Fortum Power and Heat Oy

LOVIISA LOVISA 3

Supplementing the Loviisa Nuclear Power Plant
with a Third Plant Unit

Supplementary Report to the Environmental Impact Assessment Report

Fortum

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SUPPLEMENTING FORTUM POWER AND HEAT OY'S LOVIISA NUCLEAR POWER PLANT WITH A THIRD PLANT UNIT

SUPPLEMENTARY REPORT TO THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

APPENDICES: Toppila T., Loviisa 3 EIA, Modelling of the spread of cooling water, description of the thermohydrodynamic sea area model, Fortum Nuclear Services Oy, FNS-TERMO-123, 5.11.2008. *(in Finnish)*

Toppila T., Loviisa 3, Modelling of the spread of cooling water, description and results of the studied cases, Fortum Nuclear Services Oy, GEN-LO3VALM-76, 26.11.2008. *(in Finnish)*

Hilli T. and Taskila E., Fortum Power and Heat Oy, Supplementing the Loviisa nuclear power plant with a third plant unit – supplementary assessment of the effects on watercourses and fishing for the application for a Government resolution, Pöyry Environment Oy, 9M608121, 26.11.2008, GEN-LO3VALM-86. *(in Finnish)*

Base map material:

1 INTRODUCTION

This report is a supplementary report drawn up at the request of the Ministry of Employment and the Economy made in its statement 7536/815/2008 of 15 August 2008 concerning the environmental impact assessment report on the Loviisa 3 project.

On 28 March 2007, Fortum announced that it would initiate an environmental impact assessment procedure concerning a new nuclear power plant unit (Loviisa 3) planned south of the existing Loviisa power plant units on the island of Hästholmen. The objective of the Loviisa 3 project is to build a nuclear power plant unit with a thermal output of 2800 – 4600 MW and an electrical output of 1000 – 1800 MW. The environmental impact assessment programme of the project (EIA programme) /1/ was submitted to the Ministry on 26 June 2007. The Ministry issued a statement on the EIA programme on 16 October 2007. The EIA report /2/ drawn up on the basis of the plan described in the EIA programme and on the comments made in the statements was submitted to the coordinating authority on 3 April 2008.

The coordinating authority, the Ministry of Employment and the Economy, stated in its statement on the EIA report (7536/815/2008) issued on 15 August 2008 that the contents of the EIA report on the Loviisa 3 nuclear power plant unit fulfilled the requirements established in EIA legislation and that the EIA report had been considered in a way required by EIA legislation.

In addition, the coordinating authority stated in its statement that: "The statements provided have considered the EIA report to be appropriate and exhaustive. However, the Ministry of the Environment, the Ministry of Agriculture and Forestry and the Uusimaa Regional Environment Centre, for instance, have stated that in some respects the EIA report is insufficient.".

In its statement, the Ministry of Employment and the Economy required that further studies should be conducted on some subject entities discussed in the EIA procedure. The Ministry of Employment and the Economy required that these further studies should be submitted to the Ministry for consideration of the potential application for a Government resolution.

Further studies were required about the following subject entities dealt with in the EIA procedure:

- Combined electricity and heat production plant, including environmental impacts and nuclear safety;
- Combined effects of the cooling waters from several reactors, including criticism related to the cooling water modelling;
- The most important technical data in terms of the environmental impacts of the optional plant types;
- Verification of the Natura 2000 assessment;
- Environmental impacts of nuclear waste management;
- Issues to be considered in further design of the project;
- Agricultural production, fish farming; and
- Cost structure of electricity production.

The deadline set for the studies was 30 November 2008, but assessment of the combined effects of cooling waters from several reactors is allowed, with good reason, not to keep to the above schedule. Furthermore, the schedule for the Natura study may differ from the proposed schedule and its evaluation will be made separately in accordance with the Nature Conservation Act.

The representatives of Fortum Power and Heat Oy and the Ministry of Employment and the Economy discussed the required further studies on 8 September 2008. On this occasion, Fortum Power and Heat Oy expressed its own opinion about the extent of the subject entities to be dealt with.

This report does not separately deal with verification of the Natura 2000 assessment, since the essential issues linked with the subject relate to the cooling water model described in Appendix 1, the spread of cooling waters described in Appendix 2 and the effects of cooling waters described in Appendix 3.

2 COMBINED ELECTRICITY AND HEAT PRODUCTION PLANT

At the moment, nuclear power plants produce heat along with electricity on a small scale in e.g. Russia, Bulgaria, Hungary, Slovakia, Ukraine and Switzerland. The plant-specific thermal power of the existing plants is 20–240 MW.

Combined electricity and heat production increases the power plant's overall efficiency, but, at the same time, reduces the power plant unit's electrical power. The impact on the overall efficiency depends on the reactor's thermal power and the amount of heat production. If the district heat power is 1,000 MW, the power plant unit's electrical power will decrease by 160–180 MW. In essence, the overall efficiency varies also so that in summer when the district heat demand is lowest, the overall efficiency is also at its lowest.

In practice, there are consumers for the 1,000 MW of district heat only in the Helsinki metropolitan area. The demand for district heat in this area is about 11 TWh/year, which corresponds to an average district heat power of 1,200 MW.

Connecting district heat production to a light water reactor plant is technically feasible and does not cause major modifications to the plant process. Both in pressurised water and boiling water reactor plants, the possibility of radioactivity spreading to the district heating water has been prevented. In a pressurised water reactor plant, the barriers are the clean secondary circuit and the district heat exchangers; in a boiling water reactor plant, the barriers are the clean intermediate circuit and the district heat exchangers.

Because of the secondary circuit, the turbine plant process in a pressurised water reactor plant is not radioactive during normal operation. Thus it is possible to connect the district heat exchangers directly to the turbine plant process. The spreading of radioactivity that has possibly entered the secondary circuit further to the district heating water is also prevented by designing the district heating network's operating pressure to be higher than the steam pressure of the turbine extraction. The basic implementation of district heat production in a pressurised water plant is presented in Figure 1.

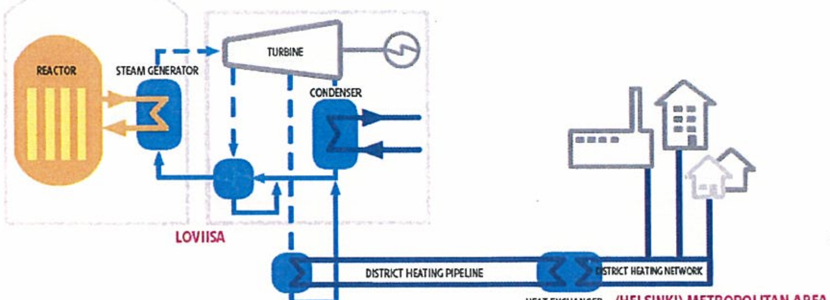

Figure 1. Basic implementation of district heat production in a pressurised water plant.

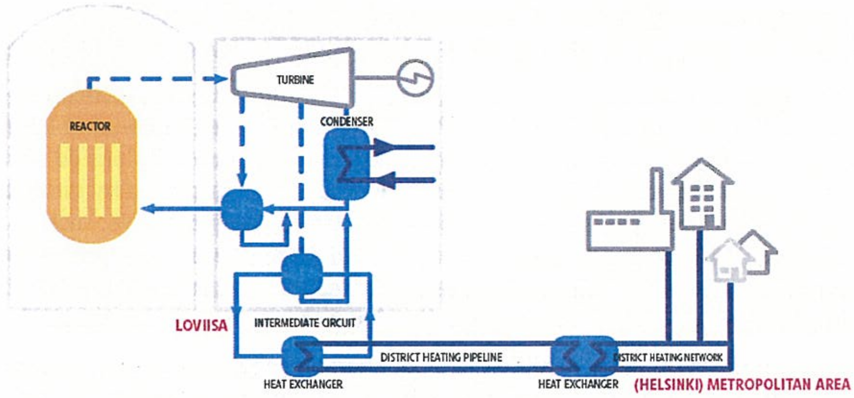

Figure 2. Basic implementation of district heat production in a boiling water plant.

Due to the activity of the turbine plant process during normal operation of a boiling water plant, an intermediate circuit is added between the district heat exchanger and the turbine plant process. The intermediate circuit's operating pressure is designed to be higher than the steam pressure of the turbine extraction. In a possible leak situation, this prevents the spread of radioactivity to the intermediate circuit. The basic implementation of district heat production in a boiling water plant is presented in Figure 2.

District heat exchangers in pressurised water reactor plants and intermediate circuit heat exchangers in boiling water reactor plants are connected parallel to the turbine plant's preheating system, and the heating steam is taken from the turbine's flow section at a stage that is best in terms of overall efficiency.

Additionally, the activity of the district heating water is monitored continuously, and the district heating water circulation is turned off if needed. The district heat output is adjusted by changing the temperature and flow of the district heating water. The main principle is to maintain steady reactor power and to adjust the electric power to correspond to district heat demand. Disruptions in district heat production do not jeopardise the safe operation of the reactor plant.

The environmental impacts (thermal power into the sea 2000 MW) of a nuclear power plant unit producing electricity (1600 MW) and district heat (1000 MW) differ from the environmental impacts (thermal power into the sea 2800 MW) of a nuclear power plant unit producing merely electricity (1800 MW) with respect to the effects of warm cooling water only. In the district heating option, the environmental impacts of warm cooling waters target a more restricted area particularly in winter, when the district heat demand is at its highest. In summer, the entire district heat production capacity cannot be utilised, and so the alleviation of environmental impacts is slighter. In an extreme case, when a power plant unit operates without the district heat load, the environmental impacts are not alleviated at all. The construction of a district heating pipeline between Loviisa and Helsinki also involves environmental impacts. Implementation of the district heating pipeline probably requires a separate environmental impact assessment procedure.

3 THE MOST IMPORTANT TECHNICAL DATA IN TERMS OF ENVIRONMENTAL IMPACTS OF THE OPTIONAL PLANT TYPES

The environmental impacts of the studied plant options do not practically differ from each other, although the length of the construction time, the amount of labour and the number and quality of transports may differ. The technical solutions do not have a considerable impact on the noise and landscape effects produced by the construction itself. Furthermore, other operations that have the greatest impacts, such as construction of the cooling water intake and discharge locations, construction of the loading and unloading site and the raw water supply arrangements, will be implemented with the same methods whatever the plant option selected.

Environmental impacts resulting from operation of the studied plant options hardly differ in practice, either. The heat transferred into the sea with the cooling water has the most significant environmental impact; the heat amount depends on the reactor's thermal power and the power plant's total efficiency. The environmental impacts of cooling water from a power plant unit with a thermal power of 2800 MW are smaller than the environmental impacts of a similar power plant unit with a thermal power of 4600 MW. In potential combined electricity and heat production, the total efficiency of the power plant improves. This also means that the amount of heat led into the sea is reduced and the environmental impacts target a more restricted area.

During operation of a nuclear power plant, radioactive materials are produced when the nuclei of the fuel split (fission products) as products of the radioactive decay chains and through neutron activation. Neutron radiation of the reactor is reduced efficiently, in addition to other radiation, by the radiation shield that surrounds the reactor. The release of radioactive materials into the environment is prevented effectively by the fuel matrix, the fuel shroud tube, the reactor cooling circuit, the containment building and the radioactive waste treatment systems (filters, ion exchangers, evaporators, degassing units, tanks) and the ventilation systems (filters). Basically the plant options are similar light water reactors that use uranium as fuel, and radioactive waste treatment systems based on the same operating principles are used in them. It is not worthwhile to compare the releases of radioactive materials from the different plant options precisely at this stage of the project, since the solutions to be adopted will not be agreed on in detail until the power plant unit is acquired.

Differences caused by technical solutions that affect the releases of radioactive materials can be demonstrated as far as tritium (^{3}H) and argon (^{41}Ar) are concerned. These differences have no great significance in terms of environmental impacts, however. In a pressurised water reactor, far more tritium is produced compared with a boiling water reactor, since in a pressurised water reactor the boron dissolved in the primary coolant captures neutrons and this reaction produces tritium. In pressurised water reactors, radioactive argon ^{41}Ar is produced when stable ^{40}Ar isotope contained naturally in the air around the reactor pressure vessel is activated through the effect of neutron flux. Unlike in pressurised water reactors, in boiling water reactors the reactor pressure vessel is surrounded by nitrogen, and so there is no argon to be activated. Radioactive carbon isotope ^{14}C is produced when the oxygen atoms of the coolant of light water reactors are activated, and the amount depends mainly on the thermal power of the reactor. In addition to the radioactive waste treatment systems, any fuel leaks, materials used for the primary circuit and the cooling circuit water chemistry, for instance, have an effect on the releases of noble gases other than ^{41}Ar and of fission and activation products.

Environmental impacts of the nuclear fuel procurement, the final disposal of spent fuel and operating and maintenance waste, and of the decommissioning differ primarily as far as the final disposal facilities are concerned. The size of the repository required for the spent fuel depends on the thermal power of the reactor, discharge burnup of the fuel and the total amount of energy generated during operation of the power plant unit. Of the studied plant options, the plant with the lowest power needs the smallest repository for spent fuel, because the other properties of the different plant options are very similar.

4 ENVIRONMENTAL IMPACTS OF NUCLEAR WASTE MANAGEMENT

With regard to nuclear waste management, more specific information was required concerning expansion of the repository for operating waste, its licensing and assessment of the environmental impacts of the spent fuel interim store. In addition, it was requested to state that the final disposal of spent fuel from Loviisa 3 would require a new Government resolution.

The application for a Government resolution necessary for the licensing of the final disposal of spent fuel from Loviisa 3 is being prepared at Posiva. In October 2008, Posiva completed an environmental impact assessment procedure concerning expansion of the repository for 12 000 tonnes of uranium required for the Government resolution application. Posiva assesses that the EIA procedure will be completed in March 2009.

4.1 Licensing and expansion of a repository for operating waste

A repository for operating waste is a nuclear plant referred to in the Nuclear Energy Act and requires its own licence. The licensing procedure is the same for an operating waste repository, a decommissioning waste repository, and a spent nuclear fuel repository. The licensing procedure for a repository starts with an environmental impact assessment, after which a Government resolution application for the repository is submitted to the Council of State. The possibility for a favourable Government resolution also requires approval from the local municipality. After receiving a favourable Government resolution, applications are submitted for a construction licence and a building permit as well as for other permits for normal construction and operation required for the repository. After the repository is complete, an operating licence is applied for. The repository is sealed when the Radiation and Nuclear Safety Authority has verified that the final disposal of the nuclear waste has been done in the required manner (NEA § 33).

The Loviisa repository has a valid operating licence until the end of 2055. The repository expansion needed by Loviisa 3 will be licensed as the expansion of the existing repository in the manner stipulated by Act and decrees. Recent studies have shown that in the Hästholmen bedrock in Loviisa there is enough room even for expansion of the repository required by Loviisa 3.

During the expansion of the repository, the biggest environmental impacts are caused by the transport of excavated rock. The transports cause some noise and dust, if the rock material is transported from Hästholmen. Because of the excavation work, the groundwater level on Hästholmen can slightly drop, but the impact is not very big compared to the current situation and does not extend beyond the island. Wastes transported to the repository are packed in steel or concrete containers that isolate the waste from the bedrock. The repository deep in the bedrock does not cause any significant environmental impacts. The radioactive releases during the repository's operation are a very small part of the nuclear power plant's releases and they do not have health impacts. The final disposal's long-term safety is assessed with safety cases made regularly, which are checked by the Radiation and Nuclear Safety Authority. Based on the safety case analyses of the final disposal of the operating waste of Loviisa's existing plant units, the repository's releases far in the future will remain below the limits set by authorities, and there will be no significant health effects. Loviisa 3's waste management can be handled in compliance with the authority's regulations and without any significant health effects.

A separate environmental impact assessment will eventually be made for the final disposal of the decommissioning waste, and that will be followed by a licensing procedure similar to that of a repository for operating waste.

4.2 Interim storage for spent fuel

The interim storage for Loviisa 3's spent fuel will be built as a part of the plant and will be licensed as a part of the nuclear power plant. The waste management solutions of the interim storage are integrated with the power plant's other waste management systems, and the environmental impacts of the interim storage, including the possible radioactive releases, are included in the power plant's environmental impacts, which were reviewed in the environmental impact assessment for Loviisa 3.

The biggest environmental impacts during operation of the spent fuel's interim storage are caused by the heat generated by the spent fuel. In the water storage alternative, the heat is transferred into the sea through the power plant's cooling system; in the air-cooled dry storage alternative, the heat is withdrawn to the air. The heat generation of spent fuel in the interim storage is small compared to the heat generation of the operating power plant, and that is why it does not have a significant impact on the nuclear power plant's heat load to the environment.

The interim storage of spent fuel does not cause significant radioactive releases. Handling damaged fuel assemblies could release small amounts of radioactive gases that get into the plant's exhaust air system. In water storage, contamination on the surface of the fuel assemblies dissolves into the water. Small amounts of fission products could also dissolve into the water if there is a leak in one of the fuel assemblies. The water of the interim storage is cleaned with the continuous-operation water treatment systems. The exhaust air is conducted into the exhaust air system. The activity of the exhaust air is monitored.

In air-cooled dry storage, the fuel assemblies are sealed in tanks placed in an efficiently ventilated area or in big concrete or steel drums. In dry storage, the biggest radioactive releases are caused by the handling and packaging of damaged fuel assemblies, releasing gaseous fission products. Releases are led into the plant's exhaust air system. The tanks used in dry storage are gas-tight and no significant amounts of radioactivity are released from them in normal operation.

After the shutdown of Loviisa 3, the spent fuel interim storage will be changed to operate as an independent plant. During independent operation, the releases of interim storage into the environment are of the same order at the most as during operation of Loviisa 3. The interim storage for spent fuel will be decommissioned when the spent fuel of Loviisa 3 has been transported to the final repository at Olkiluoto.

5 ISSUES TO BE CONSIDERED IN FURTHER DESIGN OF THE PROJECT

Many of the issues referred to in the EIA report will be studied in more detail as the Loviisa 3 project progresses. Several issues to be considered are linked with concrete work or operations, for whose implementation a permit is required from the authorities, for instance, a building permit, an environmental permit and permits based on the Water Act. Their effects will be studied in the licensing phase more thoroughly than in the EIA report. As the project progresses, various permits will be applied for from, e.g., the town of Loviisa, the Western Finland Environmental Permit Authority, the Finnish Civil Aviation Authority, the Safety Technology Authority (Tukes), the Energy Market Authority and the Radiation and Nuclear Safety Authority. In accordance with the Nuclear Energy Act, the project requires a favourable Government resolution, which presupposes that the municipality of the location and the Radiation and Nuclear Safety Authority provide their favourable statements. Furthermore, a construction licence and an operating licence will be applied for from the Government.

Investigation of the natural values has continued after the submission of the EIA report. As part of the updating of the town plan for Hästholmen, a study into the bat population and a nature survey were conducted in the area covered by the town plan in summer 2008.

More effective methods have been sought to study the spread of cooling waters from the existing power plant units. To gain deeper insight into the current situation, studies into the quality of surface waters in the nearby water areas of the existing power plant units were launched in summer 2008. The studies have included, besides the temperature, e.g., the salinity, the turbidity and the amount of nitrate nitrogen. In addition, temperature and flow measurements have been carried out in inlets and Hästholmsfjärden.

Studies of the optional intake locations of cooling water have continued. Measurements with a view to establishing the temperatures of water masses at different depths have been carried on. The first long-term flow measurements in the sea area began, and a decision on the follow-up measurements will be taken on the basis of the first results. Plans have been made to launch long-term temperature measurements in the areas of the potential intake locations.

Various potential sources of information have been reviewed related to the monitoring of, e.g., the sea water quality and temperature and the ice conditions, and information on them connected with the environment in the Loviisa region has been evaluated. The review of sources of information is being continued.

To specify the environmental impact monitoring programme, places near the potential cooling water discharge locations are being sought with the aid of which it will later be possible to assess the effects of warm cooling waters on, e.g., aquatic vegetation and zoobenthos representatively at different distances from the discharge location. The environmental impact monitoring programme will be revised upon selection of the plant option and the cooling water arrangements.

Assessment of the combined effects of cooling waters from the power plants of several operators will be verified, if necessary.

A Natura assessment will be made when the project plans have been specified, if implementation of the project requires this.

The amount of fish carried with cooling water is minimized, as far as possible, by means of the design of the cooling water intake structures. Test fishing has also been planned as a part of the studies into the intake locations.

The opportunity to implement combined electricity and heat production has been investigated. The transmission of district heat to the metropolitan area is technically feasible. The pipeline tunnel to be built for the transmission of district heat probably requires a separate environmental impact assessment procedure.

Potential ways of using and piling the rock material produced from the excavation of cooling water tunnels will be investigated. The noise impacts of both the concrete mixing plant and the rock crushing station and the opportunities to alleviate these impacts will be examined.

To discover any underwater ancient monuments and other sites, the results of the soundings performed as part of the survey of the bedrock of cooling water tunnels will be interpreted, and the results and material will be forwarded to the Maritime Archaeology Unit of the National Board of Antiquities. The studies will target the vicinities of the loading and unloading sites, the shipping lane and the cooling water intake and discharge locations.

Any polluted sediments in the area of the shipping lane to be dredged will be investigated and the piling of dredged material will be planned. Existing piling areas will be utilised, as far as possible. If necessary, the impacts of the project on the Natura 2000 network will be assessed.

Reservations for recreation and archipelago landscape areas will be taken into account in planning hydraulic construction work.

Provision for the climate change and oil damage will be assessed when considering the power plant options and cooling water arrangements and in the further design phases.

In planning the acquisition of raw water and the treatment of waste waters, the opportunities and needs of the nearby area will be taken into account. Alternative ways of supplying the water needed in the district heating option will also be studied.

The emergency plan will be revised in good time before the fuelling of the power plant unit.

6 AGRICULTURAL PRODUCTION, FISH FARMING

The nearest farm to the Loviisa Power Plant is located about 5 km east of the power plant. There are fewer than 400 agricultural and garden produce farms in the Loviisa, Pernaja, Ruotsinpyhtää and Pyhtää regions, and their total field area is over 15,000 hectares. The farms cultivate mainly grain crops, but also vegetables and root vegetables are grown commercially. The area also has domestic animal production. Samples from the area's agricultural products are taken regularly. Radioactive materials originating from the Loviisa Power Plant have not been detected in the soil, grazing grass, milk, garden produce, crops, meat or drinking water.

The impacts of the construction of the power line, raw water pipes and the possible tunnel for district heat pipes required for the new power plant unit mainly target forested areas. Also there is the potential for some impacts to individual field areas due to construction. The operation of the new power plant unit does not restrict agricultural or forestry activities.

Utilising the warm cooling waters, small fish are grown in enclosures in the Fortum-owned area around Hästholmen. There are fish farming enclosures also in the immediate vicinity of Fortum's areas to the south and southeast of Hästholmen, and they benefit from the Loviisa Power Plant's warm cooling waters during the cold season. The next closest fish farms are less than 10 km southwest of the power plant.

Local water turbidity as a result of underwater work in constructing the new power plant unit may have a temporary impact on fish farming. The new power plant unit's local discharge option and the northernmost remote discharge location options for the cooling waters will increase the temperatures in certain weather conditions on the south side of Hästholmen. The increased temperatures can weaken the fish farms' operating prerequisites during summer. On the other hand, the operating prerequisites during the cold season can improve. The impact of the warm cooling waters on the fish farms' operations decreases as the distance between the discharge location and the fish farm increases.

7 COST STRUCTURE OF ELECTRICITY PRODUCTION

There are alternative methods for electricity production (nuclear power, other condensing power, combined electricity and heat production, hydropower and wind power) and fuels (uranium, coal, gas, peat and wood), depending on the production technology. An efficient electricity production system consists of the correct ratio of complementary alternatives. Efficient production has a sufficient amount of base-load power that is produced with nuclear power, with other condensing power and with combined electricity and heat production. In combined electricity and heat production, the amount of electricity production is determined based on the local demand for heat.

Several national and international comparisons have been prepared for the electricity production options. Fortum has compared the assessments made by others and has made also its own calculations. The cost structures of the production options differ from each other significantly due to fuel costs, expenses arising from carbon dioxide emissions, power plant operating costs and power plant fixed-capital costs. The costs of alternative production forms are based on Fortum's experiences and information, and different sources. The price of fuels and emission costs fluctuate according to the market prices.

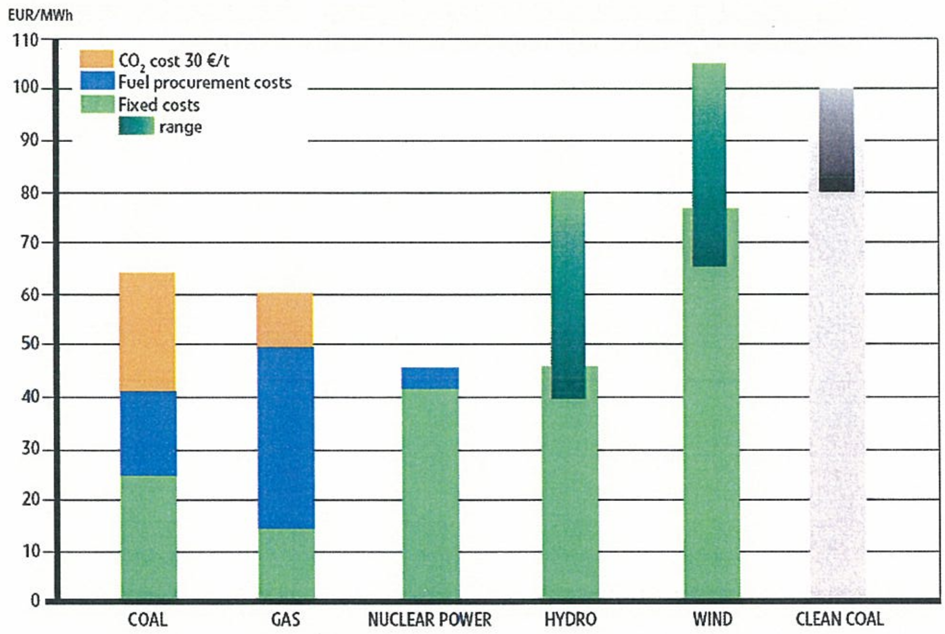

Figure 3. The costs of different forms of electricity production.

Figure 3 presents the total production costs for electricity production alternatives, itemised by fuel costs, carbon dioxide emission costs, and fixed costs (capital costs and operating costs). The costs reflect the average costs of the different production forms in 2008 monetary values. Fuel and carbon dioxide emission costs account for the majority of coal and gas energy costs. In recent years, the price of these cost factors has increased significantly because of the high international demand for fuels and the European-wide emissions reduction targets set by the European Commission. The fuel prices in the production cost comparison, however, are presumed to be significantly lower than the peak prices of 2008. A range is presented for hydropower and wind power because their costs vary significantly based on the location of a new power plant and the conditions. In the figure, clean coal represents what it would cost to produce electricity with coal if carbon dioxide emissions were cleaned and carbon dioxide was captured.

As fuel alternatives, wood and peat represent a local fuel alternative because of transportation costs. They are used primarily in local combined electricity and heat production. Their supply and price are dependent on local conditions (location of peat production areas). Wood and peat are of significance in local production, but their availability is inadequate for base-load power production.

In a nuclear power plant, fuel expenses are relatively low compared to total expenses, and there is no cost from carbon dioxide emissions. A nuclear power plant's high share of fixed costs brings price stability to the electricity produced. By constructing the nuclear power plant as a combined electricity and heat production plant, it is possible to achieve about 60% total efficiency, which according to the preliminary estimates will enable the implementation of this alternative.

8 COOLING WATER

With respect to issues linked with cooling water, this report briefly deals with the cooling water intake and discharge temperatures, carrying of nutrients with cooling water, flows in the hypolimnion, backward flow and potential modifications to the existing power plant units. The cooling water model and the spread and biological effects of cooling waters are studied in the appendices to this report.

8.1 Cooling water intake and discharge temperatures

Figure 4 shows the minima, maxima and average of the monthly averages for the cooling water intake and discharge temperatures of the existing power plant units (Loviisa 1 and Loviisa 2) in 2001-2007. In addition, the figure gives the hypolimnion temperature detected with measurements and the potential cooling water discharge temperature calculated on this basis. The temperature of the hypolimnion is represented by the monthly averages from May to October in 2007 and 2008 at a depth of 25-30 m in the vicinity of cooling water intake place O3 described in the Loviisa 3 EIA report. The temperature of the hypolimnion has also provided the basis for calculating the potential discharge temperature of the cooling water from the Loviisa 3 power plant unit (ΔT = +11° C) in May-October.

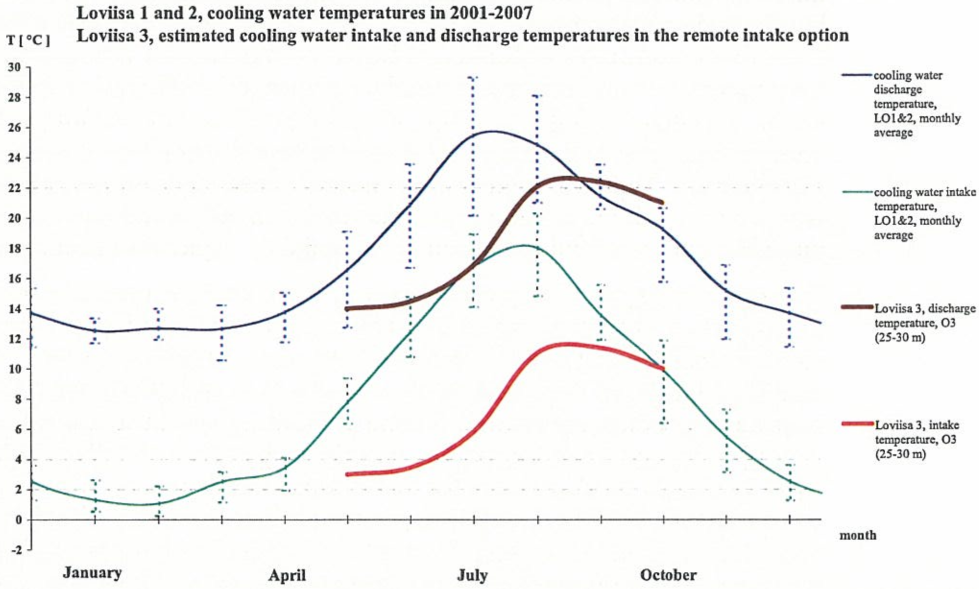

Figure 4. The minima, maxima and average of the monthly averages for the cooling water intake and discharge temperatures of the existing power plant units (Loviisa 1 and Loviisa 2) in 2001-2007; the monthly averages for the temperature of the hypolimnion from May to October in 2007 and 2008 at a depth of 25-30 m, and the potential discharge temperature of the cooling water from the Loviisa 3 power plant unit in May-October (ΔT = +11° C).

In summer, the cooling water intake depth roughly affects the intake temperature in such a way that at a depth of 20 – 25 m the water is about two degrees at the most warmer and at a depth of 15 – 20 m about four degrees at the most warmer than at a depth of 25-30 m.

A decision on the cooling water intake location or depth of the Loviisa 3 power plant unit has not yet been taken. Consequently, there is uncertainty in the basic data for the cooling water model in this respect and the area of influence of the warm cooling water may be larger than shown in the model caluculations. On the other hand, the surface water temperature of 16° C used in the basic data for the cooling water model also involves uncertainty, as the surface water temperature varies naturally and is occasionally higher than 16° C. Based on the measurements, the behaviour of the temperature in cooling water intake locations O2 and O3 at the same depths is assessed to be very similar.

The monthly average for the cooling water intake temperatures of the existing power plant units represents the surface water temperature fairly well, except for the spring season. In spring, from March to May, waters right in the surface layer are a few degrees warmer than the intake temperature of the cooling water for the existing power plant units. In summer, autumn and winter, the cooling water intake temperature represents fairly well the surface water temperature. The cooling water intake temperature naturally represents best the surface temperature in Hudofjärden, but the surface temperatures of Vådholmsfjärden (cooling water intake areas P2 and P3) do not considerably differ from what has been presented. The cooling water intake temperature does not represent the surface temperature in Hästholmsfjärden in the current situation, but it gives an idea of what the surface temperature would be like without the impact of the cooling waters from the existing power plant units. In Hästholmsfjärden, the behaviour of the surface temperature according to the season would be very similar to that in Hudöfjärden, but in spring and summer the average of the surface temperatures would naturally be slightly higher than in open water areas.

In addition to Figure 4, the potential cooling water intake temperature for the Loviisa 3 power plant unit (hypolimnion 25-30 m) in May-October has been shown in Table 1 as the monthly averages of the 2007 and 2008 measurements. In calculating the monthly average, all measurement observations from each depth range and month have been taken into account. Furthermore, Table 1 gives the temperature of surface water (0-5 m) and the difference between the temperatures of surface water and hypolimnion. In the EIA report, the case representing summer corresponded to July, when the difference between the temperatures of hypolimnion (+6° C) and surface water (16° C) is 10° C. In the EIA report, the Loviisa 3 power plant unit was presumed to raise the cooling water temperature by 11° C. This presumption is based on a cooling water flow of 60 m^3/s. At the existing power plant units, the rise in the cooling water temperature is curbed in the summertime ($\Delta T = +9°$ C) by increasing the cooling water flow compared with the winter season ($\Delta T = +11.5°$ C). A corresponding opportunity to curb the temperature rise was not utilised in modelling the impacts of the Loviisa 3 power plant unit. From May to July, the temperature of cooling water taken from deep layers would be very near the surface water temperature when discharged, and in discharge location P1 (Hästholmsfjärden) the temperature might even drop in some circumstances. In August, even the hypolimnion gets warmer and in September-October, when the water masses mix, the temperatures of surface water and hypolimnion are nearly the same. In the remote intake option, the benefit brought by the temperature differences is lost in autumn and the cooling water to be discharged is considerably warmer than the surface water.

Table 1. Monthly averages for the temperatures of surface water (0-5 m) and hypolimnion (25-30 m) in the 2007 and 2008 measurements, and the difference between the temperatures of surface water and hypolimnion.

	Surface water (0-5 m) temperature (°C)	Hypolimnion (25-30 m) temperature (°C)	Difference between the surface water and hypolimnion temperatures (ΔT °C)
May	11	3	8
June	13	4	9
July	16	6	10
August	17	11	6
September	13	11	2
October	11	10	1

8.2 Carrying of nutrients with cooling water and eutrophication

In different water areas, the nutrient contents in the surface water and the hypolimnion have been examined regularly for a long time as part of the monitoring in accordance with the environmental impact monitoring programme for the existing power plant units. These measurements provide a basis for assessment of the amount of nutrients carried with cooling water; however, they cannot represent exactly the situation in spring and summer at different depths in the possible cooling water intake locations. The carrying of nutrients with cooling water is also linked to flows in the hypolimnion and to the new state of balance that is produced when the cooling water intake for the new power plant unit begins. Incoherence of the measured data has been realized and plans have been made to measure the amount of nutrients at different depths more extensively to enable the carrying of nutrients to be assessed more exactly.

To establish flows in the hypolimnion, long-term flow measurements have been launched in the sea area near the Loviisa Power Plant. The first measurements are carried out in the deepest inlets bordering the different basins through which most of the water, particularly the hypolimnion, is assumed to flow. The purpose of these measurements is to establish what kind of flows occur in the area naturally at different depths and from where water flows to the possible cooling water intake locations.

Besides measurements, it is possible to get a picture of flows in the hypolimnion also with the aid of modelling.

The high nutrient content in the hypolimnion taken as the cooling water near the bottom increases eutrophication. In summer, the significance of the lower temperature of cooling water taken from deep layers is relatively small, since in summer the temperature is not a factor that restricts production.

8.3 Backward flow

In terms of economical operation of the Loviisa 3 power plant unit, it is of vital importance to make sure that large amounts of warm cooling water do not get from the cooling water discharge side back to the power plant unit's cooling water intake side, i.e. backward flow. The economic importance of backward flow is at its greatest in the summer, when the cooling water temperature is naturally highest. The phenomena linked with backward flow will be modelled in a later design phase. Basically backward flow can be prevented most efficiently by increasing the distance between the intake and discharge locations and by utilising the natural wind and flow conditions in the area. Such an option in which backward flow is suspected to become a serious problem will not be considered for implementation.

8.4 Potential modifications to the existing power plant units

The basis for the Loviisa 3 environmental impact assessment report has been to assess only the impact of the Loviisa 3 power plant unit on the current state of the environment. In drawing up the EIA report, potential modifications to the existing power plant units were excluded from the assessment, since inclusion of potential modifications in the EIA report would have made it increasingly difficult to present the impacts of the Loviisa 3 power plant unit. Furthermore, the implementation of any modifications to the existing power plant units requires separate studies and permits, possibly even a separate EIA. However, Fortum will investigate as part of the Loviisa 3 preparation work whether there will appear modifications related to the intake of cooling water for the existing power plant units that would be feasible without long outages. The impact of a change of the cooling water discharge location of the existing power plant units on the spread of cooling waters has been described in Appendix 2 and biological effects have been explained in Appendix 3.

9 SUMMARY

As part of consideration of the combined electricity and heat production plant, the basic implementation methods for both the pressurised water plant and the boiling water plant, the impact on nuclear safety and environmental impacts have been described. With regard to the combined electricity and heat production plant, the studies will later be essentially extended from what has been discussed in this report, if broader studies into implementation of the option in question are launched. The cooling water model and different results produced by the model, including the combined effects of cooling waters from several reactors, and biological effects have been described in the separate appendices. The most important data in terms of environmental impacts of the optional plant types have been provided. Verification of the Natura 2000 assessment is being continued on the basis of the information given in this document and its appendices. Environmental impacts of nuclear waste management have been dealt with. Issues to be considered in further design of the project have been discussed. Potential effects on agricultural production and fish farming have been reviewed. The cost structure of electricity production has also been presented on a general level.

Fortum considers that this supplementary report to the environmental impact assessment includes the required supplementary information sufficient for the Loviisa 3 preparation phase.

References

/1/ Fortum Power and Heat Oy, Supplementing the Loviisa Nuclear Power Plant Unit with a Third Plant Unit, Environmental Impact Assessment Programme, Fortum, June 2007.

/2/ Fortum Power and Heat Oy, Supplementing the Loviisa Nuclear Power Plant Unit with a Third Plant Unit, Environmental Impact Assessment Report, Fortum, April 2008.