Loviisa EIA 3

Fortum Power and Heat Oy

Supplementing the Loviisa Nuclear Power Plant
with a Third Plant Unit

Environmental Impact Assessment Report

Fortum

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FOREWORD

In spring 2007, Fortum Power and Heat Oy, a subsidiary of Fortum Corporation initiated an environmental impact assessment (EIA) with a view to building a new nuclear power plant unit (Loviisa 3) on the island of Hästholmen in Loviisa. This is subject to a procedure in accordance with the Act on Environmental Impact Assessment Procedure (hereafter "the EIA Act"). From 1 January 2008, the coordinating authority of the project is the Ministry of Employment and the Economy. Previously the coordinating authority was its predecessor, the Ministry of Trade and Industry. The coordinator in the Ministry is Special Adviser Jaana Avolahti.

After completion of the environmental impact assessment, the company will make decisions on further measures. The implementation of Fortum's Loviisa 3 project will require a supporting statement of the Loviisa Town Council and a favourable resolution (former 'decision in principle') by the Government as well as ratification of this resolution in Parliament.

Legislation in Finland forbids the applicant's economical engagement, e.g. acquisition of a plant, before a favourable resolution. The technical solutions and plans in this assessment are based on the results of general planning for the EIA procedure in Fortum Nuclear Services Ldt. and on the general characteristics of the available plant types.

The plan for assessing the environmental impacts of the project and for arranging communications, i.e. the EIA programme, was finished in June 2007. The EIA programme was presented and discussed in the Municipal Advisory Group and the Audit Group. The programme was kept on public display between 2 July and 17 September 2007 among others in the municipal government offices and libraries of Loviisa, Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää as well as on the websites of Fortum and the Ministry of Trade and Industry. Information on the programme was also given in the local newspapers. A public information event and two town square events were arranged in Loviisa. The coordinating authority submitted its statement on the programme to Fortum on 16 October 2007 (Appendix 1).

The environmental impact assessment report, the EIA report, has been compiled on the basis of the EIA programme, the statements and opinions provided on it and other interaction. The EIA report describes the present state of the environment, the results of the environmental impact assessment and the conclusions drawn as well as the plans for mitigation of the detrimental environmental impacts. Interaction and communication were similar to the EIA programme phase.

The progress of Fortum's Loviisa 3 project EIA procedure has been controlled by a management group, whose chair in 2007 was Heikki Raumolin and in 2008 Arvo Vuorenmaa. The organisation responsible for the EIA procedure in Fortum is a project team with Reko Rantamäki as the project manager and Nici Bergroth as the planning coordinator. Peter Tuominen, Eevaliisa Helén, Mari Kalmari and Christian Leisio are responsible for interaction and communication. The persons involved in compiling the EIA report are Reetta von Hertzen (procurement of nuclear fuel), Jarkko Kyllönen (waste, decommissioning of the power plant, spent fuel), Päivi Mäkinen (environmental issues), Lauri Rantalainen (radiation doses in accidents), Satu Siltanen (nuclear safety and accidents) and Timo Toppila (cooling water model). Furthermore, several persons from the Loviisa Power Plant, the Generation business unit, Fortum Nuclear Services, the corporate units and other units have taken part in compilation of the report.

Pöyry Energy Oy has been involved in the implementation. Päivi Koski, M.A., has acted as the project manager; the other project group members are Pirkko Seitsalo, M.Sc.(Eng.) (environmental impact assessment), Satu Lyyra, Ph.D. (environmental impacts), Thomas Bonn, M.A. (Swedish material), Mirja Kosonen, M.A. (health effects), Lauri Erävuori, M.A. and Tommi Lievonen, M.A. (Natura assessment), Carlo Di Napoli, M.Sc.(Eng.) (noise modelling), Arto Ruotsalainen, M.A. (social impacts), Tuija Hilli, M.Sc.(Agr.&For.) (impacts on watercourses), Eero Taskila, M.A. (impacts on fish stock and fishing) and Juha Tervonen, M.Sc.(Econ.) (impacts on regional economy).

SUMMARY

In spring 2007, Fortum Power and Heat Oy initiated an environmental impact assessment (EIA) concerning the supplementing of its Loviisa nuclear power plant located on the island of Hästholmen in Loviisa with a third power plant unit (Loviisa 3). The Ministry of Employment and the Economy (MEEC) (Ministry of Trade and Industry until 31 December 2007) is the coordinating authority in the EIA procedure.

The organisation responsible for the project is Fortum Power and Heat Oy, a wholly-owned subsidiary of Fortum Corporation. Fortum Corporation is a leading energy company in the Nordic region and other parts of the Baltic Rim. The company's activities cover the generation, distribution and sale of electricity and heat, as well as the operation and maintenance of power plants. At the end of 2007, the Government of Finland held 50.9% of the share capital of Fortum Corporation.

On the assignment of Fortum Power and Heat Oy, (hereafter Fortum), Pöyry Energy Oy has participated in the implementation of this environmental impact assessment (EIA) procedure for the Loviisa 3 project. Fortum's project team has been responsible for the EIA procedure, and its progress has been monitored by a management team at Fortum

The EIA programme for the Loviisa 3 project was submitted to the coordinating authority in June 2007, and it was on public display from 2 July to 17 September 2007. The coordinating authority issued its statement about the programme to Fortum on 16 October 2007.

In the environmental impact assessment, the impacts of the project have been examined thoroughly. The focus was on those impacts assessed and considered as being significant. Information about the issues that citizens and various interest groups consider important was obtained through communication, interaction, a resident survey, and an international hearing, among other things.

Interaction

There has been active interaction during the EIA procedure for the Loviisa 3 project. Information and discussion meetings as well as town square events have been arranged for the general public. Participants in these meetings have had an opportunity to express their opinions and receive information about the project and its environmental impacts. Additionally, information about the project has been communicated through public bulletins, Fortum's web site and press releases. In conjunction with the EIA procedure, a survey conducted among local residents provided insight about the attitudes the people in the Loviisa area have towards the project.

An Audit Group consisting of representatives of the town of Loviisa and local municipalities as well as experts and authorities was established to monitor the EIA procedure and to promote the flow and exchange of information between the organisation responsible for the project, the authorities and other interest groups.

The purpose, location and schedule of the project

Consumption of electricity in Finland in 2007 was 90.3 TWh, and it is estimated to grow to 115 TWh by 2030. The average growth until 2020 is about 1.2% per year and 0.7% from 2020 to 2030. During the past ten years, electricity consumption has increased by an average of 2.6% a year. Also electricity imports to Finland have continuously increased during recent decades. Electricity imports in 2000-2006 averaged 10 TWh annually.

Fortum's goal is that the Loviisa 3 power plant unit will replace fossil fuel-based power plants with carbon dioxide-free generation, reduce the need for electricity imports, meet the growing demand for electricity, and in the future replace the production of Fortum's existing Loviisa power plant units.

The planned site for the new nuclear power plant unit is located on the south coast of Finland, on the island of Hästholmen, in Loviisa. The location is south of Fortum's two existing power plant units in an area suitable for power plant construction and planned for this purpose. The existing power plant units were commissioned in 1977 (Loviisa 1) and 1981 (Loviisa 2). The electrical power output of each power plant unit is about 490 MW.

If Fortum decides to continue implementing the project, an application for a resolution concerning the project must be submitted. Implementing the project is subject to a resolution issued by the Government and ratified by Parliament. A prerequisite for a favourable resolution is a favourable statement on the project by the town of Loviisa and by the Radiation and Nuclear Safety Authority (STUK). If the resolution is ratified and, in addition to environmental issues, the technical and financial prerequisites for construction are fulfilled, construction of the plant can commence in 2012 and the new power plant unit can be commissioned in 2018.

Project options and limits

The environmental impact assessment examined the construction of a 1000-1800 MW power plant unit on the island of Hästholmen in Loviisa. Fortum does not have any other location options. The reactor of the new power plant unit will be a light water reactor, either a boiling water reactor or a pressurised water reactor.

Four options have been examined for the new power plant unit's cooling water intake and discharge locations:

- **Local intake and local discharge (LL):** Cooling water is taken in from Hudöfjärden and discharged to Hästholmsfjärden
- **Local intake and remote discharge (LR):** Cooling water is taken from Hudöfjärden and discharged to Vådholmsfjärden
- **Remote intake and local discharge (RL):** Cooling water is taken from Vådholmsfjärden and discharged to Hästholmsfjärden
- **Remote intake and remote discharge (RR):** Cooling water is taken from Vådholmsfjärden and discharged to Vådholmsfjärden.

The cooling water for the existing power plant units will be taken from Hudöfjärden and discharged to Hästholmsfjärden, as is the practice today. Depending on the intake and discharge locations of the new power plant unit's cooling water, the length of the cooling water tunnel can be about five kilometres.

If the project is not implemented, a scenario in which a new power plant unit is not built on the island of Hästholmen in Loviisa and the existing power plant units continue their operations has been examined.

Links to other projects and plans

Posiva Oy will dispose of the new power plant unit's spent nuclear fuel at Olkiluoto in Eurajoki. In spring 2008, Posiva Oy launched an EIA procedure to expand the disposal facility for spent nuclear fuel at Olkiluoto.

The 400 kV transmission connection to the national grid required by the new power plant unit will be built from the switching station located in the existing power plant area. From the switch yard onwards, any modifications required in the power transmission grid and related environmental impact assessments are the responsibility of the national grid operator Fingrid Oyj. The new power plant also requires the strengthening of the 110 kV transmission connection.

The new power plant unit will increase traffic to and from Hästholmen, especially during the construction phase. In 2007, the road region of south-eastern Finland compiled a master plan for improving the main road 7 (E18) to a freeway between Loviisa and Kotka. Implementation of the Koskenkylä–Loviisa–Kotka road section is proposed for 2008–2013. The general plan of the freeway presents a new junction to the Loviisa and Ruotsinpyhtää border, with a new road connection to Hästholmen. Some of the traffic to and from the Loviisa power plant will use this new road connection during the construction and operation of the new power plant unit.

The new power plant unit can be constructed so that combined heat and power (CHP) production is possible. The CHP production option isn't solely up to the organisation responsible for the project, but requires a cooperation partner or partners that will commit to the project. District heat could be utilised, e.g. in the metropolitan area. There is no industry or other operations near the Loviisa power plant that could utilise heat in significant volumes, for instance as steam. This assessment presents the environmental impacts of CHP production in terms of Hästholmen and cooling water. The environmental impacts of the district heat tunnel or pipeline possibly to be realised will be assessed separately, if it is decided to realise them.

Impacts during the construction phase

Construction of a new power plant unit is similar to construction of other big industrial work sites and takes about six years including preparations.

Impacts during plant construction

Central work site operations will be located in an approximately 30-hectare area southeast of the existing power plant units. There is an approximately 18-hectare area available for use on the mainland for receiving materials and for preparatory work. Additionally, the construction work related to cooling water structures and the unloading and loading facility extends a short distance out to the sea and, depending on the cooling water option to be implemented, possibly to the islands five kilometres away.

The earth-moving work related to construction of the new power plant unit is sizable. Depending on the length of the cooling water tunnels, there will be some 1,300,000–2,100,000 m^3 of excavated and blasted materials. Some of the blasted rock material and aggregates made from it can be used in the construction. Of the blasted rock, 660,000 m^3 can be utilised. A temporary piling area can be reserved for the blasted rock from Fortum-owned area along Atomitie road leading to Hästholmen.

The work related to the construction of the new power plant unit doesn't cause damage to the environment, nor does it jeopardise the safety of the existing power plant units or the safety of the disposal facility for low- and intermediate-level radioactive waste. The construction work has no impact on the quality of the surrounding groundwater.

The new power plant unit will be located at Hästholmen in the existing industrial area, so construction is not esti-

mated to impact the flora, fauna, or natural areas. The fundamental improvement of Atomitie road could have an impact on the locally valuable natural areas (Mysskärret and Ryssviken).

Site construction, work site traffic and separate functions (e.g. concrete station, rock crushing and the piling of blasted rock) will cause local dust during the construction phase. Vehicles and construction equipment will cause small amounts of emissions into the air, and they don't have an impact on the air quality outside the work site area.

Construction-phase noise levels vary widely and are spontaneous in places. During the construction phase, a 50-dB zone covers the entire construction area in the fourth year of construction when the construction-related traffic is heaviest. The day-time limit of 45 dB is exceeded within the maximum distance of one kilometre from the construction site, e.g. in Bodängen and Åmusholmen. Noise will carry a little further in the southwest and west, where the rock crushing plant's noise embankment doesn't have muffling effect.

Implementation of the new power plant unit requires the shipping lane leading to Hästholmen to be deepened. The aim is to carry out both the deepening of the shipping lane and the excavation and dredging work for the unloading and loading site during the same open-water season. The most significant impact of the building of the unloading and loading site and the dredging of the shipping lane is an increase in the local water's level of solid matter and the resulting turbidity in the vicinity of the work site. Blasting work and water turbidity temporarily drive fish away from the area of activity.

The environmental impacts of building the cooling water tunnels and structures are related to landscape, the transportation of excavated materials, and the temporary and local turbidity of the water caused by the underwater handling of dirt and rock materials. Construction of the gate equipment targets rocky islands or islets that at the moment are almost in their natural state. The use of these islands or islets might have to be limited due to the cooling water structures to be located there.

Transports and traffic during the construction phase

During the construction of the new power plant unit, the volume of traffic on Atomitie road will quadruple at its heaviest compared to the current volume. The majority of the traffic is commuter traffic. Especially during the initial phase of construction, the share of heavy traffic on the road will increase. Traffic noise on Atomitie road during the construction phase will not exceed 45 dB during the day-time in the holiday cottage areas. Instead, traffic noise could disturb residential settlements along Saaristotie road.

Economic impacts

Building a new power plant unit is a significant project locally, regionally and economically, and it impacts the economic area's business activities and employment in the town of Loviisa and the Loviisa region in many ways. The earth construction, the construction of the power plant structures and the equipment purchases account for the most significant share of the new power plant unit's investments. The construction phase of the new power plant unit is estimated to generate about 21,000 man years of work in Finland. In terms of employment in the Loviisa region, the construction phase of the power plant unit is very significant.

Operational phase impacts

Impacts on land use, landscape and cultural environment

The new power plant unit is located in the Loviisa power plant area and utilises the existing infrastructure. Building the new power plant unit is compliant with the land use plan in effect.

The existing power plant units are already a dominating element in the local landscape, and the new power plant unit doesn't materially change the situation. The upper parts of the power plant units' reactor structures and the ventilation stacks are visible from afar from the sea. The impact is the biggest for the holiday cottage settlements, particularly at night when the power plant area is illuminated.

Emissions to air and impact on air quality

The radioactive releases during the power plant unit's operation are low, and they do not adversely affect human health or the natural environment.

Depending on weather conditions and the characteristics of each substance, radioactive substances drift to the ground surface and vegetation, waterways and organisms. Using sensitive analysis methods, small amounts of radioactive substances originating from the power plant can be detected occasionally among other radioactive substances in samples taken in the vicinity of the Loviisa Power Plant.

The new power plant unit's standby power equipment and the heat plant generate some carbon dioxide, nitrogen oxide, sulphur oxide and particle emissions. The carbon dioxide emissions are estimated to be an average of about 3,900 tonnes, nitrogen oxide emissions less than 4 tonnes, sulphur dioxide emissions less than 1 tonne, and particle emissions about 0.5 tonnes per year. The emissions caused by the standby power equipment and the heat plant are small and have no remarkable impact on air quality.

Impacts on waterways and the fishing industry

The effects of the warm cooling water on the temperature and ice conditions of the sea waters surrounding Hästholmen have been studied with a 3D current model. A cooling-water model covers about a 10-km radius of sea area around Hästholmen. The dispersion of warm cooling waters has been modelled in static weather conditions, and the different alternatives have been studied in balanced situations.

During summer, discharging the cooling water will cause an increase in the temperature of the sea water around the discharge site in all options except the remote intake–local discharge option (RL), in which the temperature of Hästholmsfjärden will decrease from the current temperatures. In the remote intake–local discharge option in summer, the cooling water taken from deep waters is clearly colder than the surface water, so the temperature of the discharged water could then be even lower than the temperature of the Hästholmsfjärden surface water. In the local intake–remote discharge option (LR), the area of open water or thin ice cover is more extensive than with the other options.

In the local discharge options (LL and RL), the impacts target Hästholmsfjärden, and in the remote discharge options (LR and RR), Vådholmsfjärden. The flow of nutrients with the cooling water to the vicinity of the discharge location will increase in all options. In remote intake–local discharge (RL) option, there could be a return of aquatic vegetation at Hästholmsfjärden. However, the impacts the options have on water quality, sea-bed fauna, aquatic vegetation, fish populations and the fishing industry are not significant compared to the current situation, nor do they significant differ from one another.

Noise impacts

The noise during nuclear power plant operation is a constant, muffled hum around the clock, a hum that is masked by even very quiet sounds, like the ocean waves or the whisper of the wind. Narrow-band noise consists of the clearly audible, periodical hum that can be heard especially on the north side of the power plant area, on the bay of Hästholmsfjärden, where noise carries easily along the water surface. According to the noise model, noise levels exceed the Government-prescribed limits during the day in the Saukontie holiday cottage settlement area. The change to the current situation is 2 dB.

Impacts of waste and waste treatment

The spent nuclear fuel of the new power plant will be cooled initially and stored for a few years in water pools at the power plant unit. Then it will be placed in the interim storage in cooled water pools for decades – until it is disposed of at Olkiluoto, Eurajoki. The realisation of the new power plant unit requires the existing spent fuel storage facility to be expanded or building a new.

The low- and intermediate-level radioactive waste produced by the new power plant and the decommissioning waste produced during the decommissioning of the power plant unit are placed, after possible intermediate storage, to the existing power plants' repository, which will be expanded.

Posiva Oy will handle the final disposal of the spent fuel of its owners, Fortum and Teollisuuden Voima Oyj. The aim is to place the spent fuel into the bedrock in Olkiluoto at a depth of 400–500 meters. The final disposal is scheduled to start in 2020. When properly handled, radioactive waste and its final disposal do not adversely affect the environment or people.

Impacts on flora and fauna, conservation areas and natural biodiversity

The new power plant unit will be located in the immediate vicinity of the existing power plant area, so the project's direct impacts on flora, fauna and natural biodiversity are related mainly to the land areas needed for the buildings and the construction work, and thus are very minor. The project does not have significant adverse impacts on the Natura 2000 areas.

Traffic impacts

Completion of the new power plant will cause an approximately 35% increase in the traffic to Loviisa, compared to the current situation. The estimated volume of traffic to and from the Loviisa Power Plant after completion of the new power plant is 1,360 vehicles in 24 hours. During annual maintenance, the traffic volume will be about 2,060 vehicles in 24 hours.

Transports to the power plant during operation primarily consist of light goods traffic; the new power plant unit will not remarkably increase the volume of goods transports from the current situation. The traffic increase during operation will not bring a noticeable increase in the current dust, noise and vibration levels to the settlements along the road.

Impacts on employment and the local economy

Implementation of the new power plant unit will have a major, positive impact on employment in the Loviisa economic region. In addition to direct employment impacts, jobs will be created in the service sector. The impact on municipal economies and industry and commerce is positive. Employment opportunities will improve, and that will have a positive impact on the earning potential of the local population. The opportunities for developing private- and public-sector services will improve. The impact on employment was also considered a positive factor in the resident survey.

The new power plant unit requires about 250 employees. The annual need for external services is estimated to be about 50 man-years during the operation phase.

The annual maintenance of the new power plant unit will last an average of three weeks. During this time, there will be an average of about 800 additional people working at the plant through subcontractors. The domestic share of the maintenance is over 90%. In practice, the possible sequential maintenance of the three power plant units will increase the overall length of the maintenance period.

Impacts on living conditions, habitability and recreation

Residents were surveyed and several information and discussion events were held to determine the local attitudes towards the project.

2,350 resident surveys were sent to a random sampling of people in the Loviisa region, and the response rate was about 30%. About 55% of all respondents supported Fortum's Loviisa 3 project. Support for the project was higher among the temporary holiday population than among permanent residents. The Swedish-speaking Finns took a more negative attitude towards the project than Finnish-speaking people.

58% of the survey respondents estimated that the project will not impact recreation or hobby opportunities or other leisure time activities. It was believed that the new power plant unit will have an impact on fishing, boating and swimming. It was also believed that the warming of the sea water will cause changes to the ice conditions, weakening e.g. the opportunities for skiing on the ice and for ice fishing.

26% of the business owners responding to the survey believed that the project will have a positive impact on business, and 10% estimated the project will have a negative impact on conducting their business.

The construction of the new power plant unit on Hästholmen south of the existing power plant units does not change the characteristics of the area. The most significant changes targeting living conditions and habitability are the impacts to fishing and recreation caused by the warm cooling waters, landscape changes and increased noise in the Saukontie holiday cottage area.

Impacts on health

Releases of radioactive substances from the Loviisa Power Plant to the air and sea are constantly measured; the figures are used to calculate the annual radiation dose to an adult with the highest exposure in the nearby vicinity. The maximum release for a nuclear power plant's radioactive substances has been determined so that the releases do not cause a radiation dose of more than 0.1 millisieverts (mSv) per year to any person living in the vicinity of the power plant. It is estimated that the new power plant will cause a radiation dose to the nearby residents with the most exposure of a maximum of 0.0003 mSv per year, i.e. about the same as the radiation dose caused by the existing power plant units. The radiation dose caused by the three power plant units is so low that it has no significance in terms of human health.

Effects of the power grid

The new power plant unit requires the strengthening of the 110-kV transmission connection. It is possible to realise the transmission connection by replacing the existing 110-kV power line with a new, two-circuit 110 kV line laid over new power line towers and by linking the new power line connection more strongly to the main grid.

The new towers for the 110 kV power line will be placed from Hästholmen to the south side of the road 7 (E18) in the area of the existing and new 400 kV power transmission line area, and then in the western edge of the existing 400 kV power transmission line area. The connection to the main grid will occur at the Hagalund switching station northeast of Loviisa. The impact of the new 110 kV power line towers on the landscape and the need for land use will remain small.

Impact of decommissioning the power plant unit

The decommissioning of the new power plant unit is planned to occur immediately after plant operations have ceased and with a plan comparable to the one in place for the existing power plant units. The decommissioning will cause traffic at the work site, and dust and noise pollution. During the decommissioning phase, radioactive releases will be smaller than during the operation of the power plant unit. The goal is that the power plant area will not require separate monitoring after decommissioning, and that the area can be used for other purposes.

Impacts of non-implementation of the project

Locally, non-implementation of the project means that the environmental impacts caused by the construction and operation of the new power plant unit will not be realised. The current state of the environment and the impacts of the load targeting it remain unchanged, for the most part. The most significant impact of non-implementation of the project is that the economical impacts of the project will not be realised.

Nuclear safety and impacts of a serious accident

In accordance with the Nuclear Energy Act, the planning, construction and operation of a nuclear power plant must be safe and must not cause harm to people, the environment or property. The safety target can be considered as achieved when the risk caused by the normal operation and the releases of possible accidents means a very small increase in the overall risk people encounter through other activities in society and through natural hazards.

The new power plant unit will be designed so that it fulfils the safety requirements stipulated in the Nuclear Energy Act and Decree, Government decisions and authoritative guidelines. A requirement of the new power plant unit is that the frequency rate of an accident resulting in a meltdown of the reactor core is less than once every 100,000 years and major radioactive releases less than once every 2,000,000 years. The design has taken into consideration accidents causing core damage, the control of them, and the limiting of the consequences.

In addition to a passenger aeroplane crash at the power plant and an oil accident on the Gulf of Finland, the safety plan also includes preparations for external threats caused by natural phenomena as well as for the warming of the climate and the related changes, such as the warming and rising of the sea water.

Reactor safety requires the functionality of three factors in all circumstances:

- Managing the chain reaction in the uranium fuel and the power it produces
- Cooling the fuel after the chain reaction has ended, i.e. decay heat removal
- Isolation of radioactive substances from the environment.

To ensure the same safety function, several parallel systems are used and are independent of each other so that an external threat factor cannot affect all of them.

The EIA report has examined the human and environmental impacts of a radioactive release resulting from a serious reactor accident.

A release would not cause immediate adverse health effects even to the residents in the closest vicinity. After the first 24 hours, the radiation dose of an adult person 10 kilometres away caused by a release is 70 mSv over 50 years. This dose of radiation is about one third of the radiation dose caused on average by radioactive substances found in nature during the same period. Radiation doses in the vicinity of the power plant during the first 24 hours are avoided through evacuation. An accident can lead to restrictions in land use in the vicinity of the power plant and, farther away, to temporary restrictions on food substances.

Impacts of nuclear fuel production and transportations

Fuel for the new power plant unit will be procured from the international market. The operation of the mines and industrial facilities in the fuel production chain are not tied to the new power plant unit and will operate regardless of the implementation of the project.

Nuclear fuel production and transportation is conducted in each country in compliance with environmental and other regulations related to these activities. In line with Fortum's environmental policy, the continuous improvement and open interaction principle in the management of environmental issues is emphasised in the cooperation with fuel suppliers.

Uranium mining causes a significant share of the environmental impacts related to the nuclear fuel production process. The most significant environmental impacts of uranium mining are related to the radiation exposure of the workers, and the radioactive waste produced by the mining and ore milling. Mining often causes also damage to the landscape. The environmental impacts depend on the mining method used.

The waste produced in uranium mining is low-level radioactive waste, but there are relatively large amounts of the waste. The environmental risks of the waste handling are primarily related to the failure of sludge pond dams, the migration of radioactive substances into the groundwater, and soil and rock material dust. With improvements in mining technology and the automation of operations, it has been possible to reduce the radiation exposure of the uranium mining workers.

Monitoring of environmental impacts

The impacts of the new power plant unit are monitored in accordance with the same principles as the existing power plant units. The environmental impact monitoring programme for the existing power plant units includes the monitoring of:

- radioactive releases and radiation control
- cooling and waste waters
- water systems
- fishing industry
- flue gas releases
- noise
- waste accounting
- impacts on people.

Project implementation feasibility

The environmental impact assessment did not find any environmental impacts of such significance caused by the construction or operation and the different options of Fortum's Loviisa 3 power plant unit that they could not be accepted or mitigated to an acceptable level. All cooling water options are environmentally acceptable.

GLOSSARY

Activity (Bq)
The number of spontaneous nuclear disintegrations occurring in a given quantity of radioactive material within a certain time. The unit of radioactivity, the becquerel (Bq) = one disintegration per second.

Bar
Unit of pressure (1 bar = 100 kPa). Atmospheric pressure is approximately 1 bar.

Base-load station
A large power plant operating steadily at full power to meet the continuous minimum requirement for electrical power.

Boiling water reactor
A light water reactor in which water used as the coolant boils as it passes through the reactor core and the resulting steam is used for driving a turbine.

Bq (Becquerel)
The measurement unit of radioactivity. Equates to one radioactive disintegration per second. The concentration of radioactive substances in foodstuffs is expressed in becquerels per unit of mass or volume (Bq/kg or Bq/l).

Coolant
In a nuclear reactor acts as a substance which cools down the nuclear fuel. In light water reactors water H_2O is used as a coolant. Different substances are used as coolant, depending on the reactor type. For example, in the CANDU reactor type, developed in Canada, heavy water (D_2O) is used as coolant.

Cooling water
Cooling water is sea water used for cooling the steam coming from the turbines in a condenser back to water. Cooling water does not come into contact or mix with the process waters of the nuclear power plant.

dB (Decibel)
Unit of noise level. An increase of ten decibels in the noise level means the tenfold of the energy of the noise. The measurement of ambient noise level typically uses the A-weighting dB(A), which puts weight on such noise frequencies which the human ear senses best.

Decommissioning waste
Activity containing waste produced during the decommissioning that occurs after the utilization of the power plant or other nuclear facility.

Efficiency (η)
The ratio of the amount of electric energy produced by the power plant and the thermal energy produced by the reactor.

EIA
Environmental Impact Assessment. The objective of the statutory EIA procedure is to promote the assessment of environmental impacts and increase the opportunities for citizens to receive information, become involved in the planning of projects and express their opinion.

Electrical power (W)
Capacity by which a plant generates electrical energy.

Final disposal
The permanent disposal of radioactive waste in such a manner that the repository site would not need to be monitored and the radioactivity of the waste will not be a hazard to nature.

Fission
The splitting of a heavy atomic nucleus into two or more new nuclei accompanied by the release of a large amount of energy and neutrons.

Gigawatt-hour (GWh)
Unit of energy (1 GWh = 1 000 MWh = 1 000 000 kWh).

Government resolution
The use of nuclear power for generating electricity requires a Government resolution, which is ratified by Parliament. The prerequisite for a favourable resolution is, e.g. a supporting statement of the municipality where the power plant is located and a favourable safety evaluation by the Radiation and Nuclear Safety Authority.

Greenhouse gas
Greenhouse gases cause warming of the climate by preventing the heat radiation of the Sun from getting from the atmosphere back to the space. Greenhouse gases are, e.g., carbon dioxide (CO_2), methane (CH_4), dinitrogen oxide (N_2O), HFC compounds (fluorohydrocarbons), PFC compounds (perfluoride hydrocarbons), sulphur hexafluoride (SF_6), ozone (O_3) and steam.

Ion
An electrically charged atom or molecule.

Ion exchange resin
Granular or powdery material used for removing ionic impurities from water.

Ionising radiation
Electromagnetic or particle radiation that produces free electrons and ions when interacting with matter, i.e. it is capable of breaking chemical bonds. Ionisation damages DNA molecules, the genetic material of cells. Therefore, ionising radiation is hazardous to human health.

Isotope
Isotopes are different forms of the same element differing from each other in the number of neutrons in their nucleus and the characteristics of the nucleus. Almost all natural elements occur as more than one isotope. For example, hydrogen (H) has three isotopes: hydrogen (^{1}H), deuterium (^{2}H) and tritium (^{3}H), of which tritium is radioactive.

KTM
Ministry of Trade and Industry, whose responsibilities the Ministry of Employment and the Economy (TEM) took on 1 January 2008. KTM acted as the coordinating authority of this EIA procedure until 31 December 2007.

Light water reactor
Reactor type in which purified water (H_2O) is used for cooling and as a moderator. Most nuclear power plant reactors in the world are light water reactors.

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

Moderator
Substance which in thermic nuclear reactors delays the fast neutrons to a suitable energy area in respect of the fission reaction. In light water reactors, water (H_2O) is used as the moderator. Different substances are used as moderators, depending on the type of reactor. For example, in the CANDU reactor type, developed in Canada, heavy water (D_2O) is used for delaying the neutrons.

Nuclear fuel
Fuel (uranium or other fissionable material) intended for use in the reactors of nuclear power plants and manufactured into elements that either as such or combined with supporting structures can be used for producing a chain reaction based on nuclear fission.

ONKALO
An underground rock characterisation facility under construction for the investigations into final disposal of spent fuel at Olkiluoto and owned by Posiva Oy.

Pressurized water reactor
A light water reactor in which the pressure is kept so high that the water used as coolant does not boil regardless of the 300 °C temperature. The water that has passed through the reactor core releases its heat to the secondary circuit water in separate steam generators, where the secondary circuit water is vaporized and used for driving a turbine.

Radiation
Radiation can be either electromagnetic waves or particle radiation.

Radioactivity
Radioactive materials decay spontaneously into lighter elements or lower energy states of the same element. The process releases ionizing radiation that is either electromagnetic or particle radiation.

Richter scale
Mathematical logarithmic scale used for measuring the strength of an earthquake.

Sievert (Sv)
The unit of radioactive dose that represents the adverse effect on healt. Commonly used units are millisievert (mSv) or microsievert (mSv) (1 µSv = 0.001 µSv = 0.000001 Sv).

Solidification facility
Concreting and bituminization facility, where liquid waste is converted into a solid form by mixing it with concrete and letting the concrete dry, or by mixing it with hot bitumen.

Spent fuel
Nuclear fuel becomes spent fuel when it has been inside the reactor for energy production. Spent nuclear fuel contains fission products of uranium, such as cesium, and it is highly radioactive.

Steam generator
From the pressurized water reactor, the water (about 300 degrees hot and non-boiling) is conducted to the steam generator, where the steam carried to the turbines is generated.

STUK
Radiation and Nuclear Safety Authority, which is the authority controlling safety in Finland, a research institute and an expert organization.

TEM
Ministry of Employment and the Economy, to which the responsibilities of the Ministry of Trade and Industry were transferred on 1 January 2008. Since then, TEM has acted as the coordinating authority of this EIA procedure.

Terawatt-hour (TWh)
Unit of energy (1 TWh = 1 000 GWh = 1 000 000 MWh = 1 000 000 000 kWh).

Thermal power (W)
Capacity by which a plant generates thermal energy.

Uranium (U)
An element with the chemical symbol U. Uranium comprises 0.0004% of the earth's crust (four grams in a tonne). All uranium isotopes are radioactive. Natural uranium is mostly in the form of isotope ^{238}U, which has a half-life of 4.5 billion years. Only 0.71% of natural uranium is in the form of isotope ^{235}U, which can be used as a nuclear fuel.

CONTENT


Peacock butterfly, Loviisa, Antinkylä

© Timo Lindgren

1 PROJECT

1.1 Organization responsible for the project

The organization responsible for the project is Fortum Power and Heat Oy, a wholly owned subsidiary of Fortum Corporation. At the end of 2007 the Government of Finland held 50.9% of the share capital of Fortum Corporation. Fortum Corporation is a leading energy company in the Nordic countries and other parts of the Baltic Rim area. The company's activities cover the generation, distribution and sale of electricity and heat, and the operation and maintenance of power plants. Fortum Corporation and its subsidiaries employ a total of over 8 000 people, about 3 000 of whom work in Finland.

Fortum Power and Heat Oy (hereinafter Fortum) is the owner of the Loviisa nuclear power plant, which is located on the island of Hästholmen and consists of two plant units, Loviisa 1 and Loviisa 2. Commercial operation of Loviisa 1 began in 1977 and that of Loviisa 2 in 1981. The power plant units are pressurized water reactor plants with an electrical output of some 490 MW each. The present operating licences will be valid until the end of 2027 (Loviisa 1) and 2030 (Loviisa 2). The operations of the Loviisa Power Plant have been certified to the ISO 14001 Environmental Management Standard and the OHSAS 18001 Occupational Health and Safety Standard.

Fortum holds a 27% share in the existing power plants units (Olkiluoto 1 and Olkiluoto 2) of Teollisuuden Voima Oyj (TVO) and a 25% share in the nuclear power plant unit (Olkiluoto 3) under construction. In addition, Fortum is a shareholder in Swedish nuclear power plants (Oskarshamn 46% and Forsmark 26%).

In 2007, nuclear power accounted for 48% of Fortum's electricity production. In the same year, renewable energy sources covered 41% of Fortum's electricity production, which means that 89% of the production was carbon dioxide-free.

Fortum has gained experience of the design, construction, operation and maintenance of nuclear power plants. The Loviisa Power Plant has been operated for well over thirty years without any serious incidents that would affect the safety. Furthermore, the power plant has been among the best nuclear power plants in the world in terms of availability.

1.2 Project

Under the Loviisa 3 project, Fortum is examining the extension of the Loviisa Power Plant by a third power plant unit. The new power plant unit will be a light water reactor plant with an electrical output of 1 000–1 800 MW, which is either currently available on the market or will be launched onto the market in the near future. The thermal output of the reactor will be 2 800–4 600 MW. The designed technical life of the new power plant unit is at least 60 years, i.e. from 2018 until ca 2080. The location of the third power plant unit has been illustrated in the Figure 1-1.

In addition to the construction and operation of a power plant unit, the Loviisa 3 project covers intermediate storage of the spent nuclear fuel produced during operation, treatment, storage and final disposal of the low- and intermediate-level operational waste, dismantling of the power plant unit, and treatment and final disposal of the decommissioning waste. The opportunity for combined electricity and heat production has been taken into account in the assessment of environmental impacts.

Last time, environmental impacts of the Loviisa Power Plant were assessed comprehensively as part of the environmental impact assessment (EIA) procedure for the previous Loviisa 3 project in 1999 (*Fortum 1999*). The environmental impact assessment procedure was officially initiated again in June 2007 (*Fortum Power and Heat Oy 2007*).

The construction of a new power plant unit will require a supporting statement of the Loviisa Town Council and the Radiation and Nuclear Safety Authority on the project and a favourable resolution by the Government as well as ratification of this resolution in Parliament. The environmental impact assessment report will be attached to application for a Government resolution.

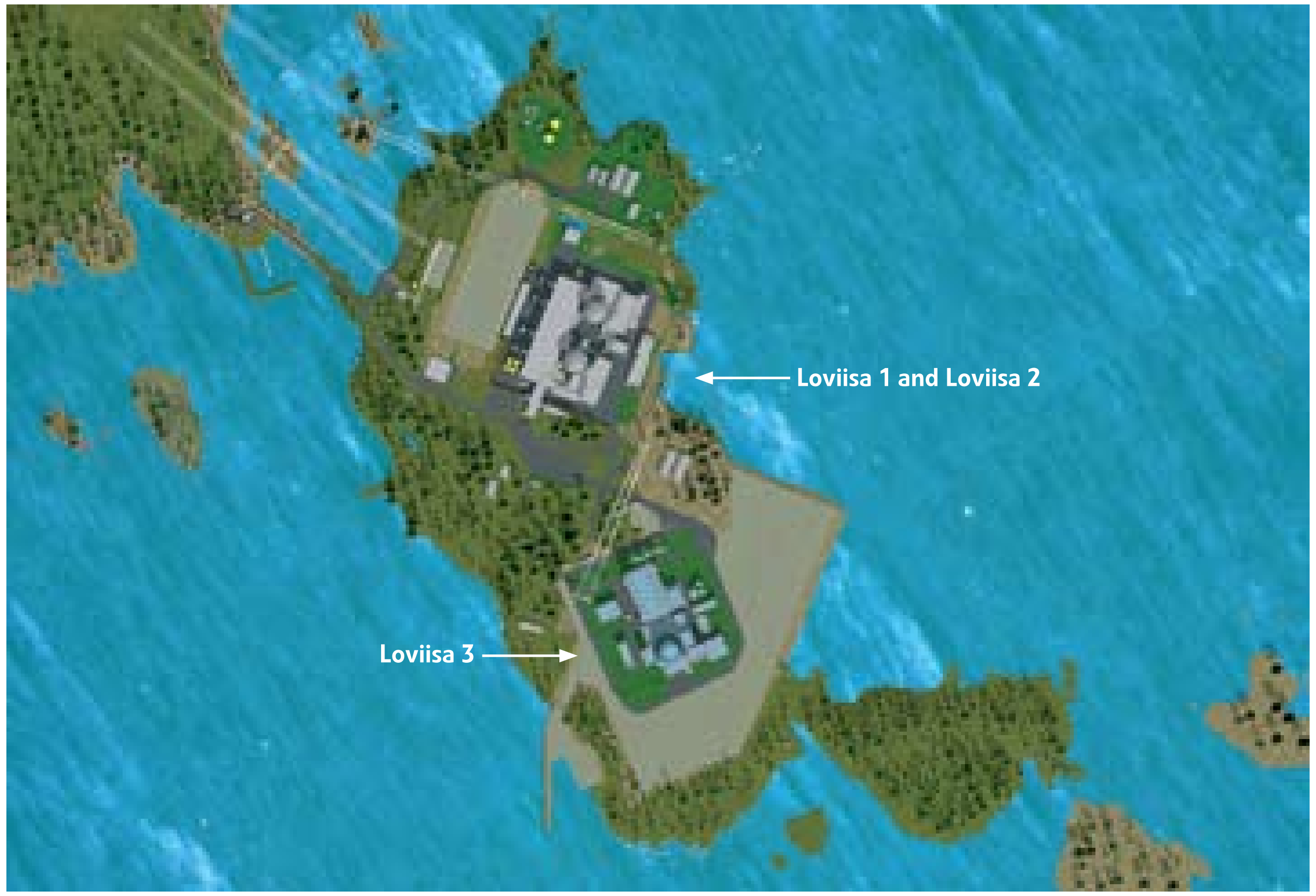


Figure 1-1. Existing power plant units (Loviisa 1 and Loviisa 2) of the Loviisa Power Plant and the location of the new power plant unit (Loviisa 3) on the island of Hästholmen.

Fortum will take a decision on the new power plant unit considering the current aspects of environmental protection and climate policy, economic conditions and the market situation. It is also possible that the new power plant unit will be implemented as a joint project with other operators.

1.3 Purpose and justification for the project

The basis for the Loviisa 3 project is to construct environmentally sound production capacity in accordance with Fortum's strategy and to reduce carbon dioxide emissions. Fortum's long-term target is to be a power and heat company with zero carbon dioxide emissions. The strategy includes energy saving, investment in renewable energy sources, development of carbon dioxide capture systems for coal-fired power plants and carbon dioxide-free nuclear power. The target set for 2020 is to keep the five-year average for carbon dioxide emissions from Fortum's electricity production in the area of the European Union below 80 grammes per kilowatt-hour produced. At present, Fortum is one of energy companies with the smallest carbon dioxide emissions per kilowatt-hour produced in Europe. In 2007, the carbon dioxide emissions from Fortum's electricity production totalled 64 grammes per kilowatt-hour produced.

The objective of Fortum's Loviisa 3 power plant unit is to replace fossil fuel-fired power plants with carbon dioxide-free production capacity, to meet the increasing demand and, in the future, to replace the production of Fortum's existing power plant units in Loviisa. The existing power plant units will be decommissioned during the designed operating life of Loviisa 3.

In Finland, electricity is generated in accordance with the principles and regulations concerning the internal energy market of the European Union (EU). In accordance with sustainable development, the EU aims to reduce harmful environmental impacts of energy production and use. Another objective is to increase the EU's competitiveness, which requires investments in the energy production and transmission capacity. It is estimated that investments of EUR 900 billion in new electricity generation capacity will be needed in the EU area during the next 20 years. To secure the reliability of energy supply, the EU focuses particular attention on curbing the increase in the need for importing oil and natural gas (*European Commission 2007*).

Finland needs new carbon dioxide emission-free electricity production capacity to meet the challenges posed by climate change, competitiveness and reliability of operation, and to ensure economic growth and the Finns' standard of living. It is estimated that a substantial amount of outdated coal-fired plant capacity will be removed from the electricity market in the coming decades. The objective is to reduce the dependence on fossil fuels. The measures proposed by the European Commission in January 2008 with a view to curbing climate change require that carbon dioxide emissions be reduced by 20% from the 1990 level in the EU area by 2020. The long-term target is to cut carbon dioxide emissions by 60–80% in the developed countries by 2050.

In accordance with the European Commission's proposal, Finland must increase the use of renewable energy sources from the current 28.5% to 38% and to improve its energy efficiency by 20% by 2020. A long-range climate and energy strategy is being prepared for Finland, and it is scheduled for completion in the summer of 2008.

In 2007, the consumption of electricity totalled 90.3 TWh. Finnish Energy Industries and the Confederation of Finnish Industries estimate that the consumption of electricity in Finland will rise to 115 TWh by 2030. The average growth by 2020 will be about 1.2% a year and from 2020 to 2030 0.7%. In the past ten years, the annual consumption of electricity has increased 2.6% on average (*Confederation of Finnish Industries EK and Finnish Energy Industries ET 2007*). Figure 1-2 shows one scenario for the development of electricity production and consumption and of the CO_2 emissions from electricity production in Finland until 2030 (*Finnish Energy Industries ET 2008*). A study conducted by Finnish Energy Industries shows that an increase in Finland's electricity self-sufficiency and a substantial reduction in greenhouse gas emissions can be achieved cost-effectively, if renewable energy sources, combined electricity and heat production, and nuclear power are utilized (Figure 1-2).

In recent decades, electricity imports to Finland have continued to grow. In 2000–2006 the imports averaged 10 TWh a year. Electricity imports and the dependence on electricity production based on fossil fuels can be reduced by building additional nuclear power.

The total energy consumption per capita is relatively high in Finland. This is due to our northern location and cold climate, sparse population and long distances, as well as the structure of our basic industry.

The forecast for electricity consumption (*Confederation of Finnish Industries EK and Finnish Energy Industries 2007*) has taken into account the targets for improving energy efficiency, climate change, industrial development in Finland and population forecast until 2030. The forecast (Figure 1-3) has taken, e.g., the following facts into account:

- electricity consumption will grow most rapidly in the metal industry and in the service sector;
- energy efficiency will improve substantially, but the economic growth and the increasing demand for products and services will compensate for this;
- the population in Finland will increase by 8% from the present 5.3 million to 5.7 million by 2030;
- the national product is expected to grow by an average of 2.2% a year;
- owing to climate change the mean temperature in Finland is expected to rise by 2.3° C by 2030 compared with the average for 1971–2000;
- 60% of the current electrically heated dwellings are expected to use a heat pump by 2030;
- renovations of electrically heated houses are expected to reduce the consumption of electricity by 15%;
- improved energy efficiency and climate change will reduce the energy consumption of electrically heated buildings calculated per area by about 30% by 2030;
- the proportion of low-energy houses of the new residential buildings is expected to increase to over 50% by 2030.

If it is possible to use nuclear power in the future also for combined electricity and heat production, this will also replace the use of fossil fuels for district heat production. In 2006, the production of district heat totalled 32.3 TWh, of which 11.1 TWh, or 34% was generated in the metropolitan area (*Finnish Energy Industries 2007a*).

According to the WM (With Measures) Scenario made by the Ministry of Trade and Industry (KTM) and updated in

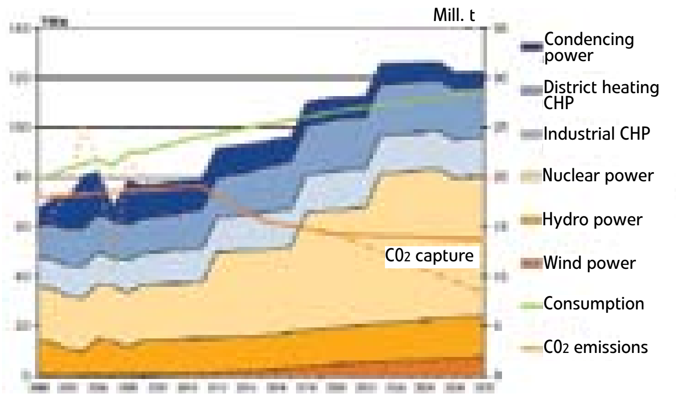


Figure 1-2. Scenario made by Finnish Energy Industries for the production and consumption of electricity and for the CO_2 emissions from production in Finland until 2030 (*Finnish Energy Industries 2008*).

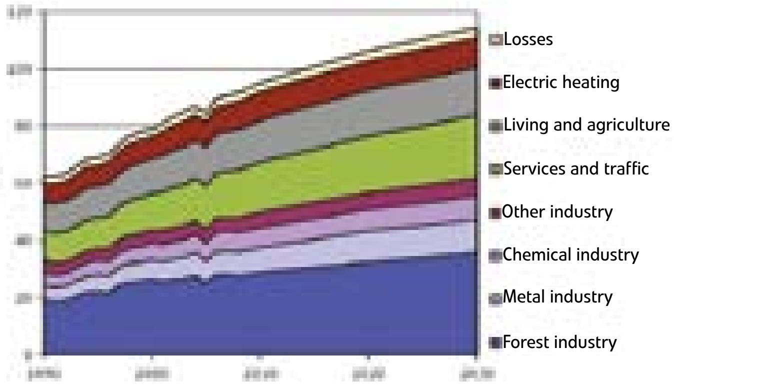


Figure 1-3. Total consumption of electricity in Finland by sector and forecast for the development of electricity consumption by 2030 (*Confederation of Finnish Industries EK and Finnish Energy Industries 2007*).

2006, the total consumption of electricity in Finland will be some 100 TWh in 2015 and some 108 TWh in 2025.

The Ministry of Employment and the Economy is currently making new forecasts for energy consumption on the basis of Finland's climate and energy strategy. The forecasts are likely to be more moderate than those given above.

1.4 Location and need for land

Fortum's Loviisa Power Plant is located in the village of Lappom on the island of Hästholmen about 12 kilometres from the town centre of Loviisa, and the new Loviisa 3 power plant unit would also be located at the same site. The Figure 1-4 shows the location of the Loviisa Power Plant. Some buildings and structures required for power plant support functions, such as security and temporary accommodation for refuelling outage workers, are located on the mainland.

The planned location of the new power plant unit is south of the existing power plant units. The site is suitable for power plant construction and planned for this purpose. The area required for the new power plant unit is about 10 hectares. On the island of Hästholmen, an area of about 30 hectares is available for site operations, when the sea filling east of the island allowed by the land use plan is implemented in full. In addition, a loading and unloading site will be built on the western shore of the island. The functions required during construction and operation of the Loviisa 3 power plant unit can be implemented in land and water areas owned by Fortum. The assessed remote cooling water intake and discharge areas are mainly located in water areas owned by the town of Loviisa.

1.5 Relation to other projects

Final disposal of spent nuclear fuel and operating waste

In accordance with the Finnish nuclear energy legislation the spent nuclear fuel and the low- and intermediate-level waste, including the radioactive decommissioning waste of power plants, will be finally disposed of in Finland's bedrock.

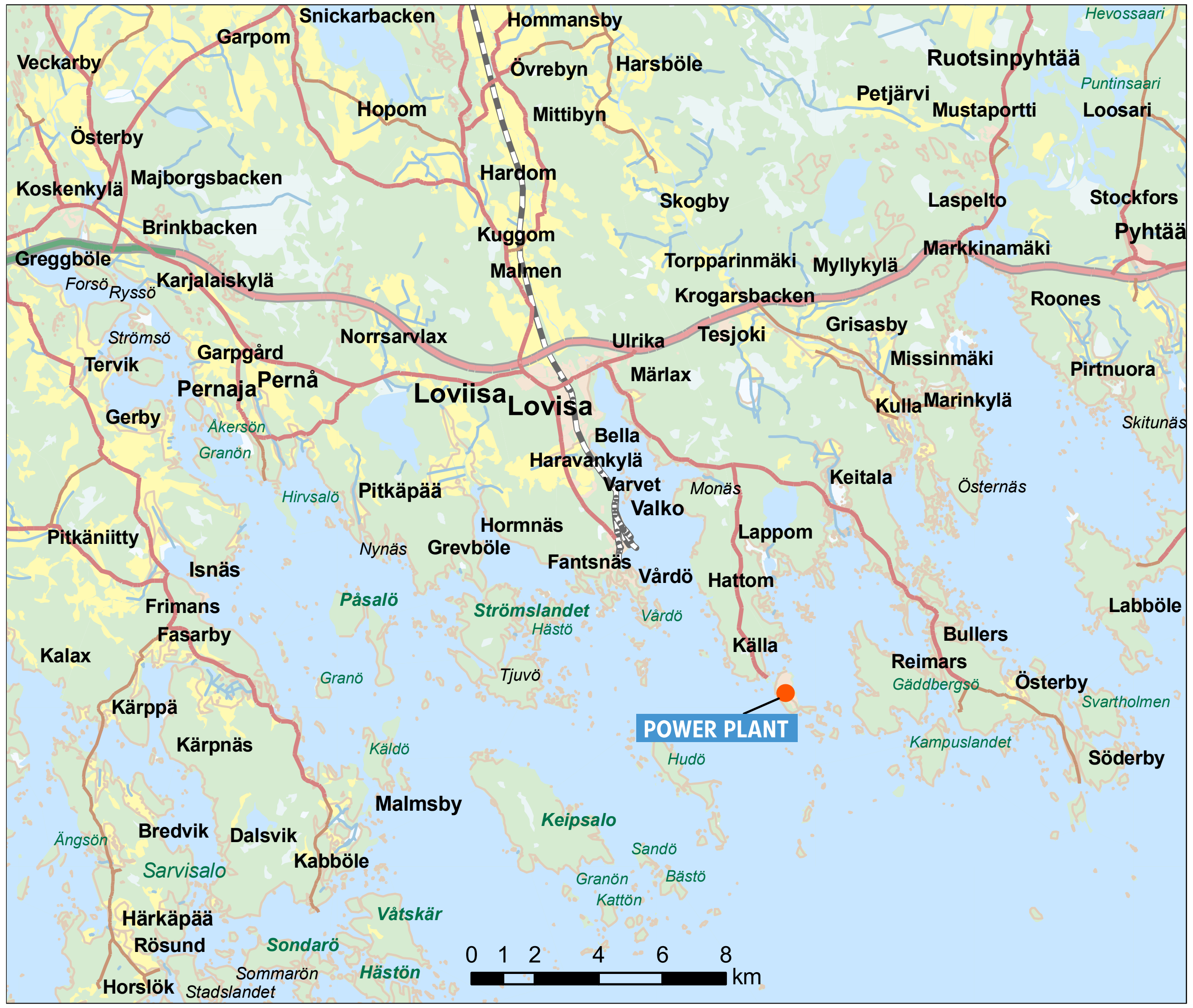


Figure 1-4. Location of the Loviisa nuclear power plant.

The licence-holder's obligation to ensure the management of the spent nuclear fuel and other nuclear waste will end, when they have been permanently placed in the bedrock and the repository has been sealed. Fortum and Teollisuuden Voima Oyj (TVO) established in 1995 a company named Posiva Oy (Posiva) to take care of the transportation of spent fuel from Fortum's and TVO's nuclear power plants to the final disposal site, and for the actual final disposal and the related research and expert tasks. Posiva builds the necessary final disposal facility, implements the required EIA procedures and applies for the necessary permits.

Fortum and TVO are responsible for all the costs of nuclear waste management of their nuclear power plants, including Posiva's costs. Like the other parties with a waste management obligation, Fortum makes provision for the costs of nuclear waste management by paying nuclear waste management fees to the State Nuclear Waste Management Fund.

The EIA procedure, implemented by Posiva, concerning the repository for spent fuel at Olkiluoto in Eurajoki, which enables the final disposal of spent fuel from six power plant units, was completed in 1999. In January 2008, Posiva Oy announced that it would launch an EIA procedure with a view to extending the final disposal facility at Olkiluoto. Upon extension, the repository will also cover the final disposal of the spent nuclear fuel from Loviisa 3 and Olkiluoto 4 power plant units.

Posiva Oy will take care of the final disposal of spent fuel from Fortum's Loviisa 3 power plant unit at Olkiluoto in Eurajoki. Chapter 14 deals with the final disposal of spent fuel and its environmental impacts.

The low- and intermediate-level operating waste and the radioactive decommissioning waste of the new power plant unit will be disposed of in the repository for low- and intermediate-level operating waste on the island of Hästholmen, which will be extended, if necessary.

Power transmission connections

Transmitting the electricity generated by the new power plant unit to the Finnish grid requires that the existing power transmission connections be strengthened. The required 400 kV power line connection to the Finnish grid will be built from the switch yard located at the current power plant site. The environmental impact assessment examines the environmental impacts of the power transmission connection to be built between the new power plant unit and the switch yard located on Hästholmen. The Finnish grid company Fingrid Oyj is responsible for the necessary modifications to the power transmission grid from the switch yard onwards and for the assessment of related environmental impacts.

The new power plant unit also requires the strengthening of the 110 kV backup connection, which can be implemented by replacing the existing 110 kV power line with a new double-circuit 110 kV power line. Chapter 9 deals with the environmental impacts of the strengthening of the backup connection.

Road connections

The new power plant unit will increase traffic to Hästholmen particularly in the construction stage. In 2007, the Road Region of southeastern Finland drew up a general plan for the improvement of Main Road 7 (E18) so as to become a motorway between Loviisa and Kotka. With regard to the road section of Koskenkylä–Loviisa–Kotka, the investment programme of a ministerial working group preparing a policy on traffic routes proposed that the project be implemented in 2008–2013. The general plan for the motorway proposes a new junction on the border of Loviisa and Ruotsinpyhtää, from which a road connection would be built to Hästholmen. The need for improving roads Saaristotie and Atomitie (road no. 1583) (road widening and building a pedestrian and bicycle way) was investigated in 1992.

Combined electricity and heat production

The Loviisa 3 power plant unit can be built in such a way that it generates both electricity and heat. The district heat could be used, e.g., in the metropolitan area. In the vicinity of the Loviisa Power Plant there is no industry or other operation that could utilize substantial amounts of heat in the form of, e.g., steam.

The opportunity to transmit district heat from the Loviisa Power Plant to the metropolitan area has been studied in two reports. In 1979–1980 the study concerned the possibility of transporting hot water by ship. In 1981–1983 the opportunity to excavate a tunnel for a 76-kilometre-long district heating pipeline with a transmission capacity of 600–900 MW of thermal power was studied. As part of this study, the pipeline area was subjected to a visual engineering geology examination of the bedrock and soil quality, and geophysical studies were conducted in covered areas and water system areas.

The construction of a combined electricity and heat production plant would be an option that is in line with Fortum's climate strategy. However, this option requires extensive technical and economic studies and a partner or partners that commit themselves to the project.

Combined electricity and heat production does not affect the scope of the Loviisa 3 project on Hästholmen. The technical implementation of combined electricity and heat production at the new power plant unit is described in Chapter 3.4 and the environmental impacts in Chapter 16. Environmental impacts of the potential district heating tunnel or pipeline will be assessed separately, if their implementation is launched.

Teollisuuden Voima Oyj's nuclear power plant project

Teollisuuden Voima Oyj (TVO) initiated an environmental impact assessment procedure with a view to expanding the Olkiluoto nuclear power plant by a fourth power plant unit (Olkiluoto 4) by submitting an EIA programme (*TVO 2007*) to the Ministry of Trade and Industry in May 2007. TVO submitted the EIA report on the project to the Min-

Figure 1-5. Location of the Loviisa 3 power plant unit on the island of Hästholmen, south of the existing power plant units (top pressurized water reactor plant, bottom boiling water reactor plant).

istry of Employment and the Economy in February 2008 (*TVO 2008*) .

Fennovoima Oy's nuclear power plant project

Fennovoima Oy initiated an environmental impact assessment procedure with a view to building a new nuclear power plant by submitting its EIA programme (*Fennovoima 2008*) to the Ministry of Employment and the Economy in January 2008. The optional sites proposed for the nuclear power plant include Gäddbergsö at about three kilometres northeast of Hästholmen and Kampuslandet at about five kilometres southeast of Hästholmen, both in the municipality of Ruotsinpyhtää. With detailed implementation plans and decisions lacking, combined effects with the Loviisa 3 project are not assessed.

1.6 Design phase of the project

A decision to build the Loviisa 3 power plant unit can be taken after a favourable Government resolution ratified by Parliament. Actual design can be launched no earlier than that.

1.7 Project schedule

The time taken by the Loviisa 3 project starting from initiation of the environmental impact assessment procedure and ending with commissioning of the power plant unit is about 11 years, of which the time required by the licensing procedures is about half. If a decision to carry out the Loviisa 3 project is taken and the project progresses as planned, the construction can begin in 2012 and the power plant unit can be commissioned in 2018.

1.8 Implementation options

The Loviisa 3 project concerns the construction of a new power plant unit on the island of Hästholmen in Loviisa, south of Fortum's existing power plant units (Figure 1-5). Fortum has no optional locations for the plant.

The reactors of the existing nuclear power plants in Finland, like most of the nuclear reactors in the world, are light water reactors. The reactor of the new power plant unit will also be a light water reactor, either a boiling water reactor or a pressurized water reactor. Their operating principles have been described in Chapter 3.2.

Several options are considered for the cooling water intake and discharge areas. Definitions of the cooling water intake and discharge areas and potential intake and discharge places have been described in Chapter 9.4. In some of the options, the arrangements for cooling water intake and discharge require the construction of an about five-kilometre-long cooling water tunnel.

The Loviisa 3 project also includes the drinking water supply system, the waste water treatment system, the construction of a loading and unloading site and a channel for heavy sea transports, and strengthening of the 110 kV power transmission connections.

1.9 Non-implementation of the project

If the Loviisa 3 project is not implemented, Fortum will keep the site on Hästholmen for later additional building of nuclear power. The impacts of non-implementation of the project are discussed in Chapter 11.

1.10 Other options

The total need for electricity depends on the overall economic and social development, which are beyond Fortum's sphere of influence. No such means of energy saving are available to Fortum by which the volume of electricity generated by the Loviisa 3 power plant unit could be replaced. Energy conservation is of vital importance, but new carbon dioxide-free production will be needed in the future, however.

Detailed analysis of competing projects in the same sector and of the options provided by other energy producers as an alternative is not possible. Site-specific electricity generation outside the Loviisa site is excluded from the options, whatever the production method. Other forms of electricity production are described in Chapter 11.

Young spruce shoot, Loviisa

2 EIA PROCEDURE, COMMUNICATION AND PARTICIPATION

2.1 The need for and objectives of an EIA procedure

The directive (85/337/EEC) issued by the European Communities (EC) has been enforced in Finland based on Annex twenty (XX) of the Treaty establishing the European Economic Community by enacting the Act (468/1994) and Decree (713/2006) on Environmental Impact Assessment Procedure (hereafter "the EIA Act" and "the EIA Decree"). According to Section 4 of the EIA Act, projects subject to the environmental impact assessment procedure shall be specified in more detail by the Government decree. According to point 7b) in the list of projects within Chapter 2, Section 6 of the EIA Decree, nuclear power plants are included in the projects subject to an assessment procedure.

The objective of the environmental impact assessment (EIA) procedure is to promote the assessment and consistent consideration of environmental impacts in planning and decision-making. Another objective of the procedure is to increase the opportunities for citizens to receive information, become involved in the planning of projects and express their opinions.

According to the Nuclear Energy Act, the process for the construction of a new nuclear power plant starts with the application for a resolution (former 'decision in principle') from the Government. The EIA report must be attached to the application for a Government resolution.

2.2 The main stages of the EIA procedure

The EIA procedure consists of a programme stage and a report stage (Figure 2-1). The environmental impact assessment programme (EIA programme) is a plan for arranging an environmental impact assessment procedure and for specifying the required studies. On 26 June 2007, Fortum submitted the EIA programme to the Ministry of Trade and Industry, which acts as the coordinating authority for the project. The Ministry of Trade and Industry gave its statement on the programme on 16 October 2007.

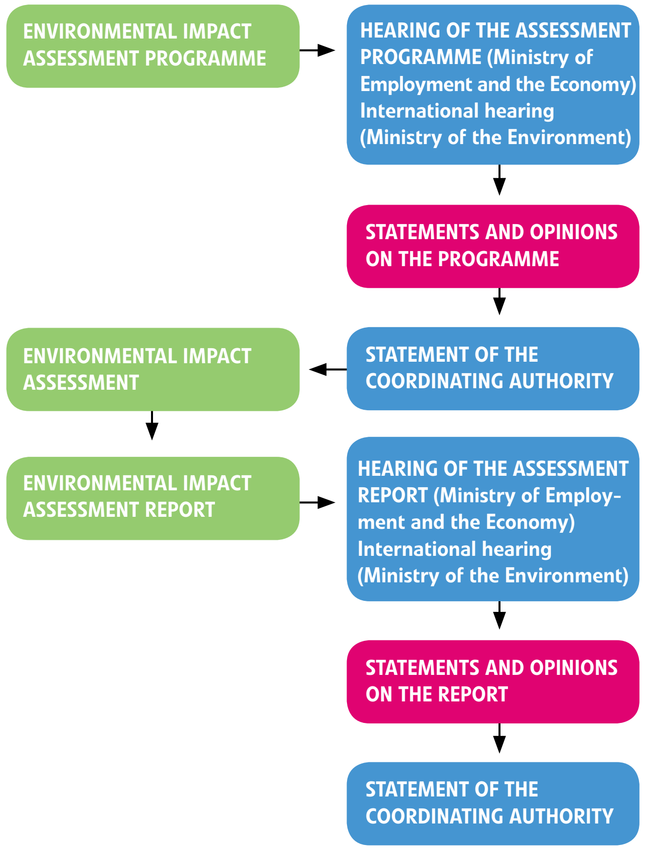


Figure 2-1. Stages of the EIA procedure.

The Ministry of Trade and Industry ceased operations on 31 December 2007. Its responsibilities were transferred to the Ministry of Employment and the Economy, which started operations as from 1 January 2008.

The EIA report will provide information about the project and a coherent assessment of its environmental impacts on the basis of the assessment procedure. The EIA report will describe

- The options under assessment;
- The present state of the environment;
- The environmental impacts of the various options, as well as their significance;

• Effects of non-implementation
• A comparison of the assessed options;
• Measures to prevent and mitigate adverse impacts;
• A proposal for an environmental impact monitoring programme;
• Actions taken to facilitate interaction and involvement during the EIA procedure;
• How the Ministry of Trade and Industry's statement on the EIA programme has been taken into account in the assessment.

Once the EIA report is completed, the citizens may express their opinions on it. Official bodies will submit their statements on the EIA report to the Ministry of Employment and the Economy (former Ministry of Trade and Industry).

The EIA procedure will be completed when the Ministry of Employment and the Economy has provided its statement on the EIA report. The licensing authorities and Fortum will use the assessment report and the Ministry's statement as basic material for their decision-making.

2.3 Communication and participation

One of the main objectives of the EIA procedure is to promote communication about the project and to improve the opportunities for citizens to participate.

During the EIA procedure, the communication and participation have been carried out according to the EIA programme. In addition to this, discussion events were held at the town square, a public meeting was arranged concerning the state of the Gulf of Finland and the impacts of cooling water and an EIA team was established.

2.3.1 Audit Group

Fortum established an Audit Group consisting of different interest groups to promote the flow and exchange of information in the EIA procedure. The following parties have taken part in the Audit Group during the EIA procedure:

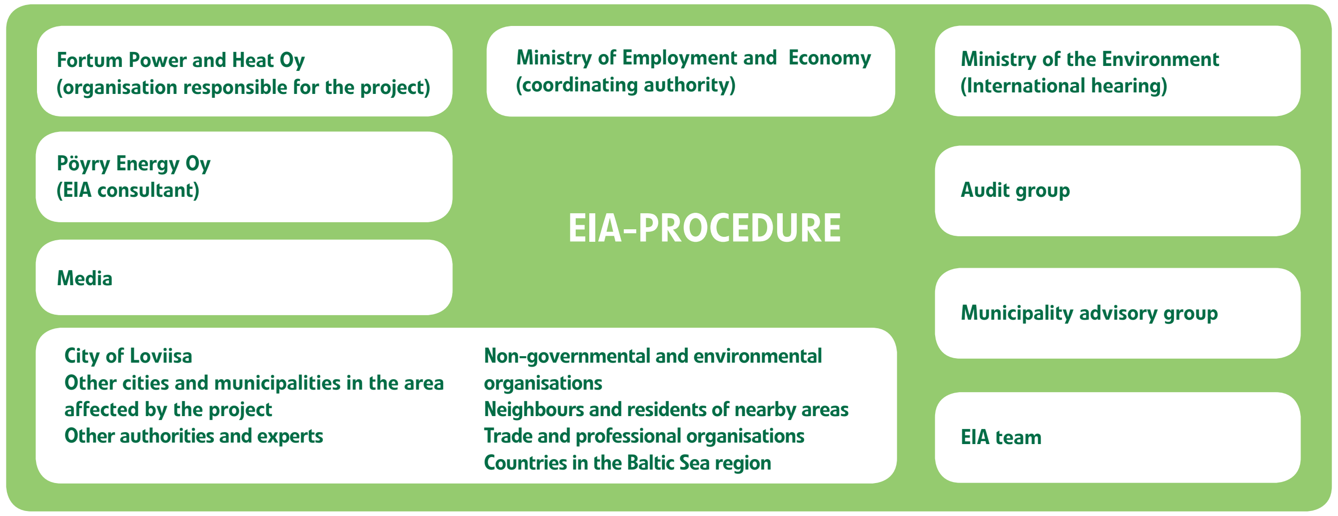
• Town of Loviisa
• Municipality of Liljendal
• Municipality of Lapinjärvi
• Municipality of Pernaja
• Municipality of Pyhtää
• Municipality of Ruotsinpyhtää
• Ministry of Employment and the Economy (former Ministry of Trade and Industry)
• State Provincial Office of Southern Finland
• Uusimaa Regional Environment Centre
• Regional Council of Itä-Uusimaa
• Western Finland Environmental Permit Authority
• Loviisa Region Healthcare Joint Municipal Authority
• Eastern Uusimaa Fire and Rescue Service
• Fortum.

In addition to these, the following were also invited: Safety Technology Authority, Uusimaa Employment and Economic Development Centre and the Radiation and Nuclear Safety Authority.

The Audit Group has convened four times during the EIA procedure, the head of the Loviisa town's technical office taking the chair.

The project, the EIA procedure, interaction and the draft of the project's EIA programme were presented to the Audit Group in the first meeting on 6 June 2007. The comments and specifications concerning the EIA programme received during and after the meeting were taken into consideration in the programme to the widest possible extent. The members of the Audit Group especially emphasized the importance of the impacts on the community, social factors and economy. Other comments were taken into consideration in the implementation of the EIA programme and in the EIA report.

The second meeting of the Audit Group was held on 9 November 2007. The meeting presented the Ministry of Trade and Industry's statement on the EIA programme and its consideration in the EIA report. Other matters discussed were the situation of town planning, and the ongoing studies of cooling water, Natura areas, noise and economic impacts.



Parties involved in the EIA procedure.


EIA Audit Group meeting at Loviisa City House.

The third meeting of the Audit Group was held on 21 January 2008. The meeting presented the results of the impact assessment and dealt with the draft of the assessment report. The Audit Group gave statements on the draft of the EIA report. The comments and specifications related to the EIA report were taken into account when finalizing the report.

The fourth meeting of the Audit Group was held as the text of the EIA report was completed.

2.3.2 Municipal Advisory Group

The Municipal Advisory Group monitored the EIA procedure at a strategic level. The group members have been the Executive Director of the Regional Council of Itä-Uusimaa, the Town Manager of Loviisa, the Municipal Managers of Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää and the representatives of Fortum.

The first meeting of the Municipal Advisory Group was held on 29 May 2007. The meeting discussed the EIA programme and the co-operation between the municipalities and between the Regional Council and the municipalities.

The second meeting of the Municipal Advisory Group was held on 14 August 2007. The meeting discussed the views and opinions of the municipalities and the Regional Council on the EIA programme (municipal managers and the Executive Director of the Regional Council), opinions of the Audit Group and other interest groups on the programme, and matters concerning town planning.

The third meeting of the Municipal Advisory Group on 20 September 2007 dealt with and approved a work programme for the assessment of the impacts on the community, social factors and economy.

The fourth meeting of the Municipal Advisory Group was held on 14 January 2008 and it dealt with the results of the assessment of impacts on regional economy.

2.3.3 EIA team

At the beginning of the programme stage an EIA team was established to monitor and support the studies carried out during the project. The meetings of the team on 27 June and 10 August 2007 dealt with town planning, and cooling water and environmental studies. The second meeting included a boat trip to the possible cooling water intake and discharge areas and a visit to the existing plants' surroundings, the water front and water areas. The team has consisted of the following:

• Loviisa town's technical office
• Ministry of Trade and Industry (present Ministry of Employment and the Economy)
• Regional Council of Itä-Uusimaa
• Western Finland Environmental Permit Authority
• Uusimaa Regional Environment Centre
• Eastern Uusimaa Fire and Rescue Service
• Pöyry Energy Oy
• Fortum.

2.3.4 Information and discussion events

During the preparation of the environmental impact assessment programme and report, information and discus-

sion events were organized. At these events, people could present opinions and views on the environmental impact assessment work and its adequacy.

Loviisa Town Administration was informed about the EIA project on 28 May 2007. Another information and discussion event was arranged for the Loviisa Town Council, Administration and the town's senior officials on 16 October 2007.

A "neighbourhood party" was held for the nearest neighbours of the power plant on 19 June 2007. The event included presentations of the contents of the EIA programme and discussion on the project. The participants took part in a resident survey.

The first event open to the public was arranged on 23 August 2007 at the Loviisa Sports Hall. The public had the opportunity to receive information and discuss the EIA procedure with Fortum and the authors of the EIA programme.

The following matters were discussed at the public event:

- the environmental impacts of cooling water and the possibility to build a lake for the cooling water
- using cooling water for the production of district heat
- the building of a possible cooling tower
- supply of information in Swedish
- the situation of the planning of road Atomitie
- the effect of a potential oil accident on the cooling water intake
- the effects of the project on flora and fauna, aquatic vegetation and the eutrophication of the area
- the carbon dioxide releases of nuclear power during the plant lifetime
- the power plant's protective zones
- energy saving
- procurement of fuel.

2.3.5 Town square events

On 4 and 18 August 2007, public events were arranged at the Loviisa town square, during which people could express their opinions and receive information as well as discuss the project with the representatives of Fortum and Pöyry Energy Oy. There was a lively discussion at the events and two people also gave written feedback.

2.3.6 Resident survey

A survey was conducted among local residents during the EIA procedure for the purpose of increasing interaction, providing Fortum with information on public attitudes towards the project and also providing local residents with information on the project and its impacts on their living environment.

The sampling, extent and results of the resident survey have been presented in Chapter 9.12.

2.3.7 EIA newsletters

During the EIA procedure, three four-paged EIA newsletters were published. The news letters were delivered with the local newspapers both in Finnish and Swedish (official languages of Finland) to all households in Loviisa, Pernaja, Lapinjärvi, Ruotsinpyhtää, Liljendal and Pyhtää. The newsletters provided information on the progress of the EIA procedure and the main impacts of the project.

The EIA newsletters dealt with the EIA procedure and its progress, interaction during the EIA process, studies to be carried out during the environmental impact assessment and the impacts to be assessed. A feedback sheet was attached to the first newsletter, four sheets were turned in. The feedback concerned the status of the Swedish language, potential disturbances during the building of the plant, procurement and final disposal of fuel, threat of terrorism and the environmental impacts of cooling water.

2.3.8 The state of the Gulf of Finland and the impact of cooling water – public event

The impacts of cooling water of the new nuclear power plant unit were recognized as one of the most considerable environmental impacts. This is why a separate public event was arranged on 20 November 2007 to discuss the state of the Gulf of Finland and the power plant's cooling waters. The event was attended by about 80 participants.

The introducers at the event were experts from the Uusimaa Regional Environment Centre, Metsähallitus (a state-owned enterprise that runs forest business activities while also fulfilling many public administration duties), the Association of Marine Fishing in southern Finland and Fortum. Time was also allowed for dealing with all asked questions. On the basis of the introductions and the discussion it was stated that the poor state of the Gulf of Finland is mainly due to various nutrient emissions, such as nitrogen and phosphor. The increased thermal stress caused by the cooling water of a power plant seems to have mainly local impacts, such as thinner ice, increased eutrophication of the discharge area and impacts on fishing.

2.3.9 Other communications

Fortum has provided information on the project through press releases and by arranging press briefings. The EIA programme and the EIA report are available for viewing at the municipal offices of the neighbouring areas and at local libraries. Fortum has established a website for the EIA procedure (www.fortum.com/loviisa, > Loviisa 3 EIA), which provides up-to-date information on the EIA procedure. Both the EIA programme and the report are also available for viewing on the website of the Ministry of Employment and the Economy (www.tem.fi > In English > Energy > Nuclear energy > EIA procedures for new nuclear power projects > EIA of the Loviisa 3 option).

2.4 International hearing

The assessment of transboundary environmental impacts has been agreed upon in what is called the Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context). Finland ratified this UNECE Convention (67/1997) in 1995. The Convention entered into force in 1997.

The parties to the Convention are entitled to participate in an environmental impact assessment procedure carried out in Finland if the detrimental environmental impacts of the project being assessed could potentially affect the country in question. Correspondingly, Finland is entitled to participate in an environmental impact assessment procedure concerning a project located in the area of another country if the impacts of the project could potentially affect Finland.

In Finland, the Ministry of the Environment is responsible for the practical arrangements relating to the international hearing. The Ministry of the Environment notified the environmental authorities of eight neighbouring countries of the Baltic Sea region (Estonia, Russia, Denmark, Germany, Sweden, Poland, Latvia and Lithuania) and Norway about the commencement of an EIA procedure and inquired their willingness to participate in the EIA procedure. The notification was accompanied by a Swedish or English EIA programme and a summary translated into the language of the receiving country, which will act as the document of international hearing.

Sweden, Norway, Germany and Estonia announced their willingness to participate in the EIA procedure and gave their statements on the EIA programme. Poland and Lithuania participated in the EIA procedure but gave no statement on the EIA programme. Russia announced its willingness to participate in the EIA procedure but will deliver the statement later. Latvia and Denmark have notified the Ministry of the Environment that they will not participate in the EIA procedure.

After the completion of the EIA report, the authorities of the countries participating in the EIA procedure will be delivered a report in Swedish or English and a summary translated into the language of the receiving country, which will act as the document of international hearing.

2.5 Statements and opinions on the assessment programme

In addition to the announcement in newspapers, the Ministry of Trade and Industry asked in writing for statements on the EIA programme from various ministries, experts, authorities, representatives of towns and municipalities, and various associations and organizations.

32 statements were turned in to the Ministry. There were also nine other statements and opinions, six of which from associations and organizations and three from private persons. Also the project responsible forwarded 11 papers to the Ministry, opinions stated at public events, the town square events or other connections.

The given statements mainly regarded the programme as appropriate and comprehensive. The statements and opinions commented, e.g., on the environmental impacts of the whole lifetime of the project, the dismantling of the plant unit, and the management and transport of nuclear waste.

A desire was expressed to have the impacts of cooling water assessed in a wide area, taking into consideration the experience gained by professional fishermen. Other matters that emerged were the combined impacts of the existing plants and the third unit, impact on people (especially habitation and comfort as well as the Swedish culture, the social impacts of languages and cottagers), climate change, other threats and the impact of threats on the possibility of accidents, the social significance of the project and other optional means of power production. Many of the opinions did not present aspects of the EIA programme, they just generally opposed or supported the idea of using nuclear power.

According to the Swedish environmental authority (Naturvårdsverket), the EIA programme was for the most part adequate. The most significant impacts focus on the sea, and information on the impacts is gathered in the environmental monitoring programmes of the existing plants. Also the Swedish nuclear safety authority (Statens Kärnkraftinspektion) considered the EIA programme adequate.

Especially the assessment of the impacts of the plant's normal operation was comprehensive.

The Swedish environmental authority gave statements, which emphasized the assessment of radioactive releases from various perspectives. It said that special attention should be paid to the long-range transport of potential releases and preparation for that, the techniques for reducing releases and the mitigation of any harmful effects. Also the impact of releases on the environment and further on sources of livelihood, e.g. fish and fishing, should be assessed. The statements also pointed out that the combined impacts of the planned unit and the existing plants on the radioactivity of the Baltic Sea should be assessed. The statement stated that the assessment of impacts should be complemented by taking into consideration the whole lifespan of the project and by assessing the environmental impacts of the production of nuclear fuel and spent fuel. The statement also remarked on the lack of the zero-option or inadequate discussion about it. The statement especially noted that optional means of power production were missing.

The Norwegian Ministry of the Environment, which acts as the environmental authority, emphasized the assessment of reactor safety, accidents, unexpected events and radioactive releases. The plans and monitoring systems devised in case of accidents and incidents should be described. The statements issued by the Norwegian Ministry of the Environment also emphasized the assessment of radioactive releases from several perspectives. Special attention should be paid to the long-range transport of potential releases and preparation for that and to the mitigation of any harmful effects. Also the impact of releases on the environment and further on sources of livelihood should be assessed. Flora and fauna as well as reindeer husbandry and recreational use were given as examples. Attention was also paid to nuclear waste management and alternatives.

The authority responsible for the German international EIA procedure (Innenministerium Mecklenburg-Vorpommern) pointed out that the assessment of radioactive releases should take into consideration the long-range transport of radioactive substances via water and air, the assessment of impacts of the long-range transport and a description of how e.g. Germany would be informed in the case of an accident. Also the assessment of impacts should be completed by an assessment model for the environmental impacts of the production of nuclear fuel and the management of spent fuel.

The Ministry of the Environment of Estonia, which acts as the country's environmental authority, emphasized from many points of view the description of accidents that would have transboundary effects. The description should bring up the effects requiring radiation protection and how the neighbouring countries would be informed in the event of an accident.

The statements also asked to take into consideration the assessment of alternative means of electricity production.

The aspects presented in other statements and opinions and during interaction have been taken into account as extensively as possible. It is not possible to go through all the points taken into consideration, but the most significant additions to be mentioned are the combined electricity and heat generation (district heat), which arose in several connections, various solutions concerning the cooling water, and fairly wide reviews of several subjects. The statements and opinions given on the assessment programme are available for viewing on the website of the Ministry of Employment and the Economy (see Chapter 2.3.9)

2.6 Statement of the coordinating authority on the EIA programme and its consideration

The Ministry of Trade and Industry gave its statement (Appendix 1) on the EIA programme of the project on 16 October 2007. The statement says that the environmental impact assessment of the Loviisa 3 project covers the content demands of EIA legislation and it has been handled as required by the legislation. The matters which, according to the statement of the Ministry, must be taken into account when carrying out the studies, compiling the assessment report and arranging the assessment procedure, have been gone through point by point. Each point includes an answer to how the matters have been taken into consideration in the assessment.

The EIA report should include a review of the current nuclear power plant types on the market which are suitable for the project under review.

Chapter 3.2.3 includes a review of the current nuclear power plant types on the market.

The safety planning criteria for the prospective plant must be presented with respect to the limitation of releases of radioactive substances and environmental impacts, as well as an assessment of the opportunities to meet the safety requirements in force.

The power plant unit is planned to meet the safety demands presented in the Nuclear Energy Act and Decree, Government decisions and the YVL Guides of the Radiation and Nuclear Safety Authority. The emissions of radioactive substances during operation, and the means for controlling them, are dealt with in Chapter 9. The design basis of the power plant unit, means for preventing emissions of radioactive substances during an accident and implementation of the safety requirements have been described in Chapter 12.

For the purposes of communicating the project, it may prove advantageous to include a short description of the cost structure of the project and its options in the EIA report.

An assessment of the general cost structure is given in Chapter 8.4.

The Ministry recommends that the EIA report introduce the energy efficiency and conservation efforts undertaken by the responsible organisation.

Fortum's energy conservation and energy efficiency methods have been described in Chapter 11.

The Ministry has the view that the impacts of cooling waters form the most significant environmental impact during normal plant operation. The selection of cooling water intake and discharge sites should be accounted for and described precisely.

The intake and discharge sites have been accounted for and described in Chapter 9.

When analysing the environmental impacts of sea water warming, any background material available must be utilised extensively and the analyses must be linked on a wider scale to the state of sea areas. In order to define the affected area, the analyses must be extended to cover a wide sea area and must take into consideration the heat load caused by the existing Loviisa power plant units.

The available background material and sea water analysis results have been utilized extensively when assessing the environmental impacts of the warming of sea water. The environmental impacts of cooling waters have been assessed on the basis of a cooling water model. The model and the results have been described in Chapter 9.

The impact of cooling waters on protected areas must be assessed, including an assessment of the need to conduct a Natura review pursuant to Section 65 of the Nature Conservation Act. The EIA report must introduce measures to reduce adverse effects. Uncertainties in calculation results must be illustrated clearly.

The impacts of cooling water on protected areas are assessed in Chapter 9 and the assessment of the need to conduct a Natura review has been reviewed in a way approved by the Uusimaa Regional Environment Centre. The assessment has studied whether the project will significantly reduce the natural values that are the basis for protection of the Natura areas. The prevention and mitigation of adverse effects have been dealt with at a general level in Chapter 16. The uncertainties in calculation of the cooling water model have been presented in Chapter 15.

The assessment of the arrangements for water supply must be supplemented by including alternative options and assessing their environmental impacts.

Alternative options for arranging water supply and their environmental impacts have been described in Chapters 8 and 9.

The report must review the environmental impacts of the 110 kV transmission connection up until the next switching substation.

The environmental impacts of the new 110 kV transmission connection have been reviewed in Chapter 9.

The Ministry finds assessment of the growth in the volume of traffic a good starting point and requires that the impacts on nature and other environment be assessed, particularly on a local level, covering a wider area wherever possible.

An assessment of the volumes and impacts of traffic during the construction and operation of the power plant unit have been described in Chapters 8 and 9. The impacts of road plans on the environment have been dealt with in the preparation of the component master plan for shore areas of Loviisa.

The Ministry finds it reasonable that the organisation responsible for the project should examine the environmental impacts of the entire fuel supply chain in general and, additionally, the company's opportunities to influence this chain. The Ministry requires a description of the assessment method.

The fuel supply chain and the environmental impacts of the entire chain have been described on the basis of existing, public reviews by international authorities and experts as well as Fortum, in Chapter 14. The Chapter also presents Fortum's procedures in the procurement of fuel.

The EIA report should review nuclear waste management as a whole, including extensions to the necessary storage and final disposal facilities and their environmental impacts.

Nuclear waste management and the environmental impacts of final disposal have been discussed in Chapter 14. The assessment of the environmental impacts of the extension to the final disposal facilities has utilized the EIA report of Posiva Oy and the reviews done after that.

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. The assessment may use the classification system of the International Atomic Energy Agency (IAEA), and the EIA report must present a clear summary of the basis used in the review.

The possible consequences of accidents with different levels of seriousness have been described with the help of the INES classification in Chapter 12. Emissions caused by a severe accident, their impact on people and the environment, and the width of the impacts have been dealt with in detail in Chapter 13.

Assessing the impacts must not be limited to the protective zone or the emergency planning zone for rescue operations. The assessment must also include a review of the possible environmental impact of radioactive substances on the countries around the Baltic Sea and on Norway.

The impacts of a severe accident have been studied within a range of 1 000 kilometres. The results shown in Chapter 13 can also be applied to the countries around the Baltic Sea and on Norway.

The Ministry finds it appropriate that the assessment of emergencies take into consideration, among other factors, the effects of climate change. The Ministry requires that the assessment include a review of preparations to cope with climate change and that special attention be paid to changes in sea level.

Sea level changes in the area of Hästholmen and the increase of oil transports on the Gulf of Finland have been described in Chapter 7. Sea level changes, impacts of climate change and other external threats are taken into consideration in the design of the power plant unit.

The Ministry proposes providing a detailed assessment of the project's impact on employment, during both construction and operation of the power plant unit. In addition, the project's impact on the current use and value of real estate and methods of mitigating any adverse effects must be examined.

The impacts on employment in the Loviisa region during construction and operation have been discussed in Chapters 8 and 9. A resident survey has been carried out to find out the residents' assessment of the impact of the new power plant unit on the value of real estate and also to see how the new power plant unit affects the willingness to move. The results of the resident survey are shown in Chapters 8 and 9.

Some comments propose adding to or further defining the assessment methods, particularly with regard to the impacts of cooling waters and emergencies, further assessing the areas of impact, and incorporating the ICRP's new guidelines on radiological protection, published in October 2007.

The assessment of impacts of cooling waters has been complemented to cover the biological impacts as well. The assessment methods of both cooling water and accidents have been specified. The radiation protection guidelines have been observed in Chapters 9 and 13, assessing the impacts on the natural environment during both normal operation and accidents.

The Ministry considers that the arrangements for participation during the EIA procedure can be made according to the plan presented in the EIA programme. However, sufficient attention should be paid in communications to, and interaction with, the entire affected area of the project, across municipal borders and all population groups. The Ministry requests that the parties consider ways of presenting the impact of participation in the EIA report.

Participation and interaction have been arranged in a way described in Chapter 2, in accordance with the EIA programme. The Audit Group, public events, EIA newsletters, a neighbourhood meeting and two public events at the Loviisa town square serve to implement communication and interaction. The effect of interaction has been discussed in Chapter 2.

2.7 Public display of the assessment report

The Ministry of Employment and the Economy will announce the public display of the assessment report once Fortum has submitted it. The public display will be arranged similarly to the display of the assessment programme. Written opinions and statements on the EIA report must be submitted to the coordinating authority within the specified time. According to the EIA Act, the deadline shall be no less than 30 days and no more than 60 days after the publication of the announcement.

2.8 Completion of the EIA procedure

The EIA procedure will be completed once the Ministry of Employment and the Economy has provided its statement on the EIA report. This will take place within two months of the deadline set for submitting opinions and statements.

The EIA report and the statement issued by the Ministry of Employment and the Economy will be attached to the licence applications related to the project, and the licensing authorities will use it as the basic material for their decision-making. As the project proceeds to the state of detailed planning, the EIA report and the interaction and all material gathered during the EIA procedure will be used as one of the starting points for the planning.


Daylily, Loviisa

© Timo Lindgren


Common gull, Hudö

© Timo Lindgren

3 TECHNICAL SPECIFICATIONS OF THE PROJECT

3.1 Commercial use of nuclear power

In the early days of the use of nuclear power, in the 1950s and 1960s, several different reactor types were studied and built, but only a few of them ended up in wide, commercial use. The first test and prototype plants represent the first generation of nuclear power plants and they created the basis for the development of nuclear power industry today. The power plants in present commercial operation are mainly designed and constructed in the 1960s and 1970s and they represent the second generation. The third generation nuclear power plants have been developed after the 1980s.

The reactors of the nuclear power plants in commercial operation today mainly use moderated neutrons and they are classified on the basis of the moderating material of neutrons and the matter cooling the fuel (coolant). A majority of the world's nuclear reactors are light water reactors, so are also the reactors in Finland, both the existing and the one under construction. They use ordinary water as moderator and coolant. In addition to light water reactors, there are less common graphite and heavy water moderated and gas cooled tube reactors in commercial use in the world.

There are two basic types of light water reactors, the boiling water reactor and the pressurized water reactor. The two existing power plant units of Fortum Power and Heat Oy in Loviisa and the third unit of Teollisuuden Voima Oyj under construction at Olkiluoto are pressurized water reactors. The two existing units at Olkiluoto are boiling water reactors.

At the moment, the fourth generation nuclear energy systems are being developed; their operating principles differ notably from those of the reactors in commercial use today. The fourth generation nuclear energy systems generally have notably higher temperatures than current reactors. Several concepts utilize fast neutrons, new fuels and special coolants, such as liquid sodium. The development work is partly based on old, promising concepts and, on the other hand, on totally new ones. It is expected that the fourth generation nuclear energy systems will be in commercial use in about 20–30 years.

3.2 Light water reactors

Light water reactors are by design and basic characteristics simple and naturally stable. They have proven secure and reliable, which explains their popularity. This is why the further development and construction of new reactors has mainly focused on light water reactors. At present, the new light water reactor plants represent the third generation nuclear power plant, although when referring to the most advanced new plant types the term three plus generation is often used.

3.2.1 Development

The construction and technology of light water reactors has remained practically the same since the 1960s. Most of the third generation light water reactors have been developed from the already existing reactors according to the newest safety requirements utilizing the latest design and manufacturing methods. Along with the development work the power of power plants has increased but, above all, their safety and operational reliability has improved.

The starting point for the improvement of safety has mainly been to reduce the risk of core damage. Safety has been improved e.g. by adding the number of parallel equipment carrying out the same function in the safety systems (redundancy) and by implementing the safety functions of systems by various operating principles (diversity). The physical separation of subsystems has also improved considerably. Furthermore, the design of the newest nuclear power plant types also takes into consideration the accidents leading to core damage and their control in the early stages of the design process. New reactors are equipped with systems to limit the consequences of a

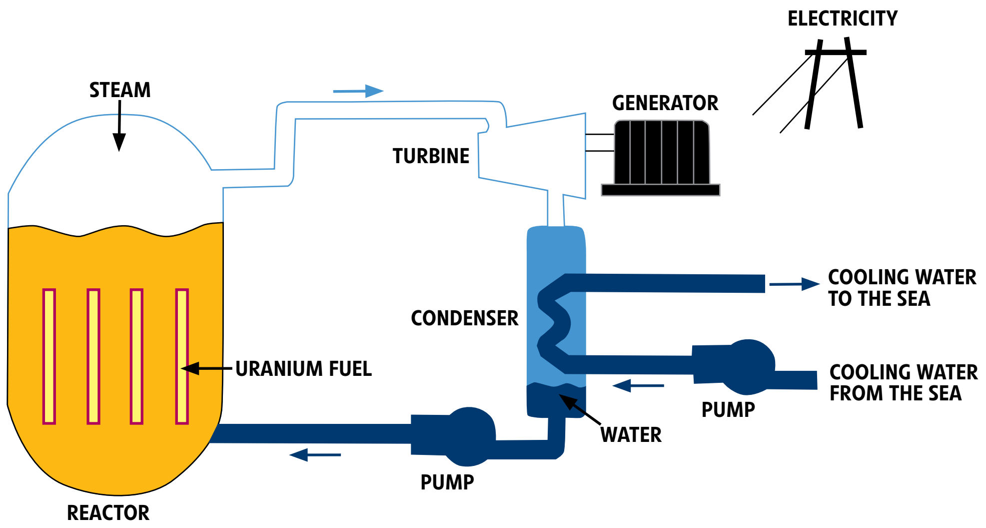


Figure 3-1. Basic operational principle of a boiling water reactor plant.

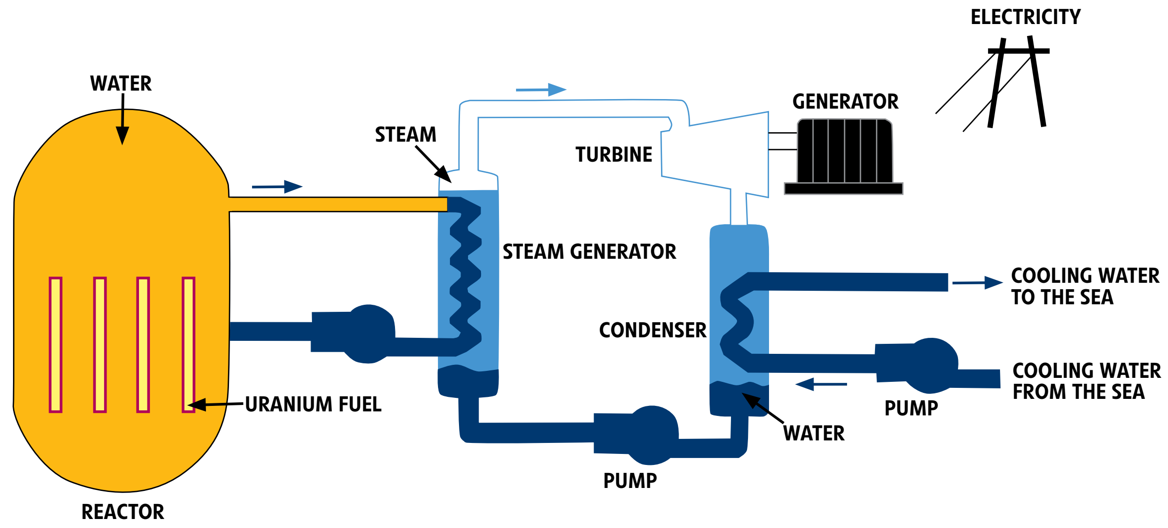


Figure 3-2. Basic operational principle of a pressurized water reactor plant.

severe reactor accident. (See Chapter 12.1)

The advanced light water reactors can be roughly divided into evolutionary plants, whose safety design is mainly based on active safety systems, and innovative plants, whose safety design is mainly based on passive safety systems. It is typical of reactors based on passive safety systems that the systems have partial or total independence from the external operational preconditions. Examples of these are systems operating with gravity, such as water tanks located high up, from where the water can be conducted to its point of use without pumps and motors. The development work on these reactors is fairly advanced and in the near future they can be regarded as commercially significant alternatives.

The starting point is that the reactor to be built to Finland must be safe, employ well-tried technology and be in line with the general development of reactor technology. Thus the new power plant unit planned for Hästholmen in Loviisa will be a third or a three plus generation pressurized water or boiling water reactor.

3.2.2 Operating principle

The main difference between a nuclear power plant and a conventional steam power plant is the heat production method. Instead of ordinary fuel (e.g. coal, natural gas or peat), a light water reactor uses enriched uranium oxide (UO_2). The use of uranium as fuel is based on the fission reaction of its isotope ^{235}U. In a fission reaction a heavy atom splits into two or more lighter atomic nuclei as a free neutron hits it. The reaction also releases some neutrons and a large amount of energy. The neutrons released in the reaction can cause new fissions, which is why a chain reaction is possible. Electricity production in a nuclear power plant is based on the utilization of the thermal energy that a controlled chain reaction yields.

In a nuclear power plant the uranium fuel is in ceramic form as small pellets packed in gas-tight metal pipes as fuel rods, which have been gathered as fuel bundles. Depending on the plant type, in the reactor core there are 100–900 fuel bundles, which contain altogether 50–150 tonnes of uranium. During operation, the fuel becomes highly radioactive. The fuel chain in a nuclear power plant from production to spent fuel final disposal is described in Chapter 14.

Boiling Water Reactor, BWR

In a boiling water reactor the energy released in the fission reaction heats the fuel, which in turn heats up the coolant flowing through the core, so that the water boils in the reactor, thus generating steam with a temperature of about 300 °C and a pressure of 70 bar. The high-pressure saturated steam is conducted via the steam separators and water separator located in the reactor pressure vessel to the turbine, which is rotated by the expanding steam. On the same shaft as the turbine there is an electric generator, which produces electricity.

After the turbine the steam is conducted into condensers, where it is condensed by the cold sea water into water. In a boiling water reactor plant the water is pumped back into the reactor pressure vessel. The sea water used for cooling is returned to the sea, somewhat warmer. The basic operational principle is shown in the Figure 3-1.

Pressurized Water Reactor, PWR

Compared to a boiling water reactor, the pressure in a pressurized water reactor is notably higher, typically 120–155 bar. The high pressure prevents the water that runs through the reactor core as it is heated by the energy released in the fission reaction from boiling inside the reactor pressure vessel. A pressurized water reactor plant has two separate circulation systems; the primary system, which circulates the water pumped through the reactor core and the secondary system, where the steam conducted to the turbine is generated.

Energy is transferred from the reactor to the primary system with the pressurized water heated up to 300–330 °C, to separate steam generators, where the energy is transferred to the secondary system water, evaporating it. The evaporated steam (260–295 °C and 45–78 bar) flows to the turbine. The primary circuit water cooled down in the steam generators is pumped back into the reactor pressure vessel.

After the turbines, the steam is conducted to the condensers, where it condenses, being cooled by cold sea water, into water. In pressurized water reactor plants the water is pumped back from the condensers to the steam generators. The sea water used for cooling is returned somewhat warmer to the sea. The basic operational principle is shown in the Figure 3-2.

Radioactive releases

During the operation of a nuclear power plant small amounts of radioactive substances are released into the air and water. Due to neutron radiation, the water flowing trough the reactor core, corrosion products and other impurities become radioactive during operation. Also small amounts of radioactive noble gases, iodine and cesium, can leak into the water from fuel rods.

The gases and waters that may contain radioactive substances are filtered and they are delayed to reduce their radioactivity before letting them out via the ventilation stack or into the sea with the cooling water. Radioactive releases into the air and sea have been discussed in Chapter 9.

3.2.3 Commercial plant options

The situation of plant suppliers has altered considerably during the last few years due to company reorganizations and branch rationalization. At the commercial level, the most important names in the light water reactor market at the moment are

- Areva
- Atomstroyexport (is responsible for exporting Russian plant concepts)
- GE (General Electric)-Hitachi Nuclear Energy
- KHNP (Korea Hydro & Nuclear Power Company)
- Mitsubishi Heavy Industries Ltd (co-operation with Areva under consideration)
- Toshiba Corporation and its affiliated company Westinghouse Electric Company.

In Europe, nuclear power plants are mainly licensed on the basis of national regulations, and national authorities are responsible for the licensing. A nuclear power plant built in Finland must fulfil the safety requirements established in the Nuclear Energy Act and Decree, Government decrees and regulatory guides (see Chapter 12.1).

There have been international efforts to harmonise licensing and other technical requirements for light water reactors by both authorities and power companies. At the moment in Europe the most important set of requirements for new nuclear power plants is a list of common technical and safety requirements, European Utility Requirements (EUR), determined by major European nuclear power companies. A general aim is that plant suppliers and power companies apply EUR documents to their new plants, but their use is not binding. EUR co-operation involves scrutinising the suppliers' plant concepts to see how they fulfil the requirements. The fulfilment of the EUR does not guarantee a licence as such in any individual European country.

At the moment, the light water reactor plant types on the market include, for instance, the following (the plant types marked with an asterisk * have gone through EUR review):

ABWR* (Advanced Boiling Water Reactor) is a 1 350–1 600 MW boiling water reactor designed by General Electric (GE) based on the technology of GE's previous boiling water plants. ABWR is an evolutionary plant, whose safety design is based on active safety systems.

Four ABWR units are in commercial operation in Japan. Two at Kashiwazaki-Kariwa, one at Hamaoka and one at the Shika power plant. One unit is under construction in Japan at the Shimane power plant and two units in Taiwan at the Lungmen power plant. In the US, ABWR has a design certificate granted by the nuclear safety authorities, and a combined construction and operating licence has been applied for for two units.

ABWR/Toshiba is a boiling water reactor, which has been developed on the basis of the Japanese ABWR plants, and specially on the basis of the 1 350 MW Hamaoka 5 unit. Toshiba's ABWR is an evolutionary plant which is based, to a great extent, on technology similar to GE-Hitachi's ABWR. Toshiba's ABWR has technical features of the BWR 90+* plant concept developed by Toshiba's affiliated company Westinghouse (former ABB Atom).

AES-2006 (Atomnaja Elektrostantsija) is a 1 150–1 200 MW pressurized water reactor designed in Russia. It has been further developed from the VVER-91/99 and AES-92 concepts. AES-2006 is an evolutionary plant, whose safety design is based on both active and passive safety systems.

AP1000* (Advanced Passive) is an innovative 1 100 MW pressurized water reactor representing a totally new plant concept designed by Westinghouse. Its safety design is based on passive safety systems.

Four AP1000 units have been ordered to the Sanmen and Haiyang power plants on the east coast of China. The goal is to start construction work at Sanmen in the beginning of 2008. In the US, AP1000 has a standard certificate granted by nuclear safety authorities, and a combined construction and operation licence has been applied for four units.

APR-1400 (Advanced Power Reactor) is a 1 450 MW pressurized water reactor designed in South Korea, which has been further developed on the basis of the US System 80+ concept developed by Westinghouse (former ABB Atom). APR-1400 is an evolutionary plant, whose safety design is based on active safety systems.

The construction of two APR-1400 units at the Shin Kor power plant in South Korea is scheduled to begin in 2008.

APWR (Advanced Pressurized Water Reactor) is a 1 540–1 700 MW pressurized water reactor designed by Mitsubishi Heavy Industries. APWR is an evolutionary plant whose safety design is based on both active and passive safety systems. In Japan, the design certificate process for APWR is ongoing, and Mitsubishi has submitted an application for a design certificate for US-APWR.

EPR* (Evolutionary Pressurized Water Reactor) is a 1 600–1 750 MW pressurized water reactor designed by Areva. It is based on the basic technology of the German 1 300 MW Konvoi series and the French 1 450 MW N4 series. EPR is an evolutionary plant whose safety design is based on active safety systems.

One EPR unit is under construction in Finland at the Olkiluoto power plant and one in France at the Flamanville power plant. Two units have been ordered to China at the Taishan power plant. In the US, the standard design certificate process for EPR is ongoing and a combined construction and operating licence has been applied for for one unit.

ESBWR (Economic & Simplified Boiling Water Reactor) is an innovative 1 390–1 560 MW boiling water reactor developed by General Electric from the ABWR plant type, originally for the European market. The safety design is based on passive safety systems. In the US, the ESBWR design certificate process is ongoing, and a combined construction and operating licence has been applied for for one unit.

SWR-1000* (Siedewasserreaktor) is an innovative 1 200–1 290 MW boiling water reactor originally designed by Siemens (nowadays a part of Areva) based on the German boiling water reactor technology. The starting points for the safety design are inherent properties and passive safety systems.

VVER-91/99 (Vodo-Vodjanoi Energetitšeskij Reaktor) is a 1 000 MW pressurized water reactor designed by Russians. It is based on the basic technology of the VVER-1000 plant. VVER-91/99 is an evolutionary plant whose safety design is based on active safety systems. A parallel version for VVER-91/99 is AES-92*, whose safety design is based on both active and passive safety systems.

Two VVER-91/99 units are in commercial use in China at the Tianwan power plant. Two AES-92 units are under construction in India at the Kudankulam power plant. A contract has been concluded to build two AES-92 units at the Belene power plant in Bulgaria.

The plant options are not limited to those above. The final choice will be made in due course among the plant types that fulfil the Finnish safety requirements and are on the market at that time. The final plant size, the starting date of the project and the commercial situation will determine the purchase criteria as well as the choice of the plant supplier. The applicability of plant options as such to the Finnish conditions will also be taken into consideration.

There are several alternatives for the scope of delivery. A power plant unit can be purchased as turnkey or the delivery can be split into several parts. It is very common to divide the supply of the reactor and the turbine into two deliveries. There are several possible turbine suppliers in the world, some of them being the same as the above mentioned reactor suppliers. Several work units, such as construction work, can be purchased from suppliers other than those of the actual plant systems.

3.3 Technical specifications

The new power plant unit will be a light water reactor plant with an electrical power of 1 000–1 800 MW, one that is on the market now or will be in the near future. The thermal power of the reactor is 2 800–4 600 MW. The power plant is a base load plant, meant to run continuously except for the maintenance outage at intervals of one to two years. The estimated service life of the plant is at least 60 years. Table 3-1 gives the preliminary technical data on the new power plant unit.

Table 3-1. Preliminary technical specifications of the new power plant unit.

Description	Value and unit
Electrical power	1 000–1 800 MW
Thermal power	2 800–4 600 MW
Overall efficiency	35–40 %
Fuel	Uranium dioxide (UO_2)
Consumption of uranium fuel	20–40 tonnes/year
Average degree of fuel enrichment	3–5 % (^{235}U)
Amount of uranium in the reactor	100–150 t
Annual electricity production	8–14 TWh
Need for cooling water	40–70 m^3/s

The same safety requirements are set for all plant alternatives and their environmental impacts do not differ from each other. This is why the environmental impact assessment has been carried out generally on a light water reactor on the basis of the largest electrical and thermal power given above. The assessment thus covers all plant alternatives. Within the power limits, the project can thus also be implemented as two smaller power plant units built next to each other, if suitable plant types are launched onto the market in the near future.

3.4 Energy efficiency

3.4.1 Electricity production

The basis for the planned power plant unit is an electricity-generating condensing power plant with an estimated total efficiency of 35–40%. The energy efficiency of current light water reactor plants can in practice be improved only by also producing district heat or process steam. This decreases the electrical power of the power plant but the total efficiency will increase. The highest realistic target for the total efficiency is about 60%.

3.4.2 Combined electricity and heat production

At the moment district heat or process steam is produced in nuclear power plants only on a small scale e.g. in Russia, Bulgaria and Switzerland. The Leningrad power plant in Sosnovyi Bor near St. Petersburg produces hot water and district heat to the nearby city of Sosnovyi Bor with 60 000 inhabitants (in 2006 the average power consumption was some 110 MW (*Leningrad NPP 2006*). In Bulgaria, the Kozloduy power plant produces district heat to the nearby town of Kozloduy with nearly 15 000 inhabitants (in 2006 the average power was about 9 MW (*Kozloduy NPP 2006*). In Switzerland, the Beznau power plant produces district heat to the needs of 15 000 inhabitants in the nearby areas (in 2006 the average power was about 20 MW (*Refuna 2006*), and the Gösgen power plant produces process steam for the nearby pasteboard factory (in 2006 the average power was about 8 MW (*Kernkraftwerk Gösgen 2006*). The production of heat has a marginal effect on the total efficiency of the power plants.

If in combined electricity and district heat production the total efficiency of a power plant with a thermal power of 4 600 MW were 60%, the power plant's electrical power would decrease from 1 800 MW to 1 560 MW and district heat power would be 1 200 MW. Nevertheless, the power plant's total efficiency varies according to district heat production. In summer, when the need for district heat is at the smallest, the total efficiency is estimated at 50% (electrical power 1 675 MW and district heat power 625 MW). The stability and operability of the district heating network also affect the total efficiency. Thermal loss in the district heating network must also be taken into consideration as well as the electricity need of district heating network pumps. Thus the average total efficiency remains in practice considerably below 60%.

In practice there are consumers for the 1 200 MW of district heat only in the metropolitan area. The need for district heat in the metropolitan area is about 11 TWh/year, which corresponds to an average district heat power of 1 260 MW. However, the introduction of district heating to the metropolitan area is not only in the hands of the project responsible (see Chapter 1.5).

The most significant benefit provided by the combined electricity and heat production in the new power plant unit would be cutting carbon dioxide emissions, if the production replaced district heat produced by fossil fuels. Implementation of the district heating alternative requires an environmental impact assessment of a district heat tunnel. This is why the environmental impacts of combined electricity and heat production are discussed here only as far as Hästholmen and the surrounding waters are concerned. The impacts of the reduction in the thermal load led into the sea in combined electricity and heat production have been described in the environmental impacts of cooling waters in Chapter 9.4.

Technical implementation

The connection of district heat production to a nuclear power plant is technically feasible. The necessary modifications to the turbine plant and the turbine are limited to the adding of district heat exchangers beside the preheaters and to the dimensioning of the turbine flow part.

A 4-5 stage heating system is needed for heating the district heating water to a temperature of 180 °C; it operates parallel with the preheating system. The loss of electricity power depends on the connections of district heat heating stages: the warmer steam is needed for heating the district heating water, the greater loss in electricity generation.

The power of district heating can be controlled by altering either the district heating water flow or temperature. Choosing the method of control depends on the length of the district heating network and thermal power. The main principle should be to keep the reactor power stable and to change the electric power according to the needs of the district heating network.

There are international technical plans for modifying turbines to produce some 1 000 MW of district heat power. Greater power would produce a better total efficiency but brings along problems regarding the adjustability of the district heating network and its effect on the turbine plant. On the other hand, provision for a district heating connection limits the optimisation of the turbine for top efficiency in mere electricity production, i.e. in condensing operation. A district heating solution always requires also the availability of adequate reserve capacity.

3.5 The buildings and structures of a nuclear power plant unit

The buildings of a nuclear power plant unit can be generally divided into the nuclear plant section buildings and the conventional plant section buildings. The buildings of the nuclear plant section include, e.g.

- the reactor building
- the auxiliary building
- the fuel building
- the interim storage for low- and intermediate-level waste
- the nuclear service building
- the security buildings
- the control room building
- the diesel buildings
- the secured sea water pumping station.

Depending on the plant type, the control room building can be connected to the security buildings. Furthermore, no interim store for low- and intermediate-level waste is not necessarily needed, if there is a repository for low- and intermediate-level operating waste at the plant site.

The buildings of the conventional plant section include, e.g., the turbine building, the electricity building, the unsecured sea water pumping station, the water treatment building, the raw water tanks, the transformers and the switchyard. Depending on the plant type, the electricity building can be separate or connected to the turbine building. The emergency diesels of the conventional plant section may be located in separate buildings, in the water treatment building or they may be connected to the diesel buildings of the nuclear plant section.

In addition to the buildings of the nuclear and conventional plant sections, the buildings and structures necessary for operation of the power plant unit include, e.g., cooling water tunnels, cooling water intake and discharge structures, and roads and tunnels at the power plant site. Other facilities needed include repair shop and storage buildings, a fire water pumping station and fire water tanks, office buildings and a fallout shelter. The fire water tanks and the fallout shelter can be underground facilities excavated in the bedrock. Depending on the water supply arrangements of the new power plant unit, a sanitary waste water treatment plant will possibly also be located at Hästholmen.

The combined volume of the power plants is estimated at 500 000–750 000 m^3 and their maximum height is about 70 metres. The highest construction is the ventilation stack with a height of 100-120 metres.

The size of the new power plant area is some 10 hectares, including the site transport area. South of the existing power plant units there is a 30-hectare area available for site functions when the sea area land filling allowed by the land use plan is implemented as a whole. On the cape next to Hästholmen, behind the present accommodation area, there is an 18-hectare area planned as a support area for energy production.

A loading and unloading site will be built on the western shore of Hästholmen for the heavy sea transports during construction of the new power plant unit. The sea route will be drawn from the 9.5- metre-deep route leading to Loviisa harbour. When planning the loading and unloading site, the use of an ice-breaker must be taken into consideration, so the depth of the route must be about eight metres.

A treatment and purification plant for process water, reserve power machinery, cleaning and handling processes for liquid, gas and solid waste containing radioactive substances, a heating plant and possibly a domestic water treating plant will also be built for the new power plant unit. The heating plant will be used for producing auxiliary steam during start-up of the plant and during the cold season to satisfy the need for warming during outages. The fuel used at the heating plant will most probably be light fuel oil.


Purple lythrum, Loviisa

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Chives, Kaunissaari

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4 LICENCES, PERMITS, PLANS, NOTIFICATIONS AND DECISIONS REQUIRED FOR THE PROJECT

The licences and decisions related to the construction and operation of a nuclear power plant are illustrated in the Figure 4-1.

4.1 Land use planning

Provincial and regional plans

Hästholmen has a valid regional plan, which enables the construction of a new nuclear power plant.

The Assembly of the Regional Council of Itä-Uusimaa approved a new provincial plan on 12 November 2007. In the provincial plan, the area of Hästholmen is marked as EN/y, which enables the construction of a nuclear power plant. The provincial plan shall be ratified by the Ministry of the Environment. Upon ratification, the provincial plan will replace the valid regional plan.

Master plans

The Hästholmen area has a valid component master plan for shores approved by the Loviisa town council in 1985 and a master plan for the entire town approved in 1987. The master plans have no legal effect in accordance with the current legislation. The master plans enable the construction of a new nuclear power plant unit.

The town of Loviisa is preparing a component master plan for shore areas, which covers the eastern shore of the Bay of Loviisanlahti and the islands south of the bay, including the island of Hästholmen. The drafts (2 pcs) of the component master plan for shores were on public display from 10 December 2007 to 8 January 2008.

Town plans

The island of Hästholmen and the support area on the mainland have valid town plans established in 1972, 1974, 1989 and 1993. On the whole, the town plans enable the construction of a new nuclear power plant unit. Particularly the improvement of road connections, the new power lines, the new harbour and extension of the accommodation area require revising the town plan.

Alteration of the town plan for the area began in autumn 2007. The draft of the town plan will be on public display during spring 2008. The town aims to approve the town plan in autumn 2008.

The contents of the plans have been described in more detail in Chapter 7.1.2.

4.2 Licences pursuant to the Nuclear Energy Act

A reform of legislation concerning nuclear power is ongoing. The Government has submitted its proposal (HE 117/2007) for an amendment to the Nuclear Energy Act to Parliament.

4.2.1 Government resolution

According to the Nuclear Energy Act (990/1987), the construction of a nuclear facility of considerable general significance shall require the Government's resolution (former 'decision in principle') that the construction project is in line with the overall good of society. A resolution is applied for by submitting an application to the Government, on which the Ministry of Employment and the Economy must obtain a preliminary safety assessment from the Radiation and Nuclear Safety Authority and a statement from the Ministry of the Environment as well as from the municipal council of the municipality intended to be the site of the facility and from its neighbouring municipalities. The granting of a favourable resolution requires a positive statement from the municipality of the intendet site and the Radiation and Nuclear Safety Authority.

The application for a Government resolution shall contain documents listed in the Nuclear Energy Decree, among others a public overall description of the project, assessed impacts on the environment and safety. The Ministry of Employment and the Economy shall give residents and municipalities in the immediate vicinity of the nuclear facility as well as the local authorities an opportunity to state their opinions on the project before the resolution is made. Furthermore, the Ministry shall arrange a public gathering in the municipality in which the planned site of the facility is located and during this gathering the public shall have the opportunity to give their opinions. Those opinions shall be made known to the Government.

The Government resolution shall be forwarded to Parliament for perusal. Parliament may decide that the resolution remains in force as given or reverse it as such.

Before Parliament has made its decision the applicant shall not take any actions which due to their economic significance might complicate the opportunities of Parliament and the Government to solve the matter at full discretion. Only after a favourable resolution the applicant can make economically binding contracts, i.e. a nuclear facility cannot be ordered before completion of the Government resolution procedure. As part of this procedure the Radiation and Nuclear Safety Authority will make a preliminary safety assessment based on the general characteristics. Only when the facility purchase has been agreed upon, in practice during the construction licence stage, a detailed facility plan and safety assessment can be compiled.

4.2.2 Construction licence

The Government grants the licences to construct and operate a nuclear facility. A licence to construct a nuclear facility may be granted if the Government resolution ratified by Parliament has deemed the construction of a nuclear facility to be in line with the overall good of society and the construction of a nuclear facility also meets the prerequisites for granting a construction licence for a nuclear facility as provided in section 19 of the Nuclear Energy Act. These preconditions include, e.g., that

- the plans concerning the nuclear facility entail sufficient safety, and the protection of workers and the safety of the population have been appropriately taken into account;
- the location of the nuclear facility is appropriate with regard to safety and environmental protection has been appropriately taken into account;
- 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, has sufficient financial prerequisites, and is otherwise considered to have the prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

In addition, a preliminary safety analysis report, among others, must be submitted to the Radiation and Nuclear Safety Authority. At this stage, more detailed safety assessments regarding the facility can be made for the first time.

4.2.3 Operating licence

The licence to operate a nuclear facility may be issued as soon as a licence has been granted to construct it, providing the prerequisites listed in section 20 of the Nuclear Energy Act are met. These preconditions include, e.g., that

- the operation of the nuclear facility has been arranged so that occupational safety of workers, the population's safety and environmental protection have been appropriately taken into account;
- the methods available to the applicant for arranging nuclear waste management are sufficient and appropriate;
- the applicant has the necessary expertise available and, in particular, the competence of the operating staff and the operating organisation of the nuclear facility are appropriate;
- the applicant is considered to have the financial and other necessary prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations.

The operating licence is granted for a fixed period. Operation of the nuclear facility shall not be started on the basis of a granted licence 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 ascertained that provision for the cost of nuclear waste management has been arranged in a manner required by law. The final safety analysis report and a probability-based safety analysis, among others, must be submitted to the Radiation and Nuclear Safety Authority.

4.3 Other permits in accordance with the Nuclear Energy Act

The permits required for the import and transport of nuclear fuel are applied for from the Radiation and Nuclear Safety Authority. The arrangements for nuclear waste management are handled in the operating licence stage. The repository for nuclear waste is a significant nuclear facility, for which a resolution and, thereafter, a construction and an operating licence are applied for from the Government. The necessary permits for the transports of nuclear waste are applied for from the Radiation and Nuclear Safety Authority.

4.4 Notifications pursuant to the Euratom Treaty

The European Atomic Energy Community (Euratom) Treaty requires that each Member State provide the Commission of the European Union with plans relating to the disposal of radioactive waste (Article 37). A group of experts will issue its statement on the plan within a time limit of six months. The licensee reports to the Commission the technical characteristics of the installation for its control (Article 78) and submits an investment notification (Article 41).

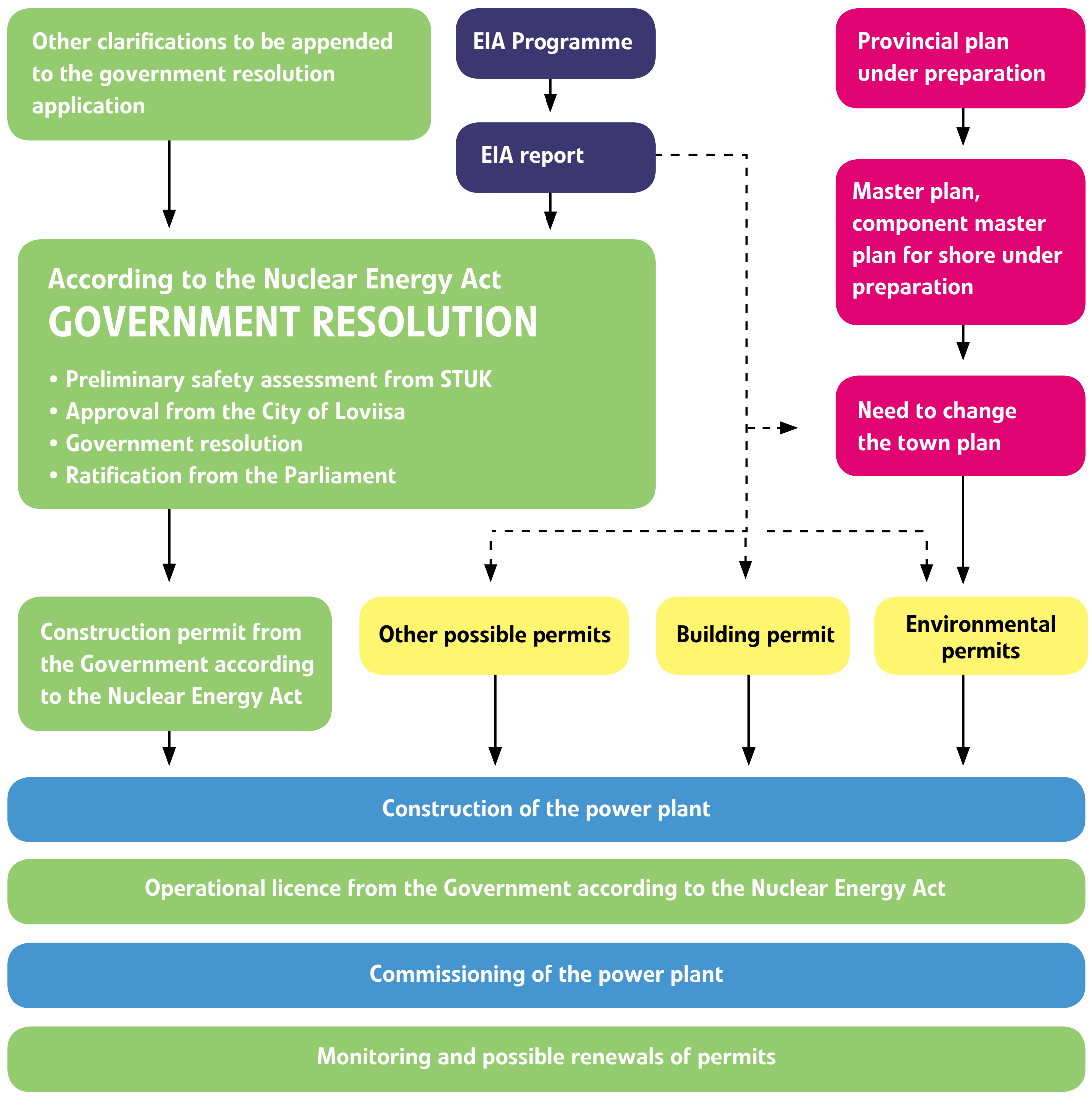

Figure 4-1. The licensing stages of the construction and operation of a nuclear power plant. The broken lines show the connection to those licensing procedures in which the EIA report is used as decision-making material.

4.5 Environmental permits during construction

During construction a rock-crushing plant will be located on the island of Hästholmen, with the operating time exceeding 50 days per year, as well as a concrete batching plant. This kind of activity requires an environmental permit; the licensing authority is the environmental protection authority of the Loviisa municipality.

4.6 Environmental permit

An environmental permit must be obtained for a power plant. The permit covers all matters relating to environmental impacts, such as atmospheric and aquatic releases, waste and noise matters as well as other related environmental matters. The permits required for the operations are based on the Environmental Protection Act (86/2000) and the Environmental Protection Decree (169/2000) enacted on the basis of the Environmental Protection Act.

The permit authority grants the environmental permit if the operations fulfil the requirements prescribed by the Environmental Protection Act and other legislation. In addition to the above, the project must not contradict with the land use planning of the area. The environmental impact assessment procedure must also be completed before the permit can be granted. The permit authority for the project is the Western Finland Environmental Permit Authority.

4.7 Water permit pursuant to the Water Act

A water permit pursuant to the Water Act (264/1961) is required for the water intake relating to the operation of the power plant or construction to watercourse, e.g., for the construction of a cooling water tunnel as well as a loading and unloading site and going below the sea-lane. The permit authority is the Western Finland Environmental Permit Authority.

4.8 Building permit

A building permit in accordance with the Land Use and Building Act (132/1999) must be applied for for all new buildings. The building permit is obtained from the building inspection authority of the Loviisa municipality, which will ensure that the construction plan is in accordance with the local detailed plan and the building codes. The building permit is required before the construction can be started.

Section 159 of the Aviation Act (1242/2005) requires that a flight obstacle permit is needed for the erection of equipment, a construction or a sign if the obstacle extends more than 30 meters above the ground level. The permit is an appendix to the building permit. The statement of Finavia (the provider of air traffic services) about the obstacle must be included in the permit request (*Finnish Civil Aviation Authority 2007*).

4.9 Other permits

Other permits of relevance with regard to environmental matters mainly include technical permits, the primary purpose of which is to ensure occupational safety and prevent material damage. These include, among others, a permit for draining wastewaters into the sewage system, pressure equipment permits and permits pursuant to chemical legislation. Furthermore, an emission permit is required for the carbon dioxide emissions from a standby power plant of more than 20 MW.

The permits required for power lines include an investigation permit to be applied for from the provincial government, a permit for placing an obstacle from the Finnish Civil Aviation Authority, a building permit in accordance with the Electricity Market Act, and an expropriation permit in accordance with the Act on the Expropriation of Immovable Property.

Ostrich fern, Loviisa

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Goosander, Ruotsinpyhtää

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5 RELATION OF THE PROJECT TO PLANS AND PROGRAMMES CONCERNING THE USE OF NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION

5.1 Relation of the project to environmental protection regulations in force

The following Table 5-1 describes the relation of the project to the valid environmental protection regulations important for the project. The table shows the content of each regulation and its binding effect on the project. Land use and planning are discussed in Chapter 7.1.2.

Table 5-1. Relation of the project to environmental protection regulations in force.

Name	Content	Relation to project
Nuclear Energy Act (990/1987)	In accordance with the Nuclear Energy Act, the Radiation and Nuclear Safety Authority is responsible for the supervision of the safe use of nuclear energy. In addition, the Radiation and Nuclear Safety Authority is responsible for the supervision of physical protection and emergency response arrangements, and for the necessary control of the use of nuclear energy.	The nuclear power plant will be designed in compliance with the instructions issued by the Radiation and Nuclear Safety Authority (YVL Guides).
Environmental Protection Act (86/2000) and Decree (169/2000)	General regulations for preventing from spoiling the environment.	Obligation to apply for an environmental permit after the EIA procedure
Reference values for noise (Government decision on guideline values for noise 993/1992)	Guideline values for the noise level in areas used for living or recreation in or near urban areas during daytime (7 am – 10 pm) are 55 dB(A) and during night 50 dB(A). In new areas the guideline value for night-time noise is 45 dB(A). In areas used for vacationing the guideline value is during daytime 45 dB(A) and night-time 40 dB(A). Guideline values for what is called narrow-band noise are lower than those for ordinary noise. If noise is found to be narrow-band, 5 dB is added to the measured noise before comparing to the guideline values.	The choice of implemented alternative is designed such that the noise guideline values in the vicinity of the power plant, including other operators in the area, are not exceeded. Abatement of noise is designed to prevent narrow-band noise.
Waste Act (1072/1993) and Decree (1390/1993)	The purpose of this Act is to support sustainable development by promoting the rational use of natural resources, and preventing and combating the hazard and harm to health and the environment arising from wastes. The goal shall be achieved primarily by cutting the amount of waste and increasing waste utilization. If utilization is not technically or at reasonable additional cost possible, waste shall be disposed of in such a way that harm to the environment and health is minimized.	Waste fractions originating from the power plant are sorted and utilized such that the requirements set in the Waste Act are met. Waste not suitable for utilization is disposed of as required in the environmental permit of the power plant.

5.2 Relation of the project to plans and programmes

The following Table 5-2 describes the relation of the project to the major plans and programmes. The table shows the content of the plans and programmes and their binding effect.

Table 5-2. Relation of the project to plans and programmes.

Name	Content	Relation to project
Water protection agenda (Government Resolution on November 23, 2006 on water protection objectives until 2015)	The Resolution introduces actions to reach a good state of waters and to prevent the worsening of the state. The programme applies to inland waters, coastal waters and groundwaters. The guidelines support the formulation of regional water management plans. They also support the drawing up and execution of the EU Marine Strategy Directive and of an action plan for the protection of the Baltic Sea jointly with the Baltic Sea countries. The aim is to: • to cut loads causing eutrophication • to reduce risks caused by detrimental substances • to alleviate harmful effects of hydraulic construction and water system regulation • to protect groundwaters • to protect the biodiversity of aquatic flora and fauna • to restore waters.	A nuclear power plant and waste water treatment plant represent the best available technology. The most significant effect of a nuclear power plant on waters is the thermal load released with cooling water into watercourses. Cooling water does not contain emissions that cause eutrophication, or any detrimental substances.
Finland's energy and climate strategy (Report on actions implemented in the near future in energy and climate policy, issued to Parliament, approved by the Government on November 24, 2005). Parliament's Economic Committee approved the review on June 2, 2006 (Economic Committee's report TaVM 8/2006 vp). Parliament approved the Economic Committee's report on the Government's review regarding the energy and climate strategy on June 6, 2006 (Plenum protocol PTK 66/2006 vp).	The reduction of greenhouse gas emissions in accordance with the commitments under the UN's Climate Convention is mainly executed by emissions trading in accordance with the Kyoto Protocol and using the Kyoto mechanisms. The strategy takes into account Finland's starting points for international negotiations after the Kyoto period aimed at limiting global greenhouse gas emissions.	Preparation for the building of a new nuclear power plant unit is in line with the national energy and climate strategy, where nuclear power generation is seen as a key factor in securing the reliability of energy supply in Finland. Excluding the use of reserve power, nuclear power operation does not cause greenhouse gas emissions. The emissions are very small, mainly consisting of the test runs of reserve diesels and boiler plants. The building of a new nuclear power plant unit contributes to cutting the average carbon dioxide emissions of electricity production and thus helps Finland to achieve both the international and the national long-term goals of reducing greenhouse gas emissions.
The EU released its package of measures concerning renewable energy and climate change on 23 January 2008.	The leaders of the EU countries committed themselves to increasing the proportion of renewable energy to 20% of the total energy consumption and to cutting greenhouse gas emissions by at least 20% by 2020. The target for emissions reduction will rise to 30%, if a new global climate convention is concluded.	The construction of a new nuclear power plant unit will cut the average carbon dioxide emissions of the electricity production in Finland and help Finland to achieve the long-term objectives set for reducing greenhouse gas emissions.
An Energy Policy for Europe January 10, 2007	An Energy Policy for Europe was issued on January 10, 2007. According to the starting points of the energy strategy, competitive and clean energy supply must be secured in the EU as an answer to the control of climate change, growing global demand for energy and uncertainties in energy supply. A ten-point plan of action has been given to implement the strategy. One of the points is the future of nuclear power. The Commission regards nuclear power as a noteworthy choice as an energy source, if the Member States of the Union aim to achieve the strict emission targets in the future. According to the Commission, benefits of nuclear power include, e.g., its relatively stable and inexpensive production costs, and small carbon dioxide emissions. Since, according to the International Energy Association IEA, the use of nuclear energy will increase worldwide, the Commission wishes the EU to retain and strengthen its technological leading position in this field. The Commission urges the authorities of its Member States to improve their licensing procedures related to nuclear power and to remove unnecessary restrictions, so that the industry can, if necessary, act rapidly when deciding on the additional construction of nuclear power.	As to its cost structure and use, a nuclear power plant is a typical long-life base load plant and the aim of the new nuclear power plant unit is to add to the production capacity of base load power. The construction of a nuclear power plant unit also increases supply in the electricity market. Excluding the use of reserve power, nuclear power operation does not cause greenhouse gas emissions. The emissions are very small, mainly consisting of the test runs of reserve diesels and boiler plants. The construction of a new nuclear power plant unit contributes to decreasing the average carbon dioxide emissions of electricity production and thus helps Finland to achieve both the international and the national long-term goals of cutting greenhouse gas emissions.

Name	Content	Relation to project
The UN Climate Convention (1997 Kyoto Climate Protocol, 1998 the EU States agreed upon the mutual sharing of emission reduction target)	In the Kyoto climate conference in December 1997 it was approved that the aim of the EU is to increase the total reduction in greenhouse gas emissions by 8% from the 1990 level. The obligation must be fulfilled during 2008–2012, which is the first commitment period. As to Finland, the reduction goal was agreed to be 0% against the 1990 level, i.e. the emissions in 2008-2012 shall be at the same level as in 1990 (71.09 million tonnes).	Excluding the use of reserve power, nuclear power operation does not cause greenhouse gas emissions. The emissions are very small, mainly consisting of the test runs of reserve diesels and boiler plants. The construction of a new nuclear power plant unit contributes to cutting the average carbon dioxide emissions of electricity production and thus helps Finland to achieve both the international and the national long-term goals of reducing greenhouse gas emissions.
International obligations regarding sulphur emissions (United Nations ECE (Economic commission for Europe) convention on long-range air pollution)	The protocol regarding the second phase of sulphur emission reduction was signed in Oslo in June 1994. According to the protocol, Finland's sulphur emissions in 2000 could not exceed 116 000 tonnes in terms of sulphur dioxide, which is 80% of the 1980 level. The goal was reached ahead of schedule, in 1996 the sulphur dioxide emissions in Finland were 105 000 tonnes.	Binds Finland as a state, not individual companies. Obligations are fulfilled by the State's steering instruments aimed at companies, as is regarded necessary. Excluding the use of reserve power, nuclear power operation does not cause sulphur dioxide emissions. The emissions are very small, mainly consisting of the test runs of reserve diesels and boiler plants. The construction of a new nuclear power plant unit does not considerably increase the sulphur dioxide emissions in Finland. Replacing combustion processes that cause sulphur emissions with nuclear power cuts sulphur emissions in Finland and helps Finland to achieve both the international and the national long-term goals of reducing sulphur emissions.
The international obligations regarding nitrogen oxide emissions (NOx) (United Nations ECE (Economic Commission for Europe) convention on long-range air pollution)	The protocol restricting nitrogen oxide emissions was ratified in 1991. According to the protocol, nitrogen oxide emissions in 1994 may not exceed the level of 1987. In addition to the actual protocol, Finland has also signed a declaration, according to which the aim is to cut nitrogen oxide emissions by about 30% by 1998. Finland chose the year 1980 as the base year for emission cuts. Reaching the goal to cut nitrogen oxide emissions has proven to be difficult due to, e.g., the diversity and the unmanageability of the emission sources and thus the emissions have not decreased substantially. The goal to freeze emissions to the 1994 level was reached but the reduction target of 30% by 1998 was not achieved.	Binds Finland as a state, not individual companies. Obligations are fulfilled by the State's steering instruments aimed at companies, as is regarded necessary. Excluding the use of reserve power, nuclear power operation does not cause nitrogen oxide emissions. The emissions are very small, mainly consisting of the test runs of reserve diesels and boiler plants. The construction of a new nuclear power plant unit does not considerably increase the nitrogen oxide emissions in Finland. Replacing combustion processes that cause nitrogen emissions with nuclear power cuts nitrogen oxide emissions in Finland and helps Finland to achieve both the international and the national long-term goals of cutting nitrogen oxide emissions.
Enforcement of the Directive on national emission ceilings (programme approved by the Government on 26.9.2002, Directive on national emission ceilings 2001/81/EC)	Directive 2001/81/EC of the European Parliament and the Council, issued in October 2001, on national emission limit for certain impurities in the air defines the maximum emission limits of sulphur dioxide, nitrogen oxide, volatile organic compounds and ammonia for each Member State in 2010. Finland will implement the emission limit directive by a programme approved by the Government. The programme contains a plan for cutting emissions. As to energy production, the means to cut emissions are mainly the renovation of energy production plants and new emission regulations since substantial investments in the cutting of sulphur and nitrogen emissions have already been made in Finland in the late 1980s and early 1990s.	As to sulphur dioxide, Finland's emission limit is 110 000 tonnes per year. Finland has already achieved the goal. The limit will be re-examined in 2008. In 2010, Finland's emission limit for nitrogen oxides will be 170 000 tonnes per year. It is estimated that the implementation of the programme will not cause additional costs to Finland since the reduction targets are probably achieved with restrictive measures that would be carried out in any case. The construction of a new nuclear power plant helps Finland to achieve the goals of the Directive on emission limit.

5.3 Relation of the project to conservation programmes

With the help of nature conservation programmes certain areas can be reserved for nature conservation purposes to safeguard natural values which are significant at a national level. The areas included in nature conservation programmes are not actual conservation areas, however. Conservation areas are areas protected by the Nature Conservation Act.

Table 5-3. Relation of the project to conservation programmes.

Name	Content	Relation to project
Natura 2000 network (Government Natura decision August 20, 1998, based on Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora and Directive 79/409/EEC on the conservation of wild birds, amendment 91/244/ETY)	The Natura 2000 network aims at the conservation of the diversity of nature in the European Union. Both valuable natural habitats and endangered animal and plant species have been chosen as objects of protection.	The Källaudden-Virstholmen area about two kilometres from Hästholmen, the sea conservation area of the bays of Pernajanlahti and the Pernaja islands about two kilometres away, and the Kullafjärden bird wetlands and the Vahterpää inlet, about seven kilometres away, are included in the Natura 2000 network.
Esker conservation programme	The objective of the programme is that the characteristic geological, geomorphological and scenic features of nationally significant esker areas will not alter much. In some areas, soil extraction should be prevented whereas in other areas the limitation of other use is not necessary.	Källa and Hamnholmen, which belong to the national esker conservation programme, are located at about two kilometres north-west of Hästholmen.
Bird wetlands conservation programme	The objective of the bird wetlands conservation programme is to keep the included areas in as natural a state as possible. The purpose is to make each area a conservation area protected by the Nature Conservation Act.	Kullafjärden in the delta of the Taasianjoki river is a bird wetland area determined as nationally valuable and is included in the bird wetlands conservation programme.
Shore conservation programme	The basic objective is to keep the areas included in the programme unbuilt and in their natural state to protect sea and lake nature.	The Pernajanlahti shore in the sea area off Hästholmen is included in the shore conservation programme.
Nationally valuable landscape protection areas and development of landscape management	The objective is to require various authorities to co-operate extensively in the arrangement of landscape management and to safeguard the valuable features of cultural landscapes. The areas rated as nationally valuable represent the best preserved and most typical cultural landscapes in rural areas. The State authorities shall take actions to promote the objectives of landscape management and take care that other projects do not simultaneously jeopardize the preservation of cultural landscapes.	The sea protection area of the bays of Pernajanlahti and the Pernaja islands is a nationally valuable landscape protection area and forms an internationally valuable ecological whole.
Valuable geological areas	Geological areas valuable in respect of nature and landscape protection. The material will support decision-making when making decisions in accordance with the Act on Soil Excavation and the Building Act. The material is also of great importance for land use planning but it has no legal status.	The rock area of Kasaberget is located at about 2.5 kilometres east of Hästholmen.
Protection of the diversity of nature and the sustainable use strategy for 2006–2016 (Continuation of the national plan of action regarding the Finnish biological diversity 1997–2005)	The objective is to stop the impoverishment of natural diversity until 2010, to stabilize the favourable development of Finland's nature during 2010–2016, to be prepared by 2016 for the worldwide environmental changes threatening Finnish nature, especially the climate change, and to strengthen Finland's global influence in the preservation of natural diversity by means of international co-operation.	About three kilometres south-west of Hästholmen lies the Kuggen bird protection area, four kilometres away a conservation area of the islands of Hudö and Lilla-Hudö with their small nearby islands. In the north, the nearest areas protected by the Nature Conservation Act are located about two kilometres away in Kristianslandet.


Young common crane, Sarvilahti lake

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Oak, Loviisa, Tamminiemi

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6 LIMITS OF THE ENVIRONMENTAL IMPACT ASSESSMENT AND EVALUATION METHODS

6.1 Limits of the environmental impact assessment

The EIA procedure has examined the environmental impacts within the areas specifically defined for each type of impact. The extent of the observed area has depended on the environmental impact being examined. The affected areas have been described in more detail in the assessment report.

Fennovoima Oy submitted an environmental impact assessment programme for a new nuclear power plant to the Ministry of Employment and the Economy in January 2008. The company listed the municipality of Ruotsinpyhtää as one of the optional locations for the new power plant, the alternative sites there being the island of Kampuslandet and the cape of Gäddbergsö, at about three kilometres northeast of Fortum's Loviisa Power Plant at the nearest. With the implementation plans and decisions lacking, no combined effects with Fortum's Loviisa 3 project have been assessed in this report. Other projects having potential combined effects are not known. Combined effects with the present operations in the area have been examined as part of the environmental impact assessment.

6.2 Evaluation methods and limits of the affected areas

6.2.1 Impacts of the construction of a power plant unit

Environmental impacts during the construction of a new power plant unit have been examined separately in Chapter 8 because they differ from the impacts during the operation of the power plant unit in terms of the duration and partly also with regard to other characteristics.

Impacts during construction

The impacts during the construction of a power plant unit have been assessed on the basis of preliminary plans and other available information as expert evaluation. The observed area has mainly been limited to the power plant site and the surroundings within about one kilometre.

The impacts of constructing a power plant unit, a loading and unloading site, a shipping lane, cooling water intake and discharge constructions and cooling water tunnel, and raw and waste water pipelines have been examined separately. The assessment has examined, e.g., the dust, noise and landscape impacts of construction.

The spreading of noise during construction has been modelled using a Nordic industrial and road noise model. The basic noise data have been obtained from actual measured equipment. The presented construction-time noise model has not taken account of an impulse correction of +5 dB, however.

The impacts during construction on the operational safety of the existing power plants have also been assessed. Other construction-time arrangements described include, e.g., the utilization or disposal of soil and blasted rock, the treatment of waste water and waste management. The impacts of construction activities on e.g., soil and bedrock, water systems, vegetation and animals have been assessed as expert evaluation.

Impacts of transport and traffic during construction

The impacts of transports and traffic during the construction of a power plant unit have been assessed on the basis of the present traffic volumes and the planned road sections as expert evaluation. The observation area of road transport has been limited to Hästholmen – Main Road 7 (E18). The observation area for ship traffic impact assessment has been the route from the Valko harbour shipping lane to the loading and unloading site to be built at Hästholmen.

The basis for the assessment has been the duration of the construction stage, workforce, traffic arrangements and volumes, and the means of transport. The routes of construction-time traffic have also been studied. The impacts of the noise, dust and exhaust gas emissions caused by traffic have been assessed on the basis of traffic-relat-

ed changes in the surroundings of the roads leading to the power plant.

Economic impacts

A separate study has been carried out on economic impacts of the construction stage. The economic impacts have mainly been examined in the economic zone of the Loviisa region, which here includes Loviisa, Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsin-pyhtää. Some impacts have also been studied in a wider area, in the provinces of Eastern Uusimaa, Uusimaa and Kymenlaakso and the whole country.

Impacts on population, employment and living conditions

The impacts during construction on the amount of population and employment have been assessed on the basis of a separate study of economic impacts. The impacts on society, i.e. comfort and safety, have been assessed taking into consideration the feedback received, among others, as part of the interaction.

6.2.2 Impacts of the power plant unit during operation

Environmental impacts of the operation of a new power plant unit have been studied in Chapter 9 with a focus on the impacts of cooling water on the water systems.

Impacts on land use

The impacts of the operation of a power plant unit on the present and planned land use and on the built surroundings have been assessed in respect of the area's land use plans and development. The assessment is based on the valid regulatory guides concerning the plant site, the protective zone and the emergency planning zone.

Impacts on the landscape and cultural environment

The impacts of a power plant unit on the landscape and cultural environment have been assessed on the basis of photographs and preliminary plans, and conceptual pictures and photomontages prepared of them. Visits to the terrain and studies of maps and aerial photographs support the assessment. The observed area in terms of landscape has been the area where the power plant buildings can be clearly distinguished from the landscape.

The impact assessment considered whether the new power plant unit would change the landscape characteristics of the site, from which directions the views towards the site would change significantly, and whether significant visual impacts on the landscape and the cultural environment would arise. The photomontages have been prepared on photographic templates taken from the viewing points that are important in terms of routes people usually take. The impacts on residential and recreational areas in the vicinity of the plant site have been examined in particular detail.

Impacts on air quality

The emissions into the air caused by operation of the boiler and reserve power machinery have been described on the basis of estimated operating times and fuel consumption. The impacts of emissions on air quality have been assessed as expert evaluation. Radioactive releases caused by operation of the power plant unit and their impacts on the environment have been assessed as expert evaluation on the basis of the results of release and environmental monitoring at the existing power plant units.

Impacts on water systems and fishing

The impacts of power plant operation on water systems and fishing have been assessed on the basis of cooling water's heat load and waste water's nutrient load. The impacts and their area of influence have been assessed on the basis of existing analysis reports and the results of cooling water dispersion model calculations as expert evaluation.

Impacts of the optional locations for cooling water discharge on the sea water temperature in the discharge area have been assessed with the help of a three-dimensional dispersion model covering a sea area of 150 km^2. The study has covered the cooling waters of both the existing and the new power plant units.

The power plant's present arrangements for fresh water supply are inadequate for the needs of the construction and operation of a new power plant unit. The assessment has studied the different options of arranging fresh water supply. The waste water load during operation of the new power plant unit and the radioactive releases into the sea have been described.

Impacts on soil, bedrock and groundwater

Impacts on the soil, bedrock and groundwater of the plant site have been assessed on the basis of the geography and the quality of soil as expert evaluation, the area being limited to the island of Hästholmen.

To assess the impacts on groundwater, the location of the power plant with respect to groundwater areas and the potential risks posed to groundwater due to construction and operation, have been examined. The need for expanding the low- and intermediate-level waste repository in the bedrock of Hästholmen due to the operation of the new power plant unit has been assessed.

Noise impact

The noise impact during the operation of a power plant unit has been assessed on the basis of a noise model made on the basis of the preliminary location of the power plant unit, power plant model and noise measurements. The noise measurements were carried out using a sound level meter fitted with an integrated digital sound recorder. The measurement was conducted in December 2007 under nearly ideal conditions. The modelling was made using a Nordic industrial and road noise model.

Impacts of waste and waste management

The quantity, quality and treatment of municipal waste, hazardous waste, low- and intermediate-level operating waste produced during operation and the decommissioning waste have been described. The environmental impacts of the final disposal of low- and intermediate-level operating waste have been assessed on the basis of existing research results and reports.

Impacts of the use and storage of chemicals

The quality and quantity of the chemicals used in the new power plant unit depend on the chosen reactor type. Chemicals are used and stored at the new power plant unit in the same way as at the existing power plant units. The chemicals to be used at the power plant and their storage systems have been described.

Impacts on flora and fauna

The power plant unit's direct and potential indirect impacts on flora and fauna have been assessed on the basis of preliminary design information as expert evaluation. The assessment has studied whether the implementation of the new power plant unit will have an adverse effect on the ecological values that form the conservation basis for the nearest Natura areas and whether there is a need for an as-

sessment in accordance with Section 65 of the Nature Conservation Act.

Impacts of traffic

The impacts of traffic during the operation of the power plant unit mainly result from commuting and the transport of chemicals and fuels.

The impacts of transport and traffic during operation have been assessed on the basis of present traffic volumes, planned road sections and number of workers as expert evaluation. The observation area of road transport has been limited to Hästholmen – Main Road 7 (E18).

Impacts on people and society

Impacts of the operation of a power plant unit on people and society have been studied on the basis of an assessment of the economic effects, results of the resident survey and feedback received during interaction. The economic impacts have mainly been studied in the economic zone of the Loviisa region, which here includes Loviisa, Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää.

The subjects of examination have been population impact and migration, employment impact, tax income, living conditions, comfort and recreation, and impacts on health. The starting point has been the present state of the Loviisa region and any changes in it brought about by the project.

The employment impacts, migration to Loviisa and tax income have been assessed on the basis of the number of posts at the new power plant unit.

Impacts on people's living conditions, comfort and recreational opportunities have been assessed mainly on the basis of the resident survey carried out among the inhabitants in the vicinity of the power plant. The attitudes of the residents towards the project were also studied as a part of the survey. The interaction within the audit group and at the discussion events as well as the information acquired from the interest groups and the media have helped to assess the impacts. To facilitate the assessment, a procedure by the National Research and Development Centre for Welfare and Health (Stakes) (*Nelimarkka and Kauppinen 2007*) and a procedure by the Ministry of Social Affairs and Health for applying the EIA Act to the assessment of impacts (*Ministry of Social Affairs ad Health 1999*) have been used.

The increase in the radiation dose to the residents in the vicinity caused by the radioactive releases during operation of the new power plant unit has been assessed on the basis of the releases from the existing power plant units. The health impacts have been assessed on the basis of the radiation dose of a person belonging to the most exposed population group.

Impacts of associated projects

A new 400 kV transmission line connection to the Finnish grid is built from the switching station beside the existing power plants. The Finnish grid company Fingrid Oyj is responsible for the necessary alterations to the transmission grid and for the assessment of the environmental impacts.

Impacts of the capacity increase of the 110 kV backup connection, required by the new power plant unit, have been assessed on the basis of the EIA report on the Loviisa – Hikiä 400 kV line project (*Fingrid 2003*) and the updated cross-sectional pictures of the line area. The study was carried out in the area Hästholmen – Hagalund. The visual impact of the transmission line, i.e. how far the towers and conductors are visible, determines the area of examination. The assessment describes the power line route and the need for land use, and evaluates impacts of the power line on the landscape.

Impacts on the energy market

Impacts of the power plant unit on the energy market have been assessed on the basis of public studies as expert evaluation.

6.2.3 Impacts of the power plant unit decommissioning

Impacts of the decommissioning of the new power plant unit have been assessed on the basis of the decommissioning plans for the existing power plant units and the safety case for the final disposal of decommissioning waste.

The various stages of the power plant unit decommissioning, produced waste and its management, and related environmental effects have been described. Potential land use of the power plant site after the decommissioning has also been studied.

6.2.4 Impacts of a severe accident

Environmental impacts of a severe accident have been studied on the basis of modelling of an accident and the safety requirements set for the new power plant unit. In addition to Finland, the impacts of an accident have been examined in the areas of the neighbouring countries at a distance of 1 000 kilometres from the power plant. The assessment methods and the regional examination of the impacts have been discussed in Chapter 13.

The assessment describes various emergencies and accidents and potential civil defence actions needed. Furthermore, the safety analyses carried out for the construction and operating licences according to the Nuclear Energy Act and for other control, have been described.

6.2.5 The nuclear fuel chain from manufacture to final disposal

The main stages of production, transport and storage of nuclear fuel and their environmental impacts have been described and assessed on the basis of existing public studies by international authorities and experts and by Fortum. Also an overview has been given of the uranium resources and markets in the world.

The quantity, method and time of storage of the spent fuel from the new power plant unit have been described. The environmental impacts of spent fuel final disposal are described on the basis of the results of the EIA carried out by Posiva Oy in 1999 (*Posiva 1999*) and the studies conducted after that.

6.2.6 Impacts of non-implementation of the project

The impacts of non-implementation of the project on the environment, employment, population and tax income have been studied, above all, with the present situation in the town of Loviisa and in the economic area of Loviisa as the starting point. The study is mainly limited to a situation where the existing power plant units in Loviisa are still in operation.

The environmental impacts of non-implementation of the project have been examined by a review of electricity imports and of public assessments of the feasibility of alternative power generation forms and their environmental impacts. Furthermore, Fortum's opportunities to improve energy efficiency and to save electricity have been described.

6.2.7 Comparison of the alternatives and assessment of the significance of environmental impacts

The implementation alternatives of the new power plant unit have been compared and the significance of environmental impacts has been illustrated with the help of a compiled table. The Table 15-1 shows the principal impacts, both favourable and adverse, as well as neutral environmental impacts. In the same connection, the environmental feasibility of the alternatives has been examined on the basis of the results of environmental impact assessment. The feedback received as part of the resident survey and interaction has supported the assessment of the significance of environmental impacts.

Squirrel, Loviisa, Antinkylä

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7 DESCRIPTION OF THE PRESENT STATE OF THE ENVIRONMENT

7.1 Land use and constructed environment

7.1.1 Functions in the area and in the surroundings

The island of Hästholmen is located in the province of eastern Uusimaa, in the town of Loviisa, about 12 km from the town centre and 7 km from the village of Valko. Fortum's Loviisa nuclear power plant consisting of two power plant units, is located on the island of Hästholmen (Figure 7-1).

Fortum owns the island of Hästhomen and the southern point of the peninsula lying north of Hästholmen, altogether about 170 hectares of land and in addition, about 240 hectares of water areas near the power plant area. The areas owned by Fortum are limited to land and water areas owned by the state of Finland, town of Loviisa and private persons. The areas owned by private persons are mainly in recreational use and the areas owned by the State are protected areas. The land areas owned by the town of Loviisa have been reserved for agriculture, forestry and recreational use in the master plan.

Power plant operations use one half of the area of Hästholmen. The shore areas of the island have structures connected to intake and outlet of cooling water and power transmission. A causeway, approximately 200 m long, leads to Hästholmen over the inlet of Kirmosund. On the mainland there are buildings and constructions connected to reception, guarding, and temporary accommodation of workers during the annual outage. In addition to the power plant there is no other industry in the nearby areas.

7.1.2 Land use planning

There are three plan levels for the planning of areas and guiding land use. The most general of the plans is the provincial plan (former regional plan), then there is the master plan and the most detailed is the town plan. The planning of a detailed plan is guided by the more general plan. The more detailed plan level is concerned, the more accurate is the presentation. The national utilization objectives of areas, approved by the Government, must be taken into consideration on all plan levels.

The provincial plans guide, according to their names,

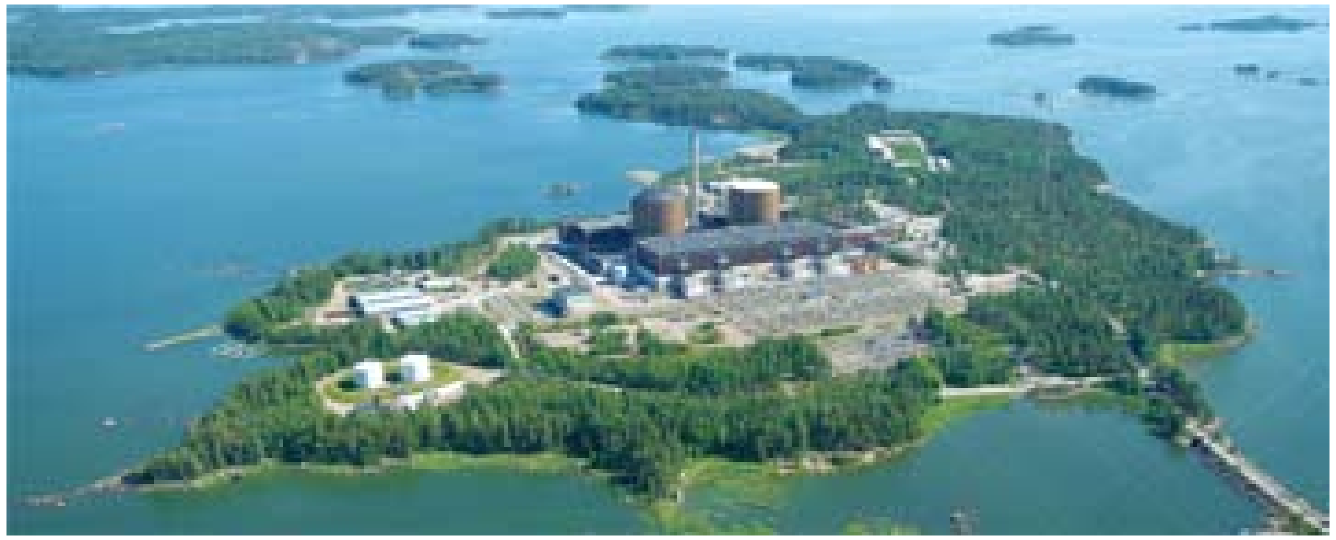

Figure 7-1. Loviisa Power Plant is located on the island of Hästholmen.

planning in the area of several municipalities (region) or in a whole province. The provincial plan is valid in the area of a master or town plans with legal effects only when they are changed. A master plan can be compiled to the area of a whole municipality or a part of it (component master plan or component master plan for shores). The town plan is the most detailed level of plans; it determines e.g. the purpose of the exact use of areas, location and size of buildings, as well as the location of playgrounds and parking lots.

Existing provincial and regional plan combination

In the provincial and regional plan combination of eastern Uusimaa, approved April 5, 2002, Hästholmen and the support area on the mainland have been marked as community management zone (ET) (Figure 7-2).

Figure 7-2. An extract from the eastern Uusimaa regional plan. The new power plant unit will be located in the community management zone (ET).

The Loviisa Power Plant is surrounded by a protective zone five kilometres wide with limited land use options. The archipelago south of Hästholmen and the eastern shore area of the Loviisanlahti bay have been designated as agriculture and forestry-intensive areas with environmental values or a need for controlling outdoor recreation (**MU**). The archipelago northwest of Hästholmen and the islands of Hudö and Lilla-Hudö located to the southwest of Hästholmen with the small islands near them have been designated as a nature conservation area (**SL**). The Svartholma fortress is a historical site (**SM**). The Smedsholmarna islands a couple of kilometres north of Hästholmen have been designated as a camping and recreational area (**VR**). Storholmen and the coastal area to the west of Smedsholmarna, plus Smedsnäs, are recreation areas (**V**). The nearest population centre (**A**) is the Valko village located on the mainland.

Provincial plan under establishment

The central council of the Regional Council of eastern Uusimaa approved a provincial plan on November 12, 2007, and it is being established in the Ministry of the Environment. After the establishment the plan will replace the valid provincial and regional plan combination.

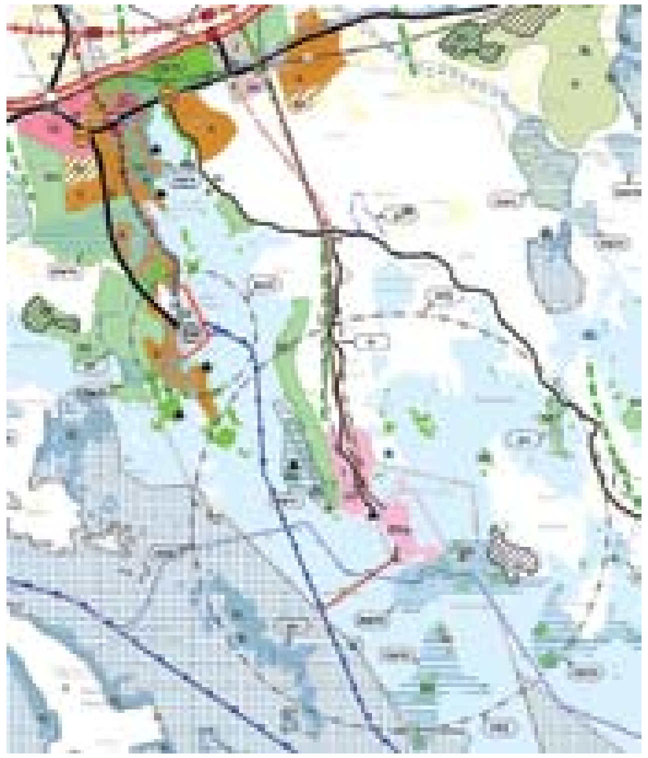

Figure 7-3. An extract of the provincial plan approved by the central council of the Regional Council of eastern Uusimaa on November 12, 2007. The location of the new power plant unit has been designated as an energy management area, where a nuclear power plant can be built (EN/y).

In the provincial plan the power plant area has been designated as an energy management area, where a nuclear power plant can be built (**EN/y**) (Figure 7-3). The support areas northwest of Hästholmen have been designated as energy management areas (**EN**). To the east of Hästholmen there is an energy management area (**EN**) and to the southeast an energy management site (**en**), which enable the implementation of cooling water intake and outlet constructions.

North of Hästholmen there are symbols of a new or considerably improved power line, to the southwest a new shipping lane and a picture of an anchor to stand for a quay area (a harbour). Between road Atomitie north of the power plant area and the junction of the planned freeway there is a need for a connection road. An area suitable for wind power (**tv**) has been marked by road Atomitie. The nuclear power plant is surrounded by a protective zone five kilometres wide, limiting the opportunities of land use.

North of Hästholmen some of the islands and shore areas have been designated as recreational areas. The islands south of Hästholmen have been planned for an agriculture and forestry-intensive area with a special environmental value (**MY**). The islands and the surrounding waters have also been marked as regionally significant areas in respect of cherishing the cultural environment or landscape. (**ma/m**). A valuable geological formation has been marked

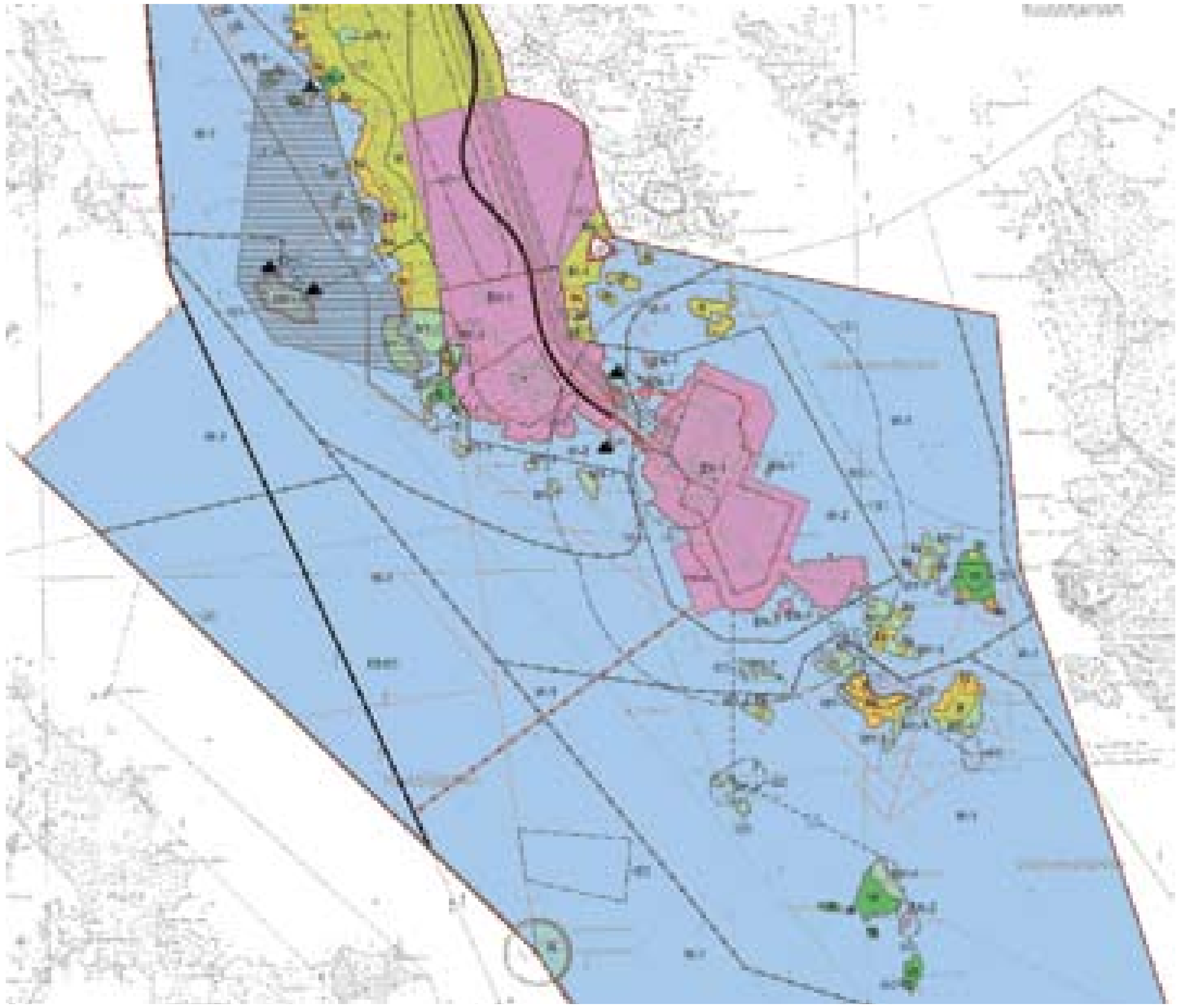

Figure 7-4. An extract of the draft of the component master shore plan (October 11, 2007), with a reservation for nuclear power plants at Hästholmen.

on the eastern side of Hästholmen.

The archipelago northwest of Hästholmen, as well as the islands of Hudö and Lilla-Hudö located to the southwest of Hästholmen and the small islands near them, are designated as a nature conservation area (**SL**). A wide Natura 2000 area has also been marked on the southwestern side. The shore of Loviisanlahti has been designated as an agriculture and forestry-intensive area with a need for controlling outdoor recreation (**MU**). The sea fortress of Svartholma has been marked as a historical site (**SM**), an area important in respect of cherishing a nationally significant cultural environment or landscape (**ma/v**), and as a Natura 2000 area.

Existing master plans

The area has a component master shore plan approved by the town council of Loviisa in 1985 and a master plan for the entire town from 1987. The master plans have no legal effect.

In the master plan of the area Hästholmen has been designated as a nuclear power plant area and the southernmost point of the mainland opposite to Hästholmen as a nuclear power plant support area. Of the islands to the south of Hästholmen, Stora Rövaren, Rövarhället and Stora Djupberget and parts of Högholmen and Småholmen have been designated as nature conservation areas. The rest of Högholmen and Småholmen have been designated as a holiday cottage area.

In the master shore plan for the town of Loviisa, the waters south of the power plant have been designated as protected outer archipelago landscape area. A few holiday cottage areas have been added on the southern islands.

Draft of the component master shore plan

The town of Loviisa is compiling a component master shore plan, which covers the eastern shore of Loviisanlahti and the archipelago south of the bay, including Hästholmen, which belong to the area of the town. The draft of the new component master shore plan (October 11, 2007) shown in Figure 7-4 was on public display between December 10, 2007 and January 8, 2008.

In the draft of the component master shore plan Hästholmen has been marked as an energy management area (**EN-1**), inside which, in a restricted area (**EN-1 v**), nuclear power plants can be built. Other allowed structures are plants for electricity transmission, underground spaces, research facilities, storage, maintenance and office buildings, conference rooms and other facilities and equipment serving the nuclear power plant as well as related buildings, constructions and assemblies. More detailed use of the area is guided by the town plan.

In the draft, an energy management area (**EN-1**) has been marked on the mainland, inside which the area for accommodation buildings (**EN-1 as**) serving energy production has been drawn. It is meant for the temporary accommodation of construction, maintenance and repair personnel of nuclear power plants and for buildings serving the use and services of the accommodation area.

On the southeastern and southern side of Hästholmen there are areas where necessary structures for the cooling water management of the power plant can be located (**en-2**). Also on the island in the south, an energy management area has been marked (**EN-2**), for the necessary structures of cooling water management of the power plant.

A water area west of Hästholmen has been designated as a part of the energy management area (**EN/we**). The area must be kept mostly as a water area but necessary structures in respect of cooling water management and a pier can be built there. The new shipping lane to the area has been marked in the plan.

The water area surrounding the island of Hästholmen has been designated as an area where necessary structures of the nuclear power plant can be built (**W-2**). Before implementing the building project in the water areas, the need for a maritime archeological underwater inventory must be discussed with the National Board of Antiquities.

One kilometre away from the power plant there is a plant area with a radius of one kilometre (**la**). The holiday cottage building sites already existing inside the area have been marked as a sub-area (**ra**), where existing buildings related to holiday living can be repaired and minor extensions are allowed but no building permits for new buildings can be granted.

The outer protective zone of the power plant is marked five kilometres away from the plant (**sv**).

Also the following areas exist near the island of Hästholmen: holiday cottage area (**RA**), residential area with a predominance of detached houses (**AP**), agriculture and forestry-intensive area (**M**), agriculture and forestry-intensive area with special environmental value (**MY-1**), camping and outdoor recreation area (**VR, VR-1**), landing place for boats (**LV-1**), historical site (**SM/v**) and water area (**W-1**). A geological formation and the Natura 2000 area have been marked to the northwest of Hästholmen in the master plan drafts.

Ruotsinpyhtää in the nearby area of the power plant has a valid Vahterpää-Gäddbergsö component master shore plan with legal effect, which has been established by the Uusimaa Regional Environment Centre in 1999. The Kulla-Lappom area component master plan became legally valid in 2005. The coast and archipelago of Pyhtää have a component master plan established in 2000. The component master plan covering the whole archipelago of Pernaja, excluding Påsalö, became legally valid in 2004.

Town plans

Hästholmen and the support area on the mainland have valid town plans, which have been established in 1972, 1974, 1989 and 1993 by the Uusimaa Country Administrative Board.

Figure 7-5. Updated town plan for Hästholmen. In the town plan, the location of the new power plant unit has been designated as a block area for industrial and warehouse buildings (TTV).

In the town plan for Hästholmen (Figure 7-5) the construction area of the existing power plants has been designated as an area for industrial and warehouse buildings (**T**) and the location of the new power plant unit is in a block suitable for power plant construction in the area of industrial and warehouse buildings (**TTV**). Part of the shore area has been designated for special structures of the power plant, such as the cooling water intake structures and recreational buildings. Part of the shore is designated as an area to be kept in a natural state (**ELL**), this part is also intended for the use of the plant with permission to build structures necessary for guarding the plant site. In the town plan, the eastern shore has been designated as an area for planting trees and bushes, with permission to build only structures necessary for guarding the area.

The town plan for Hästholmen also contains the following areas: power transmission area (**ET-1**), recreational area for the power plant personnel (**ER-1**) and combined training and short-term accommodation area related to the operation of the power plant (**ER-2**). There is also the power plant cooling water intake place (**EK**), with permission to build the structures necessary for the power plant, and an area for planting trees and bushes (**EIL**). The area can be levelled out to a maximum height of +10.00. Structures necessary for the guarding of the power plant are allowed, as well as temporary warehouse and service buildings serving the construction site. In the water areas surrounding the island of Hästholmen there are water areas (**W-1**) and (**VE**), which are allowed to be used for the purposes of the power plant and where, by the areas designated as industrial and special areas, the construction of piers and other structures necessary for the power plant is permissible to the extent allowed by the Water Act.

Figure 7-6. Updated town plan for the support area on the mainland.

Operations in the support area on the mainland are mainly carried out during the construction of the new power plant unit. Temporary accommodation buildings can be located in the support area in the accommodation building area (**A-4**). The town plan also includes a personnel parking area (**LPA**), with a capacity for 1,000 cars as well as a public parking area (**LP**). Along the road Atomitie, several areas have been designated to be kept in natural state (**E-1**).

In the area of the valid town plan, a town plan change is pending, which will update the existing town plan. The draft of the town plan will be put on public display in March 2008.

In the draft of the town plan, the construction areas remain mainly as before. In the draft the area of power transmission lines has been expanded to the northern side of the island, a new shipping lane and a harbour in the western side of the island are shown and the building area of the accommodation buildings has been changed so that the focus of the accommodation is moved further away from the road and the industrial area.

Other plans

The common component master plan of the municipalities of Loviisa and Ruotsinpyhtää is being prepared in the northern part of Loviisa and the Tesjoki area in Ruotsinpyhtää. The area has a junction for the planned new road connection from main road 7 (E18) to the Loviisa Power Plant.

Within approximately five kilometres of the plant, the following shore plans apply: the Hudö shore plan established in Pernaja in 1988, and the Hummelholmen shore plan established in 1987. Also in the municipality of Ruotsinpyhtää the following shore plans apply: the Långstrand shore plan established in 1986 and the Gäddbergsö shore plan established in 1989.

7.2 Landscape and cultural environment

The island of Hästholmen is approximately 1.5 km long and 0.6 km wide, it can be seen with its surroundings in Figure 7-7. Hästholmen and the small islands south of the island have a flat topography. The highest point of Hästholmen is about 16 metres above sea level. The area surrounding the Loviisa Power Plant consists of a fairly natural coast and archipelago landscape, with numerous red granite boulders and stony areas as a special characteristic.

The eastern shoreline of Hästholmen has undergone drastic changes as a result of the land filling during the construction of the power plant. There is no protective green zone on the eastern shore and on a part of the northern shore. Thus the plant and its structures are clearly visible from the Hästholmsfjärden sea area east of the island.

The unbuilt south and west shores of Hästholmen are mainly in their natural state. The areas are covered by a thin layer of moraine and the bedrock is bare in several places. The forest area is mainly old pine forest. On the narrow neck of land between Hästholmen and Tallholmen there is an alder grove with a representative variety of tree species, as well as a seashore forest. Even though the plant structures are visible from a wide part of the Hudöfjärden sea area west of the plant, the forest zone of the southern and western shoreline softens the landscape considerably.

There are no nationally or regionally valuable buildings or other sites of cultural history on Hästholmen. The nearest location with nationally significant cultural history value is the sea fortress of Svartholma approximately 2.5 km from the power plant site (*National Board of Antiquities 2007*).

7.3 Population and employment

7.3.1 Population

Permanent habitation

There is no permanent population less than one kilometre away from the power plant. Approximately 40 people live permanently less than five kilometres away. The habitation has concentrated mainly on the areas to the north of the power plant. The nearest permanent dwelling is located at Bodängen, at a good kilometre north of the existing power plant units.

About 12,600 people live within 20 km of the power plant. Largest of the population centres is Loviisa with a population of about 7,400 at the end of 2007. Tesjoki and the parish villages of Ruotsinpyhtää and Pyhtää are population centres with a population of almost 1,000 people each. Smaller population centres are Kuggom, Pernaja parish village, Isnäs in Pernaja and Purola in Pyhtää.

About 1.6 million people live within 100 km of the power plant, majority of them in the metropolitan areas and other

Figure 7-7. An aerial photo of the Loviisa Power Plant with its surroundings taken from southeast. In front Myssholmen, on the left side of the power plant Hudöfjärden and on the right Hästholmsfjärden.

towns, municipal centres and population centres. Besides the metropolitan area, the largest centres of population are located along the Helsinki–Hämeenlinna railway and in the Salpausselkä sand ridge area (Lahti, Kouvola, Kuusankoski) and on the coast (Kotka, Porvoo, Hamina). There are also regions belonging to Estonia and Russia, within 100 km of the power plant.

Leisure time habitation and the accommodation area

There is plenty of leisure time habitation in the vicinity of Hästholmen. The number of holiday cottages within five kilometres of the power plant is estimated at 400 and the number of temporary population is estimated at a little over 1,000. The nearest holiday homes are located on islands south and southeast of Hästholmen (Vastaholmen, Småholmen, Måsholmen, Högholmen, Myssholmen, Björkholmen and Kojholmarna) at 1.3 to 2.2 km from the existing power plant units and at 0.7 to 1.6 km from the new power plant unit. There are a total of 34 holidays homes on the islands, of which some are located at less than one kilometre from the new power plant unit. The largest holiday cottage zone within 20 kilometres of the power plant begins east of Loviisanlahti, and reaches all the way to Vahterpää, Munapirtti and Koukkusaari. There are also holiday cottage concentrations in the southern archipelago of Pernaja. Although the number of leisure time cottages is increasing, no separate cottage areas have been formed.

One kilometre northwest of the power plant lies the accommodation area owned by Fortum, with 452 beds and 80 places for camping-trailers. The accommodation area is mainly used during the annual outages.

Population development in the Loviisa region

The population of the Loviisa region is about 24,000 (Appendix 2, Table 1) and the municipalities of the region are bilingual. At the end of 2006 Swedish-speaking people were a majority in Liljendal and Pernaja. The share of the Swedish-speaking population has decreased little by little. In 2000–2005 the population decreased in all the municipalities of the region, except for Pernaja. The effect of the construction stage of the Loviisa Power Plant (Loviisa 1 was completed in 1977 and Loviisa 2 in 1981) can be seen in the population development of Loviisa. In 1980 the number of permanent residents was about 1,900 higher than in 1970 (Appendix 2, Table 1). Since 1980 the population of Loviisa has been reduced.

Natural development of the population does not keep up the population of the region. The number of people can increase if migration to the region, which began in the last few years, strengthens (Appendix 2, Table 2). In 2006 the positive migration to the Loviisa region was altogether about 140 people (Appendix 2, Table 3). With the migration, the dominant position of Finnish has strengthened in Loviisa faster than in the other municipalities.

In the municipalities of the Loviisa region the share of over 65-year-olds of the population is larger and the share of under 15-year-olds smaller than in the eastern Uusimaa and the whole country (Appendix 2, Table 4). The share of people of studying and working age in the population is slightly smaller than in the eastern Uusimaa and the whole country. The share of foreigners is in several municipalities of the area smaller than the country's average (Appendix 2, Table 5).

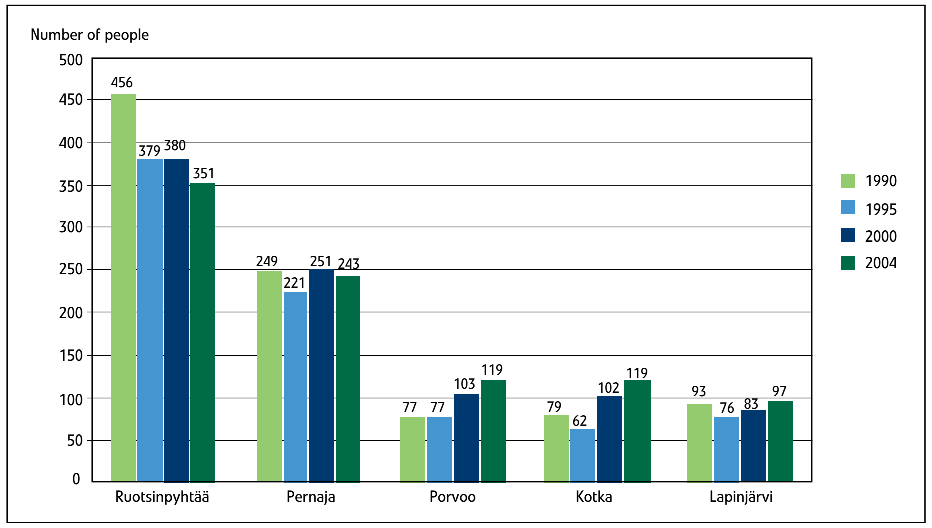

Figure 7-8. Commuting to Loviisa 1990–2004 (*Statistics Finland*).

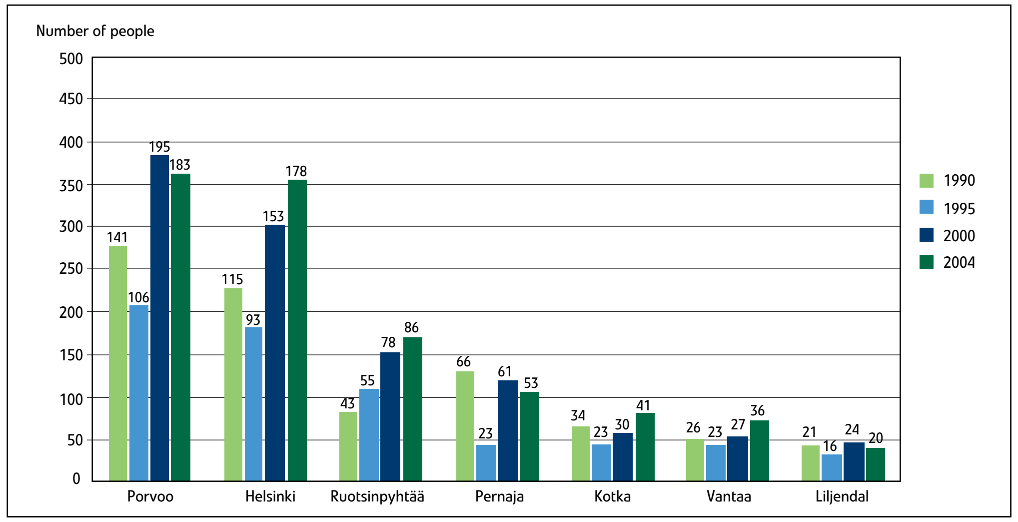

Figure 7-9. Commuting from Loviisa to other localities (*Statistics Finland*).

7.3.2 Employment and working

Loviisa region

The number of the employed in the Loviisa region, about 10,000 people, is a quarter of the employed in eastern Uusimaa. In 2006 the unemployment rate in Loviisa was 10.3%, which is clearly higher than in the whole country. The unemployment rates in other municipalities in the area are smaller (Appendix 2, Table 6).

The self-sufficiency in respect of employment in Loviisa was in 2005 clearly over 100%, which means that people from other municipalities come to work in Loviisa. In 2004 about 500 people commuted to Loviisa (Figure 7-8). A majority arrives from Ruotsinpyhtää and Pernaja. Commuting from Porvoo and Kotka has increased during the last few years.

The province of eastern Uusimaa offers work force elsewhere, mainly to the metropolitan area. In 2004 some 400 people commuted from Loviisa to Porvoo or to the metropolitan area (Figure 7-9). Commuting from Loviisa and the neighbouring municipalities to the metropolitan area has increased remarkably since 1995. Altogether over 300 people from Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää commuted to the metropolitan area in 2004. Regional commuting is mainly directed from Loviisa to Ruotsinpyhtää, Pernaja, Kotka and Liljendal. The cause of the expansion of the general working area is the centralization of jobs to regional centres and the improved means of communication.

Loviisa power plant employs

The number of permanent employees at the Loviisa Power Plant is about 460. The share of professional and managerial staff of the personnel is 30%, clerical employees 30% and workers 40%. The power plant also provides jobs for about 70 summer trainees annually.

85% of the permanent personnel live in the Loviisa region. More than 60% of the personnel live in Loviisa, the next most employees live in Ruotsinpyhtää, Kotka, Pyhtää, Pernaja and Porvoo. The significance of other individual municipalities as working areas is small, even though the working area as a whole is wide.

During operation, external services are acquired annually, whose amount corresponds to a work contribution of 100 people. During the annual outages, the number of workers is about 800 and the domestic content more than 90%.

7.3.3 Living

In the 1970s, apartment houses and terraced houses were built in Loviisa for the needs of the power plant's construction and operating personnel. The building calmed down in the latter half of the 1970s but houses were built at an even pace all the way to the 1990s. Less than half of the housing stock of Loviisa is apartment houses and little over half one-family houses, mainly detached houses.

Migration to the region in the 2000s has resulted in new building and land use planning to add the number of lots. The interest in Loviisa is based on the good road connections to the metropolitan area, the quality of the living environment and the inexpensive price level. The price level of lots in Loviisa was in 2007 about a fifth of the level in the metropolitan area. Nevertheless, the small number of available jobs in Loviisa limits the migration to the region.

In Loviisa there are several apartment house projects in hand in the town centre, near the bus station and in the quarter of Määrlahti. Also terraced house projects are planned to the quarters of Antinkylä, Määrlahti and Harmaakallio. One reason for the increased demand is the moving of pensioners from detached houses in the sparsely populated areas to apartment houses with elevators, near the services of the town centre. Also the services will develop, since the construction plans of the Loviisa town include e.g. a spa-hotel, a conference centre, travel centre and a sports centre.

The Tesjoki detached house area in Ruotsinpyhtää, which in respect of its location belongs to the service area of Loviisa, has a high degree of readiness. During the following years the municipality will offer about 130 lots for detached houses and terraced houses for sale. With the possible new road connection Atomitie – main road 7 (E18) and the improvement of main road 7 (E18), also their location in respect of Loviisa will improve.

In other municipalities the new residential areas, already planned or reserved for planning, are the Tesjoki residential and working areas, the Ahvenkoski residential and service area and the Neverkärr residential area in Ruotsinpyhtää, the residential areas of Rönnäs and Isnäs and the residential and working area of Koskenkylä in Pernaja, the residential areas of Liljendal (parish village, neck of land at main road 6) as well as the residential and service area of the parish village and the residential areas of Sjökulla and Rutumi in Lapinjärvi. (*Regional Council of Itä-Uusimaa*)

7.4 Economy and services

7.4.1 Consolidation of municipalities

In the autumn of 2007 five municipalities in the Loviisa region, Lapinjärvi, Liljendal, Loviisa, Pernaja and Ruotsinpyhtää, discussed the possibility of a consolidation of municipalities and compiled a consolidation agreement motion. On the background of the consolidation negotiations there was the act on the restructuring of municipalities and services issued at the beginning of 2007. Lapinjärvi rejected the consolidation in a council hearing in the autumn of 2007. After this the municipal division was suggested to be changed so that Liljendal, Loviisa, Pernaja and Ruotsinpyhtää would form a municipality with 15,000 residents. Ruotsinpyhtää rejected the suggestion in two separate council hearings in December 2007. At the beginning of 2008 there is no certainty whether the consolidation efforts will continue or will the region form a cooperation area for the basic health care and social services. The minimum size of such an area is 20,000 residents, determined by law. The services can be arranged as a municipal federation of by a so-called master municipality.

7.4.2 Economical situation

In 2006 the tax rate of the municipalities in the Loviisa region was 19.0–19.5% (Appendix 2, Table 7). The tax rate is higher than the average of municipalities in Finland (18.3%). The municipalities levy real estate taxes on a moderate level.

The tax foundation of the municipalities is the strongest in Loviisa. The taxable income of the residents is the highest and there are a large number of enterprises in Loviisa compared to the other municipalities. In 2005, Loviisa was per resident the most indebted municipality in the region. The amount of debt in the other municipalities was fairly low. The annual balance was the highest in Lapinjärvi and Liljendal. In Pernaja and Pyhtää the income of the municipality did not cover the expenses. In municipal economy, short-term variations are common (Appendix 2, Table 8).

The municipal taxes paid to Loviisa by the employees of the Loviisa Power Plant are more than 2 million euros per year. Loviisa levies real estate tax of about 2.5 million euros on the power plant annually. In 2006 Fortum paid an estimate of more than 4 million euros in corporation tax to the town of Loviisa.

The other municipalities of the region get tax income from the municipal taxes of the employees, altogether more than a million euros annually. The tax income is divided, according to the employees' places of residence, mainly between Ruotsinpyhtää, Kotka and Pyhtää.

The share of the Loviisa region of the Finnish gross domestic product has been in the 2000s 0.33–0.39% (Appendix 2, Tables 9 and 10). Compared to Loviisa, the economical yield is much larger in Porvoo, Kouvola and the Kotka–Hamina area. The relative significance of the Loviisa region has increased in the 2000s (Appendix 2, Table 11), and the development of the gross national product has been faster than in the rest of the country. Nevertheless, in the Porvoo region, the development has been even faster, but in the province of Kymenlaakso the development has been slower than in the rest of the country.

According to the service network survey of Itä-Uusimaa, in daily consumer goods and special goods trade, the purchasing power and its growth are mainly concentrated on the Porvoo region. (*Regional Council of Itä-Uusimaa and Finnish Consulting Group 2004*). For example the Kuninkaanportti area in Porvoo is rapidly establishing its position as the centre of trade in the region.

7.4.3 Business operations

The strong and growing branches of business in the Loviisa region are the energy branch, logistics and transport, boat industry, mechanical woodworking industry, food-processing industry and agriculture. The developing branches are, e.g., the functions related to the harbour, tourism, nursing and well-being services and creative branches.

In 2005, Loviisa was the most enterprise-intensive municipality of the region with almost 500 offices, 2500 jobs and a turnover of about 500 million euros. About a fifth of the company jobs in Loviisa are in the power plant.

Besides electricity production, the focus of the business structure of Loviisa is in the small and medium size industry, which has been focused on the junction of main road 7 (E18) (Länsiportti) and close to the harbour of Valko. (Appendix 2, Table 12). There is plenty of free, planned lot land for the needs of industry and business these areas. In the future, the location of the business areas will be affected by the new freeway alignment of main road 7 (E18) and the new junction at the border between Loviisa and Ruotsinpyhtää.

In other municipalities of the region there are numerically plenty of business offices and the distribution of branches is versatile. The average size of companies is smaller than in Loviisa. The turnover of the about 900 companies in Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää is altogether 350 million euros and the number of jobs is about 2,000.

7.4.4 Services

Services of trade

According to surveys, people in the Loviisa region are relatively satisfied with the number and location of daily consumer goods stores, but the decrease of village shops in the rural areas is a problem (*Regional Council of Itä-Uusimaa and Finnish Consulting Group 2004*). In the municipal centres the lack of special shops is regarded as a problem.

Accommodation services

There are more than 20 accommodation businesses in eastern Uusimaa, with a total of over 1,000 beds. In the Loviisa region the accommodation capacity has decreased somewhat in the 2000s. There are also various camping areas and activity centres with a possibility to arrange accommodation for groups.

Social and health services

The social and health services of the Loviisa region are focused on Loviisa. Healt services are provided by the district joint municipal authority of health care in Loviisa. In addition to the health centre, hospital and dental clinic in Loviisa, the municipalities have local health service houses. The health services of Pyhtää are arranged by the hospital district of Kymenlaakso. The municipalities also offer housing services for the elderly.

Education

There are no schools or day-care centres within a range of five kilometres from the power plant. The nearest school and day-care centre are located in the village of Valko, about seven kilometres away from the power plant.

The municipalities provide their residents with day care and, in cooperation, Finnish and Swedish-speaking comprehensive education. In Liljendal there is no Finnish-speaking elementary school. In Loviisa there are both Finnish and Swedish-speaking secondary schools and in Pyhtää there is a Finnish-speaking secondary school. In Loviisa there are both Finnish and Swedish-speaking upper secondary schools and in Lapinjärvi a Finnish-speaking upper secondary school. Porvoo vocational college offers education in vehicle and transport technology, food production and security in Loviisa. Other vocational training is not available in the Loviisa region.

The average level of secondary education among the population of the region is clearly higher than the average of the country (Appendix 2, Table 13). The number of residents with a university degree is relatively small compared to the average of the whole country, except for Loviisa and Pyhtää.

Leisure time services

There are a couple of sports halls and a leisure centre in Loviisa. A basic variety of sports facilities for outdoor sports and a covered artificial skating rink are available in Loviisa. In other municipalities of the region the opportunities for sports in a sports hall and field events are lesser. The recreational opportunities of the region also include boating and fishing.

Culture

The cultural attractions in Loviisa are the historical resorts, such as the Svartholm sea fortress, bastions Ungern and Rosen, the Commandant's House, the old quarters and the parks in the town. The cultural and tourism events take advantage of the individual setting of the town of Loviisa. Also other municipalities in the region have historical attractions, among others iron works areas.

7.5 Traffic

Main road 7, part of the major east-west route E18, goes past Loviisa. The main road has junctions both on the eastern and western sides of Loviisa. The road connection to Hästholmen via the eastern junction goes first along the Mannerheiminkatu and then road Saaristotie (1583) and after 5.8 km the road Atomitie (1583) diverges from Saaristotie and continues 7.2 km (Figure 7-10). The road connection via the western junction goes via the roads Helsingintie and Mannerheiminkatu through the centre of Loviisa before turning to road Saaristotie. A causeway about 200 metres long with a bridge over the Kirmosund inlet leads to Hästholmen.

Figure 7-10. Roads leading to the the Loviisa power plant.

The road region of southeastern Finland has in 2007 compiled a master plan for improving the main road 7 (E18) to a freeway between Loviisa and Kotka. In the investment programme by the ministerial working group drafting the traffic lane policy, the road section Koskenkylä–Loviisa–Kotka project has been proposed to be implemented in 2008–2013. The Finnish Road Administration is prepared to being able to initiate the implementation in 2009. The general plan for the freeway includes a new multi-level junction to the border of Loviisa and Ruotsinpyhtää, with a direct connection to Hästholmen. A necessity report was compiled on the Atomitie – main road 7 (E18) road connection in 1992.

The operation-time traffic of the existing plants consists of commuting and maintenance traffic, transportation of chemicals, fuel oil and gases, as well as waste management traffic. The power plant also has a large number of visitors annually, in 2007 about 4,100 people.

The average weekday traffic from Määrlahti to the crossroads of roads Saaristotie and Atomitie is about 2,000 vehicles, approximately 110 of which are heavy vehicles. The average weekday traffic of road Atomitie is about 880 vehicles, approximately 20 of which are heavy vehicles. (*Finnish Road Administration 2007*)

There are two harbours in the neighbouring municipalities of the power plant; Valko in Loviisa and Isnäs in Pernaja. Two shipping routes pass near the power plant. The route to the harbour of Valko runs near the southwestern shore of Hästholmen. At its nearest, the route is a little over a kilometre from the shore of the island. The outer shipping route is the coastal route of the Gulf of Finland, from Hamina and Kotka, passing Orrengrund.

Oil transports in the Gulf of Finland have grown fivefold during the last ten years. In 2006 the volume of transports was about 140 million tonnes. The Finnish Environment Institute assesses that the volume will increase to 165 million tonnes by 2010 and to 270 million tonnes by 2015, if all the oil terminal projects of Russia are implemented. Visits by oil tankers to the harbours in the Gulf of Finland have also increased. The increase in the size and number of the tankers

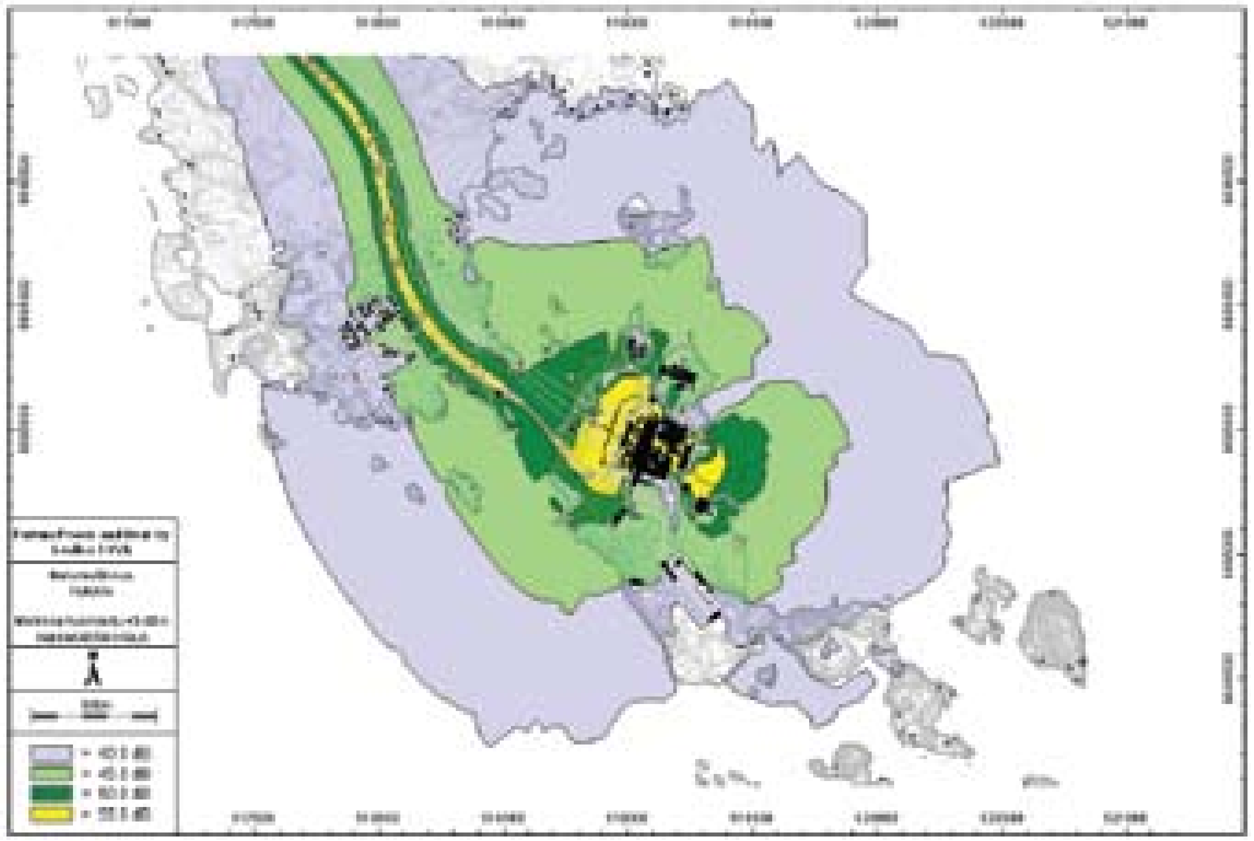

Figure 7-11. Narrow-band corrected noise in the surroundings of the power plant.

has not happened at the expense of quality, however, since an increasing number of the tankers are relatively new and in good condition. No oil tankers visit the harbour of Loviisa.

The nearest railway runs from the harbour of Valko to the city of Lahti. There is only freight traffic on this railway section. To ensure safety of the power plant and its surroundings, aviation is forbidden within a radius of four kilometres up to a height of two kilometres (*Vna 929/2006*). There is an official heliport on the island of Hästholmen, meant for the use of authorities in rescue and police matters.

7.6 Noise

The noise caused by the Loviisa Power Plant is mainly a constant hum. During normal operation, noise is mainly caused by air-conditioning equipment and transformers. An exception to this is the annual testing of steam safety valves carried out before the annual outage and informed of in advance in the local newspapers.

The present situation of noise in the power plant area and its surroundings was reviewed in 2007. The measurements showed that in some places the noise was narrow-band noise. The largest sources of narrow-band noise are the transformers located between concrete walls, which produce a clearly audible periodical hum on the 100–300 Hz frequency bands. This can especially be heard on the north side of the power plant area, on the bay of Hästholmsfjärden, where the noise is easily carried along the surface of water. About one kilometre north of the power plant (Bodängen) the weighted sound pressure level L_{Aeq} was 38 dB(A). According to a government decision (*993/1992*), a +5dB narrow band correction is added to the measurement result of narrow-band noise, therefore the total result of the farthest measurement point is 43 dB(A).

The present situation of noise was modelled using a noise calculation on a 3D digital map base according to the Nordic industrial and road traffic model. According to the results of the calculation presented in Figure 7-11, the guideline value for noise during nights in leisure time habitation areas (see Chapter 5.1) is exceeded somewhat in the Saukontie leisure time habitation area.

7.7 Geology and seismology

7.7.1 Soil, bedrock and groundwater

The Loviisa coastal area belongs to an altitude zone of 0–20 metres and its topography on the whole is relatively flat and low. The characteristic features are the numerousness of islands, bays reaching deep into the mainland and long peninsulas with a distinct tendency to lie from northwest to southeast. The bays reflect the weaker zones of the bedrock, the shape of which has been emphasized by the wear caused by the ice sheet during the ice age. The bedrock is mostly covered by layers of soil; most of the exposed rock concentrates on the highest parts of the mainland and the islands.

The highest parts of Hästholmen are 16 metres above the sea level. The sea-bed surrounding the island is generally at a depth of 5-10 metres but there are also local basins with the sea-bed 15 metres below the sea level. The bedrock on

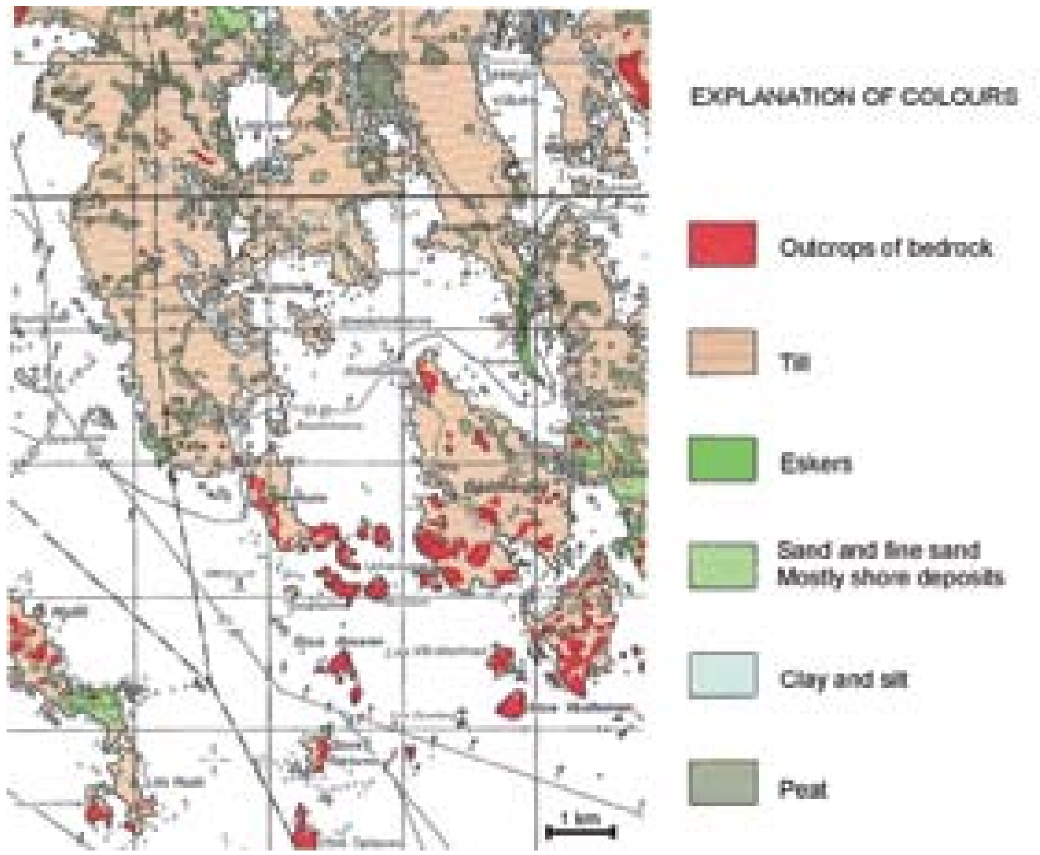

Figure 7-12. Loviisa soil map 1:100 000 (*Geological Research Institute 1963*).

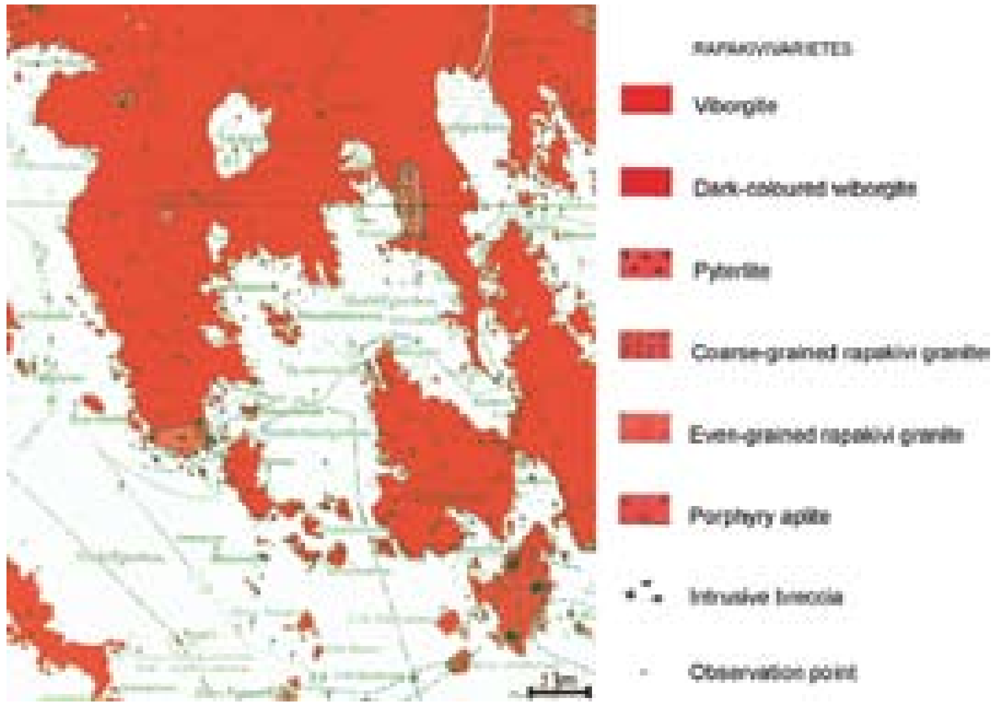

Figure 7-13. Loviisa bedrock map 1:100 000 (*Geological Research Institute 1970*).

the island is mostly exposed rock or covered only by a thin layer of soil, so the topography of the ground reflects the topography of the bedrock. To the south and east of the island the bedrock has been discovered to fall even to a level of 60–70 metres below the sea level (*Anttila 1988*). Except for these basins, the bedrock can be typically found within 20 metres below the sea level in the waters near Hästholmen.

The soil of Hästholmen and the peninsula to the north of it consists of moraine with stones and boulders (Figure 7-12). The thickness of the moraine layer on the island is usually a few metres at its thickest. The occurrence of sorted soil types, such as gravel and sand, as well as the biotic soil type, peat, is minor and occasional. When constructing the power plant, plenty of earth-moving work has been carried out, due to which the original soil is in many places covered by various filling materials.

The earth layers in the sea-bed are mainly moraine or coarse-grained soil types, gravel and sand, on top of which there are local layers of clay and silt sand. The thickest earth layers are located in the bedrock basin on the east side of Hästholmen, where their total thickness is about 60 metres.

The rock type of Hästholmen is the typical stone of the Loviisa region, rapakivi granite (Figure 7-13). Several variations of it have been discovered, the most common of which are pyterlite, wiborgite and even-grained rapakivi. The rock type is usually unweathered and massive and it has good strength properties. The weathering, locally typical of rapakivi, has mainly occurred deep in the fracture zones. The main fracturing directions are from northwest to southeast and from northeast to southwest, with the nearly horizontal fracturing forming the third main fracturing direction. The type of fracturing is cubic fracturing, typical of granite (*Anttila 1988*).

Hästholmen has a groundwater reserve of its own formed in the course of time of rain water. The level of groundwater follows mildly the topography of earth. Its depth is usually at the most a few meters from the ground level; in the littoral, the levels of groundwater and sea water are connected. Groundwater is, as typical of the islands

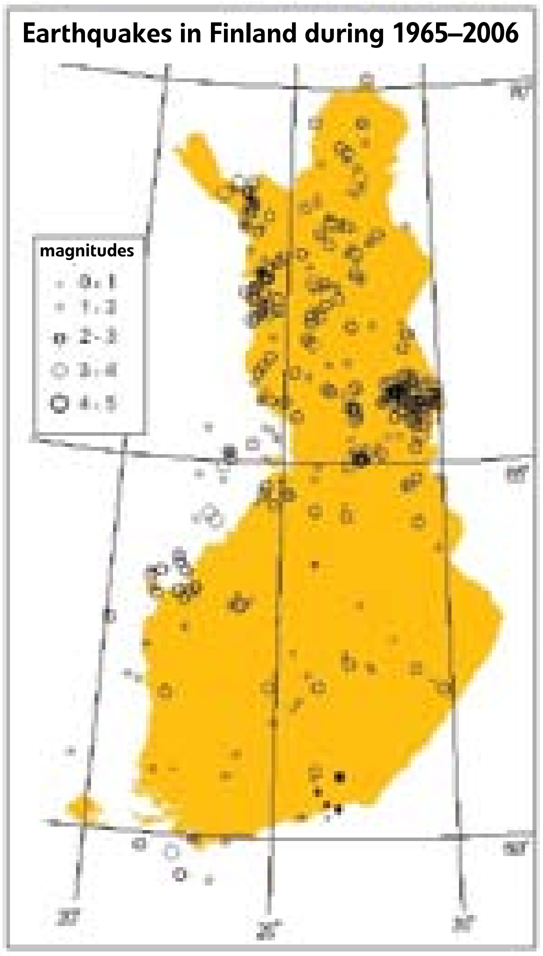

Figure 7-14. Earthquakes in Finland during 1965–2006. The magnitudes show the strength on the Richter scale (University of Helsinki 2007).

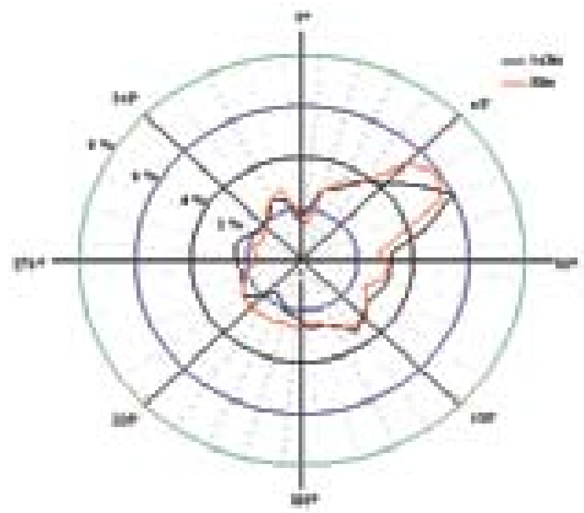

Figure 7-15. Shares of wind directions at the Loviisa Power Plant at heights of 30 and 143 metres in 1994–2007.

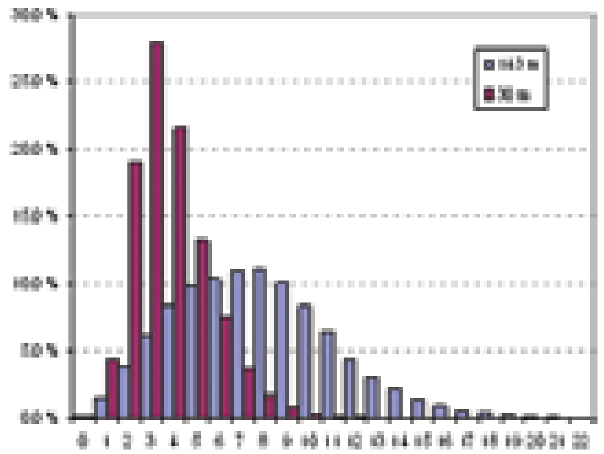

Figure 7-16. Wind velocity distributions at the Loviisa Power Plant at heights of 30 and 143 metres in 1994–2007.

of the sea, fresh on the surface, turning into more saline in the depths. In the middle part of the island the interface of fresh and saline water is at a depth of more than 100 metres (*Snellman and Helenius 1992, Hatanpää 1997*). There are no groundwater areas at Hästholmen suitable for water supply (*Uusimaa Regional Environment Centre 2005*). The nearest classified groundwater areas are located about four kilometres away. There is no domestic water or service water wells in the vicinity of the power plant.

7.7.2 Seismology

The Finnish bedrock forms a part of the Precambrian Fennoscandian shield, which belongs to the seismically steadiest areas. Nevertheless, there is rock stress, which can loosen and cause weak earthquakes. They are usually focused on the fracture zones already existing in the bedrock. Annually 10-20 earthquakes are registered in Finland. These quakes are relatively weak, 1–4 on the Richter scale.

There are known earthquake detections in Finland from a period of almost 400 years. Since 1965, when earthquakes have been observed with modern measuring devices, the most powerful quake took place in Alajärvi on February 17, 1979. It was 3.8 on the Richter scale. During 1977–2001 almost a half of all the earthquakes detected in Finland took place in the Kuusamo area. The earthquakes occurred in Finland in 1965–2006 have been shown in Figure 7-14. (*University of Helsinki 2007*).

In Finland earthquakes are usually caused by tension, which is caused by the expansion of the mid-oceanic ridge of Northern Atlantic Ocean. The crustal plates of Eurasia and North America are separating from each other about two centimetres per year, which causes a compressive stress on the whole Fennoscandian area. The slowly developed stress exceeds the strength of the rock material at some point and is suddenly loosened as an earthquake. Then the parts of the bedrock surrounding the source of earthquake move in respect of each other. This movement usually takes place along the old faults of the earth's crust. Other local causes are, e.g., uplift, which mainly causes earthquakes in the area of the Gulf of Bothnia (*University of Helsinki 2007*).

In the areas of southern Finland and the Gulf of Finland, there are two NW-SE seismic zones which are more active than the surroundings. Loviisa lies in between these zones, more than 100 km away from them. The area of Loviisa is fairly stabile, although some small earthquakes have occurred in the surrounding areas of Loviisa. The magnitude of the quakes in the area has been below three on the Richter scale.

During the seismic measurements carried out by Fortum in 1984–1996, altogether 134 micro earthquakes were registered, their magnitudes were ML= -1.8–1.3 (Richter local magnitude). No earthquakes significant in terms of the safety of the operation of the Loviisa Power Plant have been detected (*Saari and Slunga 1996, Saari 1998*).

7.8 Air quality and climate

7.8.1 Weather conditions

Owing to the Gulf of Finland, the climate at Hästholmen is marine. The sea evens out variations in temperature and, on the islands, the winds parallel to the shore prevail compared with inland areas, especially in the summer. Due to its location close to the sea, the winds on the island of Hästholmen are on average a couple tens of per cent stronger than in inland areas (*Heino and Hellsten 1983, Tammelin 1991*). The wind speed is at its highest in the autumn and winter and at its lowest in the summer. At the Loviisa Power Plant the most common direction of the wind is from the southwest, and the most uncommon from the southeast. Figure 7-15 shows the shares of wind directions and Figure 7-16 the wind velocity distribution at the Loviisa Power Plant at heights of 30 and 143 metres in 1994-2007.

In 1971–2000 the average rainfall in Loviisa was more than 650 mm annually and in 2007 more than 750. The average temperature was 4–5 °C in 1971–2000 and over 6 °C in 2007. (*The Finnish Meteorological Institute 2007*)

7.8.2 Air quality and deposition

In Loviisa there are no licence-bound industrial or energy production plants, which would affect the air quality. The most significant emission source of nitrogen oxides into the air is the traffic of main road 7 (E18) and the town centre. Heating plants cause a majority of sulphur dioxide emissions and a considerable part of the particle and nitrogen oxide emissions. The burning of wood and oil in households causes a considerable part of the particle, sulphur dioxide and hydrocarbon releases (*Kousa et al. 2007*).

On the average, the air quality in Loviisa is fairly good since there are no significant industrial sources in the area and even the emissions from the roads with the heaviest traffic are relatively small. According to the measurements carried out by Helsinki Metropolitan Area Council (YTV) and the Finnish Meteorological Institute in 2005, it can be assessed that the concentrations of fine particles are clearly below limits. The annual nitrogen oxide limit given for the protection of vegetation and ecosystems is not exceeded in the provinces of Uusimaa or eastern Uusimaa. Sulphur dioxide concentrations are low in the monitoring area and do not exceed the limits given on the health basis or for protecting the vegetation and ecosystems (*Kousa et al. 2007*).

In the bioindicator monitoring conducted in 1996 it was detected that in Loviisa the number of the lichen species on the trunks of pine trees had decreased somewhat due to air pollution. This has been affected by, e.g., the emissions from the industrial areas of Kilpilahti in Porvoo and the metropolitan area, traffic and the transboundary pollution focused on the southern coast of Finland. Near Valko, the sulphur and nitrogen concentrations of needles have been high, apparently due to the emissions from the actions in the harbour (*Pihlström and Myllyvirta 1996*).

In the bioindicator monitoring conducted in 2004 in Loviisa, the condition of epiphytic lichens Hypogymnia physodes was clearly better than on the average in the province of Uusimaa and eastern Uusimaa and the lichen species were more abundant than on the average. Epiphytic lichen, which was clearly damaged, was found near the town centre and from one sample area outside the population centre (*Kousa et al. 2007*).

7.9 State and use of waters

7.9.1 General description and hydrological specifications

Hästholmen is located in the outer inner archipelago zone in the Gulf of Finland. The open sea starts about 12 kilometres south of Hästholmen, at Orrengrund. Successive basins separated by shallow underwater sills and inlets are typical of the sea area off Loviisa. The water only mixes a little between these basins.

The island of Hästholmen and the peninsula north of it are surrounded by Hästholmsfjärden and Klobbfjärden in the east, Hudöfjärden in the south and southwest and Vådholmsfjärden in the southeast. Hästholmsfjärden is a basin between the mainland and the archipelago, connected to the outer sea area by its narrow and shallow inlets in the south and by Kirmosund. The area of Hästholmsfjärden is 9 km^2, the average depth 7.6 metres and the deepest basin 17.5 metres. The shallower Klobbfjärden is connected to the Hästholmsfjärden in the northeastern side. The total area of Hästholmsfjärden and Klobbfjärden is 15 km^2, the average depth 6.8 metres and the water volume 0.1 km^3.

Klobbfjärden is connected from its eastern part, via the narrow Jomalsundet, to the delta of the western branches of rivers Taa-sianjoki and Kymijoki. The river waters streaming via Jomalsundet and also the inlets of the southern parts of Hästholmsfjärden make the areas of Klobbfjärden and Hästholmsfjärden less marine areas than Hudöfjärden and Vådholmsfjärden.

The amount of water is larger in Hudöfjärden than in Hästholmsfjärden and Klobbfjärden and the connection to open sea somewhat more unrestricted. The greatest depth in Hudöfjärden is 24 metres, and in the surrounding shallower areas the sill depth is about 10 metres. The greatest

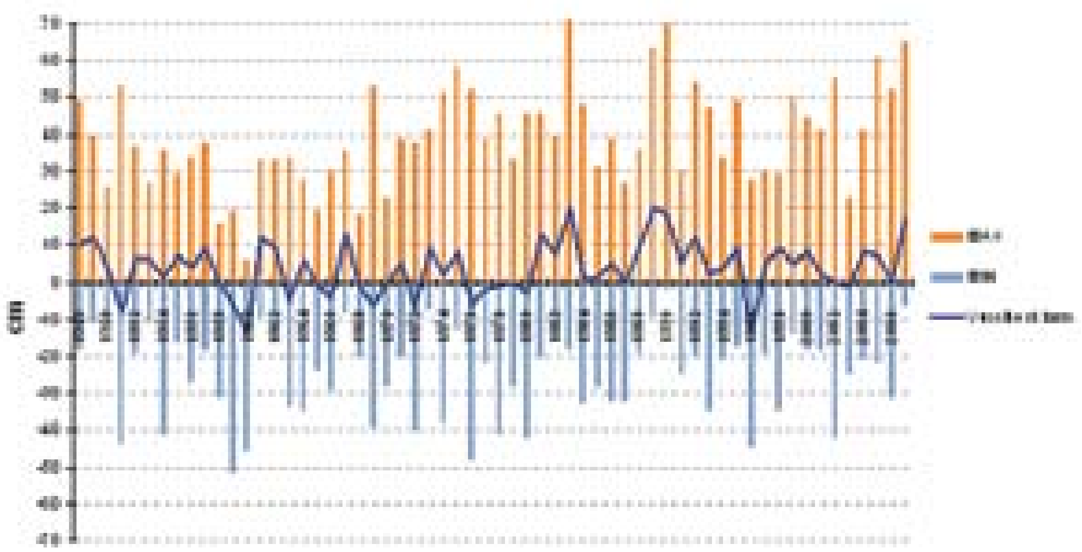

Figure 7-17. Minimum and maximum values for the daily average of the sea water level and the annual average in the sea area off Hamina in 1984-2006 (*Institute of Marine Research*).

Figure 7-18. Discharge of cooling water from the existing Loviisa Power Plant to Hästholmsfjärden.

depth in Vådholmsfjärden is 27 metres and the sill depth of the surrounding shallower areas is 9–13 metres.

River waters are the most significant load on the sea water area surrounding the whole island of Hästholmen. The load is especially caused by the nutrients, solid matter and oxygen consuming material in the river water.

Water area studies were started in the sea water area of the Loviisa Power Plant in 1966. Thanks to the studies, which were started as early as before the construction of the power plant, and to the continuous monitoring, the sea water area surrounding Hästholmen is one of the most researched and best known areas of the Finnish coast.

Sea water level

In Finland, the Institute of Marine Research monitors and compiles statistics of the level of sea water. Imatran Voima Oy started the observation of the level in the sea area of Hästholmen in 1968. At first the measurement point was in Kirmosund, but nowadays Fortum monitors the sea water level at the cooling water intake in Hudöfjärden.

Variations in the sea level off Loviisa are of the same order as off Hamina. Figure 7-17 shows the minimum and maximum values for the daily average of the sea water level and the annual average in the sea area off Hamina in 1984-2006.

In January 2005 the sea level rose to a record height. The hourly average measured at the intake of cooling water was +1.72 metres in terms of the N60 system used in the construction of the power plant. The zero level of the N60 system is the average water level in Helsinki in 1960.

On the basis of the long-term sea water level observations, Fortum has assessed the sea water level extreme values, shown in Table 7-1, which can occur in the area of Hästholmen with a frequency of once per 100 years, 1,000 years and 10,000 years.

Table 7-1. Extreme values of sea water level in the area of Hästholmen

Frequency (once/per years)	Maximum sea water level in the N60 system	Minimum sea water level in the N60 system
1/100	+1,75 m	-1,15 m
1/1 000	+2,12 m	-1,26 m
1/10 000	+2,51 m	-1,35 m

The climate change has impacts on sea water level and probably also on the frequency of occurrence of its extreme values. According to the assessment of the Intergovernmental Panel on Climate Change, IPCC, the level of sea water will rise by 9–88 cm by 2100 (*IPCC 2007*). By 2100 earth will rise in Loviisa about 30 cm compared to the present, so the relative change in the average sea level compared to the ground of Hästholmen will be about -20–60 cm in 2100.

7.9.2 Cooling water intake and discharge

Cooling water intake

The cooling water of the existing power plants (on the average about 44 m^3/s) is taken from the west side of Hästholmen, from Hudöfjärden from a depth of 8–11 metres. During annual outages, a power plant unit needs about two cubic metres of cooling water per second to remove the residual heat of the reactor. With the cooling water, 10–20 tonnes of fish are carried to the power plant annually. The amount of fish depends, on the one hand, on the amount of cooling water and, on the other hand, on its temperature. When the water is cold, more fish are carried to the power plant than when the water is warm. The share of smelt and herring of the total weight of the fish is more than 90%. Other frequent species are, e.g., sander, perch, roach, silver bream, bream, gobies, bleak, sprat, threespine, ninespined stickleback, ruff, eelpout and pipe-fish. Whitefish and trout are very uncommon in the cooling water.

Sea water warming

The cooling water, which has warmed some 8–12 °C, is led from the power plant to the eastern side of the island, to Hästholmsfjärden, where the cooling water flow spreads over the submerged weirs. Figure 7-18 shows the front of the discharge location of cooling water from the existing power plant.

According to temperature measurements, the cooling water has increased the temperature of surface water during the vegetation period (May-October) by 1–2.5 °C within the distance of one to two kilometres from the discharge place (*Mattila and Ilus 2006*). The amount and the intake and discharge temperatures of cooling water are monitored by continuous measurements. Off Loviisa, as on the whole northern coast of the Gulf of Finland, the net current direction is to the west. This also guides the movements of cooling water, especially during the ice cover period. During open water, winds affect the spreading of cooling waters and the width of the spreading area.

Cooling water flows in the summer with the wind as a few metres' layer close to the surface. Due to the difference in density, the warm surface water does not easily mix with the hypolimnion. The temperature rise in the sea is mainly limited to the front of Hästholmen and to the inlets leading from Hästholmsfjärden to open sea. Outside Hästholmsfjärden, the cooling water has not permanently affected the average temperatures of surface water during the vegetation period. Occasional temperature rises have been detected, depending on the wind conditions, a few kilometers away from the power plant, at Klobbfjärden and Vådholmsfjärden.

During the ice cover period the warm cooling water sets at Hästholmsfjärden as a few metres' layer underneath the ice cover between the cold fresh water and the cold sea water. This results in a warm halocline whose temperature can be 8–10 °C in the vicinity of the discharge place. Usually this warmer halocline can only be detected at Hästholmsfjärden and its surroundings. Further away, the temperature of the halocline decreases little by little as the cold water of the surrounding layer mixes with it. During exceptionally cold winters, when Hästholmsfjärden has been frozen for a long period of time, slightly increased temperatures have been detected at a distance of about 10 km from the power plant.

Ice conditions

The impact of the cooling waters of the power plant on the ice cover can be seen early in the winter as a wide area of unfrozen water. The ice cover is usually weak during winters off the power plant and in the inlets leading out of Hästholmsfjärden. Towards the end of winter, the ice melts rapidly in the inlets, as currents lift the warm water so as to become in touch with the ice.

During an average winter the Hästholmsfjärden freezes at most parts for a short period of time. The ice cover off the power plant and in the inlets leading to the open sea and in their front is often weak and thin even then and it melts rapidly as the temperature of the air rises. Ice is usually strong in the northern parts of Hästholmsfjärden.

During mild and very mild winters, Hästholmsfjärden remains mainly unfrozen during the winter (Figure 7-19). Since no ice cover is formed, some of the heat led to the Hästholmsfjärden is directly transferred to the atmosphere. Due to the influence of wind, the water mass mixes with the open water and becomes relatively even in terms of both temperature and salinity.

During very cold winters the Hästholmsfjärden is almost totally with ice. The area remains frozen for a month or more. The unfrozen water area in front of the discharge place is usually clearly less than one square kilometre at its smallest. This is when the warm discharge water is set almost immediately in the halocline and no large amount of heat is transferred to the atmosphere.

According to the observations of the Institute of Marine Research in 1961–2005, the permanent ice cover on the south side of Hästholmen has been at its shortest 9 days, on the average 100 days and at its longest 149 days.

Figure 7-19. Unfrozen area at Hästholmsfjärden.

7.9.3 Quality of water

The obligation of the Loviisa Power Plant to monitor the water is included in the licence (nr 64/1995/1) given by the Water Rights Court of western Finland in 1995 to Imatran Voima Oy (now Fortum Power and Heat Oy) to conduct cooling water and waste waters to the sea. The licence conditions were changed in 1998 (nr 61/1998/3) due to the power upgrading of the power plant, e.g., by increasing the largest allowed monthly average rise in cooling water temperature from 12 °C to 13 °C. The water monitoring of the Loviisa Power Plant is carried out according to a monitoring programme approved by the Uusimaa Regional Environment Centre. The programme includes the temperature and quality of sea water, ice situation and base production, zoobenthos, aquatic vegetation, phytoplankton and the monitoring of the oxygen situation of the near-bottom water in the autumn.

In 2006, the monitoring carried out by the Radiation and Nuclear Safety Authority included, according to the programme, the quality of sea water, base production and zoobenthos (*Mattila and Ilus 2007*).

The average total phosphorus content of the surface water was during the vegetation period of 2006 distinctly higher than in 2005 and in several measuring points also slightly higher than the averages of the 1980s and 1990s. The increase in the phosphorus content in the surface water was partly affected by the upwelling of sea water. Also the phosphorus contents in the near-bottom water were in 2006 higher than the average of the 1980s and 1990s, due to the weakened condition of bottom sediments and increased internal load. The nitrogen content of the surface water in 2006 was slightly higher than or roughly equal to 2005. However, compared to recent decades, the nitrogen content of the water has decreased (*Mattila and Ilus 2007*).

At the beginning of the 2000s, the underwater visibility of the area has been close to the averages of the 1980s and 1990s. Underwater visibility has decreased considerably in the monitored area starting from the 1970s, and in the last few years the average underwater visibility has been only slightly better than in the late 1990s (*Fortum Power and Heat Oy 2007b*). The underwater visibility has mainly decreased due to the general eutrophication of the Gulf of Finland. Underwater visibility improves when moving toward the outer sea. In 2006 the underwater visibilities were 1.8–3.2 metres (*Mattila and Ilus 2007*).

Estimated on the basis of the salt content of the water, the area has lost some of its marine characteristics during the recent decades. The salt content of the water is fairly low off Loviisa, only 3.5-5 per mil during the vegetation period. The low salt content and especially the great seasonal variation in the salt content of the surface water affect the normal life of both fresh and saline water organisms in the Loviisa sea area. There are fewer species than in the western parts of the Gulf of Finland, for example, where the salt content of the surface water is 1-2 per mil higher. The average salt content of the surface water has been slightly higher in 2003–2006 than in 2000–2002, and nearly as high as in the 1990s.

The solids content of the sea water increases in the spring due to river water flowing to the area. In other seasons, there are occasional increases in the solids content caused by large quantities of phytoplankton. The average solids content in 2006 (3.0 mg/l) was slightly lower than in 2005 and approximately the same as in 2004.

The late-summer oxygen content of the near-bottom water has been problematic in some of the basins of Hästholmsfjärden and Hudöfjärden for decades, but in 2006 the oxygen condition of the near-bottom water was poor at other sampling points as well, both in August and in October. The oxygen problems of the near-bottom water in the monitored area are mostly caused by the underwater sills limiting the exchange of water and the eutrophication of the Gulf of Finland.

The waste waters from the Loviisa Power Plant are treated before leading them into the sea and the releases have no significant effect on the state of sea water (see Chapter 9.4).

In 1996-2001, the total nutrient load caused by the Loviisa Power Plant averaged 7-8% of the point load in the Loviisa region (*Mattila 2002*). However, the largest load source in the area is river water (Loviisanjoki and Taasianjoki rivers), whose combined nutrient load was, on average, more than ten times as much as the total point load (Mattila 2002). At the turn of the millennium, the nutrient load of the Loviisa Power Plant accounted for about 0.5% of the nutrient load of Taasianjoki and for 1.5-2.5% of that of Loviisanjoki.

7.9.4 Plankton production, aquatic vegetation and fish stock

Plankton production

The phytoplankton of the Loviisa sea area consists of both brackish water species and sweet water species. In 2005 the majority of the phytoplankton in the monitored area were diatoms (Diatomophyceae), dinoflagellates (Dinophyceae) and cyanobacteria (Nostocophyceae). The biomass of phytoplankton is at its highest from March to May. The maximum amount of biomass was measured just before the middle of May, after which the amount of biomass decreased rapidly.

The quantity of cyanobacteria increased starting from June, and remained high in July, August and September. Generally, the amount of cyanobacteria in the eastern Gulf of Finland increased during the 1990s due to a decrease in the inorganic nitrogen-phosphorus ratio and the prevailing hydrographical conditions (Kauppila and Bäck 2001). The biomass of cyanobacteria and its share of the total biomass have clearly increased during the observation period, also in Hästholmsfjärden. In the summer, the quantity of cyanobacteria in Hästholmsfjärden has been observed to increase earlier than in other reference locations. On the other hand, in the first half of the 1970s the share of cyanobacteria of the entire biomass was occasionally higher in Hästholmsfjärden than in Hudöfjärden, although the total biomass at the time was considerably lower. It has been observed that cyanobacteria thrive in warm and nutritious waters (*Pitkänen 2004*).

The biomass of phytoplankton has grown in the monitored area since the first half of the 1970s. The change in the amount of biomass has been similar in the entire eastern Gulf of Finland during recent decades (*Kauppila and Bäck 2001*). In surveys in the Loviisa area it has been observed that the nutrient content, salt content and temperature of the water regulate the amount of the biomass of phytoplankton (*Ilus and Keskitalo 1987*). Longer growth seasons due to the rise in water temperature and shorter period of ice cover in the winter seem to have increased the biomass of phytoplankton in Hästholmsfjärden and influenced the ratio of different species. Prior to the commissioning of the power plant, the biomass of phytoplankton was regularly larger in Hudöfjärden than in Hästholmsfjärden (*Ilus 1999*). Since the start-up of the plant, the situation has been the opposite until 2005 (*Mattila and Ilus 2006*).

In the Loviisa power plant zooplankton monitoring, which ended in 1999, no changes in the abundance or species distribution were observed that could have been connected to the discharge of cooling water.

Aquatic vegetation

Regular surveys have been carried out on the aquatic vegetation of the shores near the Loviisa power plant since 1971. The stony shoreline with large boulders is typical of the area of Hästholmen. The bottom near the shoreline is mostly sand or mixed gravel and clay with a lot of boulders. There are relatively few shores with solid rock, and even these few turn into cobble immediately below the waterline. Beaches and shores with a soft bottom are rare.

During the observation history, one of the clearest environmental effects of the power plant has been the eutrophication of the aquatic vegetation at the southern and southwestern shorelines of Hästholmfjärden. Among the species benefiting from cooling waters are perennial asexually reproduced vascular plants and fast-growing filamentous algae (*Mattila 2002*). Filamentous algae have also benefited from the general increase in nutrients in the area. In the 2005 survey, vegetation in the area was still very eutrophic. The diversity of vegetation in many lines had continued to diminish, and hornweed, which prefers habitats with high nutrient availability, has proliferated in many places. Abundant loose filamentous algae were also observed at places along the Hästholmen shore zone. Warm water discharges have also been found to have an effect on the over wintering of plants and the length of growing season. Changes in vegetation have been most significant in the water area that remains open in the winter (*Mattila and Ilus 2006*).

Fish stock

The fish in the eastern parts of the Gulf of Finland are typical species in brackish water. The low salt content (4-7 ‰) does not prevent the fresh water fish species from living in brackish water. The species best adapted to brackish water is herring. Common fresh water species are several black clams, perch and ruff (*Metsähallitus 2007*). There are strong populations of sea species, e.g. sprat, flounder, lumpfish and threespine stickleback. The development of the fish populations in the Hästholmen area reflects the changes in the coastal waters of the Gulf of Finland.

Sander has only recently been spread from the coast all the way to the outer archipelago. Pike remains at the coast and is rather rare in the outer archipelago. A speciality of the area is whitefish. The salmonoids which can be found in the eastern Gulf of Finland are e.g. salmon, sea trout, Baltic whitefish and rock whitefish.

The islands, skerries and littorals of the rocks in the national park of the eastern Gulf of Finland are a very important feeding area for sea trouts and whitefish, especially during cold waters. Also some migratory species can be found in the area, e.g. eel and lamprey, which are reproduced in the rivers of the coast and which migrate to the sea for feeding. The underwater shallows and ridges usually act as the reproducing places for many fish species. For example flounder, rock whitefish and herring reproduce in the gravel shallows. Several small species, such as minnow and threespine stickleback are reproduced at the shore. The shore zone is also an important area for the growth of the fry and adults of many species (*Metsähallitus 2007*).

Herring spawns at Hästholmsfjärden in the spring-time. As soon as the ice melts, there is a large number of smelt. During the cold seasons, there is plenty of trout in the area. Also perch, pike, sander, bream and roach are common.

7.9.5 Zoobenthos and invasive species

Zoobenthos

In 2006 the zoobenthos in the sea areas of Hästholmen was scarce. During the observation period, zoobenthos communities have regressed, become less diversified and even collapsed at most of the observation points. On the other hand, the zoobenthos of the area was stated scarce in many areas already at the end of the 1960s. The regression of zoobenthos is not only peculiar to the Loviisa sea area; the regressive development is much wider in the area of the Gulf of Finland. The regression has mainly been due to the significant regression of the sea floor. Today the bottom sediments contain a large amount of organics, the dissolution of which easily wears the oxygen reserves of the sediments.

Another reason for the scarcity of bottom fauna in the Hästholmsfjärden basin seems to have been the increase of organic matter in the bottom sediment caused by eutrophication. This has led to poorer oxygen conditions in the basins and repeated hydrogen sulphide periods (*Mattila and Ilus 2007*).

Only at the outlet of cooling water the zoobenthos is more versatile and also the warm water seems to give suitable conditions for the various invasive species.

Invasive species

The recent invasive species of the water nature, the zebra mussel, the dark false mussel and the Gammarus tigrinus can also be found in the area of the national park of the eastern Gulf of Finland. In addition, there are a number of other invasive species in the estuary of the bay of Nevanlahti, which are possibly spreading to the sea area, and new incomers are expected to appear along with marine traffic. The ecological impacts of the invasive species living in the sea are not known very well and the prediction of their spreading and impacts is very difficult. In the estuary of the bay of Nevanlahti the invasive species have already gained ground from the original species and probably they will alter the functions of the communities (*Metsähallitus 2007*).

According to studies, there are e.g. the dark false mussel, the polychaete and as the newest newcomer, the Gammarus tigrinus in Hästholmsfjärden. The dark false mussel population is very dense in the vicinity of the cooling water discharge place and there are dense populations in the whole Hästholmsfjärden. The mussel has also spread to Hudöfjärden and it can be found near the cooling water intake. In 2005, the species was also found in the archipelago of Pernaja (*Mattila and Ilus 2006, 2007*).

According to the expeditions of the research vessel Aranda of the Finnish Institute of Marine Research on 2007 and 2008, the warty comb jellies (Mnemiopis leidyi) spread from the east coast of the US have spread, except for the Bay of Bothnia, to the whole Baltic Sea. At the end of 2007, Mnemiopis leidyi was found even in the far end of the Gulf of Finland and in shallower sea areas than before (*Finnish Institute of Marine Research*). In January 2008, the density of the Mnemiopis leidyi in the oxygen-rich basin of the Sea of Aland was more than sixfold compared with the densest values of 2007 (*Finnish Institute of Marine Research*). No information is available of the occurrence of the Mnemiopis leidyi in the Hästholmen area.

7.9.6 Use of the water area

In addition to professional and recreational fishing, and other recreational use, the waters are used for Loviisa power plant cooling water intake.

Fishing

Within a radius of five kilometres of the power plant, in the sea area in front of Hästholmen, two households practiced professional fishing and some 1,300 households domestic and recreational fishing in 2005 (*Ramboll Finland Oy 2006*). The amount of nets in professional fishing was relatively small. In addition to nets, there was one salmon trap in use. Professional fishing was most active on the western side of Hudöfjärden, in the nearby waters of Kejvsalö, Käldö, and Tjuvö. Domestic and recreational fishing was mainly net and pole fishing. Professional fishermen fished between April and December. The domestic and recreational fishing was focused on the open water period, between May-September. The most significant fishing period is the holiday months, between June and August.

The total catch from the sea area in front of Hästholmen in 2005 was approximately 53 tonnes, of which the share of pike was 31%, perch 21%, sander 14% and herring 12% (Table 7-2). The share of salmonoids of the total catch was minor. The total share of salmon, trout, rainbow trout and whitefish was 5%. The share of domestic fishing of the total catch was almost 97%. Economically the most significant species of catch of professional fishermen were sander, salmon and perch and correspondingly of domestic fishermen pike and perch. The household related total catch of professional fishermen was on the average 820 kg and of domestic fishermen approximately 40 kg (*Ramboll Finland Oy 2006*).

According to fishermen, the factors mostly troubling fishing in front of Hästholmen are the shortness of winter fishing period and the strong seal population and at places also the fishing tackles get dirty (*Ramboll Finland Oy 2006*).

Recreational use

The recreational area closest to the power plant, the Källa camping area and beach, which are owned by the town of Loviisa, are located about two kilometres northwest from the power plant. Closer to the centre of Loviisa there are also three public beaches. On the shore of Klobbfjärden,

Table 7-2. Total catch (kg) in the sea area off Hästholmen in 2005.

Fish species	Professional fishermen		Leisure fishermen		Total	
	kg	%	kg	%	kg	%
Salmon	392	24	1429	3	1821	3
Trout	65	4	-	-	65	0,1
Rainbow trout	-	-	545	1	545	1
Whitefish	47	3	670	1	717	1
Herring	50	3	6251	12	6301	12
Pike	149	9	15940	31	16089	31
Perch	261	16	10555	21	10816	21
Sander	535	33	6858	13	7393	14
Burbot	8	0,5	589	1	597	1
Bream	2	0,1	1393	3	1395	3
Ide	13	1	688	1	701	1
Roach	33	2	5456	11	5489	10
Others	79	5	661	1	740	1
Total	**1634**	**100**	**51035**	**100**	**52669**	**100**
kg/household	817	..	40	..	..	..

about three kilometres northeast from the power plant, there are areas which have been reserved for recreational use in the regional plan of eastern Uusimaa.

The sea fortress island of Svartholma is in active recreational use during summertime. There is a boat connection from Loviisa to the island and there are also free berths so it is popular among boaters (Figure 7-20).

On the mainland, at the gate of the power plant area, there is a quay and Fortum's Kirmosund port with 28 berths for the personnel of Fortum and for outsiders. Also near the gate, situated on the Hästholmsfjärden shore side, there is a quay with some 33 berths for the personnel.

7.10 Flora and fauna

Flora

Hästholmen and the surrounding areas represent the typical forest, coast and archipelago landscape of eastern Uusimaa. The forests of the area are stony dry peaty forests, most of which are in economic use. Due to the broken shoreline, varying soil types and numerous islands, the shore vegetation of the area is diversified. In the shore areas there are small shore meadows. There are no endangered species in the area (*Town of Loviisa 2007*).

The unbuilt areas of Hästholmen and Tallholmen are locally significant due to their shores in natural state and the old forests in the area that has been built almost to capacity. There is an extensive common alder grove and shore forest with a very representative variety of wood species on the neck of land between Hästholmen and Tallholmen, mostly on the side of Hästholmen (*Siitonen et al. 1997*).

The old forest and grove of Mysskärret, which are mainly located in the area of Ruotsinpyhtää, on boths sides of the road Atomitie, are locally very significant areas on the basis of their vegetation and tree stand, and also possibly as the living environment of insects. There is fern grove, grove woodland and fresh grove in the area. There are also wet

Figure 7-20. Svartholma sea fortress.

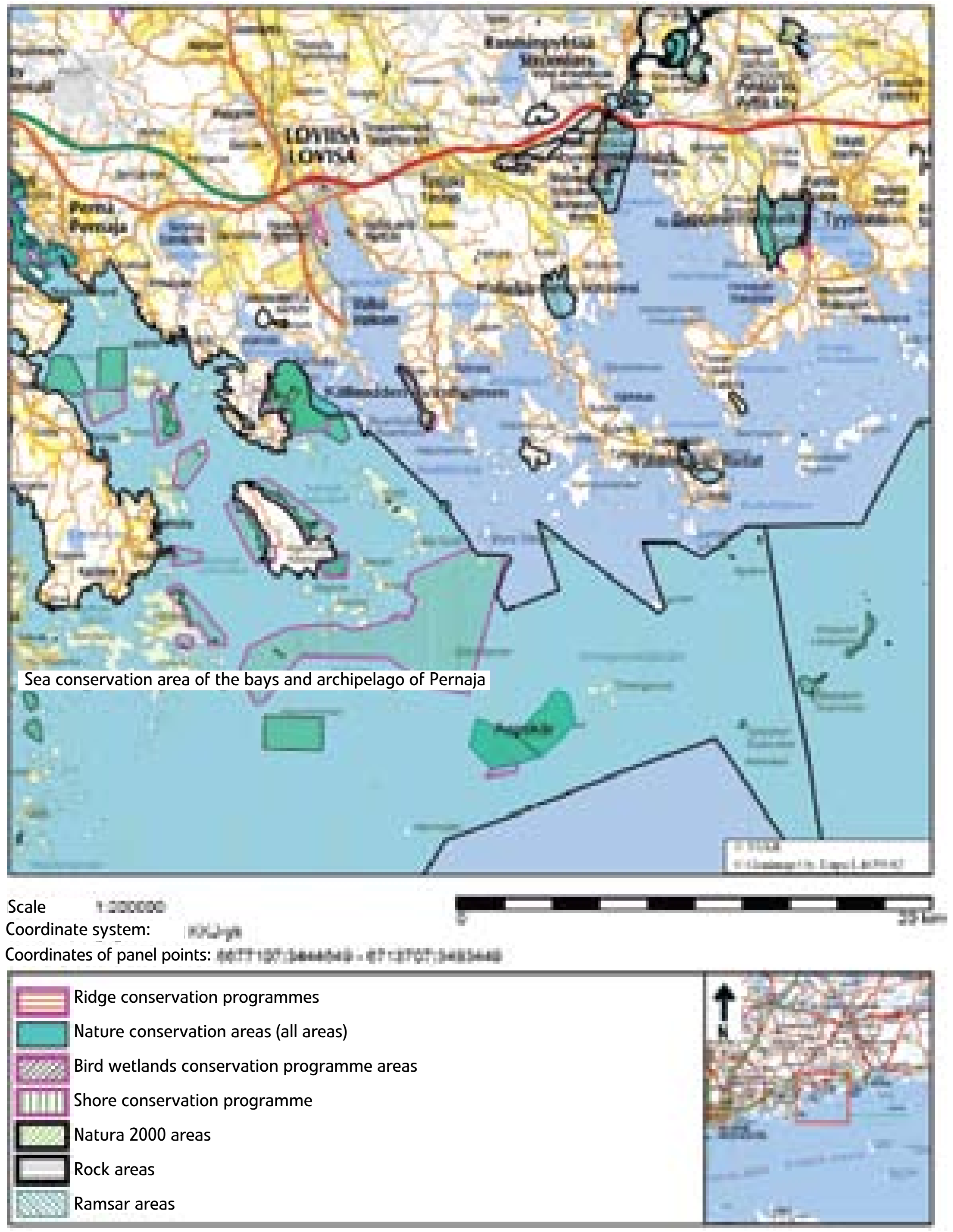

Figure 7-21. Natura 2000 areas and other nature conservation areas in the Loviisa region.

dents in the area, with occurrence of swamp vegetation. The tree stand consists of large and high alder. The vegetable species found in the area are wood chickweed, baneberry, honeysuckle and hepatica (*Siitonen et al. 1997*).

Close to the accommodation area, by the road Atomitie, in the Ryssviken shore grove area, large alder and bird cherry can be found. Also a natural occurrence of hop shoots is located in the area. The area is locally significant as a living environment and as to its vegetation (*Siitonen et al. 1997*).

Vegetation along the road Atomitie has also been charted in connection with the compilation of the component master plan for shore (*Town of Loviisa 2007*). There are no types of nature protected by virtue of Nature Conservation Act. The forests of the area are in economical use and a majority of the swamps of the area have been ditched. The area most in natural state is a non-drained marsh, on the western side of road Atomitie, but it has no particular natural value. There is also a possible site subject to Forest Act, a bare cliff with a small number of trees, in the southwestern corner of the area. The natural value of the forests is normal (*Town of Loviisa 2007*).

In the northern parts of Loviisa and in Tesjoki there are areas with vegetation that has local value, e.g. the grove of Ulrika. The endangered and protected mountain elm grows in its southwestern part. No valuable natural areas are located in the immediate vicinity of the planned road connection main road 7 (E18) – Atomitie (*Town of Loviisa and municipality of Ruotsinpyhtää 2006*).

Fauna
In Loviisa, the birds in the areas of, e.g., buildings, roads and warehouse areas have a minor conservation value than the birds in shore areas and oldish forest fragments. The rarest species of the shore area birds is Caspian tern (Sterna caspia), whose conservation and monitoring is the responsibility of the member countries of the European Union. Valuable areas in terms of waterfowl include the shore areas east of Björnviken, Lappomviken and the southern point of Hästholmen.

The fauna of Hästholmen and the surrounding areas is regular; the species have adapted to the production forests. The area is rich in waterfowl. The shore of the eastern side of the peninsula next to Hästholmen and its canegrass bays on the western side have a valuable birdlife. Also the ice-free area in front of the power plant attracts a large number of waterfowl to the area during winters, e.g. the overwintering black coot, smew and mute swan (*Town of Loviisa 2007*).

All the bat species and Siberian flying squirrel found in Finland, belong to the species listed in appendix IV(a) of the EC's Habitat Directive (*92/43/EEC*) whose breeding and rest places must not be destroyed or deteriorated, as stated in the Nature Conservation Act.

The occurrence of bats and flying squirrels has been charted in connection with the making of a general plan in the northern Loviisa and the component master plan in Tesjoki in 2005 (*Siivonen 2005*). The only breeding place of whiskered bat and long-eared bat detected in the area is located about 10 km away from Hästholmen. At the moment no other breeding and resting places of bats are known in the planned area (*Siivonen 2005*).

There is only one known observation of feces of the flying squirrel in the planned area on the eastern shore of Tesjoki, dating back to 2005 (*Vauhkonen 2006*). According to present knowledge, this is not a breeding or rest place of the flying squirrel. In Hästholmen or the peninsula next to it, there are no living environments that the Siberian flying squirrels prefer (*Town of Loviisa 2007*).

7.11 Conservation areas

Nature conservation areas
There are several nature conservation areas in the archipelago of eastern Uusimaa (Figure 7-21). The Källaudden-Virstholmen area located approximately 1.5 kilometres from the power plant, the sea conservation area about two kilometers away in the bays and archipelago of Pernaja and the Kullafjärden bird waters and the bays slowly separating themselves from the sea at Vahterpää, seven kilometers away from the plant, are parts of the Nature 2000 network.

The Källaudden-Virstholmen area (FI0100080) is located on the coast and the sea in the eastern part of Loviisa two kilometres from the plant to the northwest. The area has been added to the Natura network according to the types of nature mentioned in the EC's Habitat Directive (*92/43/EEC*). The area has a ridge formation in line with the shore and its highest peaks reach above sea level as small sand islands. The ridge formation has been found valuable and it belongs to the national ridge protection program. It is representative to its vegetation, landscape and geomorphology and due to its development caused by land uplift.

The sea conservation area of the Pernaja bays and archipelago (FI0100078) is a wide sea area starting from the Pikkupernajanlahti in the west and ending at the border of the territory of the Uusimaa regional centre in the east. In the outer sea, the area reaches the outer border of the inner territorial waters of Finland for the most parts. The area is, among other things, a landscape of national value, forming an internationally valuable ecological system. Many parts of the area have been found to have national value, and they belong to various conservation programmes. The area has been added to the Natura network according to the European Union's Bird Directive (*79/409/EEC*). In the area, several types of nature, listed in the Directive, are present as representative samples and the value of the area is also added by several bird species mentioned in the Directive.

The Kullafjärden bird waters (FI0100081) and Vahterpää bays slowly separating from the sea (FI0100083) are included in the Natura areas in the municipality of Ruotsinpyhtää. Kullafjärden is a bird nesting area of national value in the Taasianjoki delta. The Vahterpää area consists of shores and waters located at the end of the long Vahterpää peninsula in the southeastern part of Ruotsinpyhtää. The area consists of two bays separating from the sea (Hamnfladan and Furufladan), a bay already completely detached from the sea (Lillfladan) and the shores of Hamnfladan and Lillfladan.

About three kilometres southwest from the power plant there is the Kuggen bird conservation area and four kilometres away the nature conservation area of small Hudö and Lilla-Hudö islands and other minor islands near them. North of Hästholmen, on the mainland, the nearest areas protected by the Nature Conservation Act are located in Kristianslandet (the conservation forest of Bastuängen).

Sites of cultural history value
To the west of the power plant support area on the mainland there is the old Svartholma sea fortress (Figure 7-22), to whose history the islands in the Källaudden-Virstholmen Natura area are connected. The graveyard of the fortress is located on Begravningsholmen, and Krutkällarholmen has the foundation of the old gunpowder warehouse. The Svartholma sea fortress is a historical site of national importance. It also has importance for the national cultural history (National Board of Antiquities 2007). A monument of antiquity has also been found on the island. The next monument of antiquity has been found off Kampuslandet located four kilometres southeast of the new power plant unit.

Underwater monuments of antiquity
The nearest known underwater monuments of antiquity listed in the register of underwater discoveries by the National Board of Antiquities are located about one kilometre west from the power plant (Figure 7-22). Nevertheless, the National Board of Antiquities does not have comprehensive information on the location of underwater monuments of antiquity in the Loviisa area, which is interesting in respect of the history of shipping.

Figure 7-22. Sites of cultural history value near Hästholmen.

7.12 Radiation

Impact of the power plant on the radiation situation
The Loviisa Power Plant has a radiation monitoring programme of the plant environment, referred to in Government Decision 395/1991, section 26 and described in the Guide YVL 7.7 of the Radiation and Nuclear Safety Authority, used to monitor radioactive releases and concentrations in the environment. The measurement of external radiation is continuous, which enables real-time information of the changes in the radiation situation of the environment. The radiation monitoring programme of the environment is described in Chapter 17.2.

Radioactive materials originating from the operation of a nuclear power plant are effectively filtered and any releases into the natural environment are low. Man-made radioactive substances, originating e.g. from the Loviisa Power Plant, nuclear bomb experiments or the Chernobyl accident, are detected in small concentrations in the samples of the radiation monitoring programme of the environment of the Loviisa Power Plant. Man-made radioactive substances can be identified easily and distinguished even in small concentrations from nature's own radioactive substances, which include, e.g., uranium in the soil and its radioactive decay products, such as radon and polonium. In the region of Loviisa the concentrations of man-made radioactive substances in the living environment of people are insignificant and small compared with the concentrations of radioactive substances from nature.

Radioactive materials originating from the Loviisa Power Plant have been mainly detected in the sediment of the sea-bed and in organisms that effectively collect radioactivity (for instance Saduria entomon), which are not used as human food. Radioactive materials originating from the power plant have been detected in the sea water only in exceptional circumstances, and never in fish. Air and deposition samples show very minor amounts of radioactive materials a few times per year, originating from airborne releases from the Loviisa Power Plant. Radioactive materials originating from the power plant have never been detected in soil, grazing grass, milk, garden produce, crops, meat or drinking water.

In 2006, altogether 324 samples were taken from the surroundings of the Loviisa Power Plant. Radioactive materials originating from the power plant, e.g. cobalt (^{58}Co, ^{60}Co), silver (^{110m}Ag), and antimony (^{124}Sb), were detected in six samples of the sediment of the sea-bed, in nine aquatic plant samples, two deposition samples, two sea water samples, one air sample and one zoobenthos sample. The detected concentrations were small and they had no significance in terms of radiation exposure (*STUK 2007*).

Annual radiation doses to the people living in the vicinity of the power plant are calculated based on radioactive releases from the power plant. The maximum allowable radiation dose is 0.1 millisieverts (mSv) per year (VnP 395/91). The radiation dose of the nearby residents with the most exposure to emissions into the air and the sea in 2006 was approximately 0.0001 mSv. In recent years, the Loviisa Power Plant has caused an average calculated radiation dose of 0.0003 millisieverts to the most exposed person. The radiation originating from the Loviisa Power Plant to its environment is very small compared with the average radiation dose received by a Finn from other radiation sources, which is about 3.7 millisieverts (mSv) per year (see Chapter 13.5).

Occupational radiation doses
The principles and practices of radiation protection have been dealt with in Chapter 9.13.2 and the health hazards and radiation dose limits in Chapter 13.4. Case-specific limits, which are stricter than statutory limits, are usually applied at the Loviisa Power Plant. For instance, a pregnant person shall not work at the Loviisa Power Plant in tasks involving exposure to radiation, since the foetus is more sensitive to health hazards than an adult. Furthermore, all power plant workers always wear two dosimeters in the radiation area, of which one alerts in a deviating radiation situation.

In 2007, the people working at the Loviisa Power Plant received a total dose of 0.725 manSv, which was distributed in such a way that 484 of the people received a dose of less than 5 mSv and 22 people received a dose of 5-10 mSv. None of the persons received a radiation dose of more than 10 mSv. The statutory annual limit for a worker's radiation dose is 50 mSv and the total dose 100 mSv in five consecutive years.

Common wood sorrel, Ruotsinpyhtää

8 IMPACTS OF THE CONSTRUCTION OF A POWER PLANT UNIT

8.1 Organization and safety of the construction stage

8.1.1 Management and schedule

The construction of a new power plant unit is an exceptionally large project and requires developed project management of the project responsible. Special features are a long construction time, large number of workers and the exceptionally high demands on the quality of the result, which also presuppose high-quality quality assurance and quality control. This can be seen among others in the choice of contractors and suppliers and in the supervision of the work. The project responsible is responsible for seeing that all safety and quality requirements, as well as requirements by the authorities are fulfilled. The project responsible compiles a separate plan for the management and organization of the project, although the power plant unit would be supplied on turnkey basis.

The main contractor of the construction site is either the project responsible or the plant supplier. The organization method of the site, the authority of the project responsible to supervise and be responsible for the fulfilling of the safety and other requirements set for the project, are determined as part of the signing of the main agreement. More accurate plans for the use of the site areas, the splitting of works into subcontracts and their fitting to the main schedule are carried out under the lead of the main contractor. It will take about eight years from the supply of the plant to its commercial operation. The schedule of a project launched and progressing without delays is shown in the Figure 8-1.

8.1.2 Description of the construction site

The construction of a new power plant unit is similar to other large industrial sites. The central site operations will be located on the 30-hectare area southeast of the existing power plant units. There is an area of approximately 18 hectares on the mainland for receiving materials and for preparatory work. In addition, construction work related to cooling water structures and the loading and unloading site extend to the nearby sea areas, and, depending on the implemented cooling water alternative, possibly even to the islands five kilometres away. The figure shows the location of the site operations, according to preliminary plans Figure 8-2.

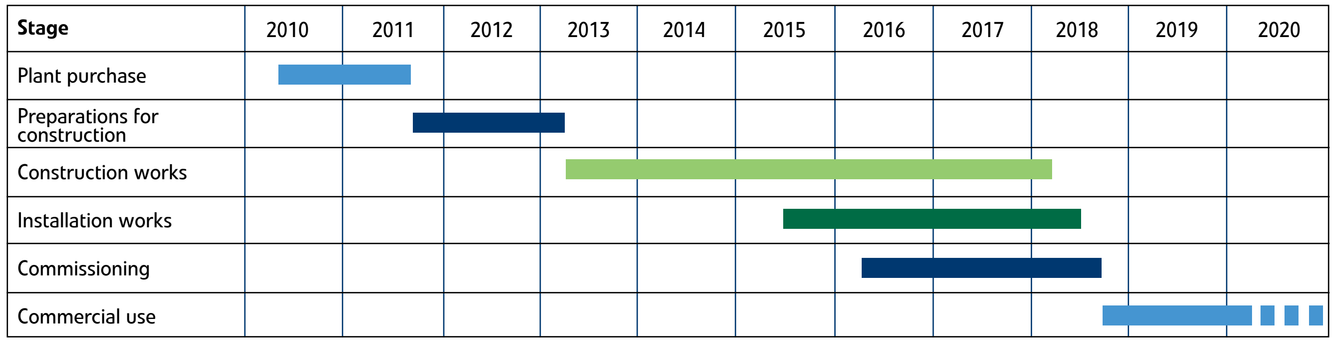

Figure 8-1. Estimated schedule of the implementation of the new power plant unit.

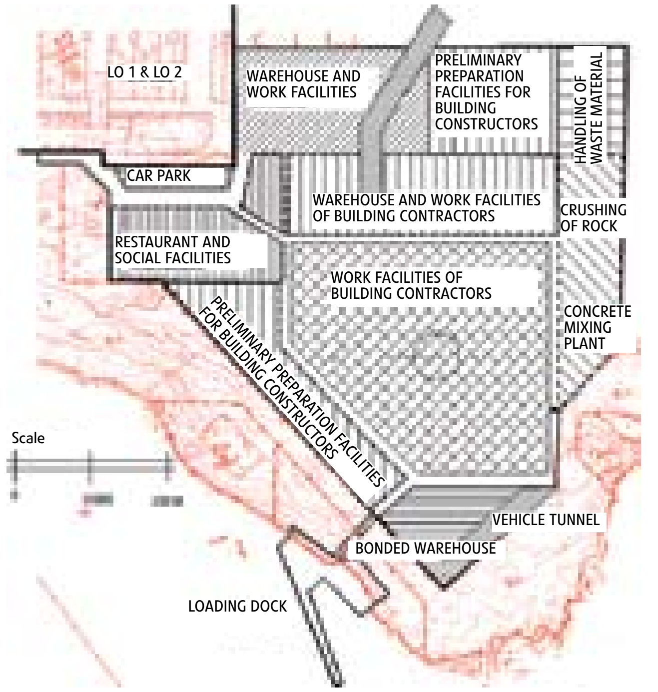

Figure 8-2. Location of the site operations of the new power plant unit according to preliminary plans.

8.1.3 Safety arrangements and access control

The safety and rescue arrangements of the construction site of the new power plant unit will be included in the corresponding plans of the existing power plant units. A separate safety plan will be drawn up for the construction site to determine access control and safety arrangements. The construction site will be outlined and separated by a fence from the operations of the existing power plant units. A separate road connection will possibly be arranged for the construction site from the mainland.

The construction work of the new power plant unit will be mainly implemented using outside contractors. Occupational safety is one component in the criteria for choosing the contractor, and the contractors are demanded to fulfill strict requirements for procedures and they will be familiarized with the construction site. The occupational safety procedures will be planned and guided thoroughly since the number of workers from foreign countries and cultures is large and the range of spoken languages is wide. Safe working conditions must be created to everyone and every worker must understand the management of safety risks of their own work. Working of the contractors is guided and controlled and faults are not ignored. Jointly with contractors, the aim is to develop the construction site to be as safe as possible.

8.2 Impacts of the construction stage

8.2.1 Construction of a power plant unit

Earth-moving work

The earth-moving work related to construction of the power plant unit is extensive. The digging and excavation materials, whose volume will be, depending on the length of the cooling water intake and discharge tunnels, 1 310 000–2 060 000 m^3, mainly consist of blasted rock. An assessed 660 000 m^3 of the amount is utilized at the site or is crushed and used as landfill and for levelling. 650 000–1 400 000 m^3 of the materials will remain unused. The Table 8-1 shows the estimated amounts and use of various materials in the construction stage.

Table 8-1. The estimated amounts and use of various materials in the construction stage of the new power plant unit.

Material	Solid volume [m^3]	Bulk volume [m^3]
MATERIAL FORMATION		
Power plant area digging material	250 000	325 000
Power plant area excavation material	400 000	650 000
Cooling water tunnel excavation material	150 000–650 000	250 000–1 000 000
Cooling water structure excavation material	15 000	25 000
Dredging and excavation materials of the shipping lane and the loading and unloading site	40 000	60 000
Total	**855 000–1 355 000**	**1 310 000–2 060 000**
USE OF MATERIALS		
As landfill at power plant area	-	40 000
As landfill in sea area	-	500 000
Use as aggregate in concrete	-	60 000
Use in diversion dams (part remaining in the sea)	-	20 000
As landfill in the loading and unloading site and building of breakwater	-	40 000
Total	-	**660 000**

The bulk of the excess material is blasted rock. The blasted rock and crushed rock can be utilized in construction. The crushed rock can be freighted by barges from Finland to Estonia, where granite rock material is not naturally available. A rock crushing station has been planned to the construction site, as a part of the concrete mixing plant. A temporary piling area for blasted rock will be reserved from the area owned by Fortum, along road Atomitie leading to Hästholmen. The area is located approximately three kilometers away from the power plant.

Sea area is filled as widely as required by the site within the limits allowed by the town plan. The filled area is used as storage and working area during the construction work. As the fill material of the sea area penetrate the thick layer of clay to the hard sea bed, the clay material pushed sideways cause temporary turbidity in Hästholmsfjärden. The extent of the area of turbidity can be limited, e.g., with the help of suitable filter cloths.

Soil, bedrock and groundwater

A layer of dirt on top of the bedrock is removed from the construction site of the new power plant unit. The handled soil types are stabile, so the risk of slope failures in pits or banks is small. After removing the dirt, a levelling excavation is carried out for the bedrock. The power plant foundations are laid on the bedrock and foundation pits are excavated for them. The strength properties of the rapakivi granite, which is the rock type of the bedrock, are good in respect of the foundation laying and the stability of rock slopes. The excavation work does not unnecessarily break the structure of the remaining bedrock with too large a charge. Also such restrictions are set for the blasting that the vibration does not cause harm to the environment or its structures and does not endanger the safety of the existing power plant units and the repository for low- and intermediate-level waste.

Since the foundation pits partly extend below groundwater level, water is infiltrated into the pits from soil layers and bedrock. The pits are kept dry by pumping. The solid matter drifted with the water is collected to a sediment basin before conducting the water to the sea. The construction work does not affect the quality of groundwater since the groundwater flows towards the construction pits. The pumping of water may lower the level of groundwater in the surroundings of the construction site, especially when the pits are open. Since the bedrock and soil of the area transmit water quite poorly, the effect does not reach far from the construction site. As the peripherals of the buildings and the yards with their covered drain and sewerage systems are completed, the level of groundwater in the surroundings will be settled to a level lower than before.

Flora, fauna and natural sites

No rare plants or endangered plants can be found on the island of Hästholmen. Construction in the vicinity of the existing power plant units does not have an impact on the natural value of the area, but the building of the loading and unloading site and the possible fundamental improvement of road Atomitie and the new road connection, main road 7 (E18)–Atomitie, can have a local impact on significant natural sites.

The natural values of the locally significant small sites of Hästholmen are safeguarded by avoiding shore construction whenever possible. In the loading and unloading site this is not possible. The new power plant unit will be located in the inner parts of Hästholmen, in the existing industrial area, and it is assessed that the construction has no impacts on the flora, fauna or natural sites. The fundamental improvement of Atomitie may have an adverse effect on the areas of both Mysskärret and Ryssviken, which are limited to Atomitie.

Dust

When constructing a power plant unit, dust is mainly raised from rock crushing, which, according to preliminary plans, will take place on the shore of Hästholmsfjärden, as shown in the Figure 8-2. Dust is released to the air from the rock crushing stations from many places and during several work stages. Usually the sources of dust are rather low, a few metres above ground. Instead of continuous working, rock is possibly crushed periodically, during the whole construction period. The duration of rock crushing mainly depends on the length of the cooling water tunnels to be excavated.

Rock material is wetted for preventing dusting. Dusting can also be prevented by technical solutions, such as protective covers, or by paving the roads of the site. According to its studies, the Finnish Road Administration recommends the distance of removable class B rock crushing stations 300 metres from habitation. In that case the two hours' suspended content in the disturbed area is at the most 0.4 mg/m^3. A stationary crushing station can be located even closer to habitation. (*Finnish Road Administration 1994*)

The dust harm caused by rock crushing and the piles of crushed stone are local and the dust does not spread to the closest settlement, which is located about one kilometre away. The dust does not cause harm to the leisure time habitation approximately 700 metres away, either. Rock crushing is carried out in such a manner that it does not cause harm to the existing power plant units. In the water area in the immediate vicinity of the crushing station, the descent of dust to the sea bottom will temporarily affect the aquatic vegetation and fauna.

Noise

During the construction stage of the power plant unit, noise is caused by, e.g., power tools, rock crushing and blasting related to excavation, as at ordinary construction sites. The noise caused by blasting is more disturbing than a continuous humming noise. The noise from blasting related to surface development may be carried one to two kilometres away from the excavation site, depending on the terrain (*LT-Konsultit Oy 1998*). The noise caused by blasting is momentary and timed to the beginning of the construction stage.

The spreading of noise caused by construction and traffic during the construction stage to the environment has been modelled using a Nordic industrial and road noise model and it is shown in the Figure 8-3. During the construction stage, the noise is strongly varying and in places impulsive by nature. When the noise originating from the existing units has been taken into account, the 50 dB zone reaches to the whole construction area in the fourth year of construction, when the traffic is at its heaviest in the whole construction period.

The noise originating from the rock crushing station is approximately 85 dB(A) at a distance of 25 metres. The noise decreases below 55 dB(A) in an unrestricted terrain on a soft surface at a distance of approximately 400 metres and on a hard surface at a distance of approximately 600 metres. The preliminary location of the rock crushing station on the shore of Hästholmsjfärden is shown in the Figure 8-2. The default in the noise model is that a five-metre-high stone bank is piled around the crushing station to prevent the spreading of noise to the archipelago to the east of the area. The guideline value for daytime (45 dB) is exceeded at a distance of one kilometre at the most, e.g., in Bodängen and Åmusholmen. Noise reaches somewhat further in the southwest and west where the noise bank of the crushing station does not have a damping impact. The noise originating from rock crushing does probably not disturb habitation, which is more than one kilometre away. In the archipelago, in the area of the nearest leisure time habitation, approximately 700 metres away, noise may cause disturbances.

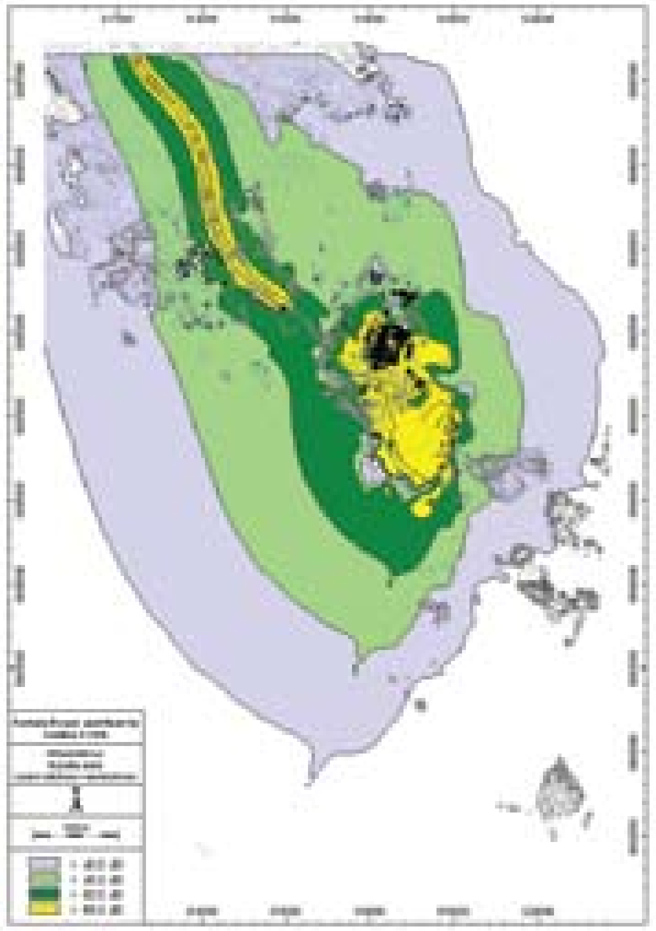

Figure 8-3. Noise caused by the existing power plant units and by the construction and traffic of the new power plant unit in the environment.

Landscape

The most visible of the impacts on the landscape during construction are the numerous hoisting cranes, which rise clearly above treetops. The construction site is clearly visible to Hästholmsfjärden over the treeless filling area. At the end of the construction stage also the turbine and reactor buildings and the ventilation stack of the new unit can be seen above the treetops. The filling of sea area and the impacts of the completed power plant unit on the landscape have been described in Chapter 9.2.

During the construction stage the area needed for the support functions on the mainland will grow. More space is needed, e.g., for temporary lodging and parking. The impacts on the landscape will remain small, although, even at present, the forest belt between the support area and the Svartholma group of islands and the camping area of Källa is narrow.

Waste management

During the construction of the power plant unit, construction waste, municipal waste and toxic waste are produced. The amount of municipal waste is larger during the construction stage than during operation, since more than 3500 people at the most will be working at the construction site.

A waste management plan is compiled for the construction site. According to the Government decision (295/1997) regarding construction waste, certain types of construction waste are sorted or kept apart from the others. The general principle is that each supplier sees to the cleanliness of its own working area and takes its own waste to the collection points. From the collection point onwards, the duty to manage the waste is on the main implementor of the construction site, who is also responsible for the cleanliness of public areas. In practice, the main implementor acquires the waste management service from an entrepreneur, who will deliver the waste to a regional waste management plant.

Use and storage of chemicals

The handling of chemicals, which includes the choice, acquisition, storage, use and treatment of chemicals as waste, is prescribed by legislation.

For each purpose, such a chemical is chosen whose harmful effect on people and the environment is as small as possible. Facilities complying with the requirements are available for the handling and storage of chemicals. The use of chemicals is arranged in such a way that exposure to the personnel is as low as possible. The treatment of chemicals as waste is included in the waste management plan drawn up for the construction site.

Operational safety of the existing power plant units

The area of the existing power plant units has been outlined using a fence to prevent unauthorized access. During the construction stage of the new power plant unit, access to Hästholmen will be restricted as appropriate. The strictest control of the impacts caused by the construction site will be on the vibration caused by excavation. The allowed vibration limits for the chosen equipment and structures will be determined in the contract documents. The supervision procedure determined for the excavation of the low- and intermediate-level waste repository is also applicable for the excavation in the construction stage. The construction of a new power plant unit does not endanger the operational safety of the existing power plant units or the low- and intermediate-level waste repository.

8.2.2 Construction of the loading and unloading site

In the western shore of Hästholmen, 200–300 metres away from the new power plant unit, a loading and unloading site will be constructed for the special heavy transports by sea during the construction stage. The loading and unloading site is designed such that after the construction stage it can be used for, e.g., the transport of excess material and spent fuel.

When constructing the loading and unloading site, approximately 5 000 m^3 of material is dredged, mainly moraine. Also bedrock will be excavated to make room for the supportive structures. The material will be used for the backfilling of the loading and unloading site, and for the breakwater with a height of about three metres below mean water level. The aim is to complete these works during one open water period.

The most considerable impact of dredging is the increase in the solid matter content of water and the resulting water turbidity in the immediate vicinity of the work site. The turbid water will be dispersed according to the prevailing winds and currents. During standard wind, the turbid water is assessed to reach about 100 metres from the work site. The turbid water is carried along the sea bottom. The content of solid matter in surface water is estimated to remain small.

The increase in solid matter content and the turbidity of water mainly have an adverse impact on the fishing industry. The harm is nevertheless regarded small since the dredged material does not contain fine soil. The turbidity of water is not estimated to cause any harm to the use of the shores. The amount of phosphor bound to the solid matter is small, due to the quality of the dredged material (moraine) and it is not estimated to cause eutrophication. Also the exchange of water is fairly good in the area, so the potential increase in the nutrient content remains so small that it cannot be detected.

Zoobenthos and aquatic vegetation disappear from the actual dredging areas. During the work, the turbidity of water weakens the lighting conditions and solid matter is sedimented on the sea bed. This will temporarily weaken the living conditions in the vicinity of the dredged area.

The construction work of the loading and unloading site and the resulting water turbidity prevent fishing and drive away fish and other aquatic animals from the construction site and its vicinity. The impacts on the fishing industry are assessed to remain small due to the short duration of the dredging work and also due to the coarse quality of the dredged soil. In addition, the loading and unloading site is located in a water area owned by Fortum and fishing, using fixed tackles, is forbidden in the area.

The construction of the loading and unloading site in the western shore of Hästholmen may affect the birdlife, so that the variety of birdlife in the power plant area becomes more modest than before. The construction of the loading and unloading site does not restrict water traffic in the area. The impacts on landscape during the construction of the loading and unloading site focus on Hudöfjärden.

8.2.3 Construction of a shipping lane

The route to the loading and unloading site can be dredged from the 9.5-m route leading to the harbour of Valko. In the planned shipping lane, a bit before its connection to the traffic area of the loading and unloading site, there is an underwater threshold, which must be removed. The amount of excavated rock material is about 25 000 m^3 and the amount of dredged moraine material is about 5 000 m^3. The materials are placed in the underwater breakwater that has been designed to the loading and unloading site.

The excavation and dredging of both the shipping lane and the loading and unloading site are sought to be carried out during the same open water period. Blasting and the turbidity of water drive away fish from the area. The impact of the work in the shipping lane on the aquatic nature is similar in quality and quantity to that of the work at the loading and unloading site (see 8.2.2).

The town of Loviisa and the Finnish Maritime Administration have submitted an application for an environmental permit to deepen the harbour of Valko and the shipping lane leading to the harbour. For the water permit application, sediment samples were taken from the eastern side of Hudö. The examined samples showed somewhat increased contents of tributyltin (TBT). As the plans to construct the shipping lane to Hästholmen become more detailed, the TBT situation in the sediment in front of Hästholmen will be examined. Any sediments with TBT concentration will be handled in a manner approved by the authorities.

The dredging area is marked properly and it does not pose any danger to water traffic. The established route will be marked according to the Decree on water passages (30.11.1979/846) and the decision of the National Board of Navigation of 29 May 1995 on the directional signing of water passages.

8.2.4 Construction of cooling water structures and tunnels

The suitable cooling water intake and discharge areas are located close to rocky islands or islets where the necessary gate equipment can be constructed. The construction of cooling water intake and discharge structures and the related digging, excavation and concreting works are implemented as dry work inside a temporary cofferdam constructed in the sea. The construction activities reach to the rocky islands and islets close to the cooling water intake and discharge areas, and a part of the area is reserved for the construction site, even though the cooling water intake and discharge structures are mainly located below sea level.

In terms of environmental impacts, the most significant work stages are the works related to the cofferdam and the excavation and dredging of the sea bed, which cause temporary water turbidity in the surroundings. The dredged material is mainly moraine, so the turbidity of water remains small. Water turbidity can also be seen in the piling area, if the dredging and excavation materials are placed in the water. It is possible to mitigate the adverse impacts by timing and the choice of the piling area.

The construction of the long cooling water tunnels is carried out either as single drift excavation or twin drift excavation. In single drift excavation all actions, including the transport of blasted rock, are carried out via Hästholmen. In twin drift excavation, some actions are carried out, in addition to Hästholmen, also via an opening in the cofferdam. In that case some of the blasted rock will be transported by sea. The adverse impacts of the excavation carried out dozens of metres below the sea bed are small. The earth layers of the sea bed absorb the excavation vibration

effectively and thus prevent, e.g., the formation of pressure shocks which can be harmful to fish.

On the whole, the environmental impacts of the construction of cooling water tunnels and structures are related to landscape, transport of blasted rock material and the local and temporary turbidity of water, caused by the underwater handling of soil and rock material. The construction of gate equipment will focus on the rocky islands and islets, which at present are almost in their natural state. Their use may have to be restricted due to the cooling water structures during both construction and operation.

8.2.5 Raw water and waste waters

Raw water

During the construction of a new power plant unit, water is mainly used for the manufacture of concrete, but also for various cleaning works and as domestic and fire water. The need of water during the construction stage is estimated at 50 000–200 000 m^3 per year, depending on the number of workers and the stage of construction. The service water (domestic, process and fire water) of the existing plant units, a total of about 200 000 m^3 per year, is prepared in the water treatment plant located on Hästholmen, of raw water pumped from Lake Lappomträsket some three kilometres north of the power plant.

The existing arrangements are inadequate both for the needs of the construction and operation of a new power plant unit, since raw water intake from Lappomträsket cannot be significantly increased from the present. For the use of the construction and operation of the new power plant unit, raw water must be pumped from a new source. The raw water used for construction and for the manufacture of process water must not be acquired from the same place as domestic water. The new network will be connected to the network of the existing power plant units, which enables shared water use between the power plant units. Preliminary plans have ended up with two main alternatives of water supply: Ahvenkoski in Kymijoki and the water distribution network, which is shared by the town of Loviisa and the neighbouring municipalities.

In the first alternative an 18-kilometre pipeline is built overland from Ahvenkoski to the northern shore of Klobbfjärden, and then further along the sea bed of Klobbfjärden and Hästholmsfjärden to Hästholmen. The step-up pumping stations will be built in Ahvenkoski and another approximately in the halfway, between Kulla–Keitala. The building of the pipeline lasts about one year. The amount of pumped raw water is small compared to the discharge of Ahvenkoski.

In the other alternative, raw or domestic water is taken from the water distribution network, which is shared by the town of Loviisa and the neighbouring municipalities. The connection is planned to Valko, where the first step-up pumping station is built. Two parallel, about 9.5-kilometre-long water pipes are built from Valko along the sea bed of Loviisanlahti and Hudöfjärden to the step-up pumping station in Hästholmen. From the pumping station the water is led to the large water tanks and further to the construction site.

During the construction of raw water pipes, power tools, truck traffic and blasting cause a lot of noise. In the forests, trees must be removed from the pipeline area and the pipes must be dug in the ground. The building of the water sections causes restrictions on water traffic at the most for a few months. Permanent changes are the pumping stations and the warning signs required by water traffic at both ends of the water sections of the pipeline.

Waste waters

A plan is drafted for waste water treatment of the new power plant unit and it will be submitted to the Western Finland Environmental Permit Authority for approval. The existing waste water treatment plant in the northwestern part of Hästholmen is a biorotor plant, where phosphor is removed using a chemical postprecipitation. It is used for the handling of domestic waste waters of the existing power plant units, the accommodation area and the sea fortress of Svartholma.

The bulk of the waste water during the construction of the new power plant unit is domestic waste water. The amount of domestic waste waters is at its largest in the fourth year of construction when there are about 3 000 people working on site, and the total amount of domestic waste water is about 150 000 m^3. There are three options for implementing domestic waste water treatment.

In the first option a biological waste water treatment plant will be built as a part of the power plant unit. It is designed such that it is capable of treating the domestic waste waters jointly with the existing waste water treatment plant.

In the second option a transfer pumping station is constructed as a part of the new power plant unit, and the existing waste water treatment plant is extended. The basin of the transfer pumping station is designed to even out the peak consumption of the day for ensuring a good purification result of the treatment plant. From the transfer pumping station the domestic waste waters are led to the extended waste water treatment plant, which is designed to be able to handle the waste waters of both the construction period and the domestic waste water of the existing power plant units. According to the labour estimate, the capacity of the waste water treatment plant must be doubled.

In the third option the domestic waste waters are purified in the waste water treatment plant of the town of Loviisa, to which a waste water line will be built along the sea bed of Hudöfjärden and Loviisanlahti. The building of the waste water line will cause restrictions on boat traffic at the most for a couple of months. Permanent changes are the warning signs required by boat traffic, at both ends of the water sections of the pipeline.

In the first and second option the purified domestic waste waters of the construction stage are led with the cooling water of the existing power plant units to Hästholmsfjärden. In the third option the purified domestic waste waters are led to Loviisanlahti. The resulting minor waste water load has no significant impact on the state of the sea areas.

The oily waste waters potentially resulting from rock crushing and other actions are treated appropriately. The sludge formed in the purification of raw water is treated with the sludge of the waste water treatment plant.

8.2.6 Underwater cultural heritage

Underwater cultural heritage includes such wrecks and parts of wreck that can be assumed to have sunk more than a hundred years ago and other man-made underwater structures. Underwater cultural heritages are protected by the Antiquities Act, section 15; those responsible for the planning of public waterworks must establish in good time whether the execution of such works will concern underwater ancient monuments.

The works related to the construction of a new power plant unit do not affect any known underwater ancient monuments. No comprehensive underwater inventory has been carried out in the sea area in front of Loviisa to locate underwater ancient monuments. As the planning of necessary underwater structures proceeds, the need of an underwater inventory will be assessed in co-operation with the National Board of Antiquities.

8.3 Transport and traffic during the construction stage

8.3.1 Traffic volumes

The traffic to the site of the new power plant unit along Atomitie is mainly commuting and traffic caused by material and maintenance transports. The need of labour is at its largest during the fourth year of construction, when also traffic is heaviest. A majority of construction site transports is heavy traffic. The largest shipments are formed of concrete, element, reinforcement element, steel construction, steel part, equipment and pit-run gravel transports. The construction of a power plant unit will increase the volume of traffic significantly on Saaristotie and Atomitie roads. The traffic volume is also increased by the larger number of visitors.

Some transports can be arranged by sea to the harbour of Valko or by rail to Loviisa and further to the site as road transport. In that case the road transport distance is reduced to the section between Loviisa and Hästholmen. The use of the loading and unloading site built for heavy transports reduces road transports.

The traffic of the construction stage has been studied in the fourth year of construction when the number of construction and installation personnel is estimated at 3 000. It is assumed that 710 construction and installation workers take lodgings in the accommodation area near the power plant, 520 commute from their homes, 520 hire a flat, 1 170 live in dormitory accommodation and 65 in the trailer area. Two thirds of the people in the accommodation area are assumed to have a car and to make an average of 2.5 personal business trips to Loviisa between Monday and

Table 8-2. Division of travels of installation and construction workers during the fourth year of construction.

Division of travels	%	Vehicles per day
Loviisa	46	1 610
West or north of Loviisa	32	1 120
South of Loviisa	22	770
Atomitie	**100**	**3 500**

Table 8-3. Division of traffic at Hästholmen during the fourth year of construction.

Division of traffic	%	Vehicles per day
Loviisa	49	2 195
West or north of Loviisa	28	1 255
South of Loviisa	23	1 030
Atomitie	**100**	**4 480**

Figure 8-4. Average weekday traffic (KALV) and the volume of heavy traffic (Raskas) in 2006 and in the fourth construction year of the new power plant unit .

Friday, i.e., on the average one one-way trip per day (470 cars per day). Two thirds of the workers living elsewhere are assumed to be using a car and they are estimated to make one round trip per day (3 030 cars per day). According to calculations, the traffic caused by construction and installation workers on Atomitie is, during weekdays, about 3 500 vehicles per day (Table 8-2).

The orientation of the trips of the construction and installation workers has been calculated according to the residence of the operating personnel of the existing power plant units. As to Loviisa the situation has been corrected so that two thirds of the workers commuting from their homes and one third of the workers in dormitory accommodation or hired flats are assumed to travel from Loviisa west or north. The division of the travels of the installation and construction workers during the fourth year of construction has been shown in the Table 8-2.

As the heavy transports (100 vehicles/day) are added to the above mentioned traffic, and the traffic by the operating personnel of the existing power plant units as well as the traffic by personnel of the external services (880 vehicles/day), the result is the division of traffic at Hästholmen during the fourth year of construction, as shown in the Table 8-3.

The average weekday traffic and the volume of heavy traffic in 2006 and in the fourth construction year of the new power plant unit are illustrated in the Figure 8-4. The traffic volumes have been estimated with the presupposition that the volumes will only grow due to the construction of the new power plant unit and, e.g., the potential increase of heavy traffic to Russia has not been taken into account.

8.3.2 Traffic arrangements

Traffic during the construction stage may hinder the functionality of the junction of Saaristotie and Mannerheiminkatu, especially during the fourth year of construction, when the traffic is at its heaviest. The situation is notably improved by the graded interchange planned on the east side of Loviisa, to main road 7 (E18), from which a direct connection to Atomitie is constructed. The construction of the road section Koskenkylä–Loviisa–Kotka is planned to be implemented in 2009. In 2016, when the most active stage of the construction of the new power plant unit is at hand, the new junction and road connection will potentially be in use.

If the connection main road 7 (E18)–Atomitie is not implemented, the construction stage will increase the volume of traffic on Saaristotie significantly and especially the volume of heavy traffic will increase. After the construction stage of the new power plant unit the traffic volumes are not large, but during annual outages, three to four months per year, the traffic is heavy.

The parking lots needed during the construction stage are located in the area marked in the town plan as power production support area.

8.3.3 Noise and dust impacts caused by traffic and exhaust gas emissions

Noise

The noise caused by motor vehicle traffic is affected by the speed of the vehicles, traffic volume, share of heavy vehicles and properties of the road. On roads with a heavy traffic the noise is usually wide-band, even hum by nature, and the sound of an individual vehicle can be distinguished every now and then. The sounds of individual vehicles are emphasized on roads with less traffic. The detected noise level in a certain place is affected by, in addition to the level of noise in its source, the distance of the review point from the route, buildings and other obstacles, forms of terrain and water areas and other reflecting levels. The doubling of the volume of traffic increases the noise level by three decibels (dB). An increase of speed from 50 km to 80 km per hour increases noise four to five decibels. Road traffic noise is generally prevented by acoustic screens, by lowering speed limits and by land use planning.

Using the Nordic traffic noise model and assessed traffic volumes of the year 2016, the noise caused by traffic on Saaristotie and Atomitie is faded out so that a 55 dB(A) noise level is reached about 40 metres away from Saaristotie and 30 metres away from Atomitie. There is no habitation along Atomitie. There is habitation at places along Saaristotie, e.g., at Määrlahti, where the speed limit is 50 or 60 km/h. The traffic is mainly focused on daytime, so the disturbing effect of noise is smaller than during nights. During the construction stage the noise caused by traffic can be assessed to harm comfort along Saaristotie but the traffic noise of Atomitie does not, according to the noise modelling, exceed 45 dB during daytime in holiday settlements.

Without the new road connection main road 7 (E18)–Atomitie, the traffic volume of Saaristotie is estimated to quadruple compared to the present in the fourth construction year of the new power plant unit. Then the noise level would increase by six decibels if the share of heavy vehicles remains the same. Correspondingly, the traffic volume of Atomitie is estimated to increase 7.5 times compared to the present situation, causing an increase of nine decibels in the noise level. The increase of noise caused by road traffic has an impact on the settlements along Saaristotie.

Dust

The roads leading to Hästholmen are paved, and therefore traffic does not cause significant dusting. For preventing dusting, also the roads of the construction site are planned to be paved and, if necessary, the wheels of blasted rock transport vehicles will be washed before they leave Hästholmen.

Exhaust gas emissions

Traffic is divided between the old and the new road section according to Figure 8-4. When calculating the exhaust gas emissions of traffic, the average emission factors of road traffic of the whole country have been used (*VTT 2006*). The average emission factors for light and heavy vehicles have been calculated thereof, taking into consideration the division of vehicle types and the kilometres driven. The emissions from the traffic in the town of Loviisa in 2016 have been calculated according to the growth prognosis by the Finnish Road Administration.

The exhaust gas emissions from traffic on Saaristotie and Atomitie have been calculated using a road section of 13 kilometres. The presupposition in the calculations is that in the fourth construction year of the new power plant unit in 2016, the new about five-kilometre-long road connection between main road 7 (E18) and Atomitie has been constructed. The amounts of emissions have been shown in the table 8-4.

Table 8-4 Emissions from weekday traffic into the air (t/year) in the town of Loviisa and on Saaristotie and Atomitie in 2006 and in 2016, the fourth construction year of the new power plant unit.

Place and year	Emission component				
	Carbon monoxide [t/year]	Nitrogen oxides [t/year]	Suplhur dioxide [t/year]	Particles [t/year]	Carbon dioxide [t/year]
Town of Loviisa 2006	226	61	0,1	3	14 200
Town of Loviisa 2016	245	66	0,1	3	15 400
Saaristotie and Atomitie 2006	36	11	0,04	0,33	1 325
Saaristotie and Atomitie 2016	153	41	0,16	1,3	5 065

Of the local sources of emissions, road traffic is the most significant in terms of air quality in Loviisa. The construction of a new power plant unit increases the volume of traffic and clearly adds to the emissions caused by traffic. Nitrogen oxide and carbon monoxide emissions are increased by about 60% and carbon dioxide emissions by 30% of the estimated emissions of the town of Loviisa in 2016. Sulphur dioxide and particle emissions remain very low. Nevertheless, it must be noted that the emissions caused by construction related traffic are significant only during the fourth year of construction (Table 8-4). During other construction years the traffic volume is smaller and thus also the emissions affecting the quality of air remain smaller. Thus the emissions caused by construction related traffic are not assessed to have significant long-term impacts on the local air quality.

8.3.4 Impacts of ship traffic on waters and the use of waters

During the construction of the new power plant unit, traffic on the shipping lane to Hästholmen is, compared to normal port traffic, slight and becomes occasional during operation.

Water depth in the new shipping lane is mainly more than 10 metres, thus the impact of slipstream on bottom sediment and the quality of water, biology and fishing industry remains small. The vessels communicating in the route are mainly ro-ro type vessels, whose wave formation is minor. There are no eroding shore types in the vicinity of the route and thus the waves or suction currents caused by the vessels are not assessed to have any adverse impact on the structure or biotic communities of the shores. Fishing by fixed tackles is not possible in the constructed route.

8.4 Economic impacts

The construction of a new power plant unit is a significant project locally, regionally and economically, and it will affect the business activities and employment of Loviisa and the Loviisa region in many ways. It is typical of large projects that a notable part of the economic impacts are realised indirectly or transferred outside the region, resulting in uncertainty in the assessment of regional impacts.

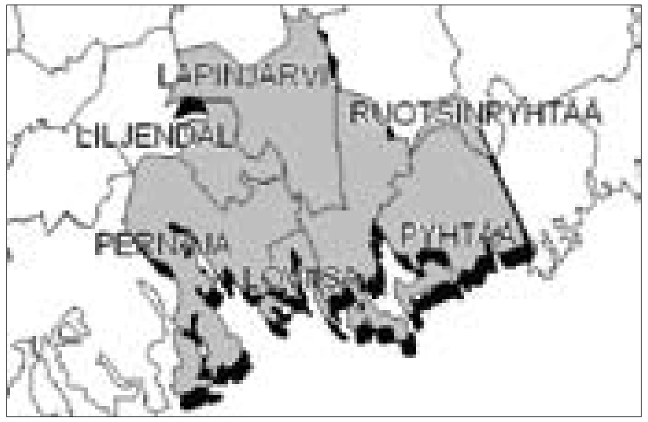

Figure 8-5. Economic area of Loviisa (Suunnittelukeskus).

The impacts of the construction of a new power plant unit were studied from the point of view of Loviisa. The area of inspection in respect of impacts on socioeconomical conditions and living conditions was the economic area of Loviisa, illustrated in the Figure 8-5, which here includes the town of Loviisa and the municipalities of Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää. Some impacts were also studied in the area of eastern Uusimaa, Uusimaa, Kymenlaakso and the whole Finland.

The investment cost of the new power plant unit (2.5–4.5 billion euros) and its distribution and domestic content depend on the plant alternatives and the scope of delivery. When assessing the economic impacts, 4 billion euros have been used as the cost estimate of the new power plant unit, of which 40% has been estimated to be of domestic supply. The domestic supply represents 1.4 billion euros of the investment without interest expenses. The Table 8-5 shows the distribution of domestic investments used in the assessment of economic impacts.

Table 8-5. Distribution of domestic investments in the new power plant unit used in the assessment of economic impacts.

Distribution of investments	Share of investments, %	Domestic content, %	Domestic share of investments, %	Domestic share of investments, million euros
Machinery and equipment	35	20	7	280
Electrical equipment	12	40	5	200
Construction work	12	40	5	200
Indirect costs	17	70	12	480
Other costs	9	70	6	240
Interests during construction	15	35	5	200
Total	**100**		**40**	**1 600**

8.5 Impacts on the number of population, employment and living conditions

8.5.1 Impacts on employment in Finland

The impacts of the investments in the new power plant unit on employment in Finland are assessed for construction work, the acquisition of machinery and equipment and the services required by the site. The cost share of the project used in the assessment of domestic employment impacts is 1.4 billion euros. The assessment of impacts on employment is based on the work contribution factors by the Statistics Finland.

The investments in Finland result in direct employment of about 13 400 man-years (Table 8-6). The direct employment impact also employs indirectly about 7 500 man-years. Totally the investments result in about 21 000 man-years of employment.

70% of the direct employment impacts aimed at Finland consist of the services required by the site, 18% of machinery and equipment manufacture and 12% of construction. The services required by the site have the most indirect impacts but the importance of machinery and equipment manufacture is a bit higher than that of the indirect impacts.

Divided evenly between six years, the amount of direct employment impacts is about 2 200 man-years/year and the indirect employment impacts about 1 250 man-years/year. Nevertheless, the employment impacts depend on the stage of the construction site.

During the preparation and earth works a few hundred people will work at the site. From the third year onwards, during two to three years, 2 000–3 000 construction and installation workers and supervisors work at the site. Once the construction and installations are completed, there are a few hundred commissioning staff working with the future operating personnel.

Table 8-6. Employment impacts of the construction of a new power plant unit in Finland.

Distribution of investments	Direct impact, man-years	Indirect impact, man-years	Total impact, man-years
Machinery and equipment	1 400	1 700	3 100
Electrical equipment	1 000	800	1 800
Construction works	1 600	1 400	3 000
Site services and other costs	9 400	3 600	13 000
Total	**13 400**	**7 500**	**20 900**

8.5.2 Division of the employment impact and the availability of labour

Of the investments in the new power plant unit, the domestic acquisition of machinery and equipment is focused on entire Finland, since there is no manufacture of those in the Loviisa region. Instead, a major part of the employment impacts of services required by construction contracts and the work site may be focused on the Loviisa region and the nearby areas.

Corresponding reviews have assessed that about 20% of the labour needs of a large site can be filled locally. Thus the construction work and site services could employ 300-350 people in the Loviisa region.

The amount of impacts on local employment depend on whether the companies have capacity, professional skills and adequate quality for the contracts and subcontracting work. The willingness of companies to participate can be supported by a service that informs of contracts, necessary knowledge and quality requirements, and combines companies and contracts.

The participation of companies can also be limited by the availability of work force. The amount of labour reserve is affected by the business cycle of national economy. During a recession more labour and free machinery is available. During an economic boom the availability of labour can be a significant challenge. For preventing labour shortage, great emphasis should be placed on recruiting and training. According to estimates, there is enough labour reserve in Uusimaa and Kymenlaakso.

8.5.3 Number of population

The construction of a new power plant unit will increase the number of population in the Loviisa region and the nearby areas temporarily, since some of the labour of the site comes from other parts of Finland or from abroad. The temporary increase in the population during the construction stage is between a few hundreds and even more than 2 000 people.

The temporary increase in population varies in the municipalities according to the phases at the site and to how the accommodation and long-term living of the employees are divided between Loviisa and the nearby regions. If the number of employees living in the Loviisa region is high, the most intensive phases of the site may increase the number of population temporarily almost by 10%.

8.5.4 Housing market and accommodation activities

The economic impacts of the accommodation of workers depend on the phase of the site and the division of lodging between various localities. It is assessed that, at the most, about 2 000 Finnish and foreign workers of the site need temporary accommodation. The construction and installation workers' need for accommodation lasts from a few months to a couple of years. The management of the project and work supervisors will need uninterrupted accommodation for several years, so their demands for accommodation are higher. Some of the personnel have their families along and that increases the level of demands and affects the choice of the place of residence.

A short distance between the place of residence and the site is an important factor for short-term workers. The workers live in accommodation villages, or have hotel, group and apartment lodgings of various sizes in the areas of Loviisa, Porvoo, Kotka and Hamina, and in the metropolitan area. The capacity of several lodging houses is not totally available for the needs of the plant site. Various camping and activity centres can mainly offer seasonal lodging opportunities. Some long-term workers live in the metropolitan area due to the international services, and some live in the Loviisa region.

There are only a few rental apartments available in Loviisa, but there are apartments for rental in, e.g., Kymenlaakso. The land use planning of the town of Loviisa enables the implementation of construction of new apartments in a couple of years. The decision to construct the nuclear power plant unit will launch the housing production.

Due to the heavy demand, rents and prices in the lodging houses will probably increase. The increase can be restrained by arranging lodging in a wide area in various places. Controlled lodging requires anticipation. The available lodging opportunities must be charted, in addition to which the need for new production must be estimated.

During the most intensive construction years lodging can create a market of millions of euros, which employs dozens of people. The effects are probably divided between several regions. The construction of apartments and accommodation villages is a separate investment which creates income and employment along with the construction of the power plant unit. The development of the existing accommodation area of the power plant offers, in addition to the arrangement of lodging during the construction stage, far-reaching opportunities also in respect of the accommodation needs during operation.

8.5.5 Other demand for services and increase of purchasing power

During the construction stage, the workers of the site need various authority and health services, and retail and leisure time services. The children in the families moving to the Loviisa region must be offered a possibility for day-care and school attendance. The foreign workers and their families will need services in foreign languages.

If those services are not locally available, at least the foreign workers with a longer employment will seek residence in the metropolitan area with, e.g., international day-care and schools and plenty of leisure time services.

Due to the large number of workers, the authority and health services must be concentrated at the site. That makes attending to matters easier and the services can be customized to the needs of the personnel. However, the quality of the services offered to the local population does not weaken. The number of foreign families moving to the region will probably remain small if the supply of the services needed by the families is small.

The need for retail and special goods trade will create a significant economic potential, which guides some of the cash flow allocated to foreign contractors to Finland. Estimated on the basis of the temporary increase in population, the personnel of the site can add the sale of retail and special goods trade in the Loviisa region annually from a few hundred thousand euros to several million euros. The increase of purchasing power may create several tens of jobs in the region. The focusing and extent of the impact is significantly affected by the width of the area where the workers are lodged.

8.5.6 Tax income

Municipal tax

The construction site of the new power plant unit and its support services can employ, according to estimates, about 300-350 people in the Loviisa region. Also the increase in the sale of the accommodation services and retail trade and the authority and health care services required by the site, may employ roughly about 50 people. The increase in the tax base of Loviisa during the construction stage can thus be about 400 man-years. If the annual pay of a worker is assumed to be about 35 000 euros, the sum allocated to the region is altogether 14 million euros per year. The share of municipal taxes levied by the home municipalities of the workers is more than two million euros. The tax base of the region is also increased by the growth of turnover of companies.

The increase of municipal tax income during the construction of the power plant unit can be compared to the municipal tax accumulation of the municipalities of the region in 2006, shown in the Table 8-7. Due to the anticipated regional employment impacts during construction and the increase of the payroll, the municipal tax income can increase in the whole region altogether about four per cent.

Real estate tax

The power plant unit under construction earns real estate tax income to the town of Loviisa even before commercial operation according to the degree of completion of the buildings. The real estate taxes of a power plant unit during construction are on the average several million euros per year, which increases the real estate tax income of Loviisa significantly.

8.6 Impacts on comfort, recreation and living conditions

8.6.1 Resident views and opinions

For establishing the attitudes towards the construction of Fortum's new power plant unit and for supporting the assessment of social impacts, a resident survey (Chapter 9.12) was carried out among the residents in the area of influence of the power plant. The survey aimed at defining the potential impacts of Fortum's project on the residents' lives and comfort and acquiring information on the matters the residents found important.

According to the responses to the resident survey, especially the permanent residents found the employment impact the most significant of the impacts during construction of the power plant unit. All respondent groups assessed the impacts on traffic arrangements to be significant. Among leisure time residents, the impacts on other natural environment were assessed to be significant. In the responses to open questions, the impacts of the temporary increase in population caused by the multi-cultural construction organization, among others to health care services and housing production, were highlighted as one of the most significant environmental impacts during construction. More information was asked, among others, on the social impacts of the project, e.g., whether Loviisa and the neighbouring municipalities are prepared to supply services and housing to the constructors of the potential new power plant and their families. Some of the responses hoped for a domestic content as high as possible and reliable contractors.

8.6.2 Summary of the impacts

The social impacts of the construction of a new power plant unit, which lasts for about six years, are significant in the Loviisa region. The employment impacts of the construction are focused on the whole country and especially on the Loviisa region, whose number of population will increase remarkably. The variety of cultures and languages will increase, since workers will arrive in the area from abroad. The utilization of the opportunities afforded by the construction and the challenging internationalization is in the hands of the municipalities, entrepreneurs and residents of the region. The arrangement of health care, training, housing and other services is of primary importance. By anticipating to the growing needs for leisure time services and recreational opportunities, any disturbances can be avoided.

The construction of the new power plant unit, its loading and unloading site, waste and raw water pipes and cooling water intake and discharge structures cause adverse impacts on the surroundings. The adverse impacts are, e.g., noise, dust and water turbidity caused by the construction work. Furthermore, the site of the new power plant unit is clearly distinguished from the landscape. The forest belt on the western and southern side of Hästholmen is preserved, if possible, for mitigating the adverse impacts on the landscape. The adverse impacts of the construction of the new power plant mainly focus on the leisure time residents and other recreational users of the area.

The construction site will increase traffic on the roads leading to Hästholmen significantly. The traffic is at its heaviest during the fourth year of construction. The adverse impacts on comfort, caused by traffic, are local.

Table 8-7. Tax income and state subsidies of the municipalities in the Loviisa region, million euros in 2006 (Statistics Finland).

	Loviisa	Lapinjärvi	Liljendal	Pernaja	Pyhtää	Ruotsinpyhtää	Total
Municipal tax	19,5	5,6	2,8	8,8	12,7	6,5	55,9
Real estate tax	3,3	0,2	0,0	0,5	0,8	0,3	5,1
Share of corporation tax	4,6	0,4	0,4	0,5	0,6	0,8	7,3
Total	**27,4**	**6,2**	**3,2**	**9,8**	**14,1**	**7,6**	**68,3**
State subsidies	10,5	6,3	1,6	4,0	4,9	2,6	29,9


Jackdaw, Loviisa

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9 IMPACTS OF THE OPERATION OF A POWER PLANT UNIT

9.1 Impacts on land use

According to the official guidelines by the Radiation and Nuclear Safety Authority, a nuclear power plant somewhat restricts the land use of the surroundings. The limitations of land use are dealt with separately in the case of each power plant related, and they are affected by plant type and the special features of the location. The guidelines determine the plant area, protective zone and emergency planning zone around the power plant.

The plant area of a nuclear power plant is determined to be an area where only functions related to the power plant are allowed. Permanent settlement is forbidden and accommodation of employees or leisure time habitation is only allowed within strict limits. There can be other activities in the area not related to nuclear operation, supposed that the operator of the power plant is able to control the area and no threat is caused to the safety of the power plant. The plant area extends about one kilometre around the power plant.

The plant area is surrounded by a protective zone which extends to about five kilometres of the power plant. There are less strict land use restrictions on the protective zone. Inside the protective zone, any dense settlement, schools, hospitals, or institutions where notable numbers of people visit or stay, or from which it is difficult to evacuate people fast, are not allowed. Nor can there be such activities that the interruption of their operation would notably harm the society. According to the official guidelines by the Radiation and Nuclear Safety Authority, no more than 200 people are allowed to live permanently inside the protective zone.

The emergency planning zone extends to about 20 kilometres from the nuclear power plant. Authorities have to compile detailed rescue plans regarding civil defence.

About 40 people live within five kilometres of the power plant. The nearest permanent settlement is located in Bodängen, 1.7 kilometres away from the new power plant unit. The settlement located near the power plant is mainly leisure time habitation. Within five kilometres of the power plant there are some 400 leisure time houses. The nearest leisure time houses are located on the islands to the south and southwest of Hästholmen, 0.7–1.6 km away from the new power plant unit. A few leisure time houses are located less than one kilometre away from the new power plant unit.

The restrictions on land use have been taken into consideration in the planning of Hästholmen area. The leisure time houses within less than one kilometre of the new power plant unit do not, according to Fortum's opinion, prevent the Loviisa power plant's opportunities to control the area. Therefore Fortum has no reason to restrict the leisure time habitation in the nearby areas. The location of the new power plant unit at Hästholmen does not cause significant changes in the width of the protective zone. In respect of rescue services the situation does not drastically change from the present.

9.2 Impacts on landscape and cultural environment

The existing power plant units are located in the northern part of Hästholmen, and the new power plant unit in the southern part of the island. As to its architectural modelling and dimensions, the new power plant unit will probably be somewhat larger than the existing units; the height of the turbine building is about 50 metres, the reactor building about 70 metres and the ventilation stack about 100-120 metres. The large buildings are visible to a wide area in the coastal and archipelago landscape with small features, in a natural state (Figure 9-1, Figure 9-2). After dark, depending on direction and distance, one can see the lights of the power plant, the alight buildings or the glimmer of the illumination. The impact of illumination can be seen especially from the holiday houses located at Hästholmsfärden and on the southern and southeastern side of Hästholmen. In addition to the power plant, there are no large buildings in the nearby areas, which emphasizes the impact of the power plant on the landscape.

Figure 9-1. Existing power plant units and the new power plant unit as seen from southeast, from Vådholmsfjärden.

Figure 9-2. Existing power plant units and the new power plant unit as seen from southwest, from Hudöfjärden.

With the new power plant, large earth works will be carried out and the sea area will be filled on the east coast of Hästholmen, within the limits allowed by the town plan. The town plan requires windbreaks to the edges of the filled areas. The fills, the new power plant unit and the power line structures from the new power plant unit to the switchyard do not change the landscape of the eastern part of the island significantly compared to the present, where the existing power plant units can be clearly seen from Hästholmsfjärden.

On the southern and western shores of Hästholmen there is now a continuous forest belt, which has value as a zone softening and protecting the power plant area. The forest belt prevents almost totally the visibility of the existing power plant units to the leisure time houses on the southern islands. With the cooling water structures and especially the loading and unloading place of the new power plant unit, the continuous forest belt of the southern and western shores is broken and the adverse visual impact focused on the landscape may decrease the recreational value and comfort of the group of islands to the south of Hästholmen. The changes to the landscape can hardly be seen from the Svartholma group of islands, which belong to the Natura 2000 programme.

During the operation of the new power plant unit, activity in the support area on the mainland is quieter than during construction, and no extended impacts on the landscape will appear. The operation of the new power plant unit will not have an impact on the underwater monuments of antiquity.

9.3 Impacts on air quality and climate

9.3.1 Radioactive releases to the air

The radioactive releases from light water reactors mainly consist of noble gases, gaseous activation products, halogens and aerosols. A majority of the radionuclides released into the air are short-lived and they are only detected occasionally in the immediate vicinity of the power plant. Radioactive noble gases are mixed with the atmosphere.

The management of radioactive gases resulting from the operation of the new power plant unit applies the principle of the best available technology. Radioactive gases are collected, filtered and delayed for reducing their activity. Gases containing small amounts of radioactive substances are led in a controlled manner via the ventilation stack into the air.

The estimated radioactive releases of the existing power plant units (in 2002–2006) and the new power plant unit into the air, and the release limits are shown in the table 9-1. At their largest, the existing power plants' releases of radioactive noble gases into the air in 2002–2006 were about 0.03% of the release limits and iodine releases about 0.005% of the release limits. The Loviisa power plant's releases of radioactive substances into the air have been well below the set release limits and the new power plant unit hardly changes the situation.

Table 9-1. The estimated radioactive releases from the existing power plant units (in 2002–2006) and the new power plant unit into the air, and the release limits.

Radioactive releases to the air	Loviisa 1 and 2 (2002–2006) [TBq]	Loviisa 3 Estimate [TBq]	Release limit [TBq]
Noble gases (^{87}Kr equivalent)	5–7	1–10	22 000
Iodines (^{131}I equivalent)	0,00000006–0,00001	0,000001–0,001	0,22
Aerosols	0,00007–0,0001	0,000003–0,0003	-
Tritium (^{3}H)	0,2	0,1–10	-
Coal ^{14}C	0,2–0,4	0,3–0,7	-

9.3.2 Other emissions into the air

The other emissions to the air by the new power plant unit are produced from the operation of the heat plant and the reserve power machinery. The heat plant and the reserve power machinery use light fuel oil as their fuel (altogether approximately 1 200 tonnes per year), whose sulphur content is at the most 0.1%. It is estimated that the heat plant will run a maximum of four weeks per year and the operation of reserve power machinery is limited to the test starts and the longer test runs carried out during the annual outages.

The total amount of emissions from the heat plant and reserve power machinery of the new power plant unit are estimated to be 4 000 tonnes of carbon dioxide, 0.7 tonnes of sulphur dioxide, 4 tonnes of nitrogen oxides and 0.5 tonnes of particulates per year. The emissions are small and they have no notable impacts on the air quality.

9.4 Impacts on waters and fishing industry

9.4.1 Raw water

Raw water is used in the power plant for the treatment of process water, domestic water and fire water. The need of raw water during the operation of the new power plant unit will be 100 000–200 000 m^3 per year, depending on the plant type. The arrangements of the water supply services have been described in Chapter 8.2.5.

9.4.2 Waste waters

Waste waters originating in the treatment of cooling water

The algae, fish and other solid matter carried to the power plant with sea water, are removed at the opening of the cooling water intake tunnel by a coarse bar screen, and closer to the power plant by various filters which are rinsed with water. The solid matter separated from the rinsing water is composted and the water is led to the sea.

Process waters

Process water means demineralized water made of raw water. The process waste waters are led via purification to the sea. Waters, which may contain oil, are led via oil separators equipped with an alarm to the sea.

Acid and basic waste waters are generated in the recovery of ion-exchange resin while treating process water at the demineralization plant. Waste waters are neutralized to the pH range 5–9 before they are pumped into the sea. Waste waters mainly contain minerals, which are a result of neutralization.

It is estimated that the treatment of process water spends about 20 tonnes of sulphuric acid, about 30 tonnes of sodium hydroxide, and 40 tonnes of marine salt per year. The daily nutrient load caused by process waters is estimated to be at the most 8 kg nitrogen and 0.1 kg phosphor. If the power plant unit will be a pressurized water reactor, an additional boron load of 20 kg per day is caused.

Washing waters

In the controlled area, where there are radioactive substances, the used protective equipment is washed in a special laundry. The activity of the waste waters of the laundry is measured and if the limits set for activity are not exceeded, the waters can be led to the sea in a controlled manner. If the limits are exceeded, the waters are led to purification.

The other washing waters possibly containing chemicals or oil, are purified before they are led to the sea.

Domestic waste waters

The domestic waste waters from the operation of the new power plant unit will be managed either in the new waste water treatment plant, in the waste water treatment plant of the existing power plants, which will be extended, or in the water treatment plant of the town of Loviisa. An estimated

Table 9-2. Amount of waste waters of the existing power plant units and nutrient loads during 2001–2006 and an estimate of the amounts of waste waters and nutrient load of the new power plant unit.

	Existing power plant units (2001–2006)	New power plant unit (estimate)
Process waste water (m^3/a)	148 022–384 160	160 000
Total nitrogen (kg/a)	276–2 712	850
Total phosphor (kg/a)	0,7–5,2	50
Domestic waste water (m^3/a)	18 834–28 841	16 000
BOD load (kg/a)	45–367	360
Total nitrogen (kg/a)	460–1 034	260
Total phosphor (kg/a)	4,4–24,6	15

10 000–15 000 m^3 of waste waters will be produced annually during the operation of the new power plant unit.

The BOD load of the domestic waste waters of the new power plant unit is estimated to be about 1.2 kg, the phosphor load 0.08 kg and nitrogen load 1.0 kg per day, if a similar technology is used in the waste water treatment plant as there is today.

Rain water and drainage water

The rain waters and drainage waters from the power plant area are led or pumped along rain water drains, equipped with inspection wells, to settling basins before leading them to sea. Rain waters from the shielding pools of oil tanks and the oil management areas are treated in oil separators before leading them to the rain water drains. The rain water collected in the shielding pools of the transformers is led via the drainage wells to rain water drains. Detected oil is removed from the wells before leading the water to the rain water drain.

9.4.3 Load of waste waters and impacts on the sea water

The impacts of the increased waste water load to the quality of sea water and eutrophication remain small and they cannot be distinguished from the impacts of the load coming from other sources.

Boron is a necessary micronutrient but it is poisonous in large quantities. In sea water there is plenty of boron naturally. Process waste waters are diluted to the cooling water led to the sea, so the boron concentration is fairly small.

The Table 9-2 shows the amount of waste waters and nutrient load of the existing power plant units during 2001–2006 and the estimation of the corresponding figures of the new power plant unit.

9.4.4 Cooling water

Need and use

The new power plant will need, depending on its power, 40–70 m^3/s of sea water for the cooling of turbine condensers, and various equipment, oils and chemicals. From the condensers the cooling water, 8–12 °C warmer, is led to the sea, via the surge chamber, either along the discharge

Table 9-3. Cooling water flows of both the existing power plant units in 2001–2006, and the estimated flow of the new power plant unit and the thermal load conducted to sea.

	Existing power plant units (2001–2006)	New power plant unit (estimate)
Cooling water (million m^3/a)	1 340–1 455	1 200–2 200
Thermal load (TJ/a)	54 100–57 200	55 000–90 000

channel or the cooling water discharge tunnel. During the annual outage the new power plant will need about four to six cubic meters of cooling water for removing residual heat from the reactor. The Table 9-3 shows the cooling water flows of both the existing power plant units in 2001–2006, and the estimated flow of the new power plant unit and the thermal load conducted to sea.

The structures of the cooling water intake place are planned so that the flow rate outside the structures is as small as possible. A small flow rate decreases the amount of fish and aquatic vegetation coming to the power plant. The planning and construction of cooling water intake structures makes provision for phenomena complicating cooling water intake, such as clogging due to algae or other materials and subcooled water.

9.4.5 Impacts of cooling water to the temperature of the nearby sea areas

9.4.5.1 Intake and discharge place options under examination

Three optional areas have been chosen as cooling water intake places of the new power plant unit; local intake from Hudöfjärden (O1) and two remote intakes from Vådholmsfjärden (O2, O3). Three areas have also been chosen as discharge areas; local discharge to Hästholmsfjärden (P1) and two remote discharges to Vådholmsfjärden (P2, P3). The existing intake and discharge places of cooling water and optional intake and discharge places have been shown in the Figure 9-3. The implementation of both remote intake and discharge places have the need to construct the structures enabling the closing of the cooling water tunnels on a nearby island or shallows. The utilization of areas O1, O2, P1 and P2 is possible at certain places without changes to the land use plan. The use of areas O3 and P3 requires changes to the land use plan.

In the remote intake options the cooling water of the new power plant unit is taken from a greater depth than in the local intake options. In the summer, the temperature of the cooling water taken from the remote intake place is lower than in the local intake option. Thus the temperature of the cooling water discharged back to the sea is, in the summer, lower, even below the surface temperature of the sea area surrounding Hästholmen. In winter, the vertical temperature variations are smaller and thus the temperatures are close to each other in the local and remote intake options. Any difference of a few degrees hardly has any significance when assessing the impacts.

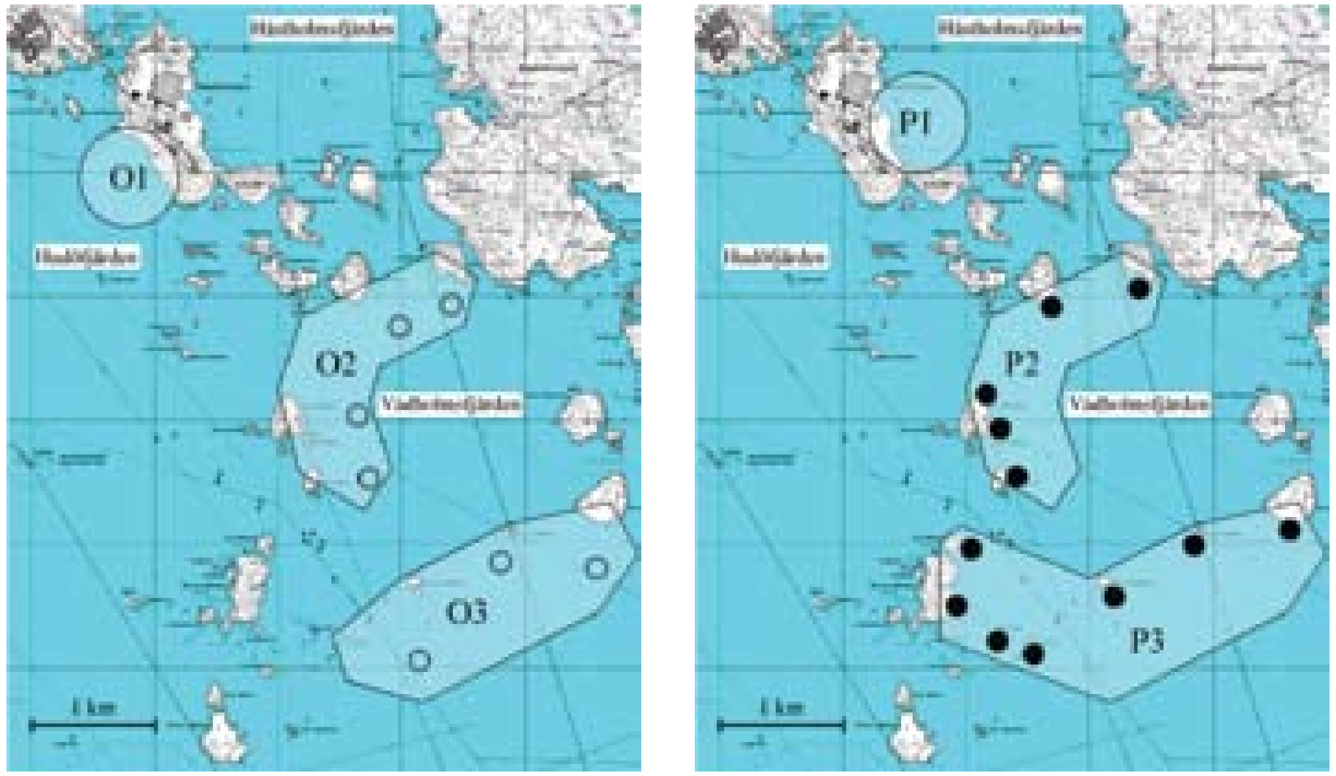

Figure 9-3. Optional intake areas (O1, O2 and O3) and discharge areas (P1, P2 and P3) of cooling water of the new power plant unit and possible intake and discharge sites.

Four options are presented in the summer-time studies. In the remote intake option the temperature of the intake cooling water in summer is the same, and thus in the modeling calculations the location of the remote intake place has no significance. In the remote discharge options the environmental impacts of cooling water discharge are similar. Of the remote discharge areas P2 is estimated to be more restricting than P3 outer in the sea, and thus only the results of the discharge area P2 are presented. The options under examination are:

- **Local intake and local discharge (LL).** Cooling water is taken from Hudöfjärden, south of the cooling water intake place of the existing power plant units (O1) and discharged to Hästholmsfjärden south of the cooling water discharge place of the existing power plant units (P1).
- **Local intake and remote discharge (LR).** Cooling water is taken from Hudöfjärden south of the cooling water intake place of the existing power plant units (O1) and discharged to Vådholmsfjärden, east of Stora Rövarn (P2), about two kilometers away from Hästholmen.
- **Remote intake and local discharge (RL).** Cooling water is taken from Vådholmsfjärden (O2) and discharged to Hästholmsfjärden, south of the cooling water discharge place of the existing power plant units (P1).
- **Remote intake and remote discharge (RR).** Cooling water is taken from Vådholmsfjärden (O2) and discharged to Vådholmsfjärden (P2).

In the studies of the winter period, the local intake option of cooling water is considered and the discharge areas are the same as in the summer-time studies. The examined options are:

- **Local intake and local discharge (LL).** Cooling water is taken from Hudöfjärden, south of the cooling water intake place of the existing power plant units (O1) and discharged to Hästholmsfjärden, south of the cooling water discharge place of the existing power plant units (P1).
- **Local intake and remote discharge (LR).** Cooling water is taken from Hudöfjärden, south of the cooling water intake place of the existing power plant units (O1) and discharged to Vådholmsfjärden, east of Stora Rövarn (P2), about two kilometers away from Hästholmen.

9.4.5.2 Cooling water model, assumptions and boundary conditions

Description of the cooling water model

The cooling water model covers the sea water area surrounding Hästholmen with a range of about 10 kilometres. The impact of the environment outside the cooling water model has been described as boundary conditions, which include the interaction between atmosphere and sea level (heat transfer, force caused by wind), the main current of the Gulf of Finland, and the cooling water flows of the existing power plant units and Loviisa 3 unit. For solving the flow and heat transfer equations of the three-dimensional model, the universal FLUENT flow solver has been used (*Fluent 2007*).

The calculation models are simplifications of nature's processes and phenomena and they take into account the uncertainties caused by calculation methods. The spreading of warm cooling waters has been modeled in static weather conditions (e.g., constant wind direction and speed) and various alternatives have been examined in balanced situations. In nature the conditions vary constantly and the alterations can be significant even within a short period of time. Despite the simplifications compared to the natural conditions, the sea water temperatures calculated by the model can be regarded accurate enough in respect of the assessment of the impacts of warm cooling waters. The calculation has been done with the same bases both for the present situation and the different alternatives. The potential errors caused by calculation are therefore parallel in all situations and their significance in the assessment of impacts is decreased. For ensuring the validity and reliability of the cooling water model, such situations were calculated using the model for which temperature measurement results are available from the sea areas surrounding Hästholmen. The results of the calculations were found to correspond to the measurements relatively well.

Wind direction and speed

During the summer period the most common wind direction in the Hästholmen area is from southwest to northeast, and the most common wind speed is 4–5 m/s. Even though the wind direction and speed vary in reality, constant conditions have been used in the calculations. The calculation was made with a 4.7 m/s southwest-northeast wind. This was to get an idea of the spreading of cooling water. The examinations of the winter period were done with the assumption that the sea was covered by ice, and thus the wind does not affect the spreading of cooling water.

In the cooling water model the impact of wind is shown as a force affecting the sea level and as an impact on heat transfer effect between the sea level and atmosphere. The impacts were described as boundary conditions according to the reference (*Launiainen 1979*). In the cooling water model, topography, trees and buildings etc. have not been modeled and therefore their impact on the wind conditions have not been taken into consideration. This is why the impact of wind on water spreading is somewhat overemphasized in the cooling water model compared to the actual situation.

Cooling water flow rate and temperature increase

In the calculation, the value used for cooling water flow rate of the existing power plant has been during summer 50m³/s and the temperature increase 9°C. The value used for cooling water flow rate of the existing power plants during winter has been 40m³/s and the temperature increase 11.5°C. The values are based on measured values. The values used for the summer and winter period calculations of the new power plant unit have been a cooling water flow rate of 60 m³/s and temperature increase of 11 °C.

Sea water flow and temperature

The main current of the Gulf of Finland on the boundary of the cooling water model is based on the model covering the whole Gulf of Finland and the Baltic Sea, used by the Finnish Institute of Marine Research (*Finnish Institute of Marine Research 2007b*). As to the current of the Gulf of Finland, the assumption used was a flow parallel to the mainland, from east to west, with a flow rate of 3cm/s.

In the summer-time calculations, the temperature of the intake water is assumed to be 16°C in the local intake option and 6°C in the remote intake option. In reality, the temperature of the local intake cooling water is, during the stratification period, lower than the temperature used in the calculation and thus also the temperature of the discharged cooling water is lower. Here the calculated result overestimates the temperature change somewhat. The temperature of the sea water surrounding Hästholmen is assumed to be 16°C.

In the winter-time calculations the assumed temperature of both the intake cooling water and the sea area surrounding Hästholmen is 1°C.

Cooling water discharge

The cooling water model assumes that the local discharge of cooling water of the new power plant unit is carried out similarly to the existing power plant units, over underwater dams to the surface level of the sea, when the heat transfer to the atmosphere is intensified. It is assumed that the cooling water discharge takes place directly to the east, at a speed of about 1m/s.

In the local discharge option the discharge places of the existing power plant units and the new power plant unit are assumed to be located separately, and thus the cooling waters do not get properly mixed. This can be most clearly seen in the remote intake-local discharge option, in which greater local temperature differences occur than in a case where the cooling waters are mixed. If the cooling waters are more efficiently mixed, the maximum temperatures become lower.

Figure 9-4. Summer, present situation. The impacts of the existing power plant units on the sea water temperature with a wind from the southwest (left-hand figure) and from the northeast (right-hand figure).

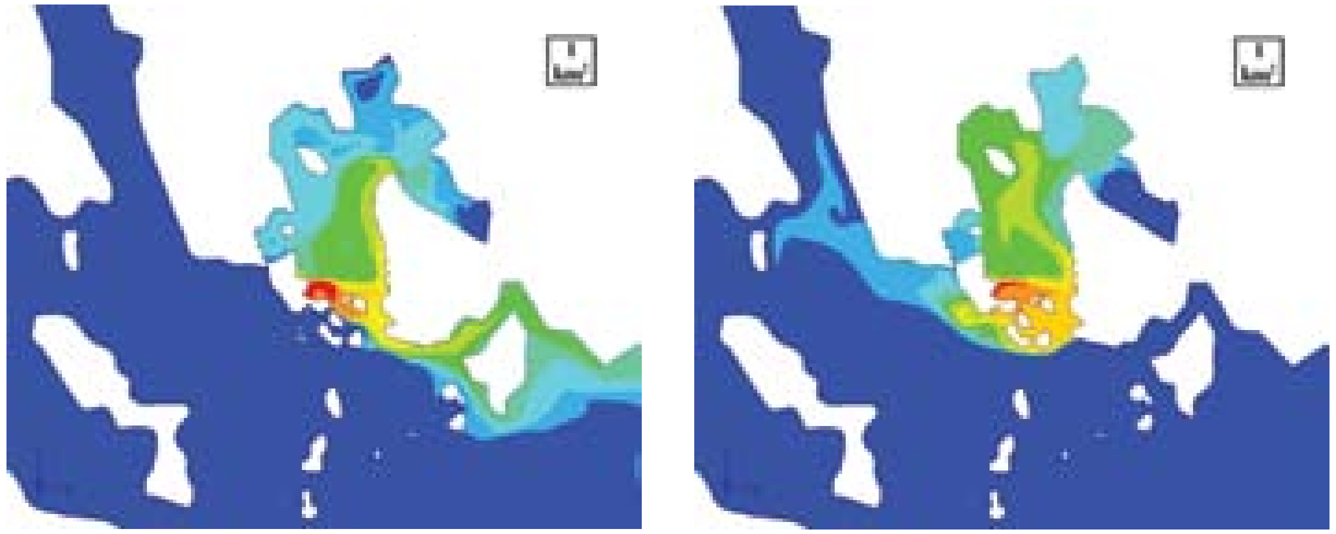

Figure 9-5. Summer (LL). The impact of the existing power plant units and Loviisa 3 (O1, P1) power plant unit on the sea water temperature during a southwest wind (left-hand figure) and northeast wind (right-hand figure).

In the remote discharge option it is assumed that the cooling water of the new power plant unit is discharged upwards from the sea bottom to a shallow area where the cooling water, warmer than its surroundings, rapidly rises to the surface level. Nevertheless, the cooling water model cannot take into consideration the mixing of the cooling water rising towards the surface, to the sea water mass, and therefore the temperature changes of the surface level are probably somewhat overestimated. The cooling water model assumes that the potential backward flow from the discharge place to the intake place does not affect the temperature of the intake cooling water.

9.4.5.3 Impact of cooling water in the summer

Present situation

The cooling water of the existing power plant units is taken from the western side of Hästholmen, from Hudöfjärden, and discharged to the eastern side of Hästholmen, to Hästholmsfjärden.

According to the results of the cooling water model, in the present situation the warm cooling water increases the temperature of the sea area surrounding Hästholmen, mainly in Hästholmsfjärden and in parts of Klobbfjärden. The temperature increase is on the average 3°C or less. Locally, in the area of the belt reaching from the discharge place to the western shore of Gäddbergsö, the temperature increase is 5–6°C. With a wind from southwest, the warm cooling water spreads with the wind to the east, to the surroundings of Kampuslandet and south of Gäddbergsö, where the temperature increase is 1–3°C. As the wind blows from northeast, no warm cooling water impacts can be found in the east, but an increase of 1–2°C can be seen on the western side of Hästholmen and on the southern side of Bodängen.

Local intake and local discharge (LL)

The cooling water of Loviisa 3 power plant unit is taken from the southern side of the intake place of the existing power

Figure 9-6. Summer (LR). The impact of the existing power plant units and Loviisa 3 (O1, P2) on sea water temperature during a southeast wind (left-hand picture) and northeast wind (right-hand picture).

Figure 9-7. Summer (RL). The impact of the existing power plant units and Loviisa 3 (O2, P1) power plant unit on the temperature of sea water during a southwest wind (left-hand figure) and northeast wind (right-hand figure).

plant units (O1) and discharged to Hästholmsfjärden (P1).

According to the results of the cooling water model, the impact of the cooling waters of Loviisa 3 power plant unit can be seen as a wider area of warm water and as higher temperatures compared to the present. During a southwest wind the Klobbfjärden is almost on the whole about 2°C warmer. In the surroundings of Kampuslandet and south of the Gäddbergsö the impact can be seen as water temperatures 2–3°C higher than today. The changed geometry of the cooling water discharge area and the increased flow have an impact on the vicinity of the discharge place, which can be seen locally as temperatures 2–5°C higher on the eastern side of Hästholmen. During a northeast wind, a distinct 2–5°C increase in temperature can be seen on the southern and southeastern side of Hästholmen. Also the temperature of Hästholmsfjärden has somewhat increased.

During a northeastern wind, the impact of cooling water backward flow is significantly larger compared to the present situation. The backward flow of cooling water to the intake places on the western side of Hästholmen decreases the efficiency of both the existing power plants and Loviisa 3 power plant unit.

Local intake and remote discharge (LR)

The cooling water of Loviisa 3 power plant unit is taken from Hudöfjärden, to the south of the cooling water intake place of the existing power plant units (O1) and discharged to outer sea areas, about two kilometers southeast of Hästholmen, on the eastern side of Stora Rövaren (P2).

According to the results of the cooling water model, the impact of the cooling water of Loviisa 3 power plant unit can be seen, compared to the present situation, in the vicinity of the cooling water discharge place, depending on the wind direction, around Stora Rövarn. During a southwest wind, the temperature of Vådholmsfjärden increases 2–3°C compared to the present. Near the shore of Stora Rövarn and the cooling water discharge place the increase in temperature is about 5°C. During a wind from northeast, the area warmed by 2–4°C reaches southwest of Stora Rövarn. Even on the eastern side of Lilla Hudö and the western side of Stora and Lilla Hudö, water is about 1°C warmer, compared to the present.

Remote intake and local discharge (RL)

The cooling water of Loviisa 3 power plant unit is taken from Vådholmsfjärden (O2) and discharged to Hästholmsfjärden (P1).

In the remote intake option the cooling water is taken from great depths and during the summer it is colder than surface water. When warmed and discharged to Hästholmsfjärden, its temperature is estimated to be only 1°C higher than the temperature of surface water. Thus the thermal load to Hästholmsfjärden is, as a whole, of the same order as in the present situation. The formation of temperature differences compared to the present depend on how the cooling water from various plants with different temperatures are mixed and spread in the discharge place of cooling water.

According to the cooling water model, the cooling water of the existing power plant units is led at Hästholmsfjärden some more to northeast-north compared to the present situation. Locally the water can be either 0–2°C warmer or colder compared to the present situation. The cooling water of Loviisa 3 power plant unit, which has nearly the same temperature as the surface water, affects the southern side of Hästholmen so that the surface water at Hästholmen is locally 0–4°C cooler than today.

Remote intake and remote discharge (RR)

The cooling water of Loviisa 3 power plant unit is taken from Vådholmsfjärden (O2) and discharged to Vådholmsfjärden (P2).

In the remote intake option the water is taken from great depths and in the summer it is clearly colder than the surface water. The temperature of the discharged cooling water is estimated to be only 1°C higher than the temperature of surface water. Since the temperature difference is so small, the impact of the discharged cooling water on the surface temperature of sea area surrounding the discharge place can hardly be seen.

Figure 9-8. Summer (RR). Impact of the existing power plant units and Loviisa 3 (O2, P2) on sea water temperature during a southwest wind (left-hand figure) and northeast wind (right-hand figure).

9.4.5.4 Impact of cooling water in the winter

In the winter the warm cooling water makes the ice cover thinner. Depending on the temperatures of the winter, the ice cover in the surroundings of Hästholmen may be formed later or leave earlier, the ice-free area may be wider around the discharge place or the thickness of ice may be smaller at places. The cooling water model was used to estimate how the warm cooling water spreads under the ice cover when the wind cannot affect the flow, and heat transfer to the atmosphere is weaker than during open water. The results of the calculation of the present situation were compared to ice observations made in the power plant during winters. Based on the results and the calculations of the discharge place options of Loviisa 3 power plant unit, insight was provided into the impacts of Loviisa 3 power plant unit on the ice cover of the sea area surrounding Hästholmen.

It has been observed in the surroundings of Loviisa power plant that during some winters, due to rivers and runoff, a layer of light, fresh and cold water is formed between the ice cover and the discharged water. This isolates the warm water from the atmosphere more efficiently than the ice cover, and thus the warm water may spread farther away from the power plant. In the cooling water model this phenomenon has not been modelled, but some estimates can be made of the impacts of Loviisa 3 power plant unit according to the results. When cooling water is discharged locally to Hästholmsfjärden, warm water will spread on a wider area and farther away from the power plant in the case of the above-mentioned stratification due to the increased amount of cooling water. In the remote discharge option, warm cooling water can be found farther away, also in new directions.

Estimates of the changes caused by Loviisa 3 power plant unit on the ice cover are results of a simplified cooling water model, and when interpreting them, even large local margins of error must be taken into consideration. When

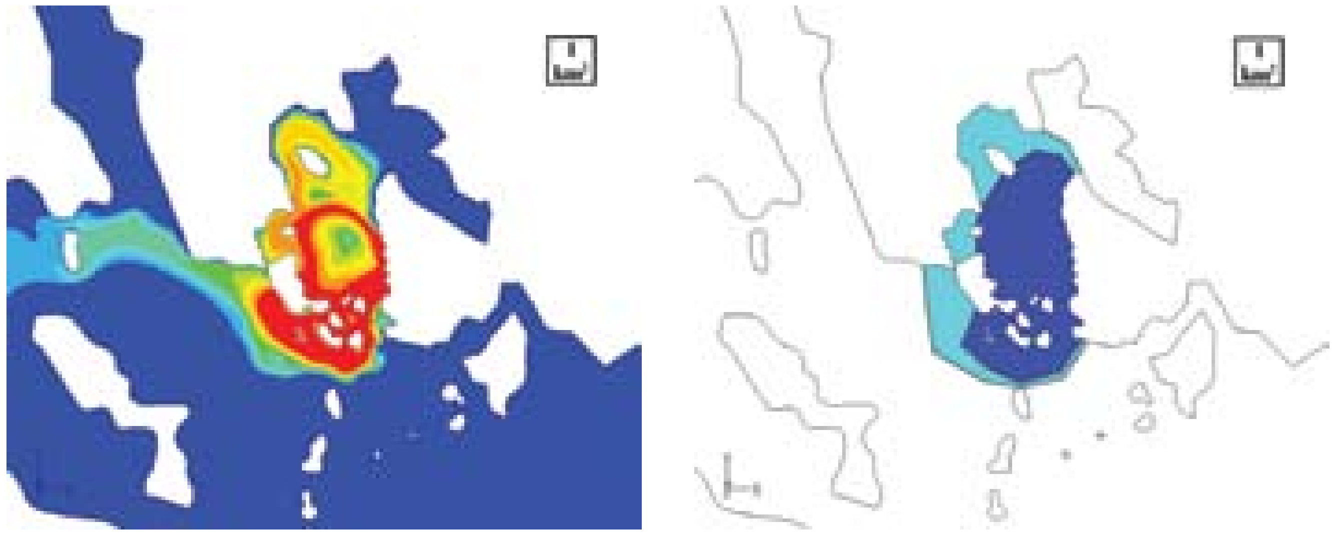

Figure 9-9. Winter, present situation. The relative temperature distribution caused by the existing power plant units (left-hand figure) and ice cover in the surroundings of Hästholmen (right-hand figure) based on observations during winters. In the figure describing the ice cover, the dark blue color represents open water and light blue open water or weak ice.

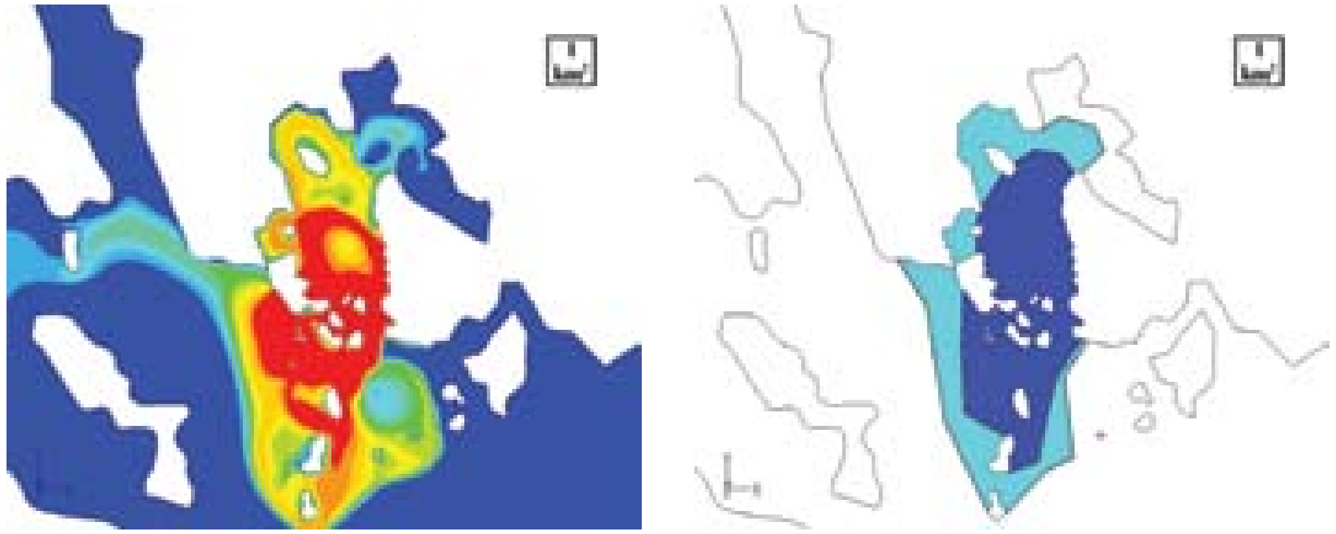

Figure 9-10. Winter (LL). The relative temperature distribution caused by the existing power plant units and Loviisa 3 (O1, P1) power plant unit (left-hand figure) and ice cover in the surroundings of Hästholmen (right-hand figure) based on calculation results. In the figure describing the ice cover, the dark blue color represents open water and light blue open water or weak ice.

comparing the calculation results of the present situation to the actual observations, such a good consistency was found between the calculation results and the observations that the cooling water model is likely to give an adequate prediction of the changes for the assessment of the environmental impacts.

Present situation

The ice situation in the sea area surrounding Hästholmen varies naturally between winters and different periods of time during one winter. The conditions used in the cooling water model were such that ice completely covered the water surface and heat transfer between water and the atmosphere was weakened. Furthermore, the wind could not affect the surface currents of water.

The relative temperature distribution of water, describing the present situation in accordance with the cooling water model results, is shown in the Figure 9-9 on the left-hand side and a simplified ice observation map based on observations on the right-hand side. On the basis of the observations made annually in the surroundings of Hästholmen, it can be stated that during winters when a complete ice cover is formed, the impacts of the existing power plant units can be seen as an ice-free area in Hästholmsfjärden and south to Hästholmen at a range of about one kilometre. An ice-free area or weak ice can also occasionally be found on the western side of Hästholmen. The temperature field given by the cooling water model explains the observations rather well.

Local intake and local discharge (LL)

The cooling water of Loviisa 3 power plant unit is taken from the southern side of the cooling water intake of the existing power plants (O1), and discharged to Hästholmsfjärden (P1).

According to the results of the cooling water model, the impact of Loviisa 3 power plant unit can be seen as a wider area of open water or weakened ice cover in the south, as shown in the Figure 9-10 on the right-hand side. The open water area may reach in the south to Stora and Yttre Täktarn. In the north, at the Klobbfjärden, the area of open water or weakened ice cover may be a little wider, no major changes will nevertheless occur. Also on the eastern and western side, the area of weakened ice may reach a little farther compared to the present situation.

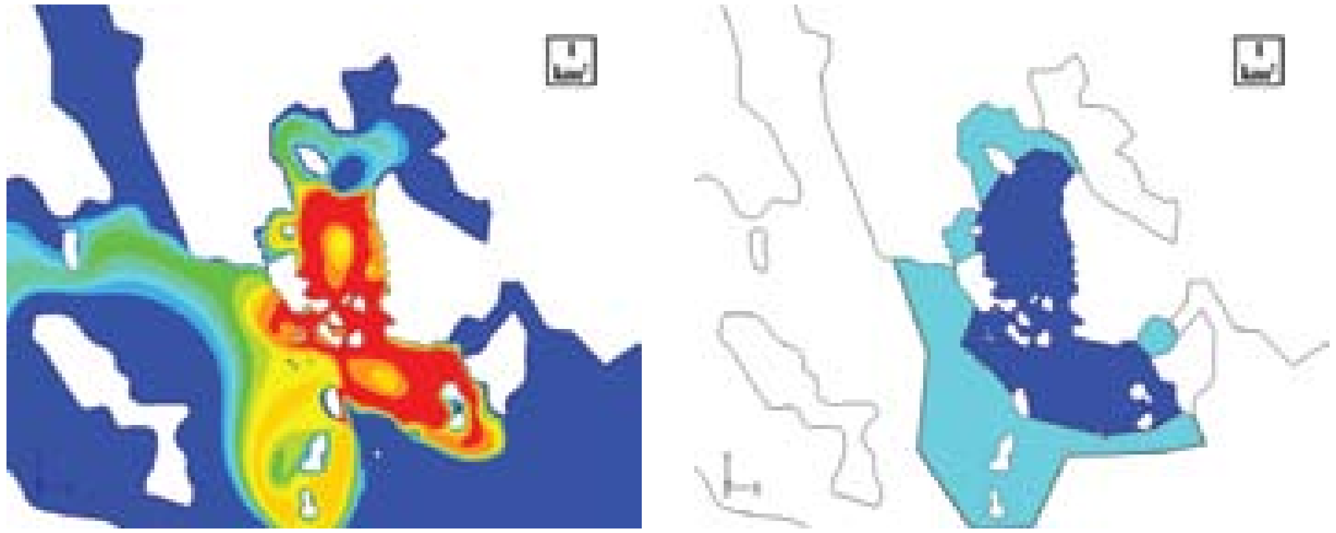

Figure 9-11. Winter (LR). The relative temperature distribution caused by the existing power plant units and Loviisa 3 (O1, P2) power plant unit (left-hand figure) and ice cover in the surroundings of Hästholmen (right-hand figure) based on calculation results. In the figure describing the ice cover, the dark blue color represents open water and light blue open water or weak ice.

Local intake and remote discharge (LR)

The cooling water of Loviisa 3 power plant unit is taken from the southern side of the cooling water intake of the existing power plants (O1), and discharged to outer sea areas, about two kilometers southeast of Hästholmen, on the eastern side of Stora Rövaren (P2).

According to the results of the cooling water model, the impact of Loviisa 3 power plant unit can be seen as wider areas of open water or weakened ice cover, mainly directed to the east, as is shown in the Figure 9-11 on the right-hand side. The area of open water may reach in the east as far as to Kampuslandet. In the south, the area of open water or weakened ice cover may reach to Stora and Yttre Täktarn. Also on the western side, the area of weakened ice may reach a little farther compared to the present situation.

9.4.6 Impacts on flows

Flows in the sea area surrounding Hästholmen are mainly formed of the impact of the wind and the main currents of the Gulf of Finland. The impact of the cooling water intake and discharge of Loviisa 3 power plant unit on the sea area flows is local and limited to the vicinity of intake and discharge places. The cooling water discharge of the existing power plant units to Hästholmsfjärden has an impact on the flows of the inlets on the southern side of Hästholmsfjärden.

According to the results of the cooling water model, in the local discharge option, when the cooling water of Loviisa 3 power plant unit is discharged to Hästholmsfjärden (LL and RL), net flow through the inlets between Tallholmen and Björkholmen as well as Björkholmen and Gäddbergsö in the southeastern point of Hästholmsfjärden, is increased. The flow travels from the inlets to the south, but it rapidly turns to the direction of wind near the surface. This does not have a significant impact on the flow rates in the area on the water surface, except for the immediate vicinity of the discharge place. When the cooling water is discharged as a surface discharge of 1 m/s, the impact can be seen as a west-east flow at Hästholmsfjärden. The flow rates are reduced rapidly, a couple of hundred metres away the rate is about 20 cm/s and close to Gäddbergsö below 10 cm/s. In the remote discharge options (LR and RR), when the cooling water is discharged from the bottom to the surface at a rate of about 1 m/s, the impact on flow rates is limited to the immediate vicinity of the discharge place.

The impact of cooling water intake on sea water flows and flow rates on the surface is, according to the results of the cooling water model, limited to the immediate vicinity of the cooling water intake places. The backward flow of warm cooling water from the discharge place to the intake place seems most probable in the local intake – local discharge option.

9.4.7 Impacts of cooling water on the quality of water and ecology

General

The impacts of the cooling water of the existing power plant units on the sea water temperature are local and the impacts cannot be distinguished from natural variation in the outer sea areas. Generally the rise in temperature caused by cooling waters accelerates biological activity. Metabolism increases and, e.g., the growth of organisms is accelerated if there is enough nutrition and the conditions are favourable. The growing season becomes longer and the higher temperature has generally an improving impact on the living conditions of vegetation. The changes caused by the rise of temperature in the waters are in many parts comparable to eutrophication caused by a nutrient load. The changes are limited to an area where the temperature is continuously more than 1°C higher than in the surroundings.

Water quality

In addition to the thermal load, cooling water has no other impacts on water, and thus it does not cause, e.g., a nutrient load or a load of oxygen-consuming substances. With cooling water, e.g., nutrients may be carried from one place to another, if the nutrient contents of the cooling water intake and discharge places differ from each other. The water quality of the potential cooling water intake places has not been examined, and thus the results of the water quality observation place closest to the cooling water intake place have been used in the study.

The nutrient contents of the hypolimnion of Vådholmsfjärden have been a little smaller in the 2000s than the nutrient contents of Hudöfjärden, and thus the cooling water intake of the new power plant from the hypolimnion of the northern parts of Vådholmsfjärden (RL and RR) would decrease the nutrient content of cooling water compared to local intake options (LL and LR). The amount of nutrients carried with the cooling water will increase compared to the present, due to the increased volume of the cooling water needed.

Both in the local and remote intake options the quality of hypolimnion is poorer than that of the surface water, and thus along with the cooling water taken from the hypolimnion, nutrients are carried to the surface water of the discharge place, which together with the thermal load of the cooling water adds to the eutrophication level of the discharge area. In the basins the oxygen situation has often been poor late in the summer, and phosphorus has been released from the sediment to the hypolimnion. The phosphorus content of the hypolimnion has been at its largest late in the summer, when the most phosphorus is carried with cooling water to the surface water of the discharge area.

In the remote intake option the temperature of the intake water is estimated to be lower than the cooling water in Hudöfjärden intake place. In the Vådholmsfjärden remote intake option, both the lower temperature of the discharged cooling water and the smaller nutrition contents seem to have a similar impact on Hästholmsfjärden, i.e. decreasing the level of eutrophication compared to the local intake option.

The cooling water, warmer than its surroundings, can strengthen the natural temperature stratification of the sea area, which has also been detected in the temperature measurements of Hästholmsfjärden (*Mattila 2002*). According to the results of the cooling water model, in the local intake-local discharge option the temperature of the surface water of Hästholmsfjärden and Klobbfjärden increases from the present, and the temperature stratification strengthens. The stratification of water can mainly have an impact on the oxygen situation of the hypolimnion and thus also on other quality of the hypolimnion. During the stratification months, the oxygen situation of the hypolimnion of Hästholmsfjärden has been poor, and the potential strengthening of temperature stratification and the prolongation of the straticifation period can further worsen it. The strengthening of eutrophication, caused by the thermal load also adds to the amount of decomposing organic material collected to the hypolimnion, which, when decomposing, consumes the oxygen reserves of the hypolimnion. Thus in the local intake-local discharge option both the strengthening of temperature stratification and the increase of eutrophication have a similar impact, i.e. worsen the oxygen situation of the hypolimnion. In the oxygen-free conditions phosphorus is dissolved in water, which further affects the eutrophication of the area.

According to the results of the cooling water model, in the remote intake-local discharge option the temperature of the surface layer of Hästholmsfjärden decreases in the summer, and thus the temperature stratification of the area can be reduced and the stratification period can become shorter, which would have a positive influence on the oxygen situation of the hypolimnion of Hästholmsfjärden. No drastic changes will nevertheless occur, since the underwater sills still limit the exchange of water in the archipelago zone.

The differences in salinity between the various cooling water intake places are relatively small, but in the optional intake places the water is more saline than in Hästholmsfjärden. A factor more important than the differences between the intake place options is the river waters with a low salinity that flow to the area.

Phytoplankton

The new power plant unit will add the thermal load on the sea, but the temperature of the cooling water does not change much. Depending on the cooling water intake and discharge place options, the sea water may become warmer or colder in the cooling water discharge area. Changes also occur in the quality of water.

In the present cooling water discharge area in Hästholmsfjärden, temperature is not a factor limiting base production during the growing season, but the amount of production mainly depends on the availability of nutrients. With the implementation of the new power plant unit, the volume of cooling water is more than doubled and the amount of nutrients carried to the area is increased since, regardless of the intake place of cooling water, the nutrient contents of cooling water taken from the hypolimnion are higher than those in the surface water. Regardless of the intake place of cooling water, the conditions of phytoplankton production in Hästholmsfjärden improve during the growing season if the cooling water of the new power plant unit is discharged to Hästholmsfjärden (LL and RL), and thus the level of eutrophication in the summer can increase from the present.

In the local intake - local discharge (LL) option, the temperature of Hästholmsfjärden, and depending on the wind direction, also its surroundings, rises. Temperature is not a factor limiting production during the growing season, but due to the temperature changes in the spring and autumn, the growing season becomes longer. Phytoplankton production is increased due to both the longer growing period and the increased nutrient load.

In the local intake - remote discharge (LR) option the situation in Hästholmsfjärden does not change from the present, since the cooling waters of the existing power plants are led to the existing discharge place. In the discharge place of the new power plant unit both the thermal load and the nutrients carried onto the surface water improve the base production conditions in the vicinity of the cooling water discharge area. In the vicinity of the cooling water discharge area the growing season becomes longer and the phytoplankton production increases compared to the present situation. The impacts are similar to the present in Hästholmsfjärden, though probably milder, since Vådholmsfjärden is a more open sea area with better exchange of water than Hästholmsfjärden. The impacts are thus focused on a new area.

In the remote intake - local discharge option (RL) the impacts on phytoplankton production are the smallest. Due to the cooling water, the temperature mainly decreases compared to the present. The growing season in Hästholmsfjärden will become shorter and the maximum temperatures in the summer become lower. The cooling water need of the new power plant unit adds the nutrient load on the area, which may increase the phytoplankton biomass late in the summer, when the production is the most limited owing to lack of nutrients. The total production of phytoplankton is decreased by the the shortening of the growing season, but correspondingly the production is increased by the larger nutrient load. As a whole the production level will probably remain lower than today.

In the remote intake - local discharge option changes may occur in Hästholmsfjärden also in the phytoplankton community. Typically cyanobacteria benefit the most from the rising temperature, if there is enough phosphorus in the water. Thus the decrease of temperature in Hästholmsfjärden would reduce the exuberance of the cyanobacteria, but on the other hand the increase of phosphorus late in the summer improves the exuberance of cyanobacteria, since they are able to utilize nitrogen in the atmosphere.

In the remote intake - remote discharge option (RR) the situation in Hästholmsfjärden and its vicinity remains as it is today. In the new cooling water discharge place the phytoplankton production will increase due to both the longer growing season and the larger nutrient contents.

Aquatic vegetation and macro-algae

If the cooling water of the new power plant unit is taken from Hudöfjärden and led to the vicinity of the discharge place of the existing power plant units, to Hästholmsfjärden (LL), the thermal load on the area is increased and the ice-free area in the winters becomes wider. No changes are assessed to happen in aquatic vegetation due to cooling waters in the vicinity of cooling water discharge place, except for the "rinsing" effect of cooling water flow in the immediate vicinity of the new cooling water discharge place. Instead, due to the expansion of the impact area, present-like impacts will be detected in a wider area than before. The occurrence of sea-bed areas suitable for aquatic vegetation has an impact on the changes observed in aquatic vegetation in the area.

In the local intake - remote discharge option (LR) impacts similar to those observed today in Hästholmsfjärden will be observed in the vicinity of the new cooling water discharge area, in the area of the sea-bed suitable for aquatic vegetation and macro-algae. In the remote intake - local discharge option (RL), positive development may happen for aquatic vegetation in Hästholmsfjärden, which will nevertheless be rather slow. The potential recovery of aquatic vegetation in Hästholmsfjärden is related to the temperature drop and size of ice-free water in the area.

In the remote intake - remote discharge option (RR) the impacts on aquatic vegetation remain small. The extension of the growing season can nevertheless increase the amount of vegetation and reduce the number of aquatic plant species in the vicinity of the cooling water discharge area.

Comb jelly

The comb jelly (Mnemiopsis leidyi) is observed to live in the Baltic Sea in the metalimnion of salinity or below it, but there are also observations from the Gulf of Finland from shallower waters. The thermal load led to the sea with cooling water is mainly focused on the surface layer, or in the winter near the surface layer, and in the Baltic Sea, locally to the sea area off Loviisa. The potential impact of the thermal load, which is increased due to the new power plant unit, on the existence or reproduction of the comb jelly is estimated to remain insignificant, and it cannot be distinguished from the impacts of other factors. According to the example of the Black Sea, the most significant factor affecting the population dynamics of the comb jelly is the lacking or existence of natural predators in the area.

Zoobenthos

The increase in the biological production is followed by a decomposing organic mass larger than before, and the lushness of the sea area favours the accumulation of species or groups which benefit of eutrophication. The warm cooling waters of the existing power plants have, via the biological cycle and the strengthening of the temperature stratification indirectly weakened the oxygen situation of the hypolimnion and thus also the quality of the bottom sediment. The zoobenthos communities have regressed and the species has become fewer at most observation places, which has a local impact on the nutrition situation of fish.

The new power plant unit will not cause a change to the present impact mechanisms, but the impact area will be extended. In the local intake - local discharge option (LL) present-like impacts will be observed within an area wider than before. In the remote discharge option (LR) the impacts on zoobenthos would reach in Hudö- and Vådholmsfjärden clearly also to a wider area than today. In the remote intake options (RL and RR) changes in quality and temperature of water will probably remain so small that a clear connection to the zoobenthos cannot be observed.

9.4.8 Impacts of the cooling water on fish stock and fishing industry

General

Changes in water temperature can change the time of the spawning season and affect the development rate of the spawn. In too warm waters the fry can hatch before their most important source of nutrition, animal plankton, has been developed adequately. On the other hand, a suitable rise in the temperature can improve the living conditions of especially such species that spawn in the spring. When the temperature of water exceeds the optimum temperature of fish, they try to reduce swimming and nutrition intake or they migrate to colder waters. A longer exposure to high temperatures causes stress to the fish and predisposes them to diseases. The immune system of fish is the most effective in water whose temperature is about 15 °C (*Svobodá et al. 1993*). Fish seek a suitable temperature, and thus they try to avoid cooling water discharge areas, where the temperature is too high.

The Fish Water Directive of the EC (78/659/ETY) determines in great detail the maximum allowed temperature rises in waters with salmonoids and black clams. At the border of cooling water mixing zone the temperature of salmonoid waters may rise at the most 1.5°C and black clams at the most 3°C compared to a comparison area (Silvo et al. 2000). The authorized authority can, nevertheless determine an area where larger deviations are allowed. Furthermore, temperature is not allowed to exceed, at the border of the mixing zone, 21.5°C in salmonoid waters and 28°C in black clam waters. During the spawning season of species requiring cold water the temperature of either water types must not exceed 10°C.

Fish stock

The rise of water temperature has divergent impacts on fish stock. Taking into consideration the mobility of fish, the cooling waters of the existing power plant units and the new power plant unit are not estimated to cause any extensive damage as a whole to the fish stock in the surroundings of Hästholmen. The impacts on fish stock will remain as today. A rise in water temperature with its consequences nevertheless favours fish species that spawn in the spring, e.g., pike, perch, sander, bream and roach. In the winter the area allures also cold water species, such as whitefish and trout.

If the cooling waters of the new power plant unit are discharged to Hästholmsfjärden (LL and RL), the maximum water temperatures do not change considerably from the present, but the impact area will extend. In the remote discharge options (LR and RR) high temperatures would also occur in the vicinity of the new cooling water discharge place. There the temperatures would not, however, rise as high as in Hästholmsfjärden, since the area is a sea area more open than Hästholmsfjärden.

The warm cooling waters do not have any impact on migrant fish stocks. According to catch statistics, the stocks of the local rock whitefish, which spawns in the autumn, are obviously small in the vicinity of Hästholmen. The harmful warming caused by the cooling waters of the new power plant unit in the possible spawning areas of rock whitefish is insignificant. The increased water temperature may harm the reproduction of burbot in the immediate vicinity of the cooling water discharge place. This is not estimated to have a significant impact on the burbot stock of the area, which has already had to adjust to the prevailing temperature conditions. The strength of the burbot stock has a reverse interdependency of the codfish stock, and today the burbot stock in the area is normal.

Parasites

The high temperature of water and the continuance of the growing season expose the fish to different parasite infections and illnesses, which has been discovered, e.g., in fish farms. Nevertheless, in the sea area the situation cannot be directly regarded equal to fish farm conditions. As far as is known, no parasite studies have been published of the cooling water discharge areas of Finnish condensing power plants (*Fagerholm 2007*). In Swedish studies no differences has been detected in the occurrence of parasites between the warming area and comparison area (*Höglund & Thulin 1988, Sandström & Svensson 1990*).

Gas bubble disease

When the temperature of water increases, the amount of gas soluble in it decreases. The water may develop a supersaturated condition in which excessive atmospheric nitrogen or oxygen present in the water will form bubbles. Supersaturation of oxygen is also present naturally, particularly in eutrophic waters during maximums of phytoplankton production. When a fish moves from cold water to warm supersaturated water, bubbles may be formed in the tissue fluid, damaging or killing the fish. Gas bubble disease may occur in the immediate vicinity of cooling water discharge places.

Fish are able to avoid supersaturated waters to some extent. Furthermore, the depth of swimming, i.e. the environmental pressure, affects the release of gas. The gas bubble disease has been noted to cause deaths in significant amounts in the cooling water discharge areas, where the natural migration route of fish passes the shallow, warm area (*Langford 1990*). In Finland no harmful effects have been noted in the cooling water discharge areas.

Fish carried with cooling water to the power plant

The intake place of cooling water has a great significance in the amount of fish carried with the cooling water of the new power plant unit. In the local intake option, the cooling water intake place is located so close to the intake place of the existing power plant units that the total amount of fish carried with the cooling waters would increase only a little. In the remote intake option the amount of fish carried with the cooling water of the new power plant unit is estimated to be smaller than today, since the intake place is located both outer in the sea and also deeper in the water, where there is less small fish than in the shore areas.

The amount of fish carried with the cooling water of the new power plant unit can be affected by the planning of cooling water intake structures. The intake structures can be planned so that cooling water flows at the structures so slowly that most of the fish can exit the flow. Then, regardless of the cooling water intake place of the new power plant unit, fewer fish are carried with the cooling water compared to the existing power plant units.

The carrying of fish with the cooling water to the new power plant unit can not totally be prevented by the choice of cooling water intake place or design of intake structures. Thus the amount of fish carried to the Loviisa power plant will increase with the new power plant unit, but probably not in large amounts. As a whole the amount of fish carried with the cooling waters of the existing power plant units and the new power plant unit is not assessed to have a significant impact on the fish stocks of the area. Today more than 90% of the fish carried to the Loviisa power plant is smelt and Baltic herring.

9.4.9 Impacts of the cooling water on the use of the sea-area

Winter period

The weakening of the ice situation due to the warm cooling waters restricts e.g. winter fishing, skiing, tour skating and passages to the holiday houses in the archipelago. The new power plant unit will extend the ice-free area and the area of thin ice but the extent and location depend on the discharge place of cooling water. The ice-free area enables boating around the year to some of the islands in the area and open water fishing.

Fishing

The new power plant unit the impact area of the cooling water is extended but the impacts on fishing will mainly remain similar to the present. If the cooling water of the new power plant unit will be discharged as remote discharge (LR and RR), the impacts clearly also extend to Vådholmsfjärden and to the eastern part of Hudöfjärden. The most extensive continuous ice-free area or area of thin ice will be formed in the remote discharge options.

A majority of fishing in the sea area off Hästholmen is done using fishnet and fishpoles. The sea area off Hästholmen is naturally has rather unstable ice conditions and the duration of ice cover is rather short. Furthermore, the cooling waters of the existing power plants make the area less suitable for winter fishing. Along with the new power plant unit, the ice-free area and the area of thin ice will be extended even more. As the possibilities to go fishing on the ice become weaker, the possibilities to long-lasting open water fishing are improved. In the winter the cold water allures among others, the cold water fish species whitefish and trout.

In the summer the general eutrophication of the Gulf of Finland together with the warm cooling waters increase the growth of algae and thus cause increasing formation of slime to the fishing tackles and increase the need to wash the tackles. In the summer the salmonoids favouring cold waters avoid the area of influence of the warm cooling waters, and the predominant species in the area are then the devalued species which spawn in the spring and favour warm waters. This can make the fishing trips longer when fishing e.g. whitefish. The warm cooling waters do not have an impact on the usability of the fish.

9.4.10 Summary of the impacts of cooling water on sea water and fishing industry

The following presents a summary of the impacts of various cooling water intake and discharge place options on waters and fishing industry. In the potential combined electricity and heat production the impacts are milder, since the amount of thermal load led to the sea is smaller. The level of mitigation depends on the ratio of electricity and heat production.

Local intake and local discharge (LL)

Temperature	• width of the warming area increases • changes in sea water temperature are small, but temperature stratification can become stronger • backward recovery to cooling water intake place more probable than today • ice-free area becomes wider
Water quality	• amount of nutrients spread to surface water of Hästholmsfjärden increases • oxygen situation of hypolimnion can become poorer and inner load can increase
Eutrophication	• level of eutrophication increases due to both longer growing season and increased nutrient load
Aquatic vegetation	• changes similar to present will be observed within a growing area
Zoobenthos	• changes similar to present will be observed within a growing area
Fish stock and fishing	• impacts on fish stock will remain small • impacts on fishing indirect: changes in ice situation and level of eutrophication affect fishing

Local intake and remote discharge (LR)

Temperature	• situation in Hästholmsfjärden and vicinity does not change • an area of warm water is formed to the discharge area, whose orientation clearly depends on the wind direction • two separate warm water areas are formed, they can interconnect in certain situations • ice-free area or area of thin ice wider than in other options • impacts are partly focuses on a new area
Water quality	• in the new cooling water discharge area nutrients are transferred to surface water • in the new cooling water discharge area the oxygen situation of hypolimnion can become poorer and the inner load can be increased
Eutrophication	• the level of eutrophication will increase both due to the longer growing season and the increasing nutrient load in the new cooling water discharge area • nevertheless, changes in the new cooling water discharge area are milder than at the present in Hästholmsfjärden
Aquatic vegetation	• impacts in the new cooling water discharge area similar to the present in Hästholmsfjärden
Zoobenthos	• impacts in the new cooling water discharge area similar to the present in Hästholmsfjärden
Fish stock and fishing	• impacts on fish stock remain small • impacts on fishing indirect; changes in ice situation and level of eutrophication affect fishing

Remote intake and local discharge (RL)

Temperature	• temperature of discharged cooling water of new power plant unit lower than today • temperature in Hästholmsfjärden will decrease, in main parts change less than 2°C • temperature stratification of Hästholmsfjärden will become smaller
Water quality	• in Vådholmsfjärden cooling water intake option nutrient loads smaller than in Hudöfjärden • nutrient load of Hästholmsfjärden increased • oxygen situation of hypolimnion of Hästholmsfjärden may be improved
Eutrophication	• shortening of growing season may decrease total production, but late in summer a larger nutrient load may increase production • total production will remain smaller than today • exuberance of cyanobacteria will diminish as temperature decreases
Aquatic vegetation	• minor recovery of aquatic vegetation anticipated, but changes will remain small • possible changes are slow
Zoobenthos	• changes mainly similar to the ones in local intake - local discharge option
Fish stock and fishing	• impacts on fish stock remain small • impacts on fishing indirect; changes in ice situation and level of eutrophication affect fishing

Remote intake and remote discharge (RR)

Temperature	• changes in temperature relatively small • in new cooling water discharge area temperature is increased excluding summer time
Water quality	• no changes to the present in Hästholmsfjärden • in new cooling water discharge area nutrient load is increased
Eutrophication	• no changes to the present in Hästholmsfjärden • in new cooling water discharge area eutrophication is increased due to both longer growing season and larger nutrient loads during growing season
Aquatic vegetation	• impacts on aquatic vegetation remain small • in new cooling water discharge area aquatic vegetation can be increased and species become fewer
Zoobenthos	• changes remain small
Fish stock and fishing	• impacts on fish stock remain small • impacts on fishing indirect; changes in ice situation and level of eutrophication affect fishing

9.4.11 Radioactive releases into the sea

The radioactive releases of the new power plant unit during operation to sea mainly consist of discharge waters of process water used in the reactor, the drainage waters of the controlled area, waste waters from the laundry and the discharge waters of evaporation waste. Before a controlled discharge to sea, the waters are purified and delayed for reducing their radioactivity. Activity is measured and discharge is only possible when the limits of the official guidelines are not exceeded. Also the drainage water of the repository for low- and intermediate-level waste is included in the release monitoring. The radioactive substances from the power plant mixed with cooling water are spread to the surrounding sea water area.

The amount of radioactive releases to sea from the existing power plants (during 2002–2006) and the estimated amount of radioactive releases into sea from the new power plant unit have been shown in the table 9-4. At their highest, the 3H releases from the existing power plant units into the sea between 2002–2006 were about 11% of the release limits and the releases of other fission and activation products about 0.4% of the release limit. The releases of radioactive substances from the Loviisa power plant into the sea have remained clearly below the set limits and the new power plant unit hardly changes the situation.

Table 9-4. The amount of radioactive releases into the sea from the existing power plant units (during 2002–2006) and the estimated amounts of radioactive releases from the new power plant unit and the release limits.

Radioactive releases to sea	Loviisa 1 and 2 (2002–2006) [TBq]	Loviisa 3 Estimate [TBq]	Release limit [TBq]
Tritium (^{3}H)	13–17	0,3–30	150
Other fission and activation products	0,0003–0,004	0,0003–0,03	0,9

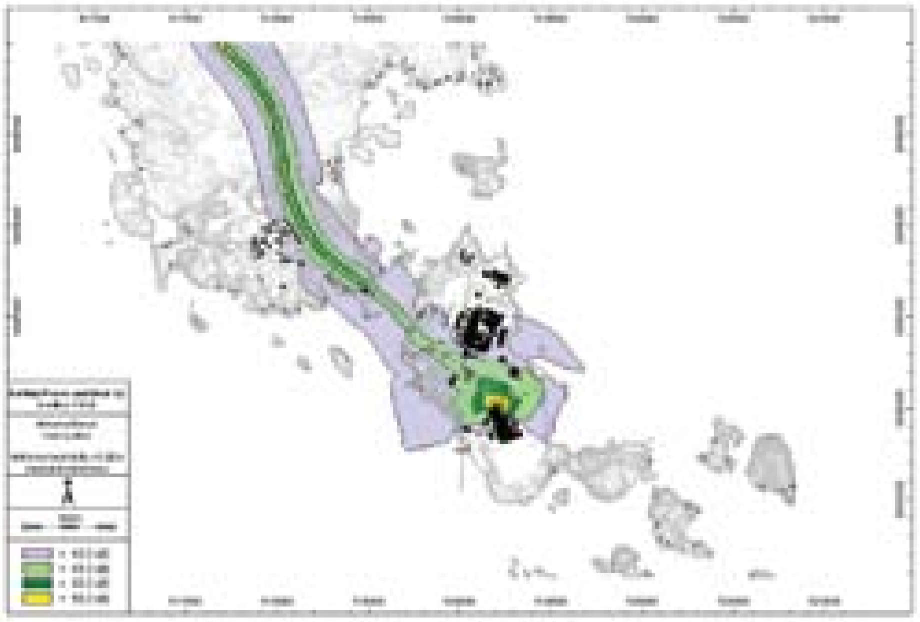

Figure 9-12. Narrow-band corrected noise from the operation of the new power plant unit.

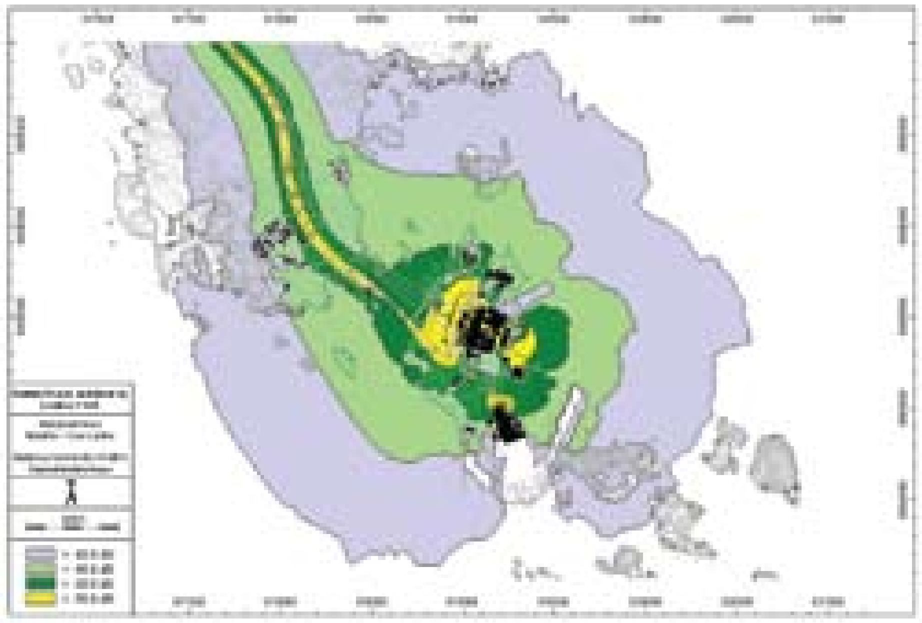

Figure 9-13. The narrow-band corrected noise caused by the operation of the existing power plant units and the new power plant unit.

9.5 Impacts on soil, bedrock and groundwater

The nearby surroundings of the new power plant unit will remain at many places in their natural state. In the constructed areas the surface and groundwaters will be led to the drainage systems of the area. When the new power plant unit will be completed, the level of groundwater will be lowered permanently in the vicinity of the structures that reach deep. Hästholmen forms a separete groundwater area, and therefore the impacts only affect the island of Hästholmen.

The operation of the new power plant unit will not have significant impacts on the soil or bedrock of the surroundings, but during operation, the repository for low and intermediate level waste at Hästholmen will be extended. The extension need is estimated to be about 10 000 m^3. The repository is located in an intact block in the bedrock between two slightly descending fracture zones, at a depth of 110 metres.

9.6 Noise

The noise caused by the new power plant unit is mainly a constant, faint hum. During normal operation, noise is caused by air-conditioning equipment and transformers. The testing of the safety valves of the steam system of a potential pressurized water reactor plant before annual outages is an exception to this.

The spreading of the noise from the new power plant unit has been modelled both separately (Figure 9-12) and with the existing power plant units (Figure 9-13). The noise is assumed to be narrow-band noise due to the nature of noise caused by transformers. According to the Government decision (993/1992), a +5 dB narrow band noise correction is added to the noise measurement result.

The design takes into consideration the noise preventing solutions so that the operation of the new power plant unit will not raise the present noise level.

After construction, about one kilometre north of the power plant (Bodängen) the average sound level L_{Aeq} will be about 40 dB(A), i.e. about 2 dB(A) higher than today. Thus the narrow-band corrected total result in the farthest measurement point will be 45 dB(A). According to calculations, the guideline value for daily noise is exceeded in the holiday house area of Saukontie. The operation of the new power plant unit does not cause such vibration outside the plant area that could be detected by human senses.

9.7 Impacts of waste and its management

9.7.1 Waste types and principles of nuclear waste management

Waste types

In addition to ordinary municipal and hazardous waste, the operation of the new power plant unit also produces radioactive nuclear waste which can be divided into three groups: operating waste produced during operation, spent fuel and decommissioning waste.

The operating waste produced during operation in the controlled area is classified according to its activity to low- or intermediate-level waste. Spent fuel is classified as high-level waste. The final disposal of spent fuel from the new power plant unit, and its impacts are described in Chapter 14. Decommissioning of the new power plant unit has been described in Chapter 10.

Principles of nuclear waste management

The Nuclear Act and Decree and the YVL guides of the Radiation and Nuclear Safety Authority control the management and disposal of nuclear waste. Nuclear Energy Act requires that nuclear waste produced in Finland must be treated, stored and disposed of in permanently in Finland. According to the law, nuclear waste produced outside Finland must not be treated, stored or disposed of permanently in Finland. The producer of nuclear waste is responsible for taking all measures related to its nuclear waste management and their appropriate preparation and also for covering their costs, including decommissioning of the nuclear power plant and its decommissioning waste management. Final disposal of nuclear waste must be carried out safely so that ensuring the safety does not require long-term monitoring. The funds for nuclear waste management must be collected in advance, as required by the Nuclear Energy Act. According to the Nuclear Energy Act, the waste management responsible shall fulfil the financial provision obligation by paying a fee confirmed annually by the Ministry of Employment and the Economy, to the State Nuclear Waste Management Fund, and shall furnish the state with the securities laid down as a precaution against insolvency. The amount of the securities is determined so that nuclear waste management can be implemented on the basis of the funds. The requirements are already applied to the power plants in Loviisa and Olkiluoto and they will also be applied to the new power plant unit.

9.7.2 Low- and intermediate-level operating waste

Operating waste

During the maintenance and repair works in the new power plant unit, dry low- and intermediate-level waste is formed in the controlled area. The waste includes, e.g., used protective gear, dismantled components and other maintenance waste. Dry waste is classified and packed into waste containers, e.g., 200-litre steel drums. After packing, the activity of the waste in the drums is measured. If the activity limit set by the authority is not exceeded, the waste can be exempted from control and treated as ordinary waste. In other case, the waste is put into final disposal. The aim is to treat metal waste first so that it can be exempted from control according to the YVL guide and, when possible, recycled. If the metal waste cannot be decontaminated, it is put into final disposal with other radioactive operating waste.

The liquid waste produced during the operation of the

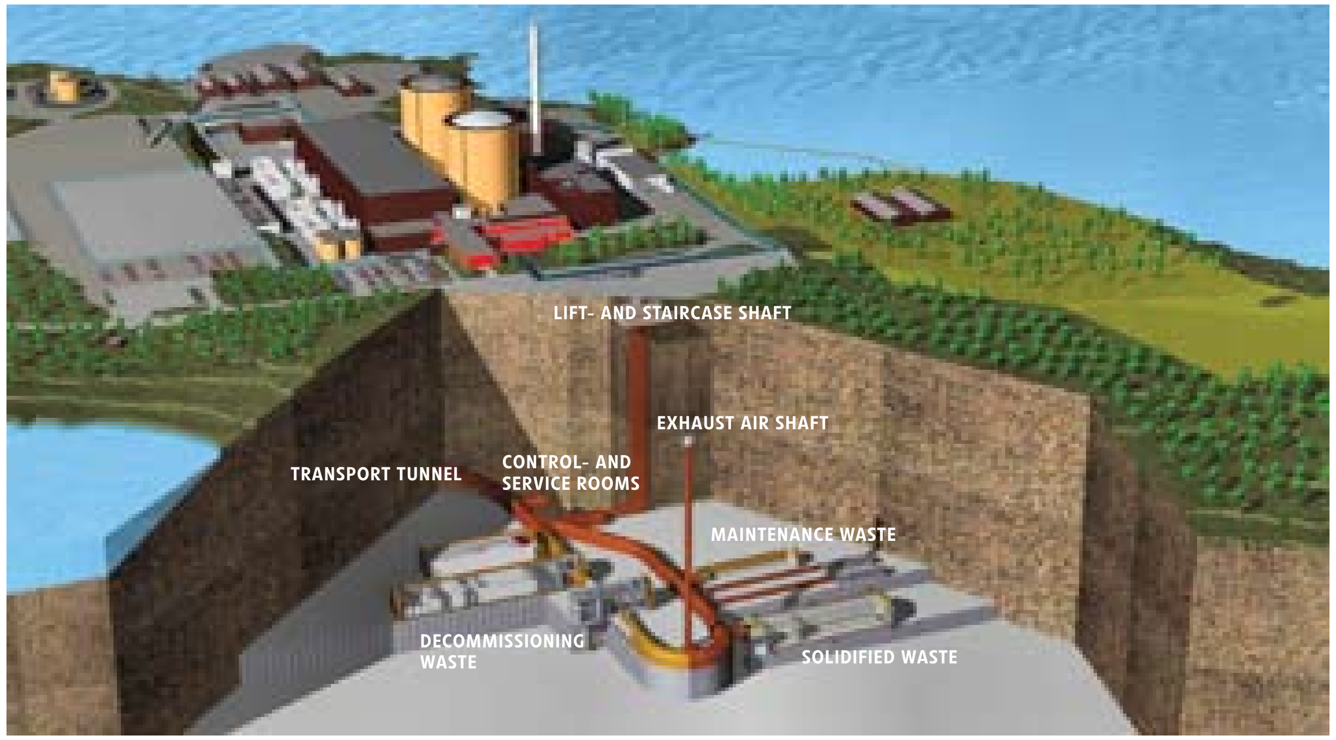

Figure 9-14. Repository for operating and decommissioning waste from the Loviisa power plant.

new power plant unit includes, e.g., the ion exchange resins used for purifying process waters, and evaporation waste. Liquid waste is solidified to make its management and final disposal safer. The existing power plants use a liquid waste solidification plant, whose operation was implemented in 2007. There the waste is solidified with concrete, blast furnace slag, and additives, to waste containers made of reinforced concrete. The containers are closed by casting a concrete lid to it. The solidified wastes are transported to the repository, where a concrete pool has been constructed for them. The solidification plant will continue operation at least until the decommissioning of the existing power plant units. The new power plant will use the existing solidification plant for solidifying its operating waste, or, if necessary, a new solidification plant will be constructed.

Final disposal of operating waste

A low- and intermediate-level waste repository has been excavated in the Loviisa power plant area for operating waste. The repository has been in use since 1998. The Figure 9-20 shows the final disposal halls at the depth of 110 metres in the bedrock of Hästholmen, in an intact block, between two slightly descending fracture zones. The repository has separete halls for maintenance waste, solidified waste, and a rock volume reserved for decommissioning waste. The construction of the main parts of the repository have been finished, and both the waste produced during the operation of the existing power plants and the decommissioning waste will be disposed of there.

For the disposal of the low- and intermediate-level waste from the new power plant unit, the existing repository can be extended. The bedrock of Hästholmen has been characterized much deeper than the existing repository, and the extension can be constructed, e.g., below the existing halls. During the extension of the repository, the traffic volume to Hästholmen will increase during the excavation, if the crushed rock is transported away from the island.

If it is assumed that the amount of nuclear waste is produced in direct proportion to the produced energy, the new power plant unit will produce 3 000–6 000 m^3 of low-level waste and 1 700–3 000 m^3 of intermediate-level waste during 60 years of operation. The need for extension of halls is estimated at about 10 000 m^3. The total activity and volume of the operating waste from the new power plant unit depends on the type of reactor and the power of the reactor.

Long-term safety of the final disposal of low- and intermediate-level waste

The long-term safety of the final disposal of low- and intermediate-level waste is assessed by safety analyses and a safety case, which are updated regularly or, when necessary. The safety case deals with, e.g., the following matters:

- Deterioration of the engineered barriers with time and release of radioactive substances.
- Flow of groundwater.
- Surrounding biosphere.
- Drilling a well or borehole to the vicinity of the repository.
- Impact of any movements of the earth's crust.

The safety case is done pessimistically so the actual situation will be, with great certainty, better than the result of the assessment. The safety case of the disposal of low- and intermediate-level waste is, as to its starting points and methods, similar to the safety case of spent fuel. The requirements for operating waste disposal, with the radiation dose limits, have been established in the YVL guides by the Radiation and Nuclear Safety Authority. The anticipated annual radiation dose to any individual person must not exceed 0.1 mSv and the radioactivity of the surroundings must not be significantly increased.

According to the latest safety case done for the operating waste of the existing power plant units, the largest anticipated radiation dose value will remain below the annual radiation dose limit. The extension to the repository, required by the operating waste of the new power plant unit, can be constructed so that the resulting radiation dose does not exceed the limits presented in the requirements.

9.7.3 Municipal and hazardous waste

The existing power plant units produce an average of 400 tonnes of ordinary municipal waste per year, of which more than 50% is recycled. The utilized types of waste are paper, cardboard, energy recovery waste, metal, glass, recyclable wood and organic waste, for which there are separate collection systems in the power plant. Municipal waste is transported to the regional waste receiving station.

A certain amount of hazardous waste is annually produced in the existing power plant units. The amount of waste depends on the work done during the year. In 2002 and 2004 transformers were replaced, and as a result the volume of waste rose to slightly over 100 tonnes owing to PCB-containing oil. In other years the volume of hazardous waste has varied between 10 and 40 tonnes.

The hazardous waste, which originate in operation and maintenance, mainly consist of various oils, solvents and chemicals, fluorescent lamps and electricity and electronics refuse. Various types of hazardous waste are sorted when collecting them and they are transported to a company which has a permit for hazardous waste treatment. The amount, treatment and utilization of waste is recorded.

The new power plant produces corresponding municipal and hazardous waste as the existing plant units. When the new power plant unit is completed, an estimated 600 tonnes of ordinary waste is produced in the power plant. The volume of hazardous waste is minimized by taking into account the treatment of chemicals and other substances as waste in the purchasing stage. Waste management of the new power plant unit will be arranged according to valid regulations and the objective is to keep the volume of produced waste as small as possible.

9.8 Impacts of the use and storage of chemicals

In the power plant, chemicals are used in the preparation of domestic and process water, control of water chemistry and the prevention of corrosion in pipes. The existing power plant units use, e.g., sodium hydroxide, aluminium sulphate, sulphuric acid, and hydrazine or other chemicals with corresponding properties. Other chemicals include the oils from the machinery and transformers of the power plant. The quality and quantity of the chemicals used in the new power plant will be affected by the chosen plant type.

In the existing power plant units, about 120 tonnes of water treatment chemicals, 190 tonnes of chemicals used in various systems and about 1 200 tonnes of light fuel oil for the heat plant and reserve power equipment are stored. The new power plant unit will increase the amount and consumption of stored chemicals.

The new storage tanks for chemicals and chemical storages will be constructed according to the requirements of the Chemicals Act, the regulations given by virtue of the Act, and the SFS standards. If more than 10 tonnes of substances classified as poisonous, or more than 1 000 tonnes of caustic and irritating or detrimental chemicals are stored, a permit for storage and treatment must be applied for the new power plant unit from the Safety Technology Authority. Necessary permits must be applied for the storage of even smaller amounts, on the basis of chemical-specific limits, and necessary notifications are made to, e.g., chemical control authorities or the rescue authorities.

For avoiding chemical accidents, comprehensive safety instructions will be compiled for the new power plant unit. The instructions will deal with prevention and control of chemical accidents. Furthermore, the personnel of the new power plant unit will be trained and guided to safe use of chemicals. Any leaks are stopped and minimized by structural means, to prevent significant amounts of detrimental substances from reaching the environment.

9.9 Impacts on flora and fauna

9.9.1 Flora and fauna

The impacts of the operation of the new power plant unit on flora and fauna are mainly related to noise and the changes in living environment caused by the construction. The new power plant unit will be located in an area already in power plant use, and thus the impacts on fauna remain small.

In the Hästholmen area the impact of human beings is already directly reflected e.g. to the birdlife, which is sensitive to noise. The shore areas east of Björnviken and Lappomviken, which are rich in waterfowl, remain rather far away from the new power plant unit. Furthermore, there are woody terrains or islands in between, and they attenuate the noise essentially and thus the impact on birdlife is small. The noise related to the operation of the new power plant unit does not essentially change the present soundscape.

The impacts of the new power plant unit on the animal and plant populations have been assessed on the basis of the largest activity concentrations detected during the environmental monitoring of the existing power plant units, taking into consideration the deposition coming from elsewhere. The assessment has been implemented according to the procedure developed in the ERICA project of the European Commission (*Beresford et al. 2007*). The minor releases of radioactive substances into the air and the sea from the new power plant unit representing the up-to-date level of technology most probably cause no impacts on the animal and plant communities.

9.9.2 Impacts on diversity of nature and conservation areas

The impacts of the operation of three power plant units on the archipelago of Pernajanlahti and Pernaja and the Källaudden–Virstholmen Natura 2000 areas were assessed in a separate Natura 2000 assessment (*Pöyry Environment 2008*). The assessment is based on the information available from the areas, which has been complemented with a nature-type survey carried out in the autumn of 2007. In the assessment, other sources used included the Natura assessment (*Paavo Ristola Oy 2001*) compiled in 1999, observation results of the Loviisa sea area, cooling water model results of the sea area temperatures and the assessment of impacts on waters, carried out as a part of the assessment of environmental impacts.

The recognized impacts potentially focused on the areas are the impacts of the warm cooling water, such as potential eutrophication and the worsening of the ice situation. The impacts have been assessed on the nature types and species which act as protection grounds in the Natura 2000 areas. The assessment does not include other species present in the area. The types of nature occurring above ground have not been discussed separately in the impact assessment since no impacts are focused on them.

The impacts of the cooling water intake and discharge options of the new power plant unit on the sea area surrounding Hästholmen, the temperatures of the summer period and the ice cover during winter, have been presented in Chapter 9.4.5. The impacts of the cooling waters on the quality of water, the ecology and fish stock have been presented in Chapter 9.4.

9.9.2.1 Impacts of local intake and local discharge on the Natura 2000 areas

In the local intake - local discharge (LL) option of the new power plant unit, the impacts of warm cooling water and the changes are mainly focused on Klobbfjärden and Hästholmsfjärden. On the average the changes are small but locally 2–5°C higher temperatures compared to the present can be observed in the area.

The sea protection area of Pernajanlahti and Pernaja archipelago

In the local intake - local discharge option the increase of sea water temperature does not reach the sea protection area of Pernajanlahti and Pernaja archipelago in the summer, and thus the project is not assessed to have significant adverse impacts on the nature types which act as the Natura 2000 protection grounds in the area. In the winter, during the ice cover period, the area of weak ice may extend to the border of Natura 2000 area at Yttre Täktarn. In the area of weak ice the ice melts sooner, and thus the base production also begins earlier. Yttre Täktarn is located on the edge of the open sea area where the mixing conditions of water are good and the melting ice cover is not assessed to change the nature types or their species significantly.

Furthermore, the local intake - local discharge option does not have any significant adverse impacts on the birdlife or grey seal which act as the protection grounds of the Natura 2000 area, since the temperature and nutrition impacts do not extend to the area. The grey seal does not have nesting or resting rocks in the vicinity of the impact area of warm cooling waters, but the species may occasionally visit the Hudöfjärden area. The warming of the sea area does not cause adverse impacts on the birdlife of the area nor do the impacts extend to the Natura 2000 area in the archipelago of Pernajanlahti and Pernaja. In the winter, the number of birds may increase in the ice-free area outside the area.

Källaudden–Virstholmen

In the local intake - local discharge option during northeast wind, a sea water temperature increase of 1–2°C may occur in the Källaudden–Virstholmen Natura 2000 area. Only about 10% of the annual wind directions are from the northeast, the west and southwest winds are prevailing. The change caused by the thermal load to the nutrient load of the Gulf of Finland cannot be distinguished. Based on the long-term observation of zoobenthos and aquatic vegetation in Hästholmsfjärden , it is assessed that the temperature increase does not have significant impacts on vegetation or zoobenthos in the Källaudden–Virstholmen area. According to the vegetation line monitoring, the impacts of a temperature increase of 1–2°C cannot be distinguished from the prevailing development. A permanent increase of temperature might boost the growth of algae, mainly in sheltered inlets and bays. The only bay separating from the sea in the Källaudden–Virstholmen area is already strongly eutrophic and full of cane-grass and the local intake - local discharge option is not assessed to have significant adverse impacts on the area, taking into consideration that the thermal load is focused at the area only occasionally.

9.9.2.2 Impacts of local intake and remote discharge on the Natura 2000 areas

In the local intake - remote discharge (LR) option of the new power plant unit, the impacts of warm cooling water can mainly be seen in the vicinity of the new cooling water discharge place, depending on wind direction, in various spots of Stora Rövarn. Locally 2–5°C higher temperatures compared to the present can be observed in the area.

The sea protection area of Pernajanlahti and Pernaja archipelago

The eastern shores of Hudö are relatively open and there are hardly any inlets or bays which would easily become eutrophic, outside the areas filled with cane-grass. The potential eutrophication of shores can be seen as the increase of common reed particularly in the sheltered places. The eastern part of the shores of Hudö are rocky shores, which are not such in their representativeness of species that they should be interpreted as Natura nature types.

During northeast wind, the temperature of the western water area of Hudö may increase 1–2°C. The changes in vegetation are slight or they cannot be distinguished from natural development when comparing the impacts of the thermal load of the existing power plants on the vegetation or zoobenthos in areas where temperature increases by 1–2°C. Slight eutrophication due to the thermal load may occur in the area, which may mean that the common reed and the surface algae and threaded algae become more common in the sheltered bays. The western shores of Hudö are already mostly covered by cane-grass and no major further eutrophication is estimated to occur, since the prevailing wind direction is from the southwest-west and the sea area surrounding the cooling water discharge place is open, and thus the exchange of water is relatively efficient.

Impacts may be focused on the nature type of rocky shores in the southern bays of Hudö. The share of affected rocky shores of the occurrence of this nature type in the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja is about 1%. The rocky shores of Hudö are not significantly representative of plant species. The impacts can be seen as the increase of cane-grass and vegetation changes of the shallow waters (among others, the parrot feather becomes more common). The impacts of the actual vegetation on the rocky shores remain slight; in the waterline the species may become fewer (common greed), whereas no changes are assessed to occur above the shore.

Furthermore, the local intake - remote discharge option does not have any significant adverse impacts on the birdlife or grey seal which act as the protection grounds of the Natura 2000 area, since the temperature and nutrition impacts do not extend to the area. The grey seal does not have nesting or resting rocks in the vicinity of the impact area of warm cooling waters, but the species may occasionally visit the Hudöfjärden area. The warming of the sea area does not cause adverse impacts on the birdlife of the area. In the winter, the number of birds may increase in the ice-free area outside the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja.

Källaudden–Virstholmen

In the local intake - remote discharge option the increase of sea water temperature is not focused on the Källaudden–Virstholmen Natura 2000 area and thus the local intake - discharge option is not assessed to have any impacts on the protection grounds of the area.

9.9.2.3 Impacts of remote intake and local discharge on the Natura 2000 areas

In the remote intake - local discharge (RL) option of the new power plant unit, the impacts of warm cooling water and the changes are mainly focused on Klobbfjärden and Hästholmsfjärden. Mainly both 0–2°C higher and lower temperatures can be observed in the area, compared to the present situation. On the southern side of Hästholmen the temperature of water is 0–4°C colder than today.

The sea protection area of Pernajanlahti and Pernaja archipelago

The impacts of the remote intake - local discharge option on the temperature of sea water are mainly focused on the north-eastern and northern side of the cooling water discharge place, on Hästhomsfjärden, and the impacts do not apply to the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja. On the Hudöfjärden side the temperature will be somewhat lower than at present. In the remote intake - local discharge option, no changes will take place in the quality or temperature of the sea water in the archipelago of Pernajanlahti and Pernaja. Thus there are no adverse impacts of the remote intake - local discharge option on the nature types in the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja.

Furthermore, the remote intake - local discharge option does not have any significant adverse impacts on the birdlife or grey seal which act as the protection grounds of the Natura 2000 area, since the temperature and nutrition impacts do not extend to the area. The grey seal does not have nesting or resting rocks in the vicinity of the impact area of warm cooling waters, but the species may occasionally visit the Hudöfjärden area. The warming of the sea area does not cause adverse impacts on the birdlife of the area. In the winter, the number of birds may increase in the ice-free area outside the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja.

Källaudden–Virstholmen

The remote intake - local discharge option roughly corresponds to the present situation in the Källaudden–Virstholmen Natura 2000 area and the changes cannot be distinguished from the general eutrophication development in the Gulf of Finland.

The increase of temperature and the resulting increase in the level of eutrophication is not reflected to the Källaudden–Virstholmen area during the prevailing wind conditions. In practice, the situation corresponds to the present situation since cold hypolimnion is used as the cooling water of the new power plant unit and the temperature of the discharged cooling water hardly differs from the temperature of the surface water. The discharge places of both the new power plant unit and the existing power plant units are located in Hästholmsfjärden, whose water exchange to Hudöfjärden is restricted. This is why the temperature and nutrient impacts, excluding the northeastern wind, hardly extend to Hudöfjärden. Thus the remote intake-local discharge option has no significant impacts on the protection grounds of the Källaudden–Virstholmen Natura 2000 area.

9.9.2.4 Impacts of remote intake and local discharge on the Natura 2000 areas

In the remote intake - remote discharge option (RR) of the new power plant unit, the impact of the warm cooling waters on the temperatures of the discharge area can hardly be seen, since the temperature of the cooling water taken from great depths is so much lower than the temperature of the surface water that the temperature of the discharged water is 0–1°C higher than the temperature of the surrounding waters.

Option	Sea protection area of Pernajanlahti and Pernaja archipelago	Källaudden–Virstholmen
Local intake–local discharge	• Thermal load does not extend to the area and the level of eutrophication is not estimated to increase. • Does not reduce the protection grounds of Natura 2000 area.	• During northeast wind, minor thermal load in the area. • Does not reduce the protection grounds of Natura 2000 area.
Local intake–remote discharge	• Potential eutrophication in the withdrawn bays of eastern and southern shores of Hudö. Potential impacts on the nature type of rocky shores. • Total impacts small, focused on approx. 1% of nature type.	• No thermal load in area. • Does not reduce the protection grounds of Natura 2000 area.
Remote intake–local discharge	• Thermal load does not extend to the area and level of eutrophication is not assessed to increase in the area. • Does not reduce the protection grounds of Natura 2000 area.	• During north-eastern wind minor thermal load in the southeastern part of area. Impacts do not differ from present state. • Does not reduce the protection grounds of Natura 2000 area.
Remote intake–remote discharge	• No impacts on area.	• No thermal load in area. • Does not reduce the protection grounds of Natura 2000 area.

In the discharge place of the new power plant unit the temperature hardly changes, since the temperature of the cooling water discharged to the sea is in the summer approximately the same as the temperature of the surface layer. In the spring the warming of the water mass is faster than in its surroundings and on the other hand, in the spring the water mass remains warm longer.

The sea protection area of Pernajanlahti and Pernaja archipelago

In the remote intake - remote discharge option the nutrient level in the vicinity of the cooling water discharge place increases somewhat. Since the cooling water discharge place is located in an open environment, with a good exchange of water, the increase in the nutrient content is not estimated to cause as strong impacts as at present in Hästholmsfjärden. The cooling water discharge place is located about two kilometres away from the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja and the local increase in nutrients is not estimated to extend to the area to a significant degree due to the water exchange and the distance. Thus the remote intake - remote discharge option is not assessed to have any adverse impacts on the nature types of the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja.

Furthermore, the remote intake - remote discharge option does not have any significant adverse impacts on the birdlife or grey seal which act as the protection grounds of the Natura 2000 area, since the temperature and nutrition impacts do not extend to the area. The grey seal does not have nesting or resting rocks in the vicinity of the impact area of warm cooling waters, but the species may occasionally visit the Hudöfjärden area. The warming of the sea area does not cause adverse impacts on the birdlife of the area. In the winter, the number of birds may increase in the ice-free area outside the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja.

Källaudden–Virstholmen

In the remote intake - remote discharge option the temperature of sea water will not change in the Källaudden–Virstholmen Natura 2000 area and no changes will occur in the nutrient content. The increase of the level of eutrophication in the vicinity of the new cooling water discharge area is not reflected on the area due to the prevailing wind conditions and the openness of the cooling water discharge area and thus the nature types are not changed due to eutrophication. Thus it is stated that the remote intake - remote discharge option has no impacts on the protection grounds of the Källaudden–Virstholmen Natura 2000 area.

9.9.2.5 Summary of the cooling water impacts on the Natura 2000 areas

The impacts of the operation of three power plant units on the Natura 2000 areas of the archipelago of Pernajanlahti and Pernaja as well as Källaudden–Virstholmen, are, regardless of the cooling water intake and discharge places, small.

The impacts on Natura 2000 areas and changes compared to present are most significant in the local intake - remote discharge option. In the local intake - remote discharge option the warm cooling waters of the new power plant unit are spread during a northeastern wind to the Natura 2000 area of the archipelago of Pernajanlahti and Pernaja, to the eastern and southern shores of Hudö, as shown on the right in the Figure 9-15. In the Loviisa region the wind blows from the northeast only on the average 10% of time. The total impacts are small and they are assessed to be focused on about one per cent of the rocky shores of the area, which is a Natura 2000 nature type.

9.10 Impacts of traffic

9.10.1 Transports

During operation, mainly various water treatment chemicals, light fuel oil and gases are transported to the new power plant unit by road. As a result of the operation of the new power plant unit, the transports are estimated to double from the present. The number of transports is small, however, compared to commuting, and thus their impact on the traffic volumes of Saaristotie and Atomitie is not significant. The transports of fresh and spent fuel have been described in Chapter 14.

9.10.2 Commuting

Traffic to and from the power plant mainly consists of commuting. Some of the commuting is done by buses, some by cars. With the implementation of the new power plant unit,

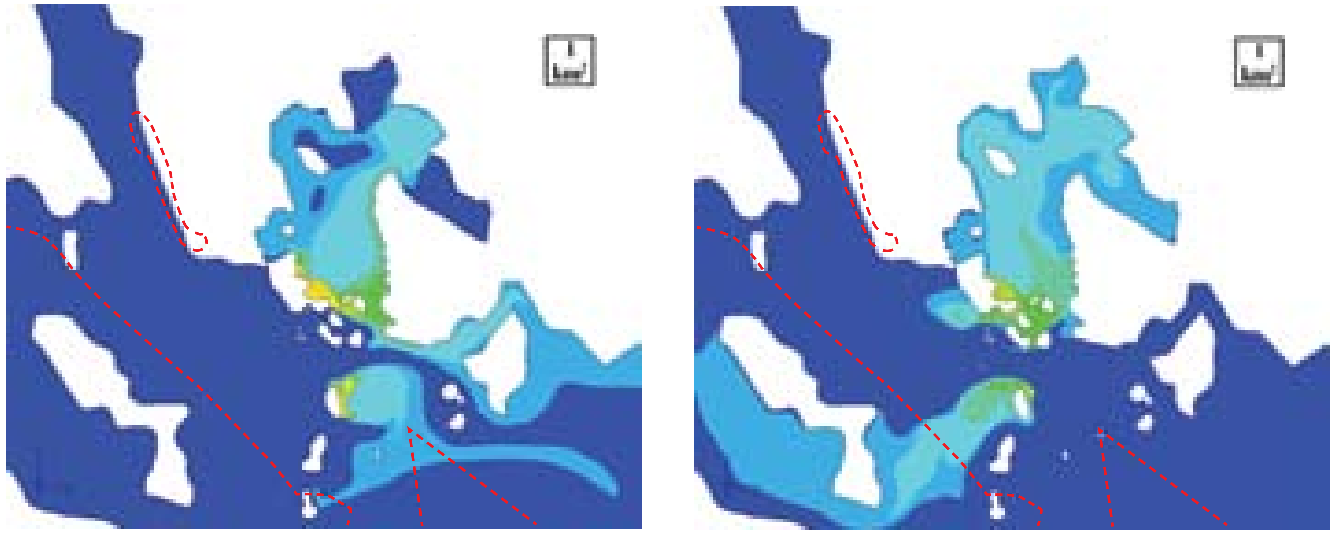

Figure 9-15. Impact of local intake - remote discharge option on the sea water temperature during a western wind (left-hand figure) and during northeastern wind (right-hand figure). The limits of the Natura 2000 areas have been marked using a red broken line.

Figure 9-16. Average weekday traffic (KAVL) in 2006 and during the operation of the new power plant unit and volume of heavy traffic (Raskas) .

Table 9-5. Distribution of traffic at Hästholmen during operation.

Distribution of traffic	%	Vehicles per day
Loviisa	63	857
West or north of Loviisa	19	258
East of Loviisa	18	245
Atomitie	100	1360

the personnel of the power plant will increase by about 250 people. During the simultaneous operation of three power plant units, the power plant may employ at the most even 700 people. Furthermore, it is estimated that the need for external services covers an annual work contribution of 150 people.

The average daily traffic (KAVL) of Atomitie in 2006 was 880 vehicles, of which the number of heavy vehicles was about 20. The average daily traffic of Atomitie during the operation of the new power plant will be about 1 360 vehicles, if traffic is anticipated to grow in proportion to the increase in the number of personnel. The number of heavy vehicles of this volume is about 40.

The distribution of the travels during the operation of the new power plant unit according to the distribution of the place of residence of the operating personnel of the existing power plant units has been shown in Table 9-5 and Figure 9-16.

During the annual outages of the new power plant unit, the number of workers will increase by about 800 people. The additional traffic on Atomitie is estimated to be 700 vehicles per day. It is assumed that 600 annual outage workers take lodgings in the accommodation area near the power plant and 200 commute from their homes. Two thirds of the people in the accommodation area and all of the workers lodging in the trailer area are assumed to have a car and to make an average of 2.5 personal business trips to Loviisa between Monday and Friday, i.e., on the average one one-way trip per day. The distribution of the travels of workers commuting from their homes has been calculated according to the residence of the operating personnel of the existing power plant units.

The distribution of the travels of the outage workers has been shown in the Table 9-6. During the annual outage the everyday traffic of Atomitie is about 2 060 vehicles per day, i.e., about 50% larger than the everyday traffic of the new power plant unit during operation.

Exhaust gas emissions

When calculating the exhaust gas emissions from traffic, the average emission factors of road traffic of the whole country have been used (*VTT 2006*). Thereof the average emission factors for light and heavy vehicles have been calculated, taking into consideration the distribution of vehicle types. The emissions of the traffic in the town of Loviisa in 2020 have been calculated according to the growth prognosis by the Finnish Road Administration.

The exhaust gas emissions from traffic on Saaristotie and Atomitie in 2006 have been calculated using a road section of 13 kilometres with a presupposition that in 2020 the new, about five-kilometre road connection between main road

Table 9-6. Distribution of travels of annual outage personnel (Suunnittelukeskus Oy, 1999).

Distribution of travels	%	Vehicles per day
Loviisa	63	441
West or north of Loviisa	19	133
East of Loviisa	18	126
Atomitie	100	700

7 (E18) and Atomitie has been constructed. The used total length of the road does not affect the driven total kilometres since the traffic is divided between Saaristotie and the new road connection, and the sections in the calculations are even in length. The amounts of emissions into the air related to the operation of the new power plant, on Saaristotie and Atomitie, have been shown in the following Table 9-7.

Table 9-7. Exhaust gas emissions of weekday traffic, tonnes per year (t/a) in Loviisa and in the Atomitie-Saaristotie section in 2006 and 2020. The calculation supposes that the new road connection has been constructed.

Place	Emission component				
	Carbon monoxide [t/a]	Nitrogen oxides [t/a]	Sulphur dioxide [t/a]	Particles [t/a]	Carbon dioxide [t/a]
Loviisa 2006	226	61	0,1	3	14 200
Loviisa 2020	252	68	0,1	3	15 900
Atomitie and Saaristotie 2006	36	11	0,04	0,33	1 325
Atomitie and Saaristotie 2020	65	18	0,07	0,56	2 230

Of the local sources of emissions, road traffic is the most significant in the terms of the air quality in Loviisa. The construction of a new power plant unit clearly increases the emissions from traffic on Saaristotie and Atomitie but the impact of the new power plant in the air quality in Loviisa is small. Thus the emissions caused by traffic are not estimated to have significant long-term impacts on the local air quality.

9.11 Impacts on people and society

9.11.1 Impact on population and migration

The number of operating personnel of the new power plant unit will be about 250 people. If the personnel will be recruited from outside the region and their place of residence will be distributed similarly to the personnel of the existing plant units, more than 200 employees and their families will move to the Loviisa region. According to the average size of Finnish households (2.1 people, Statistics Finland) the potential population increase will be some 450 people in the Loviisa region.

The settlement of the operating personnel in the region requires that new apartments should be built. The needed amount of apartments, some two hundred, is significant in the local housing market. The price level of apartments will increase if the new housing is not adequate to satisfy the demand. The place of residence will be chosen further away if the amount and quality of available apartments do not meet the expectations.

9.11.2 Impacts on employment in Finland

The recruitment of the operating personnel of the new power plant unit to be trained for and familiarized with the new power plant unit will be implemented during the construction work and the full capacity of 250 people will be reached 1.5 years before the beginning of commercial operation. The share of professional and managerial staff of the personnel is 75 people (30%), salaried employees 75 people (30%) and workers 100 people (40%). The labour is available both in the nearby regions and elsewhere in Finland.

During operation, external services are acquired annually an amount which corresponds to a work contribution of 50 people. Furthermore, the annual outage, which lasts on the average three weeks, employs about 800 people. The domestic contribution of the annual outage is more than 90%. The simultaneous operation of three power plant units lasts for 10-20 years, the number of the personnel of the power plant then being about 700.

9.11.3 Tax income

The operating staff of the new power plant that settles in the Loviisa region pays municipal tax on their income. The municipalities of the region receive, according to a rough estimate, altogether more than one million euros in tax income of the 200 employees settling in the region. Also the working spouses are tax payers. The municipal tax income in the region will increase by approximately two per cent.

The real estate tax on the completed power plant unit is at its highest about eight million euros, if the town of Loviisa will levy taxes using the highest allowed level. The sum is more than twofold compared to the real estate tax income of the town of Loviisa in 2006. The real estate tax will nevertheless be reduced gradually as the power plant unit becomes older.

The profit of the corporate tax charged of the Loviisa power plant to the town of Loviisa is determined by the annual result of Fortum Oyj and the number of workers in the power plant. After the construction of the new power plant unit, the number of Fortum's employees in Loviisa is clearly higher than today, which increases Loviisa's share of the corporate tax.

9.12 Resident survey

9.12.1 Realization of resident survey

For determining the attitudes towards the construction of Fortum's new power plant unit and for support in the assessment of social impacts, a resident survey was carried out among residents within the area of influence of the Loviisa power plant. The survey aimed at determining the potential impacts of the project on the lives and comfort of the residents and acquiring information on the matters the residents find important. Information of the project and of the environmental impact assessment procedure was attached to the survey.

The survey was sent by mail in October-November 2007 to 2 350 people. The survey was sent to all households within five kilometres of the Loviisa power plant and to the owners of all holiday houses within the same area and as a sample to other households in the Loviisa region. The random sampling was aimed at over 18-year-old residents according to the natural age and sex distribution. The sample areas and their sizes are shown in the Table 9-8.

Table 9-8. Resident survey sample areas and size of sample per area.

Area	Sample
Loviisa region	Loviisa 1 000 people Pernaja 300 people Ruotsinpyhtää 250 people Pyhtää 200 people Lapinjärvi 200 people Liljendal 50 people
Loviisa / Hästholmen - within about five kilometres from Loviisa power plant	350 people (permanent and holiday residents)
Total	2 350 people

The questionnaire mainly included multiple choice questions, to a few of which one could add complementing comments, specify the answers and express other opinions. There were also open questions in the questionnaire. A total of 698 answers were returned and the response rate was 29.7%. 27% of the respondents were Swedish-speaking. The estimation of the share of the Swedish-speaking was based on whether the open questions were answered in Finnish or Swedish.

9.12.2 Open questions

In the open questions the residents were inquired, among others, what they wished to be taken into consideration in the environmental impact assessment of the new power plant unit and in the planning of the new power plant unit.

Environmental impact assessment

In the open questions regarding environmental impact assessment, the respondents emphasized impacts on water and safety. The respondents wished for information on the impacts of warm cooling water on the water areas and the tolerance of waters. Furthermore, the respondents wished for solutions to utilize cooling water instead of leading it into the sea. The suggested options were among others, utilization as district heat or locating the discharge place as far in the sea as possible. Cooling water was stated to cause eutrophication, harmful effects on fish stocks and lessen the natural and recreational value of shores. Related to the social impacts, information was asked for whether Loviisa and the surrounding municipalities would be willing to offer services and apartments to the construction workers of the potential new power plant unit and their families. The responses presented comments on both for centralizing and decentralizing nuclear power production.

Planning of the new power plant unit

The responses brought up the wish that the planning of the new power plant unit would especially take into consideration safety matters regardless of the cost. Active information on the issues and openness were also hoped for. Furthermore, it was wished that the planning would take into consideration the utilization of cooling water. A part of the respondents were of the opinion that instead of artificially warming the natural water areas, it would be wiser to investigate the opportunities to utilize the cooling water, which would also improve the image of the power plant.

The planning of the new power plant unit should also pay attention to traffic arrangements and, if necessary, the road leading to the Loviisa power plant should be made broader. The planning stage of the power plant unit should find solutions for saving the surrounding environment as much as possible. The planning should also determine monitoring obligation in the Loviisa region, both of impacts on the nature and the people. The monitoring should be regular. Any adverse impacts on, e.g., a trade or living, should be compensated appropriately. Some of the responses hoped for a domestic content as high as possible and reliable contractors if the new power plant unit would be constructed.

9.12.3 Attitudes to the project

The general attitude to Fortum's Loviisa 3 project was rather positive or neutral, even if some fear was felt. Women's attitudes were more critical and negative than men's. The attitudes of the respondents to the project have been shown in the Figure 9-17. 57% of men were for and 25% against the project. 53% of women were for and 26% against. 58% of holiday residents were for and 25% against the project. 53% of permanent residents were for and 26% against the project. The opposition was stronger among the Swedish-speaking respondents.

9.12.4 Most significant environmental impacts

Risk factors

In the survey the respondents were asked to name the risk factor which was regarded the most significant. The most significant risk factor according to 40% of the respondents

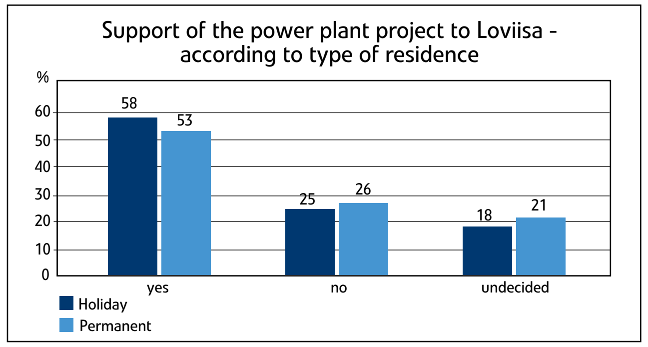

Figure 9-17. Support of Fortum's Loviisa 3 project (permanent residents and holiday residents, all respondents).

was an accident leading to radioactive releases and according to 28% the final disposal of nuclear waste. Other mentioned risk factors were human mistakes or failures in the power plant unit's safety functions, the pursuit of economical benefits beyond safety and external threats, such as eco-terrorism and demonstrations.

Impacts of the construction stage

In the resident survey responses, the most significant environmental impacts during the construction stage were impacts on waters and water quality, traffic arrangements and employment. The assessments to the respondents of the survey of the impacts of the power plant unit construction have been shown in the Figure 9-18.

Impacts during operation

In the resident survey responses, the most significant environmental impacts of the new power plant unit during operation were impacts on the water system, water quality and currents. The next most significant impacts were considered to be the impacts on employment and fish stock and the impacts of radioactive releases. The assessments of the respondents to the resident survey of the impacts of the power plant unit during operation have been shown in the Figure 9-19.

9.12.5 Comfort

Permanent settlement

In the resident survey an open question was used to inquire how the Loviisa power plant has affected comfort.

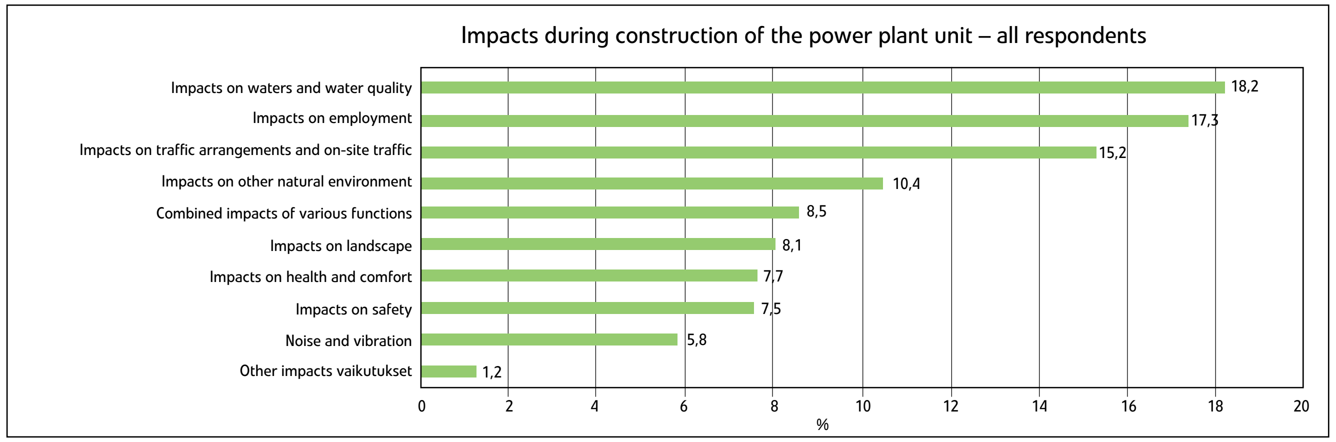

Figure 9-18. Most significant environmental impacts of the construction of a new power plant unit (all respondents).

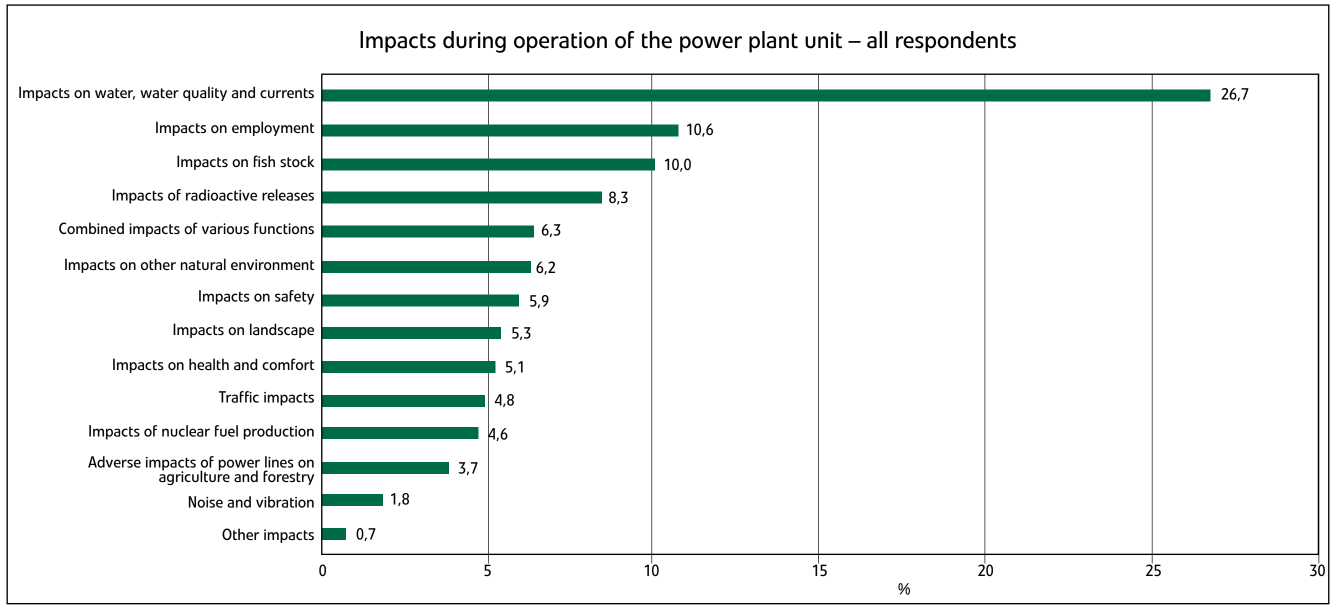

Figure 9-19. Most significant environmental impacts of the new power plant unit during normal operation (all respondents).

The most common response was that the power plant had not affected at all or had not disturbed comfort. The most common negative matter mentioned was a fear of a potential nuclear power plant accident.

The assessments of the respondents to the survey concerning the comfort of their living environment today and afterh the construction of the new power plant unit are shown in the figures 9-20 and 9-21. 96% of the female respondents and 94% of the male respondents regarded their living area at the moment comfortable or very comfortable. Only some of the respondents assessed that the new power plant unit would decrease the comfort of their living environment, since 73% of men and 63% of women assessed their living area to be comfortable even after the construction of the new power plant unit. The share of the respondents assessing their living area to be uncomfortable after the construction of the new power plant unit was 17% of men and 21% of women.

Leisure time habitation

In the resident survey, an open question was used to inquire how the Loviisa power plant has affected comfort. Holiday residents responded that the power plant had had both neutral and negative impacts on comfort. The negative impacts were connected especially with impacts on water. The warmed water was thought to have an adverse impact on the fish stock in the area and on fishing as a source of livelihood. In some responses also the noise and light originating from the power plant were seen as factors reducing comfort.

The assessments of the respondents to the resident survey concerning the comfort of their living environment today and after the construction of the new power plant unit have been shown according to the settlement type in the figures 9-22 and 9-23. 96% of the holiday residents who responded to the survey regarded their holiday settlement area at the moment comfortable or very comfortable. Some of the respondents assessed that the comfort of the leisure time settlement area would be reduced after the construction of the power plant unit, since 69% of holiday residents assessed the leisure time settlement area as comfortable or very comfortable after the construction of the new power plant unit.

At the moment only 3% of the responding holiday residents regard the leisure time settlement area as uncomfortable, whereas 18% assessed the leisure time settlement area as uncomfortable after the construction of the new power plant unit. 12% of the holiday residents could not

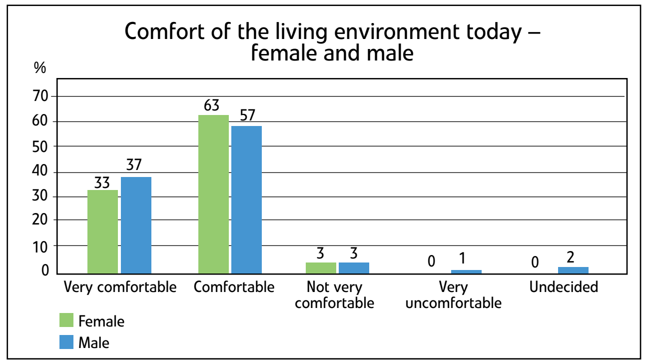

Figure 9-20. Assessment of the permanent residents concerning comfort of their living environment today (all respondents).

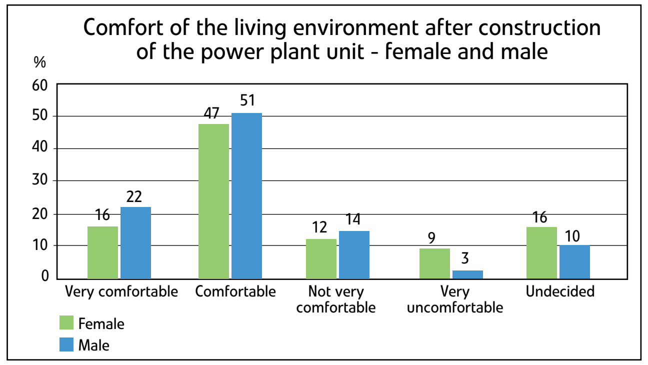

Figure 9-21. Assessment of the permanent residents concerning comfort of their living environment after the construction of the new power plant unit (all respondents).

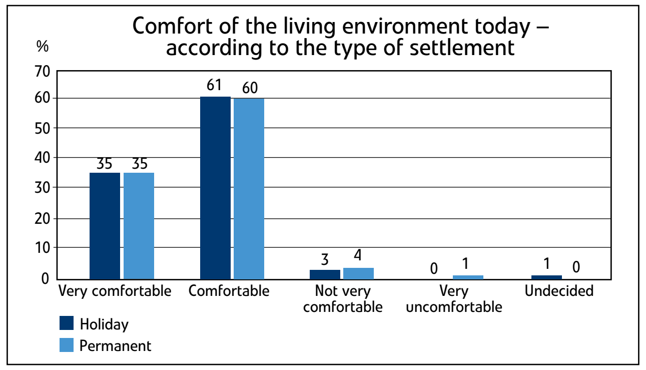

Figure 9-22. Assessment of holiday and permanent residents of the comfort of their living environment today (all respondents).

assess the comfort of their leisure time settlement after the construction of the new power plant unit.

9.12.6 Opportunities for recreation and leisure time activity

In the survey, an open question was used to inquire on which recreational or leisure time activities the respondent assessed the new power plant unit will have an impact. The most common answer was fishing. In addition to fishing, the new power plant unit was also thought to have an impact on boating and swimming. The responses also supposed that the increase of sea water temperature results in changes in the ice situation and deteriorates the opportunities to ski on the ice and to ice-fishing. The responses of the permanent residents and the leisure time residents were similar.

The assessments of the respondents of impacts on recreation and leisure time activities caused by the construction of the new power plant unit are shown in the Figure 9-24. 56% of the respondents assessed that the new power plant would have no impacts on the recreation or leisure time activity opportunities or other leisure time. 7% of all respondents assessed that the new power plant unit would have a positive or very positive impact on recreation or leisure time activity or other leisure time. 23% of the respondents assessed the impacts to be rather negative or very negative. There were no significant differences between the responses of permanent residents or holiday residents.

9.12.7 Other impacts

Need to move and value of real estate

In most cases the project is not estimated to increase the need to move away from the area. 13% of the permanent residents and 17% of the holiday residents estimated that the need to move would increase if the project is implemented. About 23% of the permanent residents believed that the project would reduce the value of their apartment and 15% believed that the value would increase. Most of the respondents did not believe that the project would have an impact on the value of the permanent settlement. 47% of the leisure time residents assessed that the value of leisure time settlement would decrease.

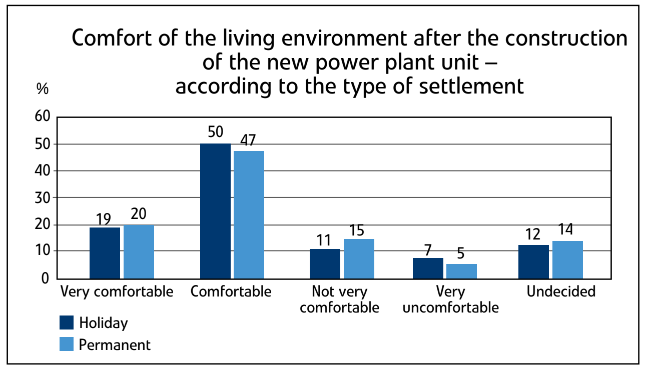

Figure 9-23. Assessment of holiday and permanent residents of the comfort of their living environment after the construction of the new power plant unit (all respondents).

Traffic and communication

67% of the respondents assessed that the new power plant unit would not have an impact on the traffic and means of communication. A little more than 10% of the respondents assessed that the new power plant unit would have a negative impact on traffic and means of communication.

Carrying on a trade

In the resident survey, entrepreneurs were in enquired of their assessment of the impact on carrying on their own trade. 26% of the respondents regarded the impacts positive. Men regarded the impacts somewhat more positive than women. Two thirds of the respondents assessed that the project has no significant impact on their own trade. 10% of all respondents assessed that the project had adverse impacts on carrying on their trade.

9.13 Health effects of new power plant unit during normal operation

9.13.1 Radiation doses of the residents in the vicinity

During normal operation of the new power plant unit, minor amounts of radioactive substances are released in a controlled manner, after treatment and delay, both into the air (see Chapter 9.3.1) and into the sea (see Chapter 9.4.10).

The radiation dose caused by the new power plant unit to the most exposed resident in the vicinity is estimated to be at the most about the same as the annual dose caused by the existing power plant units, 0.0003 mSv. Thus the total radiation dose caused by three power plant units annually to a person belonging to the most exposed population group is at the most 0.0006 mSv.

The radiation dose caused by the new power plant unit, combined with the existing power plant units to a resident of the vicinity is less than a hundredth of the annual 0.1 mSv radiation dose limit set for the operation of a nuclear power plant (Government decision 395/91) and less than a thousandth of the average radiation dose to a Finn. The radiation dose is so small that it has no immediate safety impacts on human beings. The safety impacts of a severe accident are discussed in Chapter 13.3 and the health effects

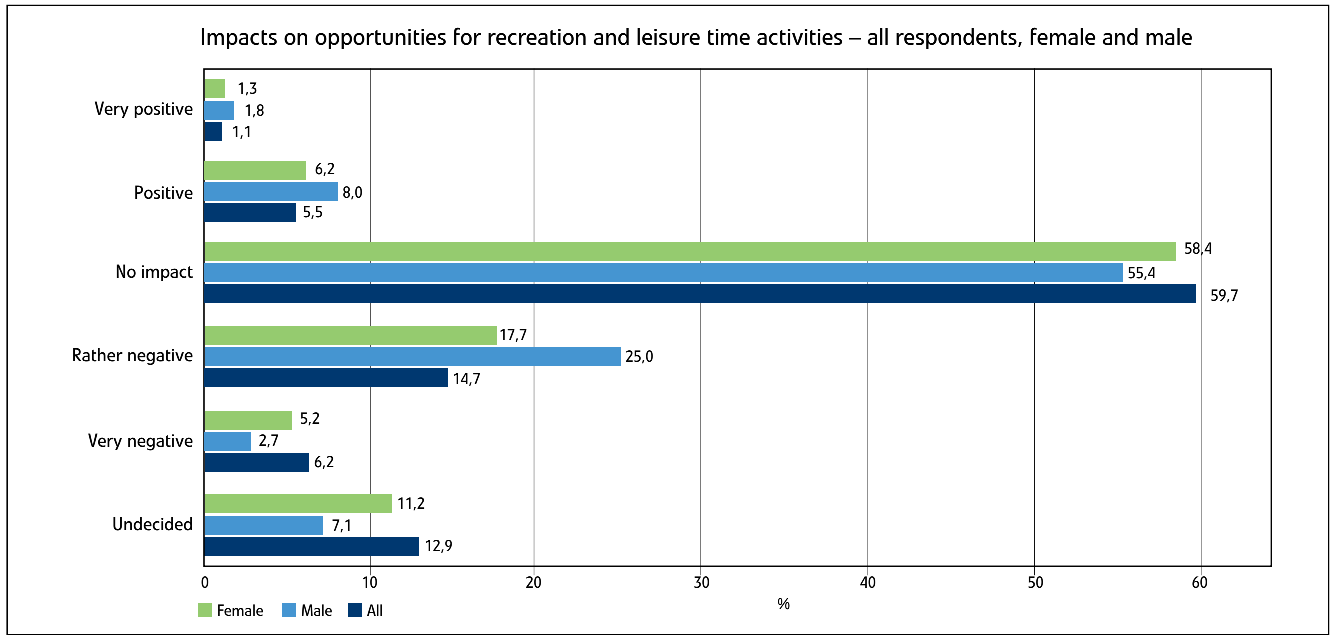

Figure 9-24. Assessment of the respondents of the impacts of the new power plant unit on the opportunities for recreation and leisure time activity (female, male and all respondents).

of radiation in general in Chapters 13.4 and 13.5.

9.13.2 Radiation doses to employees

The three principles of radiation protection in a nuclear power plant (ICRP 2007) are:

1) The alteration of the radiation situation must have more benefits than harm.
2) The radiation burden must be kept as low as possible taking into consideration economical and social factors.
3) Radiation dose limits must not be exceeded.

The first principle is related to the justification of work, for example a temporary radiation shield must decrease radiation doses more than is caused by its construction. The second principle requires constant improvement of radiation protection in a cost efficient manner. The third principle protects individuals, and the radiation dose limits must not be exceeded on any excuse.

The most powerful sources of radiation in the new power plant unit, such as the reactor, reactor coolant system and the treatment systems of radioactive waters and gases area located behind thick shields. The spreading of the radioactive substances released with potential leaks, are isolated by a closed drainage system and by maintaining a vacuum in the related rooms. The systems are controlled and the operation is monitored in a separate control room. The radiation protection of employees is also supported by activity measurements and continuous-operation alerting radiation meters.

The employees are exposed to radiation during work, e.g., maintenance and repair work, which are planned and monitored according to the power plant's radiation protection procedures. Unintended exposure to radiation is prevented by announcing radiation conditions by marking boards and by keeping the rooms of the most significant radiation sources locked. Contamination caused by radioactive substances is avoided using protective clothing, shoe covers and gloves, and when necessary, other protective equipment, such as respiratory protective equipment and multiple layers of protective clothing.

In the new power plant unit similar practices will be applied in the radiation protection of employees to those at the existing power plant units. The new power plant unit will be designed such that the radiation doses of employees will be, both during operation and maintenance, smaller than in the existing power plant units.

9.14 Impacts of related projects

The electricity produced by the new power plant unit will be transferred to the national grid by new 400 kV power lines, whose environmental impacts are assessed by the electricity transmission system operator Fingrid Oyj. The environmental impacts of the power lines required by the new power plant unit have previously been assessed in 2003 as part of the environmental impact assessment of the Loviisa-Hikiä 400 kV power transmission line project (*Fingrid 2003*). It was not known then that the existing 110 kV backup connection of the Loviisa power plant would not probably be adequate for the needs of the new power plant unit. When the construction of the new power plant unit is implemented, Fingrid will update the environmental impact assessment of the Loviisa-Hikiä 400 kV power transmission line project.

The existing backup connection of the Loviisa power plant comes via the regional grid from Koria, which is connected to the main transmission grid. The new connection, which has significantly higher transmission capacity than the existing backup connection requires a connection to the higher-capacity grid and another 110 kV power transmission line.

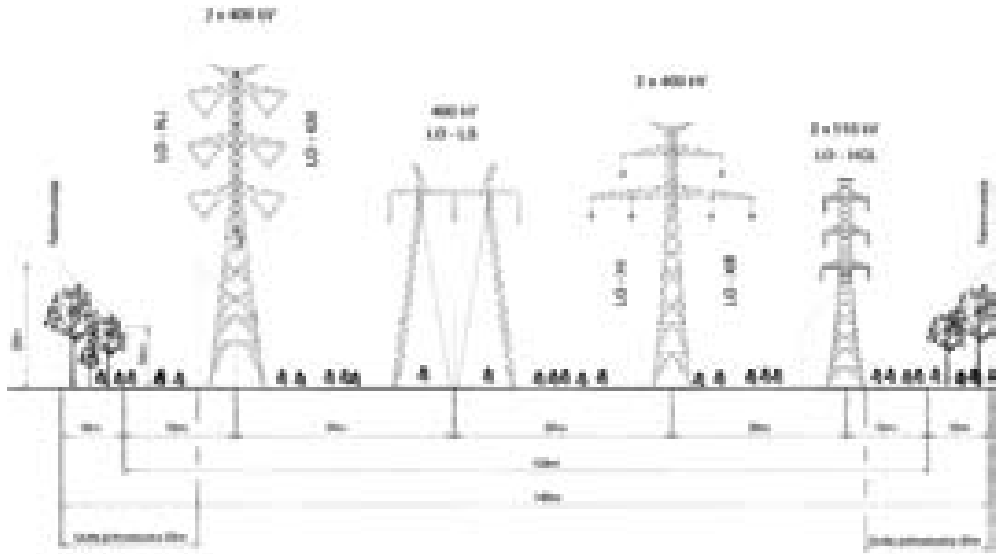

Figure 9-25. The cross profile of the planned power transmission line area in the vicinity of Hästholmen as seen from south to north. (Fingrid)

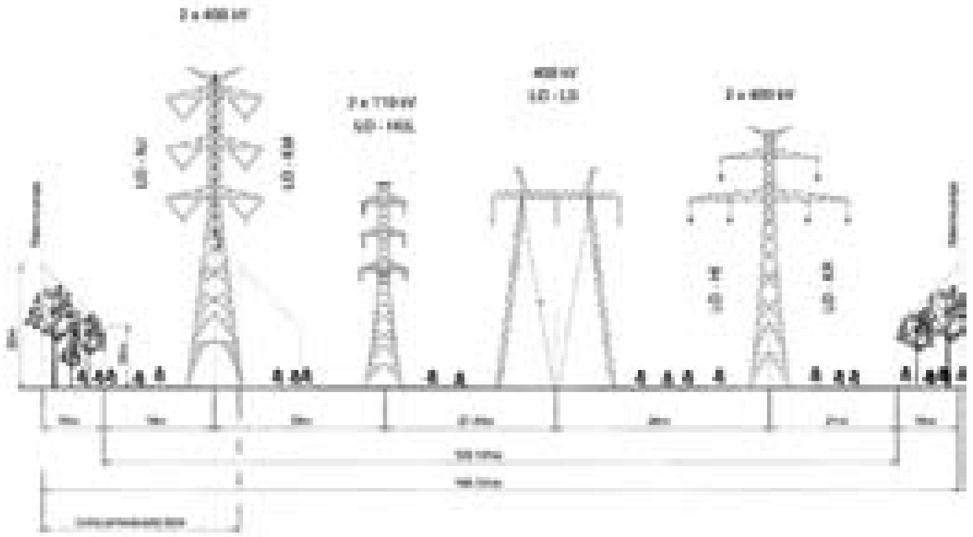

Figure 9-26. Cross profile of the planned power trasmission line area by the side of Atomitie road as seen from south to north. (Fingrid)

It is possible to implement the backup connection by replacing the existing 110 kV power transmission line with new, 110 kV two-circuit power transmission line installed on power transmission line towers and by connecting the new power transmission line with higher capacity to the main transmission grid. The connection to the main transmission grid will take place in the Hagalund switch yard located on the northeastern side of Loviisa. The line route of the backup connection between the power plant and Hagalund switching station is the same as that of the existing 110 kV power transmission line. Due to the new 400 kV power transmission lines the power transmission line area in the vicinity of Hästholmen will change. The new 110 kV power transmission line towers in the area also require that the existing power transmission line area be made 20 metres broader to the east in a section less than one kilometre long (Figure 9-25). As a result, the new 110 kV power transmission line towers are located in the Hagalund switch yard to the existing line area. The cross profile of the planned power transmission line area by the side of road Atomitie is shown in the Figure 9-26. The existing power transmission line area north of road Saaristotie has been shown in the Figure 9-27.

Compared to the environmental impacts of the construction of the new 400 kV power transmission lines (Fingrid 2003), the environmental impacts of the capacity increase of the 110 kV backup connection are small. The impacts of the new 110 kV power transmission line towers on the landscape and the need for land use are small.

The electricity transmission system operator Fingrid is also responsible for the need of disturbance reserve on a national level by virtue of the system responsibility. Fingrid owns the gas turbine plant located in Hästholmen, which is a part of the national disturbance reserve. The need for new reserves and backup power depends on the size of the new power plant unit, the total development of production capacity and the development of electricity import and export. The location of the disturbance reserves must be considered as a whole. The potential new disturbance reserve located at Hästholmen will be taken into consideration in the land use planning and may require an EIA procedure of its own.

Figure 9-27. Existing power transmission line area as seen from Saaristotie road, from south to north.

9.15 Summary of the impacts on comfort, recreation and living conditions

The implementation of the new power plant unit at Hästholmen, south of the existing power plant units will not significantly change the character of Hästholmen and the surrounding areas. The public image of Loviisa as a nuclear power plant location will be strengthened with the new power plant unit. According to a resident survey, the general opinion towards Fortum's Loviisa 3 project is positive both among the permanent and leisure time residents.

The changes to landscape caused by the new power plant unit are most significant when looking from the sea. The leisure time residents will notice the change in the evenings and nights as increased illumination in the power plant area. The implementation of the 400 kV and 110 kV power transmission lines required by the new power plant unit will be located in the existing power transmission line area and next to it. The adverse impacts caused by landscape changes are mainly focused on the leisure time residents in the vicinity of Hästholmen.

The impact of the operation of the new power plant unit on the noise level of the surroundings of Hästholmen is small and the noise exceeding the guideline values hardly spreads to new areas. During nights, the 40 dB noise level may be exceeded in the Saukontie holiday house area. If the new power plant unit is a pressurized water reactor plant, the testing of the safety valves in the steam system will cause a short noise impact, which extends to a distance of a few kilometres. The testing is announced in advance in the local newspapers.

In the winters the warm cooling waters of the new power plant unit will expand the ice-free area and the area of thin ice off Hästholmen. This will complicate movement and fishing on the ice. On the other hand, the open water fishing season lasts for a longer time. In the summer the impacts of warm cooling water depend on the cooling water intake and discharge place. The extension of the growing season increases biological production.

The traffic during the operation of the new power plant unit and the resulting noise and exhaust gas emissions are very small, and thus they do not cause any significant impacts on the residents of the area. The transports of spent fuel to the repository of Posiva at Olkiluoto will be carried out in a manner that fulfils the safety requirements, either by road, rail or sea.

9.16 Impacts focused on the energy market and reliability of energy supply

The Nordic countries form a uniform electricity market area, with high-capacity electricity transmission connections between the countries, which can be further strengthened, and where the market price of electricity is quoted in the common Nord Pool electricity exchange. From the Nordic countries, electricity is also traded to the Netherlands, Germany, Poland, Estonia and Russia. The electricity production structures of the Nordic countries supplement each other. In Sweden and Finland, nuclear energy production and the combined electricity and heat production cover the year-round need for base-load power. Hydropower, which is mainly centred in Norway and Sweden, covers daily variations in electricity consumption and wind power production. The combined electricity and heat production using fossil and renewable fuels covers the additional need for electricity during winters and in years of low rainfall levels.

The new power plant unit is a base-load plant, whose construction will decrease the dependence of Finland on imported electricity and increases the supply in the electricity market. Stable production costs are a characteristic of a nuclear power plant, which improves the predictability of the electricity market.

The adequacy of the electricity production capacity and the delivery reliability of fuel are the central issues related to the reliability of energy supply. Problems may occur in very exceptional situations of the world economy or in potential political crises. In normal situations there are no problems with the availability of nuclear fuel. A part of the nuclear fuel is replaced after one-two years. Fresh fuel is stored in the power plant, usually an amount which corresponds to the amount of one refuelling.


Dragonflie, Loviisa, Valko

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10 EFFECTS OF THE POWER PLANT UNIT DECOMMISSIONING

10.1 Decommissioning alternatives

The decommissioning of a nuclear power plant can be carried out either immediately or after a delay, even after a long period of time since the operation of the plant has ended. The benefit brought by delayed decommissioning is that the activity of radioactive substances decreases due to radioactive decay. The problem of this solution is that during the decommissioning the operating personnel of the power plant will no longer be available.

The decommissioning can be done either partially or totally. In partial decommissioning only radioactive parts and constructions are dismantled and the rest of rooms and buildings are left unchanged, so that they can be used for any later purposes. Some buildings of the power plant can possibly be needed a long time after the end of energy production, even though no new operation would be started. Buildings can be pulled down, as they become unnecessary.

A plan has been drawn up for the decommissioning of the existing power plant units in Loviisa (*Kallonen et al., 2003*), according to which the decommissioning will be carried out immediately after the shutdown of the power plant. In that case the personnel who know the power plant thoroughly will still be available. The construction of a new power plant unit gives an opportunity to reconsider the decommissioning of the existing power plant units, also with a delay, since the personnel of the new unit as well as the new infrastructure can be taken advantage of.

The existing power plant units are planned to be decommissioned partially. After the partial decommissioning, e.g. the solidification plant and the interim store for spent fuel can be extended, if necessary, and used for supporting the operation of the new power plant unit and for waste management. The existing plants' store for spent fuel will be needed 20 years after the end of energy production.

The decommissioning of the new power plant unit is planned to be carried out immediately after the operation of about 60 years using a plan similar to the one that the existing power plant units have. During the decommissioning the need for personnel will be about 200-400 people, depending on the phase and the method of implementation.

As regards the existing power plant units, preparations have been made for covering the costs of decommissioning by paying the annual nuclear waste management fees to the State Nuclear Waste Management Fund, in accordance with the Nuclear Energy Act. Corresponding action will be taken regarding the new power plant unit.

10.2 Decommissioning

If the decommissioning method chosen for the new power plant unit is complete dismantling, most of the waste originating from the decommissioning will be construction and metal waste that can be recycled or, when not recyclable, taken to the waste disposal site. A minor part of the waste must nevertheless be managed and taken to the repository as low- and intermediate-level waste.

During the operation of a nuclear power plant the components exposed to intense neutron radiation become activated (become radioactive). Such components include, e.g., the reactor pressure vessel with its internals and the radiation shield surrounding the pressure vessel. In addition, the surfaces of some components become contaminated. Components that become contaminated are, e.g., steam generators or turbines, depending on the reactor type, some heat exchangers and tanks for radioactive water. Also the equipment used for the cleaning, repair and dismantling of those components can become contaminated. The aim is to clean the contaminated components and equipment and exempt them from regulatory control. The components that remain radioactive are taken to the repository as low- and intermediate-level waste.

During the dismantling, the radiation protection of the personnel is ensured in the same way as during normal operation and maintenance. The work phases are planned such that the radiation exposure of the workers is kept as low as reasonably possible. When dismantling the most activated components, remote-controlled equipment and protection against the spreading of activity and releases are used, if necessary. The components are transported to the repository inside a radiation shield.

Planning of the decommissioning of the new power plant unit will begin as early as the construction stage and the planning will be specified during operation. Preparations for the decommissioning will be started as soon as the plant operation has ended, and the actual dismantling will begin in a few years. Before the dismantling, fuel is removed from the reactor and the water circulation systems and fuel pools in the reactor building are emptied and decontaminated. The water used for the cleaning is cleaned with the help of ion exchangers or evaporators. The dismantling of activated components is started by removing the reactor pressure vessel. After that, other activated metal components are dismantled and activated concrete structures are dismantled. All of these are taken to the repository for low- and intermediate-level waste. The reactor pressure vessel and its internals are covered with a radiation shield during the transport. When the spent fuel has been transported to Posiva's final disposal facility, the spent fuel interim storage and the rest of systems and buildings that have become useless owing to the ending of the interim storage operation are dismantled.

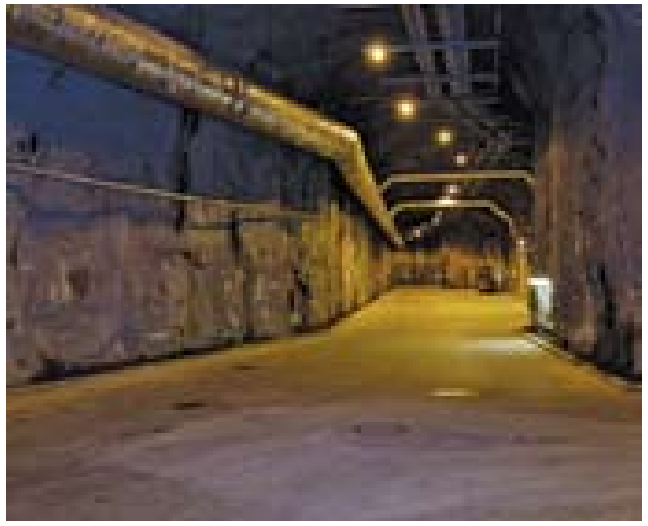
The estimated volume of the decommissioning waste from Loviisa's existing power plant units is altogether some 15 000 m^3 and the total activity two years after the shutdown will be some 200 000 TBq (*Kallonen et al., 2003*). The amount of decommissioning waste from the new power plant unit (estimated at 20 000 m^3) and especially its activity depend on the reactor type and power. A separate repository will be excavated for the decommissioning waste or the current repository for low- and intermediate-level waste will be extended.

10.3 Environmental impacts of the decommissioning

The dismantling of the new power plant unit's clean (non-radioactive) systems and constructions and their transport to the waste disposal site causes dust, noise and vibration effects. The transports increase the number of heavy vehicles in road traffic.

10.4 Safety of the final disposal of decommissioning waste

The nature and activity of decommissioning waste is mainly similar to operational waste and the safety case for its final disposal has been done in the same way as that of the operational waste (Chapter 9.7.2). The latest safety case of the decommissioning of Loviisa's existing power plant units (*Kallonen et al., 2003*) has examined, e.g., the radiation safety of the dismantling and the long-term safety of final disposal of waste. The study shows that the safety requirements set for the final disposal by authorities are fulfilled.



The highest radiation doses would be caused by final disposal if, in the future, the existence of the repository was possibly forgotten and a deep drill well were drilled in the immediate vicinity of the repository and, despite its natural salinity, the water were used as drinking and irrigation water. The activity released from the decommissioning waste of the existing power plants placed in the repository to watercourses is insignificant. The activity released to groundwater is minor and in the calculated cases remains below the activity of the naturally radioactive substances in the environment.

The radiation burden caused by the decommissioning waste of the new power plant unit will be affected by, e.g., the activity of the waste to be disposed of and the location of the extensions to the repository in the bedrock. The methods used for final disposal will be chosen such that effects on people's health and the environment will be insignificant.

10.5 After the decommissioning

After the decommissioning and dismantling of the new power plant unit, no polluted land or other residues endangering safety will remain on the island of Hästholmen. The power plant area can be utilized for energy production or other purposes. It will also be possible to return the area to its natural state if all industrial operation ends. Adequate notes of the location of the repository for radioactive waste will be made to the regional and local land use plans.


Cranberry, Pyhtää
© Timo Lindgren


Great spotted woodpecker, Loviisa

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11 THE IMPACTS OF NON-IMPLEMENTATION OF THE PROJECT

If the project is not implemented, Fortum will keep the area in Hästholmen for later additional building of nuclear power. The non-implementation of the project leads to a situation where the unrealized production will have to be replaced by other, more expensive electricity production forms or by electricity import in the coming decades. In addition, non-implementation of the project will complicate targets to replace outdated coal power capacity with carbon-free electricity production capacity in due course.

11.1 Impacts on the Loviisa region

Not building a new power plant unit would have impacts on, e.g., employment, tax income, purchasing power population development and infrastructure in the Loviisa region. Besides the town of Loviisa, the impacts would extend to the neighbouring municipalities. The impact would be especially significant at the stage when the existing power plant units in Loviisa will be decommissioned, which will happen during the planned operation period of Loviisa 3.

11.1.1 Environmental impacts

From a local point of view, non-implementation of the project means that the environmental impacts of the new power plant unit assessed in this report are not realized. The present state of the environment and the current environmental burden mainly remain as before, as long as the existing power plant units in Loviisa are being operated. The present state of the environment has been described in Chapter 7.

The immediate environmental impacts of the non-implementation of the project are directed, instead of the Loviisa region, to the nearby areas of alternative fuel sources or power plants producing electricity, either in Finland or abroad. The impacts of sulphur dioxide, nitrogen oxide and particle emissions caused by the use of fossil fuels are local but the impacts of carbon dioxide emissions are global.

11.1.2 Employment and other demand

With non-implementation of the project an economically active period with its direct and indirect impacts will be missed in the Loviisa region. The impacts are both direct and indirect. The non-implementation of the project will not improve employment situation in the Loviisa region, stimulate the region's economic life or vitalize the service sector and house building.

11.1.3 Population development

The non-implementation of the project will affect population development in the Loviisa region. If the project is not implemented, the population growth in the region will be smaller, because the migration of the operating personnel, permanent contractors and the needed indirect service providers to the Loviisa region is not realized. In the Loviisa region this means that removals of some 200 families will not take place.

11.1.4 Tax income

With non-implementation of the project, the Loviisa region will not get new taxpayers of the employees of the new power plant, providers of external services and their family members. For the town of Loviisa this means that several million euros of municipal tax revenue at most fail to be collected annually. Increases in tax income will also be unrealized in other municipalities of the region. The town of Loviisa will not get new real estate tax income either, and the foundation for corporation tax will not expand.

11.2 Alternative forms of electricity production

If the project is not implemented, the electricity need of the market is met by other projects. Reliable prediction of the location or production technology of alternative projects is not possible.

The European Union has set a goal to produce 20% of the energy consumption using renewable sources of energy by 2020. The goal set for Finland was to increase the proportion of renewable energy from 28.5% to 38% and outside the emissions trading sector to reduce greenhouse gas emissions by 16%.

Information on alternative electricity production forms is available in, e.g., the publications of the Association of Finnish Energy Industries and the Ministry of Employment and the Economy (*Finnish Energy Industries 2007, KTM 2007*).

11.2.1 Coal

Coal is a fossil fuel, suitable for both condensing power and combined electricity and heat production. In Finland, the use of coal as the main fuel is centred in the large condensing and district heating power plants on the coast. The condensing power plants have great significance for covering the seasonal variation in the electricity need and the annual variation in hydropower. In the last few years, coal has accounted for more than 10% of Finland's primary energy consumption and for 11–21% of the electricity consumption. There are no coal reserves in Finland. The environmental impacts of coal production are focused on the production areas abroad.

The burning of coal causes carbon dioxide, sulphur dioxide, nitrogen oxide and particle emissions. The present limits on sulphur dioxide, nitrogen oxide and particle emissions are met at the coal-fired power plants by improved combustion technology and the cleaning of flue gases. However, carbon dioxide emissions from the use of coal cannot be removed cost-efficiently using existing methods. The capture and storage technology of carbon dioxide (Carbon Capture and Storage, CCS) is supposed to be developed to a commercial level by the 2020s, which might globally open new opportunities to combat climate change. Fortum will study ways of recovering carbon dioxide at the Meri-Pori coal-fired condensing power plant.

The by-products from burning coal and cleaning flue gases, especially ash and gypsum, can be utilized as a material for landscaping and in the manufacture of plasterboard. 60% of the by-products can be recycled.

The increase in the proportion of renewable energy sources, in accordance with the goals set by the European Union, will probably reduce the use of coal in the future and lessen the chances of building new coal-fired power plants in Finland. At present, several large coal-fired power plants are being constructed and planned elsewhere in Europe.

11.2.2 Water

Hydropower is a renewable energy source. Finland has altogether about 3 000 MW of constructed hydropower at more than 200 hydroelectric power plants. In the last few years, hydropower has accounted for 10-20% of the electricity consumption in Finland, depending on water conditions.

The environmental impacts of hydropower are mainly caused by dams, which prevent fish from migrating to spawning areas, and by regulation. On the other hand, the regulation of hydropower has been used for preventing floods, thus decreasing the harm done by them. In practice the use of hydropower causes no solid waste or emissions into the air, water or soil.

The best hydropower sites have already been either harnessed or protected. Finland has about 1700 MW of exploitable hydropower. Of this, about 930 MW is suitable for quick regulation of electricity generation, and 270 MW is other hydropower available for development. The rest is located in border rivers or is theoretical, not feasible to be constructed. In unprotected rivers, the amount of hydropower suitable for quick regulation is 370 MW, 260 MW of which is power upgrading potential of the existing hydropower plants, which can be realized, e.g., in the refurbishment projects. Economically feasible hydropower, which is located in protected water systems, amounts to about 570 MW. Construction of these waters would require reversing the decision on the protection. (*Finnish Energy Industries 2008*)

11.2.3 Wood

Wood-based fuels are renewable sources of energy, which are especially used in the combined electricity and heat production of forest industry, where the fuel fractions produced from timber harvesting and processing, such as black liquor, bark, felling residue, wood chips and sawdust, can be utilized. In recent years, wood-based energy has accounted for about 20% of the primary energy consumption and for about 10% of the electricity consumption in Finland. Wood is a domestic fuel but it is also imported as raw material for the forest industry and for the needs of the energy industry. The environmental impacts of timber cutting are focused on production forests.

The burning of wood causes carbon dioxide, sulphur dioxide, nitrogen oxide and particle emissions. The emissions are smaller than those from burning coal and peat. The carbon dioxide emissions do not add to the carbon dioxide content of the atmosphere, since the rotting of wood would result in carbon dioxide in any case. The renewing forest also binds the carbon dioxide released in the combustion process. Emissions are controlled by combustion and flue gas cleaning technologies.

In Finland, the use of wood-based fuels for energy production will be increased substantially to reach the goals the European Union has set for Finland. The increasing use of wood-based fuels decreases the proportion of fossil fuels in energy production. The limited availability of wood-based fuels and the transport distances restrict their use as fuel.

11.2.4 Natural gas

Natural gas is a fossil fuel which is especially suitable for combined electricity and heat production. At natural gas-fired power plants much more electricity can be produced per the same amount of thermal energy than at power plants using solid fuel. In recent years, natural gas has represented about 10% of the primary energy consumption and 11% of the electricity consumption in Finland. Finland has no natural gas reserves. The environmental impacts of natural gas production are focused on the production areas abroad.

The burning of natural gas causes carbon dioxide and nitrogen oxide emissions. The emissions per produced energy unit are smaller than in the burning of coal or peat.

In Finland, the price of natural gas, in the first place, reduces profitability of the use of natural gas in separate condensing power production and no profitable implementation opportunities seem to exist at the moment. In addition to the price of natural gas, the limited scope of heat applications and the possibility of delivering natural gas only to southern Finland reduce the growth potential in the use of natural gas for combined electricity and heat production. Several large natural gas-fired power plants being are built and planned elsewhere in Europe at the moment.

11.2.5 Peat

Peat is a slowly renewing biofuel, with a regrowth rate of 2 000-3 000 years. Nevertheless, it is not counted as a renewable energy source in accordance with the targets of the European Union. Peat is mainly suitable for being one of the fuels at multi-fuel power plants, used for combined electricity and heat production, in the inner and northern parts of Finland. In the last few years, peat has accounted for 5-8% of the consumption of both primary energy and electricity in Finland. Peat is a domestic fuel. In Finland there are an estimated 1.4 million hectares of peat bogs suitable for peat production. Environmental impacts on the peat production areas include the harm caused by dust and particles, harmful effects on the landscape, and direct impacts on nature and watercourses.

The burning of peat causes carbon dioxide, sulphur dioxide, nitrogen oxide and particle emissions. The emissions are controlled by combustion and flue gas cleaning technologies.

At present, the use of peat in condensing power production is not expected to increase in Finland, due to the targets set for carbon dioxide emissions and the use of renewable energy sources. The use of peat has impacts related to regional policy and employment. Transport costs limit the use of peat in southern Finland.

11.2.6 Oil

Oil is a fossil fuel, which is used in Finland mainly in traffic, industry and oil heating in households, and at power plants as start-up, reserve and support fuel. In the last few years, oil has made up more than 20% of the primary energy consumption and about 2% of the electricity consumption in Finland. There are no oil reserves in Finland. The environmental impacts of oil production are focused on the production areas abroad, but the risks of oil transport also threaten the coast of Finland. The burning of oil causes mainly carbon dioxide, sulphur dioxide, nitrogen oxide and particle emissions. In Finland the use of oil for electricity production is not expected to increase.

11.2.7 Waste

In recent years, the proportion of waste of the electricity consumption in Finland has been about 1%. In Finland the use of waste as fuel is increasing. However, the amount of waste limits its use to small power plants with combined production of electricity and heat. Waste is also used to some extent as additional fuel at other power plants. Elsewhere in Europe the utilization of waste in energy production is substantially more common than in Finland.

11.2.8 Wind

Wind power is a renewable form of energy with no emissions into the air, water or soil. This is why efforts have been made to promote the use of wind power. The main problems with wind power are the high investment costs and the dependence of electric output on the strength of wind. In Finland, there was altogether 110 MW of constructed wind power at the end of 2007. Wind power accounted for about 0.2% of the electricity consumption in Finland in 2007.

The main environmental impact of wind power is focused on the landscape. A wind power plant exceeds the noise standard value, set for built-up areas, at a wind velocity of 8 m/s at a distance of 200–300 metres.

The production potential for and costs of wind power were studied in Finland in 2007 (*KTM 2007, Finnish Energy Industries 2007b*). According to the Ministry of Trade and Industry, if the present financial support policy continues, the production of wind power will increase to be fivefold compared with the present situation by 2020. With substantial support, the production of wind power could increase to even twenty times as much as at present. The profitability of large investments in wind power requires a considerable increase in the financial support. Not even any significant increase in wind power would meet the growing need for electricity in Finland. Elsewhere in Europe the wind power capacity is being increased considerably.

11.2.9 Solar energy

Solar energy is a renewable form of energy with no emissions into the air, water or soil. The power of solar radiation to the Earth is 170 000 TW. Despite the notable amount of energy, only a fraction of solar radiation can be utilized, but even that would fill the energy needs of humankind.

The costs of solar energy continue to be multiple compared with the present forms of electricity production. In Finland, the use of solar power is also limited by the seasonal changes in solar radiation and it is mainly suitable for the electrification of places outside the electrical network. Solar power is not expected to become profitable in Finland.

11.2.10 Others

Several new forms of electricity production are being devel-

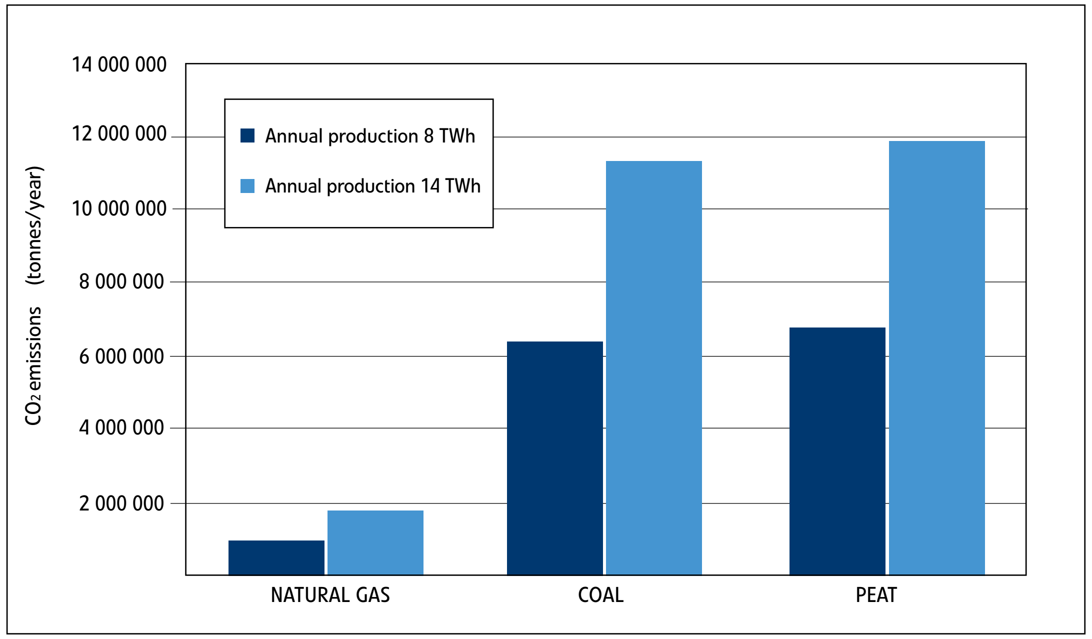

Figure 11-1. Carbon dioxide emissions caused by annual production of 8 and 14 TWh using natural gas, coal and peat (tonnes/year).

oped, such as fusion power and wave energy. Nevertheless, they are not expected to be fit for substantial construction of new production capacity in the near future. Fortum supports the research and development of fusion power and has invested in research projects of wave energy.

11.3 Emissions into the air

If the project will not be implemented, the amount of electricity corresponding to the production of the new power plant unit will be probably produced by a combination of fossil fuels, peat and renewable energy sources. Renewable energy sources will not, wood excluded, produce emissions into the air. The use of natural gas, coal or peat will cause both carbon dioxide and other emissions. Carbon dioxide emissions caused by annual production of 8 and 14 TWh using natural gas, coal and peat are presented in the Figure 11-1.

Sulphur dioxide, nitrogen oxide and particle emissions in accordance with the emission limits set in the Government's LCP Decree (Large Combustion Plants) for the annual production of 8 and 14 TWh using natural gas, coal and peat are presented in the Figure 11-2.

Generating the annual electricity production of the new nuclear power plant unit, 8-14 TWh, using coal or peat leads to significant carbon dioxide, sulphur dioxide, nitrogen oxide and particle emissions. Natural gas will cause by far the least emissions per generated energy unit.

Impacts of sulphur dioxide, nitrogen oxide and particle emissions are local, but impacts of carbon dioxide emissions global. Nuclear power production will not cause carbon dioxide, sulphur dioxide, nitrogen oxide or particle emissions.

11.4 Import of electricity

The import of electricity is an alternative to domestic electricity production. Electricity can be imported to Finland from the Nordic electricity market, Russia and via the Estlink connection from the Baltic countries. In the last few years, imported electricity has covered 12-20% of the electricity consumption in Finland.

The import price of electricity is expected to increase in the future since the need for electricity grows in other countries, emissions allowances become more expensive and the price of the natural gas used for electricity production in Russia will rise to a market-based level.

The Nordic transmission connections between Sweden and Finland will be reinforced with the Fenno-Skan 2 cable connection, which will be put into use in 2011, and by a planned third 400 kV overhead line connection between northern Sweden and northern Finland. A new Estlink 2 cable connection has been planned between Estonia and Finland.

11.5 Energy efficiency and saving of electricity

Finland's first national energy efficiency action plan (NEEAP-1) according to the Directive on energy end-use efficiency and energy services (ESD), which came into force in May 2006, was submitted to the European Commission in June 2007. Fortum's aim is, for its part, to enhance energy use to achieve the energy savings target of nine per cent set in the directive for 2008-2016.

In accordance with to the goals set by the European Union, Finland aims to promote energy efficiency and mitigate the

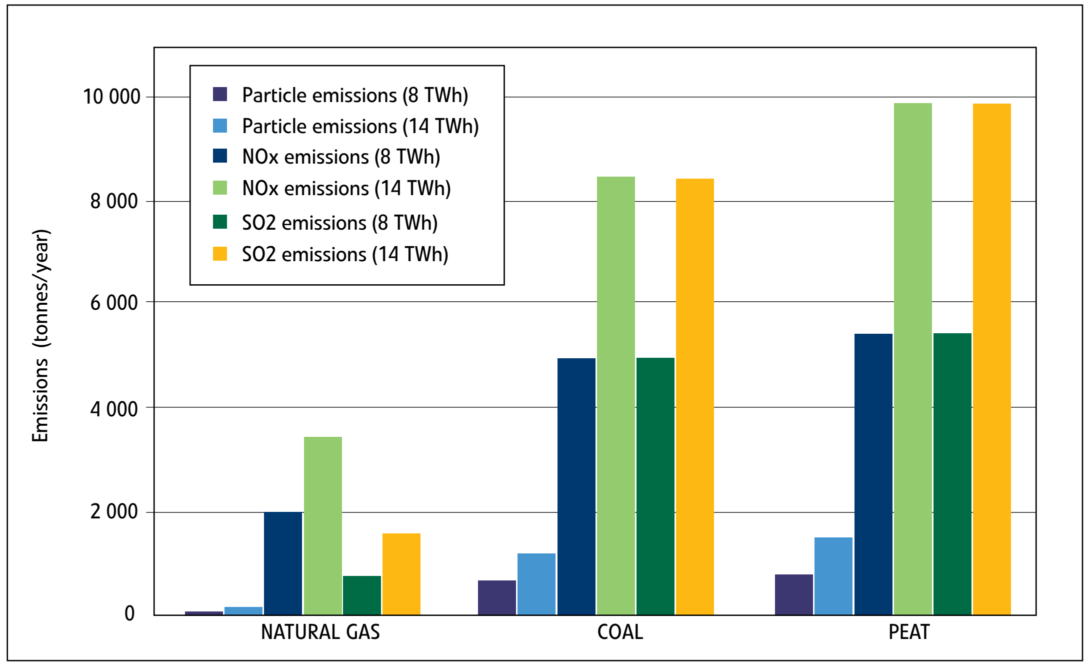

Figure 11-2. Sulphur dioxide, nitrogen oxide and particle emissions in accordance with the emission limits set in the Government's LCP Decree (Large Combustion Plants) for the annual production of 8 and 14 TWh using natural gas, coal and peat (tonnes/year).

adverse impacts of energy production. Electrically operated systems often have a considerably better efficiency in energy use than the direct use of fuels. By using electricity, the total consumption of energy can be decreased, even though the use of electricity grows at the same time.

A study by the European co-operation organization in electrical engineering, Eurelectric, assesses that e.g. in traffic, significant improvements can be brought about in the efficiency and environmental impacts of energy use by increasing the proportion of electric public transport and bringing plug-in hybrid cars into use.

Fortum's potential to improve energy efficiency and save energy focus on

- improving energy efficiency further in our own power plants and operations
- supporting customers to enhance energy use and to save energy
- public communication and informing people of the importance of energy saving.

Fortum takes all these actions in the Nordic power market. Fortum's central target is to decrease adverse environmental impacts of electricity production by saving energy, by investing in renewable energy sources and by constructing carbon-free production like, e.g., nuclear power.

In electricity production, energy efficiency is an important part of normal operation. With the help of maintenance, the condition of the equipment is monitored and maintained, and energy analyses are carried out to find areas of improvement to increase the efficiency of power plants or to decrease the energy consumption of power plants.

Fortum (Imatran Voima Oy at that time) signed the energy saving agreement for the Finnish power plant sector in 1997, and the agreement was extended by an energy efficiency agreement for years 2008–2016. The system includes a plan to improve energy efficiency, targets, monitoring of the annual energy consumption and annual reporting. The projects implemented in Fortum help to avoid carbon dioxide emissions of 3-4 million tonnes annually. The most significant projects have been the power upgrades of nuclear power and hydropower, the increase of combined heat and power production and fuel changes,. The Ministry of Trade and Industry rewarded Fortum Power and Heat Oy in 2002 as the Energy Saving Agreement company of the year.

According to its Sustainable Development Strategy, Fortum has established on 1 January 2008 a new unit for energy efficiency solutions in the Service Business Unit. The aim is to provide expert and consulting services related to energy efficiency for energy producers, distributors and end-users. Fortum has started a project called "Energihjälpen" in Sweden and the purpose is to expand the activities to Finland during 2008. The project provides free-of-charge guidance on energy saving for small enterprises, households and individual persons. In addition, plenty of information about energy efficiency and energy saving is available on Fortum's Web pages.

Fortum also invests in capital funds for clean energy technologies to promote the research of environmentally friendly energy technologies. The funds invest in companies that develop technologies contributing to energy efficiency, performance and productivity. An important goal is that the technologies also cut costs, energy consumption, and the amount of waste or emissions.


Bird cherry, Loviisa

© Timo Lindgren

12 NUCLEAR SAFETY

Nuclear electricity has been produced in Finland responsibly and safely for as long as thirty years. During these years, experience has been gained in the operation of a nuclear power plant to complement the training, and high-quality know-how has been acquired. Systematic domestic research and international co-operation have been and will be done in the field of the safety of nuclear power, not only in power companies but also in universities and research institutes.

The use of nuclear energy for electricity production is associated with a concern for the possibility of different incidents and accidents and the environmental impacts of potential radioactive releases in those situations. For preventing accidents and limiting their consequences, high safety culture and special safety principles and regulations are complied with in the design and operation of nuclear power. The use of nuclear power requires a licence and it is regulated by laws. The Finnish Radiation and Nuclear Safety Authority (STUK) controls all stages of the use of nuclear energy, starting from the planning of nuclear facilities, all the way to the decommissioning and the final disposal of radioactive waste.

12.1 Safety requirements

The safety requirements related to the use of nuclear power are based on the Finnish Nuclear Energy Act (990/1987), according to which the use of nuclear energy must be safe and it shall not cause injury to people or damage to the environment or property. According to the Nuclear Energy Act, the party having a licence to operate a nuclear facility is called a licensee.

The Nuclear Energy Act contains the principles and essential procedures for assuring safety. The Nuclear Energy Act also sets requirements for the licensing procedures, safety control and nuclear waste management of nuclear facilities, such as nuclear power plants, research reactors and nuclear waste storages. The regulations of the Nuclear Energy Act are specified in the Nuclear Energy Decree (161/1988). The general nuclear safety regulations are issued in Government Decisions (VNp 395/91, 396/91, 397/91, 398/91 and 478/1999), which cover the various fields of safety in the use of nuclear energy. The legislation regarding nuclear safety is further specified by the Regulatory Guides on nuclear safety (YVL Guides) by the Radiation and Nuclear Safety Authority, which set detailed safety standards for all fields significant in terms of safety. When compiling the legislation regarding safety and the YVL Guides, international safety requirements, such as the instructions by the International Atomic Energy Agency, IAEA (*IAEA 2007*), have been taken into consideration. The Nuclear Energy Act together with the relevant regulations and instructions determine the minimum level for the safety of nuclear facilities. Compliance with the detailed safety regulations is assessed separately for each power plant unit.

The Radiation and Nuclear Safety Authority and the licensee use their discretion to set field-specific design goals that are stricter than the valid safety requirements. The aim of these design goals is to improve the safety and operability of the power plant and to increase the reliability of the actual requirement level. The Finnish safety requirements can be considered strict by international standards.

A reform of legislation regarding nuclear energy is ongoing. The legislation is being examined as a whole and the reform will take place gradually, starting in 2008. At first Parliament will consider the Government proposal for the new Nuclear Energy Act. The next stage is to discuss the Government proposal for replacing the aforementioned Government Decisions, covering the different fields of the safety of nuclear energy operation, with four Government decrees. A structural reform of the YVL Guides of the Radiation and Nuclear Safety Authority is also underway. The guides are revised gradually as the new laws enter into force. When describing nuclear safety matters, the new nuclear energy legislation has partly been taken into account in advance.

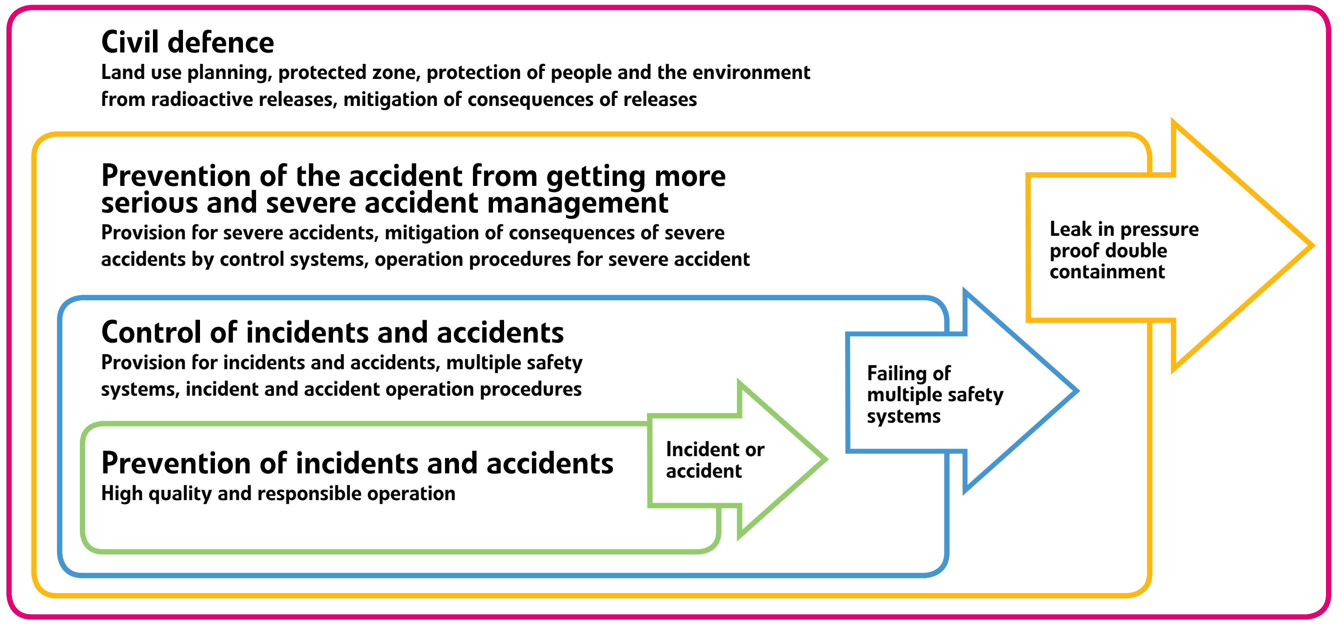

Figure 12-1. The aim is to ensure nuclear safety at several different levels. An accident can lead to an external release of radioactive material only if all protection levels fail.

12.2 Safety principles

Nuclear safety is ensured, as far as possible, with several methods that complement each other and are independent of each other in all stages of the design and operation of a nuclear power plant. A essential nuclear safety principle adopted in Finland is the Defence in Depth, which is illustrated in Figure 12-1 (*IAEA, 1996, 2000*):

- Prevention of abnormal operation and failures by conservative design and high quality in construction and operation
- Control of abnormal operation and detection of failures by the control, limiting and protection systems and other surveillance features
- Control of accidents within the design basis (Chapter 12.3.1)
- Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents
- Mitigation of radiological consequences of releases of radioactive materials if all safety functions fail, by means of efficient technical and administrative arrangements (off-site emergency response).

12.2.1 High quality, competent staff and responsible operation

In the design, construction and operation of a nuclear power plant, safety is ensured by high-quality operation and safety culture that encourages to open and responsible operation. High-quality construction and operation guarantee an even and undisturbed operation of a power plant. In addition to undisturbed electricity production, a good safety level is also reached. A high safety level is guaranteed by continuous quality control of work, procedures established in advance, internal inspections, requirements guiding the operation, and inspections by the authorities.

The responsible manager of a nuclear power plant, and the substitute, the persons in charge of nuclear materials and emergency preparedness arrangements and the operators of the nuclear power plant units must be approved by the authority. The training of the operating staff of the new power plant unit will begin as early as in the construction stage. During operation, the whole staff, especially the operators, are trained on a regular basis. The training of the operators of a nuclear power plant includes, among others, the use of a training simulator, where different situations can be practised. The operators must demonstrate their competence in regular examinations.

The Finnish nuclear power plants have technical specifications, which determine the system and equipment-specific operation restrictions and functional requirements. Structures, systems and equipment are classified according to their safety significance. The classification can be used for focusing inspection, quality assurance and independent control by the authorities on areas important in terms of safety.

Control of work quality, procedures established in advance, and developed internal inspections are key elements of the safety culture.

12.2.2 Provision for incidents and accidents

When designing a nuclear power plant, its behaviour in specified accidents that provide the design basis for safety functions is assessed in advance. Safety functions are primarily based on inherent safety characteristics. For example an uncontrollable increase of the reactor power is prevented by such design of the reactor that the loss of coolant restrains its power. The aim of the safety functions is to ensure three functions in all conditions:

- Control of the chain reaction in uranium fuel and the re actor power
- Cooldown of fuel after the end of the chain reaction, i.e. residual heat removal
- Isolation of the radioactive material from the environment.

Safety functions are implemented both with several parallel safety systems (redundancy) and with different operating principles (diversity). Parallel safety systems are isolated from each other so that, e.g. a fire or other individual external factor cannot harm all parallel systems. The safety systems can have either active or passive operating principles. The passive safety systems do not need external driving force, such as electricity, in order to operate. In case the external electricity network is lost, a nuclear power plant has separate back-up power systems. The safety systems are designed such that the failure of a single piece of equipment does not harm the system.

A power plant is designed such that during an accident there is enough time for the start-up and operation of the safety systems. Basic characteristics and automatic protections give the operator time to consider the situation and carry out possible manual controls. In addition to normal operating procedures, there are separate incident and accident operating procedures.

The design has also made provision for a very rare severe accident in which the reactor core is damaged. For controlling and monitoring a severe accident, constructions, equipment and systems are designed such that they are independent of the systems designed for normal operation of the power plant and for other accidents.

12.2.3 Prevention of radioactive releases

The uncontrolled release of radioactive material to the environment is prevented using successive isolation illustrated in the Figure 12-2. The physical barriers have been designed to withstand the forces aimed at them in potential incidents or accidents, also when the inner barriers break down.

The uranium fuel and the gastight cladding tubes of the fuel rods form the first physical barriers. The fuel rods are inside a steel reactor pressure vessel. The outermost barrier is formed by the double containment.

In a severe accident, the most important barrier preventing the spreading of radioactive material is the double containment. The containment system, which fulfils the Finnish requirements, consists of the actual pressure-proof, gastight inner containment made of special steel or concrete or a combination of them, and the outer containment made of concrete. The outer containment surrounds the inner containment so that any gas leaking from the inner containment can be collected and filtered to minimize gaseous releases. In addition to preventing releases, the outer containment acts as a radiation shield. Outside the containment the radiation level remains safely low even when activity has been released into the containment. The most important function of the strong outer containment is to protect the reactor from external hazards.

The containment of the new power plant unit is designed such that it also withstands such a severe accident in which the reactor core melts. The solid matters of the melted core and a majority of the gaseous radioactive material remain inside the containment, and so the health risk of the residents in the surroundings is small.

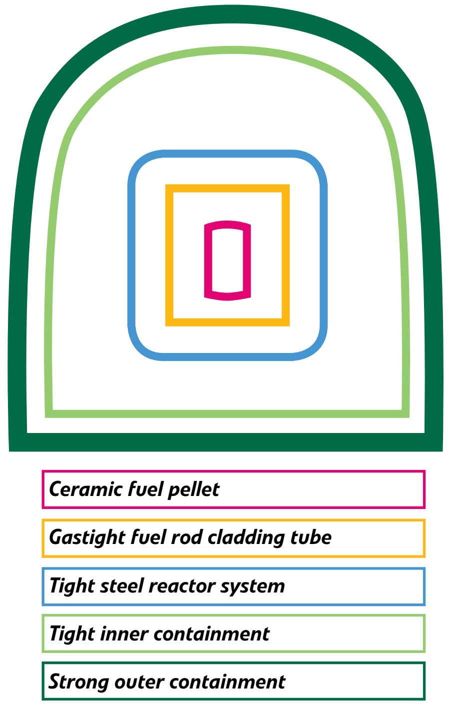

Figure 12-2. Spreading of radioactive material to the surroundings is prevented by successive barriers.

12.2.4 Assessment of safety

During the design stage of a nuclear power plant the behaviour of the plant and the impacts of the phenomena in the environment are studied experimentally and theoretically using computer models which simulate reality and have been proven reliable. Different calculation methods are used for analysing the normal operation and a wide selection of various accidents in a power plant. The methods used include, e.g., incident and accident analyses, strength analyses, failure mode and impact analyses and probabilistic risk analyses. The assumptions and simplifications made in the calculation models are verified such that when calculating uncertain factors, the worst choice in respect of the plant is always chosen. Even the worst alternatives must be managed safely.

The results are used for determining the safety functions needed in accidents, and their safety margins are designed such that they function with great certainty.

After the nuclear power plant is completed, the analyses are maintained and specified, if necessary, taking into consideration operating experience, experimental research results and the development of calculation methods. The documents are kept up to date and they are submitted to the Radiation and Nuclear Safety Authority.

The safety of the operating power plant units is assessed on a regular basis. Safety assessment is carried out either as a part of the renewal of the fixed-term operating licence of the power plant units or, at the latest, ten years after the last assessment. As part of the periodic safety assessment the licensee itself assesses the safety status of the power plant units, potential objects of development and the preservation of safety. The assessment includes a summary of the revised safety analyses and conclusions from their results. Attention is paid, e.g., to the fulfilment of the requirements set in the relevant YVL Guides, control of the aging of the power plant units, implemented plant improvements and safety culture and management. The Radiation and Nuclear Safety Authority will make a decision of approval on the periodic safety assessment and attach its own safety assessment of the power plant safety to it.

The latest safety assessment of the existing power plants in Loviisa was carried out as part of the renewal of the operating licences in 2006. According to the conditions of the operating licences issued in 2007, the future periodic safety assessments will take place every seven years.

12.3 Accidents at a nuclear power plant

12.3.1 Accident types

Operational transients and accidents, i.e. events deviating from normal operation are assessed in the design and the safety analysis reports of nuclear power plants, are classified in the reformed legislation regarding nuclear safety (see Chapter 12.1) to anticipated operational transients, postulated accidents and severe reactor accidents. All events and accidents are analysed in the design stage of the new power plant unit, and the necessary systems and actions are planned in advance.

Anticipated operational transients

Anticipated operational transients are events that can be assumed to occur once or more often during a hundred years of operation.

Anticipated operational transients are situations deviating from normal, from which the plant can be managed to a safe stable state. The new power plant unit is designed to withstand these transients so that the releases do not deviate from the small releases caused by normal operation. The limit of the annual radiation dose to an individual of the population is the same as during normal operation, i.e. 0.1 mSv. This dose is a few per cent of the annual average radiation dose of a Finn, which is about 3.7 mSv.

Postulated accidents

Postulated accidents are events used in the design and dimensioning of safety systems. In these events, the safety systems and the containment must limit the amount of radioactivity released into the environment to such a level that staying in the environment or the use of food products do not need to be restricted. The events are classified into three groups.

The frequency of Class 1 accident is less than once during a hundred years of reactor operation. The annual radiation dose of an individual receiving the largest dose among the population, during one year after the accident, must not exceed 1 mSv.

The frequency of Class 2 accident is less than once during a thousand years of reactor operation. The annual radiation dose of an individual receiving the largest dose among the population, during one year after the accident, must not exceed 5 mSv.

The extension of postulated accidents covers situations where the initiating event of a transient or an accident is combined with a common cause failure or a complicated combination of failures in the safety systems. The power plant is supposed to manage even such a situation without severe damage to the fuel. In such an accident the radiation dose of the most exposed individual of the population must not exceed 20 mSv during one year after the accident. A similar radiation dose can be received in certain areas of Finland from natural background radiation. Thousands of Finns regularly receive an annual dose of over 10 mSv from natural background radiation (*Pöllänen 2003*).

Severe reactor accident

The frequency of a severe reactor accident is less than once during 100 000 years of reactor operation. In a severe accident a considerable proportion of the fuel in the reactor is damaged and a large proportion of the radioactive material contained in the fuel is released into the containment.

The limit for the release from a severe accident has been determined in Finnish legislation such that the release must not cause acute health effects to the population in the vicinity of the power plant. The releases must not cause long-term restrictions on the use of extensive areas of land or water. According to legislation, the possibility of exceeding the release limits shall be extremely small. The impacts of a severe accident are described in Chapter 13.

In the design stage of the new power plant unit it is verified that possibility of a severe accident is less often than once during 100 000 years of reactor operation and the release limit is possibly exceeded less often than once during 2 000 000 years of reactor operation.

12.3.2 International Nuclear Event Scale - INES

The safety significance of nuclear power plant events is assessed using the international scale for nuclear events (International Nuclear Event Scale). The INES scale has been developed to illustrate the safety significance of nuclear events and to facilitate rapid communication to the media. The scale was initially applied for a trial period in 1990 and it was officially approved in 1992. Older nuclear events have been classified afterwards. The scale is used in 60 countries, of which about a half have nuclear power plants of their own. Examples of INES classified events can be found in literature (*Sandberg, 2004*).

Those nuclear power plant events that have nuclear or radiation safety significance are classified using the INES scale into eight levels in a manner shown in Figure 12-3. Deviating events belong to INES Level 0. Incidents in which civil defence actions are not necessary, belong to INES Levels 1-3. Accidents with emergency action and civil defence, as described in Chapter 12.4, belong to INES Levels 4-7. The events occurred at the nuclear power plants in Finland have been classified into INES Levels 0, 1 and 2.

According to the IAEA publication (*IAEA 2001*), the INES level is determined on the basis of safety weakening or radiation impacts on the environment, power plant area or personnel. When determining the level, all consequences of the event or accident are examined separately. If the INES level can be determined on the basis of more than one impact, the final INES level is chosen to be the highest one. In the case of an incident or accident, the licensee presents a proposal for the INES level to the Radiation and Nuclear Safety Authority.

The accident types used in the design and safety assessment of a power plant are divided into INES levels in such a way that anticipated operational transients belong to levels 1-3, postulated accidents (and extensions of postulated accidents) to level 4 and severe accidents to levels 5-7.

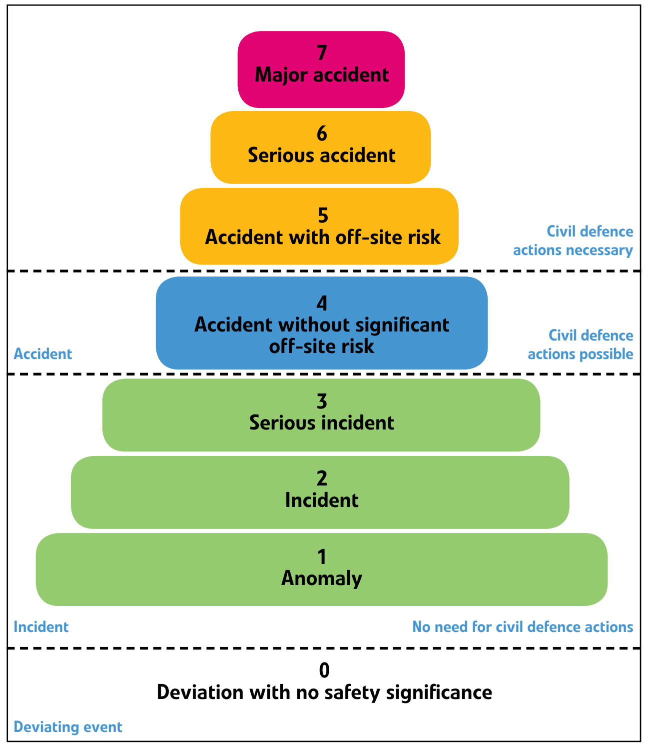

Figure 12-3. International Nuclear Event Scale

INES 0: Deviating event with no safety significance

Events with such a small safety significance that they cannot be located in the actual scale, belong to INES Level 0. The level contains, e.g., a fast shutdown of the reactor (scram). In events belonging to this level all systems function as designed.

INES 1: Anomaly affecting safety

Events of INES Level 1 do not endanger safety, but the plant situation or operation deviates essentially from the normal. The anomaly can be due to equipment failure, human error or procedural inadequacies. There have been relatively many events of this level, in Finland altogether 46 events between 1990 and 2006, and they are usually reported only nationally.

INES 2: Incident with significant failure in safety provisions

An event belonging to INES Level 2 involves significant failure in safety provisions but sufficient defence in depth still remains. The level also includes events resulting in a dose to a worker exceeding the dose limit, or the presence of significant quantities of radioactivity in on-site areas not expected by design. There have been altogether seven level 2 events in Finland, of which the latest in 1993. No events more severe than level 2 have occurred in Finland.

INES Level 2 includes, e.g., the breaking of a secondary system feed water pipe at the Loviisa power plant's unit two in 1993. The rupture was caused by the thinning of the pipe wall owing to rapid erosion corrosion. The event was classified into INES Level 2 since a corresponding pipe rupture took place at the Loviisa power plant's unit one in 1990, after which several corrective actions were implemented, e.g. concerning condition monitoring, but the broken flange at unit two had failed to be inspected in the previous year.

INES 3: Serious incident with significant failure in safety provisions

In INES Level 3 event environmental releases exceed the release limits of normal operation, set by the authorities, resulting in a dose to the individual of critical group less than one millisievert. Off-site protective measures are not needed. This level also includes on-site events resulting in doses to workers sufficient to cause acute health effects or a severe spread of activity in the nuclear facility. The level also includes incidents in which a single further failure of the safety system could lead to an accident or to a situation in which the safety system would be unable to prevent an accident as a consequence of an incident.

INES Level 3 includes an event that occurred in Hungary, at the Paks nuclear power plant in 2003. During the outage of the power plant, fuel assemblies were purified on the bottom of a deep water basin in separate purification equipment, designed for this purpose. Due to a design failure of the equipment, its cooling circulation was disturbed and the lot of 30 fuel assemblies was overheated and damaged. Due to the damage, radioactive noble gases and a very small amount of iodine was released into the reactor hall. Off-site releases were small, however, and no personal injury occurred. The radiation doses to the personnel were at the most 10% of the annual radiation dose limit. Levels of external radiation at the site or in its vicinity did not exceed normal background radiation.

INES 4: Accident without significant off-site risk
INES Level 4 accident results a dose to the individual of critical group over one millisievert. In the accident, fuel damage is caused by the partial breaking or melting of the core. The need for off-site protective actions is unlikely except possibly for a local food control. This level also contains events in which one or more workers receive rapidly a radiation dose resulting in a high probability of death.

INES Level 4 includes a criticality accident that occurred in a uranium container in Japan at the Tokaimura nuclear fuel factory in 1999, where three workers were overexposed to radiation. Two of them died later due to their exposure. The factory was located in the urban area and there was settlement in its immediate vicinity. The area was evacuated and residents further away were urged to protect themselves. The relatively thin walls of the factory building and the uranium container did not protect the environment from radiation. The largest dose to a person outside the staff was 16 mSv. Releases to the environment were nevertheless not significant.

INES 5: Accident with off-site risk
INES Level 5 accidents include a small environmental release of the radioactive material contained in the nuclear power plant. Such a release would be likely to result in partial implementation of countermeasures. The class also contains accidents with severe damage to the installation without significant external releases.

INES Level 5 includes the Three Mile Island (TMI) accident in the US in 1979, initiating from a leak in the reactor system. In the accident the operators incorrectly interrupted the reactor emergency cooling, which had been initiated automatically. This led to overheating and partial melting of the reactor core. Despite the severe damage to the reactor core, the pressure vessel and containment remained intact, preventing external releases as designed, and so the environmental impacts were small. On the basis of core damage, the accident belonged to Level 5.

INES 6: Serious accident
INES Level 6 contains accidents with large environmental releases of radioactive material. Such a release would be likely to result in full implementation of countermeasures, covered by local emergency plans, to limit serious health effects and to limit radiation doses to population farther away.

Only one INES Level 6 accident has occurred. In 1957 in the Soviet Union (in the present Russia), at a reprocessing plant near the town of Kyshtym, a tank containing high-level liquid waste exploded, causing a release of radioactive material. Health effects were limited by countermeasures, such as evacuation of the population in the environment. Based on the environmental impacts, the accident belonged to Level 6.

INES 7: Major accident
INES Level 7 includes accidents with environmental release of a large proportion of the radioactive material in a nuclear power plant or other nuclear facility. This would typically involve a mixture of short- and long-lived radioactive fission products. Such a release would result in the possibility of acute health effects; delayed health effects and long-term environmental consequences. For avoiding serious health effects, large-scale civil defence actions are initiated.

Only one INES Level 7 accident has occurred. In 1986 in the Soviet Union (in the area of the present Ukraine), the reactor of the Chernobyl nuclear power plant was destroyed in an explosion, followed by a fire of the graphite used as a moderator in the reactor (*Sandberg 2004*). The total destruction of the reactor caused a large release. Several workers of the power plant and people taking part in the cleaning died of the injuries from the accident or of the immediate health effects of radiation. An exclusion zone area of 30 kilometres was ordered around the reactor and about 135 000 people were evacuated. Based on the environmental impacts, the accident belonged to Level 7.

12.4 Emergency response arrangements and civil defence actions

Emergency response arrangements mean adequate provision made for responding to emergency situations, i.e. accidents or events affecting safety at a nuclear facility. For mitigating the consequences of an accident, the power plants and rescue service authorities maintain emergency preparedness, aimed at civil defence actions in a radiation hazard situation. Nuclear energy legislation sets requirements for civil defence, rescue and emergency response actions. The Radiation and Nuclear Safety Authority gives detailed instructions in the YVL Guides and in separate emergency preparedness instructions (VAL Guides), e.g. for radiation protection actions in a radiation hazard situation. The guidance is based on the recommendation by the IAEA on emergency preparedness (*IAEA 2002*) and civil defence actions initiated in a radiation hazard situation (*IAEA 2003*).

Emergency response arrangements at a nuclear power plant mean preparations for different incidents and accidents. The power plant has an emergency organization formed of the power plant's personnel trained for the duties. Their work specification and tasks have been defined in advance in the emergency plan. The organization has appropriate rooms, communication channels and equipment, e.g., for carrying out radiation measurements at the site and inside the protective zone. The Loviisa Power Plant also has a fire station of its own.

During an accident, the emergency organization makes the necessary announcements and alarms and takes actions for managing the situation. The emergency organization is also responsible for the evaluation of potential releases, fire protection, repair work, information and other actions needed in the situation.

Emergency situations are classified, according to their severity and controllability, into emergency standby, site emergency and general emergency. The emergency response arrangements are implemented within the scope required by the situation.

In the emergency standby, the safety level of the power plant is ensured, and therefore the preparedness is raised by manning the emergency operating center meant for emergency situations. The situation is also reported to the Radiation and Nuclear Safety Authority and the local rescue authority.

In a site emergency, safety is deteriorated or is in the danger of deteriorating significantly. The emergency organization is alerted in its full strength. The Radiation and Nuclear Safety Authority is alerted and the rescue authorities are informed.

In a general emergency, there is a risk of radioactive release requiring civil defence actions. The operation of the emergency organization is initiated on the full scale. The Radiation and Nuclear Safety Authority and the rescue authorities are alerted immediately.

In an emergency situation the rescue actions are led by the on-site emergency manager, who is responsible for initiating and managing the operation, until the rescue authority takes command. The recommendations on civil defence actions are received from the on-site emergency manager until the Radiation and Nuclear Safety Authority takes responsibility for issuing the recommendations.

Plans for civil defence have been compiled for the Loviisa region, and they have been integrated with the rescue service plans of the power plant and several authorities responsible for civil defence. The measures needed in an accident and the civil defence actions have been described in the power plant's emergency plan.

The Loviisa Power Plant's emergency planning zone includes Loviisa, Pernaja, Ruotsinpyhtää and Pyhtää. About 20 000 people live in the emergency planning zone and it reaches to about 20 kilometres from the power plant. In addition to the plans made in advance, based on accident scenarios, the emergency response in Loviisa also includes emergency exercises and rescue service training. The emergency plan is maintained and the actions are practised annually in the power plant's own emergency exercises and in regular rescue service exercises with the rescue authorities. The new power plant unit will not bring any changes to the civil defence actions of the area.

In a severe accident the necessary civil defence actions depend on the stage of the accident and the prevailing weather. At first it is important to be protected from the radiation of the release plume and avoid radiation doses via inhalation. Evacuation is most efficient, but in most accidents the radiation dose is decreased adequately enough by protecting oneself inside a building. Evacuation is implemented before the radioactive plume reaches the area. The thyroid, which is sensitive to radioactive iodine, is protected by blocking it with stable iodine. The residents of the sparsely populated surroundings of the Loviisa Power Plant, to the distance of about five kilometres, have been provided with iodine pills and instructions for use.

The use of iodine pills, evacuation of the population and restrictions on movement can efficiently decrease the largest radiation doses caused by the accident. The actions are implemented on the basis of the criteria determined in advance (IAEA 2003, VAL 1.1), shown in the Table 12-1.

Table 12-1. Criteria for protective actions used in emergency planning.

Protective action	Avoided individual dose
Protecting oneself inside (duration 48 hours)	10 mSv (1)
Taking iodine pills	Children 10 mGy, adults 100 mGy (2) (radiation dose to thyroid)
Evacuation (duration one week)	50 mSv

(1) Unit of radiation dose is usually mSv

(2) If radiation is directed to one organ, like to thyroid in the case of radioactivity, radiation dose unit mGy is used

Radiation doses caused directly by fallout and by dust, can further be decreased by temporarily transferring the population away from the contaminated area, and by possible local cleaning of the ground and buildings. Restrictions on movement are used for restricting the access of people to the contaminated area except during the necessary actions. These restrictions are only needed in a small area in the immediate vicinity of the power plant. Further away, even in the case of the worst accident, the radiation doses will be so small that no long-term restrictions on movement (see Chapter 13) will be expected.

The radiation dose from food can be affected by protecting food and the production chains. Domestic and production animals are put inside and, as far as possible, also the feed of production animals is protected. In fallout situations, instructions will be given for producing as clean feed as possible, and in special cases for reserving clean drinking water.

After an accident, the use of some foodstuffs will have to be restricted. The Table 12-2 shows the pre-established maximum permitted levels of radioactive contamination in foodstuffs in the European Union to be adopted immediately, if the circumstances so require, following a nuclear accident or any other case of radiological emergency (*Council Regulation No 3954/87*). The maximum permitted levels for long-lived nuclides (^{134}Cs and ^{137}Cs) applied currently in the EU internal trade (Council Regulation No 1707/86) are those established after the Chernobyl nuclear accident. The maximum permitted levels of ^{134}Cs and ^{137}Cs for foodstuffs are 370 Bq/kg for milk and baby foods and 600 Bq/kg for other foodstuffs. The restrictions are valid until 2010 (*Council Regulation No 616/2000*).

The Finnish Nuclear Liability Act (484/72) is based on international conventions (Paris Convention and Brussels Supplementary Convention). In accordance with the Nuclear Liability Act, the licensee of a nuclear installation is responsible for compensating for nuclear damage caused by a nuclear incident at the licensee's nuclear installation. The licensee of a nuclear installation shall take out insurance to meet the liability for nuclear damage. The insurance covers personal injuries and property damage caused by nuclear damage to outsiders, financial loss and some of the remediation costs of the environment. Fortum has taken out general liability insurance on the Loviisa Power Plant, as required by the Nuclear Liability Act. In accordance with the Act, the insurance will be extended to also cover the new power plant unit.

The States that have signed the Paris Convention and the Brussels Supplementary Convention, including Finland, have agreed on amendments to conventions relating to nuclear liability. Ratification of the amendments and their introduction into national legislation of each State are underway.

Insurance liability lies with the operator of a nuclear installation up to a specified limit. If this limit is exceeded, regulations agreed on between States will be applied.

The purpose of the nuclear liability system is to ensure that any party suffering loss, damage or injury owing to nuclear damage faces a compensation system that has been designed to function flexibly instead of the general indemnification procedure that becomes complicated.

Large-scale civil defence actions are only needed during severe accidents (INES Level 5-7), with remarkable environmental releases of radioactive material. In an INES Level 5 accident, the civil defence actions must be immediately considered, but despite the severity of the accident, the actions are relatively slight, e.g. temporary transfer of the population would probably not be necessary. The consequences of INES Level 6 accident in the environment and the necessary civil defence actions have been described in Chapter 13. In an INES Level 7 accident, large-scale defence actions are very probable.

Table 12-2. Maximum permitted levels of radioactive contamination for foodstuffs in the European Union.

Radionuclides	Activity content Bq/kg		
	Baby foods	Dairy produce and liquid foodstuffs	Other foodstuffs
Strontium isotopes	75	125	750
Iodine isotopes	150	500	2 000
Plutonium and transplutonium isotopes	1	20	80
Other radio nuclides with a half-life over 10 days, e.g. ^{134}Cs and ^{137}Cs	400	1 000	1 250

1) In the food trade within the European Union, the maximum permitted levels may be adopted, if necessary, following an accident by the Commission's decision (the levels for less frequently used foodstuffs are tenfold compared with those for the basic foodstuffs shown in this table). Special situation-specific limits may be adopted by the Council's decision.

12.5 Implementation of the safety requirements at the new power plant unit

The new power plant unit is designed such that it fulfils the requirements set by the authorities. High safety goals are set for the power plant unit and the design also takes into consideration severe accidents caused by core melting. It is required of the new power plant unit that possibility of an accident leading to core melt occurs is less often than once in 100 000 years and large environmental radioactive releases are possible less often than once in 2 000 000 years. In addition to being prepared for a severe accident, the new plant unit must also be protected against external threats and terrorism.

The containment of the new power plant unit withstands, e.g., a collision of a passenger plane and the design takes into consideration possible oil accidents in the Gulf of Finland. In addition to threats caused by humans, the safety design is prepared for external threats caused by natural phenomena and global warming and its consequences, such as the warming of sea water and a rise in the sea water level.

Fortum has gained long experience of operating the existing power plant units in Loviisa, and extensive safety studies have been carried out to support operation. They will complement the development work of the supplier of the new power plant unit aimed at safety improvements. The safety solutions chosen for the new power plant unit will fulfil the requirements set in the regulations related to the design of nuclear power plants and the environmental impacts, valid in Finland at present. The fulfilment of the requirements set for releases of radioactive material and radiation doses to the personnel will be ensured by design objectives that are stricter than the official requirements. The solutions deviating from official requirements are justified and submitted for approval to the Radiation and Nuclear Safety Authority. The combined effect of the deviating solutions must contribute to improving safety.

The present physical protection and the existing emergency response, which is practised annually, can be used to support the new power plant unit as such.

The on-site implementation of the safety solutions of the chosen plant type will be described when applying for a construction licence in accordance with the Nuclear Energy Act. The licensee and the Radiation and Nuclear Safety Authority will assess the implementation of the safety solutions throughout the construction stage, and the implemented solutions with their test run results will be assessed as a whole when applying for an operating licence in accordance with the Nuclear Energy Act.

12.6 Safety reports to be made in further developing the project

Detailed reports regarding the safety of the new power plant unit will be made as part of the operating licence procedure in accordance with the Nuclear Energy Act.

The EIA procedure of the new power plant unit will be followed by a Government resolution application in accordance with the Nuclear Energy Act, if the project will be continued. When applying for the resolution, the plant supplier has not yet been chosen, so the content of the safety

report will focus on the safety assessment described in the decision by Government regarding nuclear safety (395/91) and in the YVL Guides of the Radiation and Nuclear Safety Authority regarding design. If the resolution is favourable and Parliament ratifies it, negotiations with plant suppliers will be initiated. During these negotiations, the fulfilment of the safety level defined in the Finnish regulations will be carefully assessed by each plant alternative.

When applying for a construction licence in accordance with the Nuclear Energy Act, the plant supplier has been chosen, and detailed plant type-specific safety assessments will be supplied to the authority. In addition to the computational analyses describing accidents, probabilistic risk assessments will also be made of the probability of different events and the risks of releases. The probabilistic safety objectives for, e.g., core damage frequency must be met.

A safety assessment, a description of the planned safety verification and safety analyses calculated with safety margins, will be attached to the construction licence application. Based on the safety analyses, the authorities will form their opinion about the ability of the power plant to manage different incidents and accidents. Also preliminary plans for the implementation of physical protection and emergency response arrangements, and a report on quality management of the construction, will be attached to the construction licence application.

A condition for the granting of the operating licence in accordance with the Nuclear Energy Act is that, during construction, the safety analyses are complemented according to the implemented details. If necessary, the operation of the power plant unit's systems or equipment is specified on the basis of the analyses of test run results. Furthermore, the plans for physical protection and emergency response arrangements will be complemented and a quality management programme for operation will be compiled.

A proposal for the document describing the safety significance of the new power plant unit's components and equipment is supplied to the Radiation and Nuclear Safety Authority when applying for a construction licence. The classification proposal will be updated and complemented during construction so as to become a report covering all components and equipment, which is supplied to the Radiation and Nuclear Safety Authority when applying for an operating licence. When applying for the operating licence, also the final safety analysis report, with extensive safety studies, and the probabilistic risk assessments will be submitted to the Radiation and Nuclear Safety Authority for consideration and approval.

The systems detailed operational conditions will be finalised on the basis of computer calculations describing safety and test run results. The document describing operational conditions will be attached to the application for the operating licence. Based on the results, incident and accident procedures will be established for deviating situations, and instructions and programmes for the periodic inspections and testing of equipment will be drawn up before the commissioning of the power plant.

Young great spotted woodpecker, Loviisa

© Timo Lindgren

13 CONSEQUENCES OF A SEVERE ACCIDENT

At a nuclear power plant, an accident involving damage to a significant part of the reactor core is called a severe accident. Such accidents are classified into INES Levels 5–7 (see Chapter 12.3.2). The new power plant unit will be designed such that the possibility of a severe reactor accident occurrence is less frequently than once in 100 000 years. In a severe accident, considerable amounts of radioactive materials can be released into the environment only if the reactor containment leaks. The containment is designed to perform even in severe reactor accidents in such a way that large amounts of radioactive materials can be released into the environment less frequently than once in 2 000 000 years.

The model case studies the environmental impacts of a severe accident in which large amounts of radioactive materials are released into the environment, although the probability of such an accident is extremely little. The study includes defining the accident on the basis of the design limits set by power companies and authorities, selecting the boundary conditions of the accident and using the prevailing weather and environmental conditions as basic data. Furthermore, the calculation methods used and the assessed radiation doses and depositions at different distances from the power plant have been described. The study also considers potential emergency response actions, compares the results with known nuclear or radiation accidents, describes consequences of the accident to human health and the environment, and provides background information on the health effects of radiation.

13.1 Defining the accident

In Finland, the Government Decision on the safety of nuclear power plants (VNp 395/91) requires that a severe reactor accident shall not cause early adverse health effects to the residents in the plant vicinity or long-term restrictions on the use of extensive land or water areas. To fulfil the requirement for long-term impacts, the amount of radioactive caesium isotope ^{137}Cs released into the air shall not exceed 100 TBq. Furthermore, after three months, the other nuclides shall not pose a greater hazard than caesium.

In the model case, the thermal power of the reactor suffering damage is assumed to be the maximum power of the new power plant unit, 4600 MW, and the ^{137}Cs release is assumed to be 100 TBq. On the basis of the interrelations of the radioactive materials contained in the reactor and accident analyses, the release of radioactive iodine isotope ^{131}I is estimated at 1 500 TBq. Of the other caesium and iodine isotopes, corresponding proportions of their total amounts are assumed to be released into the environment. In addition, all radioactive noble gases, e.g. krypton and xenon, are assumed to be released into the environment. An accident involving such a release belongs to INES Level 6.

In accordance with the requirements set for European power companies, it is required of the new power plant unit that a release begins in 24 hours at the earliest from the commencement of an accident (*EUR 2001*). In addition to this hypothesis, the entire release is assumed to occur in an hour and the wind direction and velocity to remain constant. If the release spread over a longer period of time, the radiation doses in the immediate vicinity would be reduced owing to the variation in wind direction. The release is assumed to occur through the ventilation stack of the power plant unit with an assumed height of 100 metres. A release from a lower height increases radiation doses in the vicinity of the power plant. Far from the power plant unit, e.g. in Helsinki, a slight change in the release height has hardly any effect in terms of radiation doses.

13.2 Assessment methods of radiation doses and contamination

The radiation dose caused by a release has been divided into two parts: the radiation dose during the first twenty-four hours of the radiation exposure and the radiation dose during the subsequent 50 years. The radiation dose of the first twenty-four hours refers to a radiation dose received by an adult

Table 13-1. Radiation doses to an adult and depositions caused by a release from a severe accident (100 TBq ^{137}Cs).

Distance from the power plant [km]	Radiation dose during the first 24 hours [mSv]	Radiation dose during the subsequent 50 years [mSv]	^{137}Cs deposition [kBq/m²]	^{131}I deposition [kBq/m²]
1	230	250	1 700	27 000
3	120	150	620	9 300
10	30	70	180	2 700
30	10	20	60	920
100	4	5	20	270
300	1	2	5	80
500	0,5	0,7	3	40
1000	0,2	0,3	1	20

during 24 hours from the coming of the release plume.

The weather conditions used consist of weather observations gathered at the weather mast of the Loviisa Power Plant during several years. The radiation doses of the first twenty-four hours have been calculated using weather conditions in which the radiation dose caused by the release plume carried with the wind is as massive as possible. The radiation dose accumulated during the subsequent 50 years mainly results from the deposition present in precipitation. The radiation doses of the first twenty-four hours and the subsequent 50 years cannot be directly added up, since they are caused under different weather conditions.

In assessing the radiation exposure of the first twenty-four hours it has been assumed that the residents stay outdoors during the time the release plume passes overhead and during the next 24 hours. During the first twenty-four hours the dose rates are at their highest, but the deposition or the activity contained in the air have not contaminated food yet. Radiation doses are caused by both the activity getting into the body with breathing and the radiation emitted from the release plume and deposition.

The dose rate during the subsequent 50 years is lower, but radiation doses are received through various pathways. In addition to the direct radiation from deposition, the assessment has taken account of the radiation doses received via food. The population is assumed to keep to their living habits and use garden and farm produce from their place of residence and natural products from the surroundings, such as mushrooms, wild berries, fish and game. Milk and meat produced at a distance of 10 kilometres at the most from the power plant unit are not assumed to be used as food. Any restrictions on the use of milk and meat placed by the authorities farther away have not been taken into consideration. The radiation doses at a distance of more than 10 kilometres have thus been overestimated.

Computer programs have been used to assess radiation doses caused to an adult and the deposition. At Fortum, the LENA95 (*Bäverstam 1996*) and TUULET (*Saikkonen 1992*) programs are being used. However, these programs are not suitable for assessing radiation doses and deposition at long distances. Results of the TRADOS program (*Nordlund et al. 1985*) developed by the Technical Research Centre of Finland VTT and the Finnish Meteorological Institute have therefore been used to assess radiation doses and deposition at long distances.

The radiation doses and deposition during the first twenty-four hours have been assessed to a distance of 100 kilometres using the TUULET program. Assessments to a distance of 300 kilometres have been made in such a way that the results of the LENA95 program at a distance of 100 kilometres were fitted to the results of the TUULET program. Radiation doses and deposition at distances of 500 and 1000 kilometres have been estimated on the basis of the distance dependence of the heaviest radiation doses assessed with the TRADOS program.

The radiation dose during the subsequent 50 years has been assessed to a distance of 100 kilometres using the TUULET program. At greater distances (300, 500 and 1000 kilometres) the radiation dose has been estimated on the basis of the distance dependence of the heaviest radiation doses assessed with the TRADOS program.

The radiation doses during the first twenty-four hours are the same irrespective of whether the situation is considered inside or outside the Finnish borders. During the subsequent 50 years, food plays an important role. The radiation doses received through food have been assessed under the conditions in southern Finland, where the local seasonal variation, consumption of farm produce and natural products, and living habits have been taken into consideration. The proposed radiation doses received through food do not precisely illustrate the situation in countries with a milder climate, in areas with a longer growing season, on the Scandinavian Mountains ('Skanderna' or 'Kölen') or under the conditions in Lapland.

Short-term and long-term contamination of land areas, water bodies and food has been illustrated by estimating the depositions (^{131}I, ^{137}Cs). The depositions enable radiation doses received from the release to be assessed more accurately while considering the local conditions. Furthermore, the amount of contamination is assessed on the basis of the deposition resulting from the accident at Chernobyl.

13.3 Assessed consequences of an accident and civil defence actions

13.3.1 Radiation doses and deposition

The table 13-1 shows radiation doses and depositions (^{137}Cs, ^{131}I) during the first 24 hours and the subsequent 50 years caused by a release corresponding to the release limit of 100 TBq of ^{137}Cs, which has been assessed as the model case. The radiation doses and depositions shown in the table range from the power plant vicinity to a distance of 1 000 kilometres. In accordance with publication ICRP 101 of the International Commission on Radiological Protection (*ICRP 2006*), the radiation doses and deposition caused by the accident are, with 95% certainty, smaller than the figures shown in the table, since the selected hypotheses and calculation methods have been chosen so as to overestimate the radiation doses and depositions.

On the basis of the action limits given in Chapter 12.4 , the radiation doses during the first 24 hours lead to evacuation ordered by the authorities before the release plume comes to a distance of at least 10 kilometres from the power plant. There are 24 hours to carry out the preventive evacuation. The evacuation area may even be wider, since it may be difficult to anticipate the size of the release and the prevailing wind direction accurately enough. Outside the evacuation area it is adequate to protect oneself indoors. In addition, provision may be made for taking iodine pills, although in this model case there is no need for taking them. The radiation doses shown in the Table 13.1 received in the power plant vicinity during the first 24 hours can in fact be avoided by evacuation. In areas located farther away the radiation doses can be reduced efficiently by protecting oneself indoors.

The radiation doses during the subsequent 50 years result from contamination caused by the deposition, which affects the use of land and water areas.

Figure 13-1 illustrates radiation doses in the model case during the first 24 hours in the prevailing weather. In the direction of travel of the release plume, the radiation doses are less than five millisieverts at a distance of over 15 km and less than one millisievert at a distance of over 70 km.

Figure 13-1. Radiation doses in the model case during the first 24 hours in the prevailing weather. The circle has been drawn at a distance of 100 km.

13.3.2 Use of land and water areas

Deposition restricts the use of land and water areas owing to both the direct radiation and, in particular, the contamination of foodstuffs. In addition to the size of the deposition, the contamination of foodstuffs depends on the weather conditions during the accident and on the time of year. In Chapter 12.4, the table 12-2 shows the maximum permitted levels of radioactive contamination for foodstuffs in the European Union following a nuclear accident or any other case of radiological emergency.

The restrictions on the use of foodstuffs due to contamination caused by iodine may be significant, but the restrictions are temporary, since the half-life of iodine isotopes important in terms of radiation is relatively short. A release occurring in the growing season may temporarily restrict the use of milk as nutriment in wide areas. In the growing season, ^{131}I deposition of 50 kBq/m² caused by an accident leads to the action level 500 Bq/kg of the ^{131}I concentration in milk applied in the European Union (*Suolanen 1992*). The restriction on the use of milk might be imposed in some deposition areas even to a distance of 500 kilometres. The strictness of the restriction on the iodine concentration of milk adopted in the European Union is demonstrated by this example: a person who drinks one litre of milk with an iodine concentration near the maximum limit of the action level receives a radiation dose of 0.01 mSv from the iodine contained in the milk.

^{137}Cs present in the deposition causes a lower, but a long-lasting, dose rate than ^{131}I, which may lead to long-term restrictions on use. At a distance of one kilometre, the ^{137}Cs deposition is 1 700 kBq/m², which exceeds the deposition criterion of the prohibited zone (1 500 kBq/m²) defined around Chernobyl. Applying this criterion, an area at a distance of about one kilometre would not be suitable for permanent habitation owing to external radiation, and it would probably also lose its recreational value.

At a distance of 100 kilometres, the ^{137}Cs deposition is 20 kBq/m². According to the experience gained after the Chernobyl accident, deposition of this size does not hinder the use of farm produce, but the ^{137}Cs concentrations in natural products may exceed the concentrations recommended by the European Commission. This means that, depending on the weather conditions and the time of year, the release of this severe model accident may result in ^{137}Cs concentrations in natural products that exceed the recommended concentrations in the areas of Estonia and other Baltic countries or Russia that are closest to Loviisa.

The strictness of the recommended restrictions on natural products in the European Union is demonstrated by this example: in southern Finland, in the area of the largest ^{137}Cs deposition (30–53 kBq/m²) caused by the Chernobyl accident and where the concentrations in natural products clearly exceed in places the maximum concentrations imposed after the Chernobyl accident, the increase in the radiation dose received by people who use plenty of natural products is less than 0.5 mSv per year (*STUK 2004*).

At a distance of 1 000 kilometres, the ^{137}Cs deposition is 1 kBq/m². The largest ^{137}Cs deposition caused by the accident at Chernobyl at a distance 1 000 kilometres was 500–1000 kBq/m². The ^{137}Cs deposition from the accident at Chernobyl was 85 000 ± 26 000 TBq (*NEA 1995*), i.e. approximately 800-fold compared with a release of 100 TBq.

The food chains in the natural environment poor in nutrients and, in particular, in mountain areas and barren lake areas and in Lapland are much more sensitive to biomagnification as a result of radioactive deposition than the farm produce chains. After the accident at Chernobyl, the ^{137}Cs concentration in reindeer in Norway was at its height some 100 000 Bq/kg (*NKA 1990*). If a release occurred in spring and was transported to Norway, the release would increase the ^{137}Cs concentration in reindeer in Norway by about 100 Bq/kg. In the European Union, the action level for the ^{137}Cs concentration in the event of an accident is 1 250 Bq/kg.

A release ending up in the sea mixes with sea water, some of it settling on the sea bottom. The mixing and transportation are affected by wind and the prevailing sea current in the Gulf of Finland, which is from east to west off the Finnish coast. During transportation, the activity is diluted with the very large mass of water. The Gulf of Finland forms only a part of the entire Baltic Sea, but if a ^{137}Cs release of 100 TBq was discharged into the sea as a consequence of a severe reactor accident and mixed with water in the Gulf of Finland, the sea water concentration would be 0.1 Bq/litre.

13.3.3 Other natural environment

In the exclusion zone at Chernobyl (30 km from the power plant) studies have been conducted into the effects of radiation on biota. Soon after the accident, the biota most sensitive to radiation were detected to have higher death rates than normal, as expected, and the accident altered populations and communities of organisms. During well over 20 years following the accident, the dose rate caused by the radioactive deposition has been reduced to less than one per cent compared with the dose rates immediately after the accident. This is due to the radioactive decay and the migration of materials deeper into the soil. At the same time, nature has recovered from the damage caused by the accident so well that distinct harmful effects can no longer be recognized at the population level. New cell-level research methods may give new insight, and so extensive research is underway (*Hinton et al. 2007*).

Man's leaving the exclusion zone at Chernobyl has resulted in increased biodiversity of nature and recovery of the natural environment so as to be more flourishing than before the accident. This should not be considered a positive consequence of the accident, however, since nature would probably be in a good state or even in a better state, if man had left the area without an accident.

Up to now, no international recommendation has been made on the assessment of the consequences of a reactor accident for the natural environment, although there has been a growing interest in protection of the natural environment (*ICRP 2007*). The adverse effects of a release specified in the model case (100 TBq ^{137}Cs and 1 500 TBq ^{131}I) on plant and animal populations have been studied employing the ERICA method (*Ikonen 2008*). The results show that the accident does not threaten the recovery or existence of any species. In the vicinity of the accident site, at a distance of less than three kilometres, impacts can be mainly expected on the vegetation of soil organisms and on mammals:

- with regard to plants, occasional observations about impacts linked with the external appearance and reproduction;
- with regard to mammals, occasional observations about impacts linked with vitality and reproduction, large mammals seem to be more sensitive than small ones;
- with regard to other groups of organisms, no observations about statistically significant impacts.

No adverse effects are likely to arise at a distance of 10 kilometres or more. No harmful effects would be produced on organisms in the marine environment even close to the power plant, since the release mixes with a large volume of sea water.

The results show that adverse effects of the above release on plant and animal populations are to be expected in almost the same immediate vicinity whose use may have to be restricted for a long time after the accident on the basis of the civil defence criteria.

13.3.4 Health effects

Health hazards of ionizing radiation can be roughly estimated with the aid of the radiation dose. Chapter 13.4 provides background information on the health effects of ionizing radiation and Chapter 13.5 gives reference data on radiation sources and background radiation in Finland.

A release of the size specified in the mode case does not produce early health effects, since the radiation dose of an adult during the first 24 hours without protective measures, 230 mSv, is smaller than the detection limit of a change in the blood picture, 500 mSv (see Table 13-2).

During the subsequent 50 years, the radiation dose of an adult caused by the release is 70 mSv at a distance of 10 kilometres. The radiation dose is about a third of the radiation dose that is caused, on average, from the radioactive substances present in nature in the corresponding period. If a reference man is 25 years old at the time of the accident, this radiation dose can be estimated to increase the man's risk of developing cancer at the age of 75 by 0.7%. The risk of the person concerned of having cancer at the age of 75 for other reasons is 20–25%. The increase in the risk is so small that it cannot be detected in practice.

13.4 Background information on the health effects of ionizing radiation

The health effects of radiation can be divided into two main groups: deterministic, or early effects and stochastic, or late effects. The deterministic effects are inevitable adverse effects, which are due to the extensive destruction of cells caused by the heavy radiation dose. On the other hand, stochastic effects only occur years after the exposure and they can only be detected with statistical methods from among a sufficiently large population group exposed to radiation (*STUK 2005*).

13.4.1 Early effects

Early effects are produced when a person receives a massive dose of radiation in a short time. No early effects are produced below a certain dose level, i.e. a threshold value, but above the threshold value the severity of the effects increases with the increasing radiation dose. The threshold value for early effects is 500 mSv in the event of whole body exposure. Examples of the early health hazards of radiation include, e.g., skin damage, sterility, cataract, kidney condition, lung inflammation and foetal abnormality. A sudden massive whole body dose results in radiation sickness and, in the worst case, death. Radiation sickness is possible if a person receives a radiation dose of more than 1 000 mSv in a short time, and a radiation dose of 4 000 mSv is lethal, but with good care the person can be saved.

Early radiation effects have mainly been found in victims of the Hiroshima and Nagasaki atomic bombs, in power plant staff and fire fighters in the Chernobyl accident, and in situations in which people have handled, knowingly or unknowingly, powerful radiation sources produced for industrial or medical uses (*Paile 2002, STUK 2002, STUK 2005, STUK 2007m*). The Table 13-2 shows threshold values for the early effects of ionizing radiation.

Table 13-2. Threshold values for the early effects of ionizing radiation (*STUK 2005*).

Whole body dose	Direct effect
500 mSv	A change in blood picture in a few days
1000 mSv	Nausea in a few hours
4000 mSv	Lethal dose. The person can be saved with good care.
10 000 mSv	The person can not be saved
Local skin dose	
6000 mSv	Redness in a few hours
15 000 mSv	Blisters in a few weeks
20 000 mSv	Necrosis
Foetal dose	
100 mSv	Effects on brain activity
500 mSv	Serious mental retardation

13.4.2 Late health effects

The health detriment posed by radiation is due to the damage to the genotype of a cell, or to the DNA molecule. Not nearly all damage to DNA leads to a health detriment, however. Radiation may leave a permanent change in the genotype of a cell, i.e. mutation. If several mutations have accumulated and if they have occurred in genes vital to the cell division, this may result in a cancerous tumour. The way to the final damage is long and complex, and there are a number of contributory factors other than radiation in the process (*Paile 2002*).

One of the most important tasks of radiation protection is to reduce the risk of cancer at the population level. At the individual level, it is difficult to detect an increase in the cancer risk as a result of radiation. The exposure to radiation increases the probability of developing cancer, but even heavy doses of radiation do not necessarily cause cancer. With small radiation doses, the risk of an individual of developing cancer caused by radiation is low. As the radiation dose increases, the probability of having cancer rises, but the severity degree of cancer does not increase (*Paile 2002, STUK 2007k, UNSCEAR 1993, 2000*)

The average size of the cancer risk involved with radiation exposure has been sought to assess with statistical investigations. Estimates of the risk of cancer are based on the follow-up investigations of groups exposed to radiation. These groups include, e.g., survivors of the atomic bombs in Hiroshima and Nagasaki, those exposed during medical use of radiation, those exposed owing to their occupation and those exposed to a higher than normal radiation level in the environment (*Paile 2002, STUK 2007l, UNSCEAR 2000*).

Although the risks involved with high radiation doses and the health effects of high doses are known fairly well, assessing the cancer risk posed by small doses on the basis of the effects of high doses involves several uncertainty factors and hypotheses. With small doses it is difficult to distinguish the effects of radiation from the effects of other factors, which complicates the making of risk assessments. Cancer does not appear until many years after the radiation exposure, nor are all factors contributing to the development of cancer known up to now (*Paile 2002, UNSCEAR 2000*).

Although studies have not shown that very small radiation doses do not cause cancer with certainty, the risk of cancer cannot be excluded, however. In accordance with the prudence principle, it is assumed in radiation protection, to be quite sure, that the probability of having cancer is in direct proportion to the radiation dose, in other words there is no threshold value below which there would not be a harmful effect. According to the International Commission on Radiological Protection ICRP, a radiation dose of 1 000 mSv increases the risk of an adult of developing cancer by ten percentage points (*ICRP 2007*). Correspondingly, a radiation dose of 1 000 mSv increases the risk of dying of cancer by five percentage points, when the dose rates and radiation doses at the individual level are low. In that case it is assumed that when 20 000 people receive a radiation dose of one millisievert one cancer case leading to death would be caused by radiation (*ICRP 1991, Paile 2002, UNSCEAR 2000*).

In practice, cancer possibly caused by small radiation doses cannot be detected in the population, since cancer is a common disease. In Finland, some 20 000 people have cancer every year. Radiation originating from nature may contribute to some 500 cancer deaths in Finland annually (*STUK 2007l*).

Radiation is suspected of producing hereditary effects. Although hereditary effects have been discovered in animal testing, they have never been detected in any population group exposed to radiation. Hereditary health detriments have not even been detected to increase in descendants of the victims of the Hiroshima and Nagasaki atomic bombs (*Paile 2002, STUK 2002, UNSCEAR 2000*).

13.5 Reference data on radiation sources and radiation doses in Finland

The average annual radiation dose of the Finns is about 3.7 mSv (Figure 13.2). The Finns mainly receive radiation from nature and the medical use of radiation. About half the radiation dose received by the Finns, i.e. about two millisieverts originates from radon in indoor air. The annual radiation dose caused by the external radiation of soil and building materials averages 0.5 mSv per Finn. People are exposed to radiation originating from cosmic radiation everywhere, in aircraft more than near the ground. The Finns receive an annual dose of about 0.3 mSv from cosmic radiation. People also eat, drink and inhale radioactive substances present in nature. The radioactive substances present in the body originating from nature cause an average internal dose of about 0.4 mSv per year to the Finns. It has been assessed that nuclear weapon tests and the deposition from the accident at Chernobyl cause a radiation dose of about 0.02 mSv per year (*STUK 2007a and 2007b*).

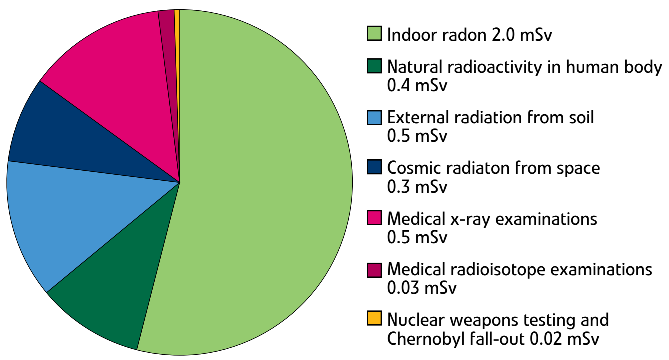

Figure 13-2. Average annual radiation dose to the Finns (*STUK 2007a*).

The amount of the radiation dose caused by natural background radiation and radon present in indoor air varies from area to area. The Finns receive their highest radiation dose from radon present in indoor air. In Finland, there are approximately 70 000 dwellings whose radon content exceeds the maximum limit set for old dwellings, 400 Bq/m³. Living in a dwelling with a maximum level of 400 Bq/m³ causes an annual radiation dose of about seven millisieverts. The annual radiation dose originating from the external radiation of soil and buildings amounts to 0.2–1 mSv. Flight crew receive an additional radiation dose of about two millisieverts from cosmic radiation per year (*STUK 2007b, 2007c, 2007d, 2007e and 2007f*).

Man also causes radiation through his own action. In Finland, the radiation dose caused by the intentional use of radiation originates almost completely from the medical use of radiation. Some 4.2 million X-ray examinations, some 1.3 million dental X-ray examinations and nearly 200 000 panoramic X-ray examinations of the teeth are carried out in Finland annually. When the radiation doses caused to patients from the various X-ray examinations are divided between all Finns, the average radiation dose is about 0.5 mSv per year. The average radiation dose of all X-ray examinations per one examination is about 0.6 mSv (*STUK 2007a, 2007h*).

The radiation dose caused by the existing nuclear power plants in Finland to the most exposed group in the power plant vicinity is less than one thousandth of the average radiation dose of the Finns (*STUK 2007b, 2007g*).

Table 13-3. Examples of radiation doses (*STUK 2007a, 2007c, 2007g, 2007h, 2007i, 2007j, VNp 395/91*).

Radiation dose	Description
0,0003 mSv	Average annual calculated radiation dose caused by emissions from the existing power plant units in Loviisa in recent years, received by a person belonging to the most exposed population group in the vicinity. Average radiation dose received outdoors by a person living in Loviisa from the radiation of natural radioactive substances present in nature and from cosmic radiation during two hours.
0,01 mSv	Radiation dose received by a patient from one dental X-ray examination.
0,02 mSv	Average radiation dose currently received by a Finn from nuclear weapon tests and from the deposition caused by the accident at Chernobyl during one year.
0,1 mSv	Radiation dose received by a patient from one X-ray examination of the lungs. Maximum annual limit of the radiation dose received by a person living in the vicinity of a nuclear power plant caused by all radioactive releases from the nuclear power plant site.
0,4 mSv	Average radiation dose caused by natural radioactive substances present in the body during one year.
0,5 mSv	Average radiation dose received by a Finn from the external radiation of soil during one year.
1 mSv	Radiation dose from the external radiation of natural radioactive substances during one year in Loviisa. Average annual radiation dose received by the users of water from drilled wells.
2 mSv	Average annual radiation dose caused by radon in Finland. Typical annual radiation dose received by a member of flight crew from cosmic radiation.
3,7 mSv	Average annual radiation dose received by a Finn from radiation.
12 mSv	Computerized axial tomography (CAT scan) of stomach.
14 mSv	Annual radiation dose received by a resident when the radon content of indoor air is 800 Bq/m³ (in Finland there are some 19 000 dwellings where the radon content is higher than this).
50 mSv	In radiation work, the dose limit within one year.
100 mSv	In radiation work, the dose limit within five years.
1 000 mSv	Symptoms of radiation sickness (e.g. fatigue, nausea) begin to appear if the radiation dose is received in less than 24 hours.
4 000 mSv	Lethal radiation dose. The person can be saved with good care.
6 000 mSv	If received suddenly the dose is likely to cause death.
10 000 mSv	Life cannot be saved even with the best care.

Moonlight, Ruotsinpyhtää

Great tit, Loviisa

14 NUCLEAR FUEL CYCLE FROM MANUFACTURE TO FINAL DISPOSAL

14.1 Stages of the nuclear fuel cycle

The fuel of a nuclear power plant is fissionable nuclear fuel manufactured from uranium ore through various chemical and mechanical stages. The lifespan of nuclear fuel, i.e. the nuclear fuel cycle, includes many stages from extraction of ore to management of spent fuel.

The nuclear fuel cycle can be either open or closed (Figure 14-1). In an open nuclear fuel cycle the spent fuel is disposed of in closed resistant canisters deep in the bedrock. The principle of the open nuclear fuel cycle is applied in Finland. In a closed nuclear fuel cycle the spent fuel is reprocessed. In the reprocessing, uranium and plutonium are chemically separated from the spent fuel and they are utilized in the manufacture of new nuclear fuel. The high-level waste from reprocessing is disposed of.

The environment is strained by mining, fuel manufacturing processes, transports, reactor operation and spent fuel management. The adverse impacts on employees, population and the environment can be caused by radioactive waste, particulate emissions or gaseous bodies. Most of the adverse impacts linked with the nuclear fuel cycle are caused by the mining industry.

14.2 Procurement of nuclear fuel

The fuel of a nuclear power plant can be procured either as complete units, fuel assemblies, or by buying each stage of the fuel manufacturing chain separately. Uranium markets are global and they are dominated by a few significant producer countries, such as Canada, Australia and Kazakhstan. The other stages of the manufacturing chain (conversion, enrichment and fuel assembly manufacture) can be bought from, e.g., Great Britain, Germany, France, Russia or the United States.

The new power plant unit spends annually 20–40 tonnes of fuel, and 170–250 tonnes of uranium concentrate (U_3O_8) are needed for its manufacture. The needed amounts of material are relatively small since the energy content of uranium is very high.

Table 14-1 shows the stages of fuel cycle and the related

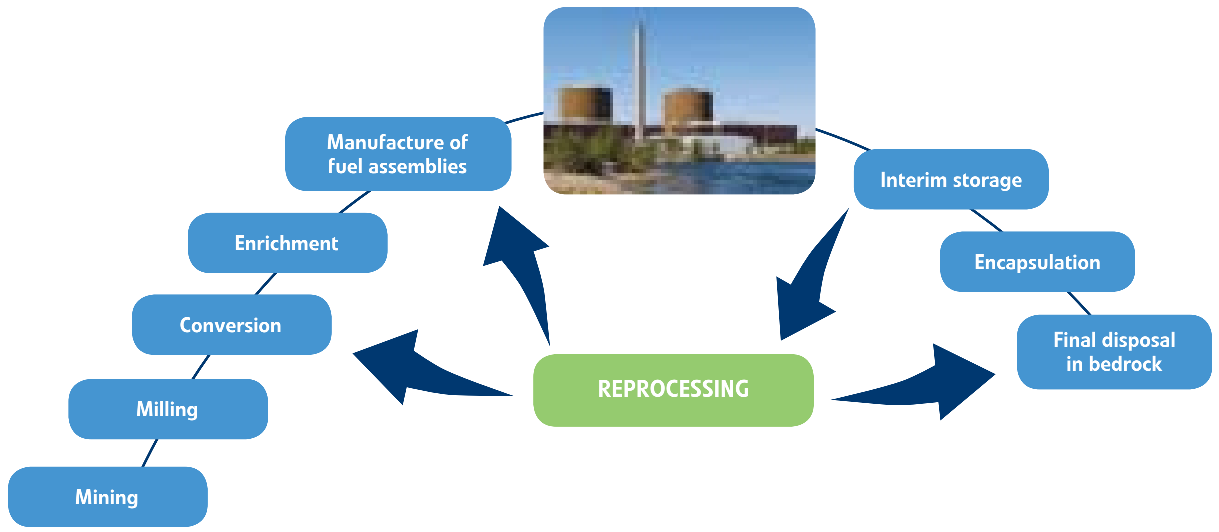

Figure 14-1. Open and closed fuel cycles. The open fuel cycle principle is applied in Finland.

material balance for a 1 000 MW power plant unit with an annual electricity production of about 8 TWh. A coal-fired power station of equal size spends annually about two million tonnes of coal, i.e. 10 000 times as much raw material as a nuclear power plant.

Table 14-1. Fuel cycle material balance for a 1 000 MW power plant unit with an annual electricity production of about 8 TWh.

Stage		Uranium	By-products
Mining and milling	U_3O_8	170 t	60 000 t of waste rock and mill tailings
Conversion	UF_6	170 t	
Enrichment	UF_6	25 t	145 t of depleted uranium
Manufacture of fuel	UO_2	25 t	
Operation	UO_2	25 t	25 t of spent fuel

14.2.1 Uranium

Uranium is a heavy, slightly radioactive metal element, whose chemical symbol is U. Uranium is the heaviest of elements found in nature, where it is mainly found as isotopes ^{238}U (99,28 %) and ^{235}U (0,71 %). The half-life of isotope ^{238}U is about 4.5 billion years and that of isotope ^{235}U about 700 million years. Uranium is a relatively common element existing everywhere in the bedrock granite. There are about four grammes of uranium per tonne of soil and about three milligrammes of uranium per tonne of sea water.

14.2.2 Global uranium resources and production

The annual demand for uranium concentrate (U_3O_8) is some 65 000 tonnes, of which new production of natural uranium covers about 2/3. The rest of the market demand is filled by emptying storages, reprocessing spent fuel and using depleted weapons-grade uranium. For more than ten years, weapons-grade uranium has been diluted to make nuclear fuel, on the basis of a contract between Russia and the US.

Owing to the common occurrence, uranium resources will be enough far into the future. The adequacy of uranium resources depends on the cost level of economically profitable uranium production. The more expensive the alternative sources of energy are, the more money can be used for uranium fuel production and the larger the available uranium resources are. The known uranium resources amount to 4 700 000 tonnes (*OECD NEA & IAEA 2005*). In addition, undiscovered resources to be mined with conventional methods are estimated at 10 000 000 tonnes. Besides these, uranium resources occurring as part of phosphate deposits amount to as much as 22 000 000 tonnes and they can be exploited fairly economically. The annual production volume of uranium at the moment has settled to some 40 000 tonnes. The amount of uranium needed for nuclear power production has been estimated to grow to 81 000 tonnes by 2020 and to 110 000 tonnes by 2030. At these consumption levels, the uranium resources will be enough for several hundred years.

The ten largest uranium producer countries produce about 90% of all uranium in the world (Figure 14-2). The overwhelmingly significant uranium producers in 2006 were Canada and Australia, which produced almost a half of the uranium in the world (*WNA 2007*). In addition to Canada and Australia, the largest known deposits of uranium exist in Kazakhstan, the US, South Africa, Namibia, Brazil, Niger and Russia (*OECD NEA & IAEA 2005*).

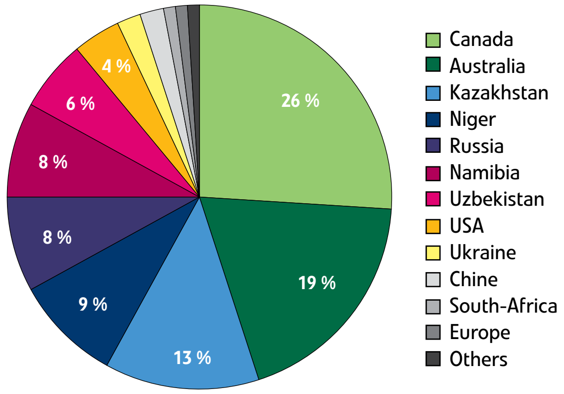

Figure 14-2. Total production of uranium in 2006. Total 39 429 tU (*WNA 2007*).

14.2.3 Uranium resources and production in Finland – history and the present

The Finnish uranium deposits have been investigated since 1955. The best known uranium deposits are located in the Kolari–Kittilä area, in Kuusamo, Koli and the province of Uusimaa. During 1958–1961 small-scale mining activity was carried out at Paukkajanvaara in Koli in Northern Karelia.

The extent of the deposits detected in Finland and the uranium content in the ore have been relatively small and, until today, the commencement of commercial mining has therefore not been economically profitable.

With the rise in the world market price of uranium the interest in uranium prospecting has also increased in Finland. International mining companies submitted their first claims to the Ministry of Trade and Industry in autumn 2005. (*Tontti 2006*)

14.2.4 Uranium mining activity

The reputation of uranium mining has suffered from the practices of past decades and the careless after-treatment of mining waste. It was common to pile the waste on the ground or it was utilized as construction material, even outside the mining area. The supervision of and regulations for mines have become notably stricter, however, since the knowledge on mining waste and the risks posed by its radiation have increased. Nowadays it is common to require an environmental impact assessment (EIA) before initiating the mining activity. The EIA procedure has also been applied for mines to be extended or decommissioned.

Canada and Australia have been pioneers in the implementation of EIA procedures in mining (*IAEA 2002*). Most of the uranium mines in these countries also apply the environmental management system in accordance with the ISO 14001 standard (*WNA 2007*). This requires the mining companies to constantly develop their operations and to regularly monitor environmental impacts. The radiation doses of workers are also continuously monitored.

The uranium mining industry accounts for a considerable proportion of the environmental impacts related to the manufacturing process of nuclear fuel. This is due to the fact that even though the waste originating from the mining industry is low-level waste, its quantity is relatively large. A special feature of uranium mining is the consideration of radiation impacts, but otherwise it is a part of normal mining industry. The most significant environmental impacts of the uranium mining stage are connected with radiation exposure and the waste generated in the mining and milling of ore. Often the mining also causes harm to the landscape.

Mining and milling

The extent of environmental impacts of uranium mining activity depends on the used mining method; uranium is extracted from underground shaft mines, open pit mines and using underground leaching method. The choice of the mining method is made on the basis of the uranium content of the deposit and the geological properties of the area. About 41% of uranium is obtained from underground mines, 26% using underground leaching, 24% from open-cast mines and 9% as the by-products of other mining products, such as gold, copper or phosphate (*WNA 2007*).

Open pit mines are mainly chosen when the deposits are close to the ground surface (Figure 14-3). When the deposit is deep, generally at a depth of more than 120 metres, a shaft mine is used (Figure 14-4). In a shaft mine the hole needed on the ground is notably smaller than an open pit mine.

Figure 14-3. McClean Lake open pit mine in Canada (Areva Resources).

Figure 14-4. McArthur River underground uranium mine in Canada (Cameco).

The uranium ore extracted from the bedrock by traditional means is crushed and ground, after which uranium is separated from the rock material using a chemical dissolution method at separate mill. After this, the uranium is precipitated, the sediment is separated, washed and dried. The result is uranium concentrate (U_3O_8, yellow cake), with a uranium content of 60–80%.

The adverse impacts on landscape caused by uranium mining activity have been mitigated using ever more frequently the leaching of uranium directly from the ore deposit (ISL, in-situ leaching) (Figure 14-5). The leaching method is used in areas where it is possible, taking into consideration the bedrock and groundwater conditions. In this method the uranium is leached into a chemical solution which is injected into the ground and collected with the help of pump wells. The uranium is chemically separated from the solution, after which the uranium is concentrated and the solution is reused for leaching.

Figure 14-5. Beverley ISL production plant in Australia (Beverley).

Using this method of uranium recovery it is possible to also utilize such deposits where ordinary mining and milling technology would be uneconomical. In addition to the smaller adverse impacts on the landscape, the benefits of leaching are the smaller amounts of waste land and waste waters. Nevertheless, underground leaching is not completely without risk to the environment. When using the method, attention must be paid not to let the chemicals contaminate groundwaters (*IAEA 2005*).

Radiation impacts

The radiation doses during the mining and milling of uranium mainly arise from three sources: the radiation of uranium ore and dust during mining and treatment, the radiation of radon gas released from uranium ore and its radioactive decay products, and the radiation of mill tailings.

The radiation from uranium itself is weak alpha radiation, which stops at clothes or skin. The largest radiation doses are acquired from the radioactive decay products, such as radium and radon.

One of the decay products of uranium, radon, is a gaseous body released into the air everywhere where there is uranium in the soil. Radon is known to predispose to lung cancer. In uranium mines uranium is released more than normally, since in mines the uranium content is higher than in soil or bedrock on average (*Vuori et al., 2002*). Nevertheless, it must be noted that radon is not just a problem of uranium mines, but relates to all mining operations, since there is always some uranium in the soil.

In open pit mines, the amount of radiation exposure caused by radon is notably smaller than in shaft mines. In shaft mines the radiation exposure can be vitally decreased by effective air conditioning. With the development of mining technology and the automation of functions, the harms caused by mining have been decreased. The newest technology has been brought into use especially in deposits that are very rich in uranium, e.g. in McArthur River and Cigar Lake areas in Canada. This has led to a reduction in the radiation exposure of mine workers (*IAEA 1998*).

Waste

Waste from uranium mining consists of fine uranium dust, process waters and radioactive soil and rock material. The milling process also generates solid and liquid waste, which contains, in addition to radioactive radium, also other detrimental substances, such as arsenic and heavy metals.

When storing the excess soil and rock material from uranium mining temporarily above ground, it must be seen to it that the soil and rock piles, which contain radioactive material, will not weather or raise dust. In most cases the piles are therefore covered with a layer of clay. If the mining is carried out underground, the solid waste is replaced, as far as possible, in the shafts.

The mill tailings are placed in dammed storage and evaporation ponds, and the solid matter settles on the bottom of the pond and the water separated from it can be conducted away. Radioactive materials and heavy metals are separated from the water by chemical precipitation, after which the water is reused, if possible, as process water. The evaporation waste is collected as sludge or crystal mass for treatment and final disposal. The environmental risks of waste treatment are mainly related to the failure of the dams in the mill tailing ponds, migration of radioactive materials to the groundwater and the dusting of soil and rock material.

14.2.5 Uranium mine activity in Russia

With regard to the production volume, the largest operating uranium mine in Russia is located in the Priargunsk (former Krasnokamensk) mine area. In 1992 a Finnish group, including the representatives of Fortum, visited the area.

The owner company of the mine, JSC PMCPA (Joint Stock Company Priargunsk Mining-Chemical Production Association), has been producing uranium since 1968. The by-products of ore are, e.g., gold, lead, molybdenum and rare earth metals.

The mine area of Priargunsk is located 10–20 km away from the city of Krasnokamensk with a population of 60 000. The area is located in Eastern Siberia, about 30 kilometres away from the border of China, near Mongolia. The size of the area is 150 km^2, consisting of eight shaft mines and two open pit mines. Nowadays the extraction is mainly carried out in underground mines, where the uranium content of ore is 0.3–0.4%. Since 1974, also a plant specializing in uranium milling and upgrading has operated in the area (*IAEA 2002*). A majority of the ore is processed at the plant, but a minor part of the low-content ore is dissolved from the pile on the ground or directly from the deposit underground.

The mining industry has caused harm to the environment due to the insufficiently managed waste treatment in the past decades. For example, the mine waters were released untreated to the environment until 1996, when an adequate waste water treatment plant was put into use. (*IAEA 2004*)

14.2.6 Conversion and enrichment of ore

The operation of a light water reactor is based on a chain reaction. The reactor physical properties needed to maintain the chain reaction require enriching the uranium in the fuel to 3–5% in relation to fissionable isotope ^{235}U.

For enrichment, the uranium concentrate (U_3O_8) is converted to uranium hexafluoride (UF_6), which, at a low temperature, is a compound that transforms into gas directly from the solid state. The enrichment is based on the difference in mass between the various uranium isotopes, when isotope ^{235}U can be separated from other uranium isotopes either by gas diffusion or centrifuge methods (Figure 14-6). In the last few years, the use of the centrifuge method has become more common, since, thanks to the technological development, its energy consumption is notably smaller than that of the gas diffusion method. (*NEA News 2001*)

At conversion and enrichment plants, the same chemicals are used as in normal chemical industry. The use of poisonous chemicals, such as fluorine compounds, requires special and precautionary measures. At conversion and enrichment plants the uranium is isolated inside the process equipment and it does not have radiation impacts on the workers or the environment.

14.2.7 Manufacture of fuel assemblies

For manufacturing fuel pellets (Figure 14-7), the enriched uranium hexafluoride (UF_6) is converted to uranium dioxide powder (UO_2) using a chemical conversion process. In modern fuel factories this conversion process is carried out as a dry process, owing to which the liquid releases caused by the process are smaller than in the conventional conversion based on a wet process.

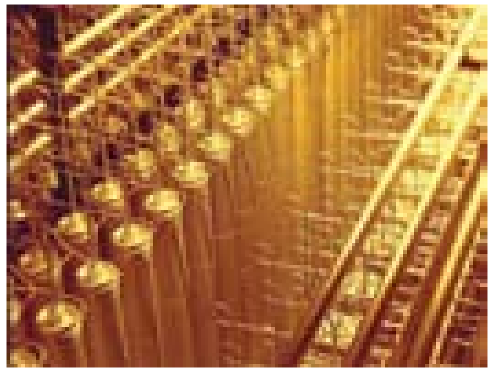

Figure 14-6. Centrifuge enrichment (Urenco).

Figure 14-7. Fuel pellets made of uranium dioxide.

The uranium dioxide powder is pressed into fuel pellets, which are sintered at a high temperature to a ceramic material. After this, the fuel pellets are ground into their final form and put into shroud tubes made of a zirconium compound. The tubes are pressurised with helium that improves heat transfer, after which they are closed hermetically. The complete fuel rods are collected in fuel assemblies with 100–300 rods, and stored for transport (Figure 14-8).

Each work phase takes place on the basis of detailed instructions and tight quality control. The radiation impacts of the work phases are not significant since the most harmful radioactive decay products of uranium, such as radium, radon and polonium, do not exist in enriched uranium.

14.2.8 Transports and storage of fresh fuel

The transports of fuel between the different stages of the fuel chain are carried out by controlled sea, railway and road transports, with special containers and normal transport equipment. The largest transport capacity is required at the beginning of the fuel chain since as the degree of processing increases, the amount of transported material decreases.

The transport packages and transport of radioactive material are regulated by instructions issued by the International Atomic Energy Agency (IAEA) and national regulations made on their basis. Uranium transports require a permit of the authorities and they must be guarded and controlled in order to prevent unjustified taking of possession. The corresponding regulations also apply to the transport of spent fuel.

The transport of enriched uranium and fresh fuel differ from the transport of natural uranium in that the possibility of occurrence of a continuous chain reaction must be excluded during the transports. This is realized by shielding and by determining the size and form of transport packages in such way that the chain reaction is not initiated even in the case of an accident. The transport packages must withstand, e.g., collisions and fires.

At present, it is typical that transports are included in the delivery. The uranium concentrate is purchased with delivery to the conversion plant and the converted uranium (UF_6) as delivered to the enrichment plant. The enriched uranium (UO_2) is bought either as delivered to the factory manufacturing fuel assemblies or the transport of enriched uranium is included in the manufacturing contract, as is also the transport of complete fuel assemblies to the power plant. The transports do not have any health impacts on the transport personnel or the people living along the transport routes, since the transported materials are not highly radiant.

Nuclear fuel is delivered to Finland by rail or by sea. To the Loviisa Power Plant the fuel is still transported by road. The annual need for fuel at the existing power plants in Loviisa is about 25 tonnes, i.e. a few lorry loads. At the Loviisa Power Plant, the amount of fresh fuel usually stored in the dry store corresponds to the needs of one or two years (Figure 14-9). The licence to possess nuclear fuel requires guarding to prevent the access of outsiders to nuclear material.

Figure 14-8. VVER-440 fuel assembly (TVEL).

Figure 14-9. Fresh fuel assemblies in a transfer basket in the dry store of the Loviisa Power Plant.

14.2.9 Recycling and reprocessing

About 10% of the current uranium need in the world is filled by recycled material. In the future this proportion will decrease since the storages of usable depleted uranium and weapons-grade uranium are reduced.

When enriching uranium, multifold amount of depleted uranium is formed compared with enriched uranium, containing 0.1–0.4% of fissionable isotope ^{235}U. The enrichment of depleted uranium is profitable if idle and inexpensive enrichment capacity is available. The mildly enriched uranium produced from depleted uranium can be used when depleting weapons-grade uranium to nuclear fuel.

The uranium from the reprocessing of spent fuel can, after conversion and enrichment, be made to uranium dioxide fuel (UO_2). The enrichment can be replaced by mixing the reprocessed uranium with weapons-grade or other highly enriched uranium. Also plutonium from reprocessing or nuclear weapons can be used for replacing the uranium enrichment needed in uranium fuel. The fuel made of depleted uranium and plutonium is called MOX (mixed oxide) fuel.

14.2.10 Fuel procurement principles in Fortum

Fortum's nuclear fuel procurement takes environmental impacts into consideration as early as when calling for bids. The bidders are expected to present their environmental management systems in the bids or to describe how the environmental impacts caused by their operations have been taken into consideration. When comparing the bids, it is estimated whether the operation is proper and adequate in respect of the legislation of the supplier's country.

Fortum carries out regular audits of the quality management systems of its fuel suppliers. During the audits, attention is paid to, e.g., the quality and performance of the environmental and quality management systems of the suppliers. Fortum also controls regularly the manufacture of fuel assemblies in the fuel factories, to which a group of specialists makes two to four quality control visits annually.

Fortum's opportunities to affect the procedures of the different parties to the supply chain of the fuel supplied to the company are limited to the obligations agreed on in the fuel contracts and to the environmental and other regulations of these operations in each country. According to the environmental policy of Fortum, the co-operation with suppliers emphasizes the principle of constant improvement and open interaction in the management of environmental matters.

The fuel assemblies of the existing power plant units in Loviisa are both Russian (TVEL) and British (Westinghouse/BNFL). The uranium used in the assemblies of both manufacturers originates in Russia.

On the basis of the contracts dating from the 1970s, whose price clauses were last revised in 2006, Fortum will procure the fuel until the end of the operating life of the existing power plant units from the Russian TVEL. According to the contract, TVEL will procure the enriched uranium used in the manufacture of fuel assembles from Russian subcontractors. Of the subcontractors of TVEL, both the zirconium material manufacturing plant ChMP (Chepetsky Mechanical Plant) and MSZ (Mashinostroitelny Zavod), which is responsible for manufacturing uranium oxide pellets and fuel assemblies, apply to their operations a certified environmental management system in accordance with the ISO 14001 standard, which requires companies to examine all their environmental impacts and continuously improve the level of environmental protection.

14.3 Nuclear fuel in the reactor

14.3.1 Fission

The use of uranium as fuel is based on the splitting reaction of the nuclei of its isotope ^{235}U, i.e. fission. In the fission reaction the heavy atom splits, as a free neutron hits it to two or more lighter atom nuclei, called fission products (Figure 14-10). A few neutrons are also released in the reaction, as well as a large amount of energy. The neutrons released in the reaction can cause new fission, owing to which the starting of a chain reaction is possible. For controlling the chain reaction, neutron capturing elements are used to consume the excess neutrons.

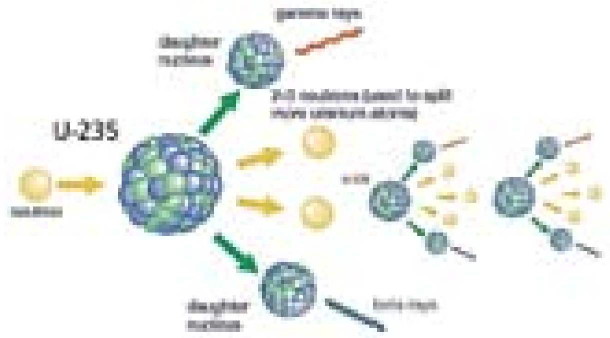

Figure 14-10. Fission of uranium.

In addition to fission, other nuclear reactions also take place in the reactor. A majority of the fuel's uranium is of isotope ^{238}U, which is not as fissionable as isotope ^{235}U. A neutron moving at a suitable energy might be absorbed into the atom nucleus of ^{238}U. As the neutron turns into a proton, plutonium (Pu) is formed. In addition to plutonium, also other elements heavier than uranium, i.e. transuranic elements, are formed. Some of the transuranic elements, such as ^{239}Pu, are involved in energy generation in the reactor.

14.3.2 Refuelling

During the refuelling outage, fuel assemblies that have reached their planned service life, typically about one quarter of the fuel, are removed from the reactor and replaced with fresh fuel assemblies. Furthermore, the positions of the fuel assemblies remaining in the reactor are changed to reach the optimal power density. Typically the refuelling shutdown is in 12 months intervals, but 18- or 24-month intervals are also possible. The longer the interval is, the larger number of fuel assemblies is replaced during the refuelling outage.

Due to the fission products and the transuranic elements formed in the fuel during operation, the radioactivity of spent fuel is so high that its management and storage require special procedures.

14.4 Spent fuel

14.4.1 Quantity

The quantity of spent fuel produced at a nuclear power plant depends on the output of the power plant, the load factor, type of the used fuel, produced output (discharge burnup) and operating life.

The existing power plant units in Loviisa and Olkiluoto produce altogether about 4 000 tonnes of spent fuel during their operating lives of 50-60 years. The third unit under construction at Olkiluoto will probably produce about 2 000-2 500 tonnes of spent fuel during its operating life of 60 years. If the new power plant unit in Loviisa will be similar with respect to its nominal output and operating life, also the quantity of spent fuel will be about the same.

14.4.2 Interim storage

After removing a spent fuel assembly from the reactor, it is cooled for a few years in a refuelling pond, where a majority of the fission products are decayed and the heat production decreases. As the fuel assembly has cooled enough, it is transported inside a radiation shield to a separate interim storage at the power plant site. The interim storage is designed so that the cooling of spent fuel is adequate and criticality is not possible. The fuel is usually stored in water pools but air-cooled dry storage is also possible. The cooling of spent fuel is continued in the interim storage until its activity and heat production are low enough so that the spent fuel can be transported to the repository for spent fuel. The duration of interim storage can be even 60 years if the discharge burnup is high. During the interim storage, the condition of the spent fuel is controlled on a regular basis. The aim is to ensure that the condition of the spent fuel remains adequate during the long-term storage, considering also the management of the fuel required by final disposal.

The spent fuel from the existing power plants in Loviisa must be kept in the interim storage for about 20 years before its final disposal. The present spent fuel interim store of the Loviisa Power Plant is shown in Figure 14-11. The spent fuel interim storage of the new power plant unit will be designed to be sufficient for the entire operating life of the new power plant unit. The interim storage has no considerable environmental impacts.

Figure 14-11. The present spent fuel interim storage at the Loviisa Power Plant.

14.4.3 Transports

A fuel lot transferred from interim storage to final disposal is moved into a transfer cask, which Posiva transports to Olkiluoto to the repository for spent fuel, either by road, sea or rail. The transport method and routes have not been decided yet, since the transports will begin in 2020, at the earliest, when the repository is scheduled for completion.

According to present plans, spent fuel from the existing power plant units in Loviisa will be transported for final disposal two or three times per year. The spent fuel from the new power plant unit will be transported for final disposal approximately two to four times per year.

14.4.4 Licensing procedure of final disposal

In Finland, each power company is responsible for its spent fuel all the way to the shutdown and sealing of the repository. Fortum and Teollisuuden Voima have agreed upon co-operation in spent fuel final disposal and transports of spent fuel from interim stores to the repository. For the practical implementation of this co-operation, Fortum and Teollisuuden Voima established a company, Posiva Oy, in 1995. The Ministry of Employment and the Economy has approved this co-operation both in spent fuel final disposal and provision for the costs. Posiva is responsible for the final disposal studies of the spent fuel from its owner companies, for construction and operation of the repository, transports of spent fuel and the sealing of the repository. Posiva's final disposal concept is based on the disposal of spent fuel in copper canisters in the repository rooms excavated in the bedrock.

Teollisuuden Voima initiated a field investigation programme regarding the site selection for the repository for spent fuel in the early 1980s according to the schedule confirmed in the Government resolution in 1983. At the final stage of site investigations, environmental impact assessment was carried out at four sites on the disposal of spent fuel from a total of six reactors. After the EIA procedure, Posiva chose Olkiluoto in Eurajoki as the site of the repository (*Posiva 1999, Vieno et al. 1999, McEwen, T. and Äikäs, T. 2000*). Having chosen the site, Posiva submitted an application for a Government resolution on the disposal of the spent fuel accumulated during the operation of the existing four power plant units. After a favourable decision by the municipality of Eurajoki, the Government made a favourable resolution on the repository in 2000, which was ratified by Parliament in 2001. As a part of the resolution on the third power plant unit at Olkiluoto, the Government made a new resolution on the basis of an application by Posiva, on a repository that covers the final disposal of spent fuel from five power plant units. Posiva has announced that it will launch in 2008 the assessment of environmental impacts of a repository that covers the final disposal of the spent fuel from the existing power plant units, the third unit at Olkiluoto and potential additional units constructed by Fortum or TVO.

At the moment an underground rock characterization facility called ONKALO is being excavated in the bedrock at Olkiluoto. The research is carried out to verify the bedrock properties and to acquire the information needed for detailed design. When the detailed investigations and the plans for the repository are finished, Posiva will apply for a construction licence in accordance with the Nuclear Energy Act from the Government. According to the planned schedule, the construction licence application for a repository located at Olkiluoto will be submitted to the Government in 2012. According to the Nuclear Energy Act, a licence for initiation of the final disposal must be applied for from the Government. The planned commissioning of the final repository will be in 2020.

14.4.5 Final disposal concept

Posiva will construct the repository on the basis of the KBS-3 concept originally developed in Sweden (*Pastina & Hellä 2006*). The final disposal system has been designed for a long-term isolation of the radioactive materials contained in the spent fuel. According to the concept, the spent fuel is packed at an encapsulation plant into a cast iron frame, which lies inside a copper canister, and the canister is closed. The canisters are placed in the bedrock, in holes in the floor of deposition tunnels drilled to a depth of 400-700 metres and lined with bentonite (Figure 14-12). Finally the final disposal tunnels are sealed with an expansive filling material, which according to present plans is Friedland clay.

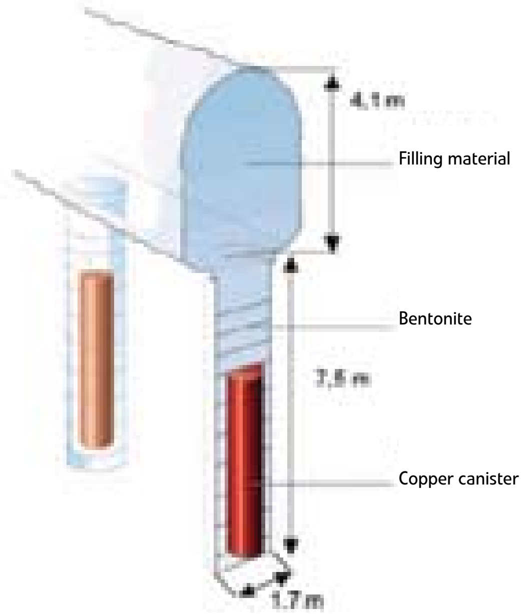

Figure 14-12. Location of encapsulated spent fuel in the bedrock.

The safety of the KBS-3 concept is based on the technical and natural multiple barriers, i.e. poorly soluble fuel pellet, copper canister, bentonite clay and the bedrock. Most materials, including the uranium of the fuel, are dissolved from the fuel canister very slowly. In the final disposal conditions, the copper canister withstands corrosion for a very long time. The clay surrounding the canister protects it from any small movements of the earth's crust, and prevents very efficiently the flowing of water in the final disposal rooms. When the copper canister finally loses its integrity the radioactive materials released from the fuel migrate poorly through the clay buffer. When they permeate the clay buffer, they remain in the minerals of the bedrock and are diluted with the groundwater in the bedrock (Figure 14–13).

The final disposal facility consists of the encapsulation plant constructed above ground and the underground final disposal tunnels. According to present plans, the main level of the repository will be located at a depth of 400-450 metres. A central tunnel network will be constructed on the main level and final disposal tunnels will branch from the central tunnel. The total area of the tunnels will be about 3 km² and their total length will be more than 30 km (Figure 14-14). The extent and location of the underground tunnels will finally be determined on the basis of the bedrock properties.

The final disposal tunnels will be filled with compacted Friedland clay blocks as the fuel meant for each tunnel has been placed in their positions. The central tunnels and other rooms are filled when all spent fuel has been placed inside the repository. The planned time of sealing is in the early 2110s if only the spent fuel from the existing power plant units and the one under construction will be disposed of and the operating life of the plant units is not extended. The building of the new power plant unit in Loviisa will postpone the sealing by a few years.

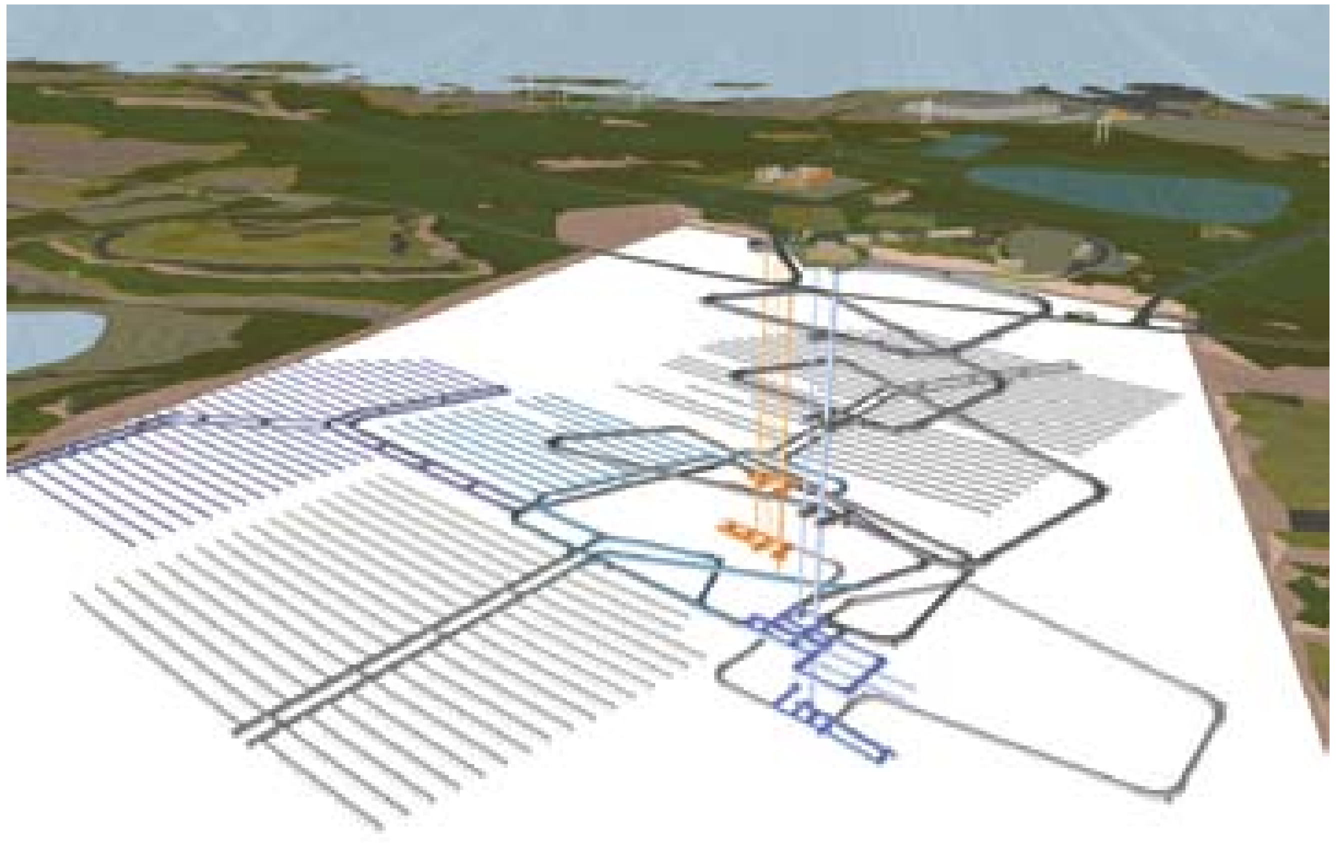

Figure 14-14. General picture of the final disposal facility above ground and underground (Posiva 2006).

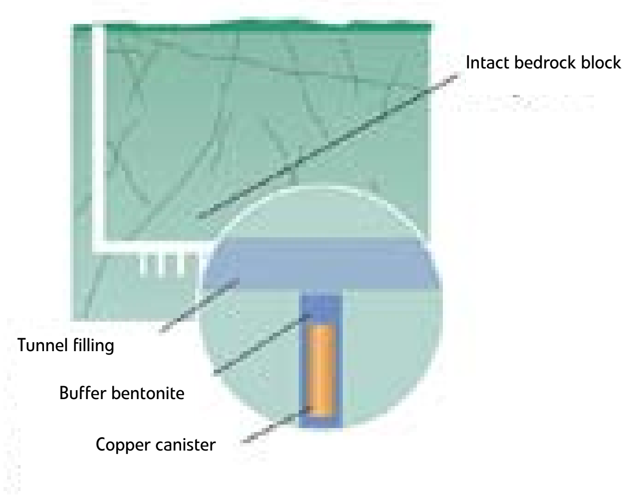

Figure 14-13. Multiple barrier principle of final disposal (*Posiva 2006*).

14.4.6 Environmental impacts of the final disposal facility

The environmental impacts of the final disposal facility for the spent fuel from six nuclear power plant units were assessed in 1997–1999 (*Posiva 1999*). According to the studies, the environmental impacts are small:

- Impacts on nature and use of natural resources are small and limited to the immediate vicinity of the power plant.
- Except for any psychosocial effects, the project has no significance for people's health.
- The project has positive socioeconomic impacts.

The final disposal of the spent fuel from the new power plant unit in Loviisa does not change the environmental impacts of the repository significantly. The growth in the quantity of spent fuel mainly has impacts on the duration of the repository operation, whereas the annual operation capacity and nature of the activity remain the same. The environmental impacts of the extended repository will be considered in the environmental impact assessment carried out by Posiva in 2008.

14.4.7 Long-term safety of final disposal

The requirements set for the long-term safety of spent fuel final disposal have been written in Government decision 478/1999, the future decree and the YVL Guides by the Radiation and Nuclear Safety Authority. According to the Guides, the annual radiation dose of the most exposed people must remain below 0.1 mSv and the annual average dose of other people must remain insignificantly low. The Guides also set annual nuclide-related release limits. The dose limits can be put into the right perspective when they are compared with the annual average radiation dose of a Finn, which is 3.7 mSv (*STUK 2007a*). Thus the annual radiation dose allowed by the Guides causes, at the most, a rise of not quite three per cent in the annual radiation dose of the most exposed person.

The long-term safety of spent fuel is assessed by making a very conservative safety analysis and justification. This way the real situation is with great certainty better than the result of the assessment. The safety analysis and justification deals, among others, with these matters:

- The weakening of constructed release barriers in the course of time and the release of radioactive materials
- Groundwater flow
- Surrounding biosphere
- Making a well or a deep drill hole near the repository
- Impact of potential movements of earth's crust, including land uplift and rock movements.

The latest safety analysis (*Vieno & Nordman 1999*) was made for the final disposal of the spent fuel from the existing four power plant units. The following actual safety justification will be completed in 2012, when Posiva must, according to the decision of the Ministry of Trade and Industry, submit a construction licence application. Progress reports will be made of the safety justification, e.g. (*Pastina & Hellä 2006*). The radiation doses from the TILA-99 analysis remained significantly below the limits set by the Radiation and Nuclear Safety Authority. Depending on the case, the annual radiation dose was, according to very conservative assessments, 1/10–1/1000 of the limits in the YVL Guide. According to the results, it can be assumed that the adding of the fuel from the new power plant units does not change the situation noticeably, although the quantity of fuel to be finally disposed of owing to the third power plant unit at Olkiluoto and the third power plant unit in Loviisa and the fourth unit at Olkiluoto, whose environmental impacts are currently being assessed, would increase significantly.

Brook, Sikilä

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Wintery landscape
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15 COMPARISON OF ALTERNATIVES AND SIGNIFICANCE OF ENVIRONMENTAL IMPACTS

15.1 General

Environmental impacts have been examined by comparing the changes caused by project implementation to the current situation. The significance of the impacts has been assessed based on the magnitude of the changes and by comparing the impacts of the new power plant unit's operations to the limits of radioactive radiation doses, environmental quality standards, and the area's current situation. Special emphasis was placed on determining and describing the impacts that were considered important on the basis of the feedback received during the EIA procedure and on the social impacts caused by the project. Relevant factors in terms of the significance of the impacts are:

- regional scope of the impact
- the target of the impact and its sensitivity to changes
- significance of the impact's target
- the reversibility or permanence of the impact
- the intensity of the impact and the magnitude of the resulting change
- impact-related fears and uncertainties
- different views on the significance of the impact.

15.2 Uncertainties in the environmental impact assessment

The available environmental data and the assessment of impacts always involve assumptions and generalisations. Furthermore, the available technical data is still very preliminary at this stage. Lack of sufficient data may cause uncertainty and inaccuracy in the assessment work.

The potential uncertainty factors have been identified as comprehensively as possible during the assessment work, and their implications on the reliability of the impact assessments has been taken into consideration. These issues are described in the assessment report.

15.3 Comparison of alternatives

The impacts of the different implementation alternatives have been compared qualitatively in Table 15-1. The major environmental impacts – positive, negative and neutral alike – are illustrated in the table. The environmental feasibility of the alternatives has also been assessed. The impacts during the construction and operation of the new power plant unit have been presented separately according to the targets of the impacts. A more detailed assessment of the impacts of the different options is presented in Chapters 8–14.

Table 15-1. The environmental impacts and their significance during the construction and operation of the new power plant. The reference point is the impact of Loviisa power plant's existing power plant units.

CONSTRUCTION PHASE	Impacts on soil, groundwater, flora and fauna, and nature conservation areas in the land area	Impacts on sea-area water quality, biological condition, fish population	Impacts on air quality and climate	Impacts on human health, living conditions and habitability, living and recreation	Impacts on landscape, land use and community structure	Impacts on employment, industry and commerce, and the economy
Construction of the power plant unit	• Significant earth-moving work in the power plant area • No adverse impact on groundwater quality • No adverse impact on flora, fauna and natural areas • Basic improvement of Atomitie road can have an impact on locally valuable natural areas located along it (Mysskärret and Ryssviken)	• Slight increase in wastewater load	• Temporary, local dust impact	• Possible public disturbance • Improvement in living conditions and more active social life • Increased demand for housing • Locally significant noise pollution in the archipelago within a 700-meter radius	• Change in landscape looking from the sea • Impacts of construction work and land use are limited to the existing power plant area and its vicinity	• The project has a positive impact on population development in the Loviisa region, but requires increased housing production • Significant employment impact of about 21,000 man-years • Increased tax revenue for municipalities in the Loviisa region • Increased demand for local services
Construction of the unloading and loading site	• No impact	• Local water turbidity caused by construction work might drive away fish and cause adversity to fishing • Zoobenthos and aquatic vegetation will disappear from the construction area • More modest variety of birdlife in the area	• No impact	• Local adverse impact on habitability for recreational population • Does not significantly limit water traffic in the area	• Local change in landscape seen from Hudöfjärden	• No impact
Building a shipping lane	• No impact	• Local water turbidity caused by blasting work and water construction work will drive away fish • Zoobenthos and aquatic vegetation will disappear from the construction area	• No impact	• Local adverse impact on habitability for recreational population	• No impact	• No impact
Construction of cooling water structures and tunnels	• No impact	• Construction below sea bed, minimal adverse impacts • Temporary water turbidity during sea-bed excavation and dredging will drive away fish	• No impact	• Possible restriction on use of rocky islands and islets in a natural state • Possible temporary adverse impact due to traffic transporting excavated material	• Temporary impact on landscape from piling excavated material	• No impact
Raw water and waste-waters	• With Ahvenkoski option, the impact of the construction of the land pipe section	• Wastewater amount at its maximum of 150,000 m^3 in the fourth year of construction • No significant impact on the condition of the sea area	• No impact	• Noise pollution impact with the construction of the Ahvenkoski option	• No restrictions on land use	• No impact
Transportation and traffic	• No impact	• No impact	• 30-60% increase in emissions compared to current situation in the Loviisa region resulting from traffic growth (nitrogen oxide, carbon monoxide, carbon dioxide emissions)	• Traffic increases the most in the fourth year of construction, i.e. about 3,600 vehicles in 24 hours • Increased risk of traffic accidents • Local noise and dust pollution in the vicinity of the Saaristotie and Atomitie roads	• No impact	• No impact

OPERATION PHASE	Impacts on soil, groundwater, flora and fauna, and nature conservation areas in the land area	Impacts on sea-area water quality, biological condition, fish population	Impacts on air quality and climate	Impacts on human health, living conditions and habitability, living and recreation	Impacts on landscape, land use and community structure	Impacts on employment, industry and commerce, and the economy
Operation of power plant unit	• No Impact	• Increased thermal load on the sea	• No Impact	• No significant change to the current situation • Local residential settlements are primarily recreational, local habitability impacts on small settlements	• No changes to land use regulations of the area surrounding the power plant area and to the extent of the safety zones • Power plant buildings can be seen from a vide area in a natural state coastal and archipelago landscape, no significant change to the current situation	• Supports the development of Loviisa region's industry and commerce, and the service structure • Employment impact for about 250 people • Positive impact on Loviisa region's income taxes, the town's corporate income tax and real estate tax revenues
Releases of radioactive substances	• No Impact	• No Impact	• No impact • Radioactive releases a fraction of the limit	• No impact • Fear of a significant radioactive release impacts sense of safety and concern, however, no big change to the current situation because nuclear power plant operations are known and the operator trusted	• No Impact	• No Impact
Cooling water and waste-water	• No Impact	• Differences between the options are very small • Increase in thermal load on the sea • Ice-free and weak ice area is bigger in remote discharge options than in local discharge options • Increase in nutrient load in the cooling water discharge area • No significant impact on aquatic vegetation and zoobenthos, however, impacts take place in a bigger area than today • In remote intake-local discharge option, vegetation could return to its earlier state, but changes are small • No significant impact on fish population compared to current situation	• No Impact	• Change in ice conditions, expanded ice-free area, activity and fishing on ice becomes more problematic • Increased fog formation • Inconvenience to habitability caused by eutrophication more widespread than today, perhaps to nearby islands	• No Impact	• No impact on fishing during open-water season • Weak ice may cause longer winter-season fishing trips • No impact on sizes of the catch

OPERATION PHASE	Impacts on soil, groundwater, flora and fauna, and nature conservation areas in the land area	Impacts on sea-area water quality, biological condition, fish population	Impacts on air quality and climate	Impacts on human health, living conditions and habitability, living and recreation	Impacts on landscape, land use and community structure	Impacts on employment, industry and commerce, and the economy
Noise	• No Impact	• No Impact	• No Impact	• Moderate habitability inconvenience to recreational population • Average noise level is about 40 dB(A), increase to the current situation is about 2 dB(A) • Noise levels will remain below limits, excluding the Saukontie holiday cottage settlement	• No Impact	• No Impact
Final disposal of nuclear waste	• No impact when properly handled and disposed of	• Groundwater seeping into the final disposal facility is treated properly before discharging into the sea	• No Impact	• Fears related to final disposal • Fears related to transportation and safety risks	• No impact, low- and intermediate-level radio-active waste is disposed of in the existing disposal facil-ity, which will be expanded	• Longer contin-ued operations of the disposal facility for spent fuel located at Olkiluoto
Other wastes and chemicals	• No impact when properly handled and disposed of	• No Impact	• No Impact	• No impact when properly handled and disposed of	• No Impact	• No Impact
Traffic and transporta-tion	• No Impact	• No Impact	• Significance of work commute emissions is small	• Local impact of increased traffic in the vicinity of Saaristotie road	• No Impact	• No Impact
Construction of 110 kV power line	• No significant impact, the power line will be placed mainly on the existing power line area	• No Impact	• No Impact	• No health impacts, no residential settlements in the immediate vicinity of the power lines • Temporary distur-bances and adverse impacts during construction	• Impact on landscape will remain very small compared to the 400 kV power lines, the power line will be placed in the existing power line area	• No significant impact on employment, and the impact on the economy is small compared to the impacts of the entire project

15.3.1 Plant options

The starting point is that the reactor to be built in Finland must be safe, employ proven technology and be in line with the general development of reactor technology. The new power plant unit will be a light water reactor, either a pressurised water reactor or a boiling water reactor. Eventually, the final selection will be made from among the plant options available on the market at the time that are compliant with Finnish safety requirements.

Safety requirements set for pressurised water or boiling water reactor plants, their safety level, environmental impacts, and social and economic impacts do not significantly differ from one another. The release of radioactive tritium is bigger with pressurised water reactors, but this doesn't have any practical significance in terms of environmental impacts. Nor are there differences in the impacts of transportation, the storage of fresh fuel, and the handling, storage and final disposal of nuclear waste.

15.3.2 Cooling water options

The new power plant unit's cooling water intake and discharge areas, and the possible intake and discharge locations have been presented in Chapter 9. The options examined are:

- **Local intake and local discharge (LL).** Cooling water is taken from Hudöfjärden, south of the current cooling water intake location for the existing power plant units (O1) and discharged to Hästholmsfjärden, south of the cooling water discharge location of the existing power plant units (P1).
- **Local intake and remote discharge (LR).** Cooling water is taken from Hudöfjärden, south of the cooling water intake for the existing power plant units (O1) and discharged to Vådholmsfjärden, east of Stora Rövarn (P2), about two kilometres from Hästholmen.
- **Remote intake and local discharge (RL).** Cooling water is taken from Vådholmsfjärden (O2) and is discharged to Hästholmsfjärden, south of the cooling water discharge location for the existing power plant units (P1).
- **Remote intake and remote discharge (RR).** Cooling water is taken from Vådholmsfjärden (O2) and is discharged to Vådholmsfjärden (P2).

Two options have been examined with the winter season conditions: the local intake–local discharge option and the local intake–remote discharge option.

In the local discharge options, the impacts target Hästholmsfjärden and in the remote discharge options Vådholmsfjärden. In the summer season, the warm cooling water will cause an increase in the temperature of the sea water around the discharge location in all the options with the exception of the remote intake–local discharge option, in which Hästholmsfjärden's temperature will decrease about 2 °C. In the local intake–remote discharge options, the area of open water and weak ice will be larger than with the remote intake–local discharge options.

The nutrient load will increase in the vicinity of the cooling water discharge location in all options. In the remote intake–local discharge option, there may be a return of aquatic vegetation to Hästholmsfjärden. However, the impacts of the options on water quality, zoobenthos, aquatic vegetation, fish population and the fishing industry are not significant compared to the current situation.

15.3.3 Raw water procurement options and wastewater treatment options

Of the options for acquiring raw water, the disadvantage with the Ahvenkoski option is the change to the landscape along 18 kilometres; it will eventually return to its original state with the regrowth in vegetation. Both the Ahvenkoski and Valko options have typical impacts of water construction, but they are relatively short term.

There is no significant difference between the three wastewater treatment options because the small wastewater load doesn't have a significant impact on the condition of the sea area.

15.4 Comparison of non-implementation of the project

The most significant impact of non-implementation of the project is that the project's positive employment impacts will not be realised. Locally, non-implementation of the project means that the current state of the environment and the impact of the load targeting it will remain unchanged, for the most part.

If the project is not implemented, the electricity generated by the new power plant unit will be substituted with alternative forms of electricity generation. Substituting the amount of electricity with fossil fuels will cause substantially more sulphur dioxide, nitrogen oxides, carbon dioxide and particle emissions. Instead of the Loviisa region, the immediate environmental impacts will target the areas close to the power plants generating electricity and close to the fuel sources either in Finland or abroad. The impacts of sulphur dioxide, nitrogen oxides, and particle emissions are regional, but the impacts of carbon dioxide emissions are global.

15.5 Project's environmental feasibility

The environmental impact assessment did not find any environmental impacts of such significance caused by the construction or operation and the different options of Fortum's Loviisa 3 power plant unit that they could not be accepted or mitigated to an acceptable level. All cooling water options are environmentally acceptable.

The EIA doesn't take a position on the acceptability of a serious accident risk in terms of an individual point of view on ethical or other personal grounds. In a sense, society has taken a position through legislation, and through the requirements and process procedures, including citizen hearings, set for the project. In any case, the assessment has aimed to present as clearly as possible the probability of a serious accident and comparison information about the related consequences so that the reader can use them as needed in the formation of their own opinion. The fundamentals of nuclear safety and the probability of a serious nuclear accident have been examined in Chapters 12 and 13.

Handled properly, the spent fuel and other radioactive waste of the new power plant unit do not cause harmful impacts on the environment or people.

16 PREVENTION AND MITIGATION OF ADVERSE IMPACTS

A new power plant unit is designed such that it complies with all regulations of the authorities. The assessment of environmental impacts has studied opportunities to prevent or mitigate adverse impacts of the project and its associated projects. The actions and technical solutions for the prevention, reduction and mitigation of adverse impacts will be determined in more detail during the design.

16.1 Impacts during the construction of a power plant unit

16.1.1 Landscape

The most visible impacts on landscape during construction are several hoisting cranes which rise clearly above treetops. The construction site is visible to the environment and this impact on landscape cannot be mitigated. There is a continuous forest belt on the western and southern sides of the island. The aim is to save most of the belt as a screen between the power plant unit and leisure time habitation and the sea. When extending the support area on the mainland, the aim is to save the landscape seen from the fortress of Svartholm as it is today.

16.1.2 Noise

The harm caused by noise and other disturbance in the vicinity of the power plant during the construction can be mitigated by timing any particularly noisy or distracting actions (e.g. blasting) to be carried out during weekdays and in the daytime. The nearest permanent and summer residents can be informed in advance of the time schedule and duration of this kind of actions. The noise made by the crushing of blasted rock can be reduced using crushing stations with acoustic screening.

16.1.3 Dust

Dust emissions from a work site can be decreased, e.g., by paving the permanent roads of the area with asphalt cover, lowering the speed limits of dirt roads and work sites, and cleaning or wetting the roads regularly. Washing the wheels of blasted rock transport vehicles when necessary can prevent the spreading of dust to public roads. Regular wetting can prevent dusting of the piles of crushed rock.

16.1.4 Hydraulic construction

The filling of the water area required by the new power plant unit and the hydraulic construction of cooling water routes, loading and unloading site, raw water pipes and potential waste water pipes can result in muddy waters, which can be reduced by using filter cloths.

16.1.5 Traffic and transport

The harm caused by traffic and transport to the nearby areas during construction can be mitigated by guiding the traffic to the planned extension of road Atomitie to main road 7 (E18), thus bypassing the centre of the town of Loviisa. Heavy traffic is scheduled, whenever possible, for weekdays between 7 a.m. and 9 p.m. Special transports are scheduled to take place outside the peak hours of everyday traffic.

16.1.6 Waste management

The aim of waste management is to reduce the quantity of produced waste and to promote reuse. Waste is sorted and delivered to waste management companies that have proper licences. Hazardous waste is collected at the work site in collecting rooms and containers, which are marked appropriately.

16.1.7 Waste waters

The waste waters originating from the construction site are treated by mechanical, chemical or biological means or by a combination of these, depending on the quality of waste water. The quantity of waste water is minimized by water use planning and recycling.

16.1.8 Chemicals and oils

The storage rooms of chemicals and oils are located properly and the rooms and containers are marked according to regulations. The workers are familiarized with the minimization of occupational safety and environmental risks posed by chemicals.

16.1.9 Operational safety of the existing power plant units

The site of the existing power plant units is surrounded appropriately with a fence to prevent unauthorized access. The arrangements and works related to the construction of a new power plant unit, e.g. blasting, will be implemented so as not to endanger the operational safety of the existing power plant units.

16.1.10 Social impacts

The aim is to be prepared for adverse social impacts and their mitigation in advance. The co-operation between Fortum, municipalities and local companies can strengthen the positive effects of the project and minimize the adverse impacts, such as any social problems caused by temporary labour.

The social impacts of the construction stage spread over a wide area since the out-of-town construction workers are lodged, in addition to Loviisa, in the nearby municipalities. Jointly with the local operators, Fortum aims to coordinate leisure activities and provide guidance on Finnish culture and practices for foreigners.

Potential disturbances and other problems caused by the construction workers' drinking are prevented by the policy of zero tolerance on alcohol use adopted at the construction site, as also currently adopted at the existing power plant units.

16.2 Impacts of the operation of a power plant unit

16.2.1 Landscape

For mitigating the impact on landscape, scenic aspects are taken into consideration when planning the filling of the sea area and the eastern part of the island. The aspects to be considered are the height and shape of the filled areas and the reservation of an area large enough for landscaping after completion of the construction work. Paying attention to the materials, colours and layout of buildings and structures also mitigates the impact on landscape.

Harmful effects of the lighting of the power plant site can be alleviated by drawing attention to the intensity and direction of the lighting.

16.2.2 Noise

The noise made by a power plant unit during operation can be reduced to a level approved by the regulations of authorities regarding occupational safety and noise level of the environment.

In the buildings, such construction techniques and materials are used that reduce the noise made by machinery and equipment efficiently. Sources of noise can also be isolated with a casing or, if necessary, they can be equipped with sound dampers. Noise resulting from vibration can be reduced by placing the vibrating equipment on a flexible base.

16.2.3 Traffic and transport

Traffic impacts of the operation of a new power plant unit can be mitigated by continuing the current cost-free bus transports of the staff to the power plant.

16.2.4 Waste management

Adverse impacts of waste management are mitigated by recycling a majority of the waste and by delivering the ordinary and hazardous waste to waste management companies that have proper licences.

16.2.5 Waste waters

The waste waters produced during operation of the power plant are treated by mechanical, chemical or biological means or by a combination of these, depending on the quality of waste water. The quantity of waste water is minimized by water use planning and recycling.

16.2.6 Chemicals and oils

In the transport, handling and storage of chemicals and oils, provision is made for incidents and accidents by drainage, shielding pools, automatic alarm system, and action plans and instructions. The risk of these substances passing into the water or soil is low.

Extensive safety instructions are drawn up for the power plant unit. The instructions deal with the prevention of chemical accidents. The staff is trained to minimize the occupational safety and environmental risks caused by chemicals.

16.2.7 Cooling water intake and discharge

Local adverse impacts caused by cooling water of the new power plant unit can be either controlled or mitigated by technical solutions. Several options are available and the choice is made in the design stage of the new power plant unit. Adverse impacts of the implementation of the options will appear in the construction stage, whereas the benefits brought by the mitigation will become apparent in the operation stage of the new power plant unit.

Cooling water intake constructions
Sucking fish with the cooling water can be reduced by designing the cooling water intake constructions in such a way that the cooling water flows by the construction so slowly that most of the fish can escape the flow. Furthermore, the sucking of fish can be prevented by taking the cooling water from great depths.

Cooling water intake from different depths
The environmental impacts of warm cooling water can be mitigated by taking the cooling water from different depths, depending on the time of the year. Effects in the summertime are minimized by taking the water from great depths, the cooling water on the discharge side then having approximately the same temperature as the surface water. During winter, the temperature of the cooling water discharge side can hardly be affected by altering the intake depth. The sinking of warm cooling water between cold brackish water and cold saline water, caused by the difference in salinity, can be prevented by taking the cooling water from the brackish water layer just under the ice cover. This solution accelerates the cooling of warm water in the discharge area and decreases the local melting of ice further from the power plant due to warm water rising onto the surface. In this solution, the ice in front of the intake place of cooling water weakens, but elsewhere the effects on the ice conditions are smaller. In practice the implementation of this solution requires two intake places of cooling water.

Increasing the exchange of water
Expanding the strait of Kirmosund improves the exchange of the water in the immedaite vicinity of the strait but, at the same time, increases effects of the warm cooling water in the area. The environmental impacts of the strait expansion are small. The landscape will not change much from the present situation and during construction the muddying of water remains local. It is possible, however, that the warm water on the discharge side circulates back via Kirmosund to the intake side of the existing plants, thus warming the cooling water.

Combined cooling water intake and discharge of three power plant units
Combination of the cooling water intake or discharge of the existing power plant units with remote intake or discharge of the new power plant unit requires, in addition to a cooling water intake or discharge tunnel, a combined intake or discharge side surge basin constructed in the vicinity of the shore of Hästholmen. In summer, this alternative makes it possible to keep the temperature of discharge cooling water neutral compared with the temperature of surface water in the surroundings. The environmental impacts in respect of landscape are the banks visible above the water surface and, during construction, local muddying of the water.

Partial discharge of the cooling water to deep layers of the sea
Partial (e.g. 1–2 m^3/s) discharge of cooling water from the new power plant unit to the anoxic deep layers of Hästholmsfjärden requires conducting pipes along the sea bottom. The partial discharge of cooling water to deep layers causes minor circulation and prevents oxygen depletion in the deep layers. The ice cover may weaken in the discharge areas.

Combined cooling water intake and discharge tunnel
Using the same tunnel as a cooling water intake and dis-

charge tunnel by turning the flow direction according to the season is not a realistic alternative. Changing the flow direction causes a safety risk to the power plant unit since the tunnel is long and large amounts of, e.g., mussels attached to its walls can get loose when the flow direction is changed.

Collection of cooling waters

By constructing cooling water basins, the warm cooling waters can be cooled efficiently and the impacts can be concentrated in a limited area. Constructing a separate cooling water basin next to the power plant unit is not possible due to the lack of space. Closest to this solution is the alternative to block the inlets in the southern parts of Hästholmsfjärden and make the water run along Jomalsundet out of the cooling water basin.

A solution applying the same idea is the construction of breakwaters in the bay of Hästholmsfjärden, from both the northern point of Hästholmen and the north-eastern corner of Tallholmen. This solution concentrates the impacts of warm cooling waters in the middle of Hästholmsfjärden.

The effective concentration of cooling water impacts is also feasible by constructing a channel for the warm cooling water around the northern point of Hästholmen, so that the water is let out into the western part of Hästholmsfjärden. In this solution a lock for boat traffic must be built in Kirmosund.

The environmental impacts in the alternatives involving the collection of cooling waters, in terms of landscape, are the banks visible above the water surface and local muddying of the water during construction.

Cooling tower

An alternative for sea water cooling is a cooling tower where the excess heat load is transferred mainly into the air. The heat is transferred by evaporation of the water to the air flowing through the tower and thus the heat load on water is small. A cooling tower is a common solution in areas where water resources are limited.

A cooling tower impairs the efficiency of the power plant and is technically unreliable in the winter conditions in Finland. The need for fresh water used in the cooling tower is very great, since the use of saline sea water would result in salty rain, whose environmental impacts are considerable. Furthermore, the cooling tower is about twice as large as the new power plant unit, and it is difficult to locate it near the new power plant unit. The most significant environmental impacts of the cooling tower are the over 100-metre-high, steaming tower in the landscape and the noise made by the fans of the tower. The cooling tower is not a realistic alternative.

Combined electricity and heat production

An efficient means to mitigate the environmental impacts of cooling water, which also improves the total efficiency of the new power plant unit, is combined electricity and heat production. The heat load released into water and the total efficiency depend on the production proportions of electricity and heat.

Gaining a significant environmental benefit requires that heat should be utilized on a large scale, e.g. as district heat in the metropolitan area or as warm water for heat pumps. Other utilization, e.g. in greenhouses, fish farming, spas etc. does not consume so much heat that it would have any practical significance in terms of the heat load released into the sea.

The harmful effects of combined electricity and heat production are mainly caused by the work linked with the excavation of tunnels and the construction of pipelines, both at Hästholmen and elsewhere along the pipelines. The closed district heating system continuously needs supplementary water, which roughly doubles the need for raw water at the new power plant unit. When using heat pumps sea water can be used for heat transfer.

16.2.8 Nuclear waste management

The waste produced at a nuclear power plant is managed properly. Spent fuel is stored in the interim store until it is disposed of in the repository in Finland's bedrock. Liquid low- and intermediate-level waste is either dried or solidified. The low- and intermediate-level waste is finally disposed of at the power plant site by extending the repository.

16.2.9 Releases of radioactive material

Even though the releases of radioactive material during operation are very small, constant development work and renovations are carried out to reduce these releases even more.

16.3 Decommissioning

In the design of the new power plant unit, provision will be made for its decommissioning. The decommissioning plan will be submitted to the Radiation and Nuclear Safety Authority for review and it will be updated on a regular basis. Up to now, only a few nuclear power plants have been decommissioned in the world. Before the decommissioning of the new power plant unit, both the existing power plant units in Loviisa and many others in the world will have been decommissioned. The experience gained when decommissioning and dismantling these power plant units, and information gained from studies can be taken advantage of when drawing up and regularly updating the decommissioning plan for the new power plant unit. The decommissioning will require a separate EIA procedure.

16.4 Accidents

In the design of the new power plant unit, provision is made for transients and accidents. The guiding principle in all action is the prevention of accidents. The safety aspects of a nuclear power plant and the actions aiming at the prevention of accidents and the mitigation of their impacts have been described in Chapter 12.

Ural owl, Ruotsinpyhtää

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Traces of mountain hare, Ruotsinpyhtää

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17 ENVIRONMENTAL IMPACT MONITORING PROGRAMME

17.1 Environmental management system of the Loviisa Power Plant

At the Loviisa Power Plant, work for the benefit of the environment is guided by an environmental management system certified according to the ISO 14001 standard. The system covers all the operations at the Loviisa Power Plant. Using the ISO 14001 standard has made work for the benefit of the environment a part of everyday operation, e.g. in modifications, acquisition of services and goods, and the limitation of detrimental environmental impacts caused by releases from the power plant.

The construction and operation of a new power plant unit will be implemented in accordance with the environmental management system. The EIA procedure with the resident opinions brings out environmental aspects of the project, which will be taken into consideration during planning.

17.2 Monitoring of radioactive releases and radiation control

17.2.1 Release measurements

Accurate release measurements of radioactive materials are used to ensure that the combined releases from the new and the existing power plants into the air or water do not exceed the release limits set by the Radiation and Nuclear Safety Authority for the plant site. The results are reported to the Radiation and Nuclear Safety Authority on a regular basis.

The releases from the nuclear power plant are monitored by power plant unit and by release route by continuously operating measuring devices and by sampling. Releases into the air are emitted in a controlled way via the ventilation stack and possibly, to a minor extent, through the air conditioning of the turbine building. Activity is conducted into the sea under control from a check-up tank. If the water is not clean enough, it is returned for further treatment. Also the auxiliary plants, such as the repository for operating waste, the spent fuel store and the liquid waste solidification plant are included in the power plant's release control.

17.2.2 Radiation control of the environment

Radiation control of the surroundings of the Loviisa Power Plant was initiated before the start-up of the existing power plant units. The radiation safety authority has carried out environmental measurements since the late 1960s and the power company since 1975. The radiation measurements of the power plant area and surroundings ensure that the radiation dose limits set by the authorities are not exceeded. Radiation monitoring also confirms the measurement results of the power plant's radioactive releases and detects any short-term and long-term changes in the normal radiation situation of the surroundings.

A radiation monitoring programme approved by the Radiation and Nuclear Safety Authority has been drawn up for the Loviisa Power Plant. Its results are reported to the Radiation and Nuclear Safety Authority separately both quarterly and annually. The radiation monitoring programme contains, e.g., external radiation measurement and analyses of activity in inhaled air and in samples representing different phases of the food chains leading to humans. In addition to the radiation monitoring programme, determinations of internal radioactivity are conducted. The content of the programme is revised when necessary, no later than every five years, however.

External radiation is measured continuously, which enables real-time information on changes in the radiation situation of the surroundings. For measuring external radiation, there are altogether 15 dose rate monitors in the surroundings of the power plant at distances of two and five kilometres and two in the power plant area (Figure 17-1). The monitors form a part of the national radiation measurement network and thus also serve regional control. The measurement results can be read in real time, e.g., in the Ministry of the Interior and the Radiation and Nuclear Safety Authority. Ten dosimeter stations have also been located in the most important directions

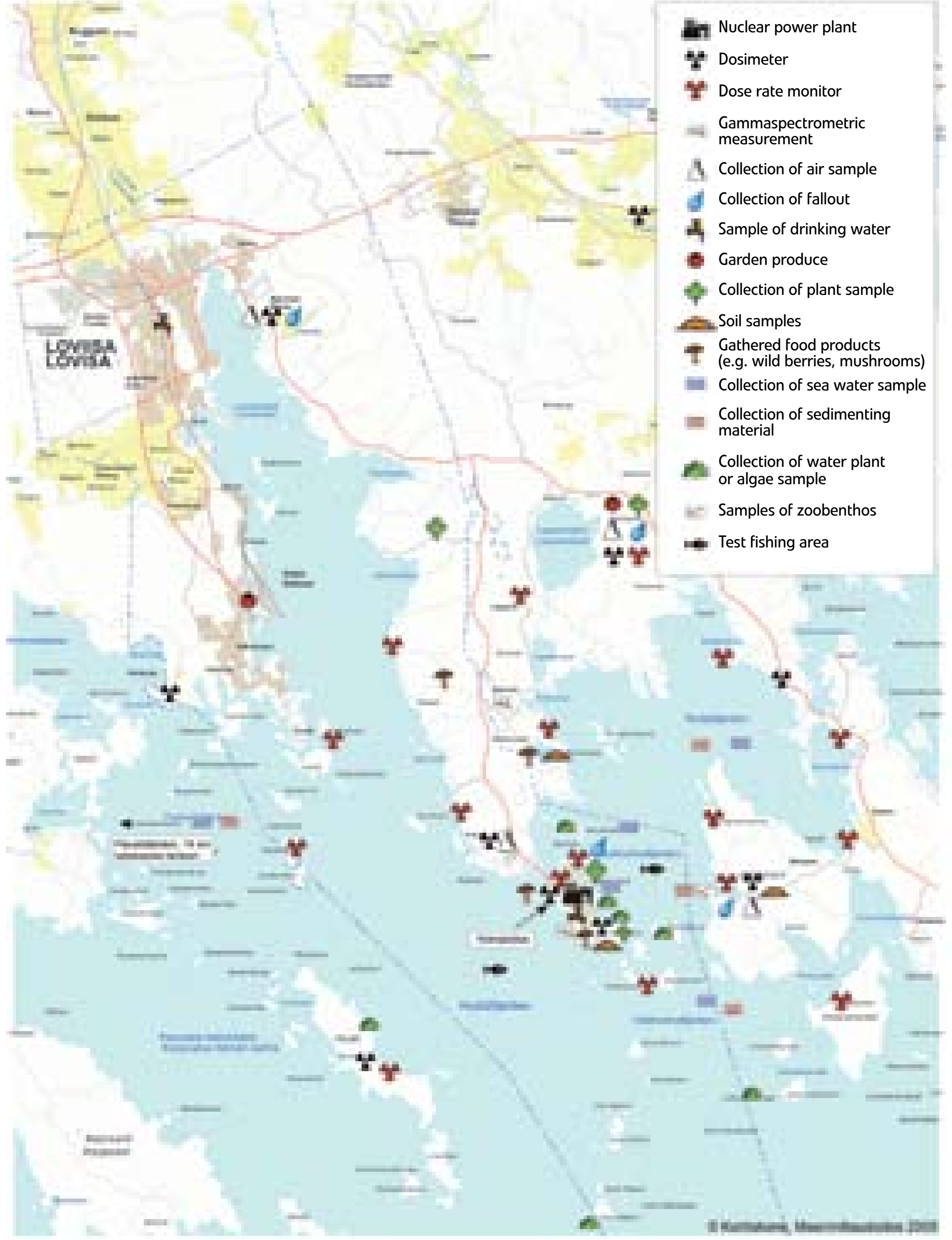

Figure 17-1. Current radiation monitoring programme of the Loviisa Power Plant surroundings.

at distances of 1-10 kilometres from the power plant.

The present radiation monitoring programme covers annually more than 500 analyses of samples taken in various locations and during all seasons. The samples are taken from indicator organisms which gather or enrich the radioactive substances contained in the releases. The samples are analysed by the Radiation and Nuclear Safety Authority. If there are deviating activity concentrations, the content of the programme is extended or the sampling frequency increased. The internal radioactivity measurements of the nearby residents ensure that there are no significant, unrecognized exposure pathways for the residents of the surroundings.

The methods used for radiation monitoring of the surroundings detect natural radioactive substances and even small releases in Finland or outside Finland, which indicates good detection sensitivity of the system.

The construction of a new power plant unit does not fundamentally change the operation of the power plant in respect of radiation monitoring. A radiation monitoring programme of the surroundings similar to the existing one, possibly with a few new monitoring spots, will probably be adequate when the new power plant unit is finished. As the operation of the power plant ends, the radiation monitoring of the surroundings will be carried out in the manner approved by the Radiation and Nuclear Safety Authority.

17.2.3 Meteorological measurements

Meteorological measurements are used for assessing the spreading of radioactive substances released into the air during the power plant's normal operation and potential accidents. The meteorological data is gathered from a weather mast located near the Loviisa Power Plant. In the mast there are measurement points all the way to a height of 145 metres. The observations of the weather mast can be read in real time at the power plant, the Finnish Meteorological Institute and the Radiation and Nuclear Safety Authority. The measured quantities include, e.g., wind speed and direction, atmospheric pressure, relative humidity, duration and amount of rainfall, and temperature.

17.2.4 Radiation dose estimates

During the operation of the nuclear power plant, the radiation exposure of residents in the surroundings is annually estimated on the basis of meteorological measurements and releases. The results are reported to the Radiation and Nuclear Safety Authority. In a potential accident, the radiation dose to the environment is estimated in real time on the basis of meteorological measurements and release information. The estimates serve the rescue services and they are compared with the results given by dose rate monitors. The Radiation and Nuclear Safety Authority has approved the radiation dose calculation programmes used in the estimation.

17.3 Monitoring of cooling and waste waters

The amount, quality and impacts of cooling and waste waters led from the power plant into the sea are monitored in a way approved by the Uusimaa Regional Environment Centre.

The amount of cooling water is monitored on the basis of operating times and output of the cooling water pumps. The temperature of cooling water taken from and led into the sea is measured continuously. The measurements are used for calculating the cooling water temperature rise in the condensers, the flow rate of cooling water and the thermal load led into the sea.

The monitoring of the amount of waste water is based on the measurements of the waste water treatment plant. Waste water monitoring covers, e.g., the amount of nutrients and suspended matters, and substances consuming oxygen.

17.4 Water system monitoring

Ice conditions and the width of the unfrozen area are monitored from early December to April as part of the temperature measurements of the sea area surrounding the island of Hästholmen. The thickness of snow and ice are measured at the sea water temperature measuring points. In addition to the temperature and ice monitoring, the physico-chemical properties of water and its biological variables, e.g. base production, phytoplancton, zoobenthos and aquatic vegetation are monitored in the sea area.

17.5 Monitoring of the fish stock management

The effects of cooling and waste waters on fish stock, fishing and catches in the sea area off the Loviisa Power Plant are monitored according to the monitoring programme for fish stock management. The programme contains, e.g., age and growth determinations of fish, breeding studies, fishing inquiries and interviews of professional, domestic use and recreational fishermen, and studies of the fishing records kept by fishermen.

The monitoring programme of fish stock management is revised on the basis of the gathered information and as the conditions change, e.g. in connection with the implementation of a new power plant unit. The monitoring is carried out in a way approved by the regional fishing industry authority, i.e. the Uusimaa Employment and Economic Development Centre's fishing industry unit.

17.6 Monitoring of flue gas emissions

The scheduled test runs of the boiler plant and reserve diesels are used for checking the operability of the burner, fans, control system and other necessary equipment. For operation of the boiler plant, the plant is fitted with equipment and measuring instruments that enable the monitoring of parameters important for the plant operation. To optimize and monitor the boiler plant water chemistry, the plant is fitted with sampling points and the necessary measuring instruments indicating parameters of the water chemistry. The emissions from the boiler plant and the reserve diesels (carbon dioxide, particles, sulphur dioxide, nitrogen oxides) are calculated annually from the mass balance of used fuel.

17.7 Noise monitoring

After the construction of a new power plant unit, noise measurements will be carried out in the surroundings to ensure that the noise caused by the power plant complies with the official and design guideline values.

17.8 Keeping records of the waste

The quality and amount of waste originating from the power plant are monitored on an annual level. The records kept of the waste show the disposal sites or uses of the waste. Keeping a record of the hazardous waste complies with the Waste Act and the regulations issued by virtue of the Act. Authorities may inspect the records kept of the waste.

17.9 Monitoring of the impacts on people

According to the Nuclear Energy Decree, when applying for an operating licence for a nuclear power plant, the final safety analysis report must be submitted to the authorities. Along with the safety basis, the report must contain, e.g., the number of residents in the nearby area, employment, sources of livelihood, leisure-time living and traffic. The impact on people is monitored on a regular basis as part of the updating of the power plant's safety analysis report.


Wintery landscape, Pyhtää

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18 FEASIBILITY OF THE PROJECT AND ITS OPTIONS

The strategy of Fortum is to construct environmentally benign production facilities and to reduce greenhouse gas emissions, with the long-term goal being totally carbon dioxide-free production capacity. Fortum has economic opportunities to implement the Loviisa 3 nuclear power plant project as a part of this strategy (Chapter 1).

The island of Hästholmen is suitable for construction a new power plant unit. The sea area surrounding the island enables adequate supply of cooling water and all the cooling water intake and discharge solutions presented in the report are feasible. Land use planning enables the construction of a new nuclear power plant unit in the area. The existing power plant units (Loviisa 1 and 2) and the existing infrastructure provide a good basis for implementation of the project. When ready, the Loviisa 3 power plant unit will support the operation of the existing units until the end of their lives. According to the resident survey, over 50% of both permanent residents and those who spend their holidays in the area support Fortum's project. (Chapters 1, 7, 9).

There are several plant suppliers in the market with several plant types that fulfil the Finnish requirements and are suitable for our conditions (Chapter 3). According to prognoses, uranium will be available for the needs of the new power plant unit. There are several fuel suppliers in the world (Chapter 14).

Normal operation of the Loviisa 3 power plant unit will be safe and will not pose hazards to people or the environment. The prevention and management of even severe accidents and the mitigation of the consequences will be taken into consideration as early as the planning phase (Chapter 12).

During the assessment of environmental impacts of Fortum's power plant unit Loviisa 3, no such considerable environmental impacts were found to result from its construction or operation, including all options, that could not be approved or mitigated to an acceptable level (Chapter 15). The plant type and the cooling water solution will be chosen on the basis of safety and environmental aspects as well as both technical and economic studies.

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Fortum Power and Heat Oy

ENVIRONMENTAL IMPACT ASSESSMENT PROGRAMME FOR THE LOVIISA 3 NUCLEAR POWER PLANT UNIT; STATEMENT BY THE CONTACT AUTHORITY

On 26 June 2007, Fortum Power and Heat Oy submitted an environmental impact assessment programme (the EIA programme) to the Ministry of Trade and Industry (MTI) in accordance with the environmental assessment procedure (hereinafter the EIA procedure), pursuant to the Environmental Impact Assessment Act (468/1994; EIA Act), on the third unit of the Loviisa nuclear power plant and the related projects. 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 MTI will act as the contact authority in the EIA procedure.

A public notice announcing the launch of the EIA procedure was published on 29 June 2007 in the following newspapers: *Helsingin Sanomat*, *Hufvudstadsbladet*, *Loviisan Sanomat*, *Östra Nyland*, *Borgåbladet*, *Etelä-Suomen Sanomat*, *Kymen Sanomat* and *Uusimaa*. The public notice and the EIA programme can be found on the MTI website at www.ktm.fi.

Members of the public were able to view the assessment programme between 2 July and 17 September 2007 in the local government offices of Loviisa, Lapinjärvi, Liljendal, Pernaja, Pyhtää and Ruotsinpyhtää. Together with the organisation responsible for the project, the Ministry organised a public meeting to discuss the project on 23 August 2007 in Loviisa.

The comments and opinions invited and presented on the assessment programme are described in Chapter 3.

The Espoo Convention (67/1997) will be applied to the assessment of the project's cross-border environmental impacts. The parties to the Espoo Convention have the right to participate in the EIA procedure. The Ministry of

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the Environment is responsible for the practical arrangements for conducting the international hearing. The Ministry of the Environment has notified the following countries of the project: Sweden, Denmark, Norway, Germany, Poland, Lithuania, Latvia, Estonia and Russia.

1 Project information

1.1 Organisation responsible for the project

The organisation responsible for the project is Fortum Power and Heat Oy, which holds the operating licences for the two present units in the Loviisa nuclear power plant until 2027 and 2030 respectively. Fortum Power and Heat Oy is a subsidiary wholly owned by Fortum Oyj.

1.2 Project and its alternatives

Fortum Power and Heat Oy is exploring opportunities to expand the nuclear power plant, located on the island of Hästholmen in Loviisa, with a third nuclear plant unit. The purpose of the project is to increase power production capacity, both to satisfy demand and replace capacity about to be withdrawn from the market.

The electrical output of the planned unit will range from 1,000 to 1,800 megawatts and the thermal power from 2,800 to 4,600 megawatts. A pressurised water reactor and a boiling water reactor are both being considered. The Loviisa 3 unit is designed as a base-load power plant and, excluding an annual service shutdown, it will run continuously throughout the year. The unit has an estimated technical life cycle of approximately 60 years.

In addition to the nuclear power plant, the project includes the intermediate onsite storage of spent nuclear fuel generated by the new unit, the treatment, storage and disposal of low- and intermediate level radioactive waste, the decommissioning of the power plant, and treatment and disposal of waste generated by the decommissioning. The project will require an overhaul of the Loviisa power plant's raw water supply system, extension of the present sewage works and construction of a loading area for sea transport. The implementation of power transmission to the national grid is also included in the project.

A situation in which the Loviisa 3 project would not be implemented is regarded as a zero option. Since Fortum would not consider building another type of power plant on the Loviisa plot instead of the new nuclear power plant unit, the zero option would entail Fortum acquiring new production capacity elsewhere or buying electricity in order to sell it.

The limitation of the alternatives is made on the basis of the importance of utilising existing infrastructure in nuclear plant projects.

According to Fortum Power and Heat Oy's plans, the construction of the nuclear power plant would take place between 2012 and 2018 or thereabouts.

2 Licensing of nuclear facilities

Pursuant to the Nuclear Energy Act, the decision-making and 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.

2.1 Environmental impact assessment

Fortum Power and Heat Oy will draw up an environmental impact assessment report (the EIA report) based on the EIA programme and the contact authority's statement; this will be followed by a public hearing on the EIA report. The responsible organisation estimates that the EIA report will be finished in spring 2008.

The EIA procedure constitutes part of the safety and environmental impact assessment for nuclear power plants laid down in a decision-in-principle pursuant to the Nuclear Energy Act (990/1987).

2.2 Decision-in-principle

The planned nuclear power unit complies with the definition of a nuclear power 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. In accordance with the Nuclear Energy Decree (161/1988), the 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 MTI 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).

The MTI 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 where it is planned that the nuclear power plant will be located (Loviisa) is in favour of the power plant, and that no facts indicating a lack of sufficient prerequisites for constructing and using a nuclear power plant 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 perusal. Parliament may reverse the decision-in-principle or decide that it should remain in force as it stands.

2.3 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, protection of workers, the population's safety and environmental protection measures must have been 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.

A hearing procedure involving municipalities, authorities and citizens will be established during the application process for the construction licence.

2.4 Operating licence

Operation of a nuclear power plant requires a licence issued by the Government. In order to receive 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 EIA programme:

Ministry of the Environment, Ministry of the Interior, Ministry of Social Affairs and Health, Ministry of Defence, Ministry of Finance, Ministry of Transport and Communications, Ministry of Labour, Ministry of Agriculture and Forestry, Ministry for Foreign Affairs, State Provincial Office of Southern Finland, Regional Council of Itä-Uusimaa, Eastern Uusimaa Fire and

Rescue Services, Western Finland Environmental Permit Authority, Finnish Environment Institute, Radiation and Nuclear Safety Authority, Safety Technology Authority, Uusimaa T&E Centre, Occupational Safety and Health Inspectorate of Uusimaa, Regional Environment Centre of Uusimaa, City of Loviisa, Municipality of Lapinjärvi, Municipality of Liljendal, Municipality of Pernaja, Municipality of Pyhtää, Municipality of Ruotsinpyhtää, Confederation of Unions for Professional and Managerial Staff in Finland (AKAVA), Confederation of Finnish Industries EK, Finnish Energy Industries, Greenpeace, Loviisan puolesta ry, Central Union of Agricultural Producers and Forest Owners, Miljöringen rf, Central Organisation of Finnish Trade Unions, Finnish Association for Nature Conservation, Federation of Finnish Enterprises, Central Union of Swedish-speaking Agricultural Producers in Finland, Finnish Confederation of Salaried Employees, WWF, Fingrid Oyj, Posiva Ltd and Advisory Committee on Nuclear Energy.

Comments were not received from the following organisations: Ministry of Social Affairs and Health, Ministry for Foreign Affairs, Western Finland Environmental Permit Authority, Finnish Environment Institute, Municipality of Lapinjärvi, Municipality of Pernaja, Greenpeace, Loviisan puolesta ry, Central Union of Swedish-speaking Agricultural Producers in Finland and Finnish Confederation of Salaried Employees.

Opinions were invited through publishing a notice and organising a public meeting.

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) and Ministry of Natural Resources (Russia).

Sweden, Norway, Germany and Estonia participate in the EIA procedure and have commented on the EIA programme. Poland and Lithuania participate in the EIA procedure but have not commented on the EIA programme. Russia will participate in the EIA procedure but has not commented on the EIA programme; Russia will submit its comment at a later date, and this comment will be delivered to the responsible organisation. Latvia and Denmark have replied to the Ministry of the Environment that they will not participate in the EIA procedure. 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

Ministry of the Environment

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 considers the programme to be a general description and deficient in parts.

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 of the following matters in particular:

- Main alternatives to the project with sub-alternatives and, in conjunction with the zero option, opportunities to increase the efficiency of power consumption
- The nuclear safety of the project and the project's impact on the current arrangements for nuclear waste management at Loviisa
- Limitations of the project and any associated projects, such as fuel procurement, power transmission, demand for back-up power and water supply
- Impacts of cooling water on the state of the sea

The Ministry draws attention to the participation opportunities.

Finally, the Ministry of the Environment stresses the importance of making both the EIA report and the contact authority's respective statement available, when comments will be invited on a potential decision-in-principle.

Ministry of the Interior

The Ministry of the Interior states that an assessment of the potential impact on rescue services should be included, stressing the importance of cooperation between local rescue services and any related parties, and the organisations implementing the programme. In addition, the programme should assess the impact of emergencies on the power production capacity.

The Ministry of the Interior finds the assessment programme comprehensive.

Ministry of Defence

The Ministry of Defence proposes the following issues to be taken into consideration in the impact assessment: serious disruptions mentioned in the targets for the security of supply; protection plans for the nuclear power plant and critical infrastructure in all situations; performance of the economy and infrastructure and security of the energy supply; threat models.

In analysing the alternatives, methods of importing power and the consequent impacts on Finland should be taken into consideration.

The Ministry of Defence finds the assessment programme appropriate.

The Ministry of Finance

The Ministry of Finance finds no cause to criticise the content of the assessment programme.

The Ministry draws attention to the social significance of the project, and to implementing an assessment of economic, social and environmental impacts from the perspective of society in general during the decision-in-principal stage. The Ministry points out that the project planner is not able to assess how demand for electricity could be met if the nuclear plant unit is not built.

Ministry of Transport and Communications

The Ministry of Transport and Communications considers the impact assessment insufficient, in that it includes scenarios for local transport only, should the nuclear plant unit receive a construction licence. Therefore, the Ministry proposes expanding the assessment by extending the area under review and taking into account the experiences accumulated from the building of the current nuclear facilities. The need for transport during the construction phase and the opportunities to switch from road transport to alternative transport methods should also be subjected to assessment.

Ministry of Labour

The Ministry of Labour finds that the EIA programme introduces the assessment appropriately and maintains that it is vital to provide a detailed assessment of the project's impact on employment, during both the construction and operational stages. A potential estimate of the availability of skilled labour may prove significant to the organisation implementing the project, since insufficient workforce may have an effect on the implementation schedule.

The Ministry finds it important to not only assess the environmental impact of exceptional and emergency situations but to also include the perspectives of employment law and occupational health and safety in the assessment.

The Ministry further notes that, although the organisation implementing the project is not required to provide an impact assessment on improving energy efficiency and conservation at this stage, these will be assessed later by the Government, Parliament and other parties during the potential licensing of the project. The long-term strategy for the climate and energy policy, currently under preparation by the ministerial working group, will have an effect on the wide-scale social assessment of the project.

Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry suggests that the EIA programme include the assessment of threats posed by changes and rise in the sea water levels because these have an impact on the reliability and safety of the nuclear power plant. The Ministry further suggests providing additional information on the environmental impact of cooling waters and sewage, with a particular emphasis on the fishing industry and monitoring of the impacts. Impacts on agriculture, food production and household water supply should also be assessed.

The Ministry further proposes some enhancements to the assessment methods.

State Provincial Office of Southern Finland

Due to the long operating life of the nuclear facility, the State Provincial Office of Southern Finland suggests that the description of land use and the related plans be further specified in the assessment report to include operations in the emergency planning zone and potential limitations of land use. The Provincial Office further proposes enhancing the assessment of health and social impacts in the following areas: risks to the use of household and swimming water during construction and operation, and impacts of traffic dust and noise during the construction phase.

The Provincial Office proposes taking into account the following aspects in order to ensure safety and uninterrupted operation: the experiences accumulated from the building and operation of the current nuclear facilities, partnerships and existing projects in the field of safety, and research initiatives. The assessment report should describe potential emergency situations during construction and how to prepare for them.

The Provincial Office points out the need to facilitate a sufficient number of discussion and feedback events during the assessment procedure, taking into consideration the most sensitive population groups, including disabled persons, in order to ensure equal opportunities for participation.

The Regional Council of Itä-Uusimaa

The Regional Council of Itä-Uusimaa finds the EIA programme fairly comprehensive and illustrating a broad range of issues. In the Council's view, the role of municipal partnerships should be stressed in the impact assessment of regional structures, economy and employment.

The Council proposes that the intake and drainage sites of cooling waters be specified and subjected to impact assessment, including an assessment of any potential the opportunities to use thermal energy of cooling water.

Eastern Uusimaa Fire and Rescue Services

The Eastern Uusimaa Fire and Rescue Services finds the EIA programme comprehensive and broad-ranging, and that it incorporates issues discussed in the project monitoring group meetings. The Fire and Rescue Services point out that, in order to limit risk, the nuclear power industry has developed a systematic approach to safety, with the objective of preventing and limiting the consequences of emergencies.

However, the Fire and Rescue Services propose enhancements to the emergency planning procedures. These should be taken into account in the environmental assessment of the project phases and a possible major disaster. In defining the affected areas, the protection zone and the emergency planning zone should be taken into consideration and their adequacy reviewed, even though these zones are subject to strict guidelines and definitions. Risk analysis and estimates should be applied to safety assessments.

The Radiation and Nuclear Safety Authority (STUK)

The Radiation and Nuclear Safety Authority (STUK) maintains that the EIA report should describe the key grounds and objectives for planning the limitation of emissions of radioactive substances and environmental impacts, alongside an assessment of the feasibility of meeting the safety requirements in force.

The EIA programme describes guidelines for analysing the environmental impacts of possible radioactive emissions in emergency situations. The EIA report should include a clear summary of the basis for such an analysis.

In comparison with the EIA programme, the selection of cooling water intake and discharge sites should be accounted for and described more precisely in the EIA report. A comprehensive dispersion calculation for waterways should also cover the seasons and a range of weather conditions.

STUK also points out that, in addition to the habitation mentioned in section 6.3, temporary residents live in the accommodation village.

Safety Technology Authority

The Safety Technology Authority proposes that the assessment report include a review of risks associated with construction and operation, including the gravity and likelihood of possible emergencies at the plant.

The Safety Technology Authority has no comments to make on the EIA programme.

Uusimaa T&E Centre

Uusimaa T&E Centre has no comments to make on the EIA programme.

Occupational Safety and Health Inspectorate of Uusimaa

The Occupational Safety and Health Inspectorate of Uusimaa finds the EIA programme comprehensive.

Uusimaa Regional Environment Centre

Uusimaa Regional Environment Centre proposes changing the project description in order to illustrate more clearly the large scope of the project in comparison to the present nuclear facilities. The impact assessment should be supplemented with an assessment of the combined effects of the planned nuclear plant unit and the existing units. This should include the impact on health of an increased radiation dose and other risks. The report should present the number of permanent habitation and summer residents.

The Environment Centre stresses the importance of carefully assessing the impact of cooling waters. Alternatives to, and combinations of, intake and drainage sites should be assessed in order to illustrate their differences. Alternative intake sites should differ with regard to intake water temperature. Changes in the cooling water intake and drainage arrangements in the present plants must be assessed. The third nuclear plant unit requires draining the cooling waters sufficiently far away from the shore. This option must be included in the alternatives. The effects on waterways are the starting point in the impact assessment of the Natura area.

The Environment Centre finds the description of assessment methods very general. When assessing the impact of cooling waters, the model calculation should be sufficiently precise, accounting for the dispersion of cooling water and describing the impacts with reference to the actual conditions.

The Environment Centre finds the structure of the assessment programme clear and its contents illustrative.

City of Loviisa

The City of Loviisa proposes the following additions to the impact assessment of waterways: The effects of the thermal load of cooling water on aquatic plants in the affected area must be assessed, since accelerated growth has been observed, based on the results of waterway monitoring and other sources of information. The impacts of water intake and drainage sites and underwater structures on the undersea physical environment should be studied. Underwater structures may affect currents, fish stocks and other natural environments, during both construction and operation. The environmental impact assessment should be expanded in the sea areas.

The City of Loviisa further proposes adding the following points to the impact assessment programme: impacts of the new road connection – Atomitie-highway 7 – on the environment, forestry and habitation, and impacts of the project on real estate, fire and rescue services and civil defence.

The City of Loviisa states that the assessment programme has been drawn up in mutual understanding with the City, with broad-ranging citizen participation, information provision and opportunities to influence the process.

Municipality of Liljendal

The Municipality of Liljendal finds assessing the social impacts during construction and reducing any negative effects important. Other issues include alternatives to cooling water intake, opportunities to utilise thermal energy, open communication during the EIA process, and protection zones. Liljendal finds the EIA programme comprehensive.

Municipality of Pyhtää

The Municipality of Pyhtää has no comments to make on the EIA programme.

Municipality of Ruotsinpyhtää

The Municipality of Ruotsinpyhtää stresses the importance of assessing the impact of the plant's waste heat on sea water, and Lappomträsket. Ruotsinpyhtää points out that the assessment will be made in partnership with local operators.

AKAVA

The Confederation of Unions for Professional and Managerial Staff in Finland (AKAVA) presents the organisation's general energy and climate policies, and AKAVA's member organisations point out the social significance of nuclear power as part of these policies.

AKAVA proposes that the reviewed options include the utilisation and profitability of condensation heat (The Finnish Medical Association) as well as energy conservation (The Finnish Union of Environmental Professionals).

In the main, the assessment is considered appropriate and comprehensive. AKAVA proposes providing additional information with regard to the impact assessment as follows: Although the safe final disposal of nuclear waste is a key question in the nuclear power industry, the utilisation of waste may present a future option for energy production (The Finnish Medical Association). Unexpected emergencies and exceptional situations should include changes in the environment, threats caused by human activities and securing basic energy production in unexpected situations. It should be determined which factors with a detrimental effect on the environment should be excluded from the zero option (The Finnish Union of Environmental Professionals).

Confederation of Finnish Industries EK

The Confederation of Finnish Industries EK finds the assessment programme comprehensive.

Finnish Energy Industries

Finnish Energy Industries considers the EIA programme comprehensive, and also notes the project's social significance.

Central Union of Agricultural Producers and Forest Owners

The Central Union of Agricultural Producers and Forest Owners finds communication and interaction important, maintaining that the communication and participation plan presented in the EIA programme provides a solid base for interaction. Residents, land owners, stakeholder groups and other potentially affected groups in the area should be heard and their views taken into account.

The Union suggests that attention should be paid to the indirect effects of the project, such as the planned power transmission structures. The Union also remarks on the project's social significance and the need to review questions relating to the energy policy in the decision making process.

Miljöringen rf

Miljöringen proposes including in the assessment the following issues: water use, utilisation of thermal energy, use of chemicals in the processes, and air pollutants, such as emissions from the diesel aggregates and gas turbines. The Association hopes that a review of energy-saving opportunities in the plant will be included.

Central Organisation of Finnish Trade Unions

The Central Organisation of Finnish Trade Unions considers uninterrupted operation and safety in all circumstances to be the key point of the assessment. The assessment should take into account the experiences accumulated from the fifth nuclear power plant, the latest international data on the safety of nuclear power plants and STUK's views as a whole.

In terms of interactivity, the Association finds it important that the trade union representatives, at all levels of staff, be informed of the projects, with a particular view to keeping the representatives of the Finnish Electrical Workers' Union and Loviisa's local professional association up to date on the project's progress.

All in all, the Organisation finds the assessment programme sufficient.

Finnish Association for Nature Conservation

The Finnish Association for Nature Conservation maintains that the need for the project should be justified to a sufficient extent. Energy conservation and renewable sources of energy should be reviewed as options.

The Association maintains that the impact assessment should be enhanced by considering 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. Combined effects should be reviewed in addition to the environmental impact of the project, including the effects of the current units. Environmental changes, which may have an effect on the project, should also be considered.

The Association also suggests providing more detailed information on the assessment of environmental impacts, such as the areas of impact, the affected area and the effects of emergencies.

Federation of Finnish Enterprises

The Federation of Finnish Enterprises states that the EIA programme has been appropriately drawn up, covering all key aspects of assessment to a sufficient extent.

The Federation would find it reasonable to review a zero option, in which emissions of different power production methods are assessed. This would provide an estimate of the realistic alternatives to the power plant.

WWF

WWF suggests that the EIA programme should give equal weight to different options which can satisfy the need for, and objectives of, the project. These options should particularly include an increase in energy efficiency and the use of renewable sources of energy. The assessment should mention how different views, such as those of citizens and organisations, have been considered when the options were formed.

WWF maintains that the impact assessment should be enhanced by considering the entire life cycle of the project, including the environmental impact of processing and transporting uranium. The environmental impact of construction should be assessed with regard to using natural resources and creating emissions.

WWF also suggests providing more detailed information on the assessment of environmental impacts, such as on the Natura area and on people, the affected area and the effects of emergencies. WWF notes that up-to-date data should be used in the assessment.

Fingrid Oyj

Fingrid has investigated the possibilities of connecting the Loviisa 3 unit to the national grid and the necessary reinforcement of the grid on the basis of data on the nuclear power plant. The necessary reinforcements of the grid are included in the long-term development plan of the national grid and also form part of the preparations for a provincial plan. Fingrid has commenced

its investigations for establishing power line routes. The environmental impacts of these changes will be assessed in separate EIA procedures.

Posiva Oy

Posiva finds no cause to criticise the EIA programme.

Advisory Committee on Nuclear Energy

The Advisory Committee on Nuclear Energy finds the extent of the EIA programme adequate. After the assessments described in the programme have been completed, sufficient basic data will be available for making the decision-in-principle.

However, the Committee finds it critical that the assessment should take into account changes in the operational environment to an appropriate degree. For example, the ICRP's new guidelines on radiological protection, currently at the drafting stage, should be taken into consideration wherever possible, since they involve an assessment of radiation doses affecting both human and other populations. Since considering the impact of climate change is vital, the EIA report should provide a description of methods for preparing for and adapting to climate change.

Sweden: Naturvårdsverket

Sweden's environmental authority, Naturvårdsverket, considers the EIA programme sufficient on the whole. The main impacts will be on the sea, and data on these is gathered under the environmental monitoring programmes of the current facilities. The EIA programme is also considered appropriate by Sweden's nuclear safety authority, Statens Kärnkraftinspektion. It finds the impact assessment of the normal use of the power plant particularly comprehensive.

Comments invited by the Swedish environmental authority 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, technologies to reduce emissions and mitigating the potential harmful effects. The impact of emissions on the environment and industries should be assessed, e.g. fish stocks and fishing. The authority notes that it would be prudent to assess the combined impacts of the planned unit and the current units on the radioactivity of the Baltic Sea.

It suggests that the impact assessment could be enhanced by examining the whole life cycle of the project and assessing the environmental effects resulting from the production of nuclear fuel and spent nuclear fuel.

The comments draw attention to the lack of, or insufficient exploration of, a zero option, with particular mention of the lack of alternative means of power production.

Norway: Ministry of the Environment

In Norway, the Ministry of the Environment acts as the environmental authority. It emphasises the assessment of reactor safety, emergency situations, unexpected events and radioactive emissions. The Ministry also suggests that it would be prudent to describe the plans and monitoring systems for emergencies and exceptional situations.

Comments invited 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. the impact on vegetation, animals, reindeer husbandry and recreational use. Nuclear waste management and alternatives are also mentioned in the statement.

Germany: Innenministerium Mecklenburg-Vorpommern

Innenministerium Mecklenburg-Vorpommern in Germany proposes taking into consideration 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 case of emergency. The Ministry suggests that the impact assessment should be enhanced by examining the environmental effects of the production of nuclear fuel and management of spent nuclear fuel.

Estonia: Ministry of the Environment

Acting as the environmental authority, the Estonian Ministry of the Environment stresses the description of cross-border emergencies from several perspectives. The description should identify any impacts requiring protection from radiation and the methods of informing neighbouring countries in emergencies.

The Ministry further suggests that alternative methods of power production be included in the assessment.

3.2 Other comments and opinions

A total of nine other comments or views were submitted. Six of these were from organisations and three from private persons. In addition, the responsible organisation delivered 11 written comments, which had been presented in public meetings, marketplace events or other occasions.

The following organisations presented a comment or opinion: The Edelleen ei ydinvoimaa popular movement against nuclear energy, Women Against Nuclear Power, Women for Peace in Finland and Amandamij (joint com-

ment), the Réseau Sortir du Nucléaire network, and the Finnish Youth for Nuclear Energy.

Several comments suggest that the environmental impact assessment should be enhanced by considering 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. Other suggestions for supplementing the project concern the public roads and power lines.

The impacts of cooling waters should be assessed across a wide area, taking into consideration the experiences of local professional fishermen. The combined effects of the present plants and the third unit should also be accounted for in the impact assessment.

In the human impact assessment, habitation and the attractiveness of the living environment should be taken into consideration, including impact on the Swedish-language culture, negative social impacts and potential impacts on the use of holiday homes.

Furthermore, the assessment should take into account climate change and other threats to the project, including the likelihood of emergencies due to these threats.

The comments also mention the project's social significance and address the need to assess other alternative means of energy production. Several opinions do not present views relating to the EIA programme in addition to the aforementioned comments but either oppose or support the use of nuclear energy in general.

4 Contact authority's statement

The Ministry of Trade and Industry states that the EIA programme for the Loviisa 3 nuclear power plant unit 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 appropriate, in the main, and quite comprehensive.

However, attention should be paid to the following issues in the investigations and the drafting of the EIA report. 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 EIA report.

4.1 Project description and the alternatives

The EIA programme presents a summary of the power range and potential types of the planned nuclear power plant, including the operational principles of the boiling water reactor and the pressurised water reactor. The Radiation and Nuclear Safety Authority (STUK) maintains that the EIA report should prescribe the key grounds and objectives for planning 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.

In the Ministry's view, the EIA report should include a review of current nuclear power plant types on the market which are suitable for the project under review. Similarly, the safety planning criteria for the prospective 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 short description of the cost structure of the project and its alternatives in the EIA report.

A situation in which the Loviisa 3 project would not be implemented is regarded as a zero option in the EIA programme. The responsible organisation would not build another type of power plant on the Loviisa plot instead of the new nuclear power plant unit; instead, the area would remain unused for the time being. This means assessing the environmental impact of a situation where the amount of electricity corresponding to the unit's production capacity would be bought from the market. Energy conservation will not be assessed 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 that would be produced by the proposed nuclear power plant.

Several comments suggest that the EIA programme be supplemented with an assessment of alternative solutions, such as energy conservation and efficiency.

The Ministry points out that the organisation responsible for the project is a company that sells electricity. Therefore, it cannot access any significant means of energy conservation or operational efficiency and has limited opportunities to influence the electricity use of its customers. The Ministry also notes that the report on the importance of a new nuclear power plant or power plants to the national energy supply, supporting the Government's decision-making with regard to reaching the decision-in-principle, will include information on energy conservation and efficiency. However, this perspective 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. Drawing up nationwide reviews of energy supply falls within the remit of the central government. The Ministry points out that the Government is currently preparing a long-term climate and energy strategy.

The Ministry recommends that the EIA report introduce the energy efficiency and conservation efforts undertaken by the responsible organisation.

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 of cooling water. The review covers cooling waters both from the present and new power plants. The calculations cover an area of approximately 150 square kilometres, focusing on the sea area west of the power plant. The EIA programme states that the plans for the water supply in the new power plant will be drawn up with the local operators.

Several comments stress the significant impact of cooling water on the state of the marine environment around the power plant, suggesting that the assessment be extended to cover a wider area. The effects of warming sea water should be included in the assessment, and the impact on the fishing industry, among others, is mentioned in several comments. The comments remark on the environmental assessment of other means and alternative arrangements for the water supply.

The Ministry is of the view that the impacts of cooling waters form the most significant environmental impact during normal plant operation. The selection of cooling water intake and discharge sites should be accounted for and described precisely. When analysing the environmental impacts of sea water warming, any background material available must be utilised extensively and the analyses must be linked on a wider scale to the state of sea areas. In order to define the affected area, the analyses must be extended to cover a wide sea area and must take into consideration the thermal stress caused by the present Loviisa power plant units. The impact of cooling waters on protected areas must be assessed, including an assessment of the need to conduct a Natura review pursuant to Section 65 of the Nature Conservation Act. The EIA report must introduce measures to reduce adverse effects. Uncertainties in calculation results must be illustrated clearly. The assessment of the arrangements for water supply must be supplemented by including alternative options and assessing their environmental impacts.

According to the EIA programme, in order to assess the impacts of related projects, the impact of the 110 kV connecting power lines, to be constructed alongside the present power lines, will be included in the assessment. The comments remark on the importance of assessing the impact of power lines. A new nuclear unit would require improved power transmission. Fingrid Oyj has investigated the possibilities of connecting the Loviisa 3 unit to the national grid with a 400 kV connection and the necessary reinforcement of the grid on the basis of data on the nuclear power plant. Fingrid has commenced its investigations for establishing power line routes. The environmental impacts of these changes will be assessed in separate EIA procedures. In the Ministry's view, the responsible organisation must extend the review of the environmental impacts of the 110 kV transmission connection up until the next switching substation.

According to the EIA programme, in order to assess the impacts of related projects, the impact of growth in traffic volumes will be included in the assessment. The comments remark on the importance of assessing the impact on public roads and extending the affected area to be observed. The Ministry finds assessing growth in the volume of traffic a good starting point and requires that the impacts on nature and other environments are assessed, particularly on a local level, covering a wider area wherever possible.

According to the EIA programme, the organisation responsible for the project will examine the environmental impacts of nuclear fuel production and transport and clarify the possible sources of uranium, including enrichment and manufacturing. 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 should examine the environmental impacts of the entire fuel supply chain in general and, additionally, the company's opportunities to influence this chain. The Ministry requires a description of the assessment method, such as a method to assess the use of existing studies and the use of public information, to be published.

According to the EIA programme, the EIA report will describe the quantity, quality and treatment of municipal and hazardous waste, low and intermediate level radioactive waste, and decommissioning waste generated at the plant unit, and will assess the related environmental impacts. The environmental impacts of the disposal of spent nuclear fuel are described using the results of the EIA procedure carried out by Posiva Oy in 1999 and the studies carried out thereafter. In the comments, grounds are presented for assessing the environmental impact of nuclear waste management using the latest data. The Ministry finds the plan proposed by the organisation responsible for the project to be appropriate, and points out that the latest available data must be quoted in the assessment. The Ministry also maintains that the EIA report should review nuclear waste management as a whole, including extensions to the necessary storage and final disposal facilities and their environmental impacts.

According to the EIA programme, the assessment includes the environmental impacts of exceptional circumstances and, among other factors, of climate change. Several comments remark on the impact assessment of exceptional circumstances and emergencies. 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. The assessment may use the classification system of the International Atomic Energy Agency (IAEA), and the EIA report must present a clear summary of the basis used in the review. Assessing the impacts must not be limited to the exclusion area or the emergency planning zone for rescue operations. The assessment must also include a review of the possible environmental impact of radioactive substances on the states around the Baltic Sea and on Norway. The Ministry finds it appropriate that the as-

sessment of exceptional circumstances take into consideration, among other factors, the effects of climate change. The Ministry requires that the assessment include a review of preparations to cope with climate change and that special attention be paid to changes in sea level.

According to the EIA programme, the impacts of alternative solutions will be examined with regard to human health, the attractiveness of the living environment and living conditions, while the impacts of construction and operation will be examined with regard to regional structure, economy and employment. Among other factors, the impact on employment and real estate values is found to be important in the comments. The Ministry proposes providing a detailed assessment of the project's impact on employment, during both construction and operational stages. In addition, the project's impact on the current use and value of real estate and methods of mitigating possible adverse effects must be examined.

The EIA programme introduces several different methods to assess various environmental impacts. For example, impacts on people and society will be assessed by calculations of radiation doses, noise testing, surveys among the residents, and separate reviews of the regional economy. Some comments propose adding to or further defining the assessment methods, particularly with regard to the impacts of cooling waters and emergencies, further assessing the areas of impact, and incorporating the ICRP's new guidelines on radiological protection, published in October 2007. The Ministry requires the responsible organisation to include the suggestions in the assessment methods wherever possible.

4.3 Plans for the assessment procedure and participation

The MTI considers that the arrangements for participation during the EIA procedure can be made according to the plan presented in the EIA programme. However, sufficient attention should be paid in communications to, and interaction with, the entire affected area of the project, across municipal borders and all population groups. The Ministry requests that the parties consider ways of presenting the impact of participation in the EIA report.

When the EIA report is finalised, the MTI will publish a public notice, make the report available, and invite various authorities and possible other parties to comment on the report. The statement on the EIA report, prepared by the MTI in its capacity as a contact authority, will be delivered to the municipalities in the affected area and to the appropriate authorities.

4.4 Assessment report

Pursuant to the Nuclear Energy Act, submitting an application to the Government for a decision-in-principle is possible before the contact authority has published a statement on the EIA report. However, pursuant to the EIA Act, the EIA procedure will not be completed until the contact authority has issued a statement on the EIA report and delivered the project-related com-

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ments and opinions on the EIA report to the organisation responsible for the project.

In its comment, the Ministry of the Environment stresses that when comments are invited on a prospective decision-in-principle, both the EIA report and the contact authority's respective statement must be made available.

The MTI 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. The Ministry hopes that the contact authority is able to submit the EIA report for comments and provide the contact authority's statement before the application for a decision-in-principle is presented to the Government.

5 COMMUNICATING THE STATEMENT

The MTI will deliver the EIA statement to those authorities that have submitted comments. The statement will also be available on the Internet at www.ktm.fi

The Ministry will send copies of the comments and opinions concerning the assessment programme to the organisation responsible for the project.

The original documents will be stored in the Ministry's archives.

Minister of Trade and Industry Mauri Pekkarinen

Counsellor Jaana Avolahti

NOTICE Authorities that have submitted comments
Finnish Environment Institute

APPENDIX 2. KEY FIGURES FOR ASSESSING IMPACTS ON REGIONAL ECONOMY

Table 1. Population development 1970–2006 (Statistics Finland).

	1970	1980	1990	2000	2006
Loviisa	6 984	8 870	8 396	7 579	7 393
Lapinjärvi	4 099	3 614	3 306	3 011	2 945
Liljendal	1 450	1 388	1 537	1 467	1 440
Pernaja	4 360	3 820	3 687	3 779	3 994
Pyhtää	5 038	5 218	5 416	5 253	5 141
Ruotsinpyhtää	3 612	3 509	3 350	3 008	2 922
Total	**25 543**	**26 419**	**25 692**	**24 097**	**23 835**

Table 2. Population forecast 2010–2040 (Statistics Finland).

	2010	2020	2030	2040
Loviisa	7 421	7 651	7 929	8 025
Lapinjärvi	2 963	3 051	3 172	3 236
Liljendal	1 416	1 394	1 412	1 420
Pernaja	4 229	4 683	5 028	5 244
Pyhtää	5 152	5 180	5 202	5 127
Ruotsinpyhtää	2 962	3 099	3 125	3 255
Total	**24 143**	**25 058**	**25 868**	**26 307**

Table 3.Population variation in 2006 (Statistics Finland).

	Total variation of population, %	Positive migration, number of people
Loviisa	0.2	62
Lapinjärvi	0.3	25
Liljendal	-1.7	-16
Pernaja	1.8	61
Pyhtää	0.1	4
Ruotsinpyhtää	0.3	8
Total	**-**	**144**

Table 4. Age structure at the end of 2006 (Statistics Finland).

Percentages of residents	Below 15 years	15–65 years	Over 65 years
Loviisa	14.6	63.6	21.8
Lapinjärvi	15.4	62.4	22.2
Liljendal	16.9	63.9	19.2
Pernaja	19.0	63.6	17.4
Pyhtää	17.4	63.7	18.9
Ruotsinpyhtää	16.2	64.3	19.5
Eastern Uusimaa	19.4	65.4	15.2
Whole country	17.1	66.4	16.5

Table 5. Share of foreign residents of population in 2006 (Statistics Finland).

Percentage of residents	Loviisa	Lapin-järvi	Liljen-dal	Per-naja	Pyhtää	Ruotsin-pyhtää	Eastern Uusimaa	Whole country
	2.2	2.3	1.4	1.5	1.5	1.2	2.0	2.3

Table 6. Employment, trade and self-sufficiency in work places in 2005 / 2006 (Statistics Finland).

	Loviisa	Lapin-järvi	Liljen-dal	Per-naja	Pyhtää	Ruotsin-pyhtää	Eastern Uusimaa	Kymen-laakso
Employed, number of people	3 116	1 148	628	1 767	2 185	1 274	43 105	76 138
Trade, %								
- primary production	1.7	22.2	21.7	15.6	10.7	12.1	4.8	4.2
- secondary production	38.4	20.3	20.4	20.3	25.8	39.6	33.9	28.0
	54.2	50.4	51.2	57.5	55.6	41.4	54.3	61.6
- services	5.7	7.0	6.8	6.6	8.0	6.9	7.0	6.2
-other								
Unemployment rate, % *	10.4	7.7	6.0	6.0	9.1	7.9	6.7	11.5
Self-sufficiency in work places, %	115.9	89.1	72.8	49.7	50.6	63.6	79.1	98.3

Table 7. Tax rates 2006 / 2007 (municipalities and the Finnish Real Estate Federation).

	Loviisa	Lapin-järvi	Liljen-dal	Per-naja	Pyhtää	Ruotsin-pyhtää
Municipal tax of earned income, % (2007)	19.5	19.0	19.0	19.0	19.0	19.0
Real estate tax, % (of taxable value) 2006						
General	0.70	0.60	0.50	0.55	0.75	0.55
Permanent settlements	0.30	0.30	0.30	0.30	0.30	0.30
Other settlements	0.85	0.85	0.90	0.90	0.90	0.85

Table 8. Key figures of municipal economy in 2005 - 2006 (Statistics Finland).

	Loviisa	Lapin-järvi	Liljen-dal	Per-naja	Pyhtää	Ruotsin-pyhtää
Taxable income €/resident (2005)	13 078	9 620	9 748	11 125	12 470	11 285
Annual profit €/resident (2006)	887	219	203	95	90	87
Relative debt, % (2006)	33.1	16.4	26.8	17.5	53.9	38.2
Loan stock €/resident (2006)	1 513	429	703	330	1 890	868

Table 9. Gross National Product m€, with 2005 prices (Statistics Finland).

	2000	2001	2002	2003	2004	2005
Whole country	128 989	135 759	142 165	146 529	151 378	156 790
Eastern Uusimaa	1 896	2 183	2 488	2 460	2 582	2 825
Porvoo	1 468	1 719	1 989	1 889	2 059	2 249
Loviisa	428	464	499	571	522	576
Kymenlaakso	4 742	5 027	5 153	5 102	5 330	5 335
Kouvola	2 768	2 943	3 025	2 997	3 012	3 024
Kotka-Hamina	1 974	2 084	2 128	2 105	2 319	2 311

Table 10. Development of gross national product as index, 100 = 2000 (Statistics Finland).

	2000	2001	2002	2003	2004	2005
Whole country	**100.0**	**105.3**	**110.3**	**113.7**	**117.4**	**121.6**
Uusimaa	100.0	106.6	108.6	111.4	114.8	121.6
Eastern Uusimaa	100.0	115.1	131.2	129.8	136.2	149.0
Porvoo	100.0	117.1	135.6	128.7	140.3	153.3
Loviisa	100.0	108.3	116.5	133.4	121.9	134.3
Kymenlaakso	100.0	106.0	108.7	107.6	112.4	112.5
Kouvola	100.0	106.3	109.3	108.3	108.8	109.2
Kotka-Hamina	100.0	105.6	107.8	106.7	117.5	117.1

Table 11. Gross national product as index comparison per resident, 100 = whole country (Statistics Finland).

	2000	2001	2002	2003	2004	2005
Whole country	100.0	100.0	100.0	100.0	100.0	100.0
Uusimaa	140.9	141.9	137.7	135.1	134.5	136.8
Eastern Uusimaa	87.2	92.8	103.2	102.3	102.0	102.7
Porvoo	86.9	92.4	105.0	100.9	104.8	104.2
Loviisa	88.2	94.4	96.7	106.7	92.3	97.7
Kymenlaakso	104.2	102.7	100.2	99.4	102.1	99.0
Kouvola	116.4	113.8	111.2	111.6	112.0	109.6
Kotka-Hamina	90.5	90.3	87.8	85.8	91.1	87.2

Table 12. Business operations in Loviisa in 2005 (Statistics Finland).

Trade	Work places	Personnel	Turnover 1 000 €
Agriculture, game husbandry and forestry	6	50	2 018
Fishing industry	5	7	1 104
Industry	43	706	96 730
Electricity, gas and water supply	8	457	245 643
Construction	70	139	12 467
Wholesale and retail trade	126	313	76 796
Accommodation and restaurants	28	96	6 587
Transport, storage and communications	61	279	31 149
Financing and insurance	8	43	-
Real estate, rental and investigation services	72	248	14 469
Training	3	3	221
Health care and social services	23	73	4 039
Other social and personal services	37	35	2 001
Total	**490**	**2 449**	**493 224**

Table 13. Education level of population in 2005 (Statistics Finland).

Percentage of residents	Loviisa	Lapin-järvi	Liljen-dal	Per-naja	Pyhtää	Ruotsin-pyhtää	Eastern Uusimaa	Whole country (2004)
Degrees	55.2	51.8	53.7	52.9	59.5	52.6	60.2	50.8
Secondary level	32.6	37.1	37.1	33.6	39.0	36.0	34.5	30.6
Academic	22.6	14.7	16.5	19.3	20.5	16.6	25.7	20.2

Nature photographs: Timo Lindgren
Timo Lindgren is an arborist and nature photographer from Loviisa.

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