and uncertainty of the people living nearby, irrespective of whether the feelings are based on real threats or not. In the vicinities of the planned nuclear power plants, there are residents and groups of people who see the project as a threat to their health, based on subjective, personal experience or information other than that originating from public authorities in Finland or from domestic research. Even though a severe accident is most unlikely, even a small possibility of one causes

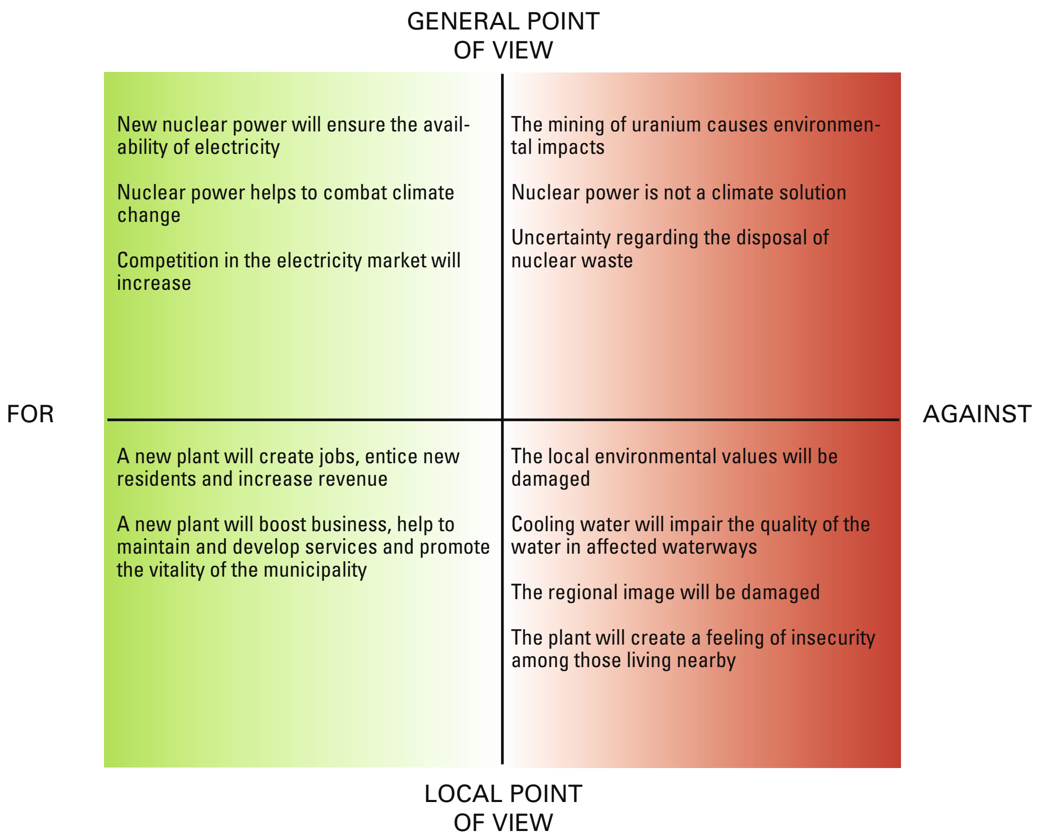


Figure 8-102. Fourfold table presenting the attitudes assumed towards building the nuclear power plant.

some individuals to experience feelings of fear and uncertainty. The psychosocial impacts of the new nuclear power plant project, experienced as early as during the planning phase, may be quite significant for some individuals.

The clarifications done while assessing the environmental impacts do not necessarily remove the residents' concerns which are based on the thinking that it is not possible to prepare for every future contingency or guarantee operation without disturbancs or adverse effects. This is the case even though the operation of a nuclear power plant is constantly monitored, and even the minutest disturbances are immediately reacted to.

Within a radius of about five kilometers of the planned site, there are restrictions implemented on land use, causing uncertainty among the residents regarding, for example, investments on homes and yards.

The implementation of a nuclear power plant changes one's environment and one's experience of it significantly. The impacts on land use and landscape are assessed else-where in Chapter 8. In addition to the visual sensation of a particular view, the experience of a landscape and place builds on mental vision. The way a place or area is experienced is always personal, because the environment is associated with meanings and any space is filled with emotions, memories, hopes and fears.

A change taking place or intended to take place in a certain environment stops people and makes them look at the landscape and furnish its places with meanings (*Raivo 1997*). In the vicinity of the plant site in each of the localities studied, the planning of the nuclear power station has meant, for some local people, that their place of peaceful country residence or their holiday home would change from a place of hopes and wishes to one of fear. The awareness of the project alone may have an effect on one's experience of place even if the plant would not be not visible in case the project were to be implemented. For example, people's interest to fish, pick berries, collect mushrooms or take physical exercise on areas near the nuclear power station may, at least temporarily, be reduced. Near the plant, the conditions for hunting and fishing will also be compromised. The nuclear power plant may be visible to the nearby residential areas on dark nights due to the illumination of the site. The importance of the increasing light among those who value country-like milieus is further amplified by the fact that darkness is, in the minds of many, a sign of untouched and original nature (*Lyytimäki 2006*).

The building of a nuclear power plant means that several hundred workers, about three thousand of them at most, are stationed in the area for 6–8 years. For Pyhäjoki, Ruotsinpyhtää and Simo this would mean the population temporarily doubling. There will be changes in the social and cultural fabric of the locations, but neither their direction or significance can be reliably estimated, because there is no information available at this stage as to where the workers might come from, how much local services they might consume or how they might participate in the social life of the locality.

The nuclear power plant's implementation also means new permanent staff and their families moving in to the locality or nearby areas. This will have a rehabilitating impact on the age structure and dependency ratio.

Risk conceptions associated with the operation of nuclear plants

The building of additional nuclear power, the threatening images associated with the generation of nuclear

Social impacts of the nuclear power plant during **the planning phase**	– formation of groups favoring or opposing the plant – expectations regarding the revitalization of development in the municipality / region – uncertainty felt among those living in the vicinity of the planned plant site, restrictions on land use – any psychosocial impacts experienced by the population
Social impacts of the nuclear power plant during **the construction phase**	– impacts on employment and the regional economy – changes occurring in the vicinity of the plant site, restrictions on land use – environmental impacts occurring during the construction phase – changing of the local social and cultural environment
Social impacts of the nuclear power plant during **the operational phase**	– property and income taxes, the impact on employment – the impact of cooling water on the use of water areas – changes occurring in the vicinity of the plant site, restrictions on land use – changes in the identity and characteristics of the area near the planned power plant – any psychosocial impacts on e.g. the feeling of security experienced by the population

Figure 8-103. Social impacts during the planning, construction and operation of the nuclear power plant.

power and the negative image associated with nuclear waste have all played their role in all of the locations, raising strong local opposition to the project. The strongest opposition has been found in the vicinities of the intended sites. The causes of these impacts in the planning phase have mainly been individual subjective experiences, risk conceptions concerning the project and various fears. The image of threat created by a nuclear power plant can trigger stress reactions in some people, which can in turn have detrimental effects on their health, if the stress continues for long.

The risk conceptions of those opposing nuclear projects and the conceptions of experts in nuclear power are somewhat conflicting. The objective magnitude of the environmental impacts of a power station (such as emissions of radioactive substances, calculated to be insignificant) do not explain the environment-related concerns caused by them. The lack of faith in experts, public authorities and representatives of the project play an essential role in the attitudes assumed towards nuclear technology (*Viinikainen 2004*).

The risk conceptions associated with operating nuclear plants can be partly explained by the time span of the eventual risk (the opponents are suspicious of, for example, the safety of the final disposal of nuclear waste and the impacts of the waste on future generations), the controllability of the risk (nuclear technology is not trusted completely or it is considered too complex), the familiarity of the risk (the risks are experienced less threatening on current plant localities), and the detectability of the risk (people have no concepts to visualize the eventual hazards).

It is likely that the images and fears people associate with nuclear power stations are a different matter than the actions they actually take. Therefore, it is possible that fears do not actualize as true social impacts such as decisions to move out of the area.

The group interviews arranged for the impact assessment showed concerns regarding the impacts on image, as people expressed their suspicion that the nearness of a nuclear power plant would cause the sales of the local agricultural and fish products to drop significantly if the project were to be implemented. The impact assessment report concerning the final disposal of the spent nuclear fuel states that consumers usually have relatively little chance to react to the risks possibly present in the products of a certain locality, because the origins of products often become blurred in the product chain (*Viinikainen 2004*). However, it is possible that the new nuclear power station will impact, momentarily, the demand for holiday homes, wilderness tour services or, for example, organically grown products.

8.10.4 Health impacts

8.10.4.1 General aspects of the health impacts of radiation

Radiation is either ionizing or non-ionizing depending on how it affects the substance it encounters. Ionizing radiation originates from radioactive substances or devices that generate radiation, such as X-ray equipment.

The health impacts of ionizing radiation can be divided into two groups: direct and longterm impacts. Direct impacts include certain adverse effects that are caused by extensive cellular damage. Long-term impacts include statistically observable adverse effects that are caused by genotype changes in a cell.

The unit of radiation dose is sievert (Sv), which is used to measure the health impacts caused by radiation. One sievert comprises a large amount of radiation, because of which one-thousandth (millisieverts, mSv) or one-millionth of sieverts are used (micro-sievert, µSv). Dose rate indicates how large a radiation dose a person receives in a certain time. The unit of dose rate is sieverts per hour (Sv/h) although smaller units are generally used.

Direct effects of radiation

Direct radiation effects can occur if a person is exposed to a very large radiation dose in a very short period of time. This may occur through accidents or radiotherapy. It is of utmost importance to protect the population from direct radiation effects.

Small radiation doses do not have any direct effects. It can be said that there is a threshold value for radiation. If a dose is smaller than the value, there will be no direct effect. If the threshold value is exceeded, the adverse effects are certain and sensitivity differences between individuals will not have much significance. (*Paile 2002*). Above the threshold value, the severity of the effect increases as the radiation dose increases. The threshold value and the severity of impact decidedly depend on the rate of the radiation dose, i.e. the dose rate. Even a high radiation dose may not have adverse health effects if the dose has accumulated slowly over a long period of time. (*STUK 2005b*).

Direct radiation effects include radiation sickness, burns, grey cataract and foetal abnormality. Radiation sickness is a life-threatening condition caused by widespread destruction of cells. The consequences of radiation exposure depend on whether the whole body is exposed to radiation, or whether the exposure is limited to a certain organ, such as the thyroid gland, or a specific area of skin. The threshold value for direct effect in the exposure of the whole body is about 500 mSv. In this case the impact can be seen as changes in the blood count within a few days. However, there will be no symptoms of radiation sickness at that time and the

The human body contains natural radioactive substances. A gym in Helsinki, 2008.

person cannot feel the effects. A dose to the whole body of more than thousand millisieverts, i.e. one sievert, received in a short period of time, will lead to radiation sickness. A sudden dose of more than four sieverts can be fatal. (*STUK 2005b*).

Radiation sickness has occurred in the victims of atomic bombs in Hiroshima and Nagasaki and those who took part in the rescue operations on the night of the accident at the Chernobyl nuclear power plant. Otherwise, radiation sickness has mainly been connected to situations where people have unknowingly handled strong sources of radiation manufactured for industrial or medical use. (*Paile 2002*).

Long-term effects of radiation

In practice, any radiation doses received by people will be much smaller than the threshold values of direct effects. Long-term radiation effects do not necessarily cause any sickness but the involve the risk of cancer at a later age. For small radiation doses, the risk of radiation-related cancer is small and even large doses of radiation may not necessarily cause cancer. Protection measures related to long-term effects are primarily aimed at minimizing the risk of cancer and hereditary damage.

All adverse long-term health effects caused by radiation result from damage to the DNA molecule, i.e. cellular genotype. However, all DNA damage does not result to health detriments, because cells can correct DNA damage. Radiation can nevertheless cause a permanent change of cellular genotype, i.e. a mutation. Several mutations may cause a cancerous tumor if the mutations have occurred in the cell's vital genes. Permanent damage only occurs as a result of a long chain of events, which are affected by many factors in addition to radiation. (*STUK 2008d*).

The assessment of the cancer risk caused by radiation exposure is based on population studies. The most important source of data has been the monitoring survey conducted on the survivors of the atomic bombs in Hiroshima and Nagasaki. Furthermore, the studies investigating the cancer risk of radiotherapy patients have produced plenty of additional information. (*Paile 2002*). There have been several studies conducted on professional and environmental exposures to radiation for the purpose of assessing the health effects of small radiation doses. (*Auvinen 2004*).

Radiation can have an effect on the development of most cancer types. Cancer occurs only years after the radiation exposure, and only some of the several factors affecting its development are known. In a single event, the cause of cancer cannot normally be identified. Cancer is a very common disease, and cancer caused by radiation cannot be distinguished from cancer caused by other factors on the basis of any properties. (*Paile 2002*).

About one-third of Finns will develop cancer at some stage of their lives (*Pukkala et al. 2006*). Even if a person is exposed to a relatively large radiation dose, it is likely that cancer occurring at a later age is caused by a reason other than radiation.

Exposure occurring in childhood increases the relative risk of cancer more than in adulthood, at which stage the probability of cancer is higher anyway. Thyroid cancer is a good example and its danger is only increased by radiation exposure occurred in childhood. (*Paile 2002*). This is why it is particularly important that children should take iodine tablets in the event of radiation exposure (see the criteria of civil defense actions in Chapter 8.15).

According to certain viewpoints, there is a threshold value for random radiation effects. Statistically significant impacts cannot be observed for doses below this value. However, there are also opposite views. According to the precautionary principle, the risk included in small doses is estimated, for civil defense purposes, on the basis of research data obtained from high radiation doses.

Cancer risk is estimated to be directly proportional to the radiation dose without any threshold value. (*Paile 2002*). The International Commission on Radiological Protection (ICRP) has estimated that exposure to a radiation dose of 1,000 mSv increases cancer risk by 5.5% on small doses and dose rates (ICRP 2007). This is the absolute risk or the likelihood of developing radiation-related cancer regardless of other factors that affect the development of cancer. This is a lifetime risk for the entire population and the risk may differ at an individual level (*Paile 2002*).

Because of the prevalence of cancer, the cancer risk caused by small radiation doses cannot be detected among the population. In Finland, approximately 20,000 people develop cancer every year and more than 10,000 people die because of cancer. Annually, about 500 cancer deaths may be in part caused by natural radiation. The total lifetime dose caused by the Chernobyl fallout to Finnish people is on average about 2 mSv, which may, according to an estimate, cause about 500 cancer deaths in Finland over 80 years, i.e. 6.25 deaths a year. The figure is lost among the statistically natural variation and is purely computational. (*STUK 2008d*).

Animal testing has shown that radiation can cause hereditary changes. However, the risk of hereditary damage is significantly smaller than the risk of cancer. (*STUK 2005b*). The International Commission on Radiological Protection, ICRP, has estimated that exposure to a radiation dose of 1,000 mSv increases the risk of hereditary damage by 0.2% (*ICRP 2007*).

The impact of small doses has been studied among the population in the immediate surroundings of nuclear power plants. Most studies show no difference in the morbidity of the population close to nuclear power stations compared to that of the rest of the population. A German study, much publicized recently, forms an exception (*Kaatsch et al 2007*), claiming children's leukaemia to be statistically more prevalent within a five kilometer radius of nuclear power plants than elsewhere. According to the researchers, the risk of developing cancer cannot be caused by any radioactive emissions from plants, because the natural background radiation provides doses 1,000–100,000 times greater.

The occurrence of leukemia among children in the vicinity of nuclear power plants has been studied in different countries since the 1980s when several cases of leukemia among children were found in the surrounding areas of the Sellafield nuclear waste reprocessing plant in Great Britain. Several other studies have been conducted in the vicinity of nuclear power plants. These have not indicated a similar connection between cancer cases and very low radioactive emissions during the operations of nuclear power plants. (*UNSCEAR 2000 and Auvinen 1997*).

In addition, the occurrence of leukemia among children has been found to be greater than in the rest of the country under scrutiny in areas where a nuclear power plant was planned but not built. The explanation for the Sellafield case is considered to be the effect of geographic factors, such as the mixing of population and infection factors. (*Paile 2002*).

Radiation and pregnancy

A developing foetus is sensitive to radiation because the division of the foetus's cells is frequent. However, there is no evidence indicating that random small radiation doses could cause any major damage to foetuses. The effect of radiation during pregnancy depends of the radiation dose, dose rate and the stage of pregnancy. (*STUK 2005b*). Pregnant women may be exposed to radiation in regular radiation-related work or if a lower abdominal X-ray examination is performed. Throughout the pregnancy, natural radiation causes a radiation dose of about one millisievert for a developing foetus (*Paile 2002*).

Radiation damage to the foetus occurs only at rather large doses (*Paile 2002*). Effects of radiation on pregnancies have not been shown except in the survivors of the Hiroshima and Nagasaki nuclear explosions (*Auvinen 2004*). In the early stages of pregnancy, a high radiation dose will easily lead to the death of the foetus which means that pregnancy will be terminated before it has been diagnosed. After the two first weeks of pregnancy, only significant cellular damage or other damage affecting the cells may endanger the development. This may happen if radiation exceeds a certain minimum value which depends on the foetus's stage of development, type of radiation and dose rate. The stage of development also has an impact on the type of development disorder caused by exposure. The foetus's central nervous system is most sensitive to damage by radiation during weeks 10–17 of the pregnancy. (*STUK 2005b*).

Radiation exposure during pregnancy can also increase the risk of childhood cancer. If a foetus is exposed to a radiation dose of 10 millisieverts during pregnancy, the risk of childhood cancer will be 1/1,700. (*STUK 2005b*).

8.10.4.2 Reference data on radiation sources and doses in Finland

Finns typically receive an annual radiation dose of about 3.7 mSv (Figure 8-104). About half of this comes from indoor air radon. There are great differences between people regarding the exposure to radon, and their own actions have a significant effect. Small amounts of radon are present everywhere in nature, and it seeps to houses from the soil. The radon contents of Finnish homes average 120 Bq/m^3 (*STUK 2008f*), corresponding to an annual radiation dose of about 2 mSv. The most effective way to reduce the Finnish people's annual radiation doses would be the reduction of the indoor air radon contents. Radon can be controlled in many ways, both when renovating old homes and when building new ones. In Finland, the radon content values of homes, work places and drilled wells are the highest in the world. High indoor radon contents are foud throughout Finland, but they are most prevalent in the province of Southern Finland and the area of Pirkanmaa (*STUK 2003*). The worst areas for high radon contents include the rough gravel ridge formations common in Southern Finland.

The soil contains naturally radioactive substances and their background radiation accounts for about 30 per cent of the annual radiation dose for Finnish people. People are exposed to radiation originating from space, i.e. cosmic radiation, everywhere but more so on airplanes than on the ground. Passenger planes fly in the altitude of about 10 kilometers where the dose rate of cosmic radiation is several ten times that of sea level. Aircraft personnel are estimated to receive a maximum additional dose of four millisieverts through cosmic radiation (*STUK 2008g*).

In addition, the human body contains natural radioactive substances that cause continuous radiation exposure. Radioactive substances enter the human body through food, drink and respiration. The biggest individual differences in internal doses are caused by radon received from drilled well water (*STUK 2008h*). Natural background radiation cannot be avoided, and the dose it causes does not vary greatly from one individual to another. The use of radiation in medicine and industry causes a radiation dose smaller than natural background radiation, approximately 0.5 mSv.

The fallout resulting from the Chernobyl nuclear power plant accident which occurred in 1986 and nuclear testing conducted in the 1960s have left artificial ra-

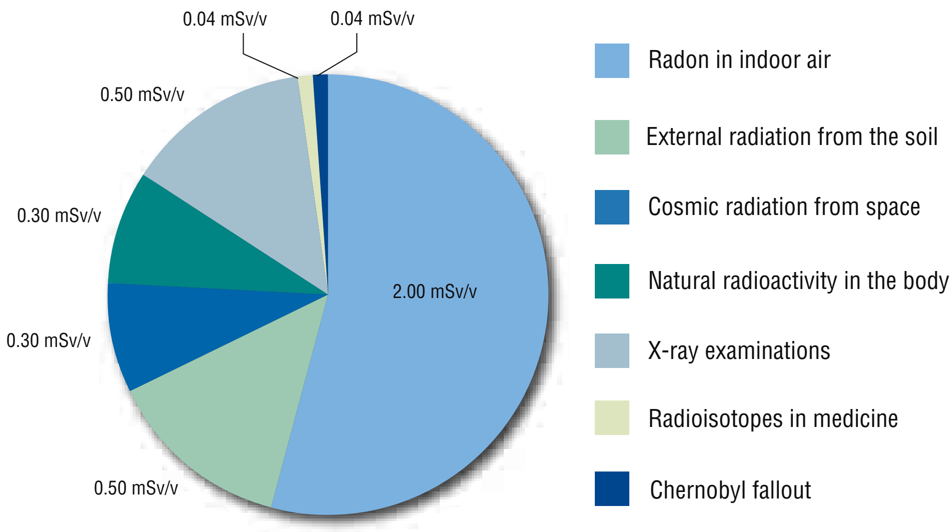


Figure 8-104. Sources of the average annual radiation dose of 3.7 mSv for Finnish people *(STUK 2008c)*.

dioactive substances in Finnish nature, caesium (Cs-137) in particular. These continue to cause an average of one per cent of the annual total dose for Finnish people. In 1986, the Chernobyl accident caused a radiation dose of 0.15 mSv for every person living in Finland (*STUK 2008i*).

The attached table (Table 8-40) presents a few examples of different radiation doses. According to the Government Decision (395/1991), the normal operation of a nuclear power plant may only cause a maximum radiation dose of 0.1 mSv per year to nearby inhabitants. The table (Table 8-40) shows that the radiation doses caused by nuclear power plants in 2007 are less than 0.001 times this limit.

8.10.4.3 Impact of a nuclear power plant unit's operations

Radiation doses for nearby residents

According to the Government Decision (395/1991), the normal operation of a nuclear power plant may only cause a maximum annual radiation dose of 0.1 mSv, i.e. 100 µSv, to nearby inhabitants. This limit value is specific to the nuclear plant location and concerns all the plant units and operations in the location. This limit value forms the basis for determining the nuclide-specific limits for the nuclear power plant's emissions of radioactive substances into the atmosphere and water. The radiation exposure received by those living in the surroundings of the existing Finnish nuclear power plants is assessed annually on the basis of the plants' emission data, environmental samples and meteorological measurements. The calculated radiation dose for the most exposed (critical) population group in the surroundings of the Loviisa and Olkiluoto nuclear power plants amounted to approximately 0,05 µSv in 2007. (*STUK 2008k*). The radiation dose for nearby inhabitants caused by Finnish nuclear power plants has only been a fraction of the average dose received by Finnish people from other sources every year (3,700 µSv) (*STUK 2008e)*.

The radiation dose caused by the emissions from the operations of Fennovoima's nuclear power plant for the most exposed residents in the immediate surroundings is, at maximum, estimated to be as high as the dose caused by the existing nuclear power plants. Hence, the radiation dose will be less than 0.01 times the annual radiation dose limit of 100 µSv set for the operations of a nuclear power plant and a fraction of the average radiation dose received by Finnish people. Therefore the radioactive emissions during the normal operation of the nuclear power plant will not cause detectable adverse health effects.

The radiation doses caused by a serious nuclear accident and the resulting health effects are discussed in Chapter 8.15.

Radiation doses for employees

According to the Radiation Act (592/1991), the use of

Table 8-40. Examples of radiation doses *(STUK 2002, STUK 2008h, STUK 2008i, STUK 2008j, STUK 2008k).*

Dose	Description
0.00005 mSv	Calculated radiation dose caused by nuclear power plant emissions for the most exposed group among the population close to the Loviisa and Olkiluoto nuclear power plants in 2007
0.01 mSv	A dose incurred by a patient by a dental X-ray imaging
0.018 mSv	Dose of cosmic radiation received on a flight from Helsinki to Rome and back
0.1 mSv	A dose incurred by a patient by X-ray imaging of the lungs
0.2 mSv	A dose incurred by a patient by mammography (X-ray imaging of the breast)
0.3 mSv	An annual dose received by Finnish people through cosmic radiation
0.8 mSv	An annual dose received by residents of Mexico City located at a height of more than two kilometers through cosmic radiation
3.7 mSv	Average annual radiation dose for Finnish people
50 mSv	Maximum annual dose allowed for a worker involved in radiation-related tasks (in 2007, the largest dose received by a Finnish worker in a nuclear power plant was under 12 mSV)
100 mSv	Maximum dose in 5 years allowed for a worker involved in radiation-related tasks (in 2003-2007, the largest accumulated dose received by a Finnish worker in a nuclear power plant was under 65 mSV)
1000 mSv	Causes symptoms of radiation sickness if received in less than a day
6000 mSv	A fatal dose if received suddenly

radiation or other operations that cause exposure to radiation shall meet the following requirements:

1) *Principle of justification:* the benefit gained through operations is greater than the damage caused by the operations
2) *Principle of optimization:* the operations are organized so that the radiation exposure causing adverse health effects is kept at an as low a level as possible through practical measures
3) *Principle of individual protection:* the radiation exposure of individuals does not exceed the maximum values to be confirmed through a decree.

According to the Radiation Decree (1512/1991), the radiation dose incurred by an employee through radiation work shall not exceed the average of 20 mSv a year over a period of five years and the value of 50 mSv during any single year (cf. the maximum limit of 0.1 mSv for nearby inhabitants). In addition, a nuclear power plant must have lower dose limitations than these so that the employees' personal radiation exposure can be kept low (YVL 7.9). The Radiation and Nuclear Safety Authority monitors the personal radiation doses of nuclear power plant employees working in Finland and the compliance with the dose limits. The actual doses are clearly below the limit values set for radiation employees. In addition to the doses for individual employees, STUK monitors the total dose for nuclear power plant employees, i.e. the collective dose. The collective doses provide information about how well the radiation protection of employees has succeeded at nuclear power plants. (*STUK 2008m*).

The radiation doses for nuclear power plant employees are mainly created during nuclear power plant outages when the employees work close to active components and open systems. The employees' radiation doses are affected by the duration of outages and tasks relevant from the point of radiation protection. (*STUK 2008n*)

The radiation doses for the employees of Fennovoima's nuclear power plant are, at maximum, estimated to be no higher than the doses incurred by the employees of the existing Finnish nuclear power plants during normal operations and outages.

Other health effects

All lines used for the transmission of electricity create low-frequency electric and magnetic fields around them. High-voltage power lines can create an electric field significant from the point of exposure, and the limit value set for the population can be exceeded if a person is permanently directly below a line of the highest voltage level, i.e. 400 kilovolts (kV). However, this does not restrict random movement, such as berry picking or farming or forestry tasks under the lines, because the limit value only applies to long-term exposure. A magnetic field occurs only in the immediate vicinity of power lines, and the limit value set for the population will not be exceeded even when staying directly below the lines. At a distance of 60–70 meters from 400 kV lines, the exposure level is less than 0.01 times the limit value set for the population (100 microteslas, *STUK 2008o*). Low-frequency electric and magnetic fields will not have serious adverse effects in cases of short-term exposure (*STUK 2005c*).

The noise impacts during the construction and operation of the nuclear power plant in the immediate surroundings of the location options are discussed in Chapters 8.2 and 8.10. It is possible that noise caused by the plant close to certain holiday homes may exceed the guideline values set for noise. Noise may also have an adverse effect on the health and well-being of those exposed by disturbing their work, rest and sleep.

8.11 Combined effects with other known projects

8.11.1 Geoneutrino research laboratory project

The Pyhäsalmi mine in Pyhäjärvi is one of the alternative locations for a geoneutrino research laboratory which is currently studied in an international venture. The mine is located about 100 kilometers south-east of the nuclear plant location studied in Pyhäjoki. The laboratory must be built deep underground in order to protect it from background radiation prevalent on the surface. The terrain in Finland is favorable for the location of the research laboratory compared to the rest of Europe because the neutrino flux originating from reactors is low here. The good bedrock and northern location of Finland are also assets considering the location for the laboratory. Other alternative locations else-where in the world have been suggested for this project.

In the present schedule, geoneutrino research projects could commence in 2013 at the latest, and they would continue at least until 2025. Speeding up the schedule would be possible, but it would require larger equipment. (*Neutrinica Oy 2008*)

The party responsible for the neutrino research laboratory project in Finland is of the opinion that new nuclear reactors will disturb neutrino research.

8.11.2 Mining projects ongoing in Finland

During recent years, international mining companies have initiated uranium prospecting operations in Finland. The first claim applications were submitted to the Ministry of Trade and Industry in the fall of 2005. Fennovoima will procure the uranium required for the nuclear power plant from the world market. Uranium is processed in several stages in production plants in different countries before it can be used in the reactor of a nuclear power plant. Therefore, the nuclear power plant project by Fennovoima will have no impact on whether or not any mining projects get implemented.

8.11.3 Laivakangas mining project

The Laivakangas gold mine project is located 15 kilometers south-east of the city center of Raahe. The distance to the Hanhikivi headland location is less than 20 kilometers. The environmental impact assessment for the project was completed on March 11, 2008.

The assessment report proposes to take the waste waters from the mine, after overland runoff, either first to Tuoreenmaanoja and from there to small rivers and onwards into the Gulf of Bothnia, or along a pipeline to the seashore to Kuljunlahti or directly into the Gulf of Bothnia. According to the assessment report, the waters still contain harmful concentrations of arsenic, cyanide and nitrogen compounds after the overland runoff field. (*Lapin Vesitutkimus Oy 2007*).

A possible discharge location for the waste waters of the Laivakangas mine (Kuljunlahti, dammed up) is located about 13 kilometers north of the Hanhikivi headland. Thus, the waste water discharge area is clearly outside the impact area of the cooling water. The prevalent direction of the currents near the shore is north; therefore, the waste waters from the Laivakangas mine will not be carried to the impact area of the cooling wa-ter. The projects will therefore not have any combined effects on the waterways.

8.11.4 Expansion of the Loviisa nuclear power plant by a third unit

An extension unit of 1,000–1,800 MW is in the planning for the nuclear power plant in Loviisa (*Fortum Power and Heat Oy 2008*). The most significant combined effects of the power plant would be associated with the heat load of the sea area caused by the cooling water. The discharge locations of the plant's cooling waters would be located at a distance of a few kilometers from the discharge locations planned for Gäddbergsjö and Kampuslandet. The combined effects of cooling waters were studied by current flow modeling.

Impacts of cooling water on the sea water temperature

The combined impacts of the heat load of the cooling water and the Loviisa 3 plant currently under planning were studied using six different alternative combinations. Two of the alternative discharge locations presented in the EIA of Loviisa 3 were studied. The more southern one of the discharge locations, L1, is found by an islet within the bounds of a Natura 2000 area about two kilometers southwest from Kampuslandet (Figure 8-105).

The more northern location, L2, is found in the south of Vådholmsfjärden by the Myssholmen island about one kilometer from Gäddbergsö. The cooling water intake of Loviisa 3 is located south of those of Loviisa 1 and 2.

Two Fennovoima intake locations (an intake from the bottom, O1, and a shore intake, O2, east of Kampuslandet) and one discharge location (P3 south of Kampuslandet) were selected for the modeling. The combined effects were studied by all three alternative combinations (Ay–Cy) using both one- and two-unit power plant options (Table 8-41).

The heating effect takes place either on Vådholmsfjärden and Orrengrundsfjärden (L2) or mainly on Orrengrundsfjärden (L1) depending on the discharge location (Figure 8-106). The smallest area was heated in alternative Ay, i.e. the most southern one (L1) of the alternative discharge locations of Loviisa 3. The result is explained by the fact that the intake water heats less and the cooling water mixes better into the main current flowing east-west in Orrengrundsfjärden.

The impacts of the location of Fennovoima's cooling water intake varied some depend-ing on the period of study. In June, intake O2 caused less area to heat, but in July, intake O1 fared better. In total, especially when studied with the smaller 1,800 MW power plant option, intake O1 caused less area to heat.

When Loviisa 3 and the Fennovoima plant are both in operation, according to the modeling results, the areas heating by more than one degree are larger than in a situation where the Fennovoima plant and the existing Loviisa plants alone are in operation.

This is because the areas heating by less than one degree under the impact of the two plants overlap. If a certain area warms up by 0.5 degrees due to one plant and 0.75 degrees due to another one, the area warms up by a total of 1.25 degrees. If the low-end limit for detectable warming is considered to be one degree, the combined impact of two plants makes the area greater than it would be if the plants were located further from one another.

In winter conditions, the southern discharge location (L1) of Loviisa 3 produced less unfrozen stretches of sea than the northern one (L2). As to unfrozen water, Fennovoima's intake location O1 was somewhat more favorable than intake O2.

The cooling water from the plants keep Hästholmsfjärden and the sea area south of the tip of Kampuslandet unfrozen (Figure 8 107). However, the area of weakened ice extends to Vådholmsfjärden and Orrengrundsfjärden. The pictures of the impact areas are occasional, and the true ice conditions may vary depending on for example temperatures, winds and currents as well as their combined effects on the movement of cooling water.

The joint impact of the plants increases the unfrozen sea area only by 1-3 square kilometers compared to the state in which Loviisa 3 were not in operation (Table 8-42). However, the area of weakened ice will grow by 20–40 square kilometers if all of the units are in operation simultaneously.

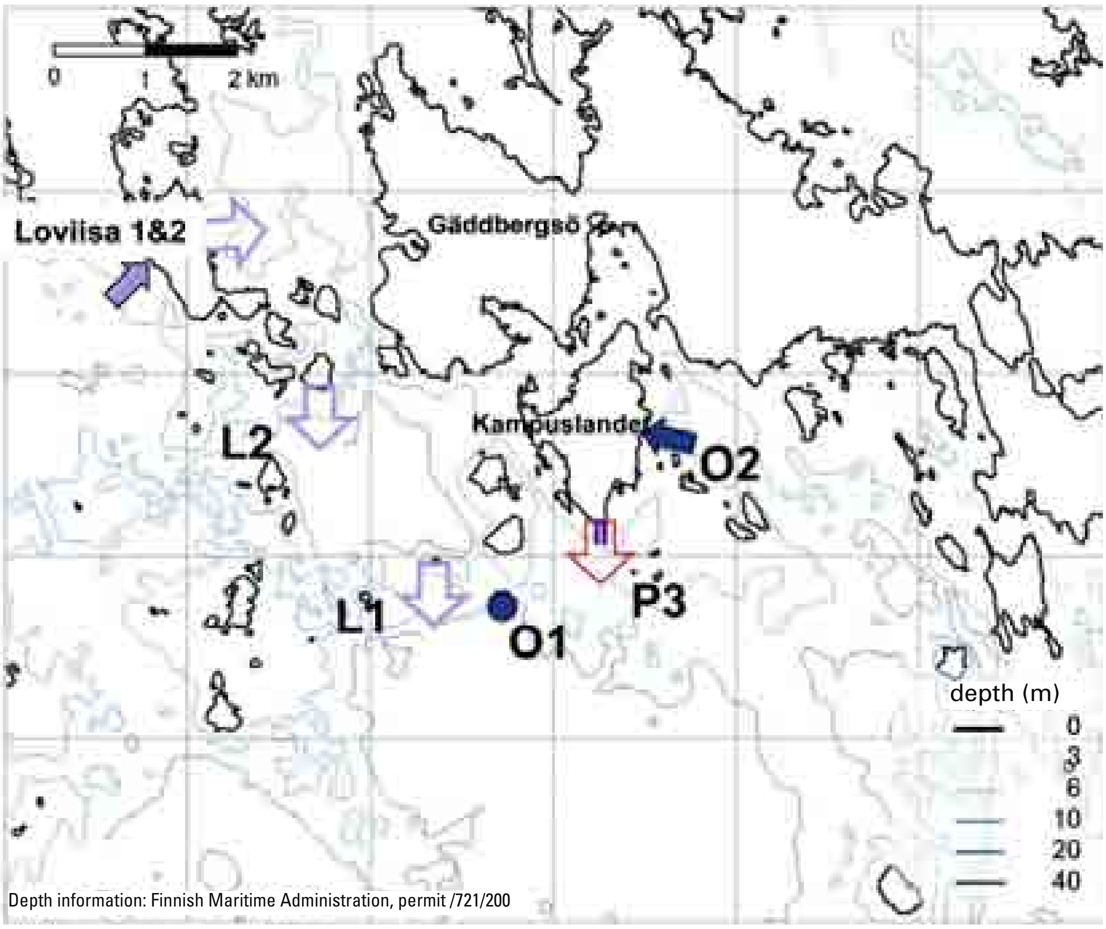


Figure 8-105. Cooling water intake and discharge locations. The blue circle (O1) shows Fennovoima's intake from the bottom, the blue arrow shows the shore intake (O2) and red arrow the discharge location (P3). The magenta-coloured arrows indicate the Loviisa plant intake and discharge locations; Loviisa 1&2 show the intake and discharge of the present plant. L1 and L2 are discharge alternatives for Loviisa 3 currently under planning.

Table 8-41. Combinations used in the modelling of the combined effects. All alternatives assume the Loviisa 1 and 2 units to be in operation.

Alternative	Electric power, MW	Intake	Discharge	Loviisa 3 discharge
Ay1	1,800	O1	P3	L1
Ay2	2,500	O1	P3	L1
By1	1,800	O2	P3	L1
By2	2,500	O2	P3	L1
Cy1	1,800	O2	P3	L2
Cy2	2,500	O2	P3	L2

Table 8-42. Areas of open sea or weak ice (less than 10 cm) in the different alternatives in the modeling throughout February (2003). The area of weak ice includes that of unfrozen water as well.

Alternative	Unfrozen water (km^2)	Weak ice (km^2)
Ay1	6.3	59.5
Ay2	7.7	69.3
By1	6.4	40.7
By2	9.4	65.1
Cy1	7.1	40.6
Cy2	7.9	42.8

Impacts of cooling water on the aquatic environment

The impacts of cooling water upon the aquatic environment are discussed in more detail in the chapter dedicated to cooling water impacts. In the case where two new power plants operate in the area, the maximum sea water temperatures do not increase in relation to the reference situation (the current Loviisa plants and the Fennovoima plant in operation), because the planned discharge locations are sufficiently far from each other. The impacts on the aquatic environment do not differ from the reference situation in this respect.

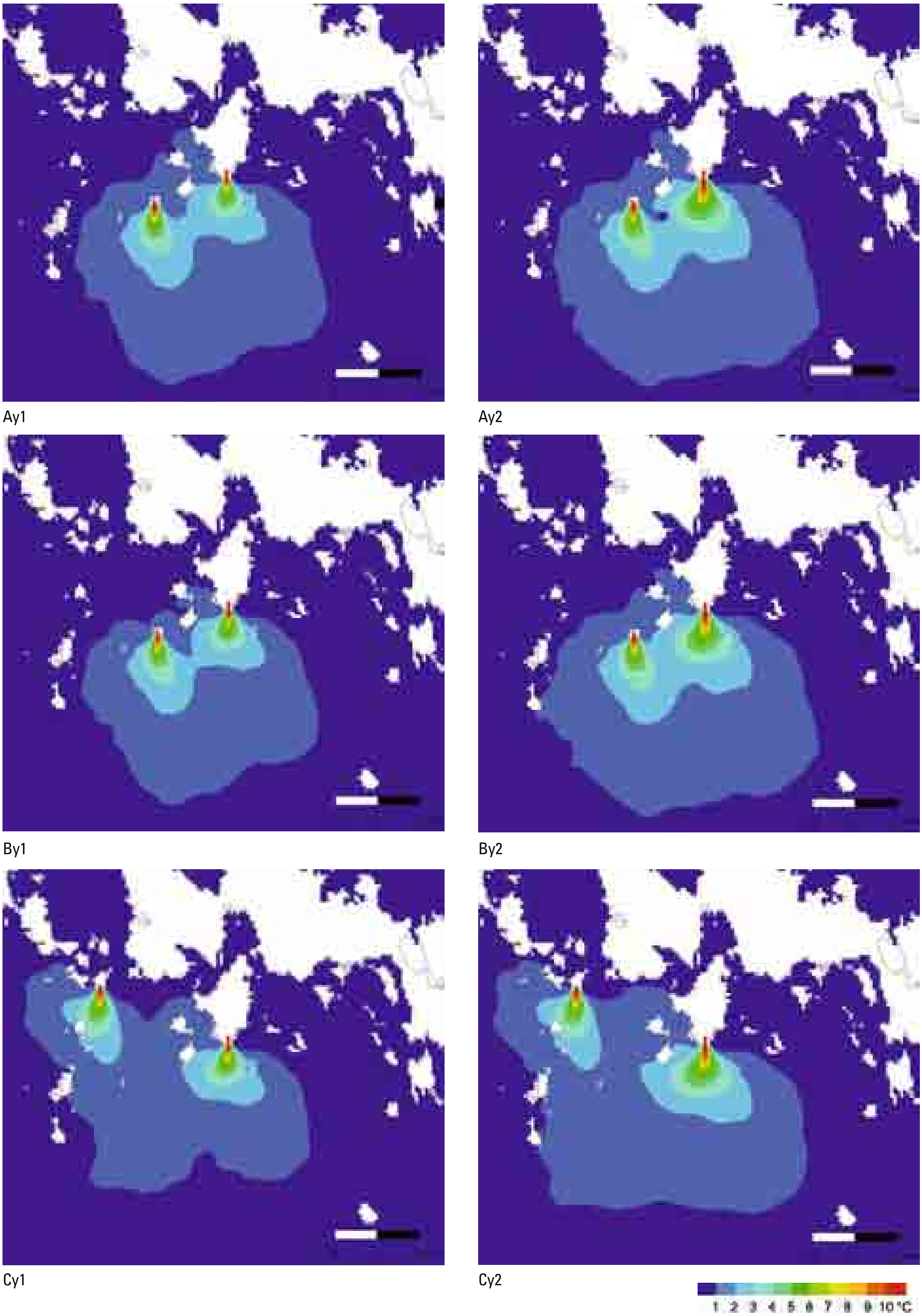
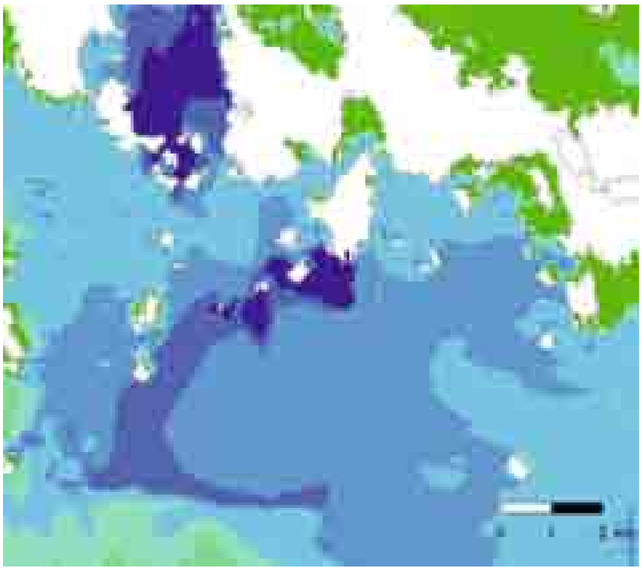
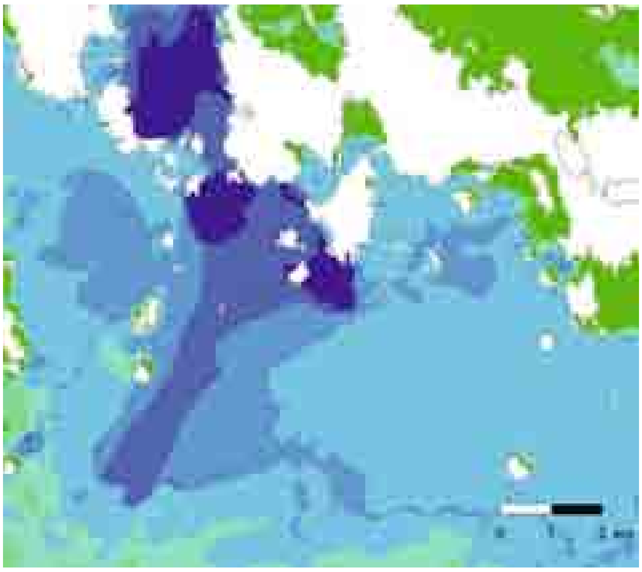


Figure 8-106. Temparature increase of the surface water (0–1 meters) caused by the combined impacts of the planned Fennovoima and Loviisa 3 plants in alternatives Ay-Cy, June averages.



Ice conditions in alternative BY2 (L1)



Ice conditions in alternative CY2 (L2)

Figure 8-107. Impact of cooling water upon the ice conditions of the area at the beginning of February in the case of two Fennovoima power plant units and Loviisa 3 being in operation. At the edges of the figures, the modeling does not illustrate the real situation (frames are formed at the edges).

The fact that the areas warming up overlap will result in the area heating by more than one degree becoming 3–4 times larger than in the reference situation. However, the areas that will warm up by more than two and more than three degrees centigrade will not grow significantly because of the combined impact, because these areas are located at sufficient distances from one another even in the worst intake and discharge combination.

The extent of the impacts depends on the location of the discharges as well. On open and deep seas, the cooling water cools down effectively as it is mixed. The impacts on the riparian zone essential for biota are also less. The heating sea area is at its smallest when the cooling water is discharged on open and deep sea (discharge L1 for Loviisa 3 and discharge P3 for Fennovoima).

Eutrophy and primary production in the sea area can be estimated to increase in a larger area than in a case where the two power plants were located further away from each other. Even though the warming areas are located distant from each other, the impacts will be targeted at the same sea area. The basic production, sedimentation and the consumption of oxygen in layers near the bottom will increase in these sea areas (Orrengrundsfjärden and Vådholmsfjärden) compared to the situation where only cooling water from Fennovoima's power plant will be discharged in the area. Because of the openness of the sea area, the impact on the coastal zone's vegetation and fish stocks will not differ greatly from the impacts of Fennovoima's power plant. There will not be any adverse impacts outside Orrengrundsfjärden and Vådholmsfjärden.

Other combined impacts with the Loviisa nuclear power station

Other combined impacts of the proximity of the two nuclear power stations include, for example, the risks involved in the centralization of the production of electricity and the security of supply of electricity. Therefore, the emergency precautions of both plants must take the proximity of the other plant into account and coordinate their emergency measures.

8.11.5 Wind power project in the Simo sea area

The EIA program of WPD Finland Oy's wind power plant project (addendum to assessment, March 2008) shows the power line route of one alternative out of the five presented to touch the shore northwest of Karsikkoniemi by Lallinperä. (*WPD Finland Oy 2008*). Fennovoima and WPD are cooperating in the planning of power lines required for the nuclear power and wind power projects. If the Karsikkoniemi option is implemented, the power lines will be located in the same line corridor. The location of the wind power plant's power lines in the same corridor with the nuclear power plant's power lines would increase the width of the corridor by a few tens of meters.

8.12 Impact of the use of chemicals

The use of chemicals and oils at the nuclear power plant will not cause any adverse environmental impacts under normal conditions. In the pressurized water reactor, boric acid used in the cooling water system will cause a boron load in the water system. Sea water contains boron naturally, and the added content due to the operation of a nuclear plant will be so small that the boron emissions will not cause any adverse effects on the water system.

The risk of chemical accidents will already be taken into account in the plant designs. The preparation for chemical accidents is discussed in Chapter 8.15. Structural meas-ures, alarm automation and control guidelines are used to prevent any undetected and uncontrolled chemical leakages. In the management of the risk of chemical accidents, training the power plant personnel and the guidelines drawn up for preventing accidents play an important role.

The use of chemicals at a nuclear power plant is extensive, requiring a safety assessment to be made. The assessment will be used to identify the danger of major accidents caused by the storage and handling of hazardous chemicals and the preparation for such accidents The risk analyses required by environmental and chemical legislation will serve to identify the probabilities of risks caused to the environment, people and property, the magnitude and creation mechanisms of any accidents and the functionality of the power plant's risk management system and organization. The probability of an accident where a dangerous volume of chemicals or oils can enter the atmosphere, water system or soil is low.

8.13 Impacts of waste management

The environmental impact arising from the handling and storage of regular, hazardous and operating waste and spent nuclear fuel produced at the nuclear power plant is assessed below. The environmental impact of the final disposal of spent nuclear fuel has been described roughly because the transportation of spent fuel from the power plant to the disposal site and the final disposal process are regulated by the EIA Act and a separate EIA procedure will be prepared for these functions.

Legislation regulating waste handling and the amount, type and handling methods of waste produced are described in more detail in Chapter 3.10 (Waste management).

8.13.1 Regular waste

Regular waste produced at a nuclear power plant consists of iron and metal sheet scrap, wood, paper and cardboard waste, as well as biowaste and energy waste. Most of the waste generated can be utilized by recycling or by using it in energy production. Sorted waste is sent for treatment, utilization and final disposal in a manner required by waste legislation and environmental license decisions.

Waste handling at the plant will not cause any environmental impacts. The amount of waste generated will be kept as small as possible and the share of waste to be utilized as high as possible. Compliance with the objectives will be monitored by entering the amount of waste, waste handling and utilization into records. With regard to municipal waste, paper and cardboard, metal, wood, biowaste, glass and energy waste will be sorted. Solids traveling to the plant through the nuclear power plant's cooling water, such as algae, garbage and fish, will be sorted using screens and filters, and they will be handled similarly to other waste as required.

8.13.2 Hazardous waste

Non-radioactive hazardous waste generated at the nuclear power plant will be handled as required by waste legislation and environmental license decisions similar to other industrial plants. Hazardous waste produced at the nuclear power plant includes batteries, fluorescent lights, lamps, oily filters, waste oil, solvents and chemicals, as well as electrical and electronic scrap.

Hazardous waste will be stored in appropriately labeled, covered and water-tight vessels or containers. Different types of hazardous waste will be kept separate from one another. The release of hazardous waste into the soil, groundwater or surface water and sewers will be prevented.

Hazardous waste will be delivered to a hazardous waste treatment plant, and a record will be created of the transfer where the information required about the delivered waste fractions will be entered. The amount of hazardous waste generated depends mainly on annual change and maintenance work. Because of the small amount of hazardous waste and appropriate handling, hazardous waste will not cause any significant environmental impacts.

8.13.3 Operating waste

Operating waste refers to waste such as low- or medium-level waste generated in handling radioactive liquids and gases, and in maintenance and repair work carried out in the controlled area. Solid waste includes protective clothing, insulation materials and cleaning equipment, and liquid waste includes radioactive concentrate and mass generated through the power plant's water treatment.

The creation of operating waste is to be prevented by avoiding the entry of unnecessary materials to the controlled area and preferring recyclable tools, clothing and materials, if possible.

Sufficient facilities for handling and storing low- and medium-level waste will be built at the nuclear power plant. The facilities will contain systems, using which the safe handling and transportation of waste and the monitoring of the amount and type of radioactive substances can be performed.

Operating waste will be collected from the plant premises without delay. For storage or final disposal, waste will be packed into vessels that make the transportation of waste easier, prevent radioactive substances from spreading and reduce the risk of fire. Typical packing methods for low-level waste include drums, boxes and containers made of steel, as well as boxes made of concrete. Typical packing methods for medium-level waste include boxes made of concrete and cylindrical tanks. Packages for low-level waste can be handled without any radiation protection. The handling and transportation of medium-level waste requires the use of radiation protection, and the packages often act as technical release barriers in final disposal.

Before final disposal, the volume of waste will be reduced using different methods and equipment. Radiation will be prevented from spreading by equipping the handling equipment with suction or filtering devices for exhaust air, or by using a handling method that does not generate dust. Wet or liquid radioactive waste will be dried or solidified. Solidification uses cement or bitumen, and facilitates the safe handling and disposal of waste.

For reprocessing and the final disposal of waste, the physical, chemical and radiological features of waste or waste packages will be determined through different measurements. Details of each lot of waste will be collected into a bookkeeping and monitoring system where the details will be stored until final disposal.

The principle of final disposal is to isolate the radioactive substances contained in the waste materials from living nature so that the safety of the environment is not put at risk at any stage. Final disposal facilities for low- and medium-level waste can be built into facilities to be located underground or inside the soil. Disposal facilities located on the ground are also possible. In Finland, the disposal facilities for low- and medium-level waste from the existing nuclear power plants are built inside the bedrock at a depth of about 100 meters in the plant area. In Sweden, for example, very low-level waste is disposed of above ground.

In underground repositories, the bedrock acts as the primary release barrier for radioactivity. The waste container also acts as a release barrier and special concrete structures can be used, if required. The spaces left between the containers can be filled with clay. In ground repositories, the principal release barrier is a concrete slab built as the foundation; it will prevent uncontrolled spreading of seepage waters into the environment. The waters generated in the area will be collected into a collection well and treated as necessary, before draining them into the environment.

Considering the nuclear power plant under investigation, the most feasible disposal options for low- and medium-level waste are estimated to be disposal in a bedrock silo or a bedrock cave disposal facility. For low- and medium-level waste, four separate caves have been preliminarily planned at a depth of 30–100 meters, depending on the geologi-cal properties of the final disposal area. A joint access tunnel will be built for the caves. The cave for medium-level waste will be reinforced, lined by spraying concrete and equipped with a bridge crane for filling. In addition, a ground repository may be built for very low-level waste.

Wastewater from the storage of operating waste will be conducted into a tight collection tank and further to a liquid waste treatment plant through radiation control, if required. Exhaust air will be treated using exhaust air filters before it is conducted to the ventilation exhaust shaft.

Waste will be transported to the disposal facilities through a tunnel using a special vehicle. Once the use of the caves is terminated, the connections will be sealed and will not require any control afterwards. Any radioactive substances contained by waste will decay through time and become safe for the environment, after which the waste will not cause any risk to organic nature.

The repository for operating waste will not cause any significant environmental impacts, and the impacts of final disposal do not differ between the alternative location municipalities.

8.13.4 Spent nuclear fuel

Some of the radioactive substances (nuclides) contained by spent nuclear fuel decay quickly into other substances, whereas some have a very long life. Radioactivity is inversely proportional to half-life; short-lived nuclides are more active than long-lived nuclides. The radioactivity of spent nuclear fuel after removing it from the reactor reduces quickly as short-lived substances decay into non-radioactive substances. The radioactivity of fuel reduces to one-hundreth in a year compared to the radioactivity immediately after the removal from the reactor. After interim storage of a few tens of years, one-thousandth of the radioactivity of nuclear fuel removed from the reactor remains. The radioactivity of spent nuclear fuel disposed of will reduce to the level corresponding with natural uranium in about 100,000 years. *(Finnish Energy Industries 2002, STUK 2004, SKB 2008b)*

8.13.4.1 Interim storage of spent nuclear fuel

After removing spent fuel assemblies from the reactor, they are moved to fuel pools, where they are allowed to cool for a few years. After removing fuel from the reactor, the radioactivity of fuel initially reduces quickly. After cooling down for a few years, once the radioactivity of the nuclear fuel has reduced sufficiently, the fuel assemblies are moved from water pools in the reactor hall to an interim storage inside a radiation protection for a few dozens of years to await final disposal. During the transfer, the fuel assemblies are kept in water, which prevents them from being damaged and protects the environment from radiation.

During interim storage, the activity and heat generation of the spent fuel continues to decrease significantly. In final disposal, only one-thousandth of the nuclear fuel's radioactivity remains. (*Posiva 2008c*). According to the Finnish Nuclear Energy Act (990/1987), all nuclear fuel used in Finland must be processed in Finland.

The interim storage facilities for spent nuclear fuel in Fennovoima's project are planned to be built in the power plant area. Water basins or dry storage can be used for interim storage (Chapter 3.10).

Water basins will be located, for example, in a building made of steel-reinforced concrete. Water acts as a radiation shield and cools the spent fuel. Using a heat exchanger, thermal energy from the water basin will be conducted to cooling circuits that are separate from the plant's other water circuits. As a result, water contained by them cannot be in contact with other water at the plant.

In the case of dry storage, spent nuclear fuel will be packed into special drums. The heat released by the spent nuclear fuel will be conducted into the surrounding air through the drum material. The drum prevents radioactivity contained in gas and particles from spreading into the environment. The drums will be stored outdoors or in a dedicated storage building. The storage facilities will be cooled as required to reduce the temperature. The drums can also be used to transport spent fuel.

During interim storage, the tightness of spent nuclear fuel containers will be monitored regularly. Active wastewater will be conducted to the nuclear power plant's liquid waste treatment plant and exhaust air from the storage facilities will be led to the nuclear power plant's ventilation exhaust shaft in a centralized manner. The volume and type of radioactive substances contained by the exhaust air will be monitored through regular samples and measurements.

The storage of spent nuclear fuel will not cause significant environmental impacts and the storage does not differ between the alternative location municipalities.

8.13.4.2 Transportation of spent nuclear fuel

After interim storage, spent nuclear fuel will be transported by road, railroad or sea to final disposal. Spent nuclear fuel will be packed into a collision-proof transport container which prevents the fuel from being damaged and radioactive substances from leaking into the environment during transportation.

Spent nuclear fuel will be transported in accordance with national and international regulations and agreements. In Finland, a license for each nuclear fuel transport must be applied for from the Radiation and Nuclear Safety Authority which inspects the transportation plan, the structure of the container, the qualifications of personnel and the provisions for accidents and malicious damage.

Plenty of national and international information about the safety of nuclear fuel transportation has been obtained. In Finland, spent fuel has been transported from power plants to interim storage and, in 1981–1996, spent fuel was transported to Russia (Soviet Union). In Sweden, spent nuclear fuel is transported from all nuclear power plants to the Oskarshamn interim storage facility by sea. (*Posiva Oy 2008c*).

8.13.4.3 Final disposal of spent nuclear fuel

Nuclear power companies are responsible for the safe implementation of the management of radioactive waste until waste has been disposed of in a manner approved by the Radiation and Nuclear Safety Authority. Final disposal refers to final isolation of spent nuclear fuel inside the bedrock so that it will not cause any damage to organic nature or people.

There is only one socially acceptable solution for the final disposal of spent nuclear fuel in Finland – that is, disposal in bedrock. It is internationally considered as the best available method for the management of long-lived nuclear waste because in bedrock, spent fuel resides in very stable conditions compared to those above ground.

Preparations for the final disposal of spent nuclear fuel have already been in progress in Finland for 30 years. Posiva started building an underground research facility, "ONKALO", in the bedrock of Olkiluoto in 2004. Its purpose is to collect accurate information about the bedrock and test final disposal technology in true conditions deep inside the bedrock.

In order to be suitable for final disposal, the bedrock area must be geologically stable and free of large cracks. The repository will consist of an encapsulating plant above ground, and its associated auxiliary facilities, plus final disposal facilities quarried deep into the bedrock. Posiva's intention is to start the disposal of spent nuclear fuel in 2020.

In the encapsulating plant, spent nuclear fuel is packed into disposal capsules which have a cast iron interior and a tight copper shell (see Chapter 3.10, Figure 3–16). The capsules are sealed and their tightness is tested. Emissions of radioactive substances caused by the encapsulation of spent fuel are insignificant; the highest possible dose caused by normal operation of the encapsulation plant in 50 years will be smaller than the dose caused by X-ray imaging of the lungs (*Posiva 2008d*).

Any radioactive substances released from the encapsulating plant will be collected from low-pressure facilities by vacuuming the surfaces and filtering water and exhaust air. Ionizing radiation will be dampened by building sufficiently thick walls. Any malfunctions at the plant have also been prepared for so that dangerous volumes of radiation cannot be released into the environment.

From the encapsulating plant, the capsules will be transported to the disposal caves hundreds of meters under ground using a special vehicle. In the caves, the capsules will be placed into drilled holes and surrounded with bentonite clay which expands strongly as it

The Finnish bedrock is stable. Rocky shoreline covered in snow in Pyhäjoki 2008.

absorbs water. This will prevent water from flowing directly onto the capsule's surface, protecting it against mechanical stress caused by bedrock movement.

The bedrock isolates nuclear waste disposed of so that it will not cause any damage to organic nature. It also protects the waste from outside effects by creating mechanically and chemically stable conditions in the disposal area and restricting the volume of water allowed to contact the disposal capsules. The capsules' copper shell is estimated to endure corrosion for at least 100,000 years.

Deep disposal guarantees sufficient isolation from natural phenomena caused by future ice ages and prevents people from breaking into the repository. If required, disposed nuclear waste can be recovered to the surface. Once all spent nuclear fuel is disposed of, the encapsulating plant will be dismantled, tunnels filled and access routes sealed. The facility does not need to be controlled after closing.

The long-term safety of the disposal of spent nuclear fuel is assessed through safety analyses, inspecting probable development paths and unlikely incidents that reduce safety. Any consequences caused for people and nature are assessed in all cases. The safety analyses help to identify the consequences generated if one or more release barriers fail. This aims at securing the safety of final disposal, even if the conditions change rapidly.

According to the long-term safety assessments, it is most probable that the capsules will not release any radioactive substances in millions of years. The bedrock in the research area is 1,650–2,650 millions of years old. Any changes inside the bedrock occurred after the creation and shaping of the bedrock have been slow and minor (*Posiva 2008b*).

At a depth of hundreds of meters, the nearly oxygen-free groundwater moves very slowly and its corroding effect on the capsules and spent nuclear nuclear fuel is very small. If, however, spent fuel is released from the disposal capsules and comes into contact with groundwater due to cracking of bedrock or an unforeseeable reason, the substances dissolved will largely remain in the surrounding bentonite barrier and the bedrock. In such an event, the radiation dose caused for those living near the repository will be at the level of the current natural background radiation at most and the number of individuals exposed will be low, limited to the surrounding areas. The bedrock dampens radiation effectively because only two meters of solid bedrock is sufficient to dampen the radiation to the level of natural background radiation. (*Finnish Energy Industries 2006, Posiva Oy 2008c)*.

8.14 Impact of decommissioning the power plant

The environmental impact caused by the decommissioning of the new nuclear power plant will be assessed later in a separate EIA procedure, but this chapter describes the decommissioning process and its impacts in order to provide a general view of the nuclear power plant project's lifespan. A nuclear power plant's estimated operating life is at least 60 years. As a result, the decommissioning of Fennovoima's plant is estimated to begin in 2078 at the earliest. Dismantling of the nuclear power plant can start quickly after the termination of operations.

The decommissioning of a nuclear power plant refers to the final shutdown of the reactors, closing the plant, dismantling operations performed at the plant in stages after closing, cleaning operations for the dismantled plant parts and the storage and transportation of the dismantled parts and other decommissioning waste.

According to the Nuclear Energy Act, the license holder of a nuclear power plant shall be responsible for seeing to the decommissioning of the power plant and its planning. The decommissioning plan will be prepared at the early stages of operating the plant and it will be revised at six-year intervals. The Radiation and Nuclear Safety Authority shall approve the plan and its revisions. No other industrial field is using a similar statutory procedure used to ensure that there will be no adverse effects or strains on outside parties after the operations have terminated.

The plan is to present the decommissioning measures and schedule, the storage of radioactive waste related to decommissioning before disposal and final disposal. The purpose of the plan is to ensure that the radioactive plant parts to be dismantled will not present any danger to the environment.

The assets required for the decommissioning of the nuclear power plant will be paid for in advance as nuclear waste management fees to the State's nuclear waste management fund in accordance with the Nuclear Energy Act.

Decommissioning methods

The decommissioning of a nuclear power plant can be implemented using the delayed dismantling method or the immediate dismantling method. A combination of these two methods can also be applied.

In the delayed dismantling method, the power plant will be dismantled decades after closing the plant. In this case, there will be significantly less radioactivity, which makes working at the plant site easier.

In the immediate dismantling method, the power plant will be dismantled immediately after terminating operations. In this case, the existing equipment and the competence and plant expertise of the power plant personnel can be utilized in dismantling, while preserving jobs in the same area. However, parts that are the most radioactive must be handled using remote controlled equipment.

When applying a combination of these two methods, some of the plant will be isolated and some will be dismantled immediately. Furthermore, dismantling can be implemented in parts when only the radioactive parts and structures will be dismantled. Other facilities and buildings will be left standing for later use (*E.ON 2004*)

Transition stage

The decommissioning of a nuclear power plant requires detailed plans similar to the power plant's construction stage. Decommissioning is started to be planned in connection with construction planning. The transition from the plant's normal operational stage to decommissioning stages requires changes in the plant's operational processes. During the transition stage, which takes 18 months, the required preparations for dismantling and related measures will be performed. The following procedures, in particular, will be performed during the transition stage (*E.ON 2004*):

- transportation of spent fuel to the disposal facility
- cleaning procedures for systems
- isolation and sealing of systems that will not be required later.

The nuclear power plant's parts will be started to be dismantled once the transition stage has been completed and the required decommissioning licenses have been granted. The work will be implemented in stages according to the applicable regulations and license terms.

Decommissioning stages

Several nuclear power plants have been decommissioned and dismantled elsewhere in the world. The decommissioning of a nuclear power plant typically takes place in the following stages.

At the first stage, the required logistics systems will be established and the dismantling procedures for the largest plant parts will be planned. In decommissioning and dismantling plans, radioactive parts will be separated from non-radioactive parts. During the first stage, all non-radioactive and radioactive systems that will not be required at later dismantling stages will be transported (e.g. radioactive water tanks, pressurized cooling tanks, turbine and generator parts). This will create more space for later work stages.

The second stage will focus on preparations for dismantling and plant part transportation. At this stage, the largest radioactive parts, such as the steam generator and pipelines and pumps in the cooling water system, will be dismantled.

At the third stage, the radioactive parts that are impossible to clean will be dismantled and transported.

These include the reactor pressure tank and its inner parts, as well as the surrounding radiation shield.

At the fourth stage, all of the remaining structures and systems will be dismantled and transported in stages. The last items to be dismantled are the liquid waste treatment plant and ventilation systems.

At the final decommissioning stage, the remaining buildings and structures in the plant area will be dismantled and transported. Regular demolition methods can be used at this stage. Concrete and steel structures and other waste materials generated at the dismantling stage will be recycled, if possible. In Germany, for example, the Grossweltzheim and Niedereichbach plants have been completely dismantled, and the plant areas have been restored to a natural state (*E.ON 2004*).

Environmental impact of decommissioning

The Radiation and Nuclear Safety Authority controls, in accordance with the Nuclear Energy Decree, that the procedures related to the management of waste created in plant decommissioning and their preparations are performed in compliance with the rules and regulations issued and the decisions made pursuant to the Nuclear Energy Act. The task of the Radiation and Nuclear Safety Authority is also to confirm how the party responsible for waste management is to record the radioactive waste generated in plant decommissioning.

The preliminary volumes of dismantling waste estimated for Fennovoima's nuclear power plant are presented in (Table 8-43). The volumes of dismantling waste depend on the plant's structure, the dismantling strategy and the handling, packaging and disposal methods for dismantling waste. Thus, the estimates can be considered to be indicative.

Table 8-43. Preliminary estimates on the volumes of dismantling waste generated in the decommissioning of the nuclear power plant.

	Option 1 PWR 1,800 MWe	Option 2 BWR 2 x 1,250 MWe
Activated steel	1,100 m³	3,800 m³
Activated concrete	600 m³	1,900 m³
Contaminated ferritic steel	4,400 m³	10,000m³
Probably contaminated steel	2,000 m³	4,600m³
Contaminated concrete	1,100 m³	2,500 m³
Contaminated insulation	300 m³	600 m³
Maintenance waste	1,800 m³	4,100 m³
TOTAL:	10,000 m³	27,500 m³

Waste generated at the dismantling stage is similar to waste generated during the plant's operations and it can be treated similarly to ordinary operating waste. Operating waste treatment is described in Chapter 3 (Waste Management). The majority of waste generated during the nuclear power plant's dismantling operations is not radioactive and can be treated similarly to ordinary waste.

Dismantling waste generated in the controlled area is tested in several stages using different methods. After testing and any cleaning operations, the waste will be classified into a specific reprocessing group according to its properties and activity (e.g. restricted or free utilization, disposal at a normal landfill site or in a repository for radioactive waste). The testing methods and results will be reported to STUK.

As many contaminated plant parts and equipment as possible will be cleaned so that they can be released from the radiation authority's control and recycled or disposed of at a general landfill site. The plant's systems will be sealed so that radioactive substances cannot spread into the environment.

Radioactive waste that cannot be cleaned for recycling or landfill sites will be treated and disposed of as low- and medium-level waste. Medium-level dismantling waste consists of waste generated when dismantling the process system, such as pumps and valves. Low-level dismantling waste consists of certain concrete and steel structures.

The need of disposal facilities for waste will be assessed in connection with the decommissioning plan. Low- and medium-level dismantling waste will be disposed of in the existing disposal caves at the dismantling stage, and the caves will be expanded, if required.

Dismantling waste will be transported to the disposal facilities inside a radiation shield. The safety requirements set for low- and medium-level waste generated during decommissioning with regard to handling and final disposal are similar to those set for operating waste. Handling and disposal of low- and medium level operating waste are described, and the resulting environmental impacts are assessed, in sections discussing the impact of waste treatment in Chapter 8.

The tools and working methods will be selected so that the employees' exposure will be as low as possible. Certain work stages will be performed in isolated areas equipped with separate ventilation systems. Air will be isolated and filtered in order to prevent radioactivity from spreading to other parts of the plant, or to the environment. Plant parts will be dismantled into as small parts as possible. If required, the parts will be reprocessed mechanically or chemically in order to clean them before final inspection tests.

On the basis of the experience obtained in the decommissioning of nuclear power plants, radioactive emissions caused by decommissioning will be smaller than emissions during the plant's operations.

Environmental impacts in the plant area and close to roads caused by the dismantling, treatment and transportation of the nuclear power plant's non-radioactive structures and systems include dust, noise and vibration. The increase in the number of heavy vehicles in road traffic during the power plant's dismantling and transportation stages may reduce road safety close to residential areas, in particular. Furthermore, in road sections with only a little other traffic, the emissions of increasing traffic will have an impact on air quality. (*E.ON 2003*).

Termination of decommissioning

Once the decommissioning procedure has been completed, the plant area has been cleaned according to the radiation safety requirements, and all waste has been appropriately disposed of or transported out of the area, an application concerning the former plant area's future purpose (e.g. an industrial area) will be submitted to the Radiation and Nuclear Safety Authority for approval. After decommissioning, any kind of oper-ation can be practiced in the power plant area. The restoration of the former plant area to its natural state is possible. Furthermore, some of the buildings can be used for other purposes after decommissioning. There will be no contaminated land areas or other factors hazardous to safety in the plant area. Sufficient marking of the disposal areas of radioactive waste will be entered in local and regional land use plans.

According to the Nuclear Energy Act, the Ministry of Employment and the Economy decides upon the termination of the obligation for responsibility for nuclear waste and the decommissioning of a nuclear power plant on the basis of the application prepared by the party responsible for waste management.

8.15 Impacts of abnormal and accident situations

8.15.1 Events at a nuclear power plant

For the purposes of planning and safety assessments, events at a nuclear power plant are divided as follows:

1) normal operation;
2) anticipated operational transients;
3) postulated accidents; and
4) severe accidents.

This chapter deals with the three latter categories, i.e. deviations from normal operation.

8.15.1.1 Abnormal situations at a nuclear power plant and the related requirements

According to the Nuclear Energy Act, the design of a nuclear power plant shall prepare for the possibility of operational transients and accidents. A nuclear power plant accident does not necessarily mean that the operating personnel of a nuclear power plant or people living near the plant are exposed to a significant level of radiation. The graver the possible consequences, the lesser the probability of an accident shall be. When designing a nuclear power plant, the primary target is to prevent accidents, but practical measures for accident management and minimization of consequences must also be included. Nuclear safety is described in more detail in Chapter 6 of this report.

The limits for residential exposure to radiation and radioactive releases in the event of a deviation from normal operating conditions of a power plant are laid down in the Decision of the Council of State on the general regulations for the safety of nuclear power plants (395/1991). This decision will be replaced with a government decree, which was being drafted at the time of the preparation of this EIA report (*July 2008*).

Anticipated operational transients

Anticipated operational transients are deviations from normal operation that can be expected to occur once during the operation of the plant. These anticipated operational transients are considered in the plant design to ensure that they will not cause higher emissions into the environment than normal operation.

The annual radiation dose limit of the individual of the population arising as the result of an anticipated operational transient is the same as the dose limit arising from normal operation of a nuclear power plant, i.e. 0.1 mSv. A nuclear power plant shall withstand all anticipated operational transients without fuel damage. Possible reasons for operational transients include individual device failures, mistakes made by plant operators, and external events, such as disturbances in the electric power transmission network and abnormal weather phenomena. (*Sandberg 2004*).

Postulated accidents

A postulated accident means an event which serves as a design basis for the engineered safety systems of a nuclear power plant. The nuclear power plant shall withstand a postulated accident without severe fuel damage and without radioactive releases that would require extensive measures for restricting the exposure of the general public in the vicinity of the facility.

The draft government decree that will supersede the Decision of the Council of State (395/1991), divides postulated accidents into two categories:

1) Accidents whose expected occurrence frequency is lower than one in a hundred operating years. In this case, the annual radiation dose limit for the most exposed individual is 1 mSv.
2) Accidents whose expected occurrence frequency is lower than one in a thousand operating years. In this

case, the annual radiation dose limit for the most exposed individual is 5 mSv.

The nuclear power plant will be equipped with safety systems that can carry out their tasks during transients and accidents even if there were faults in the systems or if maintenance was underway.

The draft defines postulated accidents to include situations where an initial event of an operational transient or an accident is combined with a common cause failure of the safety systems or a complex combination of failures. As a result of such an accident, the nuclear fuel in the reactor must not suffer extensive damage, and the maximum radiation dose permitted for the most exposed individual is 20 mSv.

Severe accidents

Following the defense in depth principle (Chapter 6), a nuclear power plant shall also prepare for a situation where the management of an anticipated operational transient or a postulated accident fails to function as planned, leading to a severe reactor accident. During a severe accident a considerable part of the fuel in the reactor is damaged.

The limit for the release of radioactive materials arising from a severe accident is a release which causes neither acute harmful health effects to the population in the vicinity of the nuclear power plant, nor any long-term restrictions on the use of extensive areas of land and water. According to the Decision of the Council of State (395/1991), in a severe accident, the limit for an environmental release of caesium-137 is 100 TBq. In addition, the combined fallout consisting of radioactive nuclides other than caesium-isotopes shall not cause, in the long term, starting three months from the accident, a hazard greater than would arise from a caesium release corresponding to the above-mentioned limit. The possibility that the limit is exceeded shall be extremely small.

According to guide YVL 2.8 of the Radiation and Nuclear Safety Authority, the probability for core damage shall be less than once in a hundred thousand years. Not all core damages cause high levels of radioactive emissions and, as a result, their probability is even lower. According to the above-mentioned YVL Guide, the probability for an emission exceeding the above-mentioned limit shall be less than once in two million years.

8.15.1.2 International Nuclear Event Scale (INES)

The International Nuclear Event Scale (INES) is used for rating nuclear events and nuclear accidents. The scale was developed in international cooperation between the International Atomic Energy Agency (IAEA), the Organization for Economic Cooperation and Development (OECD) and experts from several countries. The scale has been in official use for nuclear power plant events since 1992 and is currently used in 60 countries *(STUK 2008p)*.

The INES has promoted communication on nuclear power plant events by standardizing the related terminology. It allows for less ambiguous specification of an event's signifi-cance for nuclear safety. On the INES scale, nuclear power plant events are rated into eight categories, INES 0 – INES 7 (Figure 8-108).

The principles for rating are presented in the IAEA INES Manual (IAEA 2001), accord-ing to which the consequences of an accident are divided into three areas: off-site impact (environmental impact), on-site impact (radiation within the plant site) and impact on defense in depth (deterioration of safety). Each of these areas is considered sepa-rately when determining the INES rating. If the rating can be determined on the basis of more than one area and the starting points result in different ratings, the highest rating shall always be chosen.

The INES scale has seven actual ratings, with levels 1 to 3 representing incidents (events that compromised safety). The lowest levels 1 and 2 are mostly applicable to technical failures that have compromised plant safety. Levels 4 to 7 represent accidents of varying levels. An accident is considered to be at least on level 4 if any civic defense measures must be started outside the plant. In case of an accident, the severity level shall be determined as soon as possible and can be reviewed later. Level 0 events are below the actual scale due to their minor safety significance.

INES 0: A deviation that has no significance for nuclear or radiation safety, and thus cannot be rated on the actual scale. An example of this level is a reactor scram if all of the plant's systems operate as designed during the event.

INES 1: An anomaly that impacts safety as a result of equipment failure, human error or procedural inadequacies. Events of this level do not endanger safety, but the plant's operating condition or operations deviate substantially from normal. Level 1 may include, for example, the failure of several redundant components of a safety system even if the safety system was not required in the situation at hand.

Events of this level occur relatively often and are usually reported nationally only. In Finland, for example, there were a total of 17 events of this level between 2000 and 2007 (*STUK 2008p*).

INES 2: A significant event which impacts safety and is associated with a significant failure in factors affecting safety, but with sufficient guarantee for safety remaining. This level also includes events that cause a radioactive dose to an employee exceeding the dose limit, or events that result in substantial releases of radioactive substances into areas within the plant not expected by design.

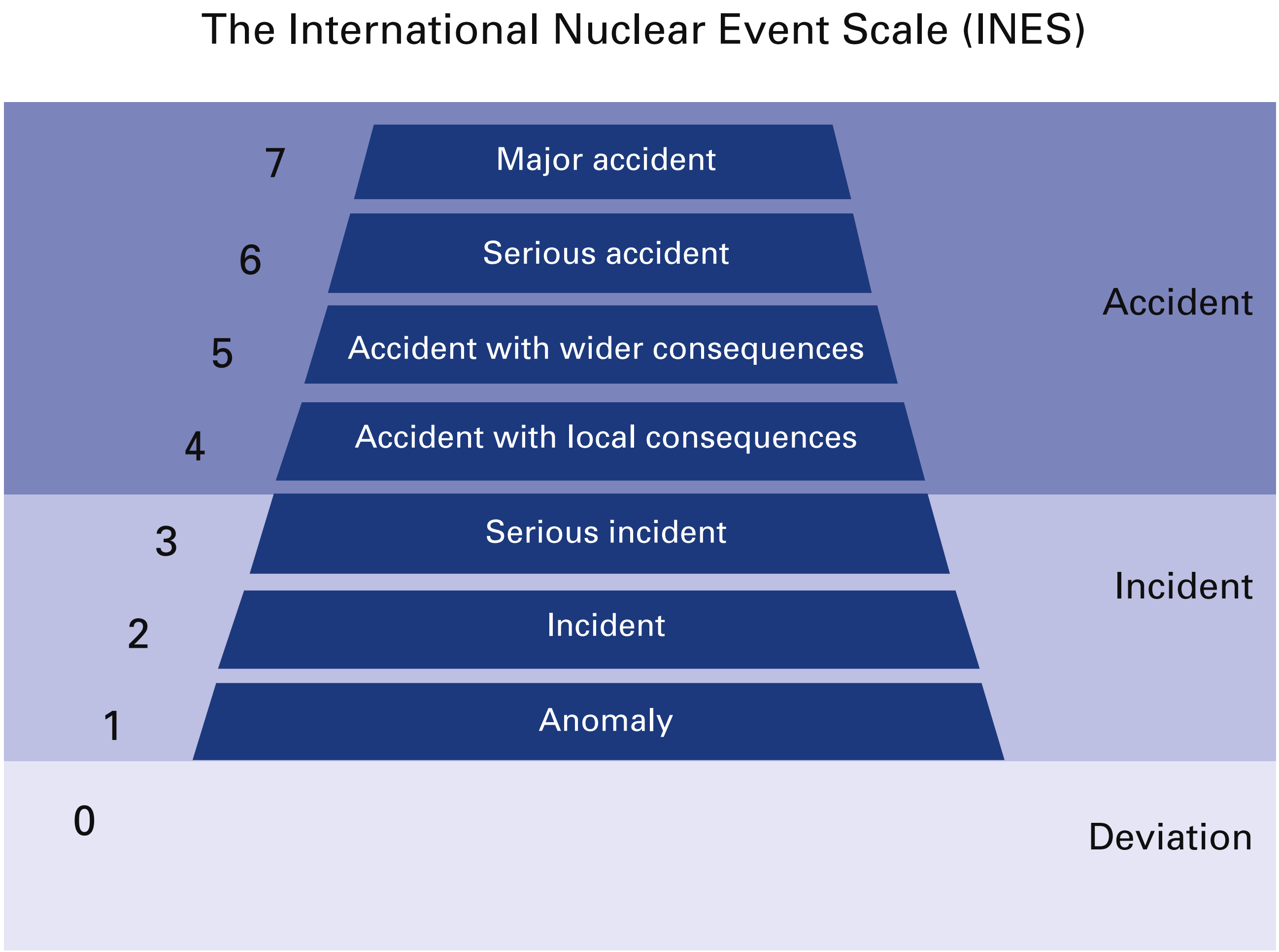


Figure 8-108. Severity levels on the International Nuclear Event Scale (INES).

Events rated at level 2 and above shall be communicated to the IAEA, which maintains a network of communication between countries that use the scale. There have been no events of this level in Finland in the 21st century but a total of 7 events between 1977 and 2007 (*STUK 2008p*).

An example of this level was a fire in the Olkiluoto 2 switchgear building in 1991, due to which the plant unit lost its connections with the external power grid. The event dem-onstrated deficiencies in securing off-site power supply and therefore belongs in level 2.

INES 3: A serious incident which impacts safety and causes an environmental release of radioactive substances exceeding the release limits approved by the authorities for normal operation. The most exposed individual resident in the vicinity of the nuclear power plant receives a radiation dose of less than one millisievert. However, no off-site countermeasures are needed. The level also includes events that result in doses to employees sufficient to cause acute health effects, or events that result in a substantial spread of radioactive substances within the plant, however allowing the material to be recovered and stored as waste. Furthermore, the level includes events in which a further single failure of a safety system could lead to an accident, or in which the required safety systems would be unable to prevent an accident as a consequence of a failure.

An example of an event rated at INES level 3 is the fire at the Vandellos nuclear power plant in Spain in 1989. The fire did not result in any release of radioactive substances, fuel damage or contamination on site. However, the event is rated at level 3 because the fire damaged several systems intended to guarantee the safety of the plant.

INES 4: An accident that results in an environmental release of radioactive substances causing a radiation dose in the order of more than one millisievert to the most exposed individual resident in the vicinity. The accident is due to substantial damage to the nuclear power plant, such as partial meltdown, and may cause a long-term interruption to plant operation. The release of radioactive substances into the environment may possibly give cause to some civic defense measures in the immediate vicinity of the plant, such as local food control. This level also includes events due to which one or more nu-clear power plant employees receive a radiation dose with a high probability of early death.

Events of INES level 4 included, for example, the release of radioactive substances into the inside of the plant at the Windscale (now Sellafield) reprocessing plant in 1973. The cause of the accident was an exothermic chemical reaction in a process vessel. The event is rated at level 4 due to the on-site impact.

INES 5: An accident causing danger to the environment, resulting in the release of radioactive substances into the environment (in the order of hundreds to thousands of terabecquerels of iodine-131 equivalents). Such a release would result in the partial implementation of civic defense measures to lessen the likelihood of health impacts. The accident is associated with severe damage to the nuclear power plant, such as extensive reactor damage, a major uncontrolled surge in power, a fire or an explosion spreading a substantial quantity of radioactive substances inside the plant.

There have been two accidents at level 5. The Three Mile Island accident in the United States in 1979 was the second most severe accident in the history of nuclear power plants and is rated at INES level 5. Such a large quantity of cooling water was lost through a stuck-open relief valve that the reactor dried up, overheated and partially melted. In spite of severe reactor core damage, the reactor pressure vessel and containment building remained intact and prevented external releases as designed, which re-ulted in minor off-site impact of the accident. However, the event is rated at level 5 due to the on-site impact. Furthermore, the accident at Windscale in Great Britain in 1957 is rated at level 5. The prototype reactor accident in Czechoslovakia in 1977 has not been officially rated but can be considered to correspond to level 5 or possibly level 4 (*Sandberg 2004*).

INES 6: Serious accident resulting in the release of a large quantity of radioactive sub-stances into the environment (in the order of thousands to tens of thousands of terabec-querels of iodine-131 equivalents). Such a release would be likely to result in the full implementation of civic defense measures to limit serious health impacts. Different civic defense measures available are discussed in more detail in Chapter 8.15.1.3.

There has only been one accident rated at INES level 6. At the Kyshtym reprocessing plant in the Soviet Union in 1957, a vessel containing high-level liquid waste exploded, and radioactive substances were released into the environment. Health impacts from the accident were limited by countermeasures including the evacuation of the local population. The accident is rated at level 6 due to its off-site impact.

This report includes a more detailed analysis of an accident rated at level 6. The spread of radioactive emissions and the resulting radiation dose have been modeled. The results of the modeling and the impacts of the accident are discussed in more detail in Chapter 8.15.1.4.

INES 7: A major accident, referring to the substantial release of radioactive substances from a large nuclear power plant into the environment. The release typically contains both short- and long-lived fission products (in the order of more than tens of thousands of terabecquerels of iodine-131 equivalents). Such a release may result in acute health impacts, delayed health impacts and long-term environmental impacts. The impacts may extend to a wide area.

The only accident rated at INES level 7 is the explosion-like destruction of the Chernobyl nuclear power plant reactor in 1986 in what is now Ukraine (formerly USSR). The most important cause leading to the accident is considered to be that the graphite-moderated RBMK type reactor did not comply with the crucial safety principle according to which any uncontrolled increase of reactor power must be prevented on the basis of physical properties. After the accident, several modifications to improve nuclear safety were made to other reactors of the RBMK type, and more detailed instructions for reactor operation were issued. The complete breakdown of the reactor caused major emissions of radioactive substances, and several people died of the acute health impact of radiation. The vicinity of the nuclear power plant was evacuated to a radius of thirty kilometers.

The different kinds of events used for the design and safety assessment of nuclear power plants are roughly divided into levels on the INES scale so that anticipated operational transients are rated at levels 1 to 3, postulated accidents and extended postulated accidents at level 4, and severe accidents at levels 5 to 7.

8.15.1.3 Preparedness actions and civic defense

Preparedness actions are actions taken in anticipation of an accident or incident where the safety of a nuclear power plant has been compromised. In addition, preparedness actions include preparation for civil defense and the planning of its implementation. Nuclear energy legislation sets demands for preparedness actions, rescue arrangements and civil defense, and the Radiation and Nuclear Safety Authority (STUK) gives additional guidance in the form of regulatory guides on nuclear safety (YVL) and separate guides on preparedness (VAL).

Co-operation between Fennovoima, local rescue departments and other bodies involved in rescue arrangements in the alternative locations has already been established during the EIA procedure. The co-operation has included discussions, and the rescue depart-

The EIA process also includes an account of decommissioning the nuclear power plant. Traditional red ochre in Pyhäjoki, 2008.

ments have participated in the audit groups of the EIA procedure. The co-operation will continue so that the preparedness arrangements will be at the required level when operation of the plant commences.

Emergency response arrangements at nuclear power plants

According to the Decision of the Council of State on the general regulations for emergency response arrangements at nuclear power plants (397/1991), any holder of a construction and operating license for a nuclear power plant shall take care of emergency response arrangements at the nuclear power plant. The licensee shall draft an emergency plan including a description of the planning, implementation and maintenance of emergency response arrangements. The emergency plan shall define actions taken in case of an emergency. The emergency response arrangements of the nuclear power plant are coordinated with the rescue and preparedness plans the authorities have drafted in the case of a nuclear power plant accident. In Ruotsinpyhtää, Gäddbergsö and Kampuslandet are located within a five kilometer radius of the Loviisa nuclear power plant. Therefore, in the Ruotsinpyhtää alternative, the emergency response arrangements of both plants shall take the proximity of the other plant into account and coordinate their emergency measures.

In order to plan emergency response activities and the classification of emergency situations, events representing different accident scenarios shall be analyzed. Also the possibility of a severe reactor accident shall be considered, and the variations concerning the state of the plant, duration of events, radioactive releases, release pathways and weather conditions shall be taken into account.

A nuclear power plant shall establish an emergency organization of trained power plant employees responsible for planning and implementing the emergency response arrangements. An emergency plan shall define the duties and responsibilities of personnel in case of an emergency, and describe how the rescue arrangements of the plant will be coordinated with the authorities and the Radiation and Nuclear Safety Authority (STUK). The emergency organization shall have adequate facilities, equipment and communication and alarm systems. A nuclear power plant shall be in a continuous state of alert to take immediate emergency action when needed.

The emergency organization is alerted in emergencies, including emergency standbys which involve alerting the organization to the extent necessary. In emergencies, the emergency organization is alerted to the full extent. The emergency plan classifies emergencies by severity and manageability into site emergencies and general emergencies.

In an emergency standby, the aim is to ensure the safety level of the plant. The emergency standby and its justification shall be promptly communicated to STUK and, if considered necessary, to the local rescue authority.

A site emergency is a situation during which the nuclear power plant's safety deteriorates or is in the danger of deteriorating significantly. STUK shall be alerted immediately and the rescue authorities notified.

A general emergency is a situation during which the hazard of such a radioactive material leak exists, which may require protective measures in the vicinity of the nuclear power plant. In the event of a general emergency, STUK and the rescue authorities shall be alerted immediately.

In an emergency, the on-site emergency manager of the nuclear power plant is in charge of on-site rescue operations until the rescue authority announces that it assumes command responsibility for the rescue operations. STUK also maintains preparedness to act in case of a nuclear power plant emergency situation. In a possible emergency situation, STUK acts as an expert authority providing support to authorities in charge of rescue services. The authorities shall draft detailed rescue plans for emergencies for areas within a radius of about 20 km from the plant (the emergency planning zone).

Before the commissioning of a nuclear power plant unit, an exercise in the practical implementation of the emergency plan shall be arranged in co-operation with the emergency and rescue organizations of relevant authorities. During the operation of the plant, emergency exercises shall be arranged at least once a year. In addition, joint exercises between the authorities and the nuclear power plant shall be organized under the leadership of the State Provincial Office at least once every three years. The objective of these exercises is to test the existing emergency response arrangements in various accident situations to identify the parties involved in emergencies and the duties involved in different stages of emergencies.

The protective zone and the emergency planning zone

According to the STUK guide for locating a nuclear power plant (YVL 1.10), precautions in the form of land use and public protection plans shall be taken with a view to the possibility of a severe accident in the environment surrounding the nuclear power plant. The general principle in the locating of nuclear power plants is to have the facilities in a sparsely populated area and far away from large population centers. What justifies placement in a sparsely populated area is that emergency planning will then be directed at a smaller population group and will thus be easier to implement.

The plant site is surrounded by a protective zone extending to about a five kilometers' radius from the facility. According to the YVL Guide 1.10, densely populated settlements and hospitals or facilities inhabited or visited by a considerable number of people are not allowed within the protective zone. The number of permanent inhabitants should not be in excess of 200 but the number of people taking part in recreational activities may be higher.

The 5 kilometer radius of the protective zone has been defined in the 1970s based on existing Finnish nuclear power plants and the surrounding areas. At the time, the objective was to guide future land use plans, and the definition did not consider possible new sites for nuclear power plants. Identical protective zones are not in use in other countries, and the surrounding areas of most of the world's nuclear power plants are far more densely populated than in Finland (*STUK 2007b*).

The objective of the protective zone is to simplify contingency plans and to ensure that, in case of a severe threat, the population may be quickly evacuated from the vicinity of the plant. In practice, the efficiency of rescue actions would be determined by many other factors beside the density of population – the location of housing, traffic connections and routes, and the extent of rescue actions, for example.

The Radiation and Nuclear Safety Authority considers the 5 km radius an appropriate starting point for land use planning (*STUK 2007b*). With regard to radiation hazard, it is impossible to define a specific geographical radius from a nuclear power plant and to show a significant decrease in the level of radiation caused by a severe accident outside that radius. When planning land use in the vicinity of new nuclear power plant sites, it is essential to highlight the possibility of fast evacuation in the event of an emergency. The most critical factor is to ensure that there are adequate routes and transport equipment for quick transport.

According to an Order of the Ministry of the Interior (SM 1/97), the Finnish nuclear power plants are surrounded by emergency planning zones extending to about 20 kilometers' distance from the facility. The authorities are responsible for drafting and implementing detailed public protection plans for these areas. In practice, the emergency planning zones of the existing nuclear power plants cover the cities and municipalities in the surrounding areas (the Loviisa nuclear power plant:

City of Loviisa, the municipality of Pernaja, the municipality of Pyhtää, and the municipality of Ruotsinpyhtää; the Olkiluoto nuclear power plant: City of Rauma, the municipality of Eurajoki and the municipality of Luvia).

The nuclear power plants shall update their safety analysis reports with current descriptions of the area surrounding the plant, its population and sources of livelihood. The number of permanent residents at the alternative locations of Fennovoima's nuclear power plant project and the environmentally or culturally sensitive sites are described in Chapter 8.11. In addition to the sensitive sites defined in Chapter 8.11, all sites that may be visited simultaneously by a considerable number of people are important from the point of view of rescue planning. Such sites include, for example, central business districts, libraries, hotels and different meeting facilities. Other special rescue sites include flammable and explosive sites, such as gas stations, certain industrial sites, and large production and storage facilities.

During the normal operation of a nuclear power plant, a protective zone or an emergency planning zone has no effect on the everyday life of the population. Iodine tablets will be distributed to the population in the protective zone for use during accident situations.

Civil defense

In the case of a nuclear accident, the need for civil defense actions is determined by the stages of the accident and the current weather conditions. In emergencies, the emergency organization of the nuclear power plant and STUK issue recommendations on civil defense actions, which will be carried out by the rescue authorities. In the case of a radiation hazard arising from a severe nuclear accident, the key civil defense actions include sheltering indoors, taking iodine tablets, evacuation, restricted access to danger areas, the protection of livestock and restrictions on the use of foodstuffs. Action is taken according to predefined criteria (Table 8-44). The authorities will broadcast information on protective measures on the radio and television.

Even in the most severe nuclear power plant accidents, sheltering indoors and taking iodine tablets are adequate protective measures in all areas located more than 20 to 30 kilometers from the facility (*STUK 2002*). People shall take shelter inside while the radioactive cloud passes to avoid breathing radioactive air outside and to reduce the radiation exposure received directly from the cloud. In comparison, a less severe protective measure is to urge people to avoid going outdoors if not necessary. People are urged to take iodine tablets if, due to the accident, the air is expected to contain high levels of radioactive iodine (I-131). Breathing carries radioactive iodine to the lungs, and it is finally stored in the thyroid gland leading to a significant thyroid radiation dose. The iodine contained in the iodine tablets is also stored in the thyroid gland and hence prevents the accumulation of radioactive iodine.

In Finland, the population of a protective zone will be evacuated in the event of a threat of serious radioactive contamination of the environment. Depending on the accident and the current weather conditions, the evacuation may be carried up to 20 kilometers downwind. If there is enough time, the evacuation shall be conducted before the radioactive cloud reaches the area. If there is not enough time, people shall take shelter inside, and the evacuation shall be conducted after the cloud has passed the area. In line with the European Utility Requirements concerning new nuclear power plants, a severe nuclear accident causes a radioactive release not earlier than 24 hours after the onset of the accident (*EUR 2001*), which provides sufficient time for initiating protective measures. In addition, access to the contaminated or contamination-risk area may be restricted for a specified time.

After the emission cloud has passed, the air outdoors does not contain radioactive substances. All rooms shall be aired carefully and surfaces wiped clean. Radioactive particles from the emission cloud will still be present on land, water and building surfaces. Natural elimination of radioactive substances in the environment may take a long time but the concentration decreases significantly during the first year. If necessary, the environment may be cleaned by washing the walls and roofs of buildings located in the most contaminated areas, for example.

Radiation doses from foodstuffs may be decreased by preventing their contamination by radioactive substances. Protective measures are of particular importance in primary production. In the food supply chain, the effects of a nuclear accident are determined by the season, crop cycle, circumstances and practices of local food production, and the production structure. The risk of an elevated radioactivity level of foodstuffs is significantly higher during the growth period than during other seasons. Radioactive substances are transferred effectively into milk and meat, and therefore farmers are urged, if possible, to shelter livestock and to cover animal feed in the event there is even a threat of an accident. Other possible measures include covering cow barns, restricting ventilation or filtering air and reserving clean water. Reasonably sized areas of vegetable, berry and fruit crops may also be covered before the radioactive fallout. After the accident, soil management and fertilizing are effective means of decreasing the amount of radio-active contamination of farm products (*Rantavaara 2006*). During processing, the concentrations of affected food products may be decreased by, for example, conversion of production, such as making cheese out of the milk so that most of the radioactive substances will be left in the whey.

The use of at least some foodstuffs shall be restricted in the aftermath of a severe accident. When neces-

Table 8-44. Planning criteria for key protective measures for emergency planning purposes.

Protective measure	Criterion: the measure is initiated when required to avoid the radiation doses listed below to an individual
Sheltering indoors (for two days)	10 mSv*
Taking iodine tablets	For children 10 mGy**, for adults 100 mGy (thyroid dose)
Evacuation (for one week)	50 mSv

* The unit of a radiation dose is Sievert (Sv)
** When referring to radiation targeted to a single organ, the unit of a radiation dose is Gray (Gy)

sary, the pre-established maximum permitted levels of radioactive contamination of foodstuffs to be placed on the market in the European Union (Council Regulation 87/3954), which are shown in the table below (Table 8-45) may be quickly adapted.

Products sold in food shops shall be sufficiently clean that they meet the safety requirements set by the authorities. STUK and the relevant ministries shall broadcast instructions and recommendations for consumers of self-made foodstuffs and natural produce from woods and lakes.

Liability in accidents

Nuclear liability means the liability of the operator of a nuclear installation for damages to a third party. According to the Nuclear Liability Act (484/1972), the licensee of a nuclear installation is liable for damage caused by nuclear incidents in their nuclear instal-lation, regardless of whether the licensee is responsible for the cause of the damage. Compensatory damage includes personal injuries, damage to property, pecuniary detriment, and the costs of environmental restoration measures and countermeasures.

In order to satisfy the nuclear liability requirement, the operator of a nuclear installation shall have valid nuclear liability insurance. The amount of liability insurance must be at least 175 million Special Drawing Rights (SDR) of the International Monetary Fund, corresponding to approximately EUR 186 million. By virtue of an amendment to the Nuclear Liability Act passed in 2005 (493/2005), the licensee's liability will become unlimited. The licensee must take out a nuclear liability insurance policy of at least EUR 700 million, which is supplemented by the liability of the country of location at EUR 500 million and the liability of the parties to the international convention at EUR 300 million.

The amendment of 2005 is not yet in force because the underlying amendment to the Paris Convention in 2004 has not been implemented in the legislation of all of the contracting states.

8.15.1.4 Progress and impacts of a nuclear accident

The event of a severe nuclear accident in a nuclear plant utilizing modern technologies and a strong nuclear safety culture is extremely unlikely because it would require several different, mutually independent failures and mistakes. According to the defense in depth principle, the safety of nuclear facilities is ensured using successive and independent protective measures, and the design of a nuclear power plant prepares for the possibility of operational transients and accidents. A more detailed description of nuclear safety is given in Chapter 6.

Table 8-45. The pre-established maximum permitted levels of radioactive contamination of foodstuffs to be placed on the market in the European Union.

Radionuclides	Activity content, Bq/kg		
	Baby food	Dairy produce and liquid foodstuffs	Other foodstuffs
Isotopes of strontium	75	125	750
Isotopes of iodine	150	500	2000
Isotopes of plutonium and transplutonium	1	20	80
All other nuclides of half-life greater than 10 days, for example ^{134}Cs and ^{137}Cs	400	1000	1250

1) Following an accident, the maximum permitted levels, as set out in the table, may be adopted when necessary for foodstuffs to be sold within the European Union market by a Commission Decision (the permitted levels for rarely used foodstuffs are ten times higher than the permitted levels for basic food-stuffs listed in the table). Situation specific permitted levels may be adopted by Council Decision.

Severe accident
According to the Decision of the Council of State (395/91), a severe reactor accident shall not cause either acute harmful health effects to the population in the vicinity of the nuclear power plant nor any long-term restrictions on the use of land.

In order to evaluate the impacts of a nuclear power plant accident, EIA measures have included modeling of the dispersion of the emission of radioactive materials arising from a severe reactor accident (INES 6) and the consequent fallout and exposure of the general public. It is not justified to include assessment of an accident more severe than INES level 6 in an environmental impact assessment because the occurrence of such an accident must be practically impossible in order to grant a construction and operating license for a nuclear power plant in Finland. The modeling procedures and the modeled case example have been described in more detail in Chapter 7.

The impacts of the accident are presented in typical weather conditions, in addition to which the effects of unfavorable weather on the results are assessed. In typical weather conditions, the dispersion takes place without any rain at any stage. The estimates for unfavorable weather conditions assume that rain occurs at the exact moment when the emission cloud passes the site at the distance in question but not elsewhere.

Radioactive contamination of areas of land and water and of foodstuffs is demonstrated by the fallout of radioactive iodine (I-131), caesium-137 (Cs-137) and strontium-90 (Sr-90) at different distances from the nuclear power plant. These are the radionuclides most significant to radiation exposure. The half-life of iodine-131 is about eight days, so it causes a significantly shorter contamination period than caesium-137 or strontium-90, whose half-life is about 30 years. The radiation dose of short-lived I-131 may be of significance at the initial stages of the fallout, especially if the fallout takes places during a growth period. The I-131 is stored in the thyroid gland and causes a thyroid radiation dose. Cs-137 and Sr-90 are important especially with a view to long-term radiation exposure.

The figures of the next page (Figure 8-109 and Figure 8-110) illustrate the importance of weather conditions for the fallout. In typical weather conditions, the amount of fallout is smaller and it is dispersed across a larger area. In these circumstances, the fallout settles on the ground more slowly, and thus the maximum fallout takes place further away from the accident site. In rainy conditions, the fallout settles faster, i.e. the maximum is observed closer to the accident site. The maximum fallout is significantly higher, but it is dispersed across a substantially smaller area. The figures illustrate the fallout of Cs-137 but weather conditions have a similar effect on other kinds of fallout and the dispersion of radiation doses.

During the first days following the accident, the radiation dose is caused mainly by radioactivity entering the body through respiration and by external radiation, i.e. radiation from the emission cloud carried by atmospheric currents and the settled fallout. In the longer term, the fallout which has settled on the ground will partially migrate to plants and further to food, which gives significance to the radiation dose accumulated through food produced in the fallout area.

To evaluate which protective measures might be required, the radiation doses from both external radiation and from radioactive substances inhaled into the body have been calculated over three different time spans: the first two days, the first seven days and the entire lifetime. The radiation dose through food ingestion and the dose accumulated in the thyroid gland during the first week following the accident are also illustrated separately. For children, calculations for a lifetime radiation dosage use the dosage accumulated over 70 years, and for adults 50 years.

Impact of a severe accident
The methods for calculating radiation doses described in Chapter 7.14 include a substantial number of assumptions that overestimate the fallout and the radiation doses. It is highly probable that the radiation doses in an actual situation will be clearly below the doses presented. Contingency planning for irregular and accident situations at a nuclear power plant is based on detailed accident modeling of the particular nuclear power plant type, as well as careful consideration of specific weather conditions at the location. The radiation doses caused in an actual accident situation are determined on the basis of facts and circumstances associated with the accident situation and the estimated development of the situation; the conservative calculations made for the project's environmental impact assessment are not used for the planning of preparedness actions or the implementation of measures during an accident.

The impacts have been illustrated from the area surrounding the plant to the distance of 1,000 kilometers. The location of observed areas surrounding each plant site is illustrated in the figure of the page 330 (Figure 8-111) and in the table of the page 331 (Table 8-46), which gives examples of large cities at different distances from the plant sites.

Fallout
The table of the page 331 (Table 8-47) gives the fallout following a severe accident. The distances listed are the maximum distances where fallout of the size in question may travel. The impact area of fallout is a fan-shaped area extending parallel to the direction of the prevailing wind. The amount of fallout reduces rapidly when mov-

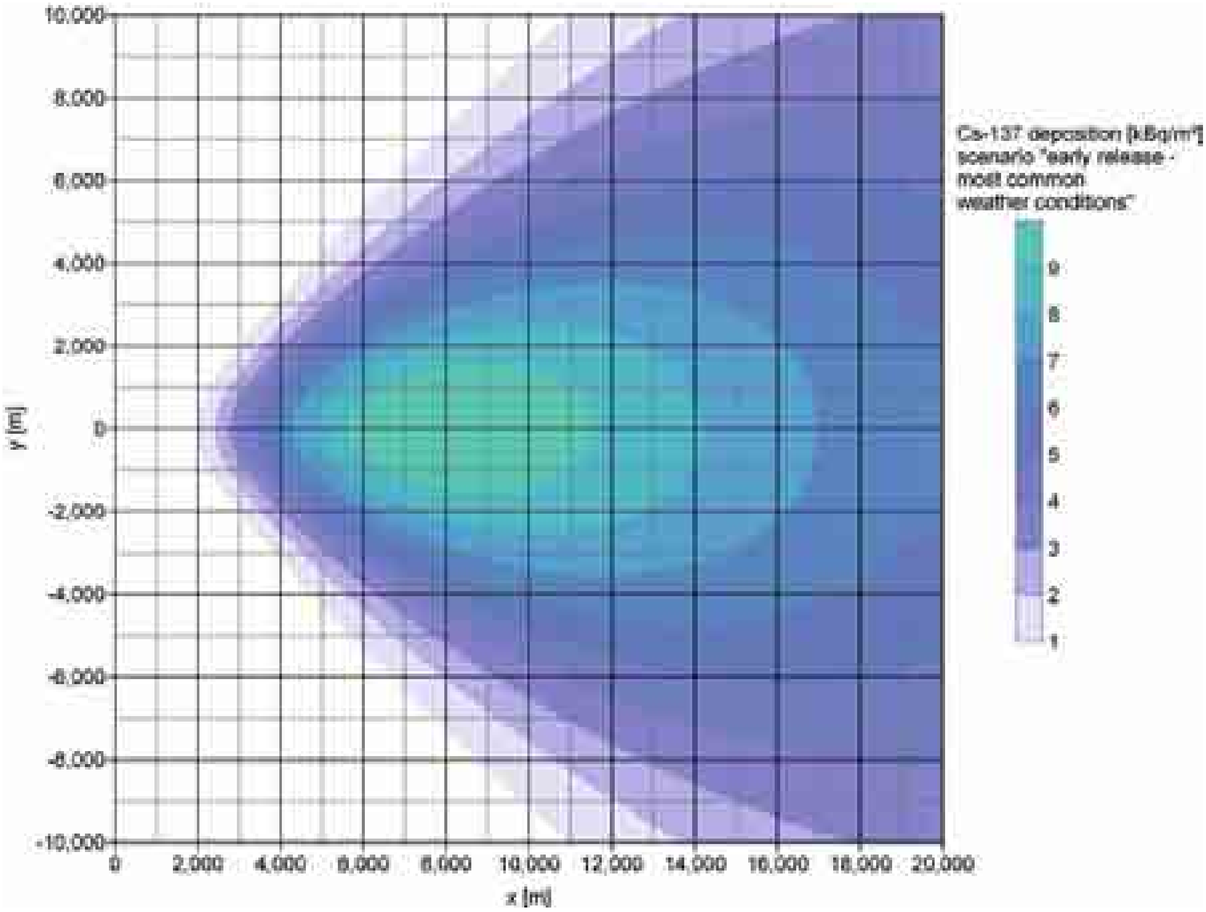


Figure 8-109. Local dispersion of Caesium-137 fallout in typical weather conditions.

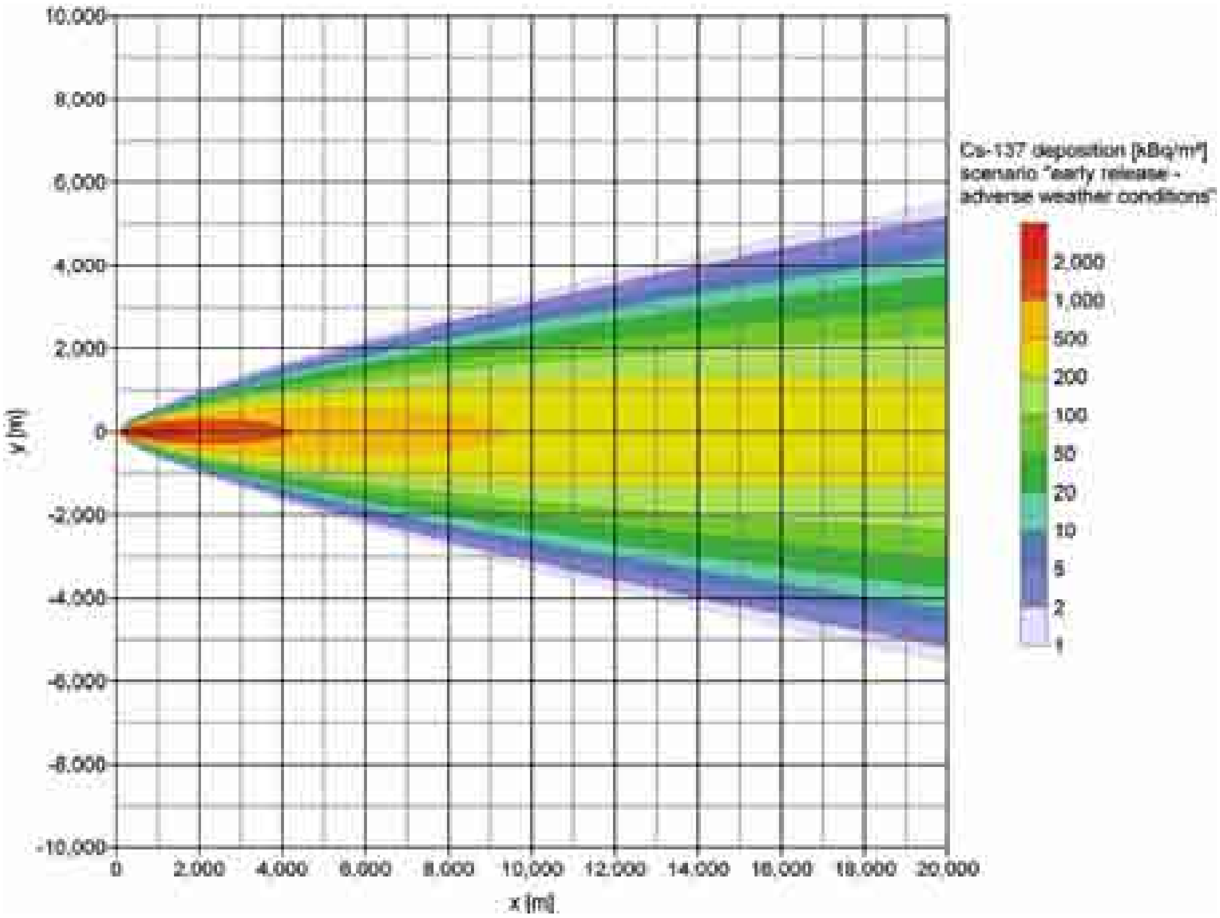


Figure 8-110. Local dispersion of Caesium-137 fallout in unfavorable weather conditions.

ing perpendicular from the centerline of the fallout trail determined by wind direction. In typical weather conditions, the fallout disperses over a larger area (Figure 8-109). Hard rain washes a significant part of the radioactive substances down from the cloud. The dispersion area is smaller (Figure 8-110) but the fallout is heavier than without rain.

Fallout following the modeled accident does not cause any restrictions on land use in typical weather conditions. Instead, in unfavorable conditions the fallout of Cs-137, in particular, may cause long-term restrictions on the use of land areas, because of which the immediate surroundings of the plant site would not be suitable for residential, agricultural or recreational use after a severe accident without efficient cleaning operations. In unfavorable conditions a fallout may also have an impact on plant and animal populations in the immediate surroundings (*Hinton et al. 2007*).

With regard to local agricultural products used as food, such as vegetables, milk and meat, the fallout in typical weather conditions will be so small that long-term restrictions are not required on their use. Without any protective measures aimed at livestock or food production, there may be a need for short-term usage restrictions of no more than a few weeks in areas within a radius of as much as 1,000 kilometers until the concentrations of I-131, which is significant to the buildup of radiation doses, have decreased sufficiently. The half-life of I-131 in agricultural products is about 8 days. In

Figure 8-111. Zones of a 100, 500 and 1,000 kilometer radius surrounding the alternative locations. The plant sites from north to south are Simo, Pyhäjoki and Ruotsinpyhtää.

unfavorable weather conditions, restrictions on the use of agricultural products ranging from a few months to a few years may be required up to a distance of approximately 10 kilometers.

In case of an accident during unfavorable weather, it is also probable that restrictions on the use of various kinds of natural produce will have to be issued in areas affected by the greatest fallout. For example, long-term restrictions on the consumption of certain mushrooms may be required in areas at a distance of 200–300 km. However, the restrictions do not extend to areas farther than a few dozen kilometers. The activity in mushrooms will depend particularly on Cs-137, which is the most important radioactive substance found in the woods with regard to radiation doses. The accumulation of caesium varies greatly in different mushroom species. The activity in edible mushrooms may vary even a hundred-fold (*Pöllänen 2003*). The Cs-137 concentration in forest berries varies depending on how nutrient-rich the habitat is. Accumulation reaches its peak on infertile or humid habitats (*Pöllänen 2003*). In cervids and other game animals, the level of accumulated radioactivity depends on the amount of radioactive substances in their food plants. The concentration of Cs-137 in mountain hare meat may be two or three times that of a fully grown elk inhabiting the same area, whereas the concentration is significantly lower in brown hare, waterfowls, and pheasants (*Pöllänen 2003*).

Radioactive fallout also contaminates surface water, which leads to increased activity in inland fish species. The average caesium concentration in consumable Finnish freshwater fish is approximately 200 Bq/kg (*STUK 2004b*). With regard to radiation exposure from fish, Cs-137 is the most noteworthy radioactive component in the fallout because it is localized in the edible parts of the fish. Sr-90, on the other hand, is localized in fish bones, which are generally not consumed. Fish species feeding on plankton, such as vendace or carp, reach maximum activity concentration of Cs-137 in a few months from the fallout. Then their concentration begins to decrease because the regeneration speed of plankton is high. Due to long food chains, predatory fish, such as northern pike or pike-perch, do not reach their maximum activity concentration until after a few years. The concentrations decrease rapidly during the first few years but after that period, the speed slows down.

In nutrient-poor lakes, the caesium concentration in fish is higher than in nutrient-rich lakes even if the amount of fallout in both lakes is equally large per volumetric unit. The concentration in fish decreases more slowly in small, nutrient-poor lakes where the rate of water exchange is low. It has been estimated that it may take over 20 years before the concentration of Cs-137 in fish will fall to the pre-fallout level in areas with highest

Table 8-46. Large cities located at different distances from the alternative locations..

Distance (km)	Pyhäjoki	Ruotsinpyhtää	Simo
0–100	- Oulu, Kokkola	- Helsinki (capital city area), Lahti	- Oulu, Tornio - Haparanda
100–500	- Tornio, Pori, Vaasa, Rovaniemi, Joensuu, Mikkeli, Kuopio, Tampere, Turku, Helsinki - Umeå, Luleå, Sundsvall, Skellefteå, Vyborg	- Turku, Tampere, Kuopio, Mikkeli, Vaasa, Pori - Tallinn, Riga, Stockholm	- Pori, Vaasa, Rovaniemi, Joensuu, Mikkeli, Kuopio, Tampere - Umeå, Luleå, Skellefteå
500–1000	- Stockholm, Oslo, Trondheim, Tallinn, Riga, St. Petersburg, Liepaja	- Oulu - Moscow, Minsk, Warsaw, Arkhangelsk, Murmansk, Vilnius, Gothenburg, Oslo, Copenhagen	- Helsinki, Turku, Lahti - Stockholm, Arkhangelsk. Murmansk, St. Petersburg, Tallinn, Riga, Oslo, Trondheim

Table 8-47. Fallout following a severe reactor accident by distance.

Distance (km)	Fallout (kBq/m²)		
	Sr-90	I-131	Cs-137
1	0.003	0.13	0.009
2	0.34	15	1.0
3	1.3	56	3.8
4	2.2	97	6.5
5	2.8	120	8,3
6	3.2	140	9.3
7	3.4	150	9.9
8	3.4	150	9.9
10	3.3	140	9.6
15	2.6	120	7.7
20	2.1	92	6.2
50	1.5	65	4.3
100	1.0	46	3.0
200	0.66	29	1.9
300	0.47	21	1.4
500	0.28	12	0.81
700	0.18	7.8	0.52
1000	0.10	4.3	0.28

Cs-137 fallout (*Pöllänen 2003*). In Finland, the highest fallouts from Chernobyl have been approximately 45 to 80 kBq/m² (*STUK 2008q*). The areas with highest fallout include southern lake Päijänne, for example *(STUK 2008r)*. In southern lake Päijänne, the activity content in northern pike decreased below the maximum permitted level established in the European Union (Table 8-45) in approximately six years, whereas the corresponding time in vendace was about one year (*Pöllänen 2003*). In the accident situation under consideration, a Cs-137 fallout of about 50 kBq/m² in unfavorable weather conditions can take place at a maximum of approximately 50 kilometers from the accident site. Consumption of inland fish species would likely be restricted following a severe accident. For predatory fish, long-term restrictions and usage recommendations would be issued.

In a sea environment, fallout generally has a less severe impact than in lakes because the larger water volume in the sea dilutes the radioactive content more effectively. After the Chernobyl accident, the highest concentrations of Cs-137 in fish in the Baltic Sea have been less than one tenth of the maximum concentrations in freshwater fish (*Pöllänen 2003*).

In a reindeer husbandry area, radioactive fallout may have a detrimental impact, especially if the fallout is rich in Cs-137. The infertile and nutrient-poor nature of Lapland promotes contamination of food chains by the radioactive elements in the fallout, and consequently the lichen-reindeer food chain accumulates caesium effectively. Following the Chernobyl accident in May 1986, the average Cs-137 concentration was 1000 Bq/m² in lichen in Lapland. The increase of caesium concentration in reindeer meat became evident after the beginning of the winter slaughter, when the average activity content of Cs-137 in reindeer meat was about 700 Bq/kg. Fifteen years after the accident, the concentration was under 200 Bq/kg (*Pöllänen 2003*). According to a recommendation of the EU Commission, the maximum permitted concentration of wild food products to be placed on the EU market is 600 Bq/kg (Recommendation 2003/274/Euratom).

Radiation doses

Radiation doses from radioactive releases following a severe accident are shown in the table 8-48.

During the first two days and first seven days following the accident, the radiation dose is caused by external radiation and activity entering the body through respiration. Radiation doses through food ingestion also have a possibly significant impact on the lifetime radiation dose. It is likely, however, that the use of contaminated foodstuffs is avoided, which in turn helps to avoid at least part of the radiation dose through food ingestion. This is why the table (Table 8-48) has separate columns for radiation exposure due to external radiation and inhalation, and radiation exposure due to food ingestion when the use of foodstuffs is not restricted.

In the modeled accident situation, the release takes place at an altitude of 100 meters. In typical weather conditions, it takes some time for the lower edge of the emission cloud to reach ground level, due to which the fallout and doses are at their maximum at approximately 8 kilometers from the plant. In unfavorable weather conditions, rain affects the maximums of fallout and doses so that they will affect the area in which it is raining at the very moment the emission cloud passes. In unfavorable weather conditions at a distance of 8 kilometers, the doses are 20- to 25-fold compared to typical weather conditions. For comparison, a Finn acquires a radiation dose of approximately 200 mSv from other sources, mainly natural background radiation, in 50 years *(STUK 2008e)*.

The radiation doses caused by a severe accident in typical weather conditions are so small at all distances that they do not require taking shelter indoors or evacuation. However, evacuation will always be carried out within the protective zone of the nuclear power plant (an approximate distance of 5 kilometers) if there is a risk of substantial emissions of radioactive substances into the environment. In unfavorable weather conditions, taking shelter indoors may be required at a distance of approximately ten kilometers from the plant, in addition to evacuation within a five-kilometer radius. People may avoid going outdoors also at a greater distance. Taking shelter indoors can reduce radia-tion doses from an accident by 50% to 90% (*IAEA 2000*). Evacuation can completely, or almost completely, prevent any radiation dose.

The radiation dose accumulated in the thyroid gland is used to determine the need for the use of iodine tablets (Table 8-49). In typical weather conditions, the use of iodine tablets is the only necessary protective measure. In an area less than 100 kilometers from the accident site, children should take iodine tablets according to guidelines issued by authorities. For adults, the use of iodine tablets is not necessary. If the weather condi-tions are unfavorable, adults should take iodine tablets if within 5 kilometers from the plant, and children within approximately 100 kilometers.

The health impacts arising from a release of radioactive substances in a severe reactor accident can be estimated on the basis of statistically calculated radiation doses. Chapter 8.10.4 has background information on the health impacts of ionizing radiation and com-parison data on the average radiation doses of Finns and on the radiation sources.

The severe reactor accident being studied does not cause any direct or immediate health impacts in the vicinity of the facility. During the first two days, the radiation doses for both adults and children in typical as well as unfavorable weather conditions are clearly under the limit for showing changes in the blood count, 500 mSv.

Delayed random impacts from radiation exposure may only be estimated statistically. Statistical assessment is based on the assumption that a large population of people is exposed to equal radiation doses. The risk of the radiation dose to an individual can be used to calculate an expected value for the incidence of radiation-incurred health impacts in a large population – that is, the number of probable health impacts in the popu-lation. It is practically impossible to link an individual delayed health impact with radiation exposure caused by an accident due to reasons described in Chapter 8.10.4.

The International Commission on Radiological Protection (ICRP) has estimated that exposure to a radiation dose of 1,000 mSv at small doses and dose rates increases the risk of cancer by 5.5% (ICRP 2007). Without the additional impact of an accident, the risk of getting cancer before the age of 70 is 15% to 20% in Finnish males, and about 15% in Finnish females (*Pukkala et al. 2006*). These cases of cancer arising from reasons other than the radiation dose from an accident are so probable that the additional risk of cancer caused by the accident is practically insignificant at all distances.

The lifetime radiation dose (adults 50 years and children 70 years) accumulated by an individual due to a severe accident can be used to estimate the expected value of cancer cases caused by the severe accident if the individual is an adult or a child of 1 to 2 years old at the time of the accident and no protection measures have been applied. Within the protective zone of the

Table 8-48. Radiation doses for adults and children following a severe reactor accident at different distances.

Distance (km)	Adult					Child				
	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)	Total (mSv)	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)	Total (mSv)
	2 days	7 days	50 yrs	50 yrs	50 yrs	2 days	7 days	70 yrs	70 yrs	70 yrs
1	0.24	0.24	0.25	0.002	0.25	0.34	0.34	0.35	0.005	0.36
2	0.28	0.29	0.72	1.4	2.1	0.39	0.41	0.96	3.3	4.3
3	0.67	0.71	2.3	5.3	7.6	0.94	1.0	3.1	13	16
4	1.1	1.1	4.0	9.1	13	1.5	1.6	5.2	22	27
5	1.4	1.4	5.0	12	17	1.9	2.0	6.7	28	35
6	1.5	1.6	5.6	13	19	2.1	2.3	7.6	31	39
7	1.6	1.7	5.9	14	20	2.2	2.4	8.0	33	41
8	1.6	1.7	6.0	14	20	2.2	2.4	8.0	33	41
10	1.5	1.6	5.7	14	20	2.1	2.3	7.7	32	40
15	1.2	1.3	4.7	11	16	1.7	1.8	6.2	26	32
20	1.0	1.0	3.6	8.6	12	1.4	1.4	4.9	20	25
50	0.69	0.73	2.6	6.1	8.7	1.0	1.0	3.5	15	19
100	0.49	0.52	1.9	4.3	6.2	0.68	0.72	2.4	10	12
200	0.31	0.33	1.2	2.7	3.9	0.43	0.46	1.6	6.5	8.1
300	0.22	0.23	0.83	2.0	2.8	0.31	0.33	1.1	4.6	5.7
500	0.13	0.14	0.48	1.1	1.6	0.18	0.19	0.65	2.7	3.4
700	0.083	0.088	0.31	0.73	1.0	0.12	0.12	0.42	1.7	2.1
1000	0.045	0.048	0.17	0.40	0.57	0.063	0.067	0.23	0.95	1.2

plant (less than 5 kilometers from the plant), the statistical life-time risk of getting cancer caused by radiation exposure from the accident is at most 1/500, which means that if the population is less than 500, the expected value for cancer cases caused by a severe accident is less than 1. At greater distances, the population within the area affected by a severe accident is larger, which also increases the expected value of cancer cases caused by an accident. The corresponding statistical risk at a distance of one hundred kilometers is at most 7/10000. If the population within this distance is assumed to be one million, the expected value for the number of cancer cases is at most 660. In a population of one million Finns, almost 170,000 get cancer from other causes by the age of 70.

In unfavorable weather conditions, the radiation doses incurred by the population in the vicinity of the plant are several dozen times higher compared to typical weather conditions, which also increases the cancer risk by several dozen times. However, the fallout in unfavorable weather conditions focuses on a smaller area, and it can be assumed that the exposed population is smaller than in typical weather conditions. In this case, the fallout to other areas is correspondingly smaller. In both weather conditions, the total radiation dose incurred by the population is the same, which means that the number of cancer cases caused by the accident is equal.

Radiation exposure may impact a developing fetus. However, radiation damage to the fetus occurs only at rather large doses (*Paile 2002*). Impacts of radiation on pregnancies have not been shown except in the survivors of the Hiroshima and Nagasaki nuclear explosions (*Auvinen 2004*). As a consequence of a severe accident, a pregnant woman at a distance of 8 kilometers will receive a maximum dose of 2 mSv from external radiation during the first month after the accident and a maxi-

Table 8-49. Thyroid dose from a radioactive release following a severe reactor accident.

Distance (km)	Thyroid dose (mGy)	
	Adult	Child
1	0.01	0.03
2	1.5	3.1
3	5.7	12
4	10	20
5	13	26
6	14	30
7	15	31
8	15	32
10	15	30
15	12	24
20	9.3	19
50	6.6	14
100	4.7	9.6
200	3.0	6.1
300	2.1	4.4
500	1.2	2.6
700	0.79	1.6
1000	0.43	0.90

mum dose of 3 mSv within one year. The person will also be exposed to radiation through food. The dose caused by the accident is not large as natural radiation alone will cause a total radiation dose of approximately 1 mSv to the developing fetus during the full course of pregnancy (*Paile 2002*).

Impacts of a postulated accident

A postulated accident means an event which serves as a design basis for the engineered safety systems of a nuclear power plant. The nuclear power plant shall withstand a postulated accident without severe damage to nuclear fuel and without radioactive releases that would require extensive measures for restricting the exposure of the general public in the vicinity of the facility.

The impacts of a postulated accident may be roughly estimated by the results of a serious reactor accident model. Based on the relationship between the radioactive emissions from a postulated accident (INES 4) and a severe accident (INES 6), the radiation doses following a postulated accident are not expected to exceed one thousandth of the radiation doses from a severe accident. The maximum radiation doses for adults and children from a postulated accident, estimated under this assumption, are in the table of next page (Table 8-50). The values presented correspond to the least favorable weather conditions because the radiation doses in typical weather conditions would be infinitesimal. For comparison, a Finn acquires a radiation dose of approximately 3.7 mSv annually (see Chapter 8.11.2) (*STUK 2008e*).

Correspondingly, the maximum thyroid radiation dose for adults is 0.7 mGy and for children 1.5 mGy. Based on the criteria used for emergency planning (Table 8-44), the event of a postulated accident would not require protective measures in the vicinity of the nuclear power plant.

8.15.2 Chemical accidents

In addition to nuclear accidents, other environmental accidents which may take place at a nuclear power plant include mainly accidents when transporting, offloading and loading, storing and using chemicals or oils. Chemicals used in the nuclear power plant are described in Chapter 3.7, and the impacts of their use in Chapter 8.12.

Risks of chemical accidents are also already considered in the design stage of the plant. The design, building and use of disassembling systems, storage and transfer hoses of chemicals shall prepare for the possibility of failures and incidents. The chemical storage tanks and chemical stores are to be built in compliance with the Chemicals Act and regulations issued pursuant to it, as well as SFS standards. Uncontrolled and undetected leaks shall be prevented with control guides and automated alarms. The design of sewers shall ensure that possible leaks are contained in protective pools, slurry and oil separation wells and a neutralization pool. The staff of the nuclear power plant shall receive appropriate training in the use and storage of chemicals. In addition, safety instructions on the prevention and control of chemical accidents and incidents are to be drawn up. The Safety Technology Authority (*TUKES*) controls the use and storage of dangerous chemicals.

As a result, accidents when storing or handling chemicals are unlikely.

8.16 Impacts of the nuclear fuel production chain

The phases of the production of nuclear fuel used in light water reactors are the excavation and extraction of uranium ore, conversion into uranium hexafluoride (UF_6), U-235 enrichment, the production of fuel pellets and fuel rods, and the manufacture of fuel assemblies.

Table 8-50. Radiation doses for adults and children following a postulated accident in the most unfavorable weather conditions and at different distances.

Etäisyys (km)	Adult				Child			
	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)
	2 days	7 days	50 yrs	50 yrs	2 days	7 days	70 yrs	70 yrs
1	0.10	0.13	1.60	0.55	0.14	0.18	2.10	1.10
2	0.06	0.07	0.89	1.20	0.08	0.11	1.20	2.30
3	0.03	0.05	0.61	0.77	0.05	0.07	0.81	1.50
5	0.02	0.03	0.38	0.46	0.03	0.04	0.50	0.88
10	0.01	0.01	0.19	0.22	0.01	0.02	0.26	0.42
50	0.00	0.00	0.02	0.03	0.00	0.00	0.03	0.06
100	0.00	0.00	0.01	0.02	0.00	0.00	0.02	0.03

8.16.1 Uranium mining and refining

Uranium mining and refining belong to normal mining operations. Natural uranium is produced by underground mines (Figure 8-112), open pit mines (Figure 8-113) and in situ leaching (ISL) (Figure 8-114). In 2006, underground mines accounted for 41% of the total production of natural uranium, open pit mines for 24% and in situ leaching 26%. Uranium produced as a by-product of other metals, such as copper and gold, accounted for 9% of the overall production (*WNA 2007*). The selection of the mining method depends on, e.g., the uranium content of the deposit and the geological properties and ground water conditions of the area. The in situ leaching method has been used for a long time in e.g. the United States and Kazakhstan, and the method is increasing its share of uranium production.

In conventional mines, the ore is excavated from the rock, crushed and milled. In the case of uranium deposits located deep in the rock, uranium is mined from the tunnels (Figure 8-115).

The fine ore is taken to an extraction plant in which the uranium is separated from the ore, typically using sulfuric acid. Generally, between 75% and 90% of the uranium contained in the ore can be recovered. The uranium is extracted from the acid solution by leaching it using a variety of solvents, after which the uranium is precipitated using ammonia into U3O8 (triuranium octaoxide). The final product of the extraction process is called yellowcake (Figure 8-116).

In the in situ leaching method, holes are drilled in the ground and an acidic or alkaline solution is circulated in the soil through them (Figure 8-117). The pH of an acidic solution is 2.5–3.0, similar to the pH of vinegar. The selection of acid or alkali leaching depends on the geology and groundwater conditions of the area. The uranium mineral is dissolved into the circulating solution, which is circulated to a surface plant and treated either using the solvent extraction or ion exchange method, depending on the acidity of groundwater. The mixture recovered from the precipitation phase (U_3O_8) is dried at a high temperature. ISL mines are operational in e.g. Kazakhstan, the United States and Australia (*WNA 2008d*).

Management of environmental impacts at uranium mines

The environmental impacts of uranium mining operations are connected with the radiation of the uranium ore, the radiation effect of the radon gas released from the ore, and wastewater.

In underground mines, the radon exposure of employees can be reduced to a level not causing any adverse health effects by ensuring good ventilation. In Canadian mines operating in areas of deposits with a high uranium content, mining has been automated and the machines are operated by remote control to avoid having employees handle ore with a high uranium content. The dust produced at mines is monitored in order to prevent radioactive minerals from entering the respiratory tract. Dust can be reduced by watering, and if necessary, access to dusty areas is limited.

Natural radon gas spreads in the environment according to the strength and direction of wind, for instance. The concentrations rapidly become weaker when spreading further from the mine. Other uranium degradation products are solid matter and can escape into the environment only through water or dust. In addition to radon, harmful radium is precipitated away from the

Figure 8-112. Subterranean uranium mine (Cameco, Rabbit Lake, Canada).

Figure 8-114. Figure Uranium mine, in situ leaching method (Cameco, Crow Butte, Canada)

process water.

The impacts of mining operations on the population are relatively small because uranium mines are primarily underground and are located in remote areas, far from settlements. The disposal of waste, extraction sand and surrounding rock produced in mining operations is taken care of in a way that prevents the dissolution of harmful substances from the waste and the release of radon from the area. The waste disposal areas are covered layer by layer to prevent the waste matter from decaying and rainwater from dissolving the radium from it. Water flowing through waste piles is monitored in order to be able to treat it as necessary. Treatment ensures that the quality of water released into the environment fulfils the appropriate requirements (*WNA 2006a*).

Radiation effects, the production of wastewater and waste as well as landscape impacts can be largely avoided by applying the in situ leaching method.

The uranium oxide produced at the extraction plant is a chemically-toxic substance and breathing it is harmful to the kidneys in a manner similar to lead oxide. Precautionary measures similar to those in lead-smelting plants are applied at the extraction plant.

The license application for constructing and operating a uranium mine includes a resto-ration plan concerning the termination of mining operations. The plan

Figure 8-113. Uranium quarry (Rio Tinto, Rössing, Namibia).

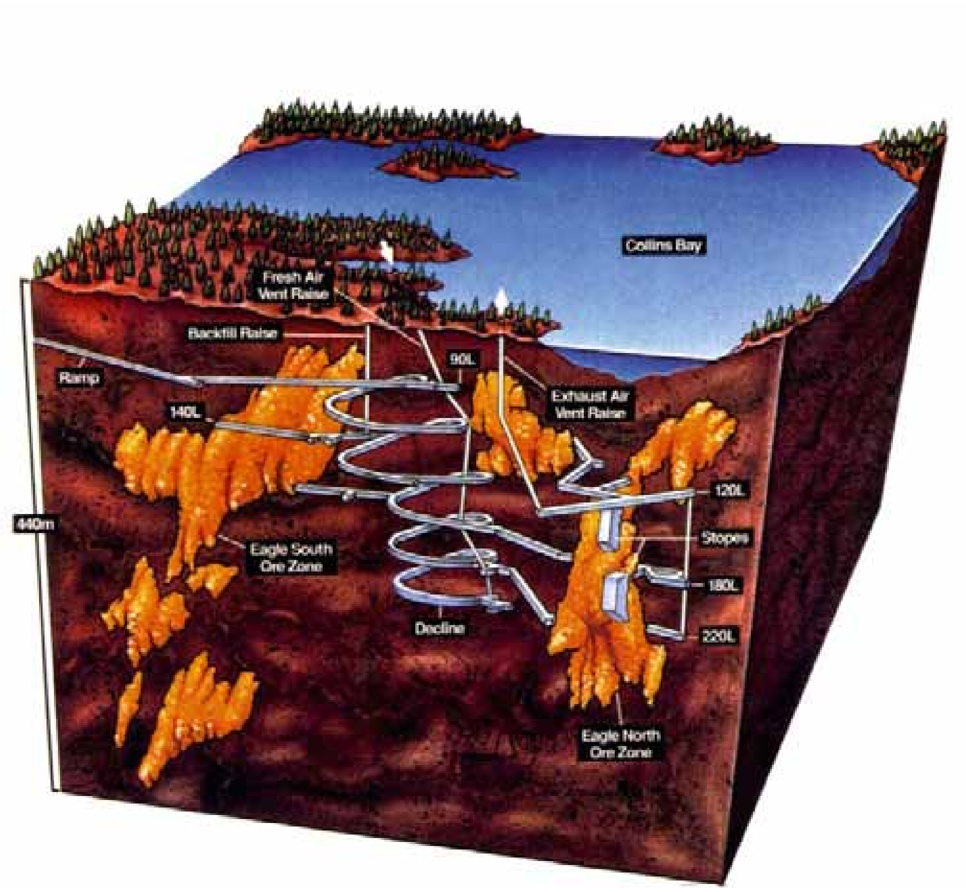


Figure 8-115. Structure of an underground uranium mine (Rabbit Lake, Canada).

Figure 8-116. Natural uranium (yellowcake).

describes in detail how the applicant is committed to take responsibility for land filling and landscaping, and to comply with standards imposed on air and water quality. The plan shall also explain how requirements related to health and safety are fulfilled. Operators must collect funds to cover for the costs of restoration and decommissioning.

Currently, in countries with uranium mining operations, such as Canada and Australia, regulations and guidelines issued by the national government and the environmental and nuclear safety authorities guide the processes connected with the mines and the further processing of uranium. The authorities monitor the operations of the mines. The status of the environment in the mining area is monitored for years after the end of operations and even after the restoration measures carried out in the mining area. Factors affecting the environment, health and safety of mining activity are increasingly managed by international standards and audits carried out by external parties.

Production companies, mines, conversion and extraction plants and fuel production and manufacture plants in the uranium fuel production chain are also audited by the nuclear power production companies that are their clients to ensure that the different phases of the uranium fuel production chain operate in an acceptable way.

8.16.2 Conversion and enrichment

For enrichment, the natural uranium (yellowcake) is converted at a conversion plant (Figure 8-118) through chemical processes into a gaseous form (Figure 8-119), uranium hexafluoride (UF6). The processes make use of a variety of chemicals and thermal energy.

In natural uranium, the share of isotope U-235 is 0.7%. In light water reactors, the ur-nium typically

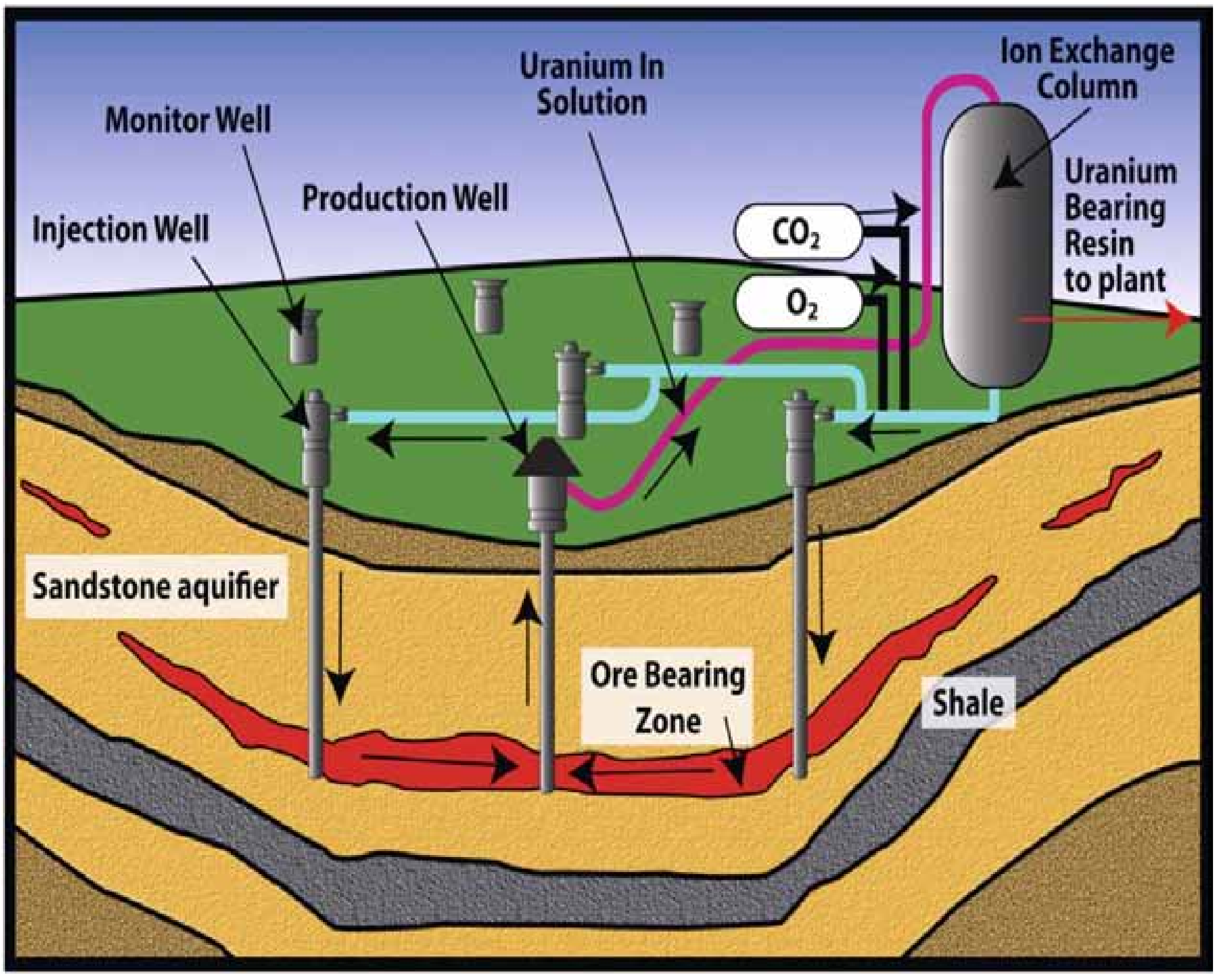


Figure 8-117. In situ leaching method.

contains 3 to 5 % U-235. Enrichment takes place either with the help of gaseous diffusion or, increasingly, by the centrifuge method, which consumes substantially less energy. In centrifugal separation, the uranium isotopes with different masses are separated from each other by centrifugal force (Figure 8-120). The enclosed figure portrays a centrifuge plant in France (Figure 8-121).

The enrichment process yields 10% to 15% of the original amount of uranium as enriched uranium, with 80% to 90% being so-called depleted uranium. Depleted uranium can mainly be used for diluting uranium derived from military use for use in civilian reactors.

Conversion and enrichment are chemical operations where hazardous chemicals are handled and stored. Several laws and regulations concerning the management of hazardous materials and wastes regulate the operations of chemical plants. Training of the employees has an important role in the prevention of environmental damage.

At the conversion plant, gaseous and liquid impurities emerge in the production of fluorine and the fluorination of the uranium compound and the solution purification processes. The most significant gaseous impurities monitored at conversion plants are hydrogen fluoride (HF), fluorine (F_2) and uranium isotopes (U).

The operation and maintenance of a centrifuge plant results in some gaseous radioactive emissions. For instance, the wastewater from the gas scrubbers of a centrifuge plant is slightly radioactive. In case of any leaks of toxic uranium hexafluoride in a gaseous form, enrichment plants have detectors that protect the plant's employees and prevent emissions outside the plant.

The liquid and gaseous emissions emerging at conversion and enrichment plants, as well as waste, are processed appropriately, and in a normal situation the plants do not cause noteworthy environmental impacts. In actual accidents, the impacts are mainly restricted to the plant area. State-of-the-art conversion plants circulate the chemicals, which reduces their use and storage needs. Environmentally-hazardous chemicals can be replaced by more environmentally-advantageous compounds, as has been done with regard to CFC compounds which destroy the ozone layer. In some cases, chemical processes can also be replaced by thermal processes (*Cameco 2008, Urenco 2006, Finnish Energy Industries 2006*).

8.16.3 Manufacture of fuel assemblies

The production phases taking place at a fabrication plant (Figure 8-122) are the conversion of uranium hexafluoride into uranium oxide, production of pellets, the production of fuel rods and the manufacture of fuel assemblies (Figure 8-123).

Both uranium oxide and fuel pellets are stored in barrels at the fabrication plant. Uranium dioxide powder is formed into pellets of approximately 1 centimeter in diameter and approximately 2 centimeters in length. The cylindrical pellets are loaded into claddings of 3 to 4 meters in length made of zirconium alloy. The claddings are sealed tightly. This makes up a fuel rod. During assembly, the fuel rods are made into fuel assemblies approximately 30 centimeters in diameter. The fuel assembly for a PWR typically contains 16 x 16 to 18 x 18 fuel rods, while the assembly for a BWR typically con-tains 10 x 10 fuel rods.

No significant radiation effects are caused at the fabrication plant as enriched uranium contains only minor amounts of the most hazardous uranium decay products in terms of radiation, such as radium, radon or polonium. Fuel criticality and/or an uncontrolled chain reaction during manufacture are impossible because no

Figure 8-118. Conversion plant (Areva, Pierrelatte, France; copyright AREVA).

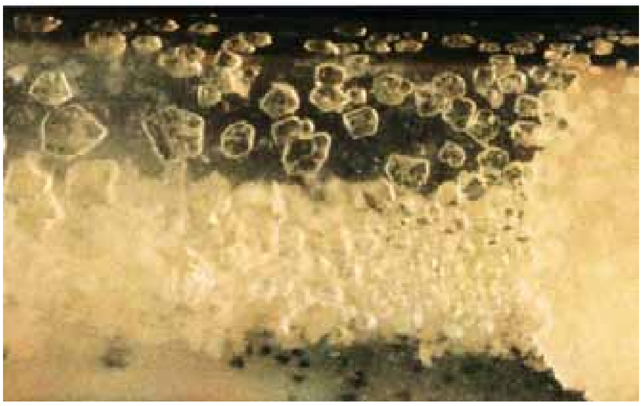


Figure 8-119. Uranium hexafluoride.

Figure 8-120. Centrifuges.

Figure 8-121. Enrichment plant (Areva, Georges Besse, France; copyright AREVA).

stage of the manufacturing process involves any moderator material (water) that would enable a chain reaction to occur.

Several hazardous chemicals are also processed at the fabrication plant, and they are handled in accordance with the laws and regulations on the processing and storage of hazardous materials.

Exhaust air and wastewater conducted outside the production plant are decontaminated as necessary before they are conducted into the environment. Air exiting the plant is conducted through a filter. The content of uranium dust in the working area is monitored with continuous measurements.

8.16.4 Transports and storage in the nuclear fuel production chain

From the extraction plant to the conversion plant

The enriched natural uranium is packed into 200-liter barrels (Figure 8-124), which are loaded into containers and transported by ship or train to intermediate storage and the conversion plant. The yellowcake is only slightly radioactive and the steel transport containers offer adequate radiation protection. The transport only requires stock suitable for transporting hazardous materials.

From the conversion plant to the enrichment plant

After the conversion, the uranium hexafluoride is stored in a solid form in pressurized 8.45-ton containers (Figure 8-125), in which it is also transported by ship, train or trucks to the enrichment plant.

Uranium hexafluoride is a highly chemically-toxic substance and appropriate precautionary measures are applied in transports. Uranium hexafluoride has been transported in considerable amounts for decades. There have been very few accidents in truck, railroad and ship transports. The accidents that have taken place have not resulted in releases of uranium hexafluoride in amounts that would have caused environmental impacts. For instance, in a serious shipping accident on the Belgian coast in 1984, uranium hexafluoride barrels sank to a depth of 15 meters and could not be retrieved until several days later due to difficult weather conditions. The barrels, however, remained intact, and no environmental impact was caused (*Urenco 2001*).

From the enrichment plant to the fabrication plant

For transportation, the enriched uranium which is in solid form is packed into containers of 0.85 to 1.54 tons, similar to those used when transporting it to the enrichment plant (Figure 8-126). The transport container has a double structure and is thermally protected to endure any fire during an accident, for example. Depleted uranium is stored in containers similar to those used for transporting natural uranium hexafluoride (Figure 8-127).

Figure 8-122. Fuel plant. (Areva, Romans, Ranska; copyright AREVA).

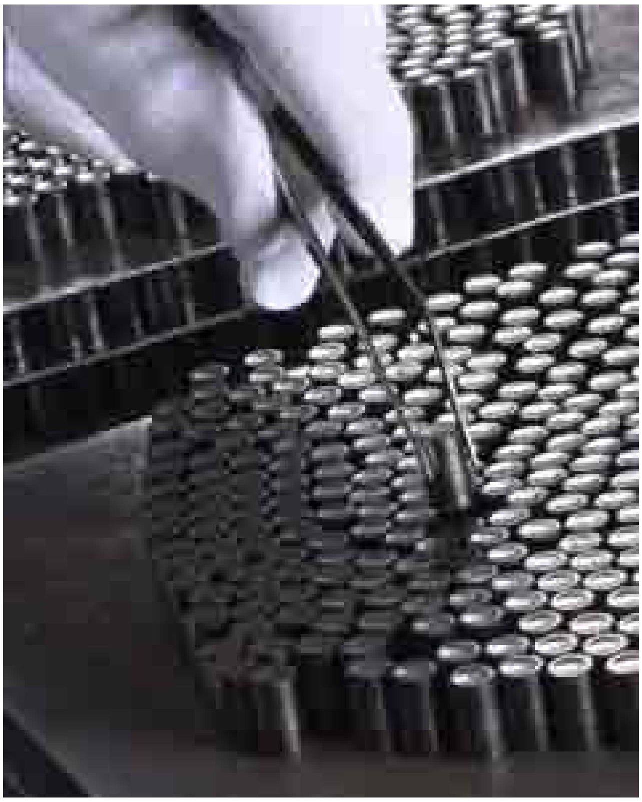


Figure 8-123. Fuel pellets and manufacture of fuel assemblies.

After enrichment, uranium is only slightly water soluble, which limits the emergence of environmental impacts in case of a shipping accident.

From the fuel plant to the nuclear power plant
Fresh nuclear fuel assemblies are transported in special packages that protect the fuel assemblies during transport (Figure 8-128). Due to low radioactivity, special radiation protection is not necessary. The criticality risk associated with the material, i.e. the risk of a nuclear reaction starting, is prevented by the special design of the container and the arrangement of the fuel assemblies in the containers, by limiting the amount of fuel placed in the container and the number of containers transported in a single vehicle.

The amount of fuel used annually in a nuclear power plant is low compared to energy production plants using other fuels, and the amounts transported are relatively low. However, transports are needed in several phases of the production chain and the transport distances can be long. In the fuel production chain, the intermediate products and fuel assemblies transported from the mines to the power plant are slightly radioactive at most. Nuclear materials are transported by specialized transportation companies that have the required qualifications and official authorizations.

National and international regulations on transports and storage of radioactive materials are widely based on the standards and guidelines issued by the IAEA (e.g. *IAEA 2005*). The purpose of the regulations is to protect people and the environment from radiation during the transport of radioactive materials.

The main principle is that the basis of protection is the transport container, regardless of the means of transport used. In addition, protection is based on the management of the radioactive content of transports, control of the radiation levels caused, prevention of criticality and prevention of damage caused by heat (*WNA 2008e, STUK 2008c*).

Figure 8-125. Uranium hexafluoride containers.

Figure 8-124. Yellowcake transport barrels.

Figure 8-126. Enriched uranium transport containers.

Figure 8-127. Depleted uranium storage barrels in the loading and monitoring area of the enrichment plant (Areva, Georges Besse, France; copyright AREVA).

8.16.5 Environmental load of nuclear fuel per energy unit produced

The amount of fuel required in the production of electricity with nuclear power is considerably lower than in the production of electricity using fossil fuels, such as coal (Figure 8-129).

Several life cycle studies have compared the CO_2 emissions of various energy production forms. With nuclear power, CO_2 emissions have been in the range of 2–40 g CO_2 equivalent/kWh. With coal, the emissions have varied between 800 and 1300 CO_2eqv/kWh and with natural gas, 400 and 700 CO_2eqv/kWh.

Life-cycle CO_2 emissions of electricity produced with nuclear power are mainly generated in the fuel production chain. In the case of fossil fuels, the life-cycle CO_2 emissions of electricity production are mainly generated in the electricity production phase (*World Energy Council 2004, World Energy Council and Energiafoorumi ry 2005, WNA 2006b*).

8.17 Impacts on the energy market

The Nordic electricity market is very dependent on hydropower production, which covers approximately one-half of total power production in a year of normal water conditions. Hydropower indeed has a substantial effect on the price of electricity and causes substantial price fluctuations in the market. Furthermore, the effect of prices of emissions rights make it difficult to forecast the price of electricity. A new nuclear power plant intended to produce base-load power will improve predictability and create price stability.

Electricity production in Finland and in the Nor-

Figure 8-128. Fuel assembly transport containers.

dic market is very concentrated. Production is mostly the responsibility of a few large operators. A report by VTT Technical Research Centre of Finland titled "Päästökaupan vaikutus pohjoismaiseen sähkökauppaan – Ehdotus Suomen strategiaksi" [The Impact of EU CO_2 Emission Trading on Nordic Electricity Market. A Proposal for Finnish Strategy] (*Kara 2005*) proposes that the Mankala principle, in which buyers commit themselves to production, should be favored because it increases competition in the market and reduces the market share of large operators. Fennovoima Oy operates according to the Mankala principle, meaning that its owners receive power from the nuclear power plant at cost price in proportion to their shares of ownership. Being a new operator, Fennovoima will increase competition in the market.

The VTT report (*Kara 2005*) estimates the impact of a new nuclear power plant on the price of electricity. The study included the fifth unit currently under construction and a sixth unit that was assumed to enter service by 2012. According to the calculations, the price of electricity after the commissioning of the fifth unit would be approximately €36/MWh in 2008–2012, while a sixth unit would bring the price to €22–26/MWh. The calculations estimated the price of carbon dioxide emission rights to be €10/tCO_2, which is clearly lower than current estimates for 2008–2012 (approximately €25–30/tCO_2). If the price of emissions rights were higher than estimated, the impact of nuclear power on reducing the price of electricity would also be greater. A reduction of the market price for power on the electricity exchange would also have a lowering effect on the price paid by consumers.

Fennovoima's nuclear power plant will improve the security of supply for power production by reducing Finland's dependence on fossil fuels and imported power. According to the National Emergency Supply Agency, with regard to the security of supply, uranium can be equated with Finnish primary energy through the use of fuel storage and fuel procurement contracts. There are a variety of sources of uranium, and they are located in politically stable areas. Producers of nuclear power use long-term contracts to secure the supply of fuel. Fuel can be stored at the plant site, and power plants usually have a sufficient supply of fuel to cater for several months or even a year of consumption. The fact that Fennovoima's nuclear power plant will be built in a new location will also improve the security of supply concerning potential failures in power transmission

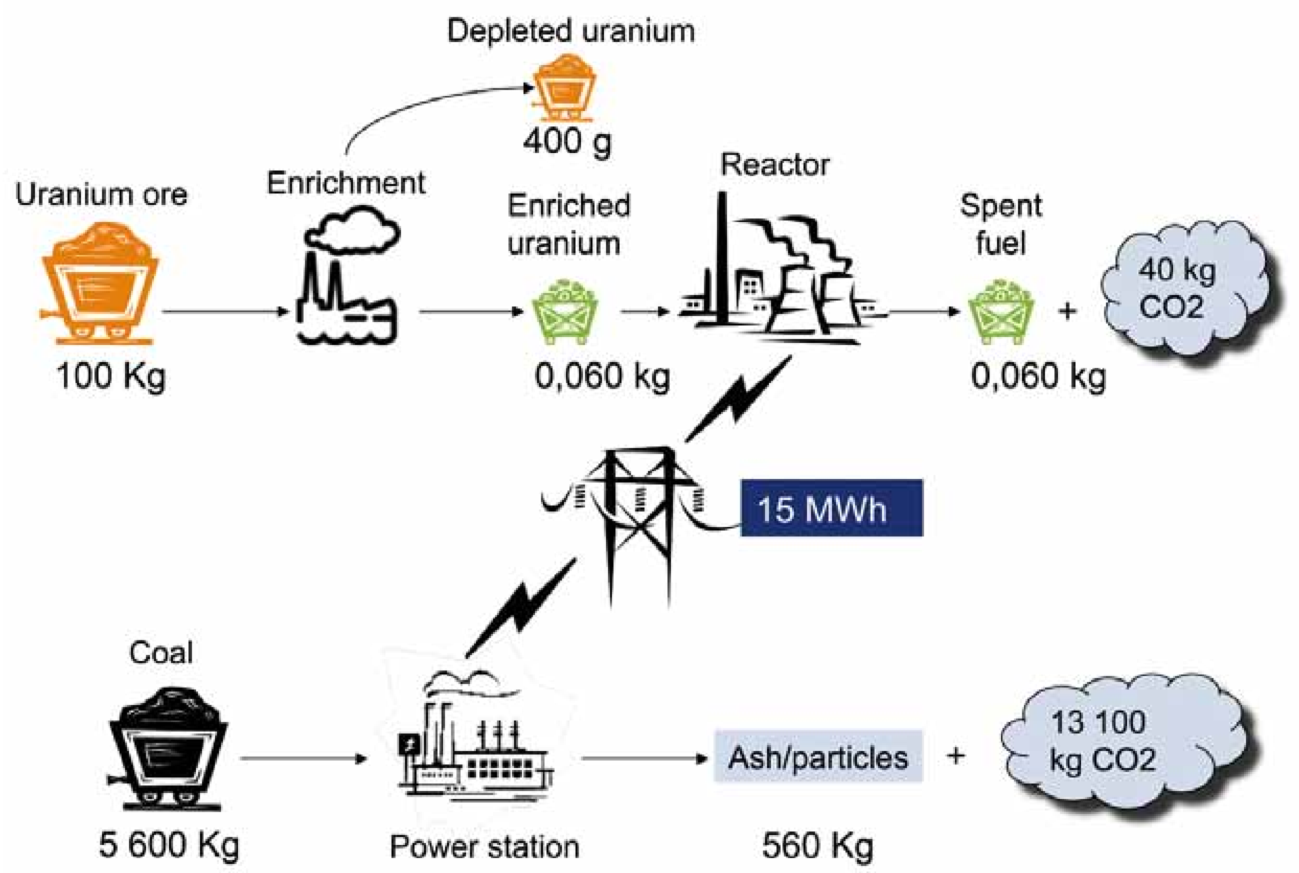


Figure 8-129. Material balances of electricity production when producing electricity with nuclear fuel and coal (WISE 2003, Wikahl 2004).

8.18 Impacts crossing the boundaries of Finland

This chapter presents a summary of the nuclear power plant's impacts that may potentially cross the boundaries of Finland. The only transboundary impact during normal operation of the nuclear power plant is the regional economic impact in the region of Haparanda. The impacts of an extremely unlikely severe nuclear power plant accident would likewise extend outside the boundaries of Finland.

The different types of impacts are discussed in more detail in designated sections elsewhere in Chapter 8.

8.18.1 Impacts on regional economy

Especially at the Simo location, the direct and indirect employment-related impacts of the project would extend to Haparanda and the surrounding areas in Sweden due to the proximity of the national border, because an internal border in the EU does not, in practice, form a hindrance to people's mobility. Even today, cooperation between Tornio and Haparanda is extensive, and the city administrations communicate and interact on a regular basis. Many basic municipal services and recreational opportunities are shared. The training and recruiting of labor is also at least partly planned jointly. Depending on circumstances such as the actions taken by the municipality itself (such as training and supplying workforce, supplying services, supplying housing), there may be significant benefits for Haparanda. The possibility of some permanent staff settling in Haparanda or in Sweden should not be excluded either. The distance between Haparanda and Maksniemi is only about 40 kilometers, and after the current road construction project is finished, most of the route will be motorway.

8.18.2 Impacts of a severe nuclear power plant accident

In order to evaluate the impacts of a nuclear power plant accident, EIA measures have included modeling of the dispersion of the release of radioactive materials arising from a severe reactor accident (INES 6) and the consequent fallout and exposure of the gen-eral public. The modeling procedures and the modeled case example have been described in more detail in Chapter 7. The impacts of a severe accident are described in more detail in Chapter 8.16. The impacts of an accident are demonstrated both in typical weather conditions of the site locations and in the most unfavorable weather condi-

Table 8-52. Large cities located at different distances from the alternative locations.

Distance (km)	Pyhäjoki	Ruotsinpyhtää	Simo
0–100	- Oulu, Kokkola	- Helsinki (capital city area), Lahti	- Oulu, Tornio - Haparanda
100–500	- Tornio, Pori, Vaasa, Rovaniemi, Joensuu, Mikkeli, Kuopio, Tampere, Turku, Helsinki - Uumeå, Luuleå, Sundsvall, Skellefteå, Vyborg	- Turku, Tampere, Kuopio, Mikkeli, Vaasa, Pori - Tallinn, Riga, Stockholm	- Pori, Vaasa, Rovaniemi, Joensuu, Mikkeli, Kuopio, Tampere - Uumeå, Luuleå, Skellefteå
500–1000	- Stockholm, Oslo, Trondheim, Tallinn, Riga, St Petersburg, Liepaja	- Oulu - Moskow, Minsk, Warsaw, Arkhangelsk, Murmansk, Vilnius, Gothenburg, Oslo, Copenhagen	- Helsinki, Turku, Lahti - Stockholm, Arkhangelsk, Murmansk, St. Petersburg, Tallinn, Riga, Oslo, Trondheim

tions. The prevailing weather conditions have a great significance on fallout as well as radiation doses. It must be noted that the dispersion modeling and the dosage calculation include several assumptions, which tend to overestimate the fallout and radiation doses.

The impacts have been illustrated from the area surrounding the plant to the distance of 1,000 kilometers. The location of observed areas surrounding each plant site are illus-trated in the figure of next page (Figure 8-130) and in the table (Table 8-51), which gives examples of large cities at different distances from the plant sites.

The above table (Table 8-52) presents the fallout following a severe accident in typical weather conditions at different distances. With regard to local agricultural products used as food, such as vegetables, milk and meat, the fallout in typical weather conditions will be so small that long-term restrictions are not required on their use.

Without any protective measures aimed at livestock or food production, there may be a need for short-term usage restrictions of no more than a few weeks in areas within a radius of as much as 1,000 kilometers until the concentrations of I-131, which is significant to the buildup of radiation doses, have decreased sufficiently. The half-life of I-131 in agricultural products is about 8 days.

In case of an accident during unfavorable weather, it is also probable that restrictions on the use of various kinds of natural produce will have to be issued in areas affected by the greatest fallout. Long-term restrictions on the consumption of some mushrooms, for example, may be required in areas at a distance of 200–300 km.

The table 8-53 presents radiation doses caused by the radioactive release following a severe accident in typical weather conditions at different distances from the nuclear power plant. The dosage calculations are based on the assumption that no protective measures are taken.

Taulukko 8-51. Fallout following a severe reactor accident at chosen distances both in typical weather conditions.

Distance (km)	Fallout (kBq/m^2)		
	Typical weather conditions		
	Sr-90	I-131	Cs-137
10	3,3	140	9,6
100	1,0	46	3,0
500	0,28	12	0,81
1000	0,10	4,3	0,28

Table 8-53. Radiation doses for adults and children following a severe reactor accident at different distances.

Distance (km)	Adult					Child				
	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)	Total (mSv)	Radiation dose (external radiation and breathing) (mSv)			Food (mSv)	Total (mSv)
	2 days	7 days	50 yrs	50 yrs	50 yrs	2 days	7 days	70 yrs	70 yrs	70 yrs
10	1.5	1.6	5.7	14	20	2.1	2.3	7.7	32	40
100	0.49	0.52	1.9	4.3	6.2	0.68	0.72	2.4	10	12
500	0.13	0.14	0.48	1.1	1.6	0.18	0.19	0.65	2.7	3.4
1000	0.045	0.048	0.17	0.40	0.57	0.063	0.067	0.23	0.95	1.2

Table 8-54. Thyroid dose from a radioactive release following a severe reactor accident.

Distance (km)	Thyroid dose (mGy)	
	Adult	Child
10	15	30
100	4.7	9.6
500	1.2	4.4
1000	0.43	0.90

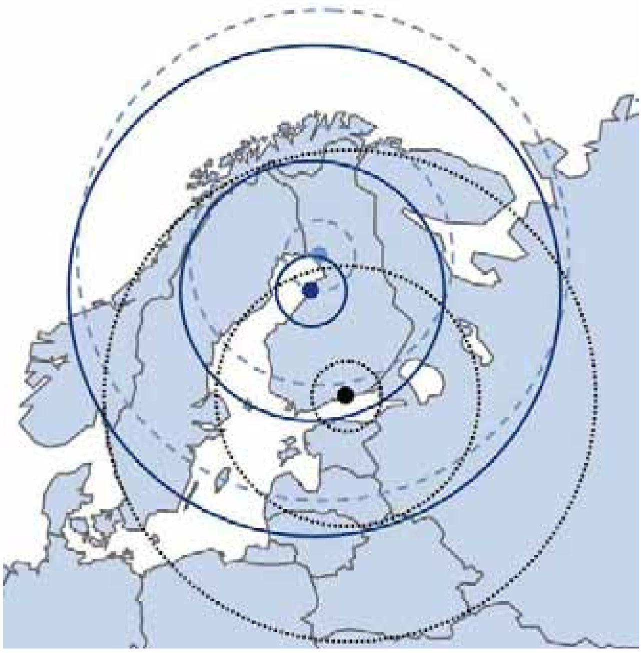


Figure 8-130. Zones of a 100, 500 and 1,000 kilometer radius surrounding the alternative locations. The plant sites from North to South are Simo, Pyhäjoki and Ruotsinpyhtää.

However, the radiation dose from food could easily be limited through various restrictions on the use of foodstuffs, for example. In addition, the thyroid radiation doses to adults and children resulting from the release have been presented (Table 8-54).

The severe reactor accident in the example does not cause any immediate health impacts on the surrounding population in any weather conditions. To limit the thyroid radiation dose, children should take iodine tablets when recommended by authorities within a distance of 100 kilometers from the accident site in all weather conditions. This impact could therefore extend to the northeastern corner of Sweden in the case of the Simo location, or the northern coast of Estonia in the case of the Ruotsinpyhtää locations. No other civic defense measures would be necessary in other countries.

In addition to a severe accident, the impacts of a so-called postulated accident (INES 4) have been assessed; these are described in more detail in Chapter 8.16. Such an accident would not lead to civic defense measures or cause any substantial environmental impacts in the vicinity of the plant. Its impacts would not cross the boundaries of Finland.

In a potential accident situation, the Radiation and Nuclear Safety Authority would report the accident to the IAEA in accordance with international agreements. The IAEA shall be notified of events rated at INES level 2 or higher, and it will forward the information to other countries. The European Union also has a notification and communication system concerning nuclear events and radiation danger situations.

8.19 Impacts of the zero-option

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

8.19.1 Demand for electric power and possibilities of savings in Finland

Demand for electric power

During the last 10 years, the consumption of electricity in Finland has increased at an average annual rate of 2%. In 2007, 90.3 TWh of electricity was used in Finland (*Finnish Energy Industries 2008a*). Programs and agreements referred to above will reduce the demand for electric power through energy savings and more efficient use of energy compared to a situation where no similar measures would be taken. However, the consumption of electricity is expected to increase in spite of the programs and agreements.

Finnish Energy Industries and the Confederation of Finnish Industries EK have estimated the consumption of electricity to amount to approximately 107 TWh in 2020 and approximately 115 TWh in 2030. The electricity consumption forecast takes into account the increase of energy efficiency alongside technological evolution, modernization of equipment and increasing political governance (*Confederation of Finnish Industries EK and Finnish Energy Industries 2007a*).

According to energy consumption forecasts associated with the new climate and energy strategy prepared by the Ministry of Employment and the Economy, electricity consumption in the baseline scenario ("without taking particular measures") would be 100 TWh in 2020 and 105 TWh in 2030. It is noted in connection with this scenario that electricity consumption according to the baseline scenario must be reduced (*Ministry of Employment and the Economy 2008*).

The Finnish Energy Industries (*Finnish Energy Industries 2008b*) has estimated that Finland will need approximately 4,500 MW of new basic capacity for electrical production by 2030 after utilizing any increases in wind power, hydropower and combined production capacity (Figure 8-131). Already at present, the supply of electricity during peak consumption relies on 2,000 MW of imports. Insufficient production capacity may cause problems for deliveries of electricity.

The following programs and agreements aimed at energy savings and energy efficiency are currently being implemented in Finland.

Finland's National Energy Efficiency Action Plan

The European Commission issued a proposal for a Directive on energy services and energy end-use efficiency on December 10, 2003. The "Energy Services Directive" entered into force on May 17, 2006, and had to be implemented nationally by May 17, 2008. The Energy Services Directive applies to all end-use of energy in Finland with the exception of shipping, air traffic and industrial facilities belonging to the scope of emissions trading. According to the Directive, Member States must set an indicative national overall energy savings target of 9% calculated on average annual consumption from 2001 to 2005, and initiate measures to promote achievement of the target.

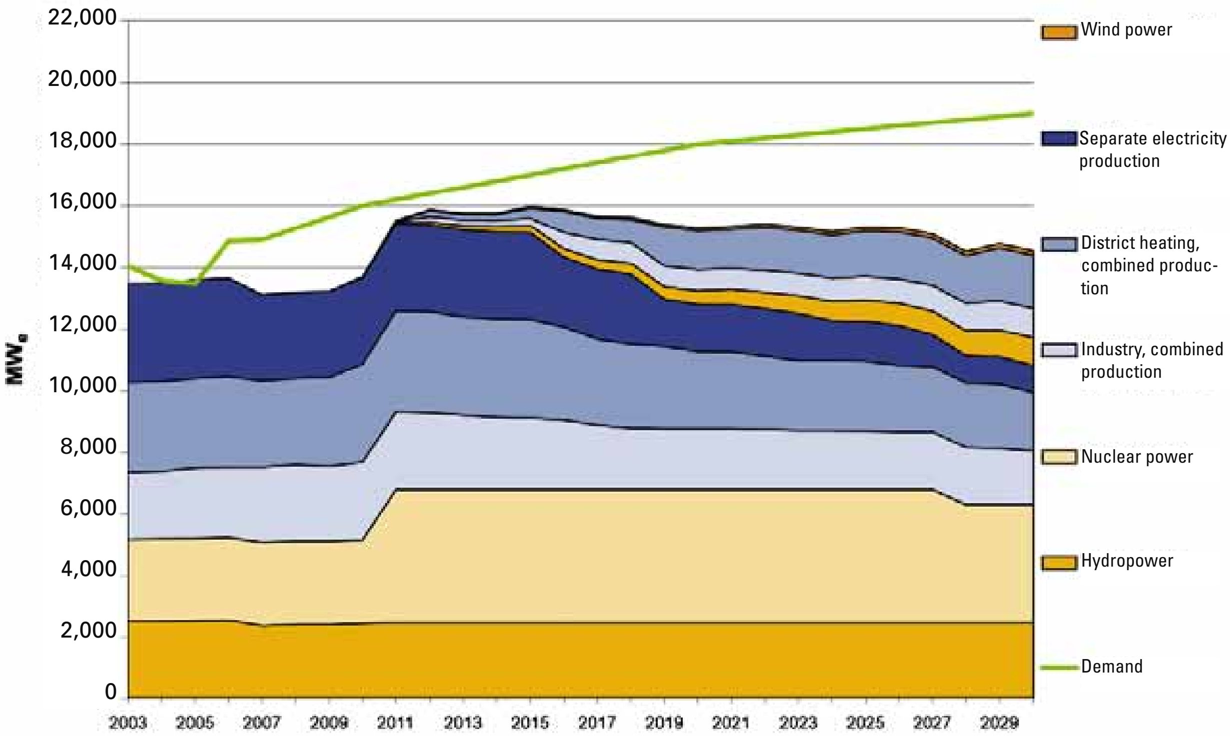


Figure 8-131. Available capacity at peak: existing plants (including those under construction), new renewable energy plants and plants for combined power and heat production (*Finnish Energy Industries 2008*).

End-use consumption of energy within the scope of application of the Energy Services Directive amounts to 197.7 TWh, and on the basis of this, Finland's national 9% energy savings target is 17.6 TWh by 2016 (*Finland's National Energy Efficiency Action Plan 2007*).

Framework agreement on increasing energy efficiency in industry

The energy efficiency agreement is a continuation to the agreement on an action plan for energy savings in industry, as well as energy savings agreements in industry, the energy sector and the real estate and construction sector. The agreement stipulates cooperation to carry out measures called for by the objectives and implementation of the energy and climate strategy approved by Government in November 2005. The target set in the energy and climate strategy was a 5% reduction in the total consumption of energy in 2015 compared to the development without any new efficiency measures.

With regard to energy production, the objective is to implement energy use efficiency measures that improve the efficiency of primary energy use and the overall efficiency of energy production. The indicative target is that the contracting enterprises should achieve total primary energy savings of 1 TWh and increase the efficiency of power production by the equivalent of 1 TWh of electric power by 2016 compared to the development without these new measures (*Framework agreement on increasing energy efficiency in industry 2007*).

The government's ministerial working group on climate and energy policy is currently drafting a new long-term climate and energy strategy that is expected to enter parliamentary procedure in the autumn of 2008.

8.19.1. Energy savings measures by Fennovoima shareholders

A survey of energy savings measures conducted among Fennovoima shareholders for this EIA report covered 59 shareholders or 92% of the shareholders. The consumption of these shareholders corresponds to 97% of the total electricity consumption of Fennovoima shareholders in Finland.

According to the survey, electricity procurement by shareholders who have committed to energy efficiency agreements in part or in full represents almost 90% of total electricity procurement by Fennovoima shareholders (Figure 8-132). Of the enterprises participating in the survey, 45% had an energy efficiency action plan. Furthermore, 9% had made a similar plan for some of their facilities. More than one-half of Fennovoima shareholders have established a numerical target for reducing their energy consumption.

One in three of the participants in the survey has carried out an energy review according to the Motiva model or a similar study in all of their facilities, and one in five has done so in some of their facilities.

75% of the shareholders have taken at least one of the following measures to improve energy efficiency:

- joining an energy efficiency agreement
- carrying out an energy review
- drafting an energy efficiency action plan
- setting a numerical target for reducing energy consumption

In addition to these four measures, the enterprises have taken numerous other measures to save energy. Industrial enterprises have been particularly active in energy efficiency operations. Some Fennovoima shareholders have their own energy efficiency systems. Shareholders are striving to reduce their energy consumption also through quality management systems. Measures to reduce the energy consumption of end users include distributing information about energy savings and promoting the remote reading of energy meters.

According to the survey, 85% of Fennovoima shareholders provide their staff with training related to energy savings. The shareholders are also actively involved in training their customers. Two-thirds of energy-producing shareholders have taken action to reduce the electricity consumption of end customers.

Fennovoima shareholders have invested a total of €120 million in energy savings between 1997 and 2008. Of this amount, 32% or some €38 million can be allocated to electricity savings. Substantial investments have included rectifiers, EFF1 electric motors of a better efficiency, as well as frequency converters. The most common investments in the power transmission business have been made in grids and transformers. During the energy savings agreement period from 1998 to 2007, the shareholders who responded to the survey have saved electricity corresponding to 777 GWh of annual consumption (Table 8-55). Upcoming investments decided by shareholders can provide further savings of

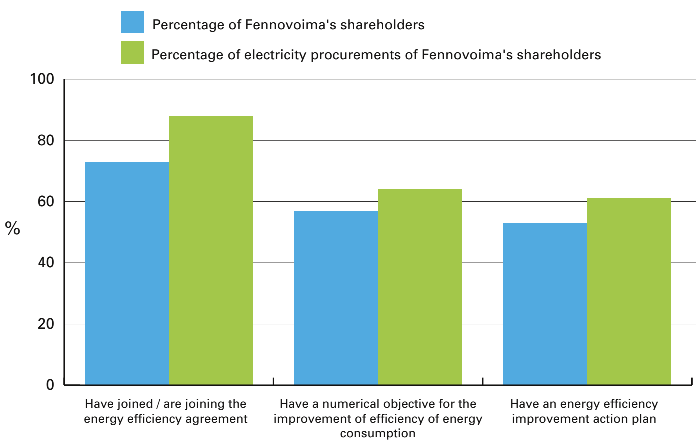


Figure 8-132. Implementation of energy savings and energy efficiency measures by Fennovoima shareholders.

Table 8-55. Electricity savings achieved and to be achieved through investments by Fennovoima shareholders (GWh).

	Total power consumption	Completed	Decided	Considered
GWh/a	28,000	780	180	40
% of consumption		2.8	0.6	0.1

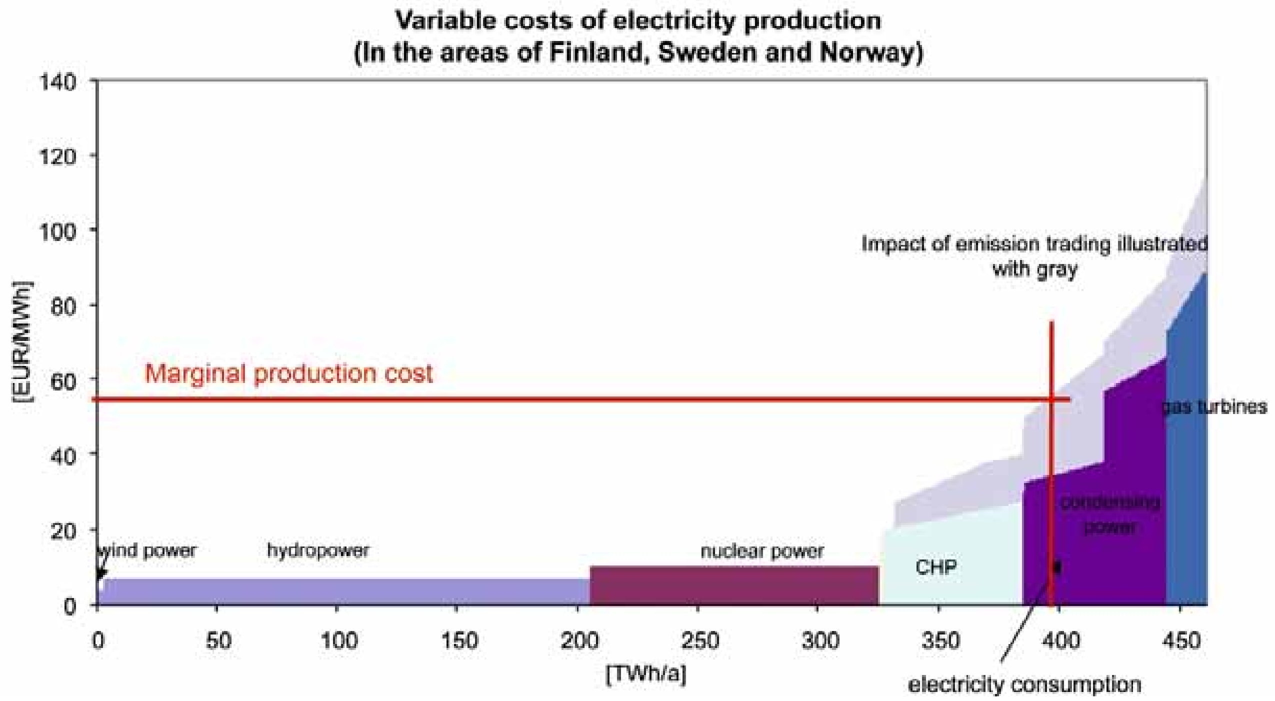


Figure 8-133. Changing costs for electricity production and the operating order of power plants on the Nordic electricity market.

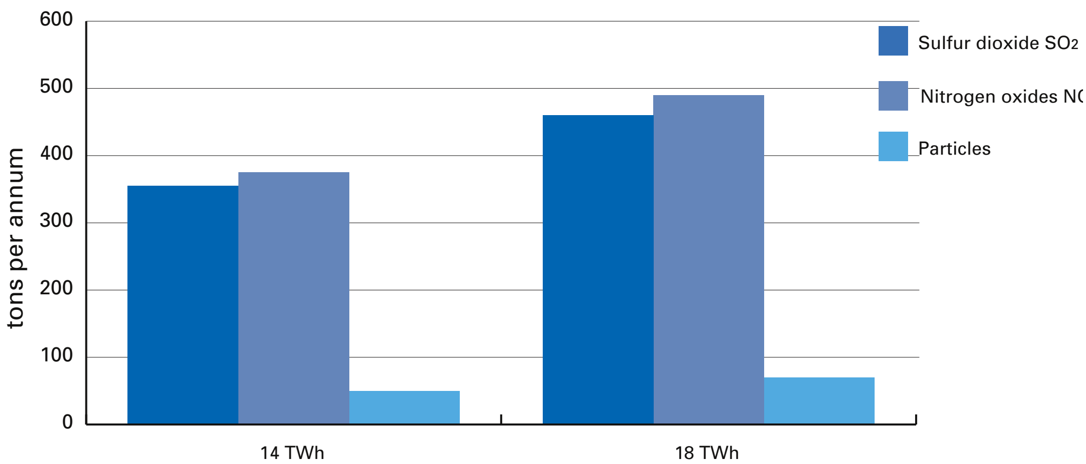


Figure 8-134. Emissions of sulfur dioxide, nitrogen oxides and particles originating from production substituting nuclear power in Finland.

177 GWh annually. In addition to investments that have already been decided, the shareholders are considering investments that could save 38 GWh of electricity annually.

Most investments affecting the consumption of electricity are made as replacement investments, in other words replacing old technology with new technology that is more energy efficient.

Investments will become even more difficult to carry out as most enterprises have already completed the most significant technically and economically feasible savings measures. In such a situation, the cost of every megawatt saved becomes high.

The remaining potential available to Fennovoima shareholders to improve the efficiency of electricity use is very minor in relation to their demand for power. Investments decided so far correspond to the annual production of a 20 MW power plant. The effect of investments under consideration is even smaller, corresponding only to the annual production of a 4 MW power plant. Based on the above, these measures cannot replace the planned 1,500- to 2,500-megawatt nuclear power plant.

8.19.3 Local impacts of the zero-option

The present state of the environment at the alternative locations has been described earlier in this EIA report. If Fennovoima's project is not completed, the present state will be impacted by other projects, operations and plans, some of which have been described in this EIA report.

8.19.4 Electricity production and cost structure on the Nordic electricity market

The plants' operating order and the production forms of electricity produced on the Nordic electricity market is determined according to the changing production costs. For example, the changing costs for water and wind power are very low because the "fuel" is free. In addition, the share of nuclear fuel costs in the production costs is small. For power plants that use fossil fuels, the share of fuel costs is relatively high in the production costs. For plants that use coal, the share of fuel costs is lower than in plants that use natural gas.

A new nuclear power capacity with relatively low production costs would replace more expensive forms of production. First, it would reduce the separate production of electricity located on the right-hand side of the cost curve based on fossil fuels (Figure 8-134).

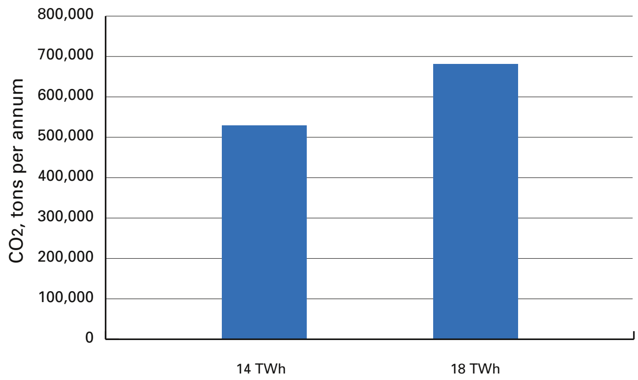


Figure 8-135. Emissions of carbon dioxide originating from production substituting nuclear power in Finland.

8.19.5 Impacts of the zero-option on emissions

If the new nuclear power plant is not build in Finland, its production will probably be replaced by imported electricity. The remaining part of electricity would be produced in Finland using the existing or new electricity production capacity, which would mainly comprise separate electricity production and, in small part, combined production of electricity and heat.

The attached figures (Figure 8 135 ja Figure 8 136) present the sulfur dioxide, nitrogen oxide and particle emissions and carbon dioxide emissions of the zero option in Finland. The zero option assumes that about 30% of the planned electricity production capacity of Fennovoima's nuclear power plant would be replaced through separate electricity production produced in Finland and, in small part, through combined production of electricity and heat. Imported powe is assumed to cover about 70%, coming from the Nordic electricity market in Sweden, Norway or Denmark, as well as from Russia. The emissions caused by the production of electricity imported to Finland in the production countries are not included in the assessment.

The figures illustrate energy production amounts of 14 and 18 TWhe, which correspond to Fennovoima's plant alternatives. Separate electricity production is assumed to be coal condensate production and combined production is assumed to be production in a natural gas combi power plant according to the operating order of plants on the Nordic electricity market (see Chapter 8.19.4).

When assessing the significance of environmental impacts, the views obtained from the monitoring groups in the alternative locations during the draft stage of the report were taken into account. Boat sheds in Simo, 2008.

As a result of the assessment, none of the project's alternative implementations have been found to have any adverse environmental impacts that were unacceptable, or could not be mitigated to an acceptable level. Thus, the project is feasible from the environmental impact perspective.

9 Comparison between alternatives and assessment of the significance of the impacts

9.1 Comparison between alternatives

For environmental impact assessment purposes, the current environmental status and impact factors have been surveyed on each alternative location based on current knowledge and surveys carried out for the EIA procedure.

Characteristics of the project to be assessed, and the factors that are essential in terms of environmental impacts have been identified on the basis of preliminary design data. Surveys and interviews on the environmental impacts have been carried out in the vicinity of the project's alternative locations. In addition, model calculations, photomon-tages and expert assessments of the impacts of future operations, based on the experience and research data from similar projects and operations, have been prepared to support the assessment.

The environmental impacts of the project have been examined by comparing the zero alternative and the changes to the current situation brought about by the implementation of the project in the four alternative locations. Moreover, differences in the implementa-tion of the two power plant alternatives and in alternative cooling water intake and discharge locations have been assessed. To obtain an overview of the project, the de-

Energy supply is an important element in ensuring the welfare of Finnish people. Urban view of Helsinki in 2008.

scription also includes parts of the project lifecycle that will take place outside the boundaries of Finland, or that will be covered by EIA procedures of their own. Also the impacts of an extremely unlikely serious accident have been considered. Special emphasis has been placed, based on the feedback given by the various audit groups during the EIA procedure, on investigating and describing the key impacts.

The significance of environmental impacts has been assessed based on the magnitude of the change, and by comparing the impacts of future operations on guidelines and limit values of environmental load, on environment and quality standards, and on the current environmental load in the area. Comments received from the audit groups from the alternative locations during the drafting of the assessment report have also been considered in the assessment of the significance of environmental impacts.

Key factors for the significance of impacts include:

– Extent of the impact area
– Impact target and susceptibility to changes
– Significance of the impact target
– Recovery or non-recovery from the impact
– Intensity of the impact and magnitude of the resulting change
– Fears and insecurities associated with the impact
– Different views on the significance of the impacts.

Impacts of the different implementation alternatives are presented in a comparison table (Table 9-1). The table gives a consistent view of the major environmental impacts of the different alternatives. At the same time, the ease of implementation of the different alternatives with respect to the environment has been evaluated. The differences between the different alternatives have also been discussed in the sections on the alternative locations, plant options and cooling water intake and discharge options following the table. A more detailed evaluation of the impacts of the different alternatives is presented in Chapter 8

Table 9-1. Major impacts of the project in the alternative site locations (Pyhäjoki, Ruotsinpyhtää ja Simo).

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Construction-phase impacts of a nuclear power plant				
The construction-phase impacts are of a temporary nature.				
Impacts of construction on the environment and people	Construction sites create local dust, and its impact on air quality is mostly restricted to the construction site. Other construction-phase impacts, such as impacts on noise or comfort, are discussed in separate sections below.			
Noise impacts during construction phase	The daytime guidance value will be exceeded on about 15 existing vacation properties in the vicinity of the power plant and on 10 vacation properties near the road.	The daytime guidance value will be exceeded on about 20 existing vacation properties in the vicinity of the power plant and on 20 vacation properties near the road.	The daytime guidance value will be exceeded on less than 20 existing vacation properties in the vicinity of the power plant and on about 30 vacation properties near the road.	The daytime guidance value will be exceeded on a few dozen existing vacation properties in the vicinity of the power plant.
Regional economic and social impacts of construction	During the construction phase, municipal tax revenue will be EUR 2.8 to 4.5 million in the economic areas, and property tax revenue in the location municipality will be determined by the stage of completion of the nuclear power plant. In the economic area, the employment impact will be 500 to 800 man-years annually. The project will boost business in the economic area, and demand for private and public services will grow.			
Impacts of construction-related transport and commuter traffic	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 20%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 40%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 40%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 20%.
	Traffic during construction will increase emissions in all of the alternatives. Traffic volumes will reach their peak in the fourth or fifth year of construction. in other construction years, traffic volumes and emissions will be considerably lower. Construction-related traffic emissions are not estimated to have any significant long-term impacts on air quality in the areas surrounding the alternative location sites.			
The Impact of building a navigation channel and harbor quay	The sea bed will have to be dredged and blasted for the quay. The length of the required new channel is about 1.5 kilometers. Dredging will cause temporary and local clouding of water.	Building the quay will not require much dredging or blasting. The existing channel is deep enough so there will be little need for dredging. Dredging will cause temporary and local minimal clouding of water.	The sea bed will have to be dredged and blasted for the quay. The existing channel requires deepening along about a 500-meter stretch. Dredging will cause temporary and local clouding of water.	The sea bed will have to be dredged and blasted for the quay. The length of the required new channel is about 500 meters. Dredging will cause temporary and local clouding of water.
The impacts of building cooling water structures	Impacts mainly depend on the chosen intake structure. The tunnel needed for bottom intake will be blasted under the seabed. Shore intake will be built by the mainland or island shoreline. When a shore intake and discharge structures are built, the shore will be excavated and/or blasted and the bottom dredged as required. Dredging will cause temporary and local clouding of water.			

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Impacts of building road connections	A new road of slightly less than 5 kilometers will be built in the plant area. There are no significant changes in land use in the area. There is no housing near the planned road so the construction will not cause disturbance to inhabitants.	Road improvement along a 7.4-kilometer stretch, and reinforcement of a bridge located on the road. About 3.5 kilometers of new road will be built. A road connection to Kampuslandet will be built across a 170 meters wide strait by means of embankment and bridge structures. There are no significant changes in land use in the area. Regional landscape will be altered. There will be temporary disturbance to road users and housing along the road. Traffic connections to holiday homes and other villages will improve.	Road improvement along a 7.4-kilometer stretch, and reinforcement of a bridge located on the road. About 2.5 kilometers of new road will be built. There are no significant changes in land use in the area. There will be temporary disturbance to road users and housing along the road. Traffic connections to holiday homes and other villages will improve.	Road improvement along about a 5-kilometer stretch. About 1 kilometer of new road will be built. There are no significant changes in land use in the area. Coast landscape will be slightly affected. There will be temporary disturbance to road users and possibly to housing along the road. A road connection to the Laitakari Island will be built. Traffic connections to holiday homes will improve.
The impact of building power lines	About 20 kilometers of new power line route will be built to connect the plant to the national grid. Restricted land use in the power line clearing. There are no nature conservation areas along or in the immediate vicinity of the power line route. Construction will disturb avifauna during nesting and migration periods, especially at the Hietakarinlahti Bay.	About 15 kilometers of new power line route will be built to connect the plant to the national grid. Restricted land use in the power line clearing. There are no nature conservation areas along or in the immediate vicinity of the power line route. Construction will disturb avifauna during nesting and migration periods.	About 15 kilometers of new power line route will be built to connect the plant to the national grid. Restricted land use in the power line clearing. There are no nature conservation areas along or in the immediate vicinity of the power line route. Impacts on historical stone structures should be considered when designing power lines.	About 20 kilometers of new power line route will be built to connect the plant to the national grid. Restricted land use in the power line clearing. Construction will disturb avifauna during nesting and migration periods. The relationship between the power line route and antiquities in Northern Karsikkoniemi should be assessed.

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Operational impacts of a nuclear power plant				
The impact on water bodies and fishery				
The impact on sea water temperature and ice cover	The extent of the warming sea area will be defined by the size of the power plant and, to some extent, by the chosen intake option. Bottom intake will cause warming of a smaller area than shore intake. Cooling waters will cause thinning of the ice cover at the Hanhikivi headland.	The extent of the warming sea area will be defined by the size of the power plant and, to some extent, by the chosen intake and discharge options. The warmed area will be most restricted if cooling water is discharged to the open sea south of Kampuslandet, and less restricted when it is discharged to a moderately shallow bay on the eastern side. Bottom intake will warm the smallest area, shore intake on Vådholmsfjärden the largest. During the winter, the uniform area of thin or nonexistent ice cover will expand. Discharge to Vådholmsfjärden would carry the largest impact.		The extent of the warming sea area will be defined by the size of the power plant and, to some extent, by the chosen intake and discharge options. The warmed area will be more restricted if cooling water is discharged to the open sea south-west of the Karsikko area. The area will be larger, if cooling water is discharged to the Veitsiluoto Bay. Bottom intake will warm the smallest area, and there is not much difference between the shore intake alternatives. Cooling waters will weaken the ice cover near Karsikko.
The impact on quality of water and ecology	Proliferation of aquatic vegetation and phytoplankton will increase on the impact area of cooling waters. The impact will be minimal due to the open and nutrient-poor sea area. According to assessments, cooling water discharge will not cause anoxia in deep waters or significantly increased flowering of the blue-green algae. The project will not affect water quality.	Proliferation of aquatic vegetation and phytoplankton will increase on the impact area of cooling waters. Due to eutrophication, flowering of the blue-green algae may increase locally, particularly if the mostly shallow sea area east of Kampuslandet is chosen as a discharge location. The project may have local adverse impacts on the oxygen level near the bottom. The impacts will be more restricted if the alternative using open sea is chosen as a discharge location. In bottom intake, nutrient concentration may increase slightly at the discharge site and intensify the impact of thermal load to some extent.		Proliferation of aquatic vegetation and phytoplankton will increase in the impact area of cooling waters. In discharge to the open sea, eutrophication is assessed to be minimal and it is not estimated to result in anoxia in deep waters or significantly increased flowering of the blue-green algae. In discharge to the more sheltered and nutrient-rich Veitsiluoto Bay, eutrophication will probably increase relatively more. On the other hand, imprint of human activity can already be seen clearly at the Veitsiluoto Bay when compared to the sea area south of Karsikkoniemi.
Impacts on fish fauna and fishery	Possible adverse impacts on fishing include the clogging of nets caused by mucilage and, in the summertime, hindered whitefish fishing especially on the fishing ground North of Hanhikivi. During the winter, the unfrozen body of water will hinder fishing from ice but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area.	Possible adverse impacts on fishing include the clogging of nets caused by mucilage, and decreased catching efficiency of trap nets used for salmonids (whitefish, trout, salmon) on the impact area of cooling waters. This will hinder fishing from ice but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area during the winter.		Possible adverse impacts on fishing include the clogging of nets caused by mucilage, and decreased catching efficiency of trap nets used for salmonids (whitefish, trout, salmon) on the impact area of cooling waters. According to assessments, cooling waters will not have an impact on fish migration. During the winter, the unfrozen body of water will hinder fishing from ice but, on the other hand, it will extend the open water fishing season and attract whitefish and trout to the area.

<table>
<tr><th></th><th>Pyhäjoki</th><th>Ruotsinpyhtää, Kampuslandet</th><th>Ruotsinpyhtää, Gäddbergsö</th><th>Simo</th></tr>
<tr><td>Impacts on vegetation, animals and protected sites</td><td>The construction period will disturb the fauna, and some habitats will be permanently altered.
The Hanhikivi headland area will change, and the nature of the area will become so fragmented that the area’s significance as a model of uninterrupted succession development will clearly deteriorate.
The Hanhikivi area is rich in bird species. The plant unit of the planned power plant would be in an area where the avifauna mainly consists of ordinary forest species.
The Hanhikivi headland is on the route of migrating birds and acts as a staging area for many species. Power lines will increase the risk of migratory bird collisions.
There are a few occurrences of endangered and otherwise noteworthy plant species at the Hanhikivi headland. If there is no construction on the habitats, the occurrence of the species in the area will probably not deteriorate.
The thermal load of cooling water may have indirect detrimental impacts on the shore meadows in the Takaranta area and thus on the Siberian primrose, for example, should the overgrowing of meadows accelerate.
The project area includes the nature conservation area of Ankkurinnokka and several habitat types defined in the Nature Conservation Act. The overgrowing of protected shore meadows may intensify.
The closest Natura area is located about 2 kilometers away, south of the area. The project is not deemed to cause any major adverse impacts on the conservation criteria of the Natura 2000 area, and a Natura assessment is not deemed necessary.</td><td colspan="2">The construction period will disturb the fauna, and some habitats will be permanently altered.
The observed bird species can mostly be deemed regular species for coastal and inland archipelago areas. The area does not include any avifauna sites of major significance to regional bird species. The project is not deemed to cause any major adverse impacts on the avifauna. Power lines will increase the risk of migratory bird collisions.
Most of the natural characteristics of the area are common for the area, and the forests are highly managed.
In the Kampuslandet alternative, the power line route will alter the entity formed by seashore groves and meadows on the eastern shore of Gäddbergsö.
The most significant ecological values are located on the shores and on the Kasaberget area. There are no significant impacts on these areas as a whole.
The total impacts of the project on the diversity of nature will be local and the regional impacts minimal.
There are no nature conservation areas or habitat types in accordance with the Nature Conservation Act in this area. The closest nature conservation areas are approximately three kilometers to the northwest and southwest. According to assessments, the project will not have an impact on the nature conservation areas.
The closest Natura area is at its closest approximately 1.5 kilometers south of Kampuslandet. The project is not deemed to cause any major adverse impacts on the conservation criteria of the Natura 2000 area, and a Natura assessment is not deemed necessary.</td><td>The construction period will disturb the fauna, and some habitats will be permanently altered.
Karsikkoniemi is rich in bird species due to the diverse habitat structure of the area.
The areas which will change the most are located in the inner parts of Karsikkoniemi headland where there are no significant sites considering the avifauna or other animals, except for the Lake Karsikkojärvi, and in the Laitakari and Korppikarinnokka area which are areas significant for the avifauna. Power lines will increase the risk of migratory bird collisions.
There are plenty of occurrences of endangered and otherwise noteworthy plant species at Karsikkoniemi headland. Construction may destroy some of the occurrences from the area.
There are no nature conservation areas in the assessment area. There are a few habitat types in accordance with the Nature Conservation Act in this area. The overgrowing of protected shore meadows may intensify on the western shore of Karsikkoniemi.
The closest Natura area is located at Ajos headland, a little over three kilometers from the assessment area. A slight heat impact from the cooling waters may occasionally extend to the area. The project is not deemed to cause any major adverse impacts on the conservation criteria of the Natura 2000 area, and a Natura assessment is not deemed necessary.</td></tr>
</table>

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Impact of radioactive emissions	Fennovoima's nuclear power plant will be designed so that its radioactive emissions fall below the set limit values. The plant's radioactive emissions will be so low that they will not have any detectable impact on the people or the environment.			
Impact of other emissions				
Traffic emissions	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 3%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approxi-mately 5%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approxi-mately 5%.	Traffic to and from the nuclear power plant will increase regional traffic emissions by approximately 3%.
	In all of the options, traffic to the plant runs mostly along highways or motorways. The traffic volumes on these roads are fairly high, and the nuclear power plant's traffic will not cause a significant change in the volumes and, as a result, in traffic emissions and air quality. The nuclear power plant's traffic emissions can be assessed as having an impact on air quality mostly along smaller, less operated roads leading to the nuclear power plant. Because air quality in all of the site options is assessed as being good, traffic emissions will not degrade air quality to the extent that it will have adverse effects on people or the nature.			
Emissions from emergency power and heat generation	The emission volumes are very small and will not affect the air quality of the alternative sites.			
Impacts on the ground, bedrock and groundwater	The most significant impacts will occur during the construction of the nuclear power plant. Construction work produces large amounts of excavation, rock blasting and dredging masses. The foundation waters and rain water drained from the construction site will contain more solids and possibly oil and nitrogen compounds than waters normally drained from tarmac-covered yards. The project will not have any detrimental impacts on usable ground-waters.			
Impacts on traffic and safety	Overall traffic volumes on the trunk road near the intersection leading to the nuclear power plant will increase by approximately 7-10% and heavy traffic volumes by about 2-4%. The new road to be built from the trunk road to the nuclear power plant will be designed to be suitable for the use of traffic required by the power plant. The intersection from the trunk road will be designed to be safe and smooth by means of preselection lanes and speed limits, for example.	The maximum increase in total traffic volumes on the trunk road or motorway will be approximately 5% and about 1% for heavy traffic. If the Atomitie road extension is completed, traffic volumes at the beginning of the Saaristotie road and on the Helsingintie and Mannerheiminkatu roads will increase slightly, because only the personnel living in downtown Loviisa will use that route to reach the plant. In this case, the traffic volume at the end of Saaristotie road from Atomitie road to Reimars will increase significantly by about 2.5 times. The traffic conditions on Saaristotie road from Atomitie road will change and traffic safety may decrease. However, the Saaristotie road will be improved to be suitable for the nuclear power plant traffic, in which case safety and traffic flow will be taken into consideration.		The total volume of traffic on the trunk road will increase by approximately 3-6% and heavy traffic by about 2-4%. The volumes of traffic on Karsikontie road will change significantly and traffic safety may decrease. However, the road will be improved to be suitable for the nuclear power plant traffic, in which case safety and traffic flow will be taken into consideration.
	Nuclear power plant traffic will only have a minor effect on traffic volumes on the main routes. The planned improvement projects for routes leading to the alternative nuclear power plant sites will improve traffic safety, and according to assessments, nuclear power plant traffic will not lead to degradation of traffic flow and safety.			

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Noise impacts	There is no activity that causes significant noise in the vicinity of the power plant. The location near the sea is quite favourable in terms of spreading noise. The nighttime guidance value will be exceeded on about 15 to 20 existing vacation properties in the vicinity of the power plant. Holiday residences on the west and southwest coast will be partly removed with the implementation of the project.	There is no activity that causes significant noise in the vicinity of the power plant. The location on the archipelago is favourable in terms of spreading noise. The nighttime guidance value will be exceeded on about 20 existing vacation properties in the vicinity of the power plant and on vacation properties close to the road.	There is no activity that causes significant noise in the vicinity of the power plant. The location on the archipelago is favourable in terms of spreading noise. The nighttime guidance value will be exceeded on a few existing vacation properties in the vicinity of the power plant.	There is no activity that causes significant noise in the vicinity of the power plant. There are no characteristics promoting or constraining the spreading of noise in the surrounding environment. The nighttime guidance value will be exceeded on a maximum of 10 existing vacation properties in the vicinity of the power plant. The holiday homes located on the south coast will probably be removed with the implementation of the project.
Impacts on the landscape and cultural environment	The power plant will alter the landscape considerably. The power plant will be placed on a highly visible area on the tip of a headland reaching out into the open sea. There is no industry or other heavy structures on the regional coastal zone. The status and character of the surroundings of the nationally valuable historical Hanhikivi antiquity will significantly change. The landscape status of Takaranta, a seashore meadow of regional importance, will change. The power line will alter the landscape but the impacts will be mainly local (the power line route).	The power plant will alter the landscape considerably. The power plant will be located in the vicinity of an existing power plant. It will be placed on the edge of the outer archipelago zone where, as seen from the sea, there are very few elements to cut off the views. Significant impacts on the surrounding environment or status in the landscape entity of regionally important areas with regard to the cultural environment or landscape. The power line will alter the landscape. In particular, the section across the strait between Gäddbergsö and Kampuslandet and the section between Reimars and Bullers have significant impacts on the landscape.	The power plant will alter the landscape considerably. The power plant will be located in the same landscape space, limited by islands and the continental coast, as the existing nuclear power plant. The area belongs to an inner archipelago zone where the views from the surrounding shores will change significantly. From the open sea, islands and trees cut off the view towards the plant in some places. There are some impacts on the surrounding environment or status in the landscape entity of regionally important areas with regard to the cultural environment or landscape. The power line will alter the landscape. In particular, the section between Reimars and Bullers will have significant impacts on the landscape.	The power plant will alter the landscape considerably. The power plant will be located on a highly visible area on a headland bordering on the outer archipelago and open sea zone. The landscape status of the nationally important Karsikko fishing village will change. The power plant will complement the industrial zone of the Kemi region. The landscape of the regional coastal strip is in transition (zones of industrial activity, extensive reserves for wind power, harbor traffic). The power line will alter the landscape but the impacts will be mainly local (the power line route).

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Impacts on living conditions, comfort and health	Normal operation of the nuclear power plant has no radiation-related, detectable impact on the health, living conditions or recreation of people living in the vicinity. Access to the nuclear power plant area is denied and the area cannot be used for recreational purposes. Warm cooling water will melt or weaken the ice and, as a result, restrict recreational activities on ice during the winter, such as fishing or walking. On the other hand, it will extend the open water fishing season. Nearby residents and operators have very different views on the nuclear power plant project, and there are local groups both opposing and supporting the project. Opposition is often based on risks and fears associated with nuclear power plants, and on the belief that nuclear power is ethically questionable. The supporters emphasize its positive economic impacts and environmental friendliness.			
Impacts on regional economy	During the operation, property tax revenue in the location municipality will be EUR 3.8 to 5.0 million a year and municipal tax revenue EUR 1.9 to 2.4 million a year in the economic area. In the economic area, employment impact will be 340 to 425 man-years annually. The arrival of new residents, boosted business and escalated building activity will increase tax revenue. The population base and housing stock will increase. Demand for private and public services will grow. There is no foreseeable, significant variation between the municipalities.			
Impacts on land use and community structure	The holiday residences on the west coast and some of the holiday homes on the southwest coast will be removed and the southwest cannot be used for recreational purposes. The new road connection will not cause any significant changes in land use. Hanhikivi remains accessible. The significance of Raahe as a strong industrial region will be-come stronger – and preconditions for development of land use may improve.	Most of the current holiday home areas may be preserved. The use of the areas for recreation or outdoor activities will be restricted. *Gäddbergsö:* the new road connection will mainly follow the layout of the existing road. Kampuslandet: the new road route will not be in conflict with current land use. A large part of the safety zone is already included inside the safety zone of the Hästholmen plant, so there are no significant changes in land use restrictions. The plant will strengthen the position of the Loviisa region as a center for energy production – and preconditions for development of land use may improve.		Holiday residences on the south coast will be removed. The current Karsikontie road can be used as a road connection. New road connections may be necessary for current land use and possible rescue routes but they will not affect land use. The plant will restrict the building of new residential areas indicated in previous plans. The significance of Kemi-Tornio as a strong industrial region will become stronger – and preconditions for development of land use may improve.
	The power line leading to the plant will restrict land use on a strip 80–120 meters wide depending on the column type. The construction of the power plant will restrict land use in the plant's safety zone. Building of workplace and residential areas and services may intro-duce new land use opportunities in villages and settlements and along roads.			
Impacts of final disposal of operating waste	Adequate facilities will be built at the nuclear power plant for the treatment and final disposal of operating waste. Careful planning and implementation will help to eliminate significant environmental impacts caused by the treatment and final disposal of operating waste. The facilities will contain systems, using which the safe handling and transportation of waste and the monitoring of the amount and type of radioactive substances can be performed. Once the use of the final disposal facilities is terminated, the connections will be sealed and will not require any control afterwards. Any radioactive substances contained by waste will become safe for the environment through time.			
Impacts of nuclear fuel procurement chain	The impacts of the nuclear fuel procurement chain will not be felt in Finland because Fennovoima procures the required uranium from the world market. The arising impacts will be assessed and regulated in each country according to local legislation. The environmental impacts of uranium mining operations are connected with the radiation of the uranium ore, radiation effect of the radon gas released from the ore, and wastewater. The possible environmental impacts from the production steps of conversion, enrichment and fuel assembly manufacturing are related to the handling of dangerous chemicals and, to a lesser extent, the handling of radioactive materials. The environmental impacts of the different stages of the production chain, starting from mines, are increasingly managed by international standards and audits carried out by external parties, in addition to legal regulations. In the nuclear fuel production chain, transported intermediate products are slightly radioactive at most. The transportation of radioactive materials will be carried out in compliance with national and international regulations on transport and storage of radioactive materials. Chemical safety will also be ensured by appropriate measures.			
Impacts of management of spent nuclear fuel	Careful planning and implementation will help to eliminate significant environmental impacts caused by handling and interim storage of spent nuclear fuel. The facilities will contain systems, using which the safe handling and transportation of fuel and the monitoring of the amount and type of radioactive substances can be performed. During interim storage for dozens of years, the status of spent fuel will be monitored regularly.			

	Pyhäjoki	Ruotsinpyhtää, Kampuslandet	Ruotsinpyhtää, Gäddbergsö	Simo
Impacts of final disposal of spent nuclear fuel	The final disposal of spent nuclear fuel will not take place at plant location but the spent fuel is transported, by sea or land, to a Finnish disposal site plant. The environmental impacts of final disposal will be addressed through a separate EIA procedure.			
Joint impacts	**Laivakangas mining project** No joint impacts.	**The planned third unit of the Loviisa nuclear power plant** When Loviisa 3 and the Fennovoima plant are both in operation, according to the modeling results, the areas heating by more than one degree are larger than in a situation where the Fennovoima plant and the existing Loviisa plants alone are in operation. This is because the areas heating by less than one degree under the impact of the two plants overlap. Even though the warming areas are located distant from each other, the impacts will be targeted at the same sea area. The basic production, sedimentation and the consumption of oxygen in layers near the bottom will increase in this sea area compared to the situation where only cooling water from Fennovoima's power plant will be discharged in the area. Because of the openness of the sea area, the impact on the coastal zone's vegetation and fish stocks will not differ greatly from the impacts of Fennovoima's power plant. There will not be any adverse impacts outside Orrengrundsfjärden and Vådholmsfjärden. The extent of the impacts depends on the location of the discharges as well. The smallest sea area to warm up by more than one degree centigrade will occur when cooling water is discharged to the open and deep sea area.		**WPD Finland Oy's wind power plant project** The power lines of the wind power plant will be placed in the same corridor with the nuclear power plant's power lines, whenever possible.
Impact of decommissioning the power plant				
	The most significant environmental impacts of decommissioning will arise from the handling and transport of radioactive decommissioning waste generated during dismantling of the controlled area of the plant. The most radioactive portion of such waste, such as power plant waste, will be treated and disposed of. As many dismantled contaminated plant parts and equipment as possible will be cleaned so that they can be released from the radiation authority's control and either recycled or disposed of at a general landfill site. The plant's systems will be sealed so that radioactive substances cannot spread into the environment. The majority of waste generated during the nuclear power plant's dismantling operations is not radioactive, however, and can be treated similarly to ordinary waste. Environmental impacts in the plant area and nearby roads caused by the dismantling, treatment and transportation of the nuclear power plant's non-radioactive structures and systems include dust, noise and vibration. Furthermore, in road sections with only a little other traffic, the emissions of increasing traffic will have an impact on air quality. The plant can be decommissioned in such a way that the plant area can be used for other future purposes. It is also possible to leave some of the buildings in the area to be utilized for other purposes or to continue to use the area for energy production or other industrial activity.			
Impacts of irregular and accident situations				
	The likelihood of a serious nuclear accident is extremely low. In the event of such an accident, the impacts of a radioactive release on the environment will strongly depend on the prevailing weather conditions. The season also has an impact on the contamination of food products. Following a serious accident (INES 6), it is not likely that the use of agricultural products will be restricted in the long term. Short-term restrictions on the use of agricultural products may apply to areas within a 1,000 km radius of the plant without any protective measures aimed at livestock or food production. In case of an accident during unfavorable weather, it is also probable that restrictions on the use of various kinds of natural produce will have to be issued in areas affected by the greatest fallout. Long-term restrictions on the consumption of some mushrooms, for example, may be required in areas at a distance of 200–300 km. Under the threat of a serious accident, the population will be evacuated, as a protective measure, from an approximately five kilometer wide safety zone surrounding the facility. In unfavorable weather conditions, protection may be necessary indoors within a maximum of 10 kilometers. The use of iodine tablets may also be necessary according to guidelines issued by the authorities. Serious accidents will have no direct health impacts. In the event of a less severe accident, belonging to the INES Category 4, no protective measures are needed in the vicinity of the nuclear power plant. Accidents when storing or handling chemicals are unlikely, and their impacts are minimal.			

9.1.1 Location alternatives

The impacts have been assessed location-specifically, and a summary of the assessment is presented in the table (Table 9-1). The location alternatives are different in terms of some impact types but all alternatives are environmentally acceptable. Because of this, and because different stakeholders attach importance to different impacts it is not possible to rank the location alternatives by their environmental merits.

It is essential, however, to consider these differences carefully, along with other deciding factors, when deciding on the plant location.

9.1.2 Plant options

The most significant differences between the plant options of one or two plants lie in the extent of the heat impact of the cooling waters and in the duration of the construction phase. In the two plant alternative, the heat impact extends to a 30 to 40% greater area, and the estimated length of the construction phase is eight years as opposed to six years.

There are no significant differences between the environmental impacts of the different plant technologies.

9.1.3 Cooling water intake and discharge options

The differences between the cooling water intake and discharge options are minimal as demonstrated in the table above (Table 9-1).

9.2 Feasibility of the project

As a result of the assessment, none of the project's alternative implementations have been found to have any adverse environmental impacts that were unacceptable, or could not be mitigated to an acceptable level. Thus, the project is feasible from the environmental impact perspective. However, the alternatives are different in terms of some impact types, and it is essential to consider these differences carefully when deciding and developing the implementation option.

9.3 Contrast to non-implementation of the project

The impacts of non-implementation of the project have been discussed in the chapter on the impacts of the zero-option.

The most significant impacts include the environmental impacts of the substitute electricity production, depending on the used forms of production, and the implications of the fact that the Finnish electricity market will continue to be dominated by a few operators.

Also the impacts of the project, both positive and negative, will remain unrealized.

9.4 Uncertainties in assessment, and their implications on the reliability of the assessment

The available environmental data and the assessment of impacts always involve assumptions and generalizations. Also, the available design data is preliminary. This will cause inaccuracy of the assessment. The description of assessment methods includes an evaluation of the related insecurities. On the other hand, the insecurites related to the mentioned issues are well known, and they have been considered in the impact assessment.

In summary, the significance and magnitude of environmental impacts has been explored reliably, and the conclusions are not uncertain.

The landscape aspects are taken into account when designing the power plant. A field in summer in Ruotsinpyhtää, 2008.

Emissions of radioactive materials during operation of the nuclear power plant will be low, and will have no significant impact in the environment or people.

10 Prevention and alleviation of adverse impacts

10.1 Construction of the power plant

10.1.1 Noise and traffic impacts

Noise during construction and other disturbances in the immediate vicinity of the plant may be alleviated by performing as many especially noisy or otherwise disturbing construction activities in the daytime as possible. Furthermore, the placement of activities and temporary noise protection structures can be used to significantly reduce the noise disturbance caused by the construction site. For example, impacts of the noise from the stone crushing plant may be prevented by constructing noise barriers from piles of stone.

Disturbances due to traffic during construction can be alleviated by means of traffic guidance and timing. Whenever necessary, vehicles can be directed to use routes which go outside the most major residential centers. Whenever possible, heavy traffic will be scheduled for weekdays between 7:00 am and 9:00 pm, and any special deliveries that may slow down the traffic flow will be scheduled for times when there is less regular traffic. Bus transport will be arranged for employees in order to reduce the volume of private car traffic in the area.

Active communication about the construction stages and the impacts of construction to the residents of neighboring areas, in particular, is also advisable.

10.1.2 Dust impacts

Dust impacts from the construction site can be reduced by paving all the permanent roads in the area as soon as possible. Proper speed limits must be set for construction site areas and sand roads, and unpaved roads can be irrigated during the hot summer months, whenever necessary. The dusting of crushed stone piles can also be prevented with irrigation.

10.1.3 Impacts on water systems

The construction works required by the nuclear power plant's cooling water structures and roads, the quay and the ship channel will be conducted during the biologically most inactive time, i.e. late autumn or even winter for some activities. This allows minimizing the biological disadvantages due to muddy water close to the construction site.

10.1.4 Impacts of waste and wastewater

Waste generated during construction will be properly sorted, and as large part of the waste as possible will be recycled or utilized in energy production. Hazardous waste will be separately collected and delivered to be properly treated.

The amount of wastewater generated at the construction site will be minimized, and the generated wastewater will be treated mechanically, chemically or biologically or by a combination of the three, depending on its quality.

10.1.5 Impacts on people and the society in adjacent areas

A large number of people having their permanent residence elsewhere will stay at the nuclear power plant construction site and close to it during the construction of the plant. The social impacts caused by the construction project can be alleviated by arranging accommodation for the employees in the location town and area as well as in adjacent municipalities. Adequate leisure activities for the employees participating in the construction work will be arranged together with various stakeholders. It is likely that most of the construction employees will come to the area from outside Finland. Adverse social impacts due to cultural differences can be alleviated by arranging training regarding the Finnish culture and practices to foreign employees.

10.1.6 Construction of power lines

The best way to alleviate the impacts of the power lines on, for example, land use, landscape and ecological values is to take these impacts as well as possible into account when planning the power line route and the pylons to be used. There are good possibilities to do just this because preliminary power line routes have been studied and various stakeholders are able to offer their views regarding the routes already during the power plant's EIA procedure. This offers good starting points for the power line EIA procedure to be carried out at the selected location and the technical design process that will utilize the results of the EIA procedure; plenty of information regarding environmentally significant issues will already be obtained before the power line EIA procedure begins.

10.1.7 Construction of roads

Environmental impacts caused by the construction of roads can be prevented and alleviated by properly designing both road routes and the construction work; issues significant for the environment and people will be taken into account. Technical solutions, such as intersection arrangements, light traffic routes, extensions, etc., can also be used to effectively reduce the detrimental impacts on people and the environment.

10.2 Power plant's operational lifetime

10.2.1 Environmental management system

An environmental management system is used to systematically link environmental issues to all operations of the nuclear power plant and to continuously improve environmental protection. Environmental aspects and environmental impacts of the operations of the plant are surveyed and evaluated as part of the system. The system includes programs and practices to minimize the environmental impacts of operations. The plant environmental policy and corresponding environmental objectives and goals will be defined. The set goals will be implemented in accordance with defined methods, and their implementation will be monitored. The best-known environmental management systems are systems based on the ISO 14001 standard and the EMAS decree.

10.2.2 Impacts of cooling water

Local impacts on water systems from the cooling water can be alleviated by means of a variety of technical solutions. However, several potential alleviation methods bring their own adverse impacts, which in some cases may be more significant than the benefits obtained from the system.

10.2.2.1 Reducing the thermal load to the water system

A part of the heat generated by the nuclear power plant will be conducted to the water system by way of direct cooling. The cooling water will be used to cool the turbine condensers; after that, the water will be discharged back into the water system approxi-mately 10–12°C warmer. The thermal power released to the water system in case of alternative 1 will be approximately 3,000–3,100 MW and in case of alternative 2 approximately 3,600–4,300 MW.

The thermal load released to the water system corresponds to approximately 24–35 TWh of energy per year. The total amount of district heating energy used in the whole of Finland is approximately the same: approximately 30 TWh in 2006 (*Finnish Energy Industries, 2007*).

The only way in which the thermal load released to the water system could be significantly decreased is so-called joint production, i.e. a power plant that generates electricity and also district heating or industrial steam. The efficiency of a joint production plant is usually approximately 80–90 per cent. The excess thermal load of the nuclear power plant could only be utilized in district heating if the temperature was increased to a minimum of approximately 140°C. However, this would reduce the efficiency of the nuclear power plant's electricity generation system. The lost electricity generation would be approximately 20–30% of the generated amount of heating energy.

District heating energy

Some nuclear power plants also generate district heating energy. For example, the Beznau nuclear power plant in Switzerland (electric power 730 MW) generates district heating energy for an area of approximately 15,000 residents (*NOK, 2008*). The thermal power currently used in district heating energy generation in nuclear power plants is only approximately 100 MW at best (*IAEA, 1997*).

It would be technically possible to implement Fennovoima's nuclear power plant project as a power and heat production plant and it would be financially justifiable in the event of a sufficiently large demand for heat. According to the views of the organization responsible for the project, district heating produced through nuclear power could have a significant role in reducing carbon dioxide emissions in energy production if the production and distribution of district heating could be agreed upon with different operators and the loss heat of a nuclear power plant will be used to largely replace heat production through fossil fuels.

The highest district heating load in Finland is in the Helsinki Metropolitan region. In 2007, 6.4 TWh of district heating energy was sold in the distribution area of the Helsinki district heating grid (*Helsingin Energia, 2008*). This amount corresponds to approximately 18–27% of the energy to be released into the sea at the Fennovoima nuclear power plant.

The Ruotsinpyhtää area is approximately 70 kilometers from the district heating tunnel at Vuosaari, Helsinki.. However, the district heating energy would have to be distributed to the Helsinki Metropolitan region at several points, and thus more than 100 kilometers of tunnels would have to be constructed. In practice, it would be possible to generate district heating energy for the entire Helsinki Metropolitan region's needs if the nuclear power plant were to be constructed in Ruotsinpyhtää. Similarly, a plant in Simo would be able to generate district heating energy for Oulu and Kemi; the required heat amounts would be smaller there than in the Helsinki Metropolitan region, however. The distance from the Simo location area to Kemi and Oulu are approximately 10 and 25 kilometers, respectively. The district heating energy consumption figures in these towns in 2006 were approximately 0.2 TWh and 1.3 TWh, respectively (*Finnish Energy Industries, 2007*).

In order to conduct district heating energy from Ruotsinpyhtää to Helsinki, two pipes with a diameter of approximately 1.5 meters would have to be built, one for outgoing and the other for incoming water. The pipes would travel in a tunnel with a diameter of approximately six meters quarried in rock. A rough cost estimate for construction of the district heating tunnel and pipelines is EUR 1,500 million. Costs would also arise from lost electricity generation output.

At present, the district heating system in the Helsinki Metropolitan region is mostly based on joint generation of electricity and heat. The district heating energy is generated by using natural gas, coal and oil. If the district heating energy came from elsewhere and the electricity generation were still to continue, the waste heat from electricity generation would have to be directed into the sea in front of Helsinki.

Fennovoima is studying the future needs and production methods of district heating and their impacts on the environment and climate at different sites, particularly in the Helsinki region. Fennovoima will perform the studies as a separate project together with its shareholders.

If it is seen to be useful in a site where it is technically and financially feasible for Fennovoima's power plant site that a significant volume of current combined heat and power production or separate heat production capacity is removed from use because of outdated production equipment or environmental reasons, Fennovoima will be prepared to take part in the project by distributing district heating to the site. The implementation of such a project will require a separate environmental impact assessment procedure.

Industrial steam

Transferring steam required by industrial applications is only feasible from a technical and an economic viewpoint when the distances are short. No industrial facilities requiring large amounts of steam are located within such a distance from any of the alternative nuclear power plant sites, however. Furthermore, even the largest steam users in Finland would only require a very small part of the energy to be transmitted to the sea from the nuclear power plant.

The nuclear power plant is meant for generation of basic power, i.e. it will continuously generate electricity at a steady full power, whereas the requirements for industrial steam – and also district heating energy – vary. This is one of the reasons why it would be difficult to use the nuclear power plant in heat generation.

Other possibilities to utilize heat energy

Other possible utilization possibilities for the thermal load include, for example, using it in heating the ground on streets or in recreational areas, such as football fields; using it as a means to promote the growth of fish at fish farms; using it in heating greenhouses; or using it in other agricultural activities. Piloting projects regarding these utilization opportunities have been conducted in several Finnish power plants. However, the heat demands in these activities are so low that the reductions in the thermal load to be discharged to the sea would hardly be reduced. Another problem with such small-scale utilization of thermal energy is also its uneconomical nature and auxiliary impacts on the environment, such as nutrients from fish farming.

Cooling tower

All the large condensation power plants in Finland use the so-called direct cooling method where the extra thermal load is transferred into cooling water travelling through the power plant and then discharged into a water system. This is because this method is the most effective from a technical and economic viewpoint, there is plenty of cold water available in Finland and the environmental impacts of thermal energy discharged into a water system have been found fairly minor and acceptable in surveys carried out over the decades. The descriptions of the power plant's impacts given in this report also assume that the direct cooling method will be used.

Since water is not so readily available in many countries, another generally used method is so-called indirect cooling, i.e. cooling towers. The extra thermal load is discharged from a cooling tower directly into the air, and the thermal impacts to the water systems will be minimal. However, there are technical, economic and environmental disadvantages with cooling towers. A cooling tower may be a fairly massive construction, in a large power plant a structure that is approximately 150 meters tall, that requires a lot of land and that can be seen from far. A could of water vapor forms above a cooling tower, especially in the wintertime. The cloud extends up to one kilometer and can be seen from far. Cooling towers placed next to the power plant, which will be approximately 50–60 meters in height, would be an element dominating the landscape.

Depending on the tower type, cooling towers also cause some noise disturbances, although the disturbances are fairly minor in case of towers operating with the chimney principle, i.e. so-called naturally ventilated towers.

There is enough room for cooling towers in all the alternative locations of the Fennovoima project. Since the 'basic tower models' are usually designed to operate at a maximum temperature of -30°C, the Finnish winter would have to be taken into account when designing towers for the Simo and Pyhäjoki locations in particular. Cooling towers could still be used also under these conditions. Cooling towers are in use in areas where the conditions are similar, such as in Canada and Russia.

In the selected plant locations, the cooling water used would possibly have to be brackish water due to the high water demand (approximately 1–2 m^3/sec), and the salinity of the water would also pose challenges to the structural solutions and functionality of the towers. Cooling towers which utilize regular seawater and brackish water are in use in several parts of the world, however. The salinity of the seawater in the Bothnian Bay is very close to fresh water, and the salinity at Ruotsinpyhtää is also clearly lower than in the oceans.

The salt included in natural water circulating in a cooling tower will be concentrated due to evaporation. Some of the salt will spread into the surrounding area when water evaporates. Naturally, the salt emissions will be the higher the more salt the water used in the tower contains. The impacts caused by cooling towers' salt emissions highly depend on, for example, the size and location of the plant, however. The emissions can also be effectively reduced by means of technical solutions. In addition to the salt spreading to the environment, another detrimental impact could be the occasional freezing of roads or structures caused by water vapor; these environmental impacts have usually not been too significant, however.

In order to prevent the cooling surfaces from becoming soiled, which would reduce the cooling efficiency, antifouling chemicals preventing microbes from growing and attaching onto the surfaces (such as chlorine) have to be used in cooling towers. These chemicals will be discharged into a water system when the water in the tower is replaced. The use of these chemicals will be controlled, however, and in small doses they will only have minimal detrimental environmental impacts.

A cooling tower reduces the power plant's efficiency by approximately 1–3% and will thus reduce the amount of electrical energy generated by the plant. Depending on the price of electricity, the monetary value of such a loss would be approximately EUR 10 million per year.

Furthermore, the investment costs arising from a cooling tower are high: the construction of cooling towers sufficient for a 1,800 MW power plant would cost roughly EUR 50–60 million and for a 2,500 MW power plant approximately EUR 70–80 million.

Due to the environmental disadvantages and technical reasons associated with cooling towers, Fennovoima is not planning to use an indirect cooling system in the power plant.

10.2.2.2 Impact area

It is possible to change the location and form of the cooling water impact area by the placement of the input and discharge structures and by various technical solutions limiting the thermal impact, such as guiding embankments and dams closing straits.

By carefully choosing the place from where the cool-

The EIA process has studied the impacts of cooling water on ice conditions. Wintery shoreline in Pyhäjoki, 2008.

ing water is taken, it is possible to minimize the size of the water area that will be heated due to the input water temperature. The colder the input water, the lower the thermal impact at the discharge zone. Water close to the bottom is colder than the surface water, especially in the summertime, and therefore taking water from close to the bottom may in some cases reduce the size of the area that will be heated.

This impact was observed in all the studied locations, most clearly with the deepest intake alternatives in Ruotsinpyhtää. The impacts of taking water from close to the bottom in the lower sea areas in Simo and Pyhäjoki were not so significant.

If necessary, the impacts of cooling water can be concentrated in a small sea area by separating the cooling water discharge area from the surrounding sea with earth embankments, for example. In such a case, the cooling water impacts will be limited to a small area but the impacts on this area will be more clearly discernible. This has been done, for example, in front of the Forsmark nuclear power plant in Sweden where an area of approximately one square kilometer has been separated from the rest of the sea. The cooling water is discharged to this area, and it will cool there a little before it is allowed to enter the sea. The area was surrounded by islands already before the power plant was constructed, however, and thus constructing a full circle of embankments was not necessary. The area is used for studying the impacts of cooling water.

Due to the depth of water, separating an area of similar size at the Fennovoima locations is not rational from a technical or an economic viewpoint, nor can it be justified based on environmental grounds due to the fact that it would not offer any major improvements and the construction works would harm the environment.

10.2.2.3 Impacts on ice cover

The impacts of the cooling water in the ice cover can be reduced by the above-mentioned methods aiming at reducing heat emissions.

In theory, the fact that cooling water will melt the ice cover could also be utilized by guiding the water into an area where a lack of ice cover would serve some purpose. Such sites include harbors and ports, for example. In practice, transferring water far from the power plant area would be technically challenging and expensive, however. There are suitable sites close-by only to the potential power plant site in Simo where the Veitsiluoto Port and the Ajos Port are located close to the discharge area.

Ajos Port

The Ajos Port is located approximately seven kilometers from the cooling water discharge site. However, the cooling water modeling shows that cooling water will not keep the ship channel leading to the port or the port area itself unfrozen.

The port areas could be kept unfrozen by pumping a major part of the cooling water to the Ajos Port. This would require investments in a pipeline and a pumping plant as well as a separate license procedure. Profitability of the project should be separately assessed.

10.2.2.4 Fish getting into the power plant system

Fish can be prevented from being driven into the cooling water intake system through different technical measures and by technical design of the cooling water intake systems.

The most commonly used method in Finland is protecting the intake with a fine mesh that will prevent larger fish from ending up in the intake pipe. Mesh is often kept in front of the intake pipe in the spring and summer when most fish would be driven into the intake pipe. The problem with using mesh is that it will be quickly clogged up by algae and other debris in the water.

A variety of repellant systems have also been developed to prevent fish from coming close to the intake structures. Most of these systems are based on sound and/or light. Devices based on electrical impulses are also in use in German power plants, for example. The systems have been observed to reduce the number of fish that end up inside the power plant; they do not completely prevent fish from getting in, however. Fennovoima will study the fish repellant technology best applicable for the Baltic Sea conditions and install such a system in the power plant.

The number of fish that end up in the intake system can be reduced when the cooling water intake is constructed close to the bottom and sufficiently far away from the shore. This will also prevent fry and roe which are usually found close to the shore from getting into the intake system. The number of fish ending up in the power plant can also be reduced by designing the cooling water intake system in such a manner that the water flow will remain low at the intake point and the flow effect will be directed into deeper waters by means of guiding embankments, for example.

10.2.3 Emissions of radioactive materials

Emissions of radioactive materials during operation of the nuclear power plant will be low, and will have no significant impact in the environment or people. The emissions of radioactive materials will be continuously monitored by means of measuring and sampling. This is to ensure that emissions into the air or water will not exceed the plant-specific limits confirmed by the Radiation and Nuclear Safety Authority. Despite the low amounts of radioactive emissions, the means of decreasing them and also other emissions will be continuously surveyed in accordance with the principle of continuous improvement.

10.2.4 Impacts on animals

Impacts during operation of the nuclear power plant can be reduced by, for example, especially taking into account the birdlife of the area during operation. The risk of birds colliding with power lines can be reduced by improving the visibility of the power line. This can be done by installing bird warning spheres on the power lines, for example. No extensive mirror-like surfaces should be used in the power line structures because these might increase the risk of collisions. If there are any migration or travelling routes of animals in the power plant area, these will be taken into account when designing the form of fenced-in areas and roads, whenever possible.

10.2.5 Landscape impacts

Since the scale of the nuclear power plant and the adjoining structures will deviate from the surrounding nature, ‘hiding’ the buildings or structures in the landscape will not be possible. It is possible to make the power plant more fitting for the landscape, however, by selecting the correct surface materials and colors, carefully planning where buildings will be placed and adding vegetation in the power plant area.

Local impacts can be reduced during more specific design by, for example, forming embankments at shores in their natural state or almost in their natural state and adding vegetation in such a manner that they will fit into the natural shoreline of the area. This should be done if there are any recreational sites or holiday homes in the area. The lighting used on the roads to the power plant can be designed in such a manner that it will not be visible from far away (light fixtures spreading light downwards). When designing the power line routes and roads, attention should be paid to how they blend in the landscape. Valuable scenic and cultural sites shall also be taken into account. Architectural solutions may also be used to make the power plant better blend in the surrounding landscape.

10.2.6 Impacts on traffic and safety

The impacts of the power plant’s operation on the traffic volume and traffic safety in the areas adjacent to the power plant can be reduced by arranging the employees’ bus transport to the worksite free of charge. Traffic safety issues must also be taken into account when deciding on the location of new traffic connections and improved traffic connections, and when designing structural solutions. Such solutions include, for example, extensions, lanes for decelerating and accelerating vehicles at intersections, traffic lights and light traffic routes.

10.2.7 Noise impacts

The internal and external noise level of the power plant must meet the guidelines of public authorities regarding occupational safety and environmental noise levels.

When designing the power plant area, attention shall be paid to noise impacts. This shall be done when choosing the locations of activities causing noise and buildings preventing noise, for example. The building materials and technology used in the power plant building can be such that absorbs noise caused by machinery and devices. Vibration can be reduced by placing all vibrating machines on flexible foundations.

The noise transients caused by vehicles passing by and the daily average sound level can be controlled by speed limits, for example.

10.2.8 Impacts of wastewater

The amount of wastewater generated at the nuclear power plant will be minimized by careful planning of water consumption. The wastewater generated by the plant will be properly treated mechanically, chemically or biologically or by a combination of the three, depending on its quality, before discharging the wastewater into the sewer system or water system.

10.2.9 Impacts from transport, use and storage of chemicals and oils

Very small amounts of chemicals and oils hazardous to the environment will be stored and used at the nuclear power plant. The relevant safety instructions and regulations will be adhered to when transporting chemicals. The chemical storage tanks and chemical stores will be built in compliance with the Chemicals Act and regulations issued pursuant to it, as well as SFS standards. There are safety guidelines for preventing chemical accidents for the nuclear power plant, and the staff will be provided with instructions on the safe use of chemicals. Structural provisions for any leaks will be made in order to prevent detrimental amounts of hazardous chemicals from getting into the environment. The accident risks pertaining to storing and using chemicals will be systematically analyzed and minimized.

10.2.10 Impacts of waste management

The objective is to minimize the generation of waste at the nuclear power plant. The detrimental impacts of waste may be alleviated by utilizing as much of the generated waste as possible by recycling or by using it in energy production. All waste will be properly treated, and the waste will not cause any major environmental impacts.

10.2.11 Impacts on people and society

The risks inherent to nuclear power are generally perceived far greater than they actually are. This is why it is important to offer information on the operation of the nuclear power plant and the risks and impacts pertaining to nuclear power in an active, appropriate and comprehensible manner. The fear of nuclear power plants may also be alleviated by providing plain language information to the general public on how safety is ensured in all nuclear power plant operations, how extremely unlikely a nuclear power plant accident is, and what kind of concrete consequences the most severe accident would have.

The nuclear power plant will be presented to the general public at a visitor's center to be built by Fennovoima in connection with the nuclear power plant. Regular and open reports on radioactive measurements and other measurements taken in the surroundings of the plant will be offered.

10.2.12 Impacts of accidents

When designing a nuclear power plant, the primary target is to prevent accidents. Its design prepares for the possibility of operational transients and accidents. The nuclear safety principles also serve to ensure the proper management of accidents. An up-to-date emergency plan shall be drawn up for the nuclear power plant and its vicinity. The emergency response arrangements of the nuclear power plant will be coordi-nated with the rescue and preparedness plans of the authorities in the case of a nuclear power plant accident. The emergency plans will be continuously updated, and their use will be regularly practiced.

10.3 Decommissioning

The environmental impacts of decommissioning the new nuclear power plant will be evaluated in a separate EIA procedure. A decommissioning plan will be drawn up at the initial stages of plant operation, however. The Radiation and Nuclear Safety Authority will approve the plan, which shall be updated every six years. One of the primary objectives of the plan is to ensure that dismantled radioactive components will not cause any harm to the environment.

The EIA process studied the impacts of the project on fishing and fishery in the sea areas. Fisherman's nets in Simo, 2008.

Cooperation with stakeholders is an important part of the business of a modern socially responsible company. The working methods and contacts created during the EIA procedure can also be utilized in the future both when monitoring the social impacts of the project and when communicating with the stakeholders.

11 Environmental impact monitoring program

11.1 Monitoring principles

In accordance with the Environmental Protection Act, a licensee must be aware of the environmental impacts of its activities. For a nuclear power plant, also the regulations and guidelines issued by virtue of the Nuclear Energy Act require environmental impact monitoring and reporting by the parties responsible for nuclear power plant projects and activities.

Legally binding obligations regarding monitoring are included in the permit regulations of the variety of permit decisions required for the construction and operation of a nuclear power plant. The environmental impacts of the project must be monitored in accordance with monitoring programs approved by the authorities. The monitoring programs define the specific details of load and environmental monitoring and reporting to be done. However, an environmental impact assessment report must already include the main principles of the project's environmental impact monitoring system.

Monitoring programs for radioactive and regular emissions of nuclear power plants are plans on how the project's (construction, operation and decommissioning of a nuclear power plant) emissions and their environmental impacts will be measured and monitored at regular intervals in the project impact area. The monitoring objectives are:

- Measuring and offering information on emissions caused by the project and their environmental impacts
- Investigating which changes in the environment have

resulted from the operation of the plant
- Investigating how the results of the environmental impact prognosis and assessment correspond to reality
- Investigating how the implemented measures for mitigating adverse impacts have succeeded
- Discovering any unforeseen adverse impacts or adverse impacts that have been more major than anticipated in order to start the necessary mitigating measures.

Regular reports on the monitoring results will be issued every couple of months or annually, depending on the monitoring program. The reports will be submitted to the relevant public authorities.

Below is a general outline of the project's environmental impact monitoring program.

11.2 Monitoring of radioactive emissions and radiation monitoring in the surroundings of the nuclear power plant

11.2.1 Measuring radioactive emissions

During normal operation of the nuclear power plant, an extremely small portion of the generated radioactive substances will be released to the environment in the form of emissions. Exhaust air and purified gases, which have been discharged from processes, will be released from the plant into the atmosphere. The main emission pathway into the air will be the vent stack of the plant. The plant process waters will be treated in the power plant's own liquid waste treatment plant from where they will be drained via a radiation control point to the cooling water discharge channel and from there to the sea.

The emission of radioactive materials will be monitored by continuous measurements and sampling. This is to ensure that emissions into the air or water will not exceed the plant-specific limits confirmed by the Radiation and Nuclear Safety Authority. The measurement methods to be used will be chosen on the grounds that their reliability and accuracy are as high as possible with the best available technology. The emission pathways can be monitored also when the system has an individual fault. Both sampling and measurement arrangements and operations will be implemented in such a way that adequate data on radioactive emissions can be obtained even in the event of a serious accident. The detailed results of the measurements of radioactive emissions will be reported to the Radiation and Nuclear Safety Authority at regular intervals (quarterly and annual reports).

Significant emission pathways of radioactive substances into the air will be monitored with continuous, fixed radiation monitoring systems. In addition, the emission flow of radioactive substances will be sampled, when necessary, to a separate sampling and measurement system. The vent stack will include a sampling system, and its particle filters will be replaced and analyzed at regular intervals. Isotope-specific samples will also be regularly collected from the gas for more detailed analysis. In addition to the actual emission pathways, significant gas migration paths within the nuclear power plant, such as exhaust air ducts in active rooms and tanks and gas purification and delay systems, will be monitored by continuous radiation measurements.

The activity of wastewater released from the plant into the water system will also be monitored with continuous, fixed radiation monitoring systems. The emission pathways can also be monitored when the system has an individual fault (*STUK, 2006b*).

11.2.2 Radiation monitoring in the surroundings of the nuclear power plant

Radiation monitoring in the surroundings of the nuclear power plant refers to monitoring the amount of radioactive substances and the radiation status in the vicinity of the plant. The radiation measurements in the power plant area and its vicinity will ensure that the radiation dose limits defined in regulations issued by the authorities will not be exceeded. The purpose of the radiation monitoring program is to identify the radiation load to the environment and the people caused by radioactive emissions, and to ensure that the radiation exposure of the population caused by the nuclear power plant will remain as low as practically possible. The licensee will draft a radiation monitoring program and submit it to the Radiation and Nuclear Safety Authority when applying for an operation permit according to the Nuclear Energy Act. The Radiation and Nuclear Safety Authority will approve the program, monitor the results and perform inspections at the plant. The radiation monitoring program of the nuclear power plant will be reviewed at least once every five years. When the nuclear power plant is decommissioned, radiation monitoring in the surroundings of the nuclear power plant will be conducted in a manner approved by the Radiation and Nuclear Safety Authority.

When planning the radiation monitoring program, a baseline condition survey on the nuclear power plant project will be conducted. The survey will assess the pre-operation situation and environmental conditions, and anticipate the impacts of operation, such as the level of emissions and their release to the environment during the normal use of the plant and in case of failures and accidents. The radiation monitoring program will define the persons responsible for the implementation of the program; identify sampling and measuring and their frequency; and describe the methods, equipment, sample and nuclide-specific observation limits, calibration of equipment and methods, and the processing and storing of measurement results. The radiation monitoring program will include external radiation measurements and analyses of outdoor air, samples representing the different stages of food chains leading to humans and analyses of radioactivity within the human body.

Dose-rate instruments, which will be read at regular intervals, and continuous, protected measurement stations will be placed in the terrestrial environment of the plant to measure external radiation. Their measurement data will be transferred to the plant and to the national radiation monitoring network, and the data can be read in real-time at the Ministry of the Interior and at the Radiation and Nuclear Safety Authority. In addition, gammaspectrometric measurements will be conducted in the vicinity of the plant at regular intervals, and continuous air samplers will be placed in the vicinity of the plant to monitor radioactive particles found in the air.

The radioactivity of the environment will also be measured by sampling at regular intervals. Samples will be collected from indicator organisms, which accumulate or enrich the radioactive substances contained in the emissions. In the terrestrial environment, measurements associated with food chains will primarily be targeted at specifying the radioactive substances in the fallout, soil, tap water, grain and garden produce, natural products, wild plants, meat, grass and milk. These sampling objects constitute a comprehensive representation of the pathways through which radioactive substances may enter the human body. The objects will be located at distances varying in the range of 1–40 kilometers from the plant. In the aquatic environment, the measurements will be targeted at specifying the radioactive substances in seawater, sedimental material and bottom sediment, hydrophytes, benthic animals and fish. Interbody measurements of activity will be conducted on the residents of the surrounding areas to ensure that there are no significant unidentified exposure pathways through which radioactive substance could enter these residents.

In addition to the radiation monitoring program, radiation dose calculations based on emission data and spreading conditions (measurement data on weather conditions) will be conducted to estimate the radiation exposure of the residents of the surrounding ar-eas. These estimates will be useful for, for example, rescue operations in possible emergencies. The calculation programs used in the assessment are approved by the Radiation and Nuclear Safety Authority (*STUK, 2006c*).

11.3 Monitoring regular emissions

11.3.1 Monitoring cooling water and wastewater

Cooling water will be used in the nuclear power plant to cool the turbine condenser and separate cooling circuits. Cooling water volume and temperature will be monitored by continuous measurements. The temperature outside the discharge site will also be regularly monitored. The annual thermal load caused by the nuclear power plant in the water system will be calculated based on the power plant unit's electricity and thermal power, and these values will be monitored by means of regular computer records.

The nuclear power plant will generate wastewater both as a result of using tap water and through plant operations. Social wastewater includes water from sanitary facilities and shower rooms, for example. Wastewater generated during power plant operation includes water used for washing various surfaces, as well as the wastewater resulting from the production and use of process water. Wastewater volume and quality will be monitored by continuous measurements and sampling. The contents and amounts of nutrients, solid matter and agents biologically consuming oxygen in the wastewater to be discharged into the environment will be monitored, for example.

Wastewater from sanitary facilities and washing and flushing water from non-active industrial facilities will be treated either at the location municipality's water treatment plant or alternatively by constructing a private water treatment plant for the nuclear power plant. The quality of wastewater coming into the treatment plant and leaving the treatment plant will normally be monitored by means of 24-hour collection samples and periodic samples. A report to be regularly drawn up, such as once a month, will describe the results of the emission monitoring activity. In addition to emission monitoring, the wastewater monitoring system will include daily (such as treated water volume, chemicals dosage) and monthly (such as electricity consumption) consumption monitoring systems. Records for the operation and use of the wastewater purification plant will be kept.

The plant process waters and the wastewater from a laundry to be included in the control area will be treated at the power plant's own liquid waste treatment plant from where they will be discharged via a radiation control point through the cooling water discharge channel into the sea. The nitrogen, phosphorus and boron loads caused by the process water and the laundry wastewater to the environment will be monitored.

Wastewater monitoring will also take place during the construction of the nuclear power plant. The wastewater load during construction will be higher than the load during operation because more people will work in the area. Storm water and rainwater from the construction site will include solid particles and possibly also traces of oil and nitrogen. This water will be collected in a sedimentation basin during construction, if necessary. If the monitored contents exceed the permissible limits, the water will be drained to the wastewater treatment plant for processing.

11.3.2 Monitoring water systems

The purpose of water system monitoring is to monitor the impacts caused by the drainage of cooling water and wastewater in the state of the sea area. Seawater temperatures and ice situation will be monitored, and physical, chemical and biological observation studies will be performed. Fennovoima will begin monitoring the water systems immediately after a decision on the location of the new power plant has been made.

The seawater temperature will be monitored at a couple of points by continuous meters and at broader areas at regular intervals by means of survey-type studies. The ice cover will be observed during the winter months at the intervals specified in the plant's environmental permit. Ice observation maps of the area will be drawn up and bulletins on the ice cover area deteriorated by the cooling water will be published in local newspapers, on the Internet and on the field by placing warning signs at points which people usually use to access the ice, for example.

Water samples at the locations defined in the environmental permit will be regularly taken in order to conduct physical and chemical water quality studies. The pH (acidity), oxygen content, electrical conductivity, opacity, oxygen consumption, nutrient contents and solid particle contents of the samples will be analyzed, for example. The biological observation studies will study the changes occurring in the flora and fauna of the project's impact area. The monitoring system may include, for example, monitoring the degree of eutrophication of the sea area, basic plant plankton production and species distribution, aquatic plant species and abundance, bottom-dwelling species and abundance and bottom sediment quality.

11.3.3 Fishing industry monitoring

The impacts of the cooling water and wastewater discharge on the fish stock and fishing in the area will be monitored in a manner approved by the local Employment and Economic Development Centre's Fishing Industry Unit. The monitoring program may include, for example, test net fishing, fish age and growth determinations, monitoring of the health and condition of fish, studying the soiling degree of traps and fishing questionnaires sent to professional and leisure fishers. Fennovoima will begin monitoring immediately after a decision on the location of the new power plant has been made.

11.3.4 Boiler plant monitoring

A boiler plant is the backup heating plant of a nuclear power plant that is normally only used for testing and possibly during annual outages of the power plant done in the wintertime. Emissions generated by the backup power machines and the production of the backup power plant (sulfur dioxide, nitrogen oxides, particles, carbon dioxide) will be annually calculated based on the properties and volumes of the fuel used, and a report as specified in the environmental permit will be issued. A report of the observed carbon dioxide emissions will also be submitted to the Energy Market Authority, the body managing greenhouse gas emission rights.

Monitoring of the boiler plant's operation will be done by means of periodic test runs or in connection with any production use and burner maintenance actions. The operation monitoring system will include, for example, the monitoring of fuel consumption, boiler temperature and pressure, combustion gas temperature and carbon dioxide levels. An annual report on the use of the boiler plant will be drawn up. The report will include details of operational periods, burners' operating hours, fuel consumption, maximum monthly consumption and maximum output as well as details of the fuels used and thermal energy generated.

11.3.5 Waste records

Ordinary waste and hazardous waste will be generated in the nuclear power plant like in any other power plant or industrial plant. Unlike other power plants, nuclear power plants produce radioactive waste. The waste quantities vary, depending on, for example, the extent of maintenance carried out on any given year.

The quality, quantity and treatment of ordinary waste generated at the nuclear power plant will be annually recorded in accordance with the Waste Act. The supervisory or permit authorities may issue regulations and guidelines on how to comply with the obligation to keep records. With regard to ordinary waste, recording and reporting will be carried out in accordance with the environmental permit decision granted for the nuclear power plant and the company responsible for its waste management. With regard to radioactive waste, record keeping will be based on the regulations issued by the Radiation and Nuclear Safety Authority.

11.3.6 Noise monitoring

After construction of the nuclear power plant, noise measurements will be performed in the surroundings of the plant to ensure that the noise caused by the plant remains within the guideline values issued by the authorities and the design guideline values. The noise level caused by the operation of the power plant will be investigated by taking measurements at the closest sites susceptible to noise. The sound levels of the most major fixed sound sources that influence the environmental noise level will be measured during normal plant operation. Noise modeling results included in the EIA procedure and possibly the environmental permit stage will be further specified based on the measurement results, if necessary.

11.4 Social impact monitoring

The impacts of the project on the living conditions, comfort and wellbeing of people have been assessed during the project period. Issues brought up in public

The law requires that the environmental impacts of nuclear power plants are monitored and reported. Boat shed in Simo, 2008.

events, statements and opinions received, and interviews of stakeholders and residents have been used in this work. Local knowledge has been utilized wherever possible also in connection with the composition of other surveys carried out as part of the assessment. The information obtained will be used to support design work and decision-making, and for alleviating and preventing potential disadvantages.

Cooperation with stakeholders is an important part of the business of a modern socially responsible company. The working methods and contacts created during the EIA procedure can also be utilized in the future both when monitoring the social impacts of the project and when communicating with the stakeholders.

12 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.

Area definitions for the location of the power plant
Location area: a geographically indicated area where the location of power plant activities is being preliminarily planned.
Plant area: an area extending to a radius of about one kilometer from the power plant buildings.
Power plant site: the area where the actual power plant buildings are to be located.

Base load station
A large power plant generally used at full power to satisfy the continuous minimum demand for electrical energy.

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

Biotope
Biotope is a living area for organisms where the key environmental conditions are similar and therefore the assemblage of flora and fauna is of a specific type. Organisms typical of the biotope in question are found in every biotope. Division of the environment into different biotopes relates to the assumption that a certain kind of environment is a precondition for the success of a specific species.

Boiling water reactor
A type of light water reactor where the water 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).

Burnup of fuel
The burnup of fuel indicates its usability. If fuel that has been in the reactor has a low burnup, it can be reused. Exhausted fuel, on the other hand, has a high burnup.

Cesium-137 (Cs-137)
Cesium-137 is a radioisotope of cesium, which is mainly formed by the splitting of the nucleus, i.e. fission. Cesium-137 has a half-life of 30 years.

Commensurable carbon dioxide amount (carbon dioxide equivalent CO_2e)
Carbon dioxide equivalent stands for the commensurable unit of greenhouse gases. Different greenhouse gases have a different global warming potential. However, when all greenhouse gases are converted into carbon dioxide equivalents using the GWP factor (Global Warming Potential), their greenhouse gas emission can be summed up.

Contamination
Contamination means pollution. For instance, exposure of tools to radioactive radiation contaminates them, and without isolation, contamination may spread further from them.

Control area
At least those premises of the plant where external radiation dose rate could exceed 3 µSv/h or where 40 weeks of weekly exposure could result in an internal radiation dose of more than 1 mSv per year must be specified as the control area. (YVL 7.9)

Cooling water
Cold sea water is called cooling water, with which the steam coming from the 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 pressurized-water reactor) and is evaporated. Cooling water is not in contact or mixed with the process waters of nuclear power plants.

dB (Decibel)
Unit of the volume of sound. An increase of ten decibels in the noise level means that the sound energy increases tenfold. Ambient noise measurements typically employ A-weighting dB(A), which emphasizes the frequencies where the human ear is most sensitive.

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

Decommissioning waste
Waste-containing activity that is generated when decommissioning the nuclear power plant or other nuclear facility after utilization.

Defense in depth
According to defense in depth, the planning and use of nuclear power plants require several independent protection levels and methods in order to prevent accidents, to manage operating failures and accident situations, and reduce the consequences of accidents.

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 the nature.

Efficiency (η)
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 the environmental impact, the objective of the statutory EIA procedure is to improve the availability of data for citizens and their possibilities for 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.

EMAS (the Eco-Management and Audit Scheme)
A voluntary environmental system for companies and other organizations, based on an EU regulation.

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.

Flada
A bay beginning to separate from the sea due to land-uplift, a habitat to be protected pursuant to the Water Act.

Gloe lake
A water area separated from the sea due to land-uplift, a habitat to be protected pursuant to the Water Act.

Gray (Gy)
The gray is the SI unit of absorbed radiation dose. One gray is the absorption of one joule of radiation energy by one kilogram of matter.

GWh
Gigawatt hour is the unit of energy (1 GWh = 1,000 MWh).

Half-life
Half-life is the time after which half of the atom nuclei of a radioactive substance have disintegrated into other atom nuclei.

High-enriched uranium
Enriched uranium has been processed so that the percentage composition of its readily fissionable isotopes 233 or 235 of the entire uranium mass increases beyond 0.7%. Uranium isotope 238, which is non-fissionable under normal conditions, constitutes nearly 99.3% of natural uranium. For nuclear reactors, uranium is enriched to a concentration of approximately 2%–5%. Uranium enriched to a concentration of more than 20% is called Highly Enriched Uranium (HEU).

IAEA
The IAEA (International Atomic Energy Agency) is an organization under the UN that seeks to promote the peaceful use of nuclear energy. The IAEA also promotes radiation safety, nuclear safety and nuclear disarmament.

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

Impact area
An area where the environmental impact is assessed to appear as a result of studies. The impact areas are presented in the EIA report.

Iodine-131 (I-131)
Iodine-131 is a radioisotope of iodine that forms in small volumes in the fission reaction of uranium-235. Iodine-131 has a half-life of only approximately eight days.

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

Ion exchange mass
A substance used to remove ion-shaped impurities in water.

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

ISO 14001
A voluntary environmental system for companies and other organizations, based on the international ISO standard.

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, 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 power plant reactors are light water reactors.

Man-year
The regular annual working hours of one person.

Mean sound level, equivalent sound level
A calculated sound level in which sound of varying intensity has been mathematically converted into steady sound.

Mixed oxide fuel
See MOX fuel

MOX fuel
MOX fuel is a mixed oxide fuel for a nuclear power plant. MOX differs from ordinary uranium fuel in that a part of its fissionable matter is plutonium-239 instead of uranium-235. Plutonium does not occur in significant amounts in nature, so it is obtained for MOX fuel by recycling spent nuclear fuel or from nuclear disarmament.

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

Natura area
A Natura area conserves the living environments of habitat types and species specified in the EU Habitats Directive.

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 that causes a chain reaction based on the splitting of nuclei.

Nuclear Power Plant
Nuclear power plant consists of at least one nuclear power plant unit with a reactor, one or two turbines and generators in each unit.

Observed area
An area defined for each environmental impact type where the environmental impact in question is studied and assessed. The extent of the review area depends on the environmental impact under review.

ONKALO
ONKALO is Posiva's underground rock characterization facility for the spent nuclear fuel disposal plant located in Olkiluoto.

Pressurized water reactor
A type of light water reactor where the pressure of the water used as a cooler and moderator is kept so high that it will not boil, even at high temperatures. The water passed through the reactor core transfers its heat in separate steam generators to the secondary circuit water, which evaporates and is led 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 ionizing radiation, which is either electromagnetic radiation or particle radiation.

Radionuclide
Radionuclide is an atom nucleus that emits radiation.

Richter scale
The Richter scale is a mathematical method used for measuring the magnitude of earthquakes.

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 (µSv) units are used (1 µSv = 0.001 mSv = 0.000,001 Sv).

Solidification plant
A cementation or bituminization plant where liquid waste is solidified by mixing it with concrete and allowing the concrete to harden or by mixing it with hot bitumen which is then allowed to cool down.

Sound level
Frequency-weighted sound pressure level. See A-weighted sound level and C-weighted sound level.

Sound pressure level
Twenty times the common logarithm of the ratio of the root-mean-square sound pressure amplitude to the reference sound pressure. The unit of sound pressure level is decibel (dB).

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 cesium, and is highly radiating.

Steam generator
A heat exchanger used in a pressurized water plant. The steam led to the turbines is generated at the steam generator's secondary side.

Strontium-90 (Sr-90)
Strontium generates heat as it splits, and it is used in space ships and remote weather observation stations, for instance. Strontium is formed as a by-product of fission reaction. Strontium has a half-life of approximately 29 years.

STUK
The Radiation and Nuclear Safety Authority

Succession
The gradual natural changing of the population of a specific location. For example, gradual change in the species of the land-uplift coast.

TEM
Ministry of Employment and the Economy (former Ministry of Trade and Industry, KTM).

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

Transuranium element
Transuranium element refers to radioactive elements heavier than uranium.

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 elements (four grams in a ton). All isotopes of uranium are radioactive. The majority of natural uranium is isotope U-238, the half life of which is 4.5 billion years. About 0.71% of natural uranium is U-235, which is suitable as a fuel in nuclear power plants.

WNA
World Nuclear Association

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ENVIRONMENTAL IMPACT ASSESSMENT PROGRAMME FOR FENNOVOIMA LTD'S NUCLEAR POWER PROJECT; STATEMENT BY THE CONTACT AUTHORITY

On 30 January 2008, Fennovoima Ltd submitted an environmental impact assessment programme (the EIA programme) to the Ministry of Employment and the Economy (hereinafter the MEE) in accordance with the environmental assessment procedure (the EIA procedure), pursuant to the Environmental Impact Assessment Act (468/1994; EIA Act), on a nuclear power project. Prepared by the organisation responsible for the project, the EIA programme presents a plan for the necessary studies and implementation of the EIA procedure. The EIA programme also includes a description of the present state of the environment in the area likely to be affected.

Pursuant to the EIA Act, the MEE will act as the contact authority in the EIA procedure.

A public notice announcing the launch of the EIA procedure was published on 5 and 7 February 2008 in the following newspapers: Helsingin Sanomat and Hufvudstadsbladet, and the following regional newspapers: Kristiinankaupunki area; Ilkka, Pohjalainen, Suupohjan Sanomat, Syd-Österbotten, Vasabladet and Satakunnan Kansa; Pyhäjoki area; Kalajokilaakso, Keskipohjanmaa, Pyhäjokiseutu, Raahelainen, Raahen Seutu, Vieskalainen; Ruotsinpyhtää area; Borgåbladet, Uusimaa, Kymen Sanomat, Loviisan Sanomat, Östra Nyland – Kotka Nyheter, Etelä-Suomen Sanomat; Simo area; Kaleva, Lounais-Lappi, Meri-Lapin Helmi, Pohjolan Sanomat.

The public notice, the assessment programme, and the comments and opinions received by the MEE during the consultation can be found on the MEE's website at HYPERLINK "http://www.tem.fi" www.tem.fi

Members of the public were able to view the assessment programme between 5 February and 7 April 2008 in the following local government offices or the environmental offices: Pyhäjoki, Ruotsinpyhtää, Simo, Kristiinankaupunki, Raahe, Alavieska, Vihanti, Merijärvi, Siikajoki, Oulainen, Kalajoki, Pyhtää, Lapinjärvi, Pernaja, Elimäki, Loviisa, Anjalankoski, Keminmaa, Tervola, Ranua, Ii, Kemi, Karijoki, Isojoki, Merikarvia, Kaskinen, Teuva and Närpiö.

In partnership with the organisation responsible for the project, the Ministry organised the following public meetings: Kristiinankaupunki 7 February 2008, Pyhäjoki 13 February 2008, Ruotsinpyhtää 11 February 2008 and Simo 12 February 2008.

The comments and opinions invited and presented on the assessment programme are summarised in Chapter 3. A summary of the comments received on the nuclear waste management programme is presented in a separate annex.

The Espoo Convention (67/1997) will be applied to the assessment of the project's cross-border environmental impacts. Correspondingly, the parties to the Espoo Convention have the right to participate in the EIA procedure. The Ministry of the Environment is responsible for the practical arrangements for conducting the international hearing and has notified the following countries of the project: Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia, Russia and Austria.

1 Project information

1.1 Organisation responsible for the project

The organisation responsible for the project is Fennovoima Ltd. Its consultant in the environmental impact assessment has been Pöyry Energy Oy.

1.2 Project and its alternatives

Fennovoima is preparing to build one or two nuclear power plant units in one of the following plant locations and municipalities: Norrskogen and Kilgrund in Kristiinankaupunki, Hanhikivi in Pyhäjoki, Kampuslandet and Gäddbergsö in Ruotsinpyhtää or Karsikkoniemi and Laitakari in Simo. Two nuclear power station options are being assessed, the first involving the construction of a nuclear power station unit with a production capacity of some 1,500–1,800 MW and thermal input of 4,500–4,900 MW.

The second alternative involves the construction of two reactors with a production capacity of around 1,000–1,250 MW respectively and a combined thermal input of 5,600–6,800 MW. A pressurised water reactor and a boiling water reactor are both being considered. For the purposes of this document, 'project' means the entire Fennovoima nuclear power plant project. Wherever the alternative involving two nuclear power plant units is discussed, the definition 'nuclear power plant units' is used.

The project also includes the intermediate onsite storage of spent nuclear fuel generated by the new unit, the treatment of low- and intermediate level waste, and the final disposal repository. Moreover, the project includes the implementation of the necessary power transmission link to the national grid.

Should the project be implemented, Fennovoima's objective is to begin the construction of the new nuclear power plant in 2012. The plant could be deployed sometime around 2018. In the case of two reactors, the first construction site would be finished one or two years ahead of the second one.

As a zero option, the EIA programme presents a situation in which the project would not be implemented. Fennovoima would not consider building another type of power plant instead of the nuclear power plant. The zero option would entail increasing the import of electricity to Finland and/or implementing other organisations' power plant projects in order to meet Finland's increasing electricity requirements. The environmental impact of the zero option is illustrated by providing an overview of public estimates of the environmental effects of different methods of power production.

2 Licencing of nuclear facilities

The Nuclear Energy Act describes the licensing procedure required for a nuclear plant. Decision-making and the licensing system is based on a principle whereby safety is continuously reviewed, the assessments being further defined throughout the procedure so that the final safety assessments are only made at the operating licensing stage.

Environmental impact assessment

Fennovoima will draw up an EIA report based on the assessment programme and the contact authority's statement, followed by a public hearing on the EIA report. The responsible organisation estimates that the EIA report will be finished in the autumn of 2008.

The EIA procedure constitutes part of the safety and environmental impact assessment for nuclear power plants laid down in a decision-in-principle under the Nuclear Energy Act (NEA 990/1987).

Decision-in-principle

The planned nuclear power plant complies with the definition of a nuclear plant of considerable general significance, as laid down in the Nuclear Energy Act, requiring the Government's project-specific decision-in-principle on whether the construction project is in line with the overall interests of society. The application for a decision-in-principle can include the option of building two nuclear power plant units. In accordance with the Nuclear Energy Decree (NED 161/1988), the application for a decision-in-principle shall include an EIA report complying with the Environmental Impact Assessment Act. The scope of the project, outlined in the application for the decision-in-principle, may not exceed that described in the EIA report.

The application for the decision-in-principle is not solely based on the material provided by the applicant. The authorities will acquire supplementary reports, both those required pursuant to the Nuclear Energy Decree and other reports deemed necessary, providing a broader analysis of the project. In preparation for the processing of the application, the MEE will obtain a statement from the council of the local authority intended to be the site of the power plant, and from its neighbouring local authorities, the Ministry of the Environment and other authorities, as laid down in the Nuclear Energy Decree. In addition, the MTI will obtain a preliminary safety assessment from the Radiation and Nuclear Safety Authority (STUK).

Pursuant to section 24(h) of the Nuclear Energy Decree, the decision-in-principle shall include an overview of the applicant's plans and available methods for arranging nuclear waste management. The submission of plans based on binding agreements involving matters such as the nuclear waste management of the nuclear power plant project cannot be expected during the decision-in-principle stage. This rule also applies to fuel supply management (section 24(g) of the Nuclear Energy Decree)).

The MEE will provide local authorities, residents and municipalities in the immediate vicinity of the power plant with an opportunity to express their opinions in writing before the decision-in-principle is made. The Ministry will arrange a meeting, where members of the public will have the opportunity to express their opinions verbally or in writing. These responses will be submitted to the Government.

Pursuant to the Nuclear Energy Act, before making the decision-in-principle, the Government shall ascertain whether the municipality comprising the planned location of the nuclear facility is in favour of the facility, and ensure that no facts indicating a lack of sufficient prerequisites for constructing and using a nuclear facility in a safe manner and not causing injury to people, or damage to the environment or property, have arisen in the statement from STUK or elsewhere during the processing of the application. The Government's decision-in-principle shall be forwarded, without delay, to Parliament for its consideration. Parliament may reverse the decision-in-principle or decide that it should remain in force as it stands.

Construction licence

The actual licensing procedure follows the Government's decision-in-principle. Construction of the nuclear power plant requires a licence issued by the Government, stating that the construction project is in line with the overall interests of society. Furthermore, sufficient safety, the protection of workers, the population’s safety and environmental protection measures must be taken into account appropriately when planning the operations, and the location of the nuclear power plant must be appropriate with respect to the safety of said operations.

Any decision regarding the construction licence shall describe how the EIA report and the related statement by the contact authorities have been applied (section 13 of EIA Act).

During the construction licence application, checks will be made to ensure that a site has been reserved for construction in the town plan and that the applicant has possession of the site, as required for the operation of the plant (section 19(4) of the Nuclear Energy Act)). Therefore, the planning process must be finalised by this stage (cf. section 9 of the EIA Act). In practice, the MEE takes this to mean that during the EIA, the arrangements required by the planning process, such as the hearings, cannot be combined with similar arrangements laid down in the EIA. However, the information and reports produced by the EIA procedure can be used in the planning process.

The EIA will be finished considerably ahead of the planning. A planning officer from the local environmental office was involved in a consultative role in the four public hearings organised by the MEE in February 2008.

A hearing procedure involving municipalities, authorities and citizens will be established during the application process for the construction licence.

Operating licence

Operation of a nuclear power plant requires a licence issued by the Government. In order to receive such a licence, the operation of the nuclear facility must be arranged so that it is in line with the overall interests of society, and so that the protection of workers, safety and environmental protection have been taken into account as appropriate.

A hearing procedure involving municipalities, authorities and citizens will be established during the operating licence application process.

3 Summary of comments and opinions

The following organisations were invited to comment on the assessment programme:

Ministry of the Environment, Ministry for Foreign Affairs, Ministry of the Interior, Ministry of Social Affairs and Health, Ministry of Defence, Ministry of Finance, Ministry of Transport and Communications, Ministry of Agriculture and Forestry, Radiation and Nuclear Safety Authority, State Provincial Office of Western Finland, State Provincial Office of Southern Finland, State Provincial Office of Oulu, State Provincial Office of Lapland, Western Finland Environmental Permit Authority, Northern Finland Environmental Permit Authority, Finnish Environment Institute, Regional Environment Centre of Lapland, Regional Environment Centre of North Ostrobothnia, Regional Environment Centre of West Finland, Regional Environment Centre of Uusimaa, Occupational Safety and Health Inspectorate of Northern Finland, Occupational Safety and Health Inspectorate of Vaasa, Occupational Safety and Health Inspectorate of Uusimaa, Safety Technology Authority, Northern Ostrobothnia TE Centre, Kainuu TE Centre, Southern Ostrobothnia TE Centre, Lapland TE Centre, Uusimaa TE Centre, Council of Oulu Region, Regional Council of Ostrobothnia, Regional Council of Lapland, Regional Council of Itä-Uusimaa, Confederation of Finnish Industries, Finnish Energy Industries, WWF, Greenpeace, Finnish Association for Nature Conservation, the Finnish Society for Nature and Environment, Central

Union of Agricultural Producers and Forest Owners, Confederation of Unions for Professional and Managerial Staff in Finland (Akava), Central Organisation of Finnish Trade Unions, Finnish Confederation of Salaried Employees, Federation of Finnish Enterprises, Fingrid Oyj, Posiva Ltd, Fortum Oyj, TVO Oyj, Finavia, Finnish Civil Aviation Authority, Ostrobothnia Fire and Rescue Services, Lapland Fire and Rescue Services, Itä-Uusimaa Fire and Rescue Services, Jokilaaksot Fire and Rescue Services and the following municipalities: Pyhäjoki, Ruotsinpyhtää, Simo, Kristiinankaupunki, Raahe, Alavieska, Vihanti, Merijärvi, Siikajoki, Oulainen, Kalajoki, Pyhtää, Lapinjärvi, Pernaja, Elimäki, Loviisa, Anjalankoski, Keminmaa, Tervola, Ranua, Ii, Kemi, Karijoki, Isojoki, Merikarvia, Teuva, Kaskinen and Närpiö. The MEE invited the National Board of Antiquities to submit a comment on 30 April. Consequently, the comment was not yet available at the time of writing this report but will be made available to the responsible organisation as soon as it is received.

Comments were not received from the following organisations: Ministry for Foreign Affairs, Ministry of Defence, Ministry of Transport and Communications, Finnish Environment Institute, Occupational Safety and Health Inspectorates of Northern Finland and Vaasa, WWF, Central Union of Agricultural Producers and Forest Owners, Finnish Confederation of Salaried Employees and the following municipalities: Vihanti, Anjalankoski, Lapinjärvi, Alavieska, Ranua and Ii.

In the assessment procedure with respect to cross-border environmental impacts, the Ministry of the Environment notified the authorities of the following countries: Swedish Environmental Protection Agency (Sweden), Ministry of the Environment (Denmark), Ministry of the Environment (Norway), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), Ministry of the Environment (Poland), Ministry of the Environment (Lithuania), Ministry of the Environment (Latvia), Ministry of the Environment (Estonia), Ministry of Natural Resources (Russia) and Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria).

Sweden, Lithuania, Norway, Poland, Germany (State of Mecklenburg-Western Pomerania), Estonia and Austria are participating in the EIA procedure and have commented on the EIA programme. Latvia has replied to the Ministry of the Environment that it will not participate in the EIA procedure.

The Ministry of the Environment has not received replies from Denmark and Russia. If any of the potential participants in the cross-border procedure submit a comment, it will be delivered to the organisation responsible for the project.

3.1 Comments invited by the MEE

Comments from the authorities

In the following presentation of the comments invited by the MEE, the comments on the entire EIA programme are followed by the comments submitted by each area in which the proposed plant is to be located. The annex to this statement includes a summary of the comments and opinions received regarding nuclear waste management.

According to the statement submitted by the Ministry of the Environment, the assessment programme generally describes matters laid down in section 9 of the Government Decree on the environmental assessment procedure (713/2006).

However, the Ministry finds the programme to be a very general description and deficient in several key parts. Consequently, the programme fails to provide sufficient information on how environmental assessment will be taken into consideration in the EIA report regarding each area.

In the summary of its statement, the Ministry of the Environment advises that the EIA report on the planned nuclear power plant should provide further details on the following matters in particular:

- Main alternatives to the project's location combined with the technical alternatives and, in conjunction with the zero option, opportunities to increase energy efficiency;
- The project's nuclear safety in relation to the location and technical alternatives;
- All stages of the project's fuel cycle and nuclear waste management;
- Environmental impacts of other projects closely related to the project, such as the building of transport links and power lines;
- Impacts of cooling water on the state of the sea according to the various intake and discharge alternatives.

The Ministry of the Environment also considers it advisable to submit any application for a decision-in-principle only after the contact authority has submitted a statement on the EIA report following the hearings.

Furthermore, the Ministry of the Environment finds it crucial that the necessary environmental decontamination measures during the after-care stage, to follow any emergency that might transpire, be assessed by the EIA. The Ministry has also identified several other points to be included in the EIA report.

According to the Department for Rescue Services of the Ministry of the Interior, the EIA programme has been comprehensively prepared and the Department for Rescue Services does not have any major suggestions for changes at this stage of the project. However, the Department for Rescue Services deems cooperation between local rescue services and any other related parties, and the organisations implementing the programme, to be important. The programme should include an assessment of the potential impact on the rescue services. While considering the plant location, an assessment should be made of whether it is appropriate to have key power production facilities located in close proximity to each other. When the location alternatives are assessed, the multiplicative effects of an emergency taking place in such a concentration should be considered.

The Ministry of Social Affairs and Health finds that, based on the EIA programme, Fennovoima is well-informed of its national and international obligations. The programme establishes that the company is familiar with the questions of radiation/human health protection both during the construction and operation of a nuclear power plant. Fennovoima will apply the best available guidelines on the assessment of the effects on humans. The Ministry considers the EIA programme sufficient and in compliance with the legislation in effect.

The Ministry of Finance finds no cause to criticise the content of the EIA programme. However, the Ministry of Finance points out the project's major social significance and would encourage the MEE to carry out a thorough assessment of the project's economic, social and environmental impacts, should a decision-in-principal be made later, pursuant to the Nuclear Energy Act.

The Ministry of Agriculture and Forestry points out that the national climate and energy strategy includes an adaptation strategy, which calls for stronger capabilities for meeting the challenges posed by climate change, such as extreme weather conditions. Rising sea levels in particular must be taken into consideration, and in order to ensure sufficient provision, the best available expertise must be applied.

The Ministry further points out the necessity of further analysis of the impacts on fish stocks and waterways, based on more specific data and concentrated effort. The impacts on agriculture, forestry and food production should be assessed as part of the EIA procedure.

The Radiation and Nuclear Safety Authority (STUK) maintains that, according to the general principle, nuclear power plants must be located in relatively sparsely populated areas and sufficiently removed from significant population centres since, during the plant's operation, the possibility of a radioactive leak following an emergency cannot be dismissed. The drawing of a protection zone for the prospective power plant site and restrictions on its population level will be subject to the requirements set out in the Ministry of the Interior's decision no. 01285, TU-311, VAL 1.1 of 15 June 2001, "Guidelines on radiation protection in the event of radiation risk", on civil defence measures and their effective implementation.

STUK further mentions that the creation of the regional, comprehensive and town plans required by a new nuclear power plant will be undertaken in accordance with the Land Use and Building Act (132/1999). Pursuant to section 58 of the Nuclear Energy Act, STUK must be consulted prior to the outlining and approval of a town plan for the area intended for the site of a nuclear facility.

The EIA report should account for and describe in more precise terms the intake and discharge of cooling water in the facility, including any possible remote intake and discharge options. A comprehensive dispersion calculation for waterway warming should cover the seasons and a range of weather conditions. In addition, the combined effect of cooling waters from the Fennovoima project and the three nearby units in Hästholmen must be assessed.

The Safety Technology Authority finds no cause to criticise the EIA programme, but points out that the assessment report must include a review of the risks associated with the construction of the plant and possible emergencies there during its operation. Kemi's Veitsiluoto area and a deepwater harbour are located in the Karsikko and Laitakari area of Simo. These areas involve sites which are monitored by the Safety Technology Authority and which are subject to safety reporting. The Loviisa power plant and Fingrid operations are located in the Ruotsinpyhtää area and the Valko port is located nearby.

A combined statement by the Northern and Western Finland Environmental Permit Authorities draws attention to the cooling water impact assessment.

3.2 Opinions by area

Kristiinankaupunki area:

The Regional Environment Centre of West Finland is of the opinion that the EIA programme is clearly structured but the current status, adjoining areas and nearby operations have not been fully and equally assessed. These should be presented in the report in a way which allows objective comparison of the alternatives. A review of the current environmental state and the impact assessment should be closely interlinked in the report. Furthermore, the report should pay attention to presenting the comparison methods and their background information in a clear and understandable manner.

The Centre regards the environmental impact assessment to be comprehensive on the whole and acknowledges the programme's glossary to be a good and necessary feature. However, the Centre makes a general point about the environmental impact assessment of construction and use, as well as the assessment of adequate reporting and monitoring, being badly undermined by the fact that the programme fails to provide a clear description of the location of the plant or the necessary infrastructure, aquatic construction, roads etc. for the various alternatives.

Furthermore, the Centre points out a number of specific areas, which must be taken up in the assessment report, such as the fisheries located within the initially planned site of the project. Therefore, the Centre considers the review of the current environmental state, as presented in the programme for the Kristiinankaupunki area, to be inadequate and imprecise.

The State Provincial Office of Western Finland considers Fennovoima's EIA programme adequate and appropriate.

Kristiinankaupunki considers the EIA programme to be in compliance with legislation but points out that the programme should be supplemented in a number of ways, as described in further detail in the Kristiinankaupunki statement.

As part of the EIA procedure, the municipality of Karijoki calls for a more in-depth assessment of the impacts of a nuclear power plant on agriculture, potato growing in particular, and on the area's ground water.

The town of Kaskinen and the municipalities of Isojoki and Merikarvia find no cause to criticise the EIA programme.

The municipality of Närpiö makes a number of detailed comments on the EIA programme to be dealt with in the EIA procedure.

The municipality of Siikajoki considers the project significant to the sub-region, and this should be taken into account when the impacts on the sub-region are being assessed.

According to the municipality of Teuva, the EIA programme has some shortcomings and requires, among other things, a more detailed review of the regional economic effects during and after the plant's construction, and specific, more in-depth traffic reviews.

The Ostrobothnia Fire and Rescue Services draw attention to the nuclear power plant's location in a new area and propose that this be taken into account in the assessment of the fire and rescue services' operations, including a number of questions regarding the available resources and evacuation. The assessment should also include a review of the handling of hazardous substances.

The Fishing Industry Unit of the Ostrobothnia TE Centre notes that the fishing industry section of the EIA programme is only cursory and, based on that review, it is not possible to assess whether the EIA programme will take account of all of the key factors influencing the fishing industry. As sufficient background data is lacking at this stage from the areas of Skaftung and Siipyy for a comprehensive EIA procedure, the assessment should first make use of the basic data on the area's fish stocks.

According to the Regional Council of Ostrobothnia, the EIA programme remains deficient in parts. For example, the programme lacks information on different transport routes and power transmission, and with respect to Kristiinankaupunki, the environmental review is poorer than the reviews of the current status of other areas.

Pyhäjoki area:

The Regional Environment Centre of North Ostrobothnia finds the assessment programme clearly structured. Its mode of presentation facilitates a comparison of the conditions found in the four alternative locations. The review of the current environmental situation in the area of Hanhikivi in Pyhäjoki is fairly comprehensive. Although lacking in some aspects, it highlights the need for a further review in order to provide background information to be used in the impact assessment. Questions regarding land use, waterways and environmental protection, in particular, require supplementary information. The Environmental Centre advises that the municipal building permission be clearly presented in the EIA report and the entire planning process explained, illustrating the nuclear power plant in the regional plan, the comprehensive plan and the town plan, and showing the area reservations for the project in each of the above.

Sources used for the cooling water dispersion model and questions affecting the review must be clearly explained in the assessment report so that the reliability of the dispersion model can be validated. Any possible room for error in the model must be clearly stated. Moreover, the impact assessment report on the effect of cooling and waste water on water quality and biology requires more detailed information. Water quality covers both the physical and chemical properties of water. The Environmental Centre also highlights a range of subject matters requiring further information, such as fishing, the presentation regarding protected areas and the procedures carried out under the Nature Conservation Act. Among the proposed alternatives, the Centre finds the Hanhikivi alternative to be the one in most serious conflict with the agreed protection decisions and biodiversity.

In the State Provincial Office of Oulu's view, the assessment programme clearly describes the project's preconditions, the operational principles of a nuclear power plant, the purpose of the EIA process, the official and permission procedures of the project, and the monitoring of operations.

According to the municipality of Pyhäjoki, the basic data of the programme appears comprehensive and the mode of presentation appropriate. However, the EIA report must be supplemented with more detailed information on the area's marine biology, fish stocks, bird life and terrestrial animals. With regard to cooling water intake, the impact of, and provision for, pack ice formations should be investigated. Pyhäjoki points out that there is actually only one prospective site on the Hanhikivi peninsula, which falls within the borders of the municipality.

The town of Raahe draws attention to a careful impact assessment of the use of cooling water on the relatively shallow and closed coastal area of the Gulf of Bothnia. An impact assessment of land use (planning development) must be undertaken, paying attention to the impact on properties in the area belonging to the town of Raahe. Furthermore, the EIA report must comment on the impact on the value and potential conservation of sites with specific natural and landscape protection interest. Raahe also highlights the project's value to the sub-region.

The town of Oulainen and the municipality of Merijärvi find no cause to criticise the EIA programme.

Jokilaaksot Fire and Rescue Services maintains that the EIA procedure should take as its starting point a scenario where the prospective nuclear plant construction site and the deployed power plant may lead to a completely new situation. The review should also take account of the practical aspects of population evacuation.

The Northern Ostrobothnia TE Centre finds it essential that the impacts on the regional economy and employment during the further stages of the assessment be described.

The Fishing Industry Unit of Kainuu TE Centre notes that Hanhikivi in Pyhäjoki falls within the Unit's remit. Carrying out an impact assessment on the fishing industry, based on the impact on the waterways, requires data on fish stocks and fishing in the area under review. However, there is little prior research on the Hanhikivi area.

According to the Council of Oulu Region, the key environmental impact of the nuclear power plant is the warm water mass produced by the plant. The Council hopes that the impact of the plant on waterways will be assessed comprehensively. The multiplicative effects of the project on the economy, the area's image and the travel industry should also be assessed.

Ruotsinpyhtää area:

Uusimaa Environmental Centre finds the EIA programme structurally clear but the planned impact assessment has been presented in such a general way that it is difficult to assess whether the assessment will be adequate.

At the next stage of the review, the Centre suggests proposing an adequate number of both individual and combined cooling water intake and discharge points in order to present all available options. It would be particularly important to pay attention to the special conditions in Ruotsinpyhtää and to undertake a thorough assessment of the combined key effects of the current power plants in Loviisa.

The Centre also points out the importance of assessing rising sea levels and nature protection (for example, an assessment of the prevalence of the Siberian flying squirrel) in the case of a new power plant site.

The Rescue Services Department of the State Provincial Office of Southern Finland maintains that certain safety aspects of road and sea transport must be taken into account in further reviews, such as the increased traffic volume on the Archipelago Route and the route following on from it, Reimarsintie, during and after the implementation phase of the project, and the increasing volume of sea transport in the Gulf of Finland.

The municipality of Ruotsinpyhtää finds it important that the further reviews investigate aspects such as cooling water, traffic solutions, water supply arrangements and reclaiming heat from cooling water. With regard to the project's impact on the regional and town economy, issues such as the development of real estate tax should be examined.

According to the town of Loviisa, the environmental impact assessment of cooling water should take account of the fact that the current, and possibly the future, plants in Hästholmen discharge their cooling water into the same mass of water as the prospective Fennovoima project.

The municipality of Pernaja finds the EIA programme's review of the current state deficient in a number of areas. The nuclear power plant sites should have been marked on the maps at the programme stage rather than using the two large ellipses, which were not suitable for the purpose. Pernaja further observes that heat from the cooling water will represent a crucial environmental impact of the nuclear power plant. Therefore, the combined effect of all existing and planned power stations in the area should be fully accounted for in the assessments and reviews. Pernaja also comments on other issues, such as the assessments and reviews of exceptional weather conditions.

The municipality of Pyhtää finds Fennovoima's EIA programme comprehensive and sufficient for creating the basis of the assessment report. The municipality of Elimäki finds no cause to criticise the EIA programme.

Itä-Uusimaa Fire and Rescue Services point out that the distance from Fennovoima's site in Ruotsinpyhtää is less than five kilometres to the Hästholmen site in Loviisa. The EIA should assess the effects of the two separate nuclear power plants on each other in exceptional circumstances, emergencies and in disasters during so-called normal times. In any circumstances, the personnel and operations of two separate power plants located a short distance apart would form a significant concentration, which should be taken into consideration in the reviews.

The Occupational Safety and Health Inspectorate of Uusimaa finds that the Occupational Safety and Health Act and its decrees do not impose any additional demands on the current EIA programme.

Uusimaa TE Centre reviews the EIA programme with a special interest in the impact on waterways and consequently on the fishing industry. The Centre finds that in the case of Ruotsinpyhtää, the data presented might prove viable to some extent, since Hästholmen has been under monitoring, but the data does not necessarily apply to the other sites suggested by Fennovoima. The Centre emphasises the importance of gathering comparable data on the fishing industry at the different sites and recommends consulting the Finnish Game and Fisheries Research Institute for any further reviews.

The Regional Council of Itä-Uusimaa finds the EIA programme fairly comprehensive and illustrative of a broad range of issues. However, the EIA report must present the project's impacts on the regional structure and economy. It should also include an assessment of the combined effect of cooling waters from the current and planned Hästholmen projects and the Fennovoima project.

Simo area:

According to the Regional Environment Centre of Lapland, the EIA programme is generally unambiguous and illustrative, and the main alternatives have been presented clearly. However, the programme is deficient in terms of presenting alternatives within the suggested locations: several factors have not been discussed and therefore cannot be assessed. These include the cooling water intake and discharge alternatives, the location of the dock, the road and power transmission routing options, and the marine transport routes. All of the above factors should be discussed in the EIA report.

With regard to the environment, the location of Karsikko and Laitakari in Simo on the north-eastern part of the Bay of Bothnia means that the southerly and south-westerly storms have a strong impact on the area. Special attention should be paid to rising sea levels due to storms, in addition to changes affected by post-glacial rebound and climate change. In any case, the assessment must account for the possible effects of extreme weather conditions (particularly the combined effect of ice and wind). With regard to assessing the impact on waterways, the effects caused by warming sea water are the most important. Similarly, more effort must be devoted to assessing the project's impact on community structures, such as access to employment during the plant's operation and commuting needs. The Centre also comments on the linking of the EIA and planning procedures.

According to the Department of Social Affairs and Health of the State Provincial Office of Lapland, the report should discuss issues involving areas of permanent habitation and holiday homes within the plant's protection zone in particular.

The municipality of Simo finds no cause to criticise the EIA programme but asks for some factual mistakes to be rectified. The municipality of Tervola has no cause to criticise the EIA programme.

The municipality of Keminmaa finds that the assessment programme has been professionally prepared and finds no cause to criticise it. While a number of questions remain open in the EIA programme at this stage, these will be answered later in the EIA process.

The town of Kemi requires that the opportunities to reclaim the cooling water from the nuclear power plant be mapped. One of the options is to keep the Ajos deepwater harbour open with the help of cooling water discharge. Kemi also notes that the plan to build a housing estate in the area of Satamakangas would be prevented if the power plant were built, and this should be taken into consideration in the EIA.

The Lapland Fire and Rescue Services maintain that a systematic approach to security in the nuclear energy industry would involve preventing emergencies and limiting their consequences. From the Rescue Services' perspective, key issues to be investigated include warning and evacuating the population in the event of an emergency and ensuring that the rescue services have operational capabilities in the area. The Rescue Services point out that other environmental impact assessments are also required, for example due to the shipping lane in the vicinity of Karsikko and Laitakari in Simo (possibility of oil tanker emergencies). The Rescue Services also note that, in the EIA procedure, the impacts of the alternatives will be compared through first identifying the key areas, one of which must be safety.

The Fishing Industry Unit of Lapland TE Centre draws attention to the need for further reviews, which should focus on gathering new biological data on the Simo area in order to assess the project's impact on fish stocks and the fishing industry. These reviews should include the comprehensive mapping of spawning areas and the dispersion of nutrients from seabed sediments into the area's fish stocks following changes in the flow conditions.

The Regional Council of Lapland reports that it has agreed to launch the regional planning process as a stage plan for a nuclear power plant. The Council recommends that, in the future, planning and EIA processes be aligned more closely and in greater detail, both in terms of their schedule and content. Generally, the Council considers the EIA programme illustrative and well-presented. However, some inaccuracies and generalisations can be found in the description of impacts in the Simo area.

3.3 Other comments invited by the MEE

The Confederation of Finnish Industries EK finds the assessment programme comprehensive. It provides a comprehensive and balanced picture of the key issues and reporting needs arising from the EIA procedure under section 9 of the EIA Decree.

Finnish Energy Industries consider the EIA programme comprehensive and professionally prepared.

The Central Organisation of Finnish Trade Unions considers uninterrupted operation and safety in all circumstances to be the key points of the assessment. The Organisation regards assessing the impact on employment important. All in all, the Organisation finds the EIA programme sufficient and notes that it will enable the undertaking of the EIA procedure in compliance with the legal requirements.

AKAVA has submitted the opinions of three of its unions (the Finnish Medical Association, the Finnish Association of Graduate Engineers and the Union of Professional Engineers in Finland). The Finnish Medical Association points out that, with regard to assessing the environmental impacts, the new locations suggested by Fennovoima are more demanding than the old power plant concentrations, but decentralisation would also bring benefits. The Finnish Association of Graduate Engineers and the Union of Professional Engineers both find it important in the EIA procedure that equal terms be applied by the authorities to all similar projects.

Greenpeace states that the environmental impacts of the entire production chain of nuclear fuel should be considered as environmental impacts of the project. It further maintains that the effects of a serious nuclear emergency should be considered as potential environmental effects. According to Greenpeace, the impact assessment of a nuclear emergency should start from the premise that a significant share of the plant's total activity can be released into the environment. Moreover, with regard to nuclear waste management, Fennovoima's reference to the project investigating nuclear waste disposal in Olkiluoto is not sufficient to solve the problem.

The Finnish Association for Nature Conservation observes that, even though the EIA programme describes the EIA process appropriately and provides a great deal of background information, the assessment programme itself remains short and cursory. The Association identifies the presentation of the alternatives as an example and recommends that, in the EIA report, each site should include three alternatives: the zero option, one plant and two plants.

All in all, the Association finds that building a power plant on a greenfield site is a poorer option than building on a brownfield site, set aside for this kind of industrial activity and not having any environmental or cultural value. According to the Association, the EIA programme should be expanded when the sites (the plant sites, power lines, roads, lanes etc.) have been specified, and the EIA process should be discontinued until this has been achieved.

The Regional District of North Ostrobothnia of the Finnish Association for Nature Conservation observes that the visual image of the EIA programme has been emphasised at the expense of the content, and the programme itself remains general. The District also points out that post-glacial rebound must be taken into consideration in the Hanhikivi peninsula in Pyhäjoki.

The Regional District of Ostrobothnia of the Finnish Association for Nature Conservation finds the EIA programme a beautiful publication with a number of illustrations but very poor content. The District emphasises that a power plant of this size should be a combination plant where condensation heat can be fully reclaimed. In further reviews of the state of waterways, the risks to the reproduction of Ctenophora should be taken into consideration.

The Regional District of Lapland of the Finnish Association for Nature Conservation requires that the infrastructure of the Simo area be taken into account in further reviews. It also points out that there is a lack of information about the fishing industry in Karsikko and that some studies, such as field studies on migrating birds, cannot be carried out in the summer.

The Regional District of Kymenlaakso of the Finnish Association for Nature Conservation observes that, in the main, the EIA programme complies with the current requirements but that, in the case of four municipalities, it has perforce remained fairly general. The District would find it particularly worrying if the plant were to be located in an area where there is no existing industry. In the case of Ruotsinpyhtää, this would mean breaking up continuous forested areas with an industrial site.

According to the Regional District of Northern Finland of the Finnish Association for Nature Conservation, more attention should be paid in further reviews to the problems or fuel sourcing and nuclear waste management. In addition, radioactive emissions from the plant operation should be specified and the hazard they pose and their impact on the local ecosystems assessed in more detail.

The Finnish Society for Nature and Environment proposes several improvements to the EIA programme and finds Chapter 7 particularly deficient. The Society indicates that an environmental impact assessment should be carried out for three alternatives: 1) the zero option, 2) one nuclear plant unit (1,500-1,800 MW) and two nuclear plant units (2x1,000-1,250 MW).

Sydbotten's Society for Nature and Environment states that nuclear power does not provide a solution to climate change. It suggests that Fennovoima should review radioactivity in the bottom sediment and food chain of the entire Baltic Sea. Referring to the proposed Kristiinankaupunki site, the Society questions Fennovoima's motives for building a nuclear power plant in an untouched and attractive natural setting.

The Federation of Finnish Enterprises finds no cause to criticise the EIA programme.

Fingrid Oyj has investigated the possibilities of connecting Fennovoima's project to the national grid and the necessary reinforcement of the grid for Fennovoima's facilities. Fingrid's grid reports are expected to be submitted by the end of the year.

The necessary reinforcements for connecting the power plant to the grid, and elsewhere in the national grid, will be taken into account in provincial planning, carried out in partnership with the regional councils alongside land use planning. The EIAs for the power lines, required to strengthen the national grid, can be launched after the network reviews have been carried out and the solutions related to the plant's site defined.

The Finnish Civil Aviation Authority reports that one of its duties under the Aviation Act is to process and issue permissions for obstacles to aircraft in flight. However, according to the Authority, this is not relevant at this stage of Fennovoima's EIA programme.

Finavia points out that, in the EIA programme, the impact of the project on the operation of airports and aerodromes has not been identified. Finavia expects this to be rectified in the programme due to the vicinity of the Simo site and the Kemi-Tornio aerodrome.

Fortum Oyj observes that among Fennovoima's proposed locations, the island of Kampuslandet and the Gäddbergsö peninsula in Ruotsinpyhtää are in the immediate vicinity of Fortum's Loviisa nuclear power plant on the island of Hästholmen. In addition, Fortum is in the process of carrying out an EIA procedure with the purpose of investigating the possibility of expanding Loviisa's power plant with a third power plant unit.

With regard to the EIA of Fennovoima's project, Fortum considers the impacts of power transmission lines, cooling water intake and discharge particularly important to the extent that they affect Fortum's plants. With regard to the cooling water intake and discharge sites, Fortum hopes that the EIA report will provide sufficiently clear and precise definitions so that any possible impacts on the current and planned power plant units in Loviisa can be assessed.

Posiva Oy and Teollisuuden Voima Oyj discuss the final disposal of spent nuclear fuel, please see the appendix.

3.4 Opinions from the international hearing

Sweden's environmental authority, Naturvårdsverket, has held a public hearing forming the basis of a statement. It received comments from 20 authorities and 15 organisations, and 41 comments or opinions from private individuals. These comments and opinions can be found on the Internet at htpp://www.naturvardsverket.se/sv/Nedre-meny/Aktuellt/Remisser/Aktuellapagaende/Finland-planerar-for nytt-karnkraftverk/.

According to Naturvårdsverket, the key authorities consider the main points of the EIA programme adequate. The sea will be significantly affected, and data on this is being gathered under the environmental monitoring programmes of the current facilities.

Sweden's state provincial offices (Norrbotten, Västerbotten, Västernorrland and Uppsala) draw attention to the impacts of any serious emergency in Sweden. The municipalities and towns which commented on the programme (Kalix, Kiiruna, Piteå, Skellefteå, Timrå, Uumaja, Örnsköldsvik and Haaparanta) suggest that the impacts any such emergency be assessed at local level in Sweden, with regard to the different plant alternatives. The municipalities require that all of the environmental impacts on Sweden be discussed in a separate chapter.

Other comments and opinions received by the Swedish environmental authority emphasise the assessment of radioactive emissions from several perspectives. In particular, the organisation's or person's view on the general use of nuclear energy has influenced their comments and opinions. These comments and opinions draw attention to the weakness of the zero option, the long-range transport of, and preparedness for, possible radioactive emissions, the mitigation of possible adverse effects in Sweden, and the impact of cooling water and waste management on the Gulf of Bothnia and the Baltic Sea.

Acting as the environmental authority, the Norwegian Ministry of the Environment welcomes the assessment of radioactive emissions from any serious reactor emergency up to a radius of 1,000 kilometres. The comments invited and submitted by the Norwegian environmental authority also emphasise the assessment of radioactive emissions from several perspectives. Particular attention should be paid to the potential long-range transportation of radioactive emissions and the related preparations, and mitigating the potential harmful effects. The impact of emissions on the environment and industries should be assessed, e.g. vegetation, animals, and cattle and reindeer husbandry.

The Lithuanian Ministry of the Environment has no comments on the extent of the EIA programme at this stage but will participate in the EIA procedure.

Innenministerium Mecklenburg-Vorpommern in Germany proposes taking consideration of the long-range transport of air- and waterborne pollutants in the assessment of radioactive emissions, including an impact assessment of long-term transport and a description of how Germany, among other countries, will be informed in an emergency. The Ministry suggests that the impact assessment be enhanced by examining the environmental effects of nuclear fuel production and the management of new nuclear fuel, should Mecklenburg-Western Pomerania be involved in these areas.

The Polish Ministry of the Environment draws attention to the fact that the distance from Poland's northern coastline to Kristiinankaupunki and Ruotsinpyhtää is 1,000 kilometres but the other two proposed sites are further away. Poland would like to extend any further reviews of serious reactor emergencies to cover the possible long-range transport and impact of radioactive substances in Poland.

Acting as the environmental authority, the Estonian Ministry of the Environment stresses the description of cross-border emergencies from several perspectives. This description should identify any impacts requiring protection from radiation and the methods of informing neighbouring countries in emergencies. Estonia's Ministry of the Environment also expects the EIA report to include a review of the energy policy. However, in section 4.1 the MEE states that these do not fall under the remit of the operation in question but are the concern of the Government, should the project proceed to the decision-in-principal stage.

In Austria, the Federal Ministry of Agriculture, Forestry, Environment and Water Management is the national representative in the process, pursuant to the Espoo Convention. In a letter addressed to the Finnish Government, the Ministry affirms that Austria will participate in the EIA procedure under certain conditions.

Enclosed with the letter is a report by Österreichisches Ökologie Institut "Fennovoima Oy Scoping Phase of the EIA Program for an NPP", Expert Statement, Vienna 2008. This report also comments on the EIA programme. In practice, Austria requests that any possible impacts of Fennovoima's project on Austria be assessed. A worst case scenario should be used as the starting point for dealing with radioactive emissions in an emergency. Use of International Nuclear Event Scale (INES) class 6 as Fennovoima's starting point must be justified in the EIA report.

The report must also justify the need for the project, discuss the risks of nuclear fuel production, and assess the risks of the nuclear power plant's normal operation in more depth than outlined in the EIA programme, paying attention, for example, to the latest German research findings on the link between nuclear power plants and leukaemia in children.

3.5 Other comments and opinions

This summary introduces the issues and views that have been presented or highlighted in other comments or opinions. A total of 153 other comments or opinions were submitted. Some 35 of those were from national communities and organisations, four from foreign organisations and 113 from private individuals (several comments or opinions were signed or sent by more than one person) from various countries.

Six petitions were submitted to the MEE, in which the signatories opposed the project in its entirety. The number of signatures totalled over 6,300. The Piehinki Village Association's petition was signed by 54 people (in addition to a separate comment), Kristiinankaupunki Landowners' statement was signed by 239 people, the "Petition against nuclear power in Siipyy – Skaftung" from the Kristiinankaupunki area was signed by 1,517 people, and the "Pro Sideby/Siipyy – Kilgrund – Skaftung Petition against nuclear power" from the same area was signed by 4,512 people. Five organisations signed the petition, "Skrivelser mot kärnkraftsetablering i Sideby - Skaftung".

The sixth address, "Opinions expressed by residents in the neighbourhoods of Skaftung and Siipyy in Kristiinankaupunki regarding Fennovoima's nuclear power plant project" encloses an official letter based on the meeting held on 13 March 2008 and attended by 60 people representing 23 associations. The discussion and letter examine the EIA programme. In the summary, it is concluded that the area (in Kristiinankaupunki) is in no way suited to building a nuclear power plant. The organisations and persons attending the meeting were unanimous in their opinion that the power company's project should be discontinued.

The following organisations presented a comment or opinion: Samkommunen för Hälsovårdscentralen i Kristinestad-Bötom, Närpiö Health Centre, Skaftung Village Association, Nylands Fiskarförbund, Stiftelsen Kilens Hembydsgård, Hepola Residential Association, the Association of Professional Fishers in Finland, Parhalahti Fishing Club, Pyhtää Nature–Pyttis Natur, Skärgårdens Vänner i Strömfors rf (Pro saaristo), Ii Environmental Association, Itä-Uusimaa Association of Nature and Environmental Protection, Pyhäjokialue Nature Conservation Association, Kemi Area Nature Conservation Association, Raahe Area Nature Conservation Association, Östra Nylands Fågel- och Naturskyddsförening, Miljöringen rf – Ympäristörengas ry, South-West Finland's Green Party, Loviisa Area Green Party, Green Party Women's Association in Lapland, Parhalahti Hunters Association, Suupohja Ornithologic Association, Northern Ostrobothnia Ornithologic Association, Raahe Area Bird Club Surnia, Maksniemi Common Waterway Partners, Siipyy Reparcelling Unit, Perämeri Fishing Area, Ostrobothnia Australis, Women Against Nuclear Power, Women for Peace in Finland, the Edelleen ei ydinvoimaa popular movement against nuclear energy, the Lappilaiset Uraanivoimaa Vastaan popular movement against nuclear energy, and Pro Hanhikivi Association.

Two individuals and the following organisations presented comments or opinions from other countries: Reseau Sortir du nucleaire, Friends of the Earth Europe, Miljöorganisationernas kärnavfallsgranskning MKG, and Atomstopp atomkraftfrei leben!.

Several comments suggest that the environmental impact assessment should be enhanced in order to consider the entire life cycle of the project, including the environmental impact of processing and transporting uranium, the decommissioning of facilities, nuclear waste management and transport.

The comments also mention the project's social significance and address the need to assess other alternative means of energy production. Several comments and opinions do not present views relating to the EIA programme in addition to the aforementioned comments, but oppose the use of nuclear energy in general. The following is a summary of some of the special questions presented in certain comments or opinions.

Pyhäjoki Fishing Club stresses that, should the project be located in Pyhäjoki, attention should be paid to the changes in the marine ecosystem caused by the thermal load of the project. The Club is worried about the preservation of fish stocks, particularly with regard to fish species, which spawn during the cold water period. Several other associations and private individuals from different localities have observed that matters regarding fishing should be further investigated, such as the Association of Professional Fishers in Finland, Nylands Fiskarförbund rf. (Ruotsinpyhtää) Parhalahti Fishing Club (Pyhäjoki) and Perämeri Fishing Area (Simo).

In a statement dated 5 April 2008, Pro Hanhikivi Association points out that its previous comments on the EIA programme draft have not been accounted for and urges that the comments presented in its statement of 5 April 2008 to the MEE be acted upon in the EIA report. Furthermore, the Association delivered a Pro Hanhikivi publication to the Ministry on 24 April 2008.

Maksniemi Common Waterway Partners point out that, since all operations of the power plant will be carried out in the area managed by the Partners (the Simo area), an overall impact assessment of waterways, and flow conditions in particular, must be undertaken as part of the EIA procedure. Sideby Skifteslags - Siipyy Reparcelling Unit for the waterways in Kristiinankaupunki area also presents a number of points regarding nature conservation and legal matters.

4 Contact authority's statement

The MEE states that Fennovoima's EIA programme meets the content requirements of EIA legislation and has been handled in the manner required by the legislation. The comments submitted consider the programme to be, in the main, appropriate and comprehensive. However, the Minister is of the opinion that the assessment programme should be reviewed and the EIA report outlined so that all points made by the contact authority in this chapter are given the appropriate level of consideration.

Moreover, the organisation responsible for the project should also account for the additional questions, notes and views presented in the comments and opinions, answering as many of them as possible in the assessment report.

Any shortcomings or inaccuracies identified in opinions and comments regarding the EIA programme must be rectified. The Ministry proposes that the organisation responsible for the project would attach a table to the EIA report, listing the issues identified by the contact authority, together with the response of the organisation responsible for the project and possible references to the relevant section of the EIA report.

Answers to the questions presented in the international assessment must be included in the summary to be prepared of the international assessment. The Ministry requires that the material, to be translated into the native languages of the countries in question, is adequate and includes the information listed in Annex II of the Espoo Convention. The EIA report shall include, as a separate chapter, a description of transboundary impacts. The material shall also indicate how the comments of nations participating in the EIA procedure within the framework of the Espoo Convention have been taken into consideration.

The EIA should include a comparison between the different alternatives, as balanced and diverse as possible, and the comparison should be included in the EIA report. Different alternatives refer for example to the sites, the thermal input volume (the number of plant units), the cooling water intake and discharge alternatives and/or cooling water reclamation. The proposed sites for the power plant units must be clearly defined as part of the general presentation and assessment of land use, even though the preliminary definitions outlined in the programme have been sufficient. In addition, the project's impact on the cultural environment must be assessed.

4.1 Project description and the alternatives

The assessment programme presents a summary of the power range and potential types of the planned power plant, including the operational principles of the boiling water reactor and the pressurised water reactor.

In the Ministry’s view, the EIA report should include an evaluation of current nuclear power plants on the market which are suitable for the project under review. Similarly, the safety planning criteria for the nuclear power plant must be presented with respect to the limitation of emissions of radioactive substances and environmental impacts, as well as an assessment of the possibilities of meeting the safety requirements in force. The Ministry suggests that, for the purposes of communicating the project, it may prove advantageous to include a brief description of the cost structure of the project and its alternatives in the assessment report.

The assessment programme briefly describes a zero option, the environmental impacts of which are illustrated by providing an overview of public assessments on the environmental impacts of different methods of power production.

In accordance with the Nuclear Energy Act, the MEE must provide the Government with a review of the importance of the nuclear power plant to Finland’s energy supply, in order to enable the Government to make its decision-in-principle.

The programme further proposes that energy conservation should not be analysed as an alternative, since the organisation responsible for the project does not have access to any energy conservation means that would allow the replacement of the quantity of electricity produced by the nuclear power plant. However, in addition to the aforementioned review, several comments propose assessments of conservation and the more efficient use of energy. The Ministry maintains that the organisation responsible for the project is a company that generates power only for its shareholders. Therefore, it cannot access any significant means of energy conservation or efficiency. However, the Ministry recommends that the assessment report briefly introduce the energy efficiency and conservation efforts undertaken by the applicant's owners.

Pursuant to the Nuclear Energy Act, the Ministry of Employment and the Economy shall submit a report on the importance of a new nuclear power plant to the national energy supply, supporting the Government's decision-making with regard to reaching the decision-in-principle. This report will include information on energy conservation and efficiency. However, the perspective of this report will cover the Finnish energy supply as a whole and thus could not be applied to the issue of replacing the power plant under review. The Ministry points out that the Government is currently preparing a long-term climate and energy strategy.

4.2 Impacts and the assessment

In the EIA programme, the impact of cooling and sewage water on water quality, biology, fish stocks and the fishing industry are assessed on the basis of existing studies and the results of dispersion model calculations. The possibilities with respect to utilising cooling waters will also be assessed.

Several comments remark on the significant impact of cooling water on the state of the marine environment around the power plant. The effect of warming on the fishing industry is also mentioned in several comments.

The Ministry is of the view that the impacts of cooling waters form the most significant environmental impact during normal plant operation. Consequently, when analysing the environmental impacts of sea water warming, any background material available must be utilised extensively. Uncertainties in calculation results must be illustrated clearly. Also, the alternatives for cooling water intake and drainage options must be presented clearly, and any possibilities for remote intake and drainage must be examined.

The calculations for cooling water should be presented in a conservative way, so that the combined thermal stress caused by all existing and planned power plants in the area is fully taken into account. The Ministry further recommends that, for all prospective localities, an option for one power plant unit should be considered, with a maximum production capacity of 1,800 MW and thermal input of 4,900 MW, alongside an option for two power plant units with a maximum production capacity of 1,250 MW and thermal input of 6,800 MW.

A new nuclear power plant would require an improvement in power transmission and a connection to the national grid. Fingrid Oyj has investigated how the nuclear power plant might be connected to the national grid, and examined the reinforcement of the grid, based on information provided by Fennovoima on the facilities.

The necessary reinforcement in connecting the power plant to the grid, and elsewhere in the national grid, has been taken into account in the provincial planning, carried out in partnership with the regional councils alongside land use planning. The company has commenced the preliminary planning of the necessary power lines, and will launch an environmental impact assessment of the power lines during 2007–2009. In its own EIA report, Fennovoima is obliged to provide information on the environmental impact of the required power transmission in the area of the proposed locations.

Assessing the impacts of exceptional and emergency situations must not be limited to the exclusion area or the emergency planning zone for rescue operations. The Ministry is of the view that the EIA report must present various emergency scenarios involving radioactive emissions and, with the help of illustrative examples, should describe the extent of the affected zones and the impacts of emissions on people and the environment. An account describing after-care following any serious emergency must be included in the EIA report.

The assessment may use the classification system (INES) of the International Atomic Energy Agency (IAEA), and the EIA report must present a clear summary of the basis of the review. The assessment must also include a review of the environmental impact of radioactive substances on the states around the Baltic Sea and on Norway. In addition, a more comprehensive assessment of the above impacts on Sweden must be undertaken in relation to all plant locations by the Gulf of Bothnia.

As exceptional situations, any eventual phenomena caused by climate change and the related preparations for coping with such phenomena must be examined (changes in sea level and other exceptional weather phenomena). The effects of post-glacial rebound must be taken into consideration.

The impact on water quality and biological factors must be assessed thoroughly and to a sufficient extent. Moreover, the state of the aquatic ecology in the affected area must be investigated at all levels of the ecosystem. The reviews should examine species both in terms of their numbers and distribution, and the quality of their habitats. Following these basic mappings, the impact of thermal load and waste waters on the aquatic ecosystem, in terms of both individual factors and the overall system, will be assessed.

The project's impacts on the natural values of the Natura 2000 areas must be investigated in detail and to a sufficient degree, by habitat and species, in order to provide an appropriate assessment of whether the project will undermine, alone or combined with other projects, those natural values which have formed the basis of the areas’ selection for the Natura 2000 network.

With regard to the socio-economic review of the EIA procedure, a detailed assessment should be provided of the project's impact on employment, during both the construction and operational stage of the power plant, taking the special characteristics of all localities and areas into consideration.

According to the EIA programme, the organisation responsible for the project will examine the environmental impacts of nuclear fuel production and transport, including mining, concentration and fuel manufacturing. The environmental impact assessment is based on existing studies. Some comments point out that the environmental impacts of the entire production chain of nuclear fuel should be considered as environmental impacts of the project. The Ministry finds it reasonable that the organisation responsible for the project examine the environmental impacts of the entire fuel supply chain in general and, additionally, the company's opportunities to influence this chain.

The locality-specific additional questions, which do not fall under the above general requirements, are as follows.

4.2.1 Special questions regarding Kristiinankaupunki

With regard to the Kristiinankaupunki area, the EIA report must pay attention to the comments (for example by the Ministry of Agriculture and Forestry, several associations and private individuals), which in particular recommend reviewing the state of the area's fisheries and agriculture, should the project be implemented. The questions presented by Sideby Skifteslags-Siipyy Reparcelling Unit concerning waterway ownership and planning must be examined in the EIA report in an appropriate manner.

4.2.2 Special questions regarding Pyhäjoki

The points made by the Pro Hanhikivi Association concerning energy conservation, nuclear waste management (See Appendix 1), pack ice and the Hanhikivi glacial erratic must be investigated in the EIA report.

With regard to the Pyhäjoki area, the assessments must pay attention to the impacts on conservation areas of interest with respect to specific bird life and bird-watching interests, as implied in several comments and opinions.

4.2.3 Special questions regarding Ruotsinpyhtää

As part of the environmental impact assessment of cooling waters, Fennovoima must also address a scenario in which there are three nuclear power plant units on the island of Hästholmen in Loviisa (Fortum Power and Heat Oy) and Fennovoima's proposed plant units in Ruotsinpyhtää. The MEE will also require Fortum to investigate this scenario, taking account of the fact that Fortum submitted the EIA report to the MEE on 3 April 2008.

(Although Fortum Power and Heat Oy has submitted an EIA report on 3 April 2008, it must also review the combined effects of the five power plant units with regard to its own solutions for cooling water.)

The Itä-Uusimaa Fire and Rescue Services have reviewed, in broader terms, the possible effects of two major power plants in close proximity to each other. Concerning preparedness planning and the rescue services, the combined effects of two power plant areas in exceptional circumstances and emergencies must also be taken into account. Skärgårdens Vänner i Strömfors r.f. and Pro Saaristo-komitea/Pro Archipelago Committee set forth questions regarding the status of the Gulf of Finland, the flow conditions of the area, and related thermal loads. The EIA report shall review these issues in an appropriate manner.

4.2.4 Special questions for Simo

Since Finavia has pointed out that the Fennovoima project to be placed in Simo has an effect on aviation service methods and aviation methods at the Kemi-Tornio aerodrome, the interdependence of the nuclear power plant and the aerodrome must be discussed in the EIA report.

Maksniemi Common Waterways Partners has commented on issues such as water flow, which must be addressed when preparing the EIA report.

One of the reclaiming methods for the nuclear power plant's cooling water, keeping open the Ajos deepwater harbour, as suggested by the town of Kemi, should be investigated.

4.3 Nuclear waste management (summary of comments and opinions, see annex)

The MEE maintains that the EIA report should review nuclear fuel and nuclear waste management as entities.

The environmental impacts of management and final disposal repository of low- and intermediate-level operating waste should, however, be assessed by site. This assessment should include a separate review of the management of waste decommissioning. The structure of the final disposal plant must be clearly presented, for example with the help of illustrations. The licensing plan for the plant must also be described in the EIA report.

The management of spent nuclear fuel must be described in general, on the same level as nuclear fuel supply management. Site management of spent fuel must be described with regard to each site and the intermediate storage of spent fuel must be described with the help of visual elements. The description of spent fuel management must also include any possible spent fuel transports from all alternative sites using transport methods deemed appropriate by Fennovoima.

In sum, the Ministry concludes that, according to Fennovoima's EIA programme, the environmental impact assessment of Fennovoima's project does not cover the final disposal of spent fuel. Pursuant to the Nuclear Energy Act, this is permissible. Therefore, the environmental impact assessment of spent fuel from the Fennovoima project must be carried out separately, when Fennovoima's plans for arranging nuclear waste management are further defined, pursuant to the Nuclear Energy Act.

4.4 Plans for the assessment procedure and participation

The MEE considers that arrangements for participation during the EIA procedure can be made according to the plan presented in the assessment programme. However, sufficient attention should be paid in communications to the entire affected area of the project, across municipal borders and all population groups, and to interaction with that area. The Ministry further requests that the parties consider ways of presenting the impact of participation in the assessment report. The sampling methods used in surveys conducted among residents and the methods used in group discussions must be described and justified in the EIA report.

When the assessment report is finalised, the MEE will publish a public notice, make the report available and invite various authorities to comment on the report. The statement on the EIA report, prepared by the MEE in its capacity as a contact authority, will be delivered to the municipalities in the affected area and to the appropriate authorities.

4.5 EIA Report, contact authority's statement on it, and the possible application for a decision-in-principle

In the licensing system pursuant to the Nuclear Energy Act, environmental impact assessment procedure is followed by an application for a decision-in-principle. Under the Act, the application to the Government for a decision-in-principle can be submitted before the contact authority has published a statement on the EIA report.

However, the Ministry of the Environment considers it advisable to submit any such application for a decision-in-principle only after the contact authority has submitted a statement on the EIA report following the hearings.

The MEE does not consider it appropriate that an EIA report and an application for a decision-in-principle be presented for comments at the same time, since they relate to the same project. Therefore, the Ministry hopes that it would at least be able to submit the EIA report for comments before the application for a decision-in-principle is presented to the Government.

5 Communicating the statement

The MEE will deliver the EIA statement to those authorities which have submitted comments and the communities which have been invited to submit a comment. The statement will be available in Finnish and Swedish on the Internet at www.tem.fi

The Ministry will provide copies of the comments and opinions concerning the assessment programme to the organisation responsible for the project. All comments and opinions received by the Ministry are published on the Internet.

The original documents will be stored in the Ministry's archives.

Mauri Pekkarinen
Minister of Economic Affairs

Jorma Aurela
Senior Engineer

Annex	Summary of comments and opinions on nuclear waste management
For information	Authorities which have submitted comments and the communities which the MEE has invited to comment on the programme