Loviisa EIA 3

Fortum Power and Heat Oy

Supplementing the Loviisa Nuclear Power Plant
with a Third Plant Unit

Environmental Impact Assessment Report Summary

Fortum

1 LOVIISA 3 PROJECT

This document presents a summary of the Environmental Impact Assessment (EIA) on supplementing Fortum's Loviisa nuclear power plant with a third plant unit (Loviisa 3). This also serves as a document for the international hearing process.

1.1 Project and its justification

In order to improve its readiness for constructing carbon dioxide-free additional production capacity, in spring 2007 Fortum Power and Heat Oy (Fortum) initiated an environmental impact assessment (EIA) procedure to expand its Loviisa nuclear power plant with a third power plant unit.

Fortum is examining the construction of a nuclear power plant unit with an electric power output of 1,000 to 1,800 MW and thermal power output of 2,800 to 4,600 MW on Hästholmen island in Loviisa, which is the location of two existing nuclear power plant units (Loviisa 1 and Loviisa 2). After the environmental impact assessment, the company will make decisions on further measures.

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.

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.

1.2 Location and need for land

The planned site for the new nuclear power plant unit is located on the south coast of Finland, on the island of Hästholmen, about 12 kilometres southeast of the town of Loviisa. The location is south of the current power plant units in an area suitable for construction and zoned for this purpose. The area required for the new power plant unit is about 10 hectares.

Figure 1. The location of Loviisa, Finland's neighbouring countries and the countries of the Baltic Sea region (Source: Pöyry Energy Oy).

1.3 Licences required for the project

According to the Nuclear Energy Act (990/1987), the new power plant unit requires a resolution (former decision-in-principle) issued by the Government and ratified by the Parliament stating that the power plant unit is in line with the overall good of society.

The prerequisites for a favourable resolution include, e.g., a favourable statement from the municipality of the location and the Radiation and Nuclear Safety Authority (STUK). An investment decision for the project cannot be made prior to the resolution. The Government grants the construction licence if the prerequisites for granting a construction licence for a nuclear facility prescribed in the Nuclear Energy Act are met.

The Government grants the operating licence if the prerequisites prescribed by the Nuclear Energy Act are met

Figure 2. The town of Loviisa and the location of the island of Hästholmen (Base map © Affecto Finland Oy, Permit L7588/08).

and the Ministry of Employment and the Economy has ascertained that provision for the cost of nuclear waste management has been arranged in the manner required by law. Other permits required include, among others, a building permit, environmental permit and the permit based on the Water Act.

1.4 Schedule

It takes about 11 years from the start of the EIA procedure to the commissioning of a new power plant unit; the licensing procedures take about half of the time. If it is decided to implement the project and it progresses as planned, the construction can start in 2012 and the Loviisa 3 power plant unit will be commissioned in 2018.

1.5 Other nuclear power plant projects in Finland

Teollisuuden Voima Oyj (TVO) has an ongoing EIA procedure for a fourth power plant unit possibly to be built in conjunction with the Olkiluoto nuclear power plant. TVO submitted the EIA report to the coordinating authority in February 2008.

Fennovoima Oy has started an EIA procedure for the construction of a new nuclear power plant by submitting its EIA programme to the coordinating authority in January 2008. The site options presented for the nuclear power plant are Kristiinankaupunki, Pyhäjoki, Ruotsinpyhtää and Simo. Without more specific implementation plans and implementation decisions, the combined effects of the Ruotsinpyhtää location with the Loviisa 3 project have not been assessed. ●

2 ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

2.1 Environmental impact assessment procedure

The directive (85/337/EEC) issued by the Council of 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. According to the list of projects within the EIA Decree, nuclear power plants are included in the projects subject to the assessment procedure. According to the EIA Act, the coordinating authority in nuclear power plant projects is the Ministry of Employment and the Economy (formerly Ministry of Trade and Industry).

The EIA programme for the Loviisa 3 project was completed in June 2007. The programme was presented at a public event and was made available for public display from 2 July to 17 September 2007. The coordinating authority issued its statement about the programme to Fortum on 16 October 2007.

The results of the EIA have been collected in the EIA report, which was submitted to the coordinating authority in April 2008. The EIA report is on public display for two months for statements and opinions. Upon conclusion of the period of public display, based on the opinions and statements, the coordinating authority will issue its own statement about the EIA report, which concludes the EIA procedure.

2.2 International hearing

The UNECE Convention on Environmental Impact Assessment in a Transboundary Context (the so-called Espoo Convention) applies to the Loviisa 3 project. The coordinating body in Finland is the Ministry of the Environment, which notified the environmental authorities of the countries of the Baltic Sea region (Estonia, Russia, Denmark, Germany, Sweden, Poland, Latvia and Lithuania) and Norway about the commencement of an EIA procedure associated with the project and inquired about their willingness to participate in the EIA procedure. Latvia and Denmark notified the Ministry of the Environment that they will not participate in the EIA procedure.

The points presented in the statements issued about the EIA programme in conjunction with the international hearing have been taken into consideration and included in the assessment report, and the most significant impacts are also included in this summary document. ●

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3 PROJECT DESCRIPTION

3.1 Assessed alternatives

The EIA has examined the construction of a nuclear power plant unit with an electric power output of 1,000 to 1,800 MW and a thermal power output of 2,800 to 4,600 MW on Hästholmen island in Loviisa. In addition to the construction and operation of the power plant, the project also includes the interim storage of the spent nuclear fuel produced by the new power plant, the treatment, storage and final disposal of low- and intermediate-level operating waste, and the decommissioning of the power plant followed by the treatment and final disposal of the decommissioning waste, all occurring at the plant site.

The possibility for combined heat and power production has been taken into consideration when assessing the environmental impacts. Among other things, the project includes intake and discharge arrangements for cooling water, drinking water supply system, wastewater treatment system, strengthening of the 110 kV power transmission connections, and construction of an unloading and loading facility for heavy sea transportation during the construction phase.

Also the impacts of non-implementation of the project have been assessed. If the Loviisa 3 project is not implemented, Fortum will reserve the area on Hästholmen island for later construction of additional nuclear power.

3.2 Technical specifications

The new power plant unit will be a light water reactor, either a boiling water reactor or a pressurised water reactor, available on the market now or in the near future. The planned power plant unit is a base-load station that runs continuously, except for maintenance outages at one-two year intervals. The technical service life of the plant is at least 60 years. Table 1 presents some technical data on the new power plant unit. The figures are preliminary.

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.

Table 1. Preliminary technical data on 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 t/v
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

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 8–12 °C warmer either via a discharge channel or through a cooling water discharge tunnel. The operating principle of a boiling water reactor is presented in Figure 3.

Pressurised Water Reactor (PWR)

Compared to a boiling water reactor, the pressure in a pressurised water reactor is notably higher, typically 120–155 bar. The high pressure prevents the water that runs through the reactor core and heated by the energy released in the fission reaction from boiling inside the reactor pressure vessel. A pressurised 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 with the primary system's pressurised water, which is heated to 300–330 °C to separate steam generators, where the energy is transferred to the secondary system water, evaporating it. The

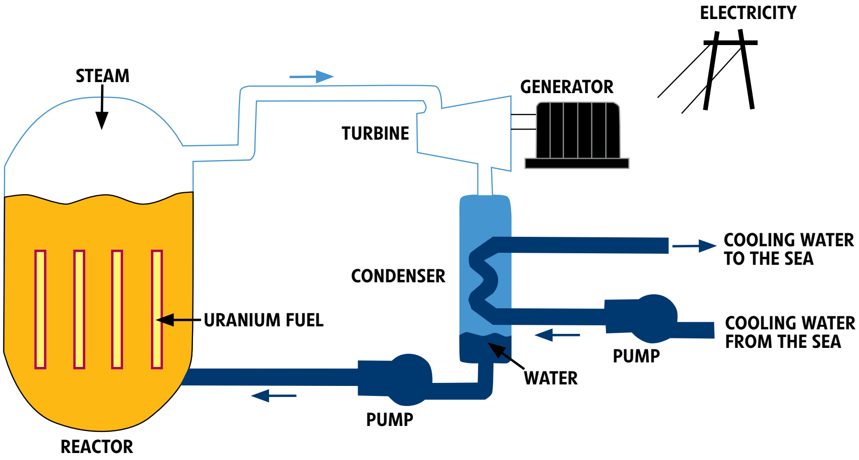

Figure 3. The operating principle of a boiling water reactor.

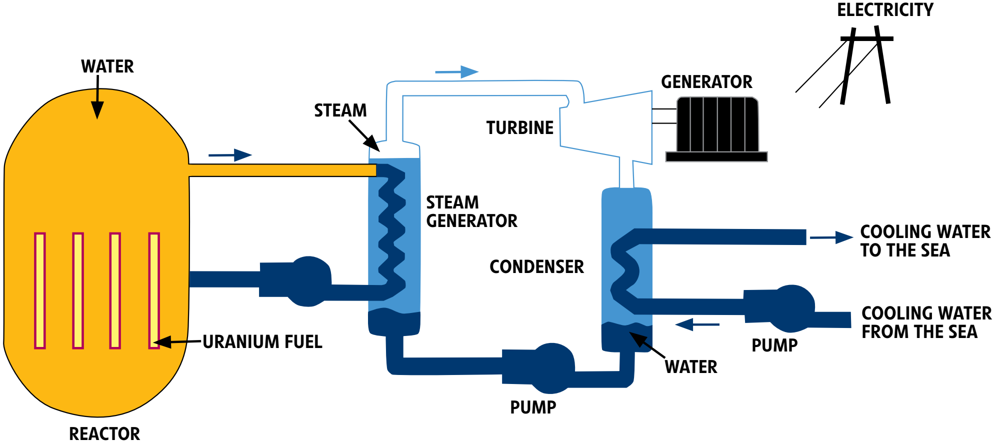

Figure 4. The operating principle of a pressurised water reactor.

evaporated steam (260–295 °C and 45–78 bar) flows to the turbine. The primary system 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, cooled by cold sea water, into water. In pressurised water reactor plants, the water is pumped back from the condensers to the steam generators. The sea water used for cooling is returned to the sea 8–12 °C warmer either via a discharge channel or through a cooling water discharge tunnel. The operating principle of a boiling water reactor is shown in Figure 4.

3.3 Cooling water alternatives

Three alternative intake areas of the cooling water for the new power plant unit have been outlined: local intake from Hudöfjärden (O1) and two remote intake areas from Vådholmsfjärden (O2, O3). Also three discharge areas have been outlined: local discharge in Hästholmsfjärden (P1) and two remote discharge areas in Vådholmsfjärden (P2, P3). The cooling water intake and discharge areas and the possible intake and discharge locations are shown in Figure 5.

The realisation of the remote intake and discharge locations requires the building of structures on some of the local islands or shoals to enable closure of the cooling water tunnels. It is possible to use areas O1, O2, P1 and P2 in certain places without changes to the zoning plan. The use of the areas O3 and P3 requires changes to the zoning plan. The cooling water intake and discharge locations for the existing power plants will remain unchanged.

3.4 Nuclear safety

In Finland, the provisions for the use of nuclear energy are stipulated by the Nuclear Energy Act and Decree. Nuclear energy legislation prescribes the requirements concerning, among other things, the general safety principles for the use of nuclear energy, the licensing procedure for nuclear facilities, the supervision of safety, and nuclear waste management.

In Finland, the Radiation and Nuclear Safety Authority (STUK) is the authority that control the safety of nuclear facilities in Finland from the design of the power plants to their decommissioning. STUK issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards. STUK is also responsible for the supervision of the use of nuclear materials and the treatment and storage of nuclear waste.

A nuclear power plant must be designed in accordance with nuclear energy legislation and the Regulatory Guides on Nuclear Safety (YVL Guides) published by STUK in order to ensure the safety of its operation. The YVL Guides contain detailed requirements concerning safety. The guides apply to the safety of nuclear installations, nuclear materials and nuclear waste, as well as to the safety systems and emergency preparedness required for the use of nuclear energy. The YVL Guides are rules the licensee or any other organisation concerned must comply with.

Safety is the central design principle of the new nuclear power plant unit. The design will take into account the latest safety requirements, and provisions will be made for severe accidents and the mitigation of their consequences. Potential hazardous situations will be analysed as early as in the

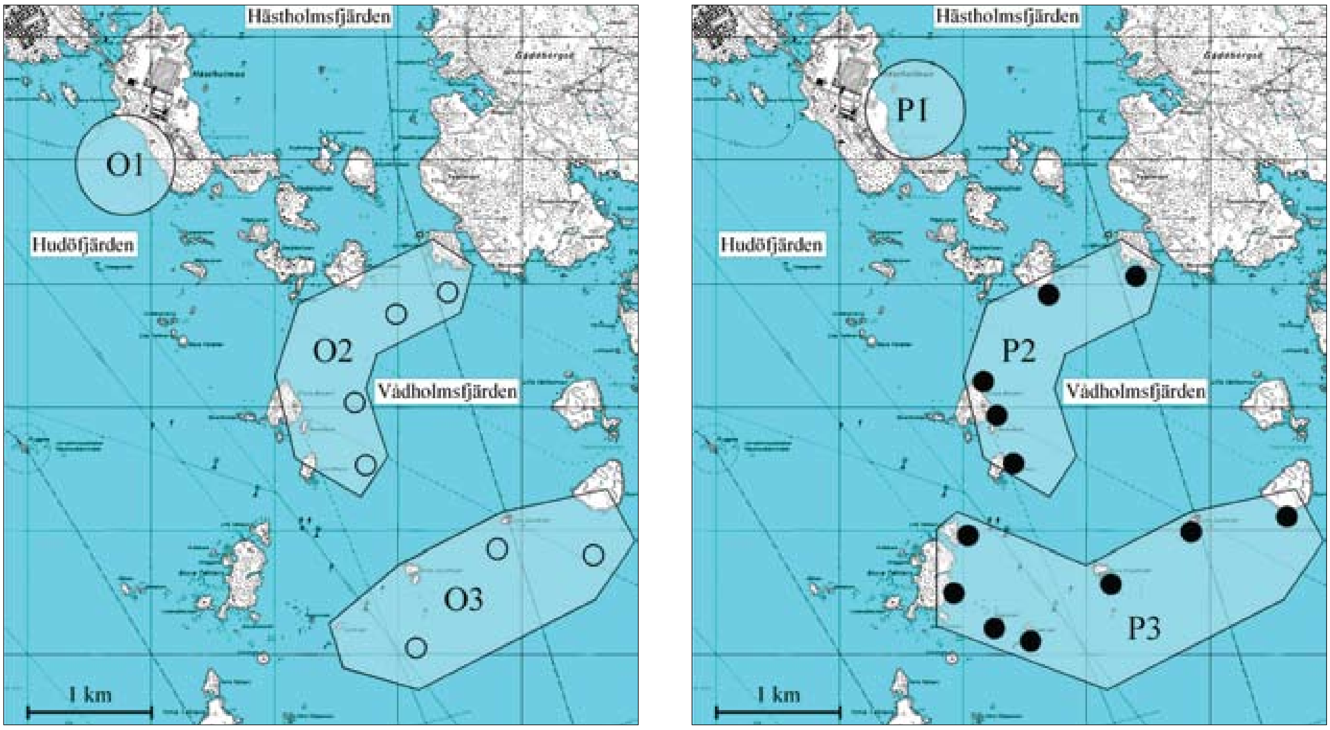

Figure 5. The alternative intake areas (O1, O2 and O3) and the discharge areas (P1, P2 and P3) of the cooling water for the new power plant unit and the possible intake and discharge locations (Base maps © National Land Survey of Finland permit number 48/MML/08).

design phase of the power plant unit, and reliable technical protection will be designed for each. Protection against external hazards, among them provisions for a major passenger aeroplane crash and exceptional weather conditions, will also be included in the design. Other contemporary threats, such as the effect of climate change, will also be considered in the design.

The goal of the safety functions is to ensure the performance of three functions in all circumstances:

- Controlling the chain reaction and the power it produces
- Cooling the fuel after the chain reaction has ended, i.e. residual heat removal
- Isolating the radioactive substances from the environment.

The fundamentals of safety include several barriers for radioactive substances and the defence-in-depth principle of safety. The principle of several barriers means that there is a series of strong and tight physical barriers between radioactive substances and the environment, preventing the substances from entering the environment in all circumstances. The uranium fuel and the gas-tight protective shielding 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. The tightness of any single barrier is enough to ensure that no radioactive substances can enter the environment. The defence-in-depth principle refers to the prevention of the occurrence of transients and accidents, as well as to the control of transients and accidents and mitigation of their consequences (Figure 6).

The objective of the power company and the control authorities is to ensure nuclear power plant safety so that plant operation does not cause radiation hazards that could endanger the safety of workers or the population in the vicinity or could otherwise harm the environment or property.

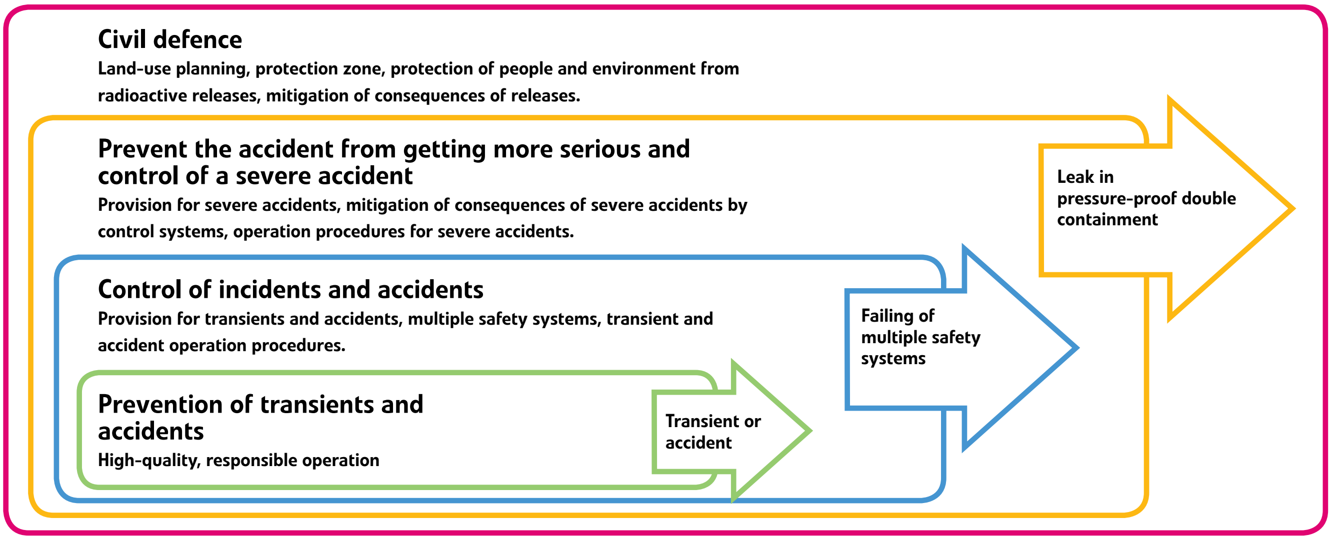

Figure 6. Nuclear safety is ensured at several different levels. An accident can result in radiation releases only if all safety levels fail.

4 STATEMENTS ABOUT THE ASSESSMENT PROGRAMME

4.1 National hearing

The coordinating authority received 32 statements from the contacted bodies. There were nine other statements and opinions submitted. Also the project responsible forwarded 11 papers to the coordinating authority, opinions that were stated at public events or conveyed in other contexts to the organisation responsible for the project.

For the most part, the statements issued considered 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 decommissioning of the power plant unit, and the environmental impact of nuclear waste management and transportation. Other project-related supplemental suggestions targeted the road network and power lines.

A wish was expressed to have the impacts of cooling water assessed in a wide area, and taking into consideration the experiences of professional fishermen. Other matters that emerged were the combined impacts of the existing power plant units and the new power plant unit, the impact on people (especially residential, habitation and social impacts), climate change, other threats and the impact of the threats on the possibility of accidents, the social significance of the project and other alternative means of power production. Many of the opinions did not present aspects related to the EIA programme, they just generally opposed or supported the idea of using nuclear power.

4.2 International hearing

In the international hearing, Sweden, Norway, Germany Estonia, Poland, Lithuania and Russia announced by the deadline their willingness to participate in the EIA procedure; Sweden, Norway, Germany and Estonia provided their statement on the EIA programme.

According to the Swedish environmental authority (Naturvårdsverket), the EIA programme was adequate, for the most part. The most significant impacts target the sea, and information about the impacts are collected in the environmental monitoring programmes of the existing power plant units. Also the Swedish nuclear safety authority (Statens Kärnkraftinspektion) considered the EIA programme adequate. The assessment of the impacts of the plant's normal operation was particularly comprehensive, according to the authority.

The statements received by the Swedish environmental authority and delivered to the Finnish Ministry of the Environment emphasised the assessment of radioactive releases from various perspectives. It said that special attention should be paid to the long-range dispersion of potential releases and the provision for that as well as to the techniques for reducing releases and the mitigation of any harmful effects. The impact of releases on the environment and further on sources of livelihood, e.g. fish and fishing, should be assessed as well. The statements also pointed out that the combined effects of the planned power plant unit and the existing power plant units on the radioactivity of the Baltic Sea should be assessed. The statements noted that the assessment of impacts should be complemented by taking into consideration the entire life span of the project and by assessing the environmental impacts of the production of nuclear fuel and spent fuel. The statements also remarked on the lack of the zero-option or inadequate discussion about it. The statements especially noted that alternative means of power production were missing.

The Norwegian Ministry of the Environment emphasised the assessment of reactor safety, accidents, unexpected events and radioactive releases. The plans and monitoring systems devised in case of accidents and anomalies should be described. The statements issued by the Norwegian Ministry of the Environment also emphasised the assessment of radioactive releases from several perspectives. Special attention should be paid to the long-range dispersion of potential radioactive releases and the provision for that and to the mitigation of potential harmful effects. Also the impact releases have on the environment and further on sources of livelihood should be assessed. Flora and fauna as well as reindeer management and recreation were given as examples. Attention was also paid to nuclear waste management and alternatives.

Germany's Innenministerium Mecklenburg-Vorpommern pointed out that the assessment of radioactive releases should take into consideration the long-range dispersion of radioactive substances via water and air, the assessment of the impacts of the long-range dispersion and a description of how e.g. Germany would be informed in the case of an accident. Also the assessment of impacts should be supplemented 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 emphasised from many perspectives the description of accidents that would have transboundary effects. The description should present the impacts requiring radiation protection and how neighbouring countries would be informed in the event of an accident.

All issues mentioned in the statements have been addressed in the EIA report. ●

5 IMPACTS OF THE PROJECT

5.1 Environmental impact assessment

In assessing the new power plant unit's environmental impacts, the current state of the environment was determined, and the changes caused by the project and their significance were assessed. The environmental impact assessment covers the entire life span of the new power plant unit. Among other things, the EIA report describes and assesses:

- The impacts of the new power plant's construction on
  - Soil, bedrock and groundwater
  - Flora, fauna and conservation areas
  - Employment and sources of livelihood
  - Well-being of residents
  - Noise levels
  - Traffic.

- The impacts of operating the new power plant unit on
  - Air quality and climate
  - Waterways, aquatic life and fishing
  - Soil, bedrock and groundwater
  - Flora, fauna and conservation areas
  - Land use, structures and landscape
  - People and society.

Other issues addressed include

- Impacts from waste and by-products and their handling
- Environmental impacts from traffic
- Impacts from transients and accidents
- Impacts from decommissioning the power plant unit
- Impacts from nuclear fuel production and transportation
- Impacts from other linked projects
- Non-implementation of the project
- Comparison of options.

5.2 Landscape and noise impacts

The new power plant unit is located in Loviisa in the Hästholmen power plant area and utilises the existing infrastructure. The current 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 reactor structures and the ventilation stacks are visible from afar from the sea.

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

Figure 7. Existing power plant units and the new pow er plant unit as seen from the southeast on Vådholmsfjärden.

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 increase about 2 dB in the immediate vicinity of the power plant area. However, the change does not increase the noise level in the settlement area.

5.3 Impacts on employment and the regional economy

Implementation of the new power plant unit will have a positive impact on the municipal economies and industry and commerce as well as employment in the Loviisa region. In addition to direct employment impacts, jobs will be created in the service sector. Improved employment opportunities 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 earth work, 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. Some of the impacts target Finns and some foreigners. In terms of employment in the Loviisa region, the construction phase of the power plant unit is very significant. The new power plant unit requires an operating staff of about 250 people. The annual need for external services is estimated to be about 50 man-years during the operation phase.

5.4 Traffic impacts

During the construction of the new power plant unit, the volume of traffic on Atomitie road leading to Hästholmen 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 by six-fold from today's volumes.

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. The traffic increase during operation will not bring a noticeable increase in the dust, noise and vibration levels to local residential areas.

5.5 Impacts on waterways and fishing

The effects of the warm cooling water on the temperature and ice conditions of the sea water surrounding Hästholmen have been studied with a 3D current model. The cooling-water model covers about a 10-km radius of sea area around Hästholmen.

The impact of the environment outside the cooling water model has been described as boundary conditions, which include the interaction between the atmosphere and the sea surface (heat transfer, force caused by wind), the main current of the Gulf of Finland, and the cooling water current of the existing power plant units and the Loviisa 3 power plant unit. The FLUENT computational fluid dynamics software was used to calculate the fluid flow and heat transfer equations.

Computational models are simplifications of natural processes and phenomena. The dispersion of warm cooling waters has been modelled in static weather conditions, and different options have been examined in a balanced situation.

In the modelling computations, the location of the remote intake site didn't have significance because the temperature of the cooling water taken in the remote intake options is essentially the same. In remote discharge options, the environmental impacts of the cooling water discharge are similar. Of the remote discharge areas, P2 is estimated to be more limiting than P3, so only the results of the P2 discharge location are presented.

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 and is discharged to Vådholmsfjärden (O2, P2).

In the winter season examinations, the cooling water is taken as a local intake and the discharge locations are the same as in summer season examinations. The options examined for the winter season are LL and LR.

Figure 8 shows the current situation, and Figure 9 an example of the calculated result of the impact of the local intake and remote discharge option (LR) of the cooling water of the existing power plant units and the new power plant unit on the sea temperature in different wind conditions.

In the local discharge options (LL and RL), the impacts are more targeted to Hästholmsfjärden, and in the remote discharge options (LR and RR), the impacts target Vådholmsfjärden.

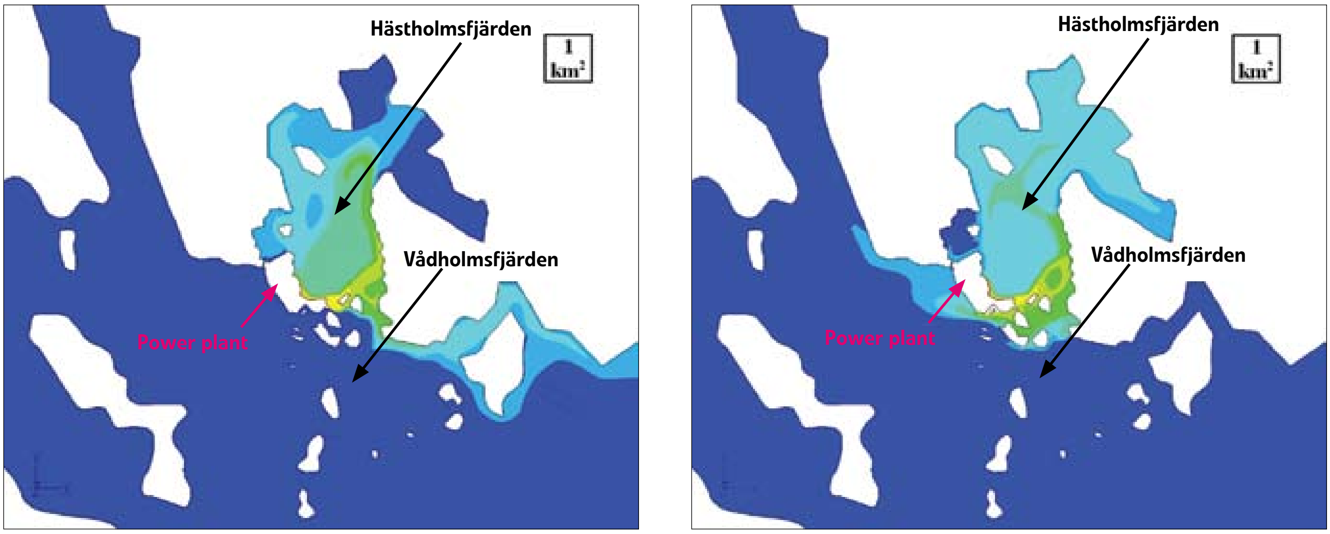

Figure 8. Summer season, current situation. The existing power plant units' impact on the sea temperature during southwest winds (left) and northeast winds (right).

In the summer season, discharging the 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 (RL), in which Hästholmsfjärden's temperature will decrease a couple of degrees from the current temperatures due to the lower temperature of the new power plant unit's cooling water. In the local intake–remote discharge option (LR), the area of open water and weak ice will be larger than with the remote intake–local discharge option (LL).

The flow of nutrients with the cooling water to the vicinity of the discharge location will increase in all options. In the remote intake–local discharge option, there could be a restoration of aquatic vegetation at Hästholmsfjärden. However, the impacts the options have on water quality, zoobenthos, aquatic vegetation, fish stocks and the fishing industry are not significant compared to the current situation, nor do they significantly differ from one another. The impacts extend a radius of a few kilometres from the warm cooling water discharge location. Overall, the impacts on the Gulf of Finland are insignificant.

5.6 Impact of radioactive releases

A nuclear power plant's allowable release of radioactive substances into the environment has been determined in such a way that no one living in the vicinity of the power plant will receive a radiation dose of more than 0.1 millisievert (mSv) per year.

The principle of the best available technology is applied in the handling of the radioactive gases generated in the new power plant unit. Radioactive gases are collected, delayed to reduce radioactivity, and filtered. After filtering, gases containing small amounts of radioactive substances are released into the atmosphere in a controlled manner through the ventilation stacks.

During operation of the new power plant unit, small amounts of radioactive substances are released in a controlled manner into the sea. The releases are formed main-

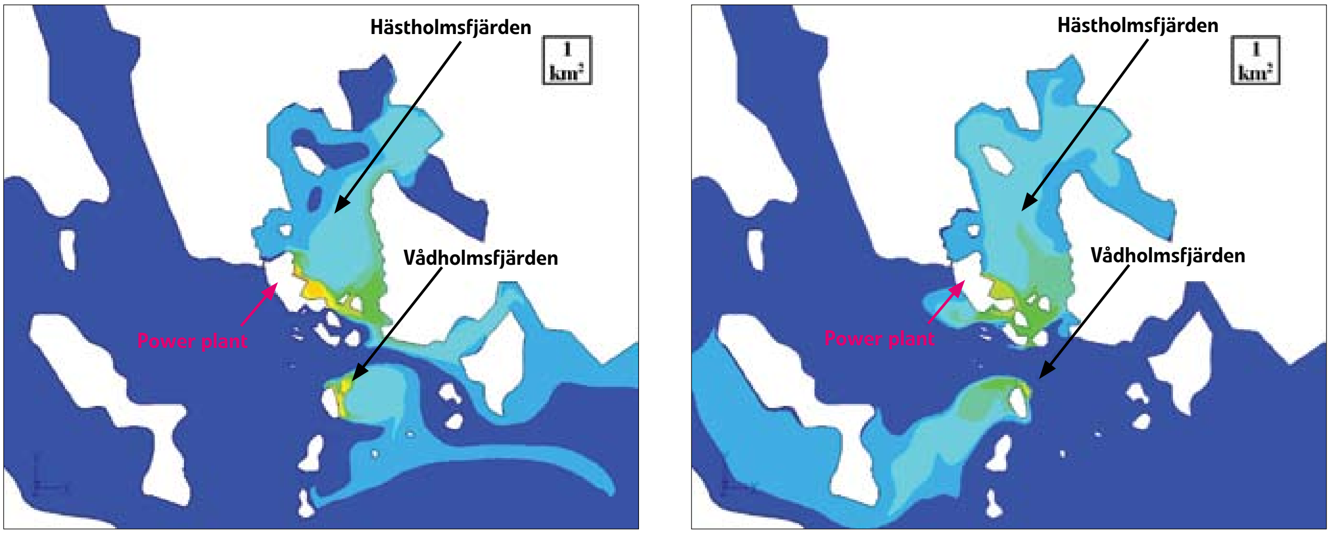

Figure 9. Summer season (LR). The impact of the existing power plant units and the new power plant unit on the sea temperature in southwest winds (left) and northeast winds (right).

ly by the exchange of the process water used in the reactor, water from the controlled area's laundry area and sewage, and the evaporation waste's discharge water. The water is treated and delayed to reduce radioactivity before being discharged into the sea.

The power plant's radioactive releases into the air and sea are monitored continuously. Radioactive substances originating from the Loviisa power plant have been detected in sea water only in exceptional cases and never in fish populations. Radioactive substances originating from the power plant have been mainly detected in the aquatic environment, such as sediment material and organisms (e.g. Saduria entomon) that particularly accumulate radioactivity and are not used as human food. A few times during the year, air and deposition samples have contained very small amounts of radioactive substances from the Loviisa power plant's releases into the air. No radioactive substances originating from the Loviisa power plant have been detected in the soil, pasture hay, milk, garden produce, grain, meat or household water.

If the amount of radioactive substances released from the power plant were substantial enough to increase the radiation level in the vicinity, the control network around the power plant would immediately detect the situation. The network consists of measuring stations 2–5 km from the power plant, and the information is automatically transmitted to the computers at the power plant units and is subject to checking at any time by the Radiation and Nuclear Safety Authority (STUK).

The radioactive releases into the air and sea during the operation of the new power plant unit are low, and they do not adversely affect human health or the natural environment, nor do they restrict agriculture or fishing.

5.7 Impacts on human health

It is estimated that the new power plant will cause an annual maximum radiation dose that is about the same for the nearby residents as the radiation dose caused by the existing Loviisa power plant units, i.e. 0.0003 mSv per year. Thus the radiation dose to an individual in the most exposed population group caused by releases during operation of the three power plant units is estimated to be a maximum of 0.0006 mSv per year.

The radiation dose caused by the new power plant to a nearby resident with the most exposure will be less than a hundredth of the annual 0.1 mSv radiation dose limit set for power plant operations and less than a thousandth of the average dose received by Finns. The radiation dose caused by the nuclear power plant units is so low that it has no significance in terms of human health.

5.8 Impacts of nuclear fuel production and transportations

The nuclear fuel production chain consists of the mining and milling of the uranium concentrate, conversion, isotope enrichment and manufacturing into fuel assemblies. Fuel for the new power plant unit will be procured from the international market. Fuel production, transportation and storage is conducted in each country in compliance with environmental and other regulations related to these activities. The operation of the mines and industrial facilities in the fuel production chain are not tied to the new power plant unit. They supply fuel on a commercial basis to nuclear power plants around the world. Fortum monitors the environmental impacts of the fuel production in its different phases.

5.9 Spent fuel and operating waste, and their impacts

According to the Nuclear Energy Act, the export and import of nuclear waste produced in nuclear power plants is prohibited. The organisation liable for the waste management is responsible for the nuclear waste handling, storage and disposal in Finland and the costs caused by them. The final goal of the nuclear waste management is the disposal of the waste in a permanent manner in the Finnish bedrock in accordance with the Nuclear Energy Act and Decree.

Depending on the power plant's output, load factor, type of fuel used, and the operating life, about 1,400–2,500 tonnes of spent fuel will be produced during the operating life of the new power plant unit. The spent fuel is cooled and stored for a few years in water pools located at the power plant unit. Then it is placed in intermediate storage for decades in the spent fuel storage located at the Loviisa power plant until its final disposal. Implementation of the new power plant unit will require an expansion to the existing intermediate storage or the construction of a new one.

The low- and intermediate-level radioactive waste produced by the new power plant unit as well as the decommissioning waste and components of the decommissioning of the power plant unit will be disposed of in the repository located more than one hundred metres below ground in the bedrock of the Loviisa power plant area. The new power plant will increase the amount of waste to be disposed of and will lead to the eventual expansion of the existing repository.

Posiva Oy is an expert organisation established in 1995 and handles the transportation of spent nuclear fuel from the Finnish nuclear power plants of its owners, Fortum and TVO, to the repository, for the disposal of the spent nuclear fuel, as well as for research associated with disposal and other expert tasks belonging to its scope of operations. Posiva will carry out the EIA procedure for the repository for the spent fuel it handles, and it will apply for the licences required for final disposal. Posiva is making preparations to dispose of the spent fuel of the new Fortum and TVO power plant units possibly to be constructed in Finland, and in early 2008 it has initiated preparations to start the EIA procedure regarding the expansion of the repository.

Posiva's final disposal concept is based on the disposal of spent fuel in copper canisters in the repository excavated 400-500 metres deep in the Olkiluoto bedrock. Final disposal is planned to start in 2020. Based on the safety assessments, the handling and final disposal of the radioactive wastes does not cause harmful impacts on the environment or people.

5.10 Comparison of options

The new power plant unit will be either a boiling water reactor or a pressurised water reactor. Both types of plants have virtually the same safety requirements, technical solutions and thus radioactive releases (with the exception of tritium), level of safety, environmental risks, and social and economic impacts. There are no differences between the pressurised water and boiling water reactors regarding the impacts of fuel transportation, fuel storage, and waste handling and storage. The release of radioactive tritium is bigger with pressurised water reactors than with boiling water reactors; the difference, however, doesn't have any practical significance in terms of environmental impacts.

In conclusion, it can be said that the environmental impact assessment did not find the construction or operation of the new power plant unit to cause any environmental impacts of such significance that they could not be accepted or mitigated to an acceptable level. All cooling water options are environmentally acceptable. ●

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6 NON-IMPLEMENTATION OF THE PROJECT

If the project is not implemented, Fortum will keep the area on the island of Hästholmen for the construction of additional nuclear power at a later date. 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 implications of the project will not be realised.

If the project is not implemented, the electricity produced by the new power plant unit will be substituted with alternative forms of electricity production somewhere else than in Loviisa. Generating an equivalent amount of electricity with fossil fuels would cause substantially more sulphur dioxide, nitrogen oxides, particle and carbon dioxide emissions. ●

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7 IMPACTS OF A SEVERE ACCIDENT

7.1 Defining the accident

The EIA examined the impacts of a radioactive release resulting from a severe reactor accident on people and the environment. The probability of the model case accident examined is less than once every 100,000 years, and the probability of a major radioactive release resulting from an accident is less than once every 2,000,000 years.

In Finland the Government Decision (395/91) on the safety of power plants requires that a severe reactor accident must not have immediate adverse health affects on the population in the region and no long-term usage restrictions on wide areas of land or water. To meet the requirement on the long-term impacts, the release of the radioactive ^{137}Cs nuclide into the atmosphere can be a maximum of 100 TBq, which corresponds to the release of a level 6 accident on International Nuclear Event Scale (INES). In addition to the 100 TBq ^{137}Cs release, the model case's theoretical release is expected to contain radioactive iodine and noble gas isotopes.

7.2 Radiation doses and impacts

The radiation doses and deposition resulting from the model case's releases to the local residents has been assessed with computer programmes developed for this purpose and used by Fortum. Additionally, the results of the example calculations of the modelling system developed by VTT Technical Research Centre of Finland and the Finnish Meteorological Institute have been used to assess radiation doses at distances of 300–1000 km. The computer models take into account e.g. the wind direction and speed. The initial data includes the magnitude, height and duration of the release and the weather conditions.

Table 2 presents the radiation doses caused by the releases and deposition of the model case within a 1,000 km radius from the vicinity of the power plant. The figures presented correspond with the 95% certainty, as per the International Commission on Radiological Protection's ICRP 101 publication. Consequently, the radiation doses and deposition caused by the accident are, with 95% probability, lower than the presented figures. Figure 10 presents the model case's radioactive doses during the first 24 hours in the most common weather conditions.

Table 2. Radiation doses to an adult caused by the model case and representing 95% certainty during the first 24 hours of exposure and the following 50 years, and the ^{137}Cs and ^{131}I deposition.

Distance from the power plant [km]	After arrival of the release plume, radiation dose in the first 24 hours [mSv]	Radiation dose in the 50 years after the first 24 hours [mSv]	^{137}Cs-deposition [kBq/m^2]	^{131}I-deposition [kBq/m^2]
1	230	250	1 700	47 000
3	120	150	620	26 000
10	30	70	180	7 200
30	10	20	60	2 300
100	4	5	20	600
300	1	2	5	200
500	0.5	0.7	3	100
1000	0.2	0.3	1	50

Table 3. Examples of radiation doses and radiation limits.

Radiation dose	Description
0,0003 mSv	The average annual computational radiation dose to an adult person in the most exposed population group in the vicinity as a result of releases by the existing Loviisa power plant units in recent years. The average radiation dose a person living in Loviisa receives during a 2-hour period outdoors in the summer from the soil's natural radioactive substances and from space.
0,1 mSv	The maximum radiation dose a person living in the vicinity receives during one year from all radioactive releases of the nuclear power plant area.
3,7 mSv	The average radiation dose a Finnish person receives in one year.
50 mSv	Maximum one-year radiation dose for a person working with radiation.
100 mSv	Maximum five-year radiation dose for a person working with radiation.
1 000 mSv	Symptoms of radiation sickness (e.g. radiation fatigue, nausea) start appearing if the radiation dose is received within a 24-hour period.

A release from the model case would not cause early adverse health affects even to the residents in the closest vicinity. After the first 24 hours, the radiation dose for 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

Figure 10. The model case's radiation doses during the first 24 hours in the most common weather conditions. The radius of the circle is 100 km. (Base map © Affecto Finland Oy, Permit L7588/08)

the average radiation dose caused by radioactive substances found in nature during the same period. Table 3 shows examples of radiation doses and radiation limits for comparison.

The civil defence actions necessary in a severe accident depend on the stage of the accident and the prevailing weather conditions. Initially, it is most important to be protected from the radiation of the release plume and avoid breathing in radioactive air. Evacuation is most efficient, but in most accidents it is enough to take cover indoors to adequately decrease the radiation dose.

The model case's radiation dose during the first 24 hours requires an evacuation of a 10-kilometre area before the release plume arrives. There is 24 hours to implement the evacuation. The evacuation area can be expanded, e.g. it can cover the 20-km emergency planning zone, because the magnitude of the release and the prevailing wind direction cannot be known in advance with sufficient accuracy. Further away, people can take cover inside and iodine tablets can also be used. Because of the evacuation, the doses during the first 24 hours can be avoided in the nearby areas, and further away the radiation doses can be effectively decreased by taking cover indoors.

In the model case, the deposition restricts the use of the land and water areas because of the external radiation and particularly the contamination of food products. The external radiation would make the area within about one kilometre of the plant unsuitable for permanent habitation. Food use restrictions resulting from the ^{131}I deposition of the model case, particularly milk restrictions, could be significant but temporary, because the half-life of iodine isotopes, which are most significant in terms of the radiation, is relatively short.

The Radiation and Nuclear Safety Authority (STUK) will report a possible accident situation to the International Atomic Energy Agency (IAEA) in accordance with international agreements. ●


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8 ENVIRONMENTAL IMPACTS OUTSIDE FINLAND

8.1 Environmental impacts during construction and operation

The construction and operation of the new power plant unit does not have any identified environmental impact outside Finnish borders. The production impacts of the fuel procured from international markets for the new power plant target areas outside Finland.

8.2 Impacts of a severe accident

In the highly unlikely event of an accident resulting in a major radioactive release similar to the model case's INES 6 level release, despite the preparedness for severe accidents and the mitigation of their consequences, there would be radiation doses of the magnitude indicated in table 2 outside Finland's borders.

The restriction of milk use as a result of the model case's ^{131}I deposition (action level 500 Bq/kg) could come into force in some deposition areas close to the 500-km radius.

Within one hundred kilometres, the ^{137}Cs deposition is 20 kBq/m^2. Based on the experiences with the Chernobyl accident, a deposition of this magnitude does not disrupt the use of agricultural products, but the ^{137}Cs concentrations of natural products could exceed the recommended concentration limits of the EU Commission. Thus depending on the weather conditions and the season, the model case's release can cause ^{137}Cs concentrations exceeding the recommended concentration limits in the natural products in Estonia and other Baltic countries, or in the Russian areas close to Loviisa. The food chains in nutrient-poor natural environments, and particularly mountainous areas and barren lake areas and in Lapland, are much more sensitive to the radioactive deposition than the agricultural product chain. If the accident were to occur in spring, and the release were to migrate to Norway, the release would cause a ^{137}Cs concentration increase of about 100 Bq/kg in Norwegian reindeer. The EU's action level for ^{137}Cs concentration in accident situations is 1,250 Bq/kg.

A release ending up in the sea will mix with the sea water and part of it will sediment in the sea bed. The mixing and the migrating are affected by the wind and the Gulf of Finland's general currents, which on the Finnish coast flow from east to west. As it migrates, the radioactivity becomes diluted in the huge volume of water. The Gulf of Finland is only one part of the Baltic Sea, but if the model case's 100 TBq ^{137}Cs release were to occur in the sea and were to mix in the Gulf of Finland, the ^{137}Cs concentration of the sea water would increase by 0.1 Bq/dm^3. ●

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CONTACT INFORMATION

Organisation responsible for the project: Fortum Power and Heat Oy
Postal address: PO Box 100, FI-00048 FORTUM, Finland
Telephone: +358 10 4511
Contact persons: Peter Tuominen, Reko Rantamäki
E-mail: firstname.lastname@fortum.com

Coorindating authority: Ministry of Employment and the Economy
Postal address: PO Box 32, FI-00023 Government, Finland
Telephone: +358 10 606 000
Contact person: Jaana Avolahti
E-mail: firstname.lastname@tem.fi

International hearing: Ministry of the Environment
Postal address: PO Box 35, FI-00023 Government, Finland
Telephone: +358 20 490 100
Contact person: Seija Rantakallio
E-mail: firstname.lastname@ymparisto.fi

For additional information about the project, you can also contact:
EIA Consultant: Pöyry Energy Oy
Postal address: PO Box 93, FI-02151 Espoo, Finland
Telephone: +358 10 3311
Contact person: Päivi Koski
E-mail: firstname.lastname@poyry.com

EIA DOCUMENTS ON THE INTERNET:

The EIA programme and report and their summaries, as well as statements and opinions issued about the EIA programme, can be viewed on the Ministry of Employment and the Economy’s web site (www.tem.fi). The EIA programme and report and their summaries can be viewed also on Fortum’s web site (www.fortum.com/loviisa och www.fortum.fi/loviisa).

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Fortum Power and Heat Oy
P.O. Box 100
FI-00048 FORTUM, Finland
www.fortum.fi/loviisa
www.fortum.com/loviisa